Coreco Imaging • 7075 Place Robert-Joncas, Suite 142 • St-Laurent, Quebec, Canada • H4M 2Z2
http://www.imaging.com

WiT

Operator Reference Manual

Edition 8.0

Part number OC-WITM-OPREF

NOTICE

© 2003 Coreco Imaging Inc. All rights reserved.

This document may not be reproduced nor transmitted in any form or by any means, either electronic or mechanical, without the express written permission of Coreco Imaging Inc. Every effort is made to ensure the information in this manual is accurate and reliable. Use of the products described herein is understood to be at the user's risk. Coreco Imaging Inc. assumes no liability whatsoever for the use of the products detailed in this document and reserves the right to make changes in specifications at any time and without notice.

Microsoft and MS-DOS are registered trademarks; Windows, Windows 95, Windows NT, and Windows XP are trademarks of Microsoft Corporation.
All other trademarks or intellectual property mentioned herein belong to their respective owners.

Printed on September 30, 2003

Document Number: OC-WITM-OPREF

Printed in Canada

CONTENTS

CONTENTS ..... **i**

Standard **1**

Blobs 1
andBlobs *1*
getBlobFeatures *1*
getFeatures *4*
getPerimeter *5*
getWarpedFeatures *6*
getWarpedPerimeter *6*
labelBlobs *7*
mergeFeatures *8*
minSizeFeatures *9*
selectBlobs *9*
Calculate 10
add *10*
addNoise *10*
aluOp *11*
applyLut *13*
autoEqualize *14*
calc1 ..... *14*
calc *15*
collectAverage *16*
compareImages *16*
complxMult *17*
conditional *18*
div *18*
equalize *19*
false *19*
fastAluOp *20*
fastUnaryOp *21*
histEqualize *22*
invert *22*
makeLut *23*
makeSeq *24*
movingAverage *25*
mul *26*
not *26*
randSequence *27*
random *28*
sub *28*
true *29*
unaryOp *29*
Calibration 30
calibrateCamera *30*
calibrateDefault *31*
calibrateRatio *32*
calibrateScale *32*
moveOrigin *32*
restoreCoordinates *33*
restoreImage *33*
Color 34
bayer *34*
convertColor *35*
convertColorFormat *35*
getChannel *36*
mergeChannels *37*
putChannel *37*
splitChannels *38*
Complex 38
complexMerge *38*
complexSplit *39*
spectrum *39*
Convert Type 40
cast *40*
castImage *41*
ct *42*
cvtCase *43*
formatString *43*
plotEdges *44*
plotFeatures *44*
plotGeom *46*
plotLines *46*
scanString *47*
splitString *48*
sprint *49*
sscan *50*
strLength *51*
vectorsToImage *51*
Display 52
clearDisplay *52*
display *53*
edit *54*
getData *55*
getData2 ..... *57*
graph *57*
iEqualize *58*
iKey *59*

iMeas *60*
iThresh *62*
overlayData *63*
prompt *64*
runTimeConst *65*
smallDisplay *66*
surface *67*
terrain *69*
volume *70*
Edges 73
getCircularXEdges *73*
getContours *74*
getXEdges *74*
getXEdgesInPoly *76*
getXEdgesOnLine *77*
traceEdges *78*
Filter 79
compass *79*
conv1d *80*
conv2d *80*
edgeDetect *81*
edgeDirection *82*
entropy *83*
gauss *83*
grad *84*
hipass1d *85*
hipass2d *86*
laplace *86*
line *87*
lopass1d *88*
lopass2d *89*
prewitt *89*
refineEdges *90*
sobel *91*
thinEdges *91*
variance *92*
Find 92
getMatch *92*
getPeaks *94*
nxcorr *95*
sod *95*
tmatch *96*
tmatchSparse *98*
xCorr *99*
Fit 100
cHough *100*
convexHull *101*
fitCircleToPts *101*
fitLineToPts *102*
fitTwoLinesToPts *103*
gCentroid *103*
gFitContoursRoi *104*
gFitLine *104*
geom2lines *105*
getBoundingBox *106*
getVertexPts *106*
hough *107*
houghDir *108*
houghDirRoi *108*
lineIntersect *109*
mergeLines *109*
pix2pt *110*
reduceLines *110*
Control 112
buf *112*
cCode *112*
clearObjs *112*
collector *112*
counterInit *113*
counterRecall *114*
counterReset *114*
counterStep *114*
data2sync *115*
delay *115*
for *115*
for2 ..... *116*
for3 ..... *116*
gate *116*
goto *116*
if *117*
if2 ..... *117*
if3 ..... *117*
if4 ..... *118*
ifCond2 ..... *118*
ifCond3 ..... *118*
ifConditional *118*
in *119*
label *119*
memConst *119*
memFree *120*
memRecall *120*
memStore *120*
mux5 ..... *121*
mux9 ..... *121*
oneshot *121*
out *122*
select5 ..... *122*
select9 ..... *122*
sequencer *122*
start *123*
stopDisable *123*
stopEnable *123*
vgate *123*
Geometry 123

flip ... *123*
getRigidBodyTransform ... *124*
getWarpTransform ... *125*
insertGraphic ... *126*
matchSize ... *126*
move ... *127*
pan ... *128*
polar ... *128*
rotate ... *129*
scroll ... *131*
shearX ... *131*
shearY ... *131*
warp ... *132*
zoomScale ... *132*
zoomSize ... *133*
Measurement ... 133
caliper ... *134*
distAllPtToPt ... *135*
distMap ... *136*
distPtToLine ... *137*
getAngle ... *137*
getDist ... *138*
grDistMap ... *138*
plotAngle ... *139*
plotDist ... *140*
Morphology ... 141
bmedian ... *141*
dilate ... *141*
erode ... *143*
hitOrMiss ... *145*
ldilate ... *145*
lerode ... *146*
median ... *146*
morphClose ... *147*
morphGradient ... *148*
morphOpen ... *149*
outline ... *150*
rank ... *151*
skeleton ... *151*
thicken ... *152*
thin ... *153*
tophat ... *153*
Objects ... 154
addElem ... *154*
cat ... *155*
concat ... *155*
const ... *156*
crGraphic ... *156*
crImage ... *158*
crObject ... *159*
crVector ... *159*
createRect ... *159*
filter ... *160*
flattenVector ... *161*
ge ... *161*
getElem ... *162*
getField ... *162*
getRect ... *163*
getRoi ... *163*
getTiles ... *164*
gf ... *165*
partition ... *165*
pf ... *166*
putField ... *166*
renumber ... *168*
selectElem ... *168*
setRoi ... *169*
shuffleVecExpr ... *169*
shuffleVector ... *170*
sortObj ... *171*
sortTwoFields ... *172*
swapBytes ... *172*
tileImages ... *173*
vecRedim ... *174*
Pixel Access ... 174
extract ... *174*
extractRoi ... *175*
fill ... *175*
getCol ... *176*
getPath ... *176*
getPixel ... *177*
getRow ... *177*
getVector ... *178*
insert ... *178*
putCol ... *179*
putPixel ... *179*
putRow ... *179*
putVector ... *180*
rasterize ... *180*
sampleLine ... *182*
zeroImage ... *182*
Pyramids ... 183
burt ... *183*
burtRecon ... *183*
burtRecStep ... *184*
burtStep ... *184*
decimate ... *185*
expand ... *185*
fsd ... *186*
fsdStep ... *187*
gaussPyramid ... *187*
reduce ... *188*
showPyramid ... *188*
unDecimate ... *189*

Segmentation 189
adaptThresh *189*
colorThresh *190*
kMeans *191*
localAdaptThresh *192*
localPeaks *194*
localThresh *194*
thresh *195*
watershed *196*
zeroX *197*
Statistics 198
backgnd *198*
bound *198*
countPix *199*
difference *199*
getSlopeMaxima *200*
histCentroid *201*
histPeaks *201*
histogram *202*
projection *203*
smoothHist *203*
stats *204*
File IO 205
CPUTime *205*
chdir *205*
directory *205*
exit *206*
fileStatus *206*
getClipboard *207*
getTime *207*
mkdir *207*
playSound *208*
print *208*
putClipboard *209*
rdText *210*
readImage *210*
readObj *212*
ringBell *212*
splitName *212*
stopSound *213*
stopWatch *213*
wrText *213*
writeImage *214*
writeObj *216*
Transforms 216
dct *216*
fft *217*
fht *218*

SmartSeries 220

SmartMatrix 220
getBC412 ..... *220*
getBarcode *221*
getCCA *221*
getCodabar *222*
getCode128 ..... *223*
getCode39 ..... *224*
getEAN13 ..... *225*
getEAN8 ..... *225*
getECC200 ..... *226*
getECC200_1 ..... *227*
getECC200_2 ..... *227*
getITF *228*
getPOSTNET *228*
getPharmacode *229*
getRSS14 ..... *230*
getUPCa *231*
getUPCe *232*
gradeECC200 ..... *232*
warpMatrix *233*
SmartOCR 233
ocrBin *233*
ocrEdit *234*
ocrGrayInit *235*
ocrGrayRun *235*
ocrLocalBin *238*
ocrMakeFont *239*
ocrMakeSemiFont *240*
ocrPerimInit *241*
ocrPerimRun *242*
ocrPlotFont *245*
ocrRoiBin *246*
ocrRun *247*
ocrSelectFont *248*
SmartSearch 248
patFind1 ..... *248*
patFind2D1 ..... *252*
patInit1 ..... *255*
patInit2D1 ..... *257*
patInterpolate *259*
patLocal1 ..... *259*
patRoi1 ..... *262*
patRotate *265*
patScale *266*
patScaleRotate *267*
searchEdit *269*
searchRun *269*
SmartWeb 269
webClusterFeatures *270*
webGetBlobFeatsRoi *271*
webGetBlobFeatures *274*
webGetBlobs *276*
webGetBlobsRoi *278*
webGetPerimeter *280*

webLabelBlob *281*
webLineCounter *282*
webPlotFeatures *283*
webRealign *284*
webRowExtend *286*
webRowRemove *286*
webScrollGraphics *287*
webWaterfall *287*

Frame Grabber and Hardware 289

SerialIO 289
openSerial *289*
closeSerial *290*
readSerial *290*
writeSerial *291*
Video Acquisition 291
acqColorkey *291*
acqCounterRead *292*
acqCounterReset *292*
acqDisplay *292*
acqExposure *293*
acqFrameTrigger *293*
acqHue *293*
acqIoRead *294*
acqIoRelease *294*
acqIoSetup *295*
acqIoWrite *295*
acqIssueTrigger *296*
acqLineTrigger *297*
acqLive *297*
acqLut *298*
acqOverlay *298*
acqRgbBrightness *299*
acqSetup *299*
acqSize *300*
acqSnapCount *300*
acqSource *301*
acqStart *301*
acqStop *302*
acqSwitchGrab *302*
acqWriteLut *303*
acqZoom *303*
acquire *303*
acquireStamped *304*
brightness *304*

Coreco Imaging Contact Information 307

Standard

Blobs

The Blobs library provides blob analysis capabilities. The library includes operators that extract and process blobs, which are connected components in binary or labeled images, and a set of features of the blobs, such as area and centroid.

andBlobs

Feature AND of blobs

Description

The **AndBlobs** operator performs an asymmetric AND of two binary images represented as run-length encoded blobs. The result of the asymmetric AND of image **A** with image **B** is an image containing those blobs from **A** which have at least one pixel in common with one or more blobs from **B**. This AND operation is not symmetric, so **A AndBlobs B** is not equal to **B AndBlobs A**.

The **AndBlobs** operator is applied to vectors of blobs, run-length encoded regions of contiguous non-zero pixels, extracted from images using the **getBlobFeatures** operator. The output at the **And** port is a vector of blobs containing those blobs from the vector on the **A** input that have at least one pixel in common with one or more blobs in the vector on the **B** input. The output at the **NAnd** port is a vector of those blobs from **A** that do not have any pixels in the blobs from **B**.

The output blob vector can be converted to a feature vector with the **getFeatures** operator or into an image with the **labelBlobs** operator.

Demo iGraph

Operators\Blobs\AndBlobs.igr
Operators\Blobs\Holes.igr

C Prototype

```
CorOpRtn cor_AndBlobs(
    CorBlobVector *A,
    CorBlobVector *B,
    CorBlobVector *And,
    CorBlobVector *NAnd
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

getBlobFeatures

Get Blobs and Blob features from a binary image

Description

The **getBlobFeatures** operator computes a number of features of blobs (connected regions) in a binary or labeled image. The operator also produces the blobs in a run length format. The blob perimeters are optionally calculated.

The input image must be an unsigned 8 or 16-bit binary or labeled image.

A Blob feature vector describes an object by measuring centroid location, major and minor axes,

bounding boxes, etc.. The Blob feature vector is sent to the output for use by analysis operators for object recognition. Blob features may be viewed using a combination of the **plotFeatures** and **overlayData** operators. The Blob feature vector consists of the following fields:

Field Name	Description
id	Unique blob identifier
npixels	Number of pixels in the blob (area if pixels are square)
xmin	Minimum x-coordinate of blob (left edge)
xmax	Maximum x-coordinate of blob (right edge)
ymin	Minimum y-coordinate of blob (top edge)
ymax	Maximum y-coordinate of blob (bottom edge)
sumx	Sum of all x-coordinates
sumy	Sum of all y-coordinates
sumxsq	Sum of all x-coordinates squared
sumysq	Sum of all y-coordinates squared
sumxy	Sum of all x-coordinates*y-coordinates
perimx	X-coordinate of a pixel on the blob perimeter (lower right corner)
perimy	Y-coordinate of a pixel on the blob perimeter (lower right corner)
xc	X-coordinate of blob centroid (sumx/n)
yc	Y-coordinate of blob centroid (sumy/n)
angle	Angle of best fit ellipse major axis (clockwise from x axis)
major	Length of best fit ellipse major axis
minor	Length of best fit ellipse minor axis
axratio	minor/major
xdiff	xmax-xmin+1
ydiff	ymax-ymin+1
boxarea	xdiff*ydiff
bxaratio	npixels/boxarea
perim	Perimeter data for blob (optional)

The perimeter fields are defined as follows:

Field Name	Description
perimLength	Total length of perimeter (# of points) around object
maxDeltaX	Max. distance along x-axis from x-centroid
minDeltaX	Min. distance along x-axis from x-centroid
maxDeltaY	Max. distance along y-axis from y-centroid
minDeltaY	Min. distance along y-axis from y-centroid
sumRadius	Sum of radial distances of each perimeter point from centroid
sumRadiusSqrd	Sum of radial distances squared
maxRadiusSqrd	Max. radial distance squared
minRadiusSqrd	Min. radial distance squared
maxRadDeltaX	Max. distance along x-axis from x-centroid at max. radial point
maxRadDeltaY	Max. distance along y-axis from y-centroid at max. radial point
minRadDeltaX	Min. distance along x-axis from x-centroid at max. radial point
minRadDeltaY	Min. distance along y-axis from y-centroid at max. radial point
maxLength	Max. length of perimeter
minLength	Min. length of perimeter
maxWidth	Max. width of perimeter
minWidth	Min. width of perimeter
points	Point vector containing all perimeter points

The operator also outputs the blobs in the form of a Blob vector. The **Blobs** output is a vector that contains the run lengths that make up the blobs in the image. Each element of the vector consists of an id, the row, start and end of the run length, and the label value of the run length. Run lengths belonging to the same connected object in the image have the same id number, which also is the id number of the corresponding element of the **BlobFeatures** vector.

The **type** parameter is used to specify whether the input image is interpreted as a binary or labeled image. In a binary image all non-zero valued pixels are equivalent and blobs are connected regions of non-zero pixels. Binary images are typically produced by the **thresh** operator. In a labeled image equal valued pixels are equivalent. In this case, the blobs are connected regions of equal valued pixels. Labeled images are produced by operators such as **kMeans** and **watershed**.

The **connected** parameter is used to specify whether the regions are edge connected (*4*) or corner connected (*8*).

The perimeters of the blobs will be traced and included in the Blob features if the **perimeter** parameter is set to *Yes*.

The parameters on the **Select** subpanel allow the operator to ignore blobs that are smaller or larger than specified sizes. The **minPixels**, **minWidth** and **minHeight** parameters specify the minimum number of pixels, the minimum width (extent in the *x* direction) and the minimum height (extent in the *y* direction), respectively, of blobs produced. The **maxPixels**, **maxWidth** and **maxHeight** parameters specify the maximums for the corresponding features. If a maximum parameter value is set to zero, no maximum limit is applied for the corresponding feature.

If the **useMask** parameter is set to *Yes* the blobs use only pixels in the intersection of the image ROI and a mask specified by the **Mask** parameter. The mask can be specified by a Geometry or Graphic object or by a binary image. The mask may also be specified by a vector of Geometry or Graphic objects, binary images or Blobs. In this case pixels may be used more than once if the elements overlap in the image.

Parameter Information

type Type: int
Default: 0
Values: binary: 0, labeled: 1

connected Type: int
Default: 1
Values: 4: 0, 8: 1

perimeters Type: int
Default: 0
Values: No: 0, Yes: 1

useMask Type: int
Default: 0
Values: No: 0, Yes: 1

mask Type: CorObj
Default: "OBJ_B T CorGeom 4
CorFpoint 2 0 0 99 99 -"

minPixels Type: int
Default: 0

minWidth Type: int
Default: 0

minHeight Type: int
Default: 0

maxPixels Type: int
Default: 0

maxWidth Type: int
Default: 0

maxHeight Type: int
Default: 0

Demo iGraph

Operators\Blobs\GetBlobFeatures
Operators\Blobs\GetBlobFeaturesMasked

C Prototype

```
CorOpRtn cor_getBlobFeatures_1(
    CorImage *In,
    CorFeatureVector *BlobFeatures,
    CorBlobVector *Blobs,
    int type,
    int connected,
    int perimeters,
    int useMask,
    CorObj *mask,
    int minPixels,
    int minWidth,
    int minHeight,
    int maxPixels,
```

```
    int maxWidth,
    int maxHeight)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

getFeatures

Generate Blob feature vectors

Description

The **getFeatures** operator computes a feature set for each blob in the blob vector input. The blob vector contains run-length encoded blobs, or contiguous non-zero regions. Blob vectors are produced by the **getBlobFeaures** operator.

Each feature set describes a blob by calculating its centroid location, major and minor axes, bounding box, etc.. Selected blob features may be viewed using a combination of the **plotFeatures** and **overlayData** operators. The Blob feature vector elments consist of the following fields:

Field Name	Description
id	Unique blob identifier
npixels	Number of pixels in the blob (area if pixels are square)
xmin	Minimum x-coordinate of blob (left edge)
xmax	Maximum x-coordinate of blob (right edge)
ymin	Minimum y-coordinate of blob (top edge)
ymax	Maximum y-coordinate of blob (bottom edge)
sumx	Sum of all x-coordinates
sumy	Sum of all y-coordinates
sumxsq	Sum of all x-coordinates squared
sumysq	Sum of all y-coordinates squared
sumxy	Sum of all x-coordinates*y-coordinates
perimx	X-coordinate of a pixel on the blob perimeter (lower right corner)
perimy	Y-coordinate of a pixel on the blob perimeter (lower right corner)
xc	X-coordinate of blob centroid (sumx/n)
yc	Y-coordinate of blob centroid (sumy/n)
angle	Angle of best fit ellipse major axis (clockwise from x axis)
major	Length of best fit ellipse major axis
minor	Length of best fit ellipse minor axis
axratio	minor/major
xdiff	xmax-xmin+1
ydiff	ymax-ymin+1
boxarea	xdiff*ydiff
bxaratio	npixels/boxarea
perim	Perimeter data for blob (must run the getPerimeter operator to fill in this structure)

The **getField** operator may be used to extract any field given its name for use with operators like **conditional** to filter certain object attributes.

Demo iGraph

Operators\Blobs\Holes

C Prototype

```
CorOpRtn cor_getFeatures(
    CorBlobVector *Blobs,
    CorFeatureVector *Features
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

getPerimeter

Find perimeter given a Blob feature

Description

The **getPerimeter** operator determines the perimeter related data corresponding to the input Blob feature vector and its associated input image. The resulting Blob feature vector is a duplicate of the input vector with the blob perimeter data set. Various statistics are generated as part of each element in the perimeter structure. For example, the maximum and minimum distance between each blob centroid and all of its perimeter pixels is provided. As with the **getBlobs** operator, any non-zero pixel is considered to be contained in a blob. The perimeter fields are defined as follows:

Field Name	Description
perimLength	Total length of perimeter (# of points) around object
maxDeltaX	Max. distance along x-axis from x-centroid
minDeltaX	Min. distance along x-axis from x-centroid
maxDeltaY	Max. distance along y-axis from y-centroid
minDeltaY	Min. distance along y-axis from y-centroid
sumRadius	Sum of radial distances of each perimeter point from centroid
sumRadiusSqrd	Sum of radial distances squared
maxRadiusSqrd	Max. radial distance squared
minRadiusSqrd	Min. radial distance squared
maxRadDeltaX	Max. distance along x-axis from x-centroid at max. radial point
maxRadDeltaY	Max. distance along y-axis from y-centroid at max. radial point
minRadDeltaX	Min. distance along x-axis from x-centroid at max. radial point
minRadDeltaY	Min. distance along y-axis from y-centroid at max. radial point
maxLength	Max. length of perimeter
minLength	Min. length of perimeter
maxWidth	Max. width of perimeter
minWidth	Min. width of perimeter
points	Point vector containing all perimeter points

The **getField** operator may be used to extract any field given its name for use with operators like **conditional** to filter certain object attributes.

Care must be taken to insure that the image used by **getBlobs** to generate the blob vector is also used by **getPerimeter** to generate the perimeter data. The **connected** parameter can be used to specify whether the perimeter pixels should be eight connected, where diagonal neighbours are considered to be touching, or four connected, where they are not. The **type** parameter is used to to specify whether the input image is considered a binary image, in which case non-zero regions will be traced, or a labeled image, in which case equal valued non-zero regions will be traced. In general, the **connected** and **type** parameters should be set to the same values as the **connected** and **type** parameters on the **getBlobs** or **getBlobFeatures** operator that was used to generate the input Blob feature vector. If they are not, the operator may have trouble correctly tracing the perimeter.

Parameter Information

connected Type: int

Default: 1
Values: 4: 0, 8: 1

type Type: int
Default: 0
Values: binary: 0, labeled: 1

Demo iGraph

Operators\Blobs\Holes

C Prototype

```
CorOpRtn cor_getPerimeter(
    CorFeatureVector *In,
    CorImage *BinaryImage,
    CorFeatureVector *Out,
    int connected,
    int type
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

getWarpedFeatures

Generate Blob features of warped objects

Description

The **getWarpedFeatures** operator computes Blob feature vectors in a perspective warped image space for each blob in the blob vector input. The blob vector is produced by applying the **getBlobFeatures** operator to the original unwarped binary image. The feature values are calculated in a warped image space, which is specified by a transformation matrix input atthe lower input port of the operator. The transformation matrix is typically produced by the **getWarpTransform** operator.

The Blob features produced by applying the **getWarpedFeatures** operator to the blobs generated from the unwarped image are approximately equal to those produced by first warping the image, then extracting the blobs and applying the **getBlobFeatures** operator. The object's perimeter is not calculated. The **getWarpedPerimeter** operator can be applied to the unwarped Blob feature vector and the unwarped image to produced the warped perimeter points.

The fields of the Blob feature object are described in the **getBlobFeatures** operator documentation.

Demo iGraph

Operators\Blobs\WarpFeatures

C Prototype

```
CorOpRtn cor_getWarpedFeatures(
    CorBlobVector *Blobs,
    CorFloatVector *Transform,
    CorFeatureVector *Warped
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

getWarpedPerimeter

Find warped perimeter given a Blob feature

Description

The **getWarpedPerimeter** operator computes perimeters of binary images and warps them into a perspective warped image space. The warped space is specified by a transformation matrix input at the **Transform** input port of the operator. The

transformation matrix is typically produced by the **getWarpTransform** operator.

The perimeter is determined for each element in the Blob feature vector input at the **Features** input port by tracing the outline of objects in the unwarped binary image input at the **SourceImage** port. As with the **getPerimeter** operator, the binary image should be the image from which the blobs used to produce the Blob feature vector were extracted. The **connected** parameter should be set to the same value as the **connected** parameter of the **getBlobFeatures** operator that produced the blobs. Notice that in this case the warped perimeter will be correctly determined, but it will not match the other features in the Blob feature object.

The perimeters produced by applying the **getWarpedPerimeter** operator to a Blob feature vector generated from the unwarped image are approximately equal to those produced by first warping the image, then extracting the Blob feature vectors and applying the **getPerimeter** operator.

Parameter Information

connected Type: int
Default: 1
Values: 4: 0, 8: 1

type Type: int
Default: 0
Values: binary: 0, labeled: 1

Demo iGraph

Operators\Blobs\WarpFeatures

C Prototype

```
CorOpRtn cor_getWarpedPerimeter(
    CorFeatureVector *Features,
    CorImage *SourceImage,
    CorFloatVector *Transform,
    CorFeatureVector *Warped,
    int connected,
    int type
)
```

Headers

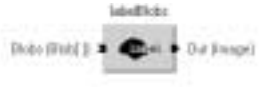
#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

labelBlobs

Convert blobs to an image



Description

The **labelBlobs** operator converts the input blob vector into an image. Blob vectors are produced by the **getBlobFeatures** operator.

The **mode** parameter is used to specify whether the output image contains the filled blob or just the blob outline. The blob outline produced by this operator only includes the end-points of the blob run-lengths rather than a complete outline of the blob.

The pixel values used for the blobs can be controlled by the **pixelValue** parameter. When this parameter is set to *Binary* all pixel values in the blob (or outline) are set to 255; when set to *Id* the blob id value is used; and when set to *Label* the blob label value is used. For *Binary* values the output image is always an 8-bit unsigned image. For *Id* or *Label* the **outType** parameter can be used to specify a 16-bit unsigned output image if the id or label values are expected to exceed 255.

The **imageSpec** parameter is used to specify the size and ROI of the output image. This parameter may be a Point, Real Point, Geometry, Graphic, or Image object or a vector of Geometry, Graphic, Image or Blob objects. If the parameter is a Point or Real Point type value, the x and y values specify the image width and height and the ROI includes the entire image. If the parameter is a Geometry or Graphic object or a vector of Geometry, Graphic or Blob objects the image and ROI will be the smallest that can contain the object(s). It the parameter is an image the output image size and ROI will match the size and ROI of the parameter image. If the parameter is a vector of images the output image

and ROI will be the smallest size large enough to contain all of the images in the input image vector. The **imageSpec** parameter is often used in the *input* mode with the original image from which the blobs were obtained fed into it to maintain the original image specifications.

Parameter Information

pixelValue Type: int
Default: 0
Values: Binary: 0, Id: 1, Label: 2

mode Type: int
Default: 0
Values: Fill: 0, Outline: 1

outType Type: int
Default: 0
Values: 8-bit: 0, 16-bit: 1

imageSpec Type: CorObj
Default: "OBJ_B T CorPoint 256 256"

Demo iGraph

Operators\Blobs\GetBlobFeatures
Operators\Blobs\GetBlobFeaturesMasked

C Prototype

```
CorOpRtn cor_labelBlobs(
    CorBlobVector *Blobs,
    CorImage *Out,
    int pixelValue,
    int mode,
    int outType,
    CorObj *imageSpec
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

mergeFeatures

Merge Blob features into a single set of features

Description

The **mergeFeatures** takes a Blob feature vector produced by the **getFeatures** operator and calculates the combined feature values for all the blobs represented by the input Blob feature vector. The output is a single Blob feature structure that contains the size (*npixels* field), bounding box (*xmin*, *xmax*, *ymin*, and *ymax* fields), and so on of the combined blobs (see the **getFeatures** operator for a complete list of fields).

The output Blob feature structure cannot be used as input to the **getPerimeter** operator since, in general, the blobs represented are not connected. The operator sets the *perimx* and *perimy* fields of the structure to -1 to prevent misuse of the structure.

Parameter Information

id Type: int
Default: 0

Demo iGraph

Operators\Blobs\MergeFeatures

C Prototype

```
CorOpRtn cor_mergeFeatures(
    CorFeatureVector *In,
    CorFeature **Merged,
    int id
)
```

Headers

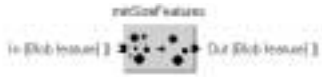
#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

minSizeFeatures

Remove small Blob features from a Blob feature vector



Description

The **minSizeFeatures** operator takes an input Blob feature vector and strips away all blobs that have fewer pixels than the number specified in the user parameter **minPixels**, or are smaller than **minWidth** or **minHeight**. The **renumberIds** parameter allows the user to either renumber the remaining Blob features, starting at a blobs id of 1, or leave the input Blob feature id's intact.

Parameter Information

minPixels Type: int
Default: 1

minWidth Type: int
Default: 1

minHeight Type: int
Default: 1

renumberIds Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Blobs\MinSizeFeatures

C Prototype

```
CorOpRtn cor_minSizeFeatures(
    CorFeatureVector *In,
    CorFeatureVector *Out,
    int minPixels,
    int minWidth,
    int minHeight,
    int renumberIds
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

selectBlobs

Select blobs by blob Id

Description

The **selectBlobs** operator partitions a blob vector based on the blob id number. The input is a Blob vector, a run length encoded representation of a binary of labeled image produced by the **getBlobFeatures** operator. Blobs or contiguous regions are represented in the Blob vector by run lengths with the same id number. Run lengths belonging to the same blob are in scan line order (ie sorted by increasing row) in the vector. Blobs are selected by specifying an id number or numbers. Run lengths with ids matching the specified ids are output at the as a Blob vector at the **Selected** output, all run lengths that do not match one of the specified ids are output at the **NotSelected** output.

The ids are specified using the **select** parameter. The parameter may be any scalar value or vector of scalar values, in which case the values are used directly to specify the ids, or it may be a Feature or vector of Features, in which case the Feature id value is used. The Feature vector is also produced by the **getBlobFeatures** operator. The Feature id is the same as blob id from corresponding blobs in the original image. A typical application selects a Feature or Features from the Feature vector using the **selectElem** or **partition** operator and applies the resulting Features to the **selectBlobs** operator as an input parameter to obtain the corresponding blobs.

Parameter Information

select Type: CorObj

Demo iGraph

Operators\Blobs\BlobStats

C Prototype

```
CorOpRtn cor_selectBlobs(
    CorBlobVector *Blobs,
    CorBlobVector *Selected,
    CorBlobVector *NotSelected,
    CorObj *select
)
```

Headers

#include "$(WITHOME)/h/wBlob.h"

Libraries

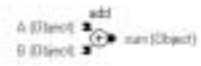
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wBlob.lib

Calculate

The Calculate library provides a range of functions based on arithmetic and logical calculations. The library includes operators that perform arithmetic and logical operations on images, vectors and numeric values; operators that equalize images; operators that average images; and operators that produce random or deterministic numbers or number sequences.

add

Add two objects



Description

Add two objects. The objects can be simple scalar values, such as integers or floating-point numbers, or vectors or images of such numbers. The type of the output is promoted to the larger of the two input types, if they are different. For example, if one of the inputs is a float and the other one an 8-bit integer, the result will be a float.

C Prototype

```
CorOpRtn cor_add(
    CorObj *A,
    CorObj *B,
    CorObj *sum
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

addNoise

Add noise to an image

Description

The **addNoise** operator injects random noise into an input image thus generating a noisy output image.

The number of pixels to which noise is added is determined by the **affectedArea** parameter. This parameter specifies the probability (as a percentage) that a pixel will be modified, and corresponds, on average, to the number pixels changed as a percentage of the total number of pixels in the image. The affected pixels are selected randomly.

The type of noise is selected using the **noiseType** parameter and its magnitude is controlled using the **noiseAmount** parameter. When the **noiseType** is *random*, a random noise offset is added to the value of the selected pixel. The amount added varies uniformly from [0, noiseAmount] for unsigned images or [-noiseAmount/2, noiseAmount/2] for signed or float images. If **noiseType** is *spike*, then the value of the selected pixels is set to **noiseAmount**. If **noiseType** is *gaussian*, the selected pixel values are offset by gaussian (normally distributed) noise with a standard deviation equal to the value of the **noiseAmount**

parameter. If the **noiseAmount** parameter is set to zero, the offset for a selected pixel is drawn from a gaussian distribution with variance equal to the pixel value.

For integer image types, values which fall outside the image type's range are clipped to the range.

The random number sequence used to generate the noise can be controlled using the **useSeed**, **seed** and **reset** parameters. A random number seed is generated the first time an operator executes or when the **reset** parameter is set to *Yes*, starting a new random number sequence. When the **reset** parameter is set to *No*, the random number sequence is a continuation of the sequence used the last time the operator executed.

When the **useSeed** parameter is set to *No* the initial random number seed is generated from a value derived from the system clock, so a different random number sequence is produced each time the graph is run. When the **useSeed** parameter is set to *Yes* the value specified in the **seed** parameter is used to initialize the random number sequence, producing repeatable noise patterns in the image. The **seed** value is a three element vector of short integers.

The operator's **NextSeed** output value is the seed value that will continue the random sequence used by the operator.

Parameter Information

affectedArea Type: int
Default: 50
Values: 0 — 100

noiseType Type: int
Default: 0
Values: random: 0, spike: 1, gaussian: 2

noiseAmount Type: float
Default: 100

useSeed Type: int
Default: 0
Values: No: 0, Yes: 1

seed Type: CorVector
Default: [1, 0, 0]

reset Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Calculate\AddNoise
Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_addNoise(
    CorImage *In,
    CorImage *Out,
    CorUshortVector *NextSeed,
    int affectedArea,
    int noiseType,
    float noiseAmount,
    int useSeed,
    CorUshortVector *seed,
    int reset
)
```

Headers

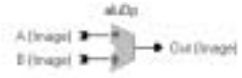
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

aluOp

Perform arithmetic and logic operations on two images



Description

The **aluOp** performs binary arithmetic and logical operations given two input images, *A* and *B*. The input images may be grayscale or color images.

If both input images are grayscale images they may be any grayscale type and the output image type may be selected using the **outputType** parameter. The default output image type is selected according to the following criteria.

Input Image Types	Output Image Type
if either input is float	output is float
otherwise, if either input is 16 bit	output is 16 bit
if either input is signed	output is signed

Color input images may be combined with any type of grayscale image or with a color image of the same type (RGB with RGB, HSV with HSV, and Yuv with Yuv). If both input images are color images the operations are applied channel by channel. If one of the images is a grayscale image its pixel values are applied to each channel of the color image. If either input image is a color image the *default* output type must be selected. The output image will be the same type as the color input image.

The aluOp will handle images with ROIs of different sizes. The **sizeOp** parameter and the **offset** parameter control the processing ROI. The **offset** parameter is used to specify an offset for image *B* relative to image *A*. If the **sizeOp** parameter is set to **clip B** then the output image ROI will be set to the intersection of the ROI of *A* and the offset ROI of *B*. If the **sizeOp** parameter is set to **expand A** then the output image ROI will be set to the bounding rectangle ROI of *A* and the offset ROI of *B*. In this case, input pixels outside the ROIs of the input images are given a value of zero, so, using addition as an example, pixels in the intersection of the two ROIs will have the value of *A + B*, pixels in the ROI of *A* only will have the value of *A*, pixels in the ROI of *B* only will have the value of *B*, and pixels not in either input ROI will have a value of zero. The output image is normally the same size as the *A* input image. If necessary, the output image will be made large enough to include the bounding ROI when **sizeOp** parameter is set to **expand A**.

Supported operations are:

+	A + B
-	A - B
*	A * B
/	A / B
OR	bitwise OR of A and B
AND	bitwise AND of A and B
XOR	bitwise XOR of A and B
src	use B where B != 0, else use A
overlay	use B if (A & overlayMask) and B != 0, else use A
expr	utilize expression to determine result
abs(A-B)	absolute value of difference between A and B
min	minimum of A and B
max	maximum of A and B

Each pixel of the output is determined by performing the indicated operation on the corresponding pixels in image *A* and image *B*. The **expression** field allows the user to specify a C style mathematical equation which will determine the output image. The top input image can be referenced in this equation using the variable A while the bottom image is given using B. The result for each pixel can be affected by that pixel's particular column and row using the X and Y variables respectively. For example, the expression *(Y >= 5) ? A : B* will produce an output image where the first 5 rows are identical to the first five rows of B. Otherwise, the output image corresponds to A. For more on the expression syntax and use see **calc**.

Parameter Information

aluOp	Type: int Default: 0 Values: A + B: 0, A - B: 1, A * B: 2, A / B: 3, OR: 4, AND: 5, XOR: 6, src: 7, overlay: 8, expr: 9, abs(A-B): 10, min: 11, max: 12
sizeOp	Type: int Default: 0 Values: clip B: 0, expand A: 1
overlayMask	Type: CorHex Default: 0xffff
offset	Type: CorPoint Default: (0, 0)
expression	Type: CorString Default: "A"

outputType Type: int
Default: 0
Values: default: 0, 8-bit unsigned: 1, 8-bit signed: 2, 16-bit unsigned: 3, 16-bit signed: 4, float: 5

Demo iGraph

Operators\Calculate\AddNoise
Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_aluOp(
    CorImage *A,
    CorImage *B,
    CorImage *Out,
    int aluOp,
    int sizeOp,
    CorHex overlayMask,
    CorPoint *offset,
    CorString expression,
    int outputType
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

applyLut

Apply a lookup table on an image

Description

The **applyLut** operator applies a lookup table (LUT) received on the bottom input port to an integer image received at the top input port. The result is to map each pixel value, *z*, in the image, *I*, to a new pixel value, *Z*, specified by a precalculated mapping function, *f*, to generate a new image, *J(Z) = f(I(z))*.

The input image must be one of the integer image types; unsigned byte, signed byte, unsigned short, or signed short. The input LUT may be a signed byte, unsigned byte, signed short, unsigned short, or float vector. To maintain compatability with earlier versions of WiT, the input LUT may also be a 32-bit signed integer vector. The LUT must include sufficient elements to cover the range of the input image; 256 elements for 8-bit images and 65,536 elements for 16-bit images. A LUT in the correct format can be produced by the **makeLut** operator.

Except in the case where the input LUT is a signed int vector, the output image is the same type as the input LUT. For unsigned input images, the input image pixel values are used directly as indexes into the LUT vector. The indexed value from the LUT is assigned to the corresponding pixel in the output image. For signed input images, the pixel values are offset to produce index values that begin at zero. For example, in a signed byte image a pixel value of -128 (the minimum pixel value) indexes element 0 of the LUT, a value of -127 indexes element 1, and so on.

When the LUT is a signed int vector, the output image is the same type as the input image. The pixel values are mapped to the LUT elements in the same way as with other input image types. It is the user's responsibility to ensure that the LUT element values are not outside the range of the output image type.

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_applyLut(
    CorImage *In,
    CorVector *Lut,
    CorImage *Out
)
```

Headers

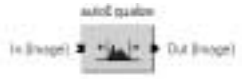
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

autoEqualize

Automatic linear rescaling of image values



Description

The **autoEqualize** operator performs automatic image contrast enhancement by computing an equalization interval based on the input integer image intensity frequency distribution. The interval is determined by searching the image histogram from each end until two values are found for which a specified percentage of the total image area falls between each value and the corresponding end of the histogram. The percentage is controlled through the **fraction** parameter. Allowable range is 0-50.

Parameter Information

fraction Type: float
Default: 5

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_autoEqualize(
    CorImage *In,
    CorImage *Out,
    float fraction
)
```

Headers

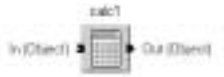
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

calc1

Perform arithmetic and logic operations on an object



Description

Same as **calc** but with only one input.

Parameter Information

expression Type: CorString
Default: "A"

userConstant Type: double
Default: 0

type Type: int
Default: 0
Values: default: 0, char: 1, uchar: 2, short: 3, ushort: 4, int: 5, uint: 6, float: 7, double: 8

conversion Type: int
Default: 0
Values: round: 0, floor: 1, ceiling: 2

C Prototype

```
CorOpRtn calc1(
    CorObj *In,
    CorObj *Out,
    CorString expression,
    double userConstant,
    int type,
    int conversion
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

calc

Perform arithmetic and logic operations on two input objects

Description

The **calc** operator performs ALU type operations on two input objects. The input objects may be any combination of primitive objects or vectors of primitives. The output is cast to integer or double following the same casting rules as in the C programming language. The operation to be performed is specified by a C style mathematical expression, entered using the **expression** parameter. The **userConstant** field allows the user to specify a constant of type double for use in the specified expression.

There are five case insensitive variables available for access by the user:

Variable	Value
A or a	top input
B or b	bottom input
X or x	current vector column value
Y or y	current vector row value
K or k	the value specified by userConstant

The available operators (ordered by precedence from highest to lowest) are listed below and may be used to form the expression:

Binary operators	
`**`	exponentiation
`* / %`	multiplication, division, modulus
`+ -`	addition, subtraction
`<< >>`	bit shift left, bit shift right
`< > >= <= == !=`	boolean comparisons
`& | ^`	bitwise and, or, xor
`&& ||`	boolean conjunction, boolean disjunction
Unary operators	
`- !`	unary negation, boolean not
`abs() sqrt() exp()`	absolute value, square root, e**x
`sin() cos() tan()`	trigonometric functions
`asin() acos() atan()`	inverse trigonometric functions
`log() log10() log2()`	natural log, log base 10, log base 2
`floor() ceil() round()`	floor, ceiling and rounding functions. (rint() may be used in place of round())
General	
?	Conditional operator (comparison) ? (result if true) : (result if false)
Precedence	parentheses ( ) can be used to alter precedence

Note that all calculations are performed using double precision except for the modulus and bit operations, which have their operands cast to integer first. To perform integer division, rather than floating point division, use floor(A/B) rather than A/B.

Parameter Information

expression Type: CorString
Default: "A"

userConstant Type: double
Default: 0

type Type: int
Default: 0
Values: default: 0, char: 1, uchar: 2, short: 3, ushort: 4, int: 5, uint: 6, float: 7, double: 8

conversion Type: int
Default: 0
Values: round: 0, floor: 1, ceiling: 2

C Prototype

```
CorOpRtn cor_calc(
    CorObj *A,
    CorObj *B,
    CorObj *Out,
    CorString expression,
    double userConstant,
    int type,
    int conversion
)
```

Headers

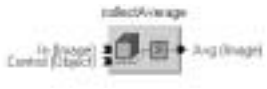
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

collectAverage

Produce the average or sum of a sequence of images



Description

The **collectAverage** operator collects a number of images and forms a single average or sum image from them. The **type** parameter value determines whether an average or sum is formed.

The number of images collected is controlled by the **number** parameter. If the **number** parameter is set to 0, images are accumulated with no output produced while integer 0 objects are received at the **Control** input. When a non-zero integer object is received at the **Control** input the input image is added to the accumulated image and an output image is produced. The operator is cleared and a new sum or average is started when the next image is received. If **number** is set to a non-zero value, the parameter value specifies the number of images that will be collected to form the output image. The operator is similar to the **collector** operator, except it produces the average or sum of images received rather than a vector of images.

The operator will accept integer or float gray-scale images or color images. All images in the sequence of input images must be the same type and must have the same ROI. The output image is the same size as the input image. In the *Average* mode, the output image is the same type as the input image. In the *Sum* mode, eight bit input images produce 16-bit output images, while 16-bit integer and float input images produce float output images.

Parameter Information

number Type: int
Default: 0

output Type: int
Default: 0
Values: Average: 0, Sum: 1

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_collectAverage(
    CorImage *In,
    CorObj *Control,
    CorImage *Avg,
    int number,
    int output
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

compareImages

Compare pixel values in two images.

Description

The **compareImages** operator performs a pixel by pixel comparison of the values in two input images to produce a binary image. The **A** and **B** input images may be any scalar image type (uint8, int8, uint16, int16, or float32). They do not have to be the same type. The **condition** parameter specifies the test applied to values of corresponding pixels in images **A** and **B**. The tests available are: $A < B$ (**A** less than **B**); $A \leq B$ (**A** less than or equal to **B**); $A == B$ (**A** equal to **B**); $A \geq B$ (**A** greater than or equal to **B**); $A > B$ (**A** greater than **B**); and $A != B$ (**A** not equal to **B**).

The output image is a uint8 binary image. Non-zero values in the output image indicate pixels in which the values in the input images meet the specified condition. The output image is the same size as the **A** input image. The output image ROI is set to the intersection of the ROIs of the two input images. Pixels values are compared only within the output image ROI.

An error tolerance can be specified when float images are compared for equality or inequality using the **floatEqError** parameter. Floating point pixel values will be considered to be equal if the pixel value from image **B** is greater than or equal to the pixel value from image **A** minus the error tolerance and less than or equal to the pixel value from image **A** plus the error tolerance.

Parameter Information

condition Type: int
Default: 0
Values: A < B: 0, A <= B: 1, A == B: 2, A >= B: 3, A > B: 4, A != B: 5

floatEqError Type: float
Default: 0

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_compareImages(
    CorImage *A,
    CorImage *B,
    CorImage *Out,
    int condition,
    float floatEqError
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

complxMult

Multiply a complex image by a real or complex image

Description

The **complxMult** operator performs pixel by pixel multiplication of two complex images or of a complex image and a real image. The **A** port accepts a complex image and the **B** input port accepts a real (integer or float) image or a second complex image. The output complex image is the product of the two input images.

The operator is usually used for processing complex images produced by a forward **fft** operation. Complex images may also be produced from pairs of float or integer images representing the real and imaginary components using the **complexMerge** operator.

The output image is the same size as the **A** input image. The output image ROI is the intersection of the ROIs of the two input images. Image values outside the ROI are undefined.

Demo iGraph

Operators\Transforms\FourierFilter

C Prototype

```
CorOpRtn cor_complxMult(
    CorImage *A,
    CorImage *B,
    CorImage *Product
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

conditional

Compare numbers or strings and output a boolean result

Description

The **conditional** operator performs conditional testing on two inputs. The user selects the condition operation using the **condition** parameter. Currently, the following conditionals are supported:

```
==
>
<
!=
>=
<=
```

The inputs must be one of the basic WiT types, i.e., an integer, float, character, or string. The output type is an integer and is set to 1 if the conditional is true and 0 if false.

Parameter Information

condition Type: int
Default: 0
Values: ==: 0, >: 1, <: 2, !=: 3, >=: 4, <=: 5

Demo iGraph

Operators\Transforms\FourierFilter

C Prototype

```
CorOpRtn cor_conditional(
    CorObj *In0,
    CorObj *In1,
    int *Out,
    int condition
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

div

Divide one object with another

Description

Divide the first input by the second. See add for more information about supported types. Dividing a scalar (first input) by a vector or image is not allowed.

Demo iGraph

Operators\Transforms\FourierFilter

C Prototype

```
CorOpRtn cor_div(
    CorObj *A,
    CorObj *B,
```

```
    CorObj *quotient
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

equalize

Linear image rescaling

Description

The **equalize** operator may be used to re-map the frequency distribution of an image. Pixel values between the range **fromLo** to **fromHi** can be compressed or expanded to the new range **toLo** to **toHi**. The contrast of an image, for example, may be increased by choosing a **from** range which represents a greyscale area of interest and mapping these pixels to cover the entire range of the image.

Parameter Information

fromLo Type: float
Default: 0

fromHi Type: float
Default: 255

toLo Type: float
Default: 0

toHi Type: float
Default: 255

Demo iGraph

Operators\Transforms\FourierFilter

C Prototype

```
CorOpRtn cor_equalize(
    CorImage *In,
    CorImage *Out,
    float fromLo,
    float fromHi,
    float toLo,
    float toHi
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

false

Generate a zero-valued integer object

Description

The **false** operator is used to convert any object received at its input port into a zero-valued integer object. This operator is useful for input to a variety of flow control operators requiring an integer value.

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_false(
    int *Out)
```

Headers

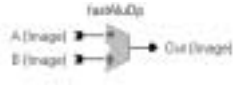
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

fastAluOp

Faster aluOp, requires same size images



Description

The **fastAluOp** performs basic pixel by pixel arithmetic and logical operations on two input images. Arbitrary expressions written in the C language syntax, which may also include the pixel location, can also be performed.

The input images may be grayscale or color images. If both input images are grayscale images the output image type is selected according to the following criteria:

Input Image Types	Output Image Type
if either input is float	output is float
if either input is 16 bit	output is 16 bit
if either input is signed	output is signed

Operations may result in values which fall outside the range of the output type, out of range values are clipped to the maximum or minimum range value. To avoid clipping, the input images can be cast a higher precision type using the **castImage** or **matchSize** operators.

Color input images may be combined with any type of grayscale image or with a color image of the same type (RGB with RGB, HSV with HSV, and Yuv with Yuv). If both input images are color images the operations are applied channel by channel. If one of the images is a grayscale image its pixel values are applied to each channel of the color image. The output image will be the same type as the color input image.

The output image will be the same size as the *A* input image. The output image ROI will be the intersection of the ROIs of the *A* and *B* images. The specified operation will only be applied to pixels in the output image ROI.

Supported operations on input images *A* and *B* are:

+	A + B
-	A - B
*	A * B
/	A / B
OR	bitwise OR of A and B
AND	bitwise AND of A and B
XOR	bitwise XOR of A and B
src	use B where B != 0, else use A
overlay	use B if (A & overlayMask) and B != 0, else use A
expr	utilize expression to determine result
abs(A-B)	absolute value of difference between A and B
min	minimum of A and B
max	maximum of A and B

Each pixel of the output is determined by performing the indicated operation on the corresponding pixels in image *A* and image *B*. The **expression** field allows the user to specify a C style mathematical equation which will determine the output image. The top input image can be referenced in this equation using the variable A while the bottom image is given using B. The result for each pixel can be affected by that pixel's particular column and row using the X and Y variables respectively. For example, the expression *(Y >= 5) ? A : B* will produce an output image where the first 5 rows are identical to the first five rows of B. Otherwise, the output image corresponds to A. For more on the expression syntax and use see **calc**.

This operator is faster than **aluOp**, but has some limitations on manipulation of the image ROI and does not allow the specification of the output image type. Relative offset can be set and image size matched using the **matchSize** operator.

Parameter Information

aluOp Type: int
Default: 0
Values: +: 0, -: 1, *: 2, /: 3, OR: 4, AND: 5, XOR: 6, src: 7, overlay: 8, expr: 9, abs(A-B): 10, min: 11, max: 12

overlayMask Type: CorHex
Default: 0xffff

expression Type: CorString
Default: "A"

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_fastAluOp(
    CorImage *A,
    CorImage *B,
    CorImage *Out,
    int aluOp,
    CorHex overlayMask,
    CorString expression
)
```

Headers

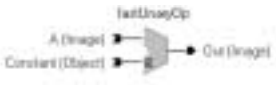
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

fastUnaryOp

Faster unaryOp



Description

The **fastUnaryOp** operator performs basic arithmetic and logical operations involving an image and a scale value. Arbitrary expressions written in the C language syntax, which may also include the pixel location, can also be performed.

The operator supports grayscale and color input images. If the input image is a grayscale image then the input constant must be a numeric value. If the input constant is an integer, the output image type is the same as the input image type. If the input constant is a float or double the output image is a float image, regardless of input image type. Out of range values for integer images are clipped to the range of the image type. If the input image is a color image then the input constant may be a color object of the same type as the input image or a numeric value. In this case the output image will be the same type as the input image.

Supported operations for an image *A* and a scalar *K* are:

+	A + K
-	A - K
*	A * K
/	A / K
|	logical OR
&	logical AND
>>	shift right
<<	shift left
expression	utilize expression to determine result

The indicated operation is performed on each pixel in *A*. The **expression** field allows the user to specify a C style mathematical equation which will determine the output image. The image can be specified in this equation using the variable A while the constant is specified using K. The result for each pixel can be affected by that pixel's particular column and row using the X and Y variables respectively. For example, the expression *(X >= 5) ? (A >> K) : A* will produce an output image where every pixel was right shifted by *K* bits, unless the pixel fell within the first five columns of the image. For more on the expression syntax and use see **calc**.

This operator is faster than **unaryOp**, but does not allow the specification of the output image type.

Parameter Information

unaryOp Type: int
Default: 0
Values: +: 0, -: 1, *: 2, /: 3, OR: 4, AND: 5, >>: 6, <<: 7, expr: 8

expression Type: CorString
Default: "A"

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_fastUnaryOp(
    CorImage *A,
    CorObj *Constant,
    CorImage *Out,
    int unaryOp,
    CorString expression
)
```

Headers

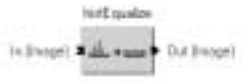
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

histEqualize

Histogram equalization



Description

The **histEqualize** operator may be used to re-map the frequency distribution of an image so that the image histogram is approximately flat. This has the effect of spreading the range around values found in many pixels and compressing the range around values found in few pixels. This often has the effect of improving perceived image contrast around the dominant values in the image. It should be noted that precision of the relative image values cannot be improved by this method.

The output image produced is the same type as the input image.

A mask can be used to specify which pixels are used to calculate the equalization mapping. If the **useMask** parameter is set to *No* all pixels in the image ROI are used. If the **useMask** parameter is set to *Yes* the pixels in the intersection of the image ROI and a mask specified by the **Mask** parameter are used to calculate the mapping. The mask can be specified by a Geometry or Graphic object or by a binary image. The mask may also be specified by a vector of Geometry or Graphic objects, binary images or Blobs. Once the mapping has been determined equalization is applied to the entire image ROI.

Parameter Information

useMask Type: int
Default: 0
Values: No: 0, Yes: 1

mask Type: CorObj
Default: "OBJ_B T CorGeom 4 CorFpoint 2 0 0 99 99 -"

Demo iGraph

Operators\Calculate\HistEqualize

C Prototype

```
CorOpRtn cor_histEqualize_1(
    CorImage *In,
    CorImage *Out,
    int useMask,
    CorObj *mask
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

invert

Invert an image

Description

The **invert** operator inverts the input image. The input image must be an integer, float or color image type.

Unsigned integer images and color images are inverted using the formula: nz = Z - z, where Z is the maximum pixel value for the input image type, z is the old pixel value, and nz is the new pixel value. Signed integer images are inverted using the formula: nz = -(z + 1). Float images are inverted using the fomula nz = -z. The output image is the same type as the input image.

Demo iGraph

Operators\Calculate\HistEqualize

C Prototype

```
CorOpRtn cor_invert(
    CorImage *In,
    CorImage *Out
)
CorOpRtn cor_invert_consume(
    CorImage *In
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

makeLut

Generate a lookup table

Description

The **makeLut** operator produces a lookup table (LUT) by parsing a C expression representing the desired mapping function. The LUT is used as an input to the **applyLut** operator to implement point operations on images.

The LUT provides a mapping from the integers **A** over the range of the pixel values in the expected input image type (for the **applyLut** operator) to pixel values in the output image. The mapping is specified by a function *f(***A***)* as defined by the parameter **expression**. The **userConstant** parameter allows the user to specify a constant for use within the expression. For more on the syntax and usage of **expression** see **calc**.

The LUT is output from the operator as a vector of values in which the size of the vector and type of the values is determined by the **inputType** and **outputType** parameters. The **inputType** parameter must be set to the type of input images expected to be applied to the **applyLut** operator. It may be set to one of the integer image types; *ubyte*, *byte*, *ushort*, or *short*. The size of the output vector is determined by the range of input type; 256 elements for *ubyte* and *byte*, 65,536 elements for *ushort* or *short*. For the unsigned types, *ubyte* and *ushort*, the vector element indexes correspond directly to the LUT range values, so the first element contains *f(*0*)* and the *i*-th element contains *f(i)*. For the signed types, *byte* and *short*, the vector element indexes correspond to the LUT range values offset so that the minimum pixel value appears in the first vector element. For example for a *byte* image, the first element contains *f(*-128*)* and the *i*-th element contains *f(i*-128*)*.

The **outputType** parameter determines the type of the elements of the output vector, which in turn determines the type of the output image of the **applyLut** operator. It may be set to one of the integer or float image types; *ubyte*, *byte*, *ushort*, *short*, or *float*. The output values are calculated using floating point arithmetic and, if necessary, converted to integer values as specified by the **conversion** parameter. Fractional values of 0.5 are always rounded up in the *round* mode. For the integer types, values greater than the maximum value in the image type range are set to the

maximum value in the range and values less than the minimum value in the range are set to the minimum.

Many of the common mapping functions can be constructed. Refer to the table below for a list of the most useful.

Function	Equation
digital negative *f*(A) = k - A *where k = maximum pixel value*	k-A
thresholding *f*(A) = k if A > threshold, otherwise 0	(A > threshold) ? k : 0
slicing with background *f*(A) = k if r1 <= A <= r2, otherwise A	(A <= r2) ? ((A >= r1) ? k : A) : A
slicing without background *f*(A) = k if r1 <= A <= r2, otherwise 0	(A <= r2) ? ((A >= r1) ? k : 0) : 0
range compression *f*(A) = c*log10(1 + abs(A)) *where c = k/log10(1 + k)*	(k/log10(1 + k))*log10(1 + abs(A))
bit removal, MSB *f*(A) = 2*A%(k + 1)	2*A%(k + 1)
bit removal, LSB *f*(A) = 2*(A/2)	2*(A/2)
bit extraction *f*(A) = k*(i - 2*j) *where* i = $A/2^{(B - n)}$ j = $A/2^{(B - (n - 1))}$ B = number of bits per image n = n^{th} most significant bit to extract	k*(((A/2)**(8 - n)) - 2*((A/2)**(8 - (n - 1))))

Parameter Information

expression Type: CorString
Default: "A"

userConstant Type: int
Default: 0

inputType Type: int
Default: 0
Values: ubyte: 0, byte: 1, ushort: 2, short: 3

outputType Type: int
Default: 0
Values: ubyte: 0, byte: 1, ushort: 2, short: 3, float: 4

conversion Type: int
Default: 0
Values: round: 0, floor: 1, ceiling: 2

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_makeLut(
    CorVector *LUT,
    CorString expression,
    int userConstant,
    int inputType,
    int outputType,
    int conversion
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

makeSeq

Generate a vector containing a number sequence

Description

The **makeSeq** operator produces a sequence of numbers as a WiT vector by parsing a C expression representing the desired mapping function from the vector index values to the vector element values.

The number of elements in the sequence vector is specified by the **size** parameter. The element values are calculated are as a function of the array index values (from 0 to **size** - 1) as defined by the parameter **expression**. The symbol **A** is used to represent the index value in the expression. The symbol **K** is optionally used in the expression to represent a constant value that is specified in the **userConstant** parameter. For more on the syntax and usage of **expression** see **calc**.

The type of the elements in the output vector is specified by the **type** parameter. Calculations are performed at double precision and cast to the required output type after the calculations are completed. The **conversion** parameter can be used to specify whether the values are rounded to the nearest (*round*), nearest lower (*floor*) or nearest greater (*ceil*) integer value when one of the integer types is specified. The *byte*, *ubyte*, *short* and *ushort* output values outside the range of the type are truncated to the minimum or maximum range values.

Parameter Information

expression	Type: CorString Default: "A"
size	Type: int Default: 255
userConstant	Type: double Default: 0
type	Type: int Default: 4 Values: byte: 0, ubyte: 1, short: 2, ushort: 3, int: 4, uint: 5, float: 6, double: 7
conversion	Type: int Default: 0 Values: round: 0, floor: 1, ceiling: 2

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_makeSeq(
    CorIntVector *Sequence,
    CorString expression,
    int size,
    double userConstant,
    int type,
    int conversion
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

movingAverage

Take the running average of a sequence of images

Description

The **movingAverage** operator produces an output image that is an average of the current input image and previous input images. The way in which the operator calculates the average is controlled by the **type** parameter.

When the **type** parameter is set to *Window* the operator produces the mean of the last *N* images received by the operator, where *N* is the smaller of the number specified using the **number** parameter and total number of images received.

When the **type** parameter is set to *Weighted* the output image is the sum of 1/*N* times the input image and (*N*-1)/*N* times the previous output image. Again *N* is the smaller of the number specified

using the **number** parameter and total number of images received.

All input images to the operator must be the same image type and size and the ROIs must be the same. The output image has the same type, size and ROI as the input images.

Parameter Information

number Type: int
Default: 4

type Type: int
Default: 0
Values: Window: 0, Weighted: 1

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_movingAverage(
    CorImage *In,
    CorImage *Avg,
    int number,
    int type
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

mul

Multiply two objects

Description

Multiply two objects. See add for more information about supported types.

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_mul(
    CorObj *A,
    CorObj *B,
    CorObj *product
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

not

Logical NOT

Description

The **not** operator takes the logical NOT of an input integer object and sends the result to its output.

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_not(
    int In,
    int *Out
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

randSequence

Produce a vector of random integer or float numbers

Description

The **randSequence** operator produces a vector of random integer or float numbers from a uniform distribution over a specified range. The number of values produced is specified by the **number** parameter. The type of the output vector elements is specified by the **type** parameter, and the range of numbers from which they are selected is specified by the **low** and **high** parameters. The range for integers is [ceil(low), floor(high)], so if the **low** and **high** values are integers they are both included in the range. The range for floats is [low, high); that is, the **low** value is included in the range, the **high** value is not.

The random number sequence used to generate the numbers can be controlled using the **useSeed**, **seed** and **reset** parameters. A random number seed is generated the first time an operator executes or when the **reset** parameter is set to *Yes*, starting a new random number sequence. When the **reset** parameter is set to *No*, the random number sequence is a continuation of the sequence used the last time the operator executed.

When the **useSeed** parameter is set to *No* the initial random number seed is generated from a value derived from the system clock, so a different random number sequence is produced each time the graph is run. When the **useSeed** parameter is set to *Yes* the value specified in the **seed** parameter is used to initialize the random number sequence, producing repeatable sequences of random numbers. The **seed** value is a three element vector of short integers.

The operator's **NextSeed** output value is the seed value that will continue the random sequence used by the operator.

Parameter Information

useSeed Type: int
Default: 0
Values: No: 0, Yes: 1

seed Type: CorVector
Default: [1, 0, 0]

number Type: int
Default: 10

type Type: int
Default: 0
Values: int: 0, float: 1

low Type: float
Default: 0

high Type: float
Default: 100

reset Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_randSequence(
    CorVector *Out,
    CorUshortVector *NextSeed,
    int useSeed,
    CorUshortVector *seed,
    int number,
    int type,
    float low,
    float high,
    int reset
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

random

Produce a random integer or float number

Description

The **random** operator produces a random integer or float number from a uniform distribution over a specified range. The type of the output value is specified by the **type** parameter, and the range of numbers from which it is selected is specified by the **low** and **high** parameters. The range for integers is [ceil(low), floor(high)], so if the **low** and **high** values are integers they are both included in the range. The range for floats is [low, high); that is, the **low** value is included in the range, the **high** value is not.

The random number sequence used to generate the numbers can be controlled using the **useSeed**, **seed** and **reset** parameters. A random number seed is generated the first time an operator executes or when the **reset** parameter is set to *Yes*, starting a new random number sequence. When the **reset** parameter is set to *No*, the random number sequence is a continuation of the sequence used the last time the operator executed.

When the **useSeed** parameter is set to *No* the initial random number seed is generated from a value derived from the system clock, so a different random number sequence is produced each time the graph is run. When the **useSeed** parameter is set to *Yes* the value specified in the **seed** parameter is used to initialize the random number sequence, producing repeatable sequences of random numbers. The **seed** value is a three element vector of short integers.

The operator's **NextSeed** output value is the seed value that will continue the random sequence used by the operator.

Parameter Information

useSeed Type: int
Default: 0
Values: No: 0, Yes: 1

seed Type: CorVector
Default: [1, 0, 0]

type Type: int
Default: 0
Values: int: 0, float: 1

low Type: float
Default: 0

high Type: float
Default: 100

reset Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_random(
    CorObj *Out,
    CorUshortVector *NextSeed,
    int useSeed,
    CorUshortVector *seed,
    int type,
    float low,
    float high,
    int reset
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

sub

Subtract two objects

Description

Subtract the second input value from the first input value. See add for more information about supported types. Subtracting a vector or image (second input) from a scalar (first value) is not allowed.

Demo iGraph

Operators\Calculate\Lut

C Prototype

```
CorOpRtn cor_sub(
    CorObj *A,
    CorObj *B,
    CorObj *diff
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

true

Generate a non-zero valued integer object

Description

The **true** operator is used to convert any object received at its input port into a non-zero valued integer object. This operator is useful for input to a variety of flow control operators requiring an integer as input.

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_true(
    int *Out)
```

Headers

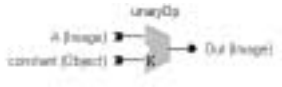
#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

unaryOp

Perform a unary operation on an image using a value



Description

The **unaryOp** operator performs unary operations when both an image *A* and a constant *K* are received at the top and bottom input ports respectively.

The operator supports grayscale and color input images. If the input image is a grayscale image then the input constant must be a numeric value. Output image image type may be specified using the **outputType** parameter. If the input image is a color image then the input constant may be a color object of the same type as the input image or a numeric value. In this case the **outputType** parameter must be set to *default* and output image will be the same type as the input image.

Supported operations are:

+	A + K
-	A - K
*	A * K
/	A / K
|	logical OR
&	logical AND

>> shift right

<< shift left

expression utilize expression to determine result

The indicated operation is performed on each pixel in *A*. The **expression** field allows the user to specify a C style mathematical equation which will determine the output image. The image can be specified in this equation using the variable A while the constant is specified using K. The result for each pixel can be affected by that pixel's particular column and row using the X and Y variables respectively. For example, the expression *(X >= 5) ? (A >> K) : A* will produce an output image where every pixel was right shifted by *K* bits, unless the pixel fell within the first five columns of the image. For more on the expression syntax and use see **calc**.

Parameter Information

unaryOp Type: int
Default: 0
Values: +: 0, -: 1, *: 2, /: 3, OR: 4, AND: 5, >>: 6, <<: 7, expr: 8

expression Type: CorString
Default: "A"

outputType Type: int
Default: 0
Values: default: 0, 8-bit unsigned: 1, 8-bit signed: 2, 16-bit unsigned: 3, 16-bit signed: 4, float: 5

Demo iGraph

Operators\Calculate\CollectAverage

C Prototype

```
CorOpRtn cor_unaryOp(
    CorImage *A,
    CorObj *constant,
    CorImage *Out,
    int unaryOp,
    CorString expression,
    int outputType
)
```

Headers

#include "$(WITHOME)/h/wCalcul.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalcul.lib

Calibration

The Calibration library supports 2D calibration, which provides means to compensate perspective and lens distortions and convert image coordinates to real world coordinates.

calibrateCamera

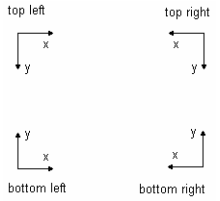
Perform calibration of the camera to avoid distortions

Description

The **calibrateCamera** operator computes a transformation for correcting perspective and non-linear lens distortions using a checkerboard pattern. The resultant calibration object can be used by the **restoreImage** and **restoreCoordinates** operators to restore images or coordinates (graphic objects) respectively.

To use this operator, a physical checkerboard should be prepared and imaged. The checkerboard must consist of high contrast and uniform black and white squares. When the image is taken, the checkboard must fill the entire image area. It is all right to have squares only partially visible around the edges of the image. The length of the side of each square can be set by the **cellSize** parameter. The **interpolation** parameter determines whether perspective or bilinear interpolation is used within each square. The **origin** parameter can be used to set the origin and direction of the axes of the coordinate system of the transformation. If set to **none** then coordinate system is computed to maximize the amount of the image visible after restoration with the **Y** axis pointing down, **X** axis pointing right and origin close to the left top corner

of the image. In all other cases the origin set at the corner of the square closest to the selected corner and have both edges forming the corner fully visible in the image.



Notice that because natural image coordinate system has the X-axis down and origin at the upper left corner, the image will appear to be flipped depending on the **origin** setting.

The scale factor is kept in such a way that measurements in the original image and destination image are as close as possible. This way the corrected image and data points can be displayed as an image similar in size to the original one. The **proportion** output is the ratio between physical units (corresponding to the **cellSize** paramter) and pixels. If measurements in physical coordinates are needed, they can be computed by multiplying positions and lengths in the corrected image by **proportion**. The **proportion** value can also be used for the **calibrateScale** operator so that the correct pixel to physical coordinate scaling can be applied automatically when **restoreCoordinates** is used.

Parameter Information

cellSize Type: float
Default: 1

interpolation Type: int
Default: 0
Values: perspective: 0, bilinear: 1

origin Type: int
Default: 0
Values: none: 0, bottomLeft: 1, topLeft: 2, topRight: 3, bottomRight: 4

Demo iGraph

Operators\Calibration\calibrate.igr

C Prototype

```
CorOpRtn cor_calibrateCamera(
    CorImage *chessBoard,
    CorCalibrateInfo **calibrateInfo,
    float *proportion,
    float cellSize,
    int interpolation,
    int origin
)
```

Headers

#include "$(WITHOME)/h/wCalibration.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

calibrateDefault

Create default camera calibration transformation

Description

The **calibrateDefault** operator creates a calibration object for a trivial one to one transformation. See **calibrateCamera** operator for more interesting non-trivial transformations. **calibrateDefault** is useful for creating a transformation object for operators that require it, but when no transformation is necessary. **width** and **height** parameteres should be the same as the size of all images that will the calibration will be applied to.

Parameter Information

width Type: int
Default: 640

height Type: int
Default: 480

interpolation Type: int
Default: 0
Values: perspective: 0, bilinear: 1

origin Type: int
Default: 0

Values: none: 0, bottomLeft: 1, topLeft: 2, topRight: 3, bottomRight: 4

C Prototype

```
CorOpRtn cor_calibrateDefault(
    CorCalibrateInfo **calibrateInfo,
    int width,
    int height,
    int interpolation,
    int origin
)
```

Headers

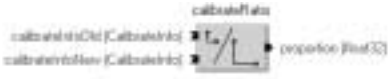
#include "$(WITHOME)/h/wCalibration.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

calibrateRatio

Calculate scale ratio between two camera calibrations



Description

The **calibrateRatio** operator computes the scale ratio between two calibration transformations. It is useful when some graphic or geometric objects have been created using an old transformation but a re-calibration is necessary. The **proportion** output from **calibrateRatio** can be used to scale all the old coordinates to fit in the new transformation.

C Prototype

```
CorOpRtn cor_calibrateRatio(
    CorCalibrateInfo *calibrateInfoOld,
    CorCalibrateInfo *calibrateInfoNew,
    float *proportion
)
```

Headers

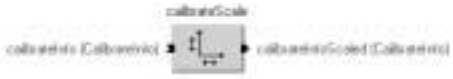
#include "$(WITHOME)/h/wCalibration.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

calibrateScale

Scale calibration transformation



Description

The **calibrateScale** operator changes a calibration transformation to scale the object multiplying all coordenates by **scale**.

Parameter Information

scale Type: float

C Prototype

```
CorOpRtn cor_calibrateScale(
    CorCalibrateInfo *calibrateInfo,
    CorCalibrateInfo
**calibrateInfoScaled,
    float scale
)
```

Headers

#include "$(WITHOME)/h/wCalibration.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

moveOrigin

Apply shift and rotation to calibration transformation

Description

The **moveOrigin** operator changes a calibration transformation to translate the origin (**dx**, **dy**) to the specified location, and to rotate (**angle**) the coordinate system about the origin.

Parameter Information

dx Type: float

dy Type: float

angle Type: float

C Prototype

```
CorOpRtn cor_moveOrigin(
    CorCalibrateInfo *calibrateInfo,
    CorCalibrateInfo
**transformedCalibrateInfo,
    float dx,
    float dy,
    float angle
)
```

Headers

#include "$(WITHOME)/h/wCalibration.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

restoreCoordinates

Apply calibration transformation to geometry or graphic objects

Description

The **restoreCoordinates** operator transforms coordinates in the input **data** object using the **calibrateInfo** object created by **calibrateCamera** operator. If **mode** is **forward** then the transformation is from screen to real coordinates. Otherwise the transformation is from real to screen coordinates. The input may be a Geometry or Graphic object, a vector of Geometry or Graphic objects, or a vector of Point or Fpoint objects.

Parameter Information

mode Type: int
Default: 0
Values: forward: 0, backward: 1

Demo iGraph

Operators\Calibration\calibrate.igr

C Prototype

```
CorOpRtn cor_restoreCoordinates(
    CorObj *coordData,
    CorCalibrateInfo *calibrateInfo,
    CorObj *transformedData,
    int mode
)
```

Headers

#include "$(WITHOME)/h/wCalibration.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

restoreImage

Apply calibration transformation to an image

Description

The **restoreImage** operator transforms the input image using **calibrateInfo** object created by **calibrateCamera** operator. If **mode** is **forward** then the transformation is from screen to real coordinates. Otherwise the transformation is from real to screen coordinates.

Parameter Information

mode Type: int

Default: 0
Values: forward: 0, backward: 1

Demo iGraph

Operators\Calibration\calibrate.igr

C Prototype

```
CorOpRtn cor_restoreImage(
    CorImage *image,
    CorCalibrateInfo *calibrateInfo,
    CorImage *transformedData,
    int mode
)
```

Headers

#include "$(WITHOME)/h/wCalibration.h"

Libraries

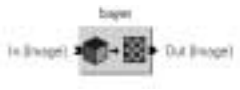
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wCalibration.lib

Color

The Color library provides support for manipulating color images. The library includes operators that convert between color formats and operators that convert between single and multi-channel images.

bayer

Perform conversion between RGB and Bayer format



Description

The **bayer** operator converts images between the Bayer color image format and RGB. The Bayer format assigns each pixel in an unsigned eight bit image the value of one color channel. RGB images are created by interpolating neighbouring pixel values to get the two missing color channels at each pixel. RGB images are sampled to create Bayer format images.

Pixels in a row of a Bayer image alternate between the green channel value and either the red or the blue channel value as shown below.

G1	**R2**	**G3**	**R4**
B5	**G6**	**B7**	**G8**
G9	**R10**	**G11**	**R12**
B13	**G14**	**B15**	**G16**

RGB images are converted to the Bayer format by sampling the appropriate color channel value at each pixel.

When converting from the Bayer format to an RGB image, the missing color channel values are determined by linear interpolation using neighbouring pixel values for the color channel in question. If the **method** parameter is set to *Linear* the interpolated values are used directly in the output image. If **method** is set to *ColorCorrect* color correction using neighbouring pixel values is applied. The color correction method usually produces better looking results when the image contains sharp vertical or horizontal edges.

Bayer encoded images normally start with a green pixel in the first column of the first row and a red pixel in the second column of the first row. However, if subimages are extracted from a Bayer encoded image the pattern may be offset. The **start** parameter allows the operator to process such subimages. When set to *GR*, the operator treats the first and second pixels of the first row of the Bayer image as green and red, respectively. This setting works with standard Bayer images and subimages in which the upper left corner is located at an even row and even column. When set to *RG* the two pixels are treated as red and green. This setting is used with subimages in which the upper left corner is located at an even row and odd column. When set to *BG* the two pixels are treated as blue and green. This setting is used with subimages in which the upper left corner is located at an odd row and even column. When set to *GB* the two pixels are treated as green and blue. This setting is used with subimages in which the upper left corner is located

at an odd row and odd column. The **start** setting may be used for both encoding and decoding images.

Parameter Information

direction Type: int
Default: 1
Values: RGB->Bayer: 0, Bayer->RGB: 1

method Type: int
Default: 0
Values: Linear: 0, ColorCorrect: 1

start Type: int
Default: 0
Values: GR: 0, RG: 1, BG: 2, GB: 3

Demo iGraph

Operators\Color\Bayer

C Prototype

```
CorOpRtn cor_bayer(
    CorImage *In,
    CorImage *Out,
    int direction,
    int method,
    int start
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

convertColor

Perform color space conversions

Description

The **convertColor** operator can be used to convert RGB images to and from HSV, Yuv, and gray scale images. The input and output image types must correspond to the types specified by the **conversion** parameter.

Conversion to and from *Gray* images require or produce 8 bit unsigned images. *RGB->Gray* conversions produce a gray scale image that corresponds to the Y (intensity) channel of a Yuv image. *Gray->RGB* conversions produce an RGB image with equal gray values in all channels at each pixel.

Parameter Information

conversion Type: int
Default: 0
Values: RGB->HSV: 0, HSV->RGB: 1, RGB->Yuv: 2, Yuv->RGB: 3, RGB->Gray: 4, Gray->RGB: 5

Demo iGraph

Operators\Color\HSV
Operators\Color\Brighten

C Prototype

```
CorOpRtn cor_convertColor(
    CorImage *In,
    CorImage *Out,
    int conversion
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

convertColorFormat

Convert between banded and packed color formats

Description

The **convertColorFormat** operator converts between the obsolete WIT_RGB banded color image format and WIT_COLOR packed color image format. This operator is intended primarily to maintain compatability for user written operators that use the WIT_RGB format. Existing WiT operators that accept color images as input will process WIT_RGB or WIT_COLOR format images. Operators that produce color images as output will produce WIT_COLOR format images. In the future, new operators or modified operators that can accept color images may not accept the old format.

The format change will not affect the operation of graphs that use only existing WiT operators, however it may be necessary to add a **convertColorFormat** operator to existing graphs convert color images to the banded format if they are input to user written operators. In addition, it may be necessary to convert the output from user written operators or older stored images to the packed format if they are input to new WiT operators or operators that previously did not handle color input.

This operator is intended to facilitate transition to the new WIT_COLOR format and we recommend that operators be converted to use the new format.

Parameter Information

direction Type: int
Default: 0
Values: ->packed: 0, ->banded: 1

Demo iGraph

Operators\Color\HSV
Operators\Color\Brighten

C Prototype

```
CorOpRtn cor_convertColorFormat(
    CorImage *In,
    CorImage *Out,
    int direction
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

getChannel

Get a single channel from a multichannel image

Description

The **getChannel** operator extracts a single channel from a multichannel input image. The input image must be a RGB, HSV, or Yuv image. The output is an 8 bit unsigned image.

The **channel** parameter specifies which channel is extracted from the input image. For RGB, HSV and Yuv images, respectively, channel *0* is the red, hue, or Y (intensity) channel; channel *1* is the green, saturation, or u channel; and channel *2* is the blue, value, or v channel.

Parameter Information

channel Type: int
Default: 0
Values: 0: 0, 1: 1, 2: 2

Demo iGraph

Operators\Color\Brighten

C Prototype

```
CorOpRtn cor_getChannel(
    CorImage *In,
    CorImage *Out,
    int channel
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

mergeChannels

Merge three images into a multichannel image

Description

The **mergeChannels** operator combines three grayscale input images into a multichannel output images. The input images must be 8 bit unsigned images. For RGB, HSV and Yuv images, respectively, *ch0* is the red, hue, or Y (intensity) channel; *ch1* is the green, saturation, or u channel; and *ch2* is the blue, value, or v channel.

The output image is an RGB, HSV, or Yuv image, as specified using the **outType** parameter. The output image is the same size as the *ch0* input image and the output image ROI is the intersection of the input image ROIs.

Parameter Information

outType Type: int
Default: 0
Values: RGB: 0, HSV: 1, Yuv: 2

Demo iGraph

Operators\Color\HSV

C Prototype

```
CorOpRtn cor_mergeChannels(
    CorImage *Ch0,
    CorImage *Ch1,
    CorImage *Ch2,
    CorImage *Out,
    int outType
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

putChannel

Put an image into one channel of a multichannel image

Description

The **putChannel** operator inserts an image into a single channel of a multichannel image. The multichannel input image must be a RGB, HSV, or Yuv image. The inserted input image must be an 8 bit unsigned image. The output image is the same type and size of as the multichannel input image. The output image ROI is the intersection of the ROIs of the two input images.

The **channel** parameter specifies the channel into which the gray scale image is inserted. For RGB, HSV and Yuv images, respectively, channel *0* is the red, hue, or Y (intensity) channel; channel *1* is the green, saturation, or u channel; and channel *2* is the blue, value, or v channel.

Parameter Information

channel Type: int
Default: 0
Values: 0: 0, 1: 1, 2: 2

Demo iGraph

Operators\Color\Brighten

C Prototype

```
CorOpRtn cor_putChannel(
```

```
    CorImage *In0,
    CorImage *In1,
    CorImage *Out,
    int channel
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

splitChannels

Split multichannel image into its three component channels

Description

The **splitChannels** operator separates a multichannel input image into three single channel output images. The input image must be a RGB, HSV, or Yuv image. The output images are 8 bit unsigned images. For RGB, HSV and Yuv images, respectively, *ch0* is the red, hue, or Y (intensity) channel; *ch1* is the green, saturation, or u channel; and *ch2* is the blue, value, or v channel.

Demo iGraph

Operators\Color\HSV

C Prototype

```
CorOpRtn cor_splitChannels(
    CorImage *In,
    CorImage *Ch0,
    CorImage *Ch1,
    CorImage *Ch2
)
```

Headers

#include "$(WITHOME)/h/wColor.h"

Libraries

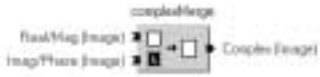
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wColor.lib

Complex

The Complex library provides support for complex images. The library includes operators that create complex images from real images and operators that extract real components or derived images from complex images.

complexMerge

Merge real/imaginary component images into a complex image



Description

The **complexMerge** operator converts two input images into a complex output image. The **input** parameter determines whether the input images are interpreted as the the real and imaginary components of the complex image or as the magnitude and phase. The operator accepts integer and float input images and does not accept color or complex images.

The output image is the same size as the **Real/Mag** input image. The output image ROI is the intersection of the ROIs of the two input images. Image values outside the ROI are undefined.

Parameter Information

input Type: int
Default: 0
Values: real/imag: 0, mag/phase: 1

Demo iGraph

Operators\Transforms\CrossCorrelation

C Prototype

```
CorOpRtn cor_complexMerge(
    CorImage *Real_Mag,
    CorImage *Imag_Phase,
    CorImage *Complex,
    int input
)
```

Headers

#include "$(WITHOME)/h/wComplex.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wComplex.lib

complexSplit

Split complex image into its real and imaginary component images

Description

The **complexSplit** operator converts a complex image into two float images. The **output** parameter determines if the output images are the real and imaginary components of the complex image or the magnitude and phase.

The **complexSplit** operator is typically used to split the complex output of the **fft** operator into float images so they can be processed by other WiT operators. The processed component images can be merged into a complex image using the **complexMerge** operator.

The output images are the same size and have the same ROI as the input image. Image values outside the ROI are undefined.

Parameter Information

output Type: int
Default: 0
Values: real/imag: 0, mag/phase: 1

Demo iGraph

Operators\Transforms\CrossCorrelation

C Prototype

```
CorOpRtn cor_complexSplit(
    CorImage *Complex,
    CorImage *Real_Mag,
    CorImage *Imag_Phase,
    int output
)
```

Headers

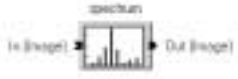
#include "$(WITHOME)/h/wComplex.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wComplex.lib

spectrum

Generate power spectrum of an image



Description

The **spectrum** operator converts a complex or float frequency domain image to a power spectrum representation. The input image is generally produced by a forward **fft** operation or, in the case of a float input image, by applying the **complexSplit** operator the output of the **fft**. The operator produces an 8-bit unsigned image that represents a logarithmic scaling of the input image.

The output image is an 8-bit unsigned image formed by taking the base 10 logarithm of the squared magnitude of the input image, scaled to the range 0 to 255. Due to this scaling, pixel values in the output image cannot be directly related to the input image values. A value of 1 is added to the squared magnitude of each image pixel before the logarithm is taken to ensure that the result is non-negative. This will distort the spectrum near small magnitude values.

The output image is the same size and has the same ROI as the input image. Image values outside the ROI are undefined.

Demo iGraph

Operators\Transforms\Transforms

C Prototype

```
CorOpRtn cor_spectrum(
    CorImage *In,
    CorImage *Out
)
```

Headers

#include "$(WITHOME)/h/wComplex.h"

Libraries

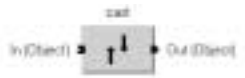
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wComplex.lib

Convert Type

The Convert Type library supports changes in object type and data representation. The library includes operators that cast between numeric types; string management operators; and operators that prepare objects for display.

cast

Convert basic object to another type (large icon)



Description

The **cast** operator converts its input object to the output type specified by the **type** parameter. The operator is primarily used to convert between the various integer and float object types, including conversions between Point and Real Point objects, or to convert numbers to strings or strings to numbers. It can be used to cast single objects or vectors of objects.

Conversions between floating point objects (float and double types), integer objects (byte, ubyte, short, ushort, int, uint, hex8, hex16, hex and char types) and between Point and Real Point objects result in the value of the input object being assigned to an output object of the selected type. If the value of the input object falls outside the range of the output object type, the value is clipped to the range. If the input is a vector of one of these types, the output will be a vector of the same size in which the elements are of the type specified in the **type** parameter.

The **conversion** parameter determines how float or double types are converted to one of the integer output types and how the x and y fields in Real Point objects are converted to the corresponding fields in the Point object. Selecting *round* will set the output value to the nearest integer of the input value, *floor* will set it to the nearest integer less than or equal to the input value, and *ceiling* will set it to the nearest integer greater than or equal to the input value.

Casting to a String or File type from one of the floating point, integer or point (including Real Point) types results in a text string representation of the value. For example, an int object with value 10 will be converted to the string *"10"* and a Point object with x=0, y=0 will be converted to the string *"(0, 0)"*.

Input String or File type objects can be cast to numeric types. When a string is converted to a signed or unsigned integer type it is interpreted using the C programming language convention. Strings starting with a "0" are interpreted as octal numbers and strings starting with "0x" or "0X" are interpreted as hexadecimal numbers. For example, the strings "12", "014", and "0xC" are all cast to the integer 12. If the entire string cannot be converted to the specified numeric type an error occurs, halting the igraph.

Parameter Information

type	Type: int Default: 0

Values: byte: 0, ubyte: 1, short: 2, ushort: 3, int: 4, uint: 5, float: 6, double: 7, String: 8, File: 9, Point: 10, Real point: 11, char: 12, hex8: 13, hex16: 14, hex: 15

conversion Type: int
Default: 0
Values: round: 0, floor: 1, ceiling: 2

C Prototype

```
CorOpRtn cor_cast(
    CorObj *In,
    CorObj *Out,
    int type,
    int conversion
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

castImage

Convert image from one type to another

Description

The **castImage** operator converts an integer or floating point input image to a specified integer or floating point type. The input image can be any scalar image type; int8, int16, int32, uint8, uint16, uint32, float32, or float64. The output image may be any scalar image type as specified by the **outType** parameter.

WiT processing and display operators do not normally handle int32, uint32, or float64 format images. Images in these formats can be created using, for example, the **crObject** operator or **vectorsToImage** operator. Images in the int32 format are used for the kernel parameter in many of the operators in the **Filter** and **Morphology** libraries. Images in these formats can only be cast in the *Clip* conversion mode.

The **mode** parameter allows the selection of *Clip*, which preserves image pixel values where possible, or one of three mapping modes, which scale pixel values to fit the output image range. In the *Clip* mode original image pixel values are retained where they fall within the range of the output image type. Input image pixel values that fall outside the output image range are set to the range minimum or maximum, depending on whether they are under or over the range.

The remaining modes provide a linear mapping from an input pixel value range to an output pixel value range.

All mapping modes work in the same way for float type input images. Float type to integer type casts map from the range of pixel values in the input image to the full range of the output image type. Float type to float type casts map from the range of pixel values in the input image to the range specified by the **min** and **max** parameters.

In the *MapRange* mode the full range of the input image type is used as the input image range, so integer type to integer type casts map from the full range of the input image type to the full range of the output image type; and integer type to float type casts map from the full range of the input image type to the range specified by the **min** and **max** parametes.

In the *MapValue* mode the range of pixel values in the input image is used as the input image range, so integer type to integer type casts map from the range of pixel values in the input image to the full range of the output image type; and integer type to float type casts map from the range of pixel values in the input image to the range specified by the **min** and **max** parametes.

The *MapMSB* mode is similar to the *MapValue* mode except for integer output images the values are mapped to a range that is at least half the full range of the output image type. This mode may

have a speed advantage over the *MapValue* mode, depending on available hardware.

Parameter Information

outType Type: int
Default: 3
Values: int8: 0, int16: 1, int32: 2, uint8: 3, uint16: 4, uint32: 5, float32: 6, float64: 7

mode Type: int
Default: 0
Values: Clip: 0, MapRange: 1, MapValue: 2, MapMSB: 3

min Type: float
Default: 0

max Type: float
Default: 1

C Prototype

```
CorOpRtn cor_castImage_1(
    CorImage *In,
    CorImage *Out,
    int outType,
    int mode,
    float min,
    float max
)
CorOpRtn cor_castImage_1_consume(
    CorImage *In,
    int outType,
    int mode,
    float min,
    float max
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

ct

Convert basic object to another type

Description

The **ct** (cast) operator converts its input object to the output type specified by the **type** parameter. The operator is primarily used to convert between the various integer and float object types, including conversions between Point and Real Point objects, or to convert numbers to strings or strings to numbers. It can be used to cast single objects or vectors of objects.

Conversions between floating point objects (float and double types), integer objects (byte, ubyte, short, ushort, int, uint, hex8, hex16, hex and char types) and between Point and Real Point objects result in the value of the input object being assigned to an output object of the selected type. If the value of the input object falls outside the range of the output object type, the value is clipped to the range. If the input is a vector of one of these types, the output will be a vector of the same size in which the elements are of the type specified in the **type** parameter.

The **conversion** parameter determines how float or double types are converted to one of the integer output types and how the x and y fields in Real Point objects are converted to the corresponding fields in the Point object. Selecting *round* will set the output value to the nearest integer of the input value, *floor* will set it to the nearest integer less than or equal to the input value, and *ceiling* will set it to the nearest integer greater than or equal to the input value.

Casting to a String or File type from one of the floating point, integer or point (including Real Point) types results in a text string representation of the value. For example, an int object with value 10 will be converted to the string *"10"* and a Point object with x=0, y=0 will be converted to the string *"(0, 0)"*.

Input String or File type objects can be cast to numeric types. When a string is converted to a signed or unsigned integer type it is interpreted using the C programming language convention. Strings starting with a "0" are interpreted as octal numbers and strings starting with "0x" or "0X" are interpreted as hexadecimal numbers. For example, the strings "12", "014", and "0xC" are all cast to the

integer 12. If the entire string cannot be converted to the specified numeric type an error occurs, halting the igraph.

Parameter Information

type Type: int
Default: 0
Values: byte: 0, ubyte: 1, short: 2, ushort: 3, int: 4, uint: 5, float: 6, double: 7, String: 8, File: 9, Point: 10, Real point: 11, char: 12, hex8: 13, hex16: 14, hex: 15

conversion Type: int
Default: 0
Values: round: 0, floor: 1, ceiling: 2

C Prototype

```
CorOpRtn cor_cast(
    CorObj *In,
    CorObj *Out,
    int type,
    int conversion
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

cvtCase

Convert a string to all upper or all lower case

Description

The **cvtCase** operator converts the input character string, **src**, to either all upper case or all lower case, depending on the **to** parameter.

Parameter Information

to Type: int
Default: 0
Values: Upper: 0, Lower: 1

C Prototype

```
CorOpRtn cor_cvtCase(
    CorString Src,
    CorString *Dst,
    int to
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

formatString

Concatenate a vector of strings into a string

Description

The **formatString** operator concatenates strings from the input vector and delimiter strings into a single string. The delimiter strings are specified in the operator's parameters. The **colDelimit** string is inserted after each element except the last. The **prepend** string is inserted at the beginning of the output string and the **append** string is inserted at the end.

Multi-column vectors of strings are no longer supported, so the **rowDelimit** parameter now has no effect.

Parameter Information

colDelimit Type: CorString
Default: ""

rowDelimit Type: CorString
Default: ""

prepend Type: CorString

Default: ""

append Type: CorString
Default: ""

C Prototype

```
CorOpRtn cor_formatString(
    CorStringVector *In,
    CorString *Out,
    CorString colDelimit,
    CorString rowDelimit,
    CorString prepend,
    CorString append
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

plotEdges

Convert edge vectors to graphic descriptions

Description

The **plotEdges** operator converts an edge or vector of edges into a vector of graphic objects that can be displayed on an image using the **overlayData** operator. The graphic objects include a geometric object for each edge, for example a point for crossing edges found using **getXEdges** and may also include an arrow indicating the edge direction and a label. Since multiple graphic objects are used to represent each edge, a single edge input results in a vector of graphic objects output.

The color of the graphical objects can be selected using the parameters in the **Color** subpanel.

Parameter Information

r Type: int

g Type: int
Default: 0
Values: 0 — 255

b Type: int
Default: 0
Values: 0 — 255

showArrow Type: int
Default: 0
Values: no: 0, yes: 1

arrowSize Type: int
Default: 12

arrowR Type: int
Default: 255
Values: 0 — 255

arrowG Type: int
Default: 255
Values: 0 — 255

arrowB Type: int
Default: 0
Values: 0 — 255

C Prototype

```
CorOpRtn cor_plotEdges(
    CorObj *Edges,
    CorGraphicVector *PlottedEdges,
    int r,
    int g,
    int b,
    int showArrow,
    int arrowSize,
    int arrowR,
    int arrowG,
    int arrowB)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

plotFeatures

Convert Blob feature vectors to graphic descriptions

Description

The **plotFeatures** operator converts the input Blob feature object or vector of Blob features into a graphic object or vector of graphic objects for viewing with the **overlayData** operator. The type of feature for viewing is specified by the **featureType** parameter and can be one of: *centroids*, *ellipse axes*, *bounding boxes*, *perimeters*, or *centers of bounding boxes*.

In order to plot perimeters, input Blob features must include the optional perimeter data. Blob feature vectors produced by the **getBlobFeatures** operator with its **perimeter** parameter set to *Yes* include perimeter data. Blob feature vectors produced by the **getBlobFeatures** operator with this parameter set to *No* or by the **getBlobs**, **getFeatures** combination do not contain perimeter data. The perimeter data can be added to these blob features by passing them through the **getPerimeter** operator.

The color of the output graphics can be controlled using parameters on the **Color** subpanel. If the **colors** parameter is set to custom the remaining parameters can be used to specify whether the output graphics are outlines or filled graphic objects and to specify the color of the objects. The default graphics are yellow outlines. The label field of each graphic object is set to the id number of the associated element of the Blob feature vector.

Parameter Information

featureType Type: int
Default: 0
Values: centroids: 0, major axis: 1, bbox: 2, perimeter: 3, bbox center: 4

colors Type: int
Default: 0
Values: default: 0, custom: 1

outline Type: int
Default: 0
Values: off: 0, on: 1

penR Type: int
Default: 0
Values: 0 — 255

penG Type: int
Default: 0
Values: 0 — 255

penB Type: int
Default: 0
Values: 0 — 255

fill Type: int
Default: 0
Values: off: 0, on: 1

fillR Type: int
Default: 0
Values: 0 — 255

fillG Type: int
Default: 0
Values: 0 — 255

fillB Type: int
Default: 0
Values: 0 — 255

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_plotFeatures(
    CorObj *Features,
    CorObj *PlottedFeatures,
    int featureType,
    int colors,
    int outline,
    int penR,
    int penG,
    int penB,
    int fill,
    int fillR,
    int fillG,
    int fillB)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

plotGeom

Convert Geometry object to Graphic object

Description

The **plotGeom** operator converts a Geometry object or vector of Geometry objects to a Graphic object or vector of Graphic objects that can be displayed using the **overlay** operator.

The parameters on the **Color** subpanel can be used to set the color of the output Graphics.

Parameter Information

outline Type: int
Default: 1
Values: off: 0, on: 1

penR Type: int
Default: 255
Values: 0 — 255

penG Type: int
Default: 0
Values: 0 — 255

penB Type: int
Default: 0
Values: 0 — 255

fill Type: int
Default: 0
Values: off: 0, on: 1

fillR Type: int
Default: 255
Values: 0 — 255

fillG Type: int
Default: 0
Values: 0 — 255

fillB Type: int
Default: 0
Values: 0 — 255

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_plotGeom(
    CorObj *Geom,
    CorObj *Gfx,
    int outline,
    int penR,
    int penG,
    int penB,
    int fill,
    int fillR,
    int fillG,
    int fillB)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

plotLines

Convert line vectors to graphic descriptions

Description

The **plotLines** operator converts a Line object or a vector of Line objects into a vector of Graphic objects, which can be displayed using the **overlayData** operator. The input vector of Line objects is generally produced by the **geom2lines** operator. Since multiple graphic objects may used to represent each line, a single line input results in a vector of graphic objects output.

The graphic representation can include the lines alone, the endpoints of the lines or both, as specified by the **graphicType** parameter. The color

of the lines and endpoints can be specified separately.

The color of the output graphics can be controlled using parameters on the **Color** subpanel. The **linePen** and **pointPen** parameters are used to turn on and off the pens for lines and points, respectively. The **lineR**, **lineG** and **lineB** and the **pointR**, **pointG** and **pointB** control the respective colors.

Parameter Information

graphicType Type: int
Default: 1
Values (bitwise OR): lines: 1, endpoints: 2

linePen Type: int
Default: 1
Values: off: 0, on: 1

lineR Type: int
Default: 255
Values: 0 — 255

lineG Type: int
Default: 255
Values: 0 — 255

lineB Type: int
Default: 0
Values: 0 — 255

pointPen Type: int
Default: 1
Values: off: 0, on: 1

pointR Type: int
Default: 255
Values: 0 — 255

pointG Type: int
Default: 0
Values: 0 — 255

pointB Type: int
Default: 0
Values: 0 — 255

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_plotLines(
    CorObj *Lines,
    CorGraphicVector *PlottedLines,
    int graphicType,
    int linePen,
    int lineR,
    int lineG,
    int lineB,
    int pointPen,
    int pointR,
    int pointG,
    int pointB)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

scanString

Convert a string to a vector of substrings

Description

The **scanString** operator allows the user to extract substrings from the input string and assemble these substrings into a vector of strings. The input string is divided at any character or combination of characters from the string entered in the **splitChars** parameter. The characters from **splitChars** string are not include in the substring. For example, the input string "*{1, 2, 3}*" scanned with the **splitChars** string "*{, *" (where the last character in this string is a space) will result in the a three element vector containing the strings "*1*", "*2*", and "*3*".

Multi-column vectors of strings are no longer supported. The **nCols** parameter has no effect, all settings are equivalent to a setting of 1 in versions prior to WiT 6.0.

Parameter Information

splitChars Type: CorString
Default: ", "

nCols Type: int
Default: 1

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_scanString(
    CorString In,
    CorStringVector *Out,
    CorString splitChars,
    int nCols
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

splitString

Split a string into two substrings

Description

The **splitString** operator partitions an input string into two substrings. The point at which the string is split may be specified by a position in the string, a specific character, or at the end of prefix containing specified characters. The method of locating the split point is specified using the **splitBy** parameter.

When **splitBy** *position* is selected, the first substring contains the number of characters given in the **splitPosition** parameter. The second substring contains the remaining characters of the input string. If the **splitPosition** value is greater than the length of the input string, the first output string contains the entire input string and the second output string is empty.

Setting **splitBy** to *char* causes the string to be split at either the first or last (as specified by the **splitAt** parameter) occurence of any character in the **splitChars** parameter string. The string can be split before or after the character as specified by the **split** parameter.

If **splitBy** is set to *prefix* the first output string contains a prefix of the input string made up of characters from a specified set. The second output string starts at the first occurence of a character not in the set and all subsequent characters in the string (whether they are in the set or not). If the **prefixChars** parameter is set to *in set*, the prefix will contain only characters from the **splitChars** parameter string. If it is set to *not in set*, the prefix will contain only characters not in the **splitChars** parameter string.

Parameter Information

splitBy Type: int
Default: 0
Values: position: 0, char: 1, prefix: 2

splitPosition Type: int
Default: 0

splitChars Type: CorString
Default: ""

splitAt Type: int
Default: 0
Values: first: 0, last: 1

split Type: int
Default: 0
Values: before: 0, after: 1

prefixChars Type: int
Default: 0
Values: in set: 0, not in set: 1

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_splitString(
    CorString In,
    CorString *Prefix,
    CorString *Suffix,
    int splitBy,
    int splitPosition,
    CorString splitChars,
    int splitAt,
    int split,
    int prefixChars
)
```

Headers

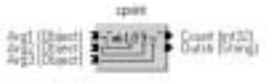
#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

sprint

Print formatted output to a string (in the style of C's 'sprintf').



Description

The **sprint** operator prints formatted output to a string, in the style of C's 'sprintf' function. The operator converts the input objects to strings and forms the output string based on the **format** parameter. The inputs must be numeric or string objects.

The **format** parameter is a 'sprintf' style format string that specifies up to three arguments. The operator scans the format string, copying characters to the output string, until '%' encountered. If next character is '%', it is copied. Otherwise, the following character(s) up to and including the first conversion character are treated as a printf style format specifier, and the string representation of the corresponding input object is appended to the output string. Input objects are matched from top (*Arg1*) to bottom (*Arg3*) with the format specifiers as they are encountered. Unneeded (extra) input objects are just ignored. The unused inputs must be connected and must receive an object for the operator to fire.

An error occurs if the input object type does not match the corresponding format specifier or if more than three arguments are required by the format string.

The **sprint** operator produces two outputs; Outstr,the completed output string; and Count,the number of chars written to the string.

The 'C' sprintf conversion characters are:

- d, i: signed decimal notation
- o: unsigned octal notation
- x, X: unsigned hexadecimal notation
- u: unsigned decimal notation
- c: single character
- s: string
- f: fixed point decimal notation
- e, E: decimal notation in mantissa / exponent form
- g, G: use %e or %E if exponent is less than -4, otherwise use %f
- p: not implemented in WiT
- n: not implemented in WiT

Departures from the behaviour of Microsoft's 'C' standard library sprintf:

- Sprint does not allow the precision to be greater than 510. (MSC sprintf may crash.)
- Sprint does not allow the width or precision to be negative. (MSC sprintf unreliable.)
- The '%n' and '%p' conversions are not supported. (Inappropriate in WiT.)

Parameter Information

format Type: CorString

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_sprint(
    CorObj *Arg1,
    CorObj *Arg2,
    CorObj *Arg3,
    int *Count,
    CorString *Outstr,
    CorString format
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

sscan

Decode formatted input from a string (in the style of C's 'sscanf').

Description

The **sscan** operator deals with formatted input, in the style of C's 'sscanf' function. The operator breaks the input string down into its elements, as controlled by the **format** parameter. These elements are collected into a vector to form the output.

The **format** parameter is a 'sscanf' style format string that contains the conversion specifications and directs the interpretation of the input. The **format** parameter may contain one or more of the following:

- White space characters (ie. spaces, tabs), which are read and not stored. One white space character in the format string matches any number (including zero) of white space characters in the input string.
- Non white space characters, except for the percent sign (%), which are expected to match the next non white space character in the input string. If the characters do not match, sscanf terminates. These characters are read, but not stored.
- Format specifications, introduced by the percent sign (%). Format specifications cause sscanf to read and convert the characters of the input string into a value of a specified type. This value becomes one of the elements in the output vector. A format specification can be suppressed by using the * character following the % character, in which case the input field is read and not stored.

The following format specifications are supported by WiT:

- d, i: decimal integers
- u: unsigned integer
- o: octal int, returns the decimal value
- x, X: hexadecimal int, returns the decimal value
- c, C: a string one character long
- s, S: string
- e, E, f, g, G: float
- [...]: reads and stores until the first character that does not appear in the brackets
- [^...]: reads and stores until the first character than does appear in the brackets
- %: read as a literal %, no assignment is made

Sscan produces two outputs: Out, which holds the vector of elements converted, and Count, which holds the number of elements converted. If there are more arguments in the input string than required by the format parameter, the extras are discarded. If there are not enough format parameters, the extras are ignored.

Notes:

- 'Count' is an optional output: value always computed, but reported only if it is connected in igraph (of course).
- 'Out' must be connected to calculate 'Count.'
- The %n parameter is not supported. Its use will cause unpredictable results.
- If the input object type is not a string, sscan will not work. Strings in WiT must start with a character (ie. the input string "44 hello world" will be considered to be an integer type and cause sscan to fail.
- The case []...] where the first] is included in the set is not supported.
- The case [^]...] where the first] is included in the set is not supported.
- Width specifiers (single byte / wide) are not supported for c, C, s, and S.
- Format specifiers %xi and %oi are unsupported, use %x and %o to get hex and octal.
- The I64 prefix for integers is not supported by WiT.

Parameter Information

format Type: CorString

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_sscan(
    CorObj *In,
    int *Count,
    CorVector *Out,
    CorString format
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

strLength

Get string length

Description

The **strLength** operator outputs the length of the input string.

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_strLength(
    CorString In,
    int *Length
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

vectorsToImage

Convert a vector of vectors into an image.

Description

The **vectorsToImage** operator creates an image from a vector of vectors, with the element vectors (the vectors that are elements of the input vector) making up the rows of the image. The base type of the element vectors can be any type, including

vectors, images, or user defined types. The output image will be the same type as the element vectors.

WiT processing operators will generally only accept images from among the scalar types uint8, int8, uint16, int 16 and float32; color types RGB, HSV and YUV; and the Complex type. In addition the display operators will display these types as rendered images, all other types are displayed in a text format similar to the vector text display format.

The element vectors may be of varying length. The output image width will be equal to the length of the longest element vector. Empty image elements (pixels) will be filled with zero valued versions of the element vector base type. This may result in inconsistent data values for compound data types such as the Graphic type. The **setRoiWidth** parameter allows the user to specify whether the the sith of the intrinsic image ROI should be set to the width of the shortest element vector, by selecting *Min*, or to the length of the longest element vector (the entire image), by selecting *Max*.

The parameters on the **Rows** subpanel control duplication and spacing of rows in the output image. If the **dataThickness** parameter is set to a value greater than one, each element vector will be copied into that number of adjacent rows in the output image. The **gapThickness** parameter allows the user to specify the number of rows of zero valued elements that separate the row or rows copied from each element vector. Again this may result in inconsistent data values for compound data types. If the **addLastGap** parameter is set to *No* the gaps will only be added between the row or groups of rows copied from the element vectors. If it is set to *Yes* the gap will also be added after the last copied row.

Parameter Information

setRoiWidth Type: int
Default: 1
Values: Min: 0, Max: 1

dataThickness Type: int
Default: 1

gapThickness Type: int
Default: 0

addLastGap Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Blobs\GetBlobFeatures.igr
Operators\Blobs\GetBlobFeaturesMasked.igr
Operators\Blobs\SelectFeatures.igr

C Prototype

```
CorOpRtn cor_vectorsToImage(
    CorVectorVector *Vectors,
    CorImage *Image,
    int setRoiWidth,
    int dataThickness,
    int gapThickness,
    int addLastGap
)
```

Headers

#include "$(WITHOME)/h/wConvert.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wConvert.lib

Display

Display and interactive operators.

clearDisplay

Clear all pop-up displays

Description

On receiving a token at its input, the **clearDisplay** operator closes all of the pop-up displays that were were previously opened to display data.

display

Display object data in a pop-up window

Description

The **display** operator creates a pop-up frame containing the data of the object received at its input port. If the object is an image, then the pop-up will present a rendered image. If the object is not an image, then **display** will pop up a frame with text showing all the pertinent data contained within the object.

When data arrives at a display operator, the data is shown in a detached window. Display detects the type of the input object. If it is an image or a vector of images, then it brings up an image window, otherwise it brings up a general object window.

The position of the pop-up window is controlled by the **Placement** option in the Advanced Options panel. The default is to tile windows on the screen. You can override auto placement by specifying an explicit position for the **X** and **Y** parameters in the **Placement** sub-panel of the **display** property panel.

The name of the pop-up display can be set using the **name** parameter. Operators with the same name will display objects in the same pop-up window, with the new object replacing any existing displayed object.

For images, the size of the pop-up window is the actual size of the image. For general objects, the size is just big enough to show the entire object with the default font. If the object size is larger than the screen, then the window size is limited to the screen size, and scroll bars appear automatically. You can also specify a maximum size with the **MaxW** and **MaxH** parameters in the **Placement** sub-panel. **MaxW** and **MaxH** only affects the initial window size, they do not limit any subsequent manual resizing of the object window.

More controls are available from the pop-up menu (press right mouse button inside window). Pop-up menus are different for image and non-image data objects.

Display is a powerful and often used tool. Refer to the section 'Operators/Libraries' in the *User's Manual* for details.

See Also

smallDisplay

Parameter Information

name	Type: CorString Default: "display"
Placement	Type: int Default: 0 Values (bitwise OR): Fix position: 1, Max size: 2, Min size: 4
X	Type: int Default: 0 If *Fix position* of the *Placement* parameter is enabled (bit 1, 0x1), the *X* parameter specifies the horizontal position on the screen of the upper left hand corner of the display window. If *Fix position* is not enabled, the *X* parameter is ignored.
Y	Type: int Default: 0 If *Fix position* of the *Placement* parameter is enabled (bit 1, 0x1), the *Y* parameter specifies the vertical position on the screen of

the upper left hand corner of the display window. If *Fix position* is not enabled, the *Y* parameter is ignored.

MaxW Type: int
Default: 0

MaxH Type: int
Default: 0

MinW Type: int
Default: 0

MinH Type: int
Default: 0

Range Type: int
Default: 0
Values: Auto: 0, User: 1

RangeLow Type: float
Default: 0

RangeHigh Type: float
Default: 255

Equalize Type: int
Default: 2
Values: Actual: 0, User: 1, Max: 2

EqLow Type: float
Default: 0

EqHigh Type: float
Default: 255

XScale Type: float
Default: 1

YScale Type: float
Default: 1

Inspect Type: int
Default: 0
Values (bitwise OR): X-Profile: 1, Y-Profile: 2, Magnifier: 4

Track Type: int
Default: 0
Values: Mouse drags: 0, Mouse moves: 1

Colormap Type: int
Default: 0
Values: Grayscale: 0, Pseudo-color: 1, Shared: 2, Custom: 3

ColormapName Type: CorFile

Format Type: int
Default: 0

FontFamily Type: CorString
Default: ""

Style Type: int
Default: 0
Values: Normal: 0, Italics: 1, Bold: 2, Bold-Italics: 3

Size Type: int
Default: 11

TextRed Type: int
Default: 0
Values: 0 — 255

TextGreen Type: int
Default: 0
Values: 0 — 255

TextBlue Type: int
Default: 0
Values: 0 — 255

BackRed Type: int
Default: 255
Values: 0 — 255

BackGreen Type: int
Default: 255
Values: 0 — 255

BackBlue Type: int
Default: 255
Values: 0 — 255

edit

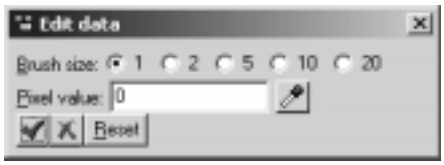
Edit data interactively

Description

The **edit** operator allows you to interactively modify data objects.

If the input object is an image, then **edit** brings up a simple painting tool which allows you to modify the pixel values in the image. It displays the image magnified according to the **magnification** parameter. The higher the magnification, the larger

each pixel will appear. **Edit** also displays a property window next to the image:



When **edit** is running, any left mouse buttons clicks or mouse drags inside the image will set the pixel(s) to the pixel value indicated by the **Pixel value** control in the **edit** properties window. **Brush size** controls the area painted for each mouse position. Brush sizes are always square in shape. The button switches the operation mode to sample mode. In sample mode, the cursor changes to . When you click the left mouse button, the value of the pixel is copied to the **Pixel value** control in the **edit** property window. After one sample, **edit** automatically switches back to edit mode.

The button terminates the **edit** session and sends the modified image to the output. The button terminates the session but does not produce any output. The modified image is discarded. The **Reset** button resets the image back to the original.

If the input type is not an image, then **edit** brings up the Object Editor. See the User's Manual for details about the Object Editor.

For WiT Professional Toolkit users, the **edit** operator supports the **witControlDisplay** function for the commands: **brushSize**, **cancel**, **ok**, **pixVal**, **reset**, and **sample**. See the WiT Professional Toolkit Manual for details.

Parameter Information

name Type: CorString
Default: "data"

magnification Type: int
Default: 0
Values: 1: 0, 2: 1, 4: 2

C Prototype

```
CorOpRtn cor_edit(
    CorObj *In,
    CorObj *Out,
    CorString name,
    int magnification
)
```

Headers

#include "$(WITHOME)/h/wDisplay.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wDisplay.lib

getData

Interactive specification of graphical objects

Description

The **getData** operator allows interactive specification of Graphic objects associated with an image. The Graphic objects can be geometric shapes such as points, lines or polygons, or text. A color can be associated with each object, and the method of drawing geometric shapes (outlined, filled or both) can be specified. The resulting graphical objects can be displayed on the original image or other images, using the **overlayData** operator, or used in later processing and analysis steps, for example with the **extract** or **statsRoi** operators.

The **getData** operator is interactive, requiring direct user input. When an image object arrives at the input port it is displayed and the user can define graphical objects on the image using the mouse and a graphical editor panel, as described below.

Once the objects are defined, the user selects *OK* from the pull down menu obtained by clicking the right mouse button in the **getData** image. The operator then outputs a vector containing the Graphic objects specified by the user. You can also press the Enter key on the keyboard to achieve the same effect.

Alternately, the user can select *Cancel*, in which case execution will terminate with no output produced, or *Reset*, which will delete all of the graphical objects and allow the user to start again. Operators following **getData** in the igraph will not be executed until the user defines the data required.

The **type** parameter specifies the graphical object type initially desired. The choices are: *points*, *lines*, *rectangles*, *circles*, *polylines*, *polygons*, or *text*. The object type can be changed interactively by selecting one of the buttons on the lower row of the editor panel.

Once the object type is selected the object can be drawn on the image using the left mouse button. A single click specifies a point or the starting cursor position for text entry. Lines, rectangles and circles are specified by pressing, dragging and releasing the mouse button, with the press and release points specifying the two end points of a line, the upper left and lower right corners of a rectangle or the center and radius of a circle. Polylines and polygons are drawn with a mouse click for each segment end point and a double click to terminate point placement. Polyline and polygon points can be deleted in reverse order before the the point placement is terminated by clicking the center mouse button. Once the object has been drawn, another object of the same type can be entered or you can change the object type using the Graphics Editor. Completed graphical objects are displayed overlayed on the image.

The completed objects can be adjusted, moved or deleted by clicking on the select button, the arrow icon at the left of the lower row of the editor panel. An object is selected by clicking on the object, causing the object to turn red. A selected object can be moved by dragging it with the mouse, or can be deleted by clicking on the delete button, the scissors icon at the left of the upper row of the editor panel. After clicking the select button, objects can be resized by pressing the left mouse button near the part of the object to be modified and dragging it to the desired position (the object must *not* be selected before you begin this operation). The cursor will turn into a screwdriver icon in this mode.

The editor panel also allows the specification of outline or fill mode for the objects and the color associated with each as well as control of the fonts for text.

Parameter Information

name Type: CorString
Default: "getData"

type Type: int
Default: 0
Values: point: 0, line: 1, polyline: 2, polygon: 3, rectangle: 4, circle: 5, text: 6

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

XScale Type: float
Default: 1

YScale Type: float

Default: 1

getData2

Interactive specification of graphical objects

Description

The **getData2** operator behaves like the **getData** operator, except that it accepts a second input which contains an initial set of graphic objects (vector of Graphic). This input can be a **sync** token also, which allows **getData2** to fire with a blank set of graphics data.

Parameter Information

name Type: CorString
Default: "getData2"

startMode Type: int
Default: 0
Values: Data entry: 0, Select: 1, Always selected: 2, Select first: 3

type Type: int
Default: 0
Values: point: 0, line: 1, polyline: 2, polygon: 3, rectangle: 4, circle: 5, text: 6

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

XScale Type: float
Default: 1

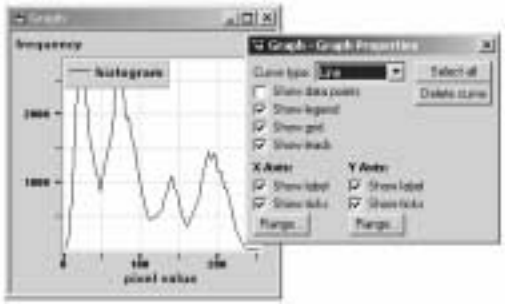
YScale Type: float
Default: 1

graph

Create line, bar, histogram, or scatter plots

Description

The **graph** operator accepts either a single vector or compound vector (vector of vectors) of values for plotting single or multi-line graphs. The operator can generate line graphs, bar charts, histograms and scatter plots.



The graph operator accepts vectors of integer points or float points, or vectors of integer or float scalar numbers. Point input data is plotted using the *(x,y)* coordinates from the data. Scalar data is plotted using the vector index (starting from 0) as the *x* coordinate and the element value as the *y* coordinate. It is also possible to plot a multi-line graph from a compound vector (vector of vectors) or from multiple individual vectors (described below).

When input data arrives, a graph frame pops up, displaying the graph as specified by the operator's parameters. A properties panel can be invoked from the pop-up menu inside the graph region, and can be used to change the method of displaying the graph data. Pressing the left mouse button while the cursor is on the graph gives the exact cursor position in graph coordinates. The graph can be scaled and panned in the same manner as an igraph.

Graph is a powerful and often used tool. See chaper ‘Operators/Libraries’ in the *User’s Manual* for details.

Parameter Information

grTitle	Type: CorString Default: "Graph"
name	Type: CorString Default: "Curve"
type	Type: int Default: 0 Values: Line: 0, Bar Chart: 1, Histogram: 2, Scatter Plot: 3
cumulative	Type: int Default: 0 Values: No: 0, Yes: 1
allowDuplicateNames	Type: int Default: 1 Values: No: 0, Yes: 1
showDataPts	Type: int Default: 0 Values: No: 0, Yes: 1
showLegend	Type: int Default: 0 Values: No: 0, Yes: 1
legendPos	Type: CorPoint Default: (0, 0)
xaxis	Type: CorString Default: "x-axis"
axisXScale	Type: int Default: 0 Values: Auto: 0, Manual: 1
xaxisRange	Type: CorString Default: "0 100"
xShowTicks	Type: int Default: 1 Values: No: 0, Yes: 1
yaxis	Type: CorString Default: "y-axis"
axisYScale	Type: int Default: 0 Values: Auto: 0, Manual: 1
yaxisRange	Type: CorString Default: "0 100"
yShowTicks	Type: int Default: 1 Values: No: 0, Yes: 1
Placement	Type: int Default: 0 Values (bitwise OR): Fix position: 1
X	Type: int Default: 0
Y	Type: int Default: 0
width	Type: int Default: 500
height	Type: int Default: 500

C Prototype

```
CorOpRtn cor_graph(
    CorObj *In,
    CorImage *Graph,
    CorString grTitle,
    CorString name,
    int type,
    int cumulative,
    int allowDuplicateNames,
    int showDataPts,
    int showLegend,
    CorPoint *legendPos,
    CorString xaxis,
    int axisXScale,
    CorString xaxisRange,
    int xShowTicks,
    CorString yaxis,
    int axisYScale,
    CorString yaxisRange,
    int yShowTicks,
    int Placement,
    int X,
    int Y,
    int width,
    int height)
```

Headers

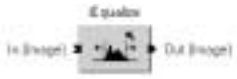
#include "$(WITHOME)/h/wDisplay.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wDisplay.lib

iEqualize

Interactive histogram equalization



Description

The **iEqualize** operator displays a grayscale image in a separate window and provides controls for selecting an appropriate contrast. The effect of the ramp window changes can be seen immediately as the windowing arrows are moved. When the desired equalized image is achieved, click and the image you see is sent to the output.

Properties:

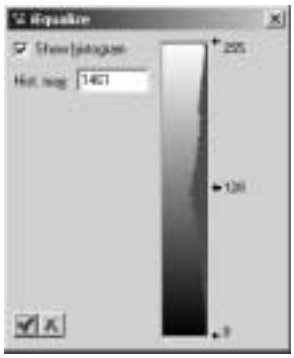
Main panel:

name	Name of the window used to display the data.

Placement sub-panel:

Placement	If **Fix position** is checked, values of the **X** and **Y** properties are used to position the data window. Otherwise, the current automatic placement rules are used.
X	The **X** position of the data window if **Placement** is set to **Fix position**
Y	The **Y** position of the data window if **Placement** is set to **Fix position**

Property Panel:



Show histogram	Enable/disable histogram display on ramp.
Hist. max	Control scale of histogram displayed on ramp. The larger the scale, the taller the histogram will appear. Default value is maximum value of histogram.
Ramp	Similar to the ramp on the image property panel.
	Accept the current thresheld image and send it to the output.
	Abort the iEqualize session. No output is produced.

Parameter Information

name Type: CorString
Default: "iEqualize"

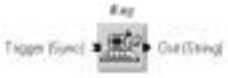
Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

iKey

Prompt the user for a keyboard character



Description

The **iKey** operator is used when the user needs to be prompted for a single character from the keyboard during igraph execution. The input object triggers this operator to create a pop-up window which requires the user to hit a key on the keyboard. As soon as the key is hit, an output object (a string with a single character) is produced with the key as the first character of the string.

The user can hit the **cancel** button to cancel the operator. In this case, no output is produced.

The **label** parameter is used as a label on the dialog.

Parameter Information

label Type: CorString
Default: "Hit a key:"

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

C Prototype

```
CorOpRtn cor_iKey(
    CorString *Out,
    CorString label,
    int Placement,
    int X,
    int Y
)
```

Headers

#include "$(WITHOME)/h/wDisplay.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wDisplay.lib

iMeas

Interactive image measurement

Description

The **iMeas** operator allows image measurements, such as the length of a path or the area and average pixel value in a region of interest, to be made interactively. The image region to be measured is specified by a graphical object drawn on the image using the mouse and the Graphics Editor, as described for the **getData** operator.

Measured values related to the graphic object and to the pixel values in the graphic are displayed in a popup panel. The measured values related to the graphic include the length of the graphic (perimeter, in the case of solid geometric objects such as polygons or circles), the area of the graphic, and the bounding box height and width of the graphic. These values are scaled by the value, specified by the **UnitsPerPixel** parameter, to convert them into an appropriate coordinate system and may have an associated unit, specified by the **UnitName** parameter. For example, you can specify that each pixel represents 2.5 microns by setting the **UnitsPerPixel** parameter to 2.5 and the UnitName to micron. Then all subsequent measurements will be scaled accordingly. For example, a line 10 pixels long will be reported to be 25 units long.

Measured values related to the pixel values include the mean, standard deviation, minimum and maximum of the pixel values. Pixel values on the perimeter can also be plotted on a popup graph.

Properties:

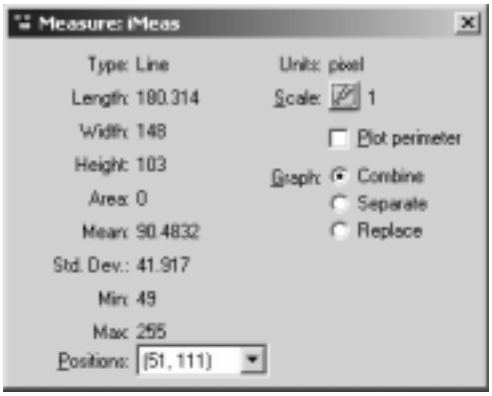
Main panel:

name	Name of the window used to display the data.
type	The *initial* graphic type to be entered on the image.
UnitName	The unit name used to report measurements on the pop-up panel. Can be any valid string.
UnitsPerPixel	A floating-point scale factor that specifies the number of linear units each pixel represents. This scale factor is used to scale all reported measurements.

Placement sub-panel:

Placement	If **Fix position** is checked, values of the **X** and **Y** properties are used to position the data window. Otherwise, the current automatic placement rules are used.
X	The **X** position of the data window if **Placement** is set to **Fix position**
Y	The **Y** position of the data window if **Placement** is set to **Fix position**

Property Panel:



Type	Type of graphic being used for measuring.
Length	Length of graphic.
Width	Width of bounding box of graphic.
Height	Height of bounding box of graphic.
Area	Area of graphic.
Mean	Mean pixel value within graphic area.
Std. Dev.	Standard deviation of pixel values within graphic area.
Min	Minimum pixel value within graphic area.
Max	Maximum pixel value within graphic area.
Positions	List of (x, y) coordinates of each vertex of graphic.
Units	Unit name. From operator **UnitName** parameter.
Scale	Ratio of pixel count to physical length. For example, if **Scale** is set to 2 and a line 5 pixels long is entered, then a length of 10 physical units will be reported. The initial value of **Scale** is set from the **UnitsPerPixel** operator parameter. You can change it interactively by clicking the button.
Plot perimeter	If checked, the pixel values along the perimeter of the graphic are plotted whenever a new graphic is entered. Does not apply to **point** or **text** graphic types. You can control whether plots should be done in one single graph or as separate graphs with the **Graph** control below.
Graph	Control the placement of new perimeter plots. If **Combine** is chosen, subsequent plots are merged with the existing graph. This makes it easy to compare values. If **Separate** is selected, subsequent plots are displayed on a separate graph window. If **Replace** is chosen, each subsequent plot clears the existing plots on the graph window before being plotted.

Parameter Information

name	Type: CorString Default: "iMeas"
type	Type: int

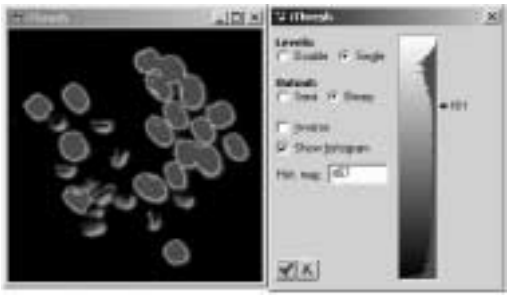
	Default: 0 Values: point: 0, line: 1, polyline: 2, polygon: 3, rectangle: 4, circle: 5
UnitName	Type: CorString Default: "pixel"
UnitsPerPixel	Type: float Default: 1
Placement	Type: int Default: 0 Values (bitwise OR): Fix position: 1
X	Type: int Default: 0
Y	Type: int Default: 0

iThresh

Interactive thresholding

Description

The **iThresh** operator displays a grayscale image in a window and provides controls for selecting the threshold level. The effect of the threshold level can be seen immediately as the level is moved. When the desired threshold effect is achieved, click **OK** and the image you see is sent to the output.



Properties

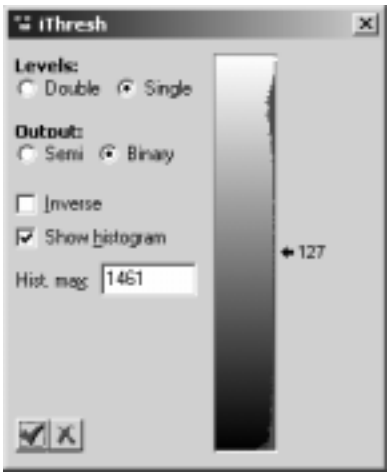
Main panel:

grTitle	The title of the graph. If there are multiple **graph** operators in an igraph, you can send all the plots to the same graph by setting the **grTitle** of the operators to the same name. Also, if you have set **Auto clear** in the Options panel to false, then you can plot curves from different igraphs to the same graph, provided that the **grTitle** are set to the same name.
name	The name of the curve or curve set. If the input is a list of curves, you can enter muliple names. E.g., if you are sending a vector of 3 curves, then you can set the **name** parameter to apples oranges "a complex name" then the curves will be labeled accordingly on the graph. If only one name is specified, then each individual curve is labeled with this name plus an identification number, e.g. curve-1, curve-2, etc.

Placement sub-panel:

Placement	If **Fix position** is checked, the parameters **X** and **Y** are used to position the window. Otherwise, the current automatic window placement strategy is used to position the window.
X	The X (horizontal) position of the window on the screen, if **Placement** has **Fix position** checked.
Y	The Y (vertical) position of the window on the screen, if **Placement** has **Fix position** checked.
width	The width of the window used to display the surface plot.
height	The height of the window used to display the surface plot.

Property Panel



Levels	If **Double** is chosen, two threshold levels are needed. If **Single** is chosen, only one threshold level is needed.
Output	If **Semi** is selected, the threshold range will preserve its original pixel values, pixel values which are outside the threshold range will be black. If **Binary** is selected, pixels in the threshold range will be turned white.
Inverse	Reverse the threshold range. E.g. if the image is 8-bit unsigned and level is single at 128, then normally pixel values above 128 will be set to 255, pixels below 128 will be set to 0. But if Inverse is chosen, then pixels above 128 will be black, and pixels below 128 will be white instead.
Show histogram	Enable/disable histogram display on ramp.
Hist. max	Control scale of histogram displayed on ramp. The larger the scale, the taller the histogram will appear. Default value is maximum value of histogram.
Ramp	Similar to the ramp on the image property panel. If Levels is set to **Single**, there is only one pointer on the ramp, which indicates a singe threshold level. If Levels is set to double, two pointers appear on the ramp.

Parameter Information

name Type: CorString
Default: "iThresh"

invert Type: int
Default: 0
Values: No: 0, Yes: 1

levels Type: int
Default: 0
Values: Single: 0, Double: 1

result Type: int
Default: 0
Values: Binary: 0, Semi-Threshold: 1

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

overlayData

Display graphical data overlaid on image

Description

The **overlayData** operator provides a means of viewing data generated by **getData** or other operators with outputs in **Graphic** format, such as **plotFeatures**.

The operator accepts an image of any type and a vector of graphic objects as input. The input image is displayed with the graphic objects overlayed in color. The source of the color used for the graphic objects is specified by the **useColor** parameter. If it is set to *original* the color of each graphic object is taken from the **penColor** and **fillColor** fields in the object itself. If **useColor** is set to *forced*, a graphical object is drawn using the color whose red, green and blue components are defined by the **forcedR**, **forcedG** and **forcedB** parameters. Rectangles,

circles and polygons are not filled in the *forced* mode.

The output of **overlayData** is a color image as displayed by the operator.

Most of the operator properites of **overlayData** are the same as the **display** operator.

Parameter Information

name Type: CorString
Default: "overlay"

background Type: int
Default: 0
Values: No: 0, Yes: 1

useColor Type: int
Default: 0
Values: original: 0, forced: 1

forcedR Type: int
Default: 255
Values: 0 — 255

forcedG Type: int
Default: 255
Values: 0 — 255

forcedB Type: int
Default: 0
Values: 0 — 255

showLabels Type: int
Default: 0
Values: Labels: 0, None: 1, Serial: 2, Labels & Serial: 3

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1, Max size: 2, Min size: 4

X Type: int
Default: 0

Y Type: int
Default: 0

MaxW Type: int
Default: 0

MaxH Type: int
Default: 0

MinW Type: int
Default: 0

MinH Type: int
Default: 0

Range Type: int
Default: 0
Values: Auto: 0, User: 1

RangeLow Type: float
Default: 0

RangeHigh Type: float
Default: 255

Equalize Type: int
Default: 2
Values: Actual: 0, User: 1, Max: 2

EqLow Type: float
Default: 0

EqHigh Type: float
Default: 255

XScale Type: float
Default: 1

YScale Type: float
Default: 1

Inspect Type: int
Default: 0
Values (bitwise OR): X-Profile: 1, Y-Profile: 2, Magnifier: 4

Track Type: int
Default: 0
Values: Mouse drags: 0, Mouse moves: 1

Colormap Type: int
Default: 0
Values: Grayscale: 0, Pseudo-color: 1, Shared: 2, Custom: 3

ColormapName Type: CorFile

prompt

Show a prompt message

Description

The **prompt** operator displays a message in a pop-up message box and may wait for a user response.

The message is displayed when the operator receives any object at its input. The message displayed is specified by the **Message** string parameter. The **Type** parameter specifies the user interaction and operator output. In the *Display* mode no user interaction is required, an integer *0* is produced immediately. In the *Acknowledge* mode a single check-box appears with the message. The operator produces an integer *1* when the user clicks on the check-box. In the **Conditional** mode two check-boxes appear with the message. The operator produces an integer output when either of the boxes is selected. If the box with the green check mark is selected the output is a *1*; if the box with the red X is selected the output is a *0*.

Parameter Information

Type Type: int
Default: 0
Values: Display: 0, Acknowledge: 1, Conditional: 2

Message Type: CorString
Default: "Hello"

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

C Prototype

```
CorOpRtn cor_prompt(
    CorObj *In,
    int *Out,
    int Type,
    CorString Message,
    int Placement,
    int X,
    int Y
)
```

Headers

#include "$(WITHOME)/h/wDisplay.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wDisplay.lib

runTimeConst

Prompt the user for a constant

Description

The **runTimeConst** operator is used when the user needs to be prompted for a value during igraph execution. The input object triggers this operator to create a pop-up window which requires the user to enter a value (see **constant** operator for allowable types). When the **OK** button is clicked, an output object is produced with the value.

Parameter Information

label Type: CorString
Default: "Enter value"

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

C Prototype

```
CorOpRtn cor_runTimeConst(
    CorObj *Constant,
    CorString label,
    int Placement,
    int X,
    int Y
)
```

Headers

#include "$(WITHOME)/h/wDisplay.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wDisplay.lib

smallDisplay

Display object data in a pop-up window

Description

smallDisplay performs the same function as **display**. **smallDisplay** has a small icon which makes it more convenient to use in large igraphs.

See Also

display

Parameter Information

name Type: CorString
Default: "display"

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1, Max size: 2, Min size: 4

X Type: int
Default: 0

Y Type: int
Default: 0

MaxW Type: int
Default: 0

MaxH Type: int
Default: 0

MinW Type: int
Default: 0

MinH Type: int
Default: 0

Range Type: int
Default: 0
Values: Auto: 0, User: 1

RangeLow Type: float
Default: 0

RangeHigh Type: float
Default: 255

Equalize Type: int
Default: 2
Values: Actual: 0, User: 1, Max: 2

EqLow Type: float
Default: 0

EqHigh Type: float
Default: 255

XScale Type: float
Default: 1

YScale Type: float
Default: 1

Inspect Type: int
Default: 0
Values (bitwise OR): X-Profile: 1, Y-Profile: 2, Magnifier: 4

Track Type: int
Default: 0
Values: Mouse drags: 0, Mouse moves: 1

Colormap Type: int
Default: 0
Values: Grayscale: 0, Pseudo-color: 1, Shared: 2, Custom: 3

ColormapName Type: CorFile

Format Type: int
Default: 0
Values: Yes: 0, No: 1

FontFamily Type: CorString
Default: ""

Style Type: int
Default: 0
Values: Normal: 0, Italics: 1, Bold: 2, Bold-Italics: 3

Size Type: int
Default: 11

TextRed Type: int
Default: 0
Values: 0 — 255

TextGreen Type: int
Default: 0
Values: 0 — 255

TextBlue Type: int
Default: 0
Values: 0 — 255

BackRed Type: int
Default: 255
Values: 0 — 255

BackGreen Type: int
Default: 255
Values: 0 — 255

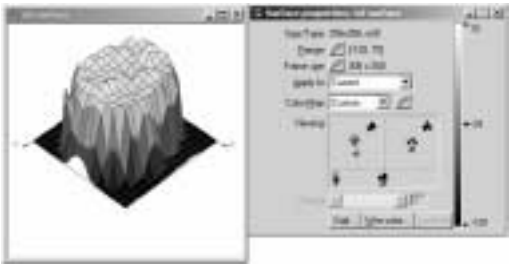
BackBlue Type: int
Default: 255
Values: 0 — 255

surface

Display 3D perspective view of image surface

Description

The **surface** operator generates a 3D surface view of an image or a vector of images. The Z coordinate value and the surface color (grayscale value) are determined from the pixel values of the input image. The output of the operator is a color image as displayed by the operator.



Properties:

Main panel:

name	Name to be used on the window title. When a new object reaches a **surface** operator, all existing data object windows are searched to look for a matching name. If an existing object window has the same name, then the new object is displayed in the existing window. This way you can track data changes without having too many windows. If no matching window name is found, a new window is popped-up.

Viewing sub-panel:

hAngle	The horizontal viewing angle. Refer to the chapter 'Three-Dimension Viewing Widgets' in the *Reference* manual for details.
vAngle	The vertical viewing angle. Refer to the chapter 'Three-Dimension Viewing Widgets' in the *Reference* manual for details.
zoom	The distance between the eye position and the focus position. Refer to the chapter 'Three-Dimension Viewing Widgets' in the *Reference* manual for details.
grid	The density of the grid squares, in pixels. Pixels are grouped into square tiles and pixels within the same tile are drawn with the average color of all the pixels in that tile. If this value is 0, the tile sizes will be calculated automatically. If this value is -1, the surface is not shown, only the wireframe is shown.
wireframe	The density of the wireframe, in pixels. A value of -1 means that the wireframe will have the same density of the surface tiles (**grid**). Otherwise, the grid can be denser than the wireframe, but not the other way. If the surface is not shown (**grid** is -1), then the wireframe edges will follow each pixel value.
wireColor	The color to be used for the wireframe. The value should be an RGB triplet. E.g. 255 0 0 means red.

Placement sub-panel:

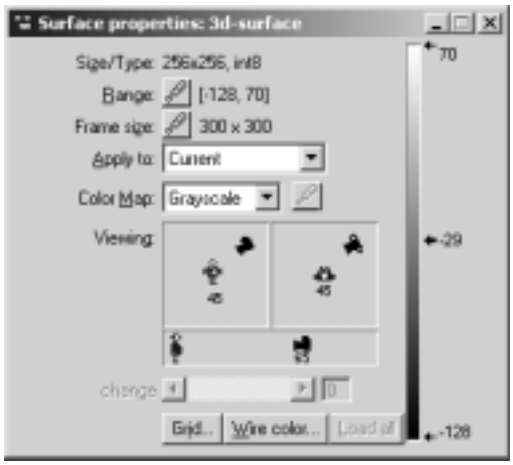
Placement	If **Fix position** is checked, the parameters **X** and **Y** are used to position the window. Otherwise, the current automatic window placement strategy is used to position the window.

X	The X (horizontal) position of the window on the screen, if **Placement** has **Fix position** checked.
Y	The Y (vertical) position of the window on the screen, if **Placement** has **Fix position** checked.
width	The width of the window used to display the surface plot.
height	The height of the window used to display the surface plot.

Image sub-panel:

Same as **Image** sub-panel for the **display** operator.

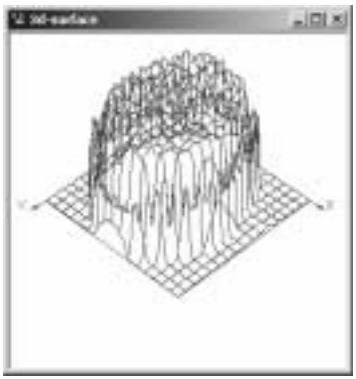
Property Panel



Size/Type	Original width and height of image, and the type of each pixel.
Range	Similar to the same control in the image property panel. See chapter 'Operators/Libraries' in *User's Manual* for details.
Frame size	Similar to the same control in the image property panel.
Apply to	Similar to the same control in the image property panel.
Color Map	Similar to the same control in the image property panel.
Viewing	Controls the viewpoint from which the surface is observed.
Image index	Similar to the same control in the image property panel.
Grid	Brings up the surface grid panel (see below) for adjusting the grid and wireframe used to render the surface.
Wire color...	Brings up a color panel for changing the color used to draw the wireframe and axis labels.
Load all	Similar to the same control in the image property panel.

Grid Panel

Scale	The magnification applied to the image intensity to compute the height of each point on the surface. A smaller magnification means the surface will appear flatter.
Pix/sq	Pixel per square. The 3-D surface is drawn as a rectangular mesh. Each rectangle (square) on the surface represents an area of one or more pixels in the image. A small **Pix/sq** gives you a fine and more accurate surface, but takes longer to render. So when you are adjusting your view angle, distance, etc., it is a good idea to first set **Pix/sq** to a large value, do the viewing adjustments, and then set **Pix/sq** to the value you want. **Pix/sq** behaves slightly differently on a color and a monochrome display. On a color display, no boundaries are

	drawn between the squares. Boundaries are drawn with the size specified by **Wireframe** (see below). If **Wireframe** is less than **Pix/sq**, no wireframe is drawn. On a monochrome display, boundaries are drawn between the **Pix/sq** squares, and the **Wireframe** is not drawn, *except* when **Pix/sq** is set to zero. When **Pix/sq** is zero, then for both color and monochrome displays, the 3-D surface will no longer appear solid. Instead, a wireframe is drawn at the size of **Wireframe**. The figure below shows such a view: 
Wireframe	Specifies the size of the visible grid overlaid on the 3-D surface. **Wireframe** behaves differently in color and monochrome displays. See **Pix/sq** above for details.

Parameter Information

name	Type: CorString Default: "3d-surface"
background	Type: int Default: 0 Values: No: 0, Yes: 1
hAngle	Type: float Default: 45
vAngle	Type: float Default: 45
zoom	Type: int Default: 65
scale	Type: float Default: 1
grid	Type: int Default: -1
wireframe	Type: int Default: -1
wireColor	Type: CorString Default: "255 0 0"
Placement	Type: int Default: 0 Values (bitwise OR): Fix position: 1
X	Type: int Default: 0
Y	Type: int Default: 0
width	Type: int Default: 500
height	Type: int Default: 500
Range	Type: int Default: 0 Values: Auto: 0, User: 1
RangeLow	Type: float Default: 0
RangeHigh	Type: float Default: 255
Equalize	Type: int Default: 0 Values: Auto: 0, User: 1
EqLow	Type: float Default: 0
EqHigh	Type: float Default: 255
Colormap	Type: int Default: 0 Values: Grayscale: 0, Pseudo-color: 1, Custom: 2
ColormapName	Type: CorFile

terrain

Display 3D terrain

Description

The **terrain** operator generates a 3D surface terrain image based on values in the two input images. The elevation (Z coordinate value) of the terrain is determined from the **elevation** input image. The surface color (grayscale value) is determined from the pixel values in the **image** input image. When the same image is applied to both inputs the operation of the **terrain** operator is identical to that of the **surface** operator.

Refer to the **surface** operator for details.

Parameter Information

name	Type: CorString Default: "terrain"
hAngle	Type: float Default: 45
vAngle	Type: float Default: 45
zoom	Type: int Default: 65
scale	Type: float Default: 1
grid	Type: int Default: -1
wireframe	Type: int Default: -1
wireColor	Type: CorString Default: "255 0 0"
Placement	Type: int Default: 0 Values (bitwise OR): Fix position: 1
X	Type: int Default: 0
Y	Type: int Default: 0
width	Type: int Default: 500
height	Type: int Default: 500
Range	Type: int Default: 0 Values: Auto: 0, User: 1
RangeLow	Type: float Default: 0
RangeHigh	Type: float Default: 255
Equalize	Type: int Default: 0 Values: Auto: 0, User: 1
EqLow	Type: float Default: 0
EqHigh	Type: float Default: 255
Colormap	Type: int Default: 0 Values: Grayscale: 0, Pseudo-color: 1, Custom: 2
ColormapName	Type: CorFile

volume

Display volume rendering of a vector of images

Description

The **volume** operator computes and displays a volume rendering of a vector of images in which each image represents a slice of a 3D volume. The color and opacity of rendered objects are determined from the pixel values, and can be changed interactively by the user. The user can also interactively control the viewpoint and a cut plane. Rendered images can be saved in the WiT image format.

The input must be a vector of 8-bit unsigned images, in which each image represents one slice of a volume. All images in the vector must be the same size. The **volume** operator assumes the volume sampling is equal in all three dimensions. If this is not the case the vector of images must be

preprocessed to equalize the sampling or the resulting rendered volume will be distorted.

The output of the operator is a color image as viewed by the operator. The current displayed image can be saved to disk as a WiT image at any time using the **Save** button on the image properties panel. Any number of images can be saved from each invocation of the **volume** operator by changing the name of the stored image for each save operation.

Properties:

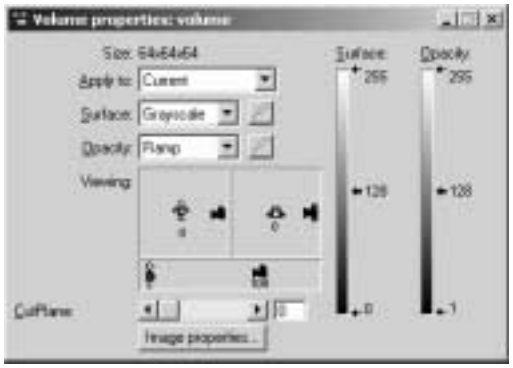
Main panel:

name	Name to be used on the window title. When a new object reaches a **volume** operator, all existing data object windows are searched to look for a matching name. If an existing object window has the same name, then the new object is displayed in the existing window. This way you can track data changes without having too many windows. If no matching window name is found, a new window is popped-up.

Placement sub-panel:

Placement	If **Fix position** is checked, the parameters **X** and **Y** are used to position the window. Otherwise, the current automatic window placement strategy is used to position the window. If **Max size** is checked, then the parameters **MaxW** and **MaxH** are used to limit the maximum size of the window. If the object requires a window larger than the maximum size, then scroll bars will appear.
X	The X (horizontal) position of the window on the screen, if **Placement** has **Fix position** checked.
Y	The Y (vertical) position of the window on the screen, if **Placement** has **Fix position** checked.
MaxW	The maximum width of the window, if **Placement** has **Max size** checked.
MaxH	The maximum height of the window, if **Placement** has **Max size** checked.

Property Panel



Size	The size of the volume data set, displayed as width x height x depth. Depth is the number of slices in the volume.
Apply to	Similar to the same control in the image property panel. See chapter 'Operators/Libraries' in *User's Manual* for details.
Surface	Controls the surface color of visible objects and the color of semi-transparent materials. If **White** is selected, all visible pixels are colored white. If **Grayscale** is selected, visible pixels are colored based on the pixel value. If **Pseudo** is selected, visible pixels are colored based on the pixel value, mapped to the standard pseudo-color colormap used in image displays. If **Custom** is selected, visible pixels are colored based on the pixel value, mapped to a custom colormap specified by the user. The surface map editor pops up

	automatically when the custom color mode is first selected or can be brought up to modify the existing custom map by clicking the button. The map editor will then come up. In all cases, surface color changes are applied to the rendered image and to the **Surface** ramp control. On the rendered image, surface colors are modified by lighting and shading to give the rendered image its 3D effect.
Opacity	Controls the visibility of pixels in the volume, based on pixel value. Opacity changes require that the entire volume be reclassified, so these changes may be slow for large volumes, depending on available memory and processor speed. If **Threshold** is selected, values below the threshold are transparent, values above the threshold are opaque. The threshold level is set using the lower level arrow on the **Opacity** ramp control. If **Ramp** is selected, pixel values between the upper and lower level arrows of the **Opacity** ramp control are semi-transparent, with opacity varying linearly from transparent at the lower level to opaque at the upper level. Values below the lower level arrow are transparent and values above the upper level arrow are opaque. If **Custom** is selected, you can define an arbitrary mapping of pixel values to opacity using the Map Editor. The opacity changes are not applied to the

Viewing	Controls the viewpoint from which the volume is observed. Refer to the chapter 'Three-Dimension Viewing Widgets' in the *Reference* manual for details.
Cutplane	Allows viewing the interior of a volume. The slider specifies the position of a plane perpendicular to one of the volume axes as a percent of the volume size in that direction. All pixels in front of the cut plane are transparent. The cut planes are limited to planes perpendicular to the current primary viewing axis, which may change depending on view point.
Image properties	Bring up the image properties panel. See chapter 'Operators/Libraries' in *User's Manual* for details.
Surface Ramp	The operation of the **Surface** ramp control is similar to the colormap ramp for images except that the color changes affect surface color before shading is applied, rather than affecting the rendered image colors directly.
Opacity Ramp	The **Opacity** ramp control

	arrows can be used to compress and shift the selected opacity map. Transparent values are represented by black, opaque by white and semi-transparent by gray.

Parameter Information

name Type: CorString
Default: "volume"

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1, Max size: 2

X Type: int
Default: 0

Y Type: int
Default: 0

MaxW Type: int
Default: 0

MaxH Type: int
Default: 0

Edges

The Edges library supports the extraction of edges and contours from images. The library includes operators that find point, line or circular edges based on image profiles and operators that extract contours from grayscale or binary images.

getCircularXEdges

Fits a circle to the edge points

Description

The **getCircularXEdges** operator finds edge points near a nominal circle or circular arc and fits a circle to the points. The operator's inputs are **In**, a grayscale image; and **NomCircle**, a circle or arc type Graphic or Geometry object. The operator searches for edges along a number of radial sample lines through the image that are defined by the **NomCircle** and the **numLines** parameter. The operator takes the best edge found on each radial sample line that meets the criteria specified in the operator's parameters and fits a circle to them using a least squares fit. The operator's outputs are **PtEdges**, a vector of point type edges containing the edge point found on each radial sample line; **CircleEdge**, an Edge object containing the best fit circle or arc; and **NFound**, the number of edge points found. The **CircleEdge** output will be a circle if the **NomCircle** input is a circle and an arc if **NomCircle** is an arc. The slope and level field values of the **CircleEdge** are the average of the corresponding edge point values. Positive slope values represent rising edges and negative slope values represent falling edges. For circles the direction field value is always zero, and for arcs the direction field value is the angle of the radial line to the center of the arc.

It should be noted that the operator will output a circle even when fewer than three edge points are found. If no edge points are found the operator outputs the nominal circle. If one or two edge points are found the operator outputs the nominal circle translated to include the edge point or points. These conditions can be detected by monitoring the **NFound** output value.

The radial sample lines are spaced evenly around the circle or over the length of the arc. The number of sample lines is specified by the **numLines** parameter. The length of the radial sample lines is specified by the **lineLength** parameter. The radiial sample lines are centered on the nominal circle if its radius is greater than half the sample line length, otherwise the lines extend from the nominal circle center out to the specified length. Image value sampling along the sample line is controlled by the **lineWidth** and **smoothing** parameters, as described for the **getXEdgesOnLine** operator. Edge selection is controlled by the **edgeType**, **slopeThresh**, **levelThresh**, and **subpixel** parameters. These parameters are also explained in the **getXEdgesOnLine** operator help. If the **edgeType** parameter is set to *unknown*, the operator will chose either all rising or all falling edges, based on which type has the greater average level change over all the sample lines.

Parameter Information

slopeThresh Type: float

levelThresh Type: float

edgeType Type: int
Default: 0
Values: rising: 0, falling: 1, unknown: 2

subpixel Type: int
Default: 0
Values: No: 0, Yes: 1

lineLength Type: float
Default: 20

numLines Type: int
Default: 12

lineWidth Type: int
Default: 1

smoothing Type: int
Default: 1

Demo iGraph

Operators\Edges\FindCircle

C Prototype

```
CorOpRtn cor_getCircularXEdges(
    CorImage *In,
    CorObj *NomCircle,
    CorEdgeVector *PtEdges,
    CorEdge **CircleEdge,
    int *NFound,
    float slopeThresh,
    float levelThresh,
    int edgeType,
    int subpixel,
    float lineLength,
    int numLines,
    int lineWidth,
    int smoothing)
```

Headers

#include "$(WITHOME)/h/wEdges.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wEdges.lib

getContours

Extract contours from a skeletonized binary image

Description

The **getContours** operator extracts contours represented by chains of pixels from a binary image. The operator's output is a vector of geometric polyline objects, in which each polyline represents a chain of contiguous (8 connected) nonzero valued pixels in the input image. No heuristics are used to ensure qualities other than connectedness in the chains.

The polylines produced by **getContours** can be processed by the **geom2lines** operator, which converts the polyline into straight line segments. These lines can be further processed with the **mergeLines** operator.

Demo iGraph

Operators\Edges\FindCircle

C Prototype

```
CorOpRtn cor_getContours(
    CorImage *In,
    CorGeomVector *Contours
)
```

Headers

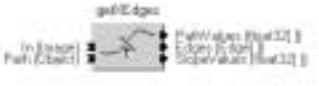
#include "$(WITHOME)/h/wEdges.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wEdges.lib

getXEdges

Find edges crossing a specified path in the image



Description

The **getXEdges** operator finds step or peak edges along a given path in image. The inputs to the operator are an integer or float image at the upper input port and graphic or geometric object, which specifies the path, at the **Path** input port. The path may be of any geometric type except text. The image is sampled at equally spaced intervals along the specified path. The **sampleSpacing** parameter controls the distance between samples and bilinear interpolation is used to obtain subpixel values for the samples (as in the **getPath** operator). The **smoothing** parameter allows a moving average filter to be applied to the sampled path values. The value of the parameter specifies the width of the filter in pixels.

The **Edges** output is a vector of edges that meet the criteria specified by the parameter settings. Each element of the edge vector is a structure containing a Geom object that locates the edge, a **direction** field that specifies the edge direction, **level** and **slope** fields that indicate the edge "strength", a **serial** number and a **label**. The **edgeType** parameter can be set to detect *rising*, *falling* or *rising or falling* step edges or positive *peak* edges. The way in which the **location**, **level** and **slope** values are calculated depends on the type of edge.

The Geom element that locates the edge is an Fpoint that gives the location in pixel coordinates of the point where the edge crosses the path. Edge crossing points between the sample point positions are located by linear interpolation. For step edges the edge location can be chosen to be either the edge's half value point or the point of maximum slope by setting the **edgeLocation** parameter. When this parameter is set to *HalfValue* the start and end of the edge are defined by where the slope crosses the slope threshold. The edge location is set to the point at half value between the two threshold crossings. When the **edgeLocation** parameter is set to *MaxSlope* the edge is located at the point of maximum slope and the start and end of the edge are the points on the path on either side of this point where the slope crosses zero or changes direction (from increasing to decreasing or decreasing to increasing), whichever is nearer. In both cases the slope value is set to the maximum slope over the edge and the level value is the absolute value of thelevel change between the start and edge of the end. For peak edges the edge location is the zero crossing of the path slope.

The edge **direction** is parallel to the path at the crossing point, in the direction of the path for rising step or peak edges, in the opposite direction for falling step edges. The slope value assigned to peak edges is the slope of the path slope (approximating the second derivative in the path direction) where the path slope crosses zero. The level is the image value on the path at the zero crossing point.

Two threshold values may be used to extract edges, based on the slope and the level of the edge. The criterion used for each of the thresholds depends on whether the edges are step edges or peak edges. For step edges the slope criterion is the slope of the edge and the level is the step change in value over the edge. For peak edges the slope criterion is the sharpness of the peak and the level criterion is the actual value at the peak. The threshold values are set using the **slopeThresh** and **levelThresh** parameters. Each threshold value can be either *relative* or *absolute*, as specified by the **slopeType** and **levelType** parameters. Relative thresholds are specified as a percentage of the maximum value of the corresponding quantity found on the path, while absolute thresholds are based on the actual value of the quantity.

The operator also produces vectors containing the sampled path values and the smooothed slope values along the path. These vectors can be displayed using the **graph** operator. They can be helpful when determining settings for the thresholds and other parameters of the operator.

Parameter Information

edgeType	Type: int Default: 2 Values: rising: 0, falling: 1, rising or falling: 2, peak: 3
edgeLocation	Type: int Default: 0 Values: HalfLevel: 0, MaxSlope: 1

slopeType Type: int
Default: 0
Values: relative: 0, absolute: 1

slopeThresh Type: float
Default: 20

levelType Type: int
Default: 0
Values: relative: 0, absolute: 1

levelThresh Type: float
Default: 50

sampleSpacing Type: float
Default: 1

smoothing Type: int
Default: 1

Demo iGraph

Operators\Edges\EdgesOnCircle

C Prototype

```
CorOpRtn cor_getXEdges(
    CorImage *In,
    CorObj *Path,
    CorEdgeVector *Edges,
    CorFloatVector *PathValues,
    CorFloatVector *SlopeValues,
    int edgeType,
    int edgeLocation,
    int slopeType,
    float slopeThresh,
    int levelType,
    float levelThresh,
    float sampleSpacing,
    int smoothing)
```

Headers

#include "$(WITHOME)/h/wEdges.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wEdges.lib

getXEdgesInPoly

Find a edge in a polygon

Description

The **getXEdgesInPoly** operator finds edge points in a polygon and fits a line to the points to find the best edge crossing the polygon. The operator's inputs are **In**, a grayscale image and **Polygon**, a polygon type Graphic or Geometry object. The operator searches for edges along a number of sample lines through the image that are defined by the input polygon and the **numLines** parameter. The operator takes the best edge found on each sample line that meets the criteria specified in the operator's parameters and fits an edge line to them using a least squares fit. The operator's outputs are **PtEdges**, a vector of point type edges containing the edge points found on each sample line; **LineEdge**, a line type edge object containing the best fit line; and **NFound**, the number of edge points found. The slope and level field values of the **LineEdge** are the average of the corresponding edge point values. The direction field value is the angle the perpendicular to the line edge pointing in the direction of the rising edge.

It should be noted that the operator will output a line even when fewer than two edge points are found. If no edge points are found the operator outputs the first edge of the input polygon. If one edge point is found the operator outputs a line parallel to the first edge of the polygon that goes through the single edge point. These conditions can be detected by monitoring the **NFound** output value.

The input polygon should be a quadrilateral or triangle. The starting end-points of the sample lines are equally spaced along the first edge of the polygon. If the polygon is a triangle the third vertex point is the second end-point for all of the sample lines. If the the polygon has four (or more) sides the sample lines' second endpoints are equally spaced along the third edge of the polygon. The number of sample lines is specified by the **numLines** parameter. Image value sampling along the sample line is controlled by the **lineWidth** and **smoothing** parameters, as described for the **getXEdgesOnLine** operator. Edge selection is controlled by the **edgeType**, **slopeThresh**, **levelThresh**, and

subpixel parameters. These parameters are also explained in the **getXEdgesOnLine** operator help. If the **edgeType** parameter is set to *unknown*, the operator will chose either all rising or all falling edges, based on which type has the greater average level change over all the sample lines. The **LineEdge** slope value is positive if the edge is a rising edge and negative if the edge is a falling edge.

Parameter Information

slopeThresh Type: float

levelThresh Type: float

edgeType Type: int
Default: 0
Values: rising: 0, falling: 1, unknown: 2

subpixel Type: int
Default: 0
Values: No: 0, Yes: 1

numLines Type: int
Default: 3

lineWidth Type: int
Default: 1

smoothing Type: int
Default: 1

Demo iGraph

Operators\Edges\XEdgesInPoly

C Prototype

```
CorOpRtn cor_getXEdgesInPoly(
    CorImage *In,
    CorObj *Polygon,
    CorEdgeVector *PtEdges,
    CorEdge **LineEdge,
    int *NFound,
    float slopeThresh,
    float levelThresh,
    int edgeType,
    int subpixel,
    int numLines,
    int lineWidth,
    int smoothing)
```

Headers

#include "$(WITHOME)/h/wEdges.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wEdges.lib

getXEdgesOnLine

Find edges crossing a specified line in the image

Description

The **getXEdgesOnLine** operator finds step edges crossing a given line in an image. The inputs to the operator are an integer or float image at the upper input port and line type graphic object at the **Line** input port.

The operator produces a vector of Edge objects that meet the criteria specified by the operator's parameter values. Edges are located at local slope maxima or minima with an absolute value greater than the **slopeThresh** parameter value and with an associated pixel value level change that is greater than the **levelThresh** parameter value. Each Edge object's *slope* field contains the maximum (positive) slope value for rising edges and the minimum (negative) slope value for falling edges. The *level* contains the level change associated with the slope, measured from the nearest slope zero crossing or local minimum on either side of the slope maximum. The *direction* field contains the direction of the line.

The operator also produces vectors containing the sampled path values and the slope values along the path. These vectors can be displayed using the **graph** operator. They can be helpful when determining settings for the thresholds and other parameters of the operator.

The **edgeType** parameter determines if the operator looks for rising edge, falling edges, or both. The **subpixel** parameter can be used to specify the use of interpolation along the sample line to obtain a sub-pixel estimate of the edge location.

Values are extracted from the input image at one pixel intervals along the specified line. The **lineWidth** parameter determines how many pixels on either side of the line are used to calculate these values. The pixel values are weighted by a linear decreasing function of their distance from the line. The **lineWidth** parameter value is the half value width of the linear weighting function. A **lineWidth** value of *0* gives nearest neighbour sampling and a value of *1* gives linear interpolation using the pixels nearest the line. The **smoothing** parameter allows a moving average filter to be applied to the sampled path values. The value of the parameter specifies the width of the filter in pixels.

Parameter Information

edgeType	Type: int Default: 0 Values: rising: 0, falling: 1, rising or falling: 2
slopeThresh	Type: float
levelThresh	Type: float
subpixel	Type: int Default: 1 Values: No: 0, Yes: 1
lineWidth	Type: int Default: 1
smoothing	Type: int Default: 1

Demo iGraph

Operators\Edges\XEdgesOnLine

C Prototype

```
CorOpRtn cor_getXEdgesOnLine(
    CorImage *In,
    CorGraphic *Line,
    CorEdgeVector *Edges,
    CorFloatVector *PathValues,
    CorFloatVector *SlopeValues,
    int edgeType,
    float slopeThresh,
    float levelThresh,
    int subpixel,
    int lineWidth,
    int smoothing)
```

Headers

#include "$(WITHOME)/h/wEdges.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wEdges.lib

traceEdges

Traces edges on the grayscale images

Description

The **traceEdges** operator traces edges on the image. Edges represented by chains of connected edge pixels from a grayscale image. The operator's output is a vector of geometric polyline objects, in which each polyline represents a chain of contiguous (8 connected) edge pixels in the input image. The inputs of the operator is a grayscale image.

Parameter **thresh** defines minimum magnitude value for the edge to be traced. **minLength** is the minimum length of the continuous edge segment. **maxMemSize** is the maximum size in bytes occupied by vector of geometric polyline objects. If 0, memory is unlimited.

Parameter Information

type	Type: int Default: 0 Values: prewitt: 0, sobel: 1
threshold	Type: float
minLength	Type: int
mode	Type: int Default: 0 Values: arbitrary: 0, straight: 1
maxMemSize	Type: int

Demo iGraph

Operators\Edges\XEdgesOnLine

C Prototype

```
CorOpRtn cor_traceEdges(
    CorImage *EdgeImage,
    CorGeomVector *Edges,
    int *Truncated,
    int type,
    float threshold,
    int minLength,
    int mode,
    int maxMemSize
)
```

Headers

#include "$(WITHOME)/h/wEdges.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wEdges.lib

Filter

The Filter library supports convolution filtering of images. The library includes general convolution operators as well as optimized special cases of the convolution filters and operators which produce images derived from convolved images.

compass

8-point directional edge enhancement

Description

The **compass** operator enhances edges in the input image perpendicular to one of eight directions. Edge enhancement is often a preliminary step to edge finding and segmentation procedures.

The operator applies a first-order derivative-based filter to the input image. The orientation of the derivative is specified by the **direction** parameter and can be set to one of the eight compass points: *N, NE, E, SE, S, SW, W,* or *NW,* where *N* is north or up in the image (negative *y* direction) and *E* is east or right (positive *x* direction) and so on. The compass direction selects filter weights such that the magnitude of the values in the output image will be largest for edges perpendicular to the compass direction and will fall to zero for edges parallel to the direction. Rising edges produce positive values and falling edges produce negative values.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

The operator accepts integer, float type input images and color images in the case **optimization** paramiter is **speed**. An unsigned integer input image produces a signed integer output image with the same number of bits as the input image. In all other cases, the output image is the same type as the input image. The output is scaled so that for integer images a full scale step edge in the specified direction will produce a line in the output image with the maximum image value.

Parameter Information

direction Type: int
Default: 0
Values: N: 0, NW: 1, W: 2, SW: 3, S: 4, SE: 5, E: 6, NE: 7

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filters\compass.igr

C Prototype

```
CorOpRtn cor_compass(
    CorImage *In,
    CorImage *Out,
    int direction,
    int optimization
```

```
)
CorOpRtn cor_compass_consume(
    CorImage *In,
    int direction,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

conv1d

General one-dimensional image convolution

Description

The **conv1d** operator applies one-dimensional convolution by a user specified kernel to each row of the input image. With an appropriate choice of kernel values, the **conv1d** operator can perform such operations as smoothing, edge or peak enhancement, position shifting on a row by row basis.

The one-dimensional convolution kernel is an integer vector specified by the **kernel** parameter. The kernel size and weight values can be changed with the array editor by clicking on the modify button for the **kernel** parameter. The entire vector is used as a one dimensional convolution kernel, regardless of the number of rows specified in the array. The convolution operator functions with odd or even kernel sizes. The user may specify a factor, using the **scale** parameter, by which all values in the convolved image will be divided. This allows the specification of normalized filters.

The operator will accept integer and floating point input images. The output image is the same type as the input image, except when filters with negative weights are applied to unsigned integer images (8 or 16-bit). In this case, the output image type will be a signed integer with the same number of bits as the input image type. This may result in truncation of out of range values. If truncation occurs, relative image values can be maintained by increasing the value of the **scale** parameter or, if the absolute image values are important, the input image can be cast to a higher precision type (16-bit for 8-bit images, float for 16-bit images).

Parameter Information

kernel Type: CorVector
Default: [1, 1, 1]

scale Type: int
Default: 3

Demo iGraph

Operators\Filters\conv1d.igr

C Prototype

```
CorOpRtn cor_conv1d(
    CorImage *In,
    CorImage *Out,
    CorIntVector *kernel,
    int scale
)
CorOpRtn cor_conv1d_consume(
    CorImage *In,
    CorIntVector *kernel,
    int scale
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

conv2d

General two-dimensional convolution

Description

The **conv2d** operator applies two-dimensional convolution by a user specified kernel to the input image. With an appropriate choice of kernel values, the **conv2d** operator can perform such operations as smoothing, edge or peak enhancement, position shifting on the image.

The two dimensional convolution kernel is an integer array specified by the **kernel** parameter. The kernel size and weight values can be changed with the array editor by clicking on the modify button for the **kernel** parameter. The convolution operator functions with odd or even kernel sizes. The user may specify a factor, using the **scale** parameter, by which all values in the convolved image will be divided. This allows the specification of normalized filters of the type used in the **gauss** operator.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

The operator will accept integer, floating point input images and color images in the case **optimisation** parameter value is **speed**. The output image is the same type as the input image, except when filters with negative weights are applied to unsigned integer images (8 or 16-bit). In this case, the output image type will be a signed integer with the same number of bits as the input image type. This may result in truncation of out of range values. If truncation occurs, relative image values can be maintained by increasing the value of the **scale** parameter or, if the absolute image values are important, the input image can be cast to a higher precision type (16-bit for 8-bit images, float for 16-bit images).

Parameter Information

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

scale Type: int
Default: 9

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filters\conv2d.igr

C Prototype

```
CorOpRtn cor_conv2d(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel,
    int scale,
    int optimization
)
CorOpRtn cor_conv2d_consume(
    CorImage *In,
    CorIntImage *kernel,
    int scale,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

edgeDetect

Create a binary or gray scale edge image

Description

The **edgeDetect** operator finds edges in images by detecting areas of high slope using Prewitt or Sobel gradient type operations. The **output** parameter can be used to select either a grayscale output image, in which the output image represents an approximation to the gradient magnitude, or a binary output image, in which case the **threshold** is applied to the gradient magnitude image to extract edges.

The **edgeDetect** operator uses the maximum of eight directional derivatives, calculated using either

Prewitt or Sobel kernels as specified by the **type** parameter, to approximate the gradient magnitude. This approach is somewhat faster than the method used to produce the magnitude output of the **grad** operator.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Parameter Information

type Type: int
Default: 0
Values: Prewitt: 0, Sobel: 1

output Type: int
Default: 0
Values: Binary: 0, Gray Level: 1

threshold Type: float
Default: 0

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filters\conv2d.igr

C Prototype

```
CorOpRtn cor_edgeDetect(
    CorImage *In,
    CorImage *Out,
    int type,
    int output,
    float threshold,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

edgeDirection

Gradient magnitude and direction filter

Description

The **edgeDirection** operator finds edges in images by detecting areas of high slope using Prewitt or Sobel gradient type operations. Then the edges are shrinked in the perpendicular direction. The operator produces two output images, representing the magnitude and direction of the edges vectors at each pixel. The magnitude output image is 8-bit unsigned integer image for magnitude and 8-bit signed image for orientation if **degrees** paramiter is 256 and float image if it is 360. The top output is the magnitude image and the bottom output is the orientation. The direction is in the conventional units in the range -128 to 127 or in degrees range from -180.0 to 180.0. The **output** parameter can be used to select either a grayscale output image, in which the output image represents a gradient magnitude, or a binary output image. All the edges below **threshold** are not included.

Parameter Information

type Type: int
Default: 0
Values: Prewitt: 0, Sobel: 1, Roof: 2

output Type: int
Default: 0
Values: Binary: 0, Gray Level: 1

threshold Type: float
Default: 0

degrees Type: int
Default: 0
Values: 360: 0, 256: 1

Demo iGraph

Operators\Filters\conv2d.igr

C Prototype

```
CorOpRtn cor_edgeDirection(
    CorImage *In,
```

```
    CorImage *magnitude,
    CorImage *orientation,
    int type,
    int output,
    float threshold,
    int degrees
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

entropy

Compute local pixel value entropy

Description

The **entropy** operator produces an image made up of the entropy of the input image pixel values in a specified neighbourhood around each image pixel. The entropy is calculated by summing the product -p(i) * ln(p(i)) over all pixel values i, where p(i) is the fraction of pixels in the neighbourhood with value i. The operator accepts a gray-scale integer or float image input and produces a float image as output.

The size of the neighbourhood over which the entropy is calculated is specified by the **width** and **height** parameters.

Parameter Information

width Type: int
Default: 5

height Type: int
Default: 5

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\VarianceTexture

C Prototype

```
CorOpRtn cor_entropy(
    CorImage *In,
    CorImage *Out,
    int width,
    int height
)
```

Headers

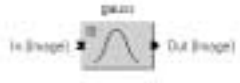
#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

gauss

Two-dimensional gaussian smoothing



Description

The **gauss** operator performs a two-dimensional smoothing of the input image using a discrete approximation to a gaussian kernel. The effect of the smoothing operation is to blur the image, reducing the sharpness of edges and fine detail in the image and reducing the effects of high frequency noise. An analytic gaussian filter more closely approximates a perfect low pass filter than the moving average filter used in the **lopass2d** operator, while avoiding the ringing artifacts associated with the perfect low pass filter.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Four different discrete approximations to gaussian filters are provided. A filter of size 2x2, 3x3, 5x5 or 7x7 may be selected using the **filterSize** parameter. Use of the **gauss** operator is equivalent to using **conv2d** with the following filters and scale parameters:

```
Type 2x2: Scale=4
   1   1
   1   1

Type 3x3: Scale=16
   1   2   1
   2   4   2
   1   2   1

Type 5x5: Scale=256
   1   4   6   4   1
   4  16  24  16   4
   6  24  36  24   6
   4  16  24  16   4
   1   4   6   4   1

Type 7x7: Scale=2048
   0   5  13  16  13   5   0
   5  25  52  64  52  25   5
  13  52 102 126 102  52  13
  16  64 126 156 126  64  16
  13  52 102 126 102  52  13
   5  25  52  64  52  25   5
   0   5  13  16  13   5   0
```

The operator accepts integer and float type input images and color images in the case **optimisation** parameter value is **speed**. The output image is the same type as the input image.

Parameter Information

filterSize Type: int
Default: 0
Values: 2x2: 0, 3x3: 1, 5x5: 2, 7x7: 3

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\VarianceTexture

C Prototype

```
CorOpRtn cor_gauss(
    CorImage *In,
    CorImage *Out,
    int filterSize,
    int optimization
)
CorOpRtn cor_gauss_consume(
    CorImage *In,
    int filterSize,
    int optimization
)
```

Headers

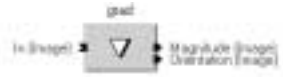
#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

grad

Gradient magnitude and direction filter



Description

The **grad** operator computes an approximation to the gradient of the input image. The gradient kernel is selected by the **type** parameter to use either Sobel or Prewitt filter weights. The operator accepts integer or float input images. The operator produces two output images, representing the magnitude and direction of the gradient vectors at each pixel. The direction is in degrees, in the range -180 to 180 in the case **degrees** is 360 or in special units in the range -128 to 127 if **degrees** is 256. The magnitude output is the same type as imput image type and orientation is float if parameter **degrees** is 360 and 8-bit integer otherwise. The top output is the magnitude image and the bottom output is the direction image of the gradient vectors.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results. In the case

speed is selected operator supports only 8-bit integer input images.

The **grad** operator is often used for edge enhancement, with the magnitude related to the slope of the edge and the direction related to its orientation. A faster approximation to the magnitude of the gradient can be obtained using the **edgeDetect** operator.

Parameter Information

type Type: int
Default: 0
Values: Prewitt: 0, Sobel: 1

degrees Type: int
Default: 0
Values: 360: 0, 256: 1

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filters\grad.igr

C Prototype

```
CorOpRtn cor_grad(
    CorImage *In,
    CorImage *Magnitude,
    CorImage *Orientation,
    int type,
    int degrees,
    int optimization
)
```

Headers

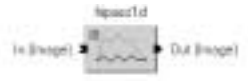
#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

hipass1d

One-dimensional high frequency enhancing filter



Description

The **hipass1d** operator applies one-dimensional high-pass filtering or sharpening in the *x* direction to the input image. The effect of the operator is to enhance local contrast along each row in the image and to suppress slow changing values in each row. One-dimensional high-pass filtering is faster than two-dimensional high-pass filtering. Also,since the filtering is only performed along the *x* axis, original image information along the *x* axis is preserved.

First, a smoothed image is calculated over the image as described for the **lopass1d** operator. The smoothed image is then subtracted from the original image to give the high pass filtered image. The size of the kernel used for the smoothing is specified by the **width** parameter. Increasing the kernel size lowers the cut-off frequency of the filter and decreases local contrast enhancement.

The operator accepts integer and float type input images. An unsigned integer input image produces a signed integer output image with the same number of bits as the input image. In all other cases, the output image is the same type as the input image.

Parameter Information

width Type: int
Default: 3

Demo iGraph

Operators\Segmentation\ZeroCrossing

C Prototype

```
CorOpRtn cor_hipass1d(
    CorImage *In,
    CorImage *Out,
    int width
)
CorOpRtn cor_hipass1d_consume(
    CorImage *In,
    int width
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

hipass2d

Two-dimensional high frequency enhancing filter

Description

The **hipass2d** operator applies high-pass filtering or sharpening to the input image to enhance local contrast and suppress slow changing values. This technique is helpful in enhancing image detail and edges and in eliminating gradually changing global effects such as lighting variations from camera images.

First, a smoothed image is calculated over the image as described for the **lopass1d** operator. The smoothed image is then subtracted from the original image to give the high pass filtered image. The size of the kernel is specified by the **width** and **height** parameters. Increasing the kernel size lowers the cut-off frequency of the filter and decreases local contrast enhancement.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

The operator accepts integer and float type input images and color images in the case **optimisation** is **speed**. An unsigned integer input image produces a signed integer output image with the same number of bits as the input image. In all other cases, the output image is the same type as the input image.

Parameter Information

width Type: int
Default: 3

height Type: int
Default: 3

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_hipass2d(
    CorImage *In,
    CorImage *Out,
    int width,
    int height,
    int optimization
)
CorOpRtn cor_hipass2d_consume(
    CorImage *In,
    int width,
    int height,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

laplace

Laplacian 2nd-order edge enhancement

Description

The **laplace** operator enhances changes in local contrast by applying a filter that approximates a

laplacian second derivative operation to the image. The filter subtracts an average of neighbouring pixels from each pixel in the image emphasizing points, lines and edges and suppressing values in regions of constant gradient.

Three types of laplacian filter, corresponding to different methods of averaging the neighbouring pixels, are selected using the are determined using the **type** parameter. The filter weights for each type are:

```
Type 0:          0  -1   0
                -1   4  -1
                 0  -1   0

Type 1:         -1  -1  -1
                -1   8  -1
                -1  -1  -1

Type 2:          1  -2   1
                -2   4  -2
                 1  -2   1
```

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

The operator accepts integer and float type input images and color images in the case **optimisation** parameter value is **speed**. An unsigned integer input image produces a signed integer output image with the same number of bits as the input image. In all other cases, the output image is the same type as the input image.

Parameter Information

type Type: int
Default: 0
Values: 0: 0, 1: 1, 2: 2

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_laplace(
    CorImage *In,
    CorImage *Out,
    int type,
    int optimization
)
CorOpRtn cor_laplace_consume(
    CorImage *In,
    int type,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

line

Directional line enhancement

Description

The **line** operator enhances lines with a specific orientation in the image. The lines may be ridges, a line of pixels higher than the surrounding pixels, with the resulting enhanced line positive or troughs, a line of pixels lower than the surrounding pixels, with the resulting enhanced line negative. The magnitude of the enhanced line depends on the orientation of the line relative to the specified orientation and the difference between the pixels on the line and the adjacent pixels.

The line orientation is specified as one of *E-W*, *NE-SW*, *N-S*, or *NW-SE* with the **direction** parameter. A second derivative filter is applied to the image to detect changes in the image gradient in the direction perpendicular to the orientation. The magnitude of the resulting image is greatest for pixels which are part of lines with the specified orientation and falls to zero for pixels that are not part of a line or are

part of a line perpendicular to the orientation. The operator responds most strongly to ridge (or trough) type lines but also enhances step edges.

The operator accepts integer and float type input images. An unsigned integer input image produces a signed integer output image with the same number of bits as the input image. In all other cases, the output image is the same type as the input image. The output is scaled so that for integer images a full scale difference between a line in the specified orientation and its surrounding pixels will produce a line in the output image with the maximum image value.

Parameter Information

dir Type: int
Default: 0
Values: E-W: 0, NE-SW: 1, N-S: 2, NW-SE: 3

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_line(
    CorImage *In,
    CorImage *Out,
    int dir,
    int optimization
)
CorOpRtn cor_line_consume(
    CorImage *In,
    int dir,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

lopass1d

One-dimensional image smoothing

Description

The **lopass1d** operator applies one-dimensional low-pass filtering (smoothing) to each row of the input image. The effect of the smoothing operation is to blur the image in the *x* direction, reducing the sharpness of vertical edges and fine detail in the image in the *x* direction and reducing the effects of high frequency noise. One-dimensional low-pass filtering is faster than two-dimensional low-pass filtering. Also, since the filtering is only performed along the X-axis, original image information along the Y-axis is preserved.

The smoothing operation is performed with one-dimensional a moving average kernel of a size in pixels specified by the **width** parameter. The effect of **lopass1d** is equivalent to that of the **lopass2d** with a **height** of 1.

The operator accepts integer and float type input images. The output image is the same type as the input image.

Parameter Information

width Type: int
Default: 3

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_lopass1d(
    CorImage *In,
    CorImage *Out,
    int width
)
CorOpRtn cor_lopass1d_consume(
    CorImage *In,
    int width
```

)

Headers

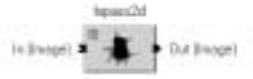
#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

lopass2d

Two-dimensional smoothing



Description

The **lopass2d** operator applies two-dimensional low-pass filtering (smoothing) to the input image. The effect of the smoothing operation is to blur the image, reducing the sharpness of edges and fine detail in the image and reducing the effects of high frequency noise. Both of these effects may be useful before segmentation or feature recognition is performed.

The smoothing operation is performed with a moving average kernel of a size in pixels specified by the **width** and **height** parameters. The effect of **lopass2d** is equivalent to that of the **conv2d** operator with kernel size **height** by **width**, all kernel values equal to 1, and a scale factor equal to the number of elements in the kernel array, but the simple kernel structure allows a more efficient implementation.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

The operator accepts integer and float type input images and color images in the case **optimisation** is **speed**. The output image is the same type as the input image.

Parameter Information

width Type: int
Default: 3

height Type: int
Default: 3

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_lopass2d(
    CorImage *In,
    CorImage *Out,
    int width,
    int height,
    int optimization
)
CorOpRtn cor_lopass2d_consume(
    CorImage *In,
    int width,
    int height,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

prewitt

Prewitt edge enhancement

Description

The **prewitt** operator performs a convolution of the input image with Prewitt horizontal or vertical

kernels. The effect of the Prewitt operation is to enhance the horizontal or vertical edges of the image.

Two different filters are provided. A horizontal or vertical edges enhancement filter may be selected using the **direction** parameter. Use of the **prewitt** operator is equivalent to using **conv2d** with the following filters and scale parameters:

```
Type horizontal:
Scale=6
                1   1   1
                0   0   0
               -1  -1  -1
Type vertical:
Scale=6
                1   0  -1
                1   0  -1
                1   0  -1
```

optimisation paramiter defines wether fast or precise version will run. The operator accepts integer and float type input images for precise and integer type for fast executin. The output image type is the signed version of the input image type.

Parameter Information

direction Type: int
Default: 0
Values: horizontal: 0, vertical: 1

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_prewitt(
    CorImage *In,
    CorImage *Out,
    int direction,
    int optimization
)
CorOpRtn cor_prewitt_consume(
    CorImage *In,
    int direction,
    int optimization
)
```


Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

refineEdges

Finds edges on the image

Description

The **refineEdges** operator finds edges in images by detecting areas of high slope using Prewitt or Sobel gradient type operations. Parameter **threshold** is applied to the image to eliminate weak edges. The **refineEdges** operator uses derivatives, calculated using either Prewitt or Sobel kernels as specified by the **type** parameter, to approximate the gradient magnitude. Only the maximum value of the gradient in the vertical or horisontal direction is left.

Parameter Information

type Type: int
Default: 0
Values: Prewitt: 0, Sobel: 1

threshold Type: float

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_refineEdges(
    CorImage *In,
    CorImage *Out,
    int type,
    float threshold
)
```

Headers

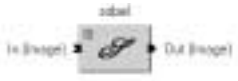
#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

sobel

Sobel edge enhancement



Description

The **sobel** operator enhances the horizontal or vertical edges of the image by performing a convolution of the input image with a Sobel horizontal or vertical kernel. The **direction** parameter selects between the *horizontal* or *vertical* kernel types. These kernel types are equivalent to using **conv2d** with the following kernel values and a scale of 8:

Horizontal	Vertical
1 2 1 0 0 0 -1 -2 -1	1 0 -1 2 0 -2 1 0 -1

The **optimization** parameter defines whether the *fast* or *precise* algorithm will be used. The operator accepts integer and float type input images if **optimization** is *precise*. Only integer input images are supported for *fast*. The output image type is the signed version of the input image type.

Parameter Information

direction Type: int
Default: 0
Values: horizontal: 0, vertical: 1

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_sobel(
    CorImage *In,
    CorImage *Out,
    int direction,
    int optimization
)
CorOpRtn cor_sobel_consume(
    CorImage *In,
    int direction,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

thinEdges

Reduces the width of the thick edges in grayscale images

Description

The **thinEdges** operator reduces the width of the thick edges in images, processed by **grad**, **edgeDirection** or **edgeDetect** operators. Parameter **threshold** is applied to the image to eliminate weak edges.

Parameter Information

threshold Type: float

Demo iGraph

Operators\Filter\Entropy
Operators\Filter\Variance

C Prototype

```
CorOpRtn cor_thinEdges(
    CorImage *Edges,
    CorImage *ThinEdges,
    float threshold
)
CorOpRtn cor_thinEdges_consume(
    CorImage *Edges,
    float threshold
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

variance

Compute local image variance

Description

The **variance** operator calculates the mean and the variance or standard deviation of the image pixel values in a specified neighbourhood around each image pixel. The operator accepts a gray-scale integer or float image input and produces float images as output.

The **output** parameter is used to specify whether the operator produces the variance or standard deviation image as output. The size of the neighbourhood over which the variance is calculated is specified using the **width** and **height** parameters.

Parameter Information

output Type: int
Default: 0
Values: variance: 0, std dev: 1

width Type: int
Default: 5

height Type: int
Default: 5

Demo iGraph

Operators\Filter\Variance
Operators\Filter\VarianceTexture

C Prototype

```
CorOpRtn cor_variance(
    CorImage *In,
    CorImage *Mean,
    CorImage *Var,
    int output,
    int width,
    int height
)
```

Headers

#include "$(WITHOME)/h/wFilter.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFilter.lib

Find

The Find library provides operators that search images for pixel value peaks or pixel patterns. The library includes template matching operators, operators that search for peaks in an image and image to image correlation operators.

getMatch

Directed search for image maxima or minima

Description

The **getMatch** operator performs directed search for values that exceed a specified threshold. The operator searches specified ROIs in the target for pixels which are greater (or less) than a threshold value. The output is a vector of graphic objects that specify locations of such pixels.

The operator requires two inputs: the top input is an integer or float image and the bottom input is a graphic object or vector of graphic objects that controls the search strategy. The operator searches the pixels included in the graphic objects specified by the input. In addition, point graphic objects initiate a spiral search starting at the point and extending out to the number of pixels specified by the **searchRange** parameter. These pixels are compared to the value specified in the **threshold** parameter to find those pixels which are greater than the threshold, if **find** is set to *maxima* or less than the threshold if **find** is set to *minima*. The operator selects from among the pixels exceeding the threshold based on the other parameters, as described below. The selected points are output as a vector of graphic point objects.

The **numToMatch** applies a limit to the number of outputs collected. If more than **numToMatch** matches are found, the **selectMatches** parameter determines if the first matches found or the best matches found are reported. If the first matches are specified the operator stops searching when **numToMatch** values above the threshold are found. If the best matches are required, the entire set of pixels specified by the input graphic object (and the **searchRange** parameter in the case of points) is searched.

The **vicinity** parameter is used to compare matched objects with similar position. If a new match is found which is within **vicinity** pixels in *x* and *y* of a previously found match point, then only the better of the match points is recorded.

Parameter Information

numToMatch Type: int
Default: 5

selectMatches Type: int
Default: 0
Values: First: 0, Best: 1

vicinity Type: int
Default: 5

searchRange Type: int
Default: 5

threshold Type: float
Default: 0.5

find Type: int
Default: 0
Values: maxima: 0, minima: 1

color Type: int
Default: 0
Values: default: 0, select: 1

red Type: int
Default: 255
Values: 0 — 255

green Type: int
Default: 0
Values: 0 — 255

blue Type: int
Default: 0
Values: 0 — 255

Demo iGraph

Operators\Find\NXCorr
Operators\Find\SoD
Operators\Find\XCorr

C Prototype

```
CorOpRtn cor_getMatch(
    CorImage *In,
    CorObj *ROI,
    CorGraphicVector *Positions,
    int numToMatch,
    int selectMatches,
    int vicinity,
    int searchRange,
    float threshold,
    int find,
    int color,
    int red,
    int green,
    int blue)
```

Headers

#include "$(WITHOME)/h/wFind.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

getPeaks

Find local maxima or minima

Description

The **getPeaks** operator finds local maxima or minima in a grayscale image. For this operator, a local maximum (minimum) is defined as a single pixel that whose value is greater (less) than the values of the eight connected pixels or a group of up to four pixels in a 2x2 block whose values are greater (less) than the values of the 12 pixels surrounding the 2x2 block. The operator output is a vector of Point value objects, in which the *value* field is the pixel value at the peak and the *pt* field is the peak location. The peaks are sorted in decreasing order of value for maxima and in increasing order for minima.

The **type** parameter is used to specify whether the operator should search for *Minima* or *Maxima*.

The **threshold** and **relThreshold** parameters are used to set a threshold for the peak pixel values. Only peak pixel values above the **threshold** for maxima or below the threshold for minima are accepted. The **relThreshold** can be used to set the threshold to a percentage of the actual range of values in the image. For maxima the relative threshold value is set to the specified fraction of the range from the image minimum value to the image maximum value, so that a value of *0* gives a threshold equal to the image minimum and a value of *100* gives a threshold equal to the image maximum. For minima the value is set to the fraction of the range from the maximum to the minimum, so that a value of *0* gives a threshold equal to the image maximum and a value of *100* gives a threshold equal to the image minimum. If the value calculated using **relThreshold** is greater than the **threshold** for maxima or less than the **threshold** value for minima then it replaces the **threshold** value.

The **maxPeaks** parameter specifies the maximum number of peaks to be output. If more peaks than the maximum number of peaks are found, the peaks with the highest pixel values are output for maxima and the peaks with the lowest pixel values are output for minima.

If the **subpixel** parameter is set to *Yes* pixel values in the neighbourhood of the maximum or minimum value pixel will be used to estimate a sub-pixel location for the peak. If **subpixel** is set to *No* and the peak is includes more than one pixel, the location will be the upper-left pixel for maxima and the lower right pixel for minima.

Parameter Information

threshold	Type: float
relThreshold	Type: float
maxPeaks	Type: int Default: 10
type	Type: int Default: 0 Values: maxima: 0, minima: 1
subpixel	Type: int Default: 0 Values: No: 0, Yes: 1

Demo iGraph

Operators\Measurement\CircleCenters

C Prototype

```
CorOpRtn cor_getPeaks(
    CorImage *i0,
    CorVector *Peaks,
    float threshold,
    float relThreshold,
    int maxPeaks,
    int type,
    int subpixel
```

)

Headers

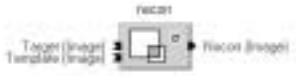
#include "$(WITHOME)/h/wFind.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

nxcorr

Calculate normalized cross-correlation of target and template



Description

The **nxcorr** operator produces the normalized cross-correlation image from a target image and a smaller template image. The template image used is the ROI of the **Template** input image. A pixel value in the output image represent the normalized cross-correlation value calculated with the upper left corner of the template image at the corresponding pixel in the input target image. Values are only calculated when the template is entirely inside the target image ROI, so the template can be no larger than the target ROI.

Demo iGraph

Operators\Find\NXCorr

C Prototype

```
CorOpRtn cor_nxcorr(
    CorImage *Target,
    CorImage *Template,
    CorImage *Nxcorr
)
```

Headers

#include "$(WITHOME)/h/wFind.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

sod

Calculate sum of differences between target and template

Description

The **sod** operator produces the sum of differences image from a target image and a smaller template image. The template image used is the ROI of the **Template** input image. A pixel value in the output A pixel value in the output image represent the sum of differences value calculated with the upper left corner of the template image at the corresponding pixel in the input target image. Values are only calculated when the template is entirely inside the target image ROI, so the template can be no larger than the target ROI.

Demo iGraph

Operators\Find\SoD

C Prototype

```
CorOpRtn cor_sod(
    CorImage *Target,
    CorImage *Template,
    CorImage *Sod
)
```

Headers

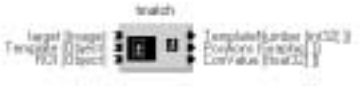
#include "$(WITHOME)/h/wFind.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

tmatch

Template matching



Description

The **tmatch** operator performs directed template matching using sum of differences, normalized cross correlation or binary comparison. Given a target image and a smaller template image (or a vector of template images), the operator searches specified ROIs in the target for subregions which match the template image. The main (center) output is a vector of graphic objects that specify locations in the target which matched the templates. The label field of each graphic object contains its position in the output vector. This label can be displayed using the **overlayData** operator and allows a graphic to be easily related to the corresponding element in the vector of match values. The lower output is a vector of floats that represent the match value (between 0 and 1) of the corresponding graphic. The upper output is a vector of integers that indicates which template provided the match when a vector of templates is used (if a single template image is used all elements in this vector are zero).

The operator requires three inputs: the **Target** input is an integer or float image; the **Template** input is an integer or float image or vector of images; and the **ROI** input is a graphic object or vector of graphic objects that controls the search strategy.

A template is formed from the ROI of the **Template** input if the input is a single image or from the ROI of each image if the input is a vector of images. The template is compared to regions in the target corresponding to each pixel in the input graphic object or objects. The template image is aligned so that the specified target pixels correspond to the center of the template if the **result** (in the **Result** sub-panel) parameter is set to *center* or *bounding box*, or to upper left corner of the template if **result** is set to *upper left*. For point graphic objects, the operator will also search concentric squares of pixels around the point, out to the distance specified by the **searchRange** parameter. A comparison will be made for a pixel only if the entire template falls within the target image. To search the entire image, the bounding rectangle may be obtained from the target image using the **getRect** operator and apply it to the lower input port. If a vector of template images is specified, the entire search region in the target image will be scanned for a template image before the next template image is used.

The **method** parameter is used to select one of the sum of differences, normalized cross correlation or binary comparison methods. The binary and sum of differences methods are faster, but normalized cross correlation is more robust in the presence of noise, changing illumination or background, and scale differences between the target and template. The three methods use different approaches, outlined below, to generate a value for the quality of the match between the template and target at each pixel specified by the ROI input.

The sum of differences method generates a match value based on the sum of the absolute value of the differences between corresponding pixel values in the template and target. The binary method generates a match value by counting the number of corresponding pixels that are either both zero or both non-zero. The sum of differences and binary count are normalized so that a value of 1 indicates a perfect match, and 0 indicates no match. In the normalized cross correlation method, the match value is the correlation coefficient between the template and the underlying region of the target. The correlation coefficient is a value between -1 and 1, where values near 1 indicate strong correlation; near zero, no correlation; and near -1, negative correlation. The **correlation** parameter can be used with the normalized cross correlation method to specify whether to use positive correlation, negative correlation or both.

The match values are compared to the value of the **threshold** and **sufficient threshold**parameters, which are set between 0 and 1. The **numToMatch** parameter applies a limit to the number of matches collected for output. Regions of the target for which the match value exceeds the value of the **sufficient threshold** parameter are considered to be matches to the template. If **numToMatch** matches that exceed this threshold are found, the search stops and the matches are output. Regions of the target for

which the match value exceeds the value of the **threshold** parameter are considered to be potential matches to the template. If the entire search region is searched without finding **numToMatch** matches over the **sufficient threshold**, the best matches over the **threshold** value will be output. The match value locations are output in decreasing order of match value.

Reduced sampling of the template can be specified using the parameters on the **SubSampling** sub-panel. The **templateSampling** parameter value specifies the pixel sampling period in the template used to calculate the match value at each pixel in the target. The **templateXOffset** and **templateYOffset** parameters specify where in template sampling starts. The **targetSampling** parameter value specifies the pixel sampling period in the target image. The **targetXOffset** and **targetYOffset** parameters allow the samples to be taken at various points in the sample grid.

Parameters on the **Result** sub-panel control the some aspects of the output format. The **result** parameter is used to select the graphic object that locates the matched subimage regions in the target image. Selecting *center* or *upper left* will produce a point located at the center or upper left of each region, while selecting *bounding box* will produce a rectangle corresponding each regions bounding box. The vector of graphic objects can be sent to the **overlay** operator for display on the input image or used to extract a subimage from the target image. The **result** parameter also controls how the template is overlayed relative to the selected target pixels, as described above.

The **vicinity** parameter is used to compare matched objects with similar position. If a new match is found which is within **vicinity** pixels in *x* and *y* of a previously found match point, then only the better of the match points is recorded.

The **red**, **green** and **blue** parameters can be used to control the color of the output graphics. The default color is red.

Parameter Information

method	Type: int Default: 1 Values: Sum of Diff: 0, Norm Corr: 1, Binary: 2
correlation	Type: int Default: 0 Values: positive: 0, negative: 1, both: 2
threshold	Type: float Default: 0.5
sufficient threshold	Type: float Default: 1
numToMatch	Type: int Default: 5
templateSampling	Type: int Default: 1
templateXOffset	Type: int Default: 0
templateYOffset	Type: int Default: 0
targetSampling	Type: int Default: 1
targetXOffset	Type: int Default: 0
targetYOffset	Type: int Default: 0
searchRange	Type: int Default: 5
result	Type: int Default: 2 Values: center: 0, upper left: 1, bounding box: 2
vicinity	Type: int Default: 5
red	Type: int Default: 255 Values: 0 — 255
green	Type: int Default: 0 Values: 0 — 255
blue	Type: int Default: 0 Values: 0 — 255

Demo iGraph

Operators\Find\TMatch

C Prototype

```
CorOpRtn cor_tmatch(
    CorImage *target,
    CorObj *Template,
    CorObj *ROI,
    CorIntVector *TemplateNumber,
    CorGraphicVector *Positions,
    CorFloatVector *CorrValue,
    int method,
    int correlation,
    float threshold,
    float sufficient_threshold,
    int numToMatch,
    int templateSampling,
    int templateXOffset,
    int templateYOffset,
    int targetSampling,
    int targetXOffset,
    int targetYOffset,
    int searchRange,
    int result,
    int vicinity,
    int red,
    int green,
    int blue)
```

Headers

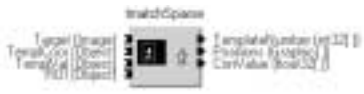
#include "$(WITHOME)/h/wFind.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

tmatchSparse

Template matching



Description

The **tmatchSparse** operator performs template matching using a template specified as a vector of points and a vector of corresponding pixel values. The *TemplateCoor* input must be a vector of Point objects, indicating the point locations in the template that will be evaluated. The *templateVal* input is a vector of numeric values that represent the template values at the points specified in the *templateCoor* vector. This allows the specification of templates at sparse or irregular sampling intervals.

The remaining inputs and outputs and the operator parameters are described in the **tmatch** operator documentation. The bounding box produced by setting the *result* parameter to *bounding box* is the bounding box of the points specified in the *templateCoor* vector.

Parameter Information

method	Type: int Default: 1 Values: Sum of Diff: 0, Norm Corr: 1, Binary: 2
correlation	Type: int Default: 0 Values: positive: 0, negative: 1, both: 2
threshold	Type: float Default: 0.5
sufficient threshold	Type: float Default: 1
numToMatch	Type: int Default: 5
templateSampling	Type: int Default: 1
templateXOffset	Type: int Default: 0
templateYOffset	Type: int Default: 0
targetSampling	Type: int Default: 1
targetXOffset	Type: int Default: 0
targetYOffset	Type: int Default: 0
searchRange	Type: int Default: 5
result	Type: int Default: 2 Values: center: 0, upper left: 1, bounding box: 2
vicinity	Type: int

	Default: 5
red	Type: int Default: 255 Values: 0 — 255
green	Type: int Default: 0 Values: 0 — 255
blue	Type: int Default: 0 Values: 0 — 255

Demo iGraph

Operators\Find\TMatchSparse

C Prototype

```
CorOpRtn cor_tmatchSparse(
    CorImage *Target,
    CorObj *TemplCoor,
    CorObj *TemplVal,
    CorObj *ROI,
    CorIntVector *TemplateNumber,
    CorGraphicVector *Positions,
    CorFloatVector *CorrValue,
    int method,
    int correlation,
    float threshold,
    float sufficient_threshold,
    int numToMatch,
    int templateSampling,
    int templateXOffset,
    int templateYOffset,
    int targetSampling,
    int targetXOffset,
    int targetYOffset,
    int searchRange,
    int result,
    int vicinity,
    int red,
    int green,
    int blue)
```

Headers

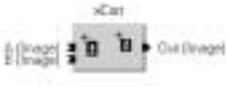
#include "$(WITHOME)/h/wFind.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

xCorr

Image cross correlation



Description

The **xcorr** operator performs the cross correlation of image **A** and image **B**. The cross correlation operation is performed by taking the inverse discrete Fourier transform (DFT) of the product of the DFT of image **A** and the complex conjugate of the DFT of image **B**.

The operator accepts two integer or float images. The width and height of image **A** must be greater than or equal to the width and height, repectively, of image **B**. The output is a float image the size of image **A**, where the pixel values are the cross correlation values for corresponding offsets of image **B**. Values are only calculated at pixels where the entire image **B** lies within the boundaries of image **A**.

Demo iGraph

Operators\Find\XCorr

C Prototype

```
CorOpRtn cor_xCorr(
    CorImage *A,
    CorImage *B,
    CorImage *Out
)
```

Headers

#include "$(WITHOME)/h/wFind.h"

Libraries

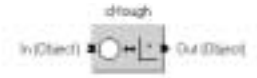
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFind.lib

Fit

The Fit library supports the production of higher level or derived geometric representations from image or geometric data. The library includes operators that fit image or geometric data to lines or circles and operators that find centroids, bounding boxes, and convex hulls of image or geometric data.

cHough

Circular Hough transform



Description

The **cHough** operator computes the forward or reverse circular Hough transform of the input. The **direction** parameter specifies whether the *forward* or *reverse* transform is performed.

The forward circular Hough transform of a binary image (unsigned 8 or 16 bit) is a three dimensional function of *x*, *y* and *r* (radius) giving the fraction of pixels on a circle of radius *r* centered at (*x*, *y*) that are set. This transform can be used to locate circles in images. The forward transform generates a vector of unsigned 8 bit images where each image in the vector corresponds to circles of one radius. A pixel value in an output image represents the fraction of set pixels in the input image on a circle centered at the corresponding pixel with a radius equal to the radius value associated with the image. The pixel values are normalized to a value of 255 for a complete circle. The radius values corresponding to each image range from **startRadius** to **endRadius** in one pixel steps. For example, pixel (*x*, *y*) of image *i* in the output vector gives the fraction of pixels on a circle in the input image centered at (*x*, *y*) with radius *i* + **startRadius** that are turned on, scaled to the range 0 to 255.

The reverse transform converts points in the input image to circles in the output image. It is not a true inverse in that when it is applied to a tranformed image it does not exactly reproduce the original image. The **cHough** operator in the reverse mode takes a vector of unsigned 8 or 16 bit images (or a single image, which is treated as a one element image vector) as input and produces a 16 bit output image. Each pixel in the input images contributes to a circle in the output image. The center of the circle corresponds to the (*x*, *y*) position of the input pixel. The radius is derived from the element number of the image in the input vector, with the first image corresponding to circles with radius **startRadius** and subsequent images' radii increasing in one pixel steps. The **accumulate** parameter determines how the output pixel values are determined from the input image pixel values. It may be set to **max**, **sum** or **incr** modes. These modes are described in detail in the **hough** operator documentation.

Parameter Information

direction Type: int
Default: 0
Values: forward: 0, reverse: 1

startRadius Type: float
Default: 0

endRadius Type: float
Default: 0

accumulate Type: int
Default: 0
Values: max: 0, sum: 1, incr: 2

C Prototype

```
CorOpRtn cor_cHough(
    CorObj *In,
    CorObj *Out,
    int direction,
    float startRadius,
    float endRadius,
    int accumulate
)
```

Headers

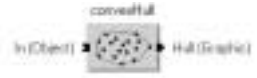
#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

convexHull

Find the convex hull of an image or point set



Description

The **convexHull** operator calculates the convex hull or envelope of a binary image, set of points or geometric object.

An image input must be unsigned 8 or 16 bit image. The convex hull encloses all non-zero pixels in the image ROI, based on the pixel centers. The operator also accepts vectors of Point or Real point objects and both vectors of geometric objects and single geometric objects. Geometric objects include Graphic, Geometry, Edge and Line objects.

The operator output is a polygon Graphic object. The color associated with the graphic can be set using the parameters on the **Color** subpanel.

Parameter Information

outline Type: int
Default: 1
Values: off: 0, on: 1

penR Type: int
Default: 255
Values: 0 — 255

penG Type: int
Default: 0
Values: 0 — 255

penB Type: int
Default: 0
Values: 0 — 255

fill Type: int
Default: 0
Values: off: 0, on: 1

fillR Type: int
Default: 0
Values: 0 — 255

fillG Type: int
Default: 0
Values: 0 — 255

fillB Type: int
Default: 0
Values: 0 — 255

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_convexHull(
    CorObj *In,
    CorGraphic **Hull,
    int outline,
    int penR,
    int penG,
    int penB,
    int fill,
    int fillR,
    int fillG,
    int fillB)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

fitCircleToPts

Iterative least squares circle fit to points

Description

The **fitCircleToPts** operator performs an iterative least squares fit to fit a Circle to the input points.

The operator's input may be a vector of Point, Fpoint, PtValue, Graphic, Geometry, or Edge objects or a single Graphic or Geometry object. If the input is a vector of Graphic, Geom or Edge object, each object in the vector must of point type. There must be at least three points in the input. If

the input is a Graphic or Geometry object it may be any type except circle and text. In this case, the circle will be fit to the vertices treated as independent points. If the input is a vector of PtValue objects the *value* field of the elements of the vector will be used as a weight value for a weighted least squares fit. Negative weight values are ignored.

The operator's main output is a single circle Graphic object. The number of iterations required is to fit the points is also produced.

The if **autoInit** parameter is set to *Yes* the operator will use the centroid of the point positions as an initial guess at the circle's center position. If it is set to *No* the user must supply an initial center position using the *initCenter* parameter. The *maxIterations* parameter can be used to limit the number of iterations the operator will perform.

Parameter Information

autoInit	Type: int Default: 1 Values: No: 0, Yes: 1
initCenter	Type: CorFpoint
maxIterations	Type: int Default: 256

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_fitCircleToPts(
    CorObj *Points,
    CorGraphic **Circle,
    int *Iterations,
    int autoInit,
    CorFpoint *initCenter,
    int maxIterations
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

fitLineToPts

Least squares line fit to points

Description

The **fitLineToPts** operator performs a least squares fit to fit a line to the input points.

The operator's input may be a vector of Point, Fpoint, PtValue, Graphic, Geometry, or Edge objects or a single Graphic or Geometry object. If the input is a vector of Graphic, Geom or Edge object, each object in the vector must of point type. If the input is a Graphic or Geometry object it may be any type except circle and text. In this case, the line will be fit to the vertices treated as independent points. If the input is a vector of PtValue objects the *value* field of the elements of the vector will be used as a weight value for a weighted least squares fit. Negative weight values are ignored.

The operator's output is a single line Graphic object. The endpoints of the line are the extremes of projected positions of the points in the input set onto the best fit line. The direction of the line follows the relative position of points generating the endpoints in the input.

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_fitLineToPts(
    CorObj *In,
    CorGraphic **Out
)
```

Headers

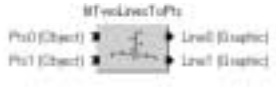
#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

fitTwoLinesToPts

Fit right angle or parallel lines to two sets of points



Description

The **fitTwoLinesToPts** operator fits a lines to each of two input point sets using a least square fit, with the constraint that the lines are either at right angles or are parallel.

The operator's input may be a vector of Point, Fpoint, PtValue, Graphic, Geometry, or Edge objects or a single Graphic or Geometry object. If the input is a vector of Graphic, Geom or Edge object, each object in the vector must of point type. If the input is a Graphic or Geometry object it may be any type except circle and text. In this case, the line will be fit to the vertices treated as independent points. If the input is a vector of PtValue objects the *value* field of the elements of the vector will be used as a weight value for a weighted least squares fit. Negative weight values are ignored.

The operator produces two line type Graphic objects, with **Line0** corresponding to the input point set **Pts0** and **Line1** corresponding to the input point set **Pts1**. The output lines minimize the sum of the squared distances from the line to the points in the corresponding point set. The **lines** parameter is used to specify whether the two output lines are at right angles or are parallel.

Parameter Information

lines Type: int

Default: 0
Values: Right Angle: 0, Parallel: 1

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_fitTwoLinesToPts(
    CorObj *Pts0,
    CorObj *Pts1,
    CorGraphic **Line0,
    CorGraphic **Line1,
    int lines
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

gCentroid

Compute weighted centroid of an ROI

Description

The **gCentroid** operator determines the centroid of a given region of interest (ROI) based on the values in the input image.

The centroid is calculated by a center of mass type calculation, with the x coordinate *xc* given by *xc = sum(fi * xi)/sum(fi)*, where *fi* is the value and *xi* is the x coordinate of pixel i and the sums are over all pixels i in the ROI. The y coordinate is calculated in the same way.

The input ROI can be either a graphic object or by a binary image. Graphic object ROIs are rasterized and all pixels in the input image corresponding to the rasterized pixels (including boundary pixels) are

used in the calculation of the centroid. When a binary image ROI is used, all pixels in the input image that correspond to non-zero pixels in the ROI image are used . The ROI used for the centroid calculation is the intersection of the input ROI and the image ROI.

The graphic objects may be generated by the **getData** and **createRect** operators or may be constructed using the **createGraphics** and **putField** operators. Binary images are often produced by one of the thresholding operators, **thresh**, **iThresh** or **localThresh**.

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_gCentroid(
    CorImage *In,
    CorObj *ROI,
    CorObj *Centroid
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

gFitContoursRoi

Find straight lines within a ROI

Description

Find straight lines within a ROI

Parameter Information

thresh Type: float

startAngle Type: int
Default: -128

endAngle Type: int
Default: 127

range Type: int
Default: 0

degrees Type: int
Default: 0
Values: 360: 0, 256: 1

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_gFitContoursRoi(
    CorImage *In,
    CorObj *ROI,
    CorGeomVector *Contours,
    CorFloatVector *intensity,
    float thresh,
    int startAngle,
    int endAngle,
    int range,
    int degrees
)
```

Headers

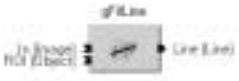
#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

gFitLine

Least square line fit to pixel values in ROI



Description

The **gFitLine** operator finds the line which gives the best least squares fit to the pixels of a region of interest (ROI) weighted by the values in the input image.

The input ROI can be either a graphic object or by a binary image. Graphic object ROIs are rasterized and all pixels in the input image corresponding to the rasterized pixels (including boundary pixels) are used in the calculation of the centroid. When a binary image ROI is used, all pixels in the input image that correspond to non-zero pixels in the ROI image are used. The ROI used for the line fitting is the intersection of the input ROI and the image ROI.

The graphic objects may be generated by the **getData** and **createRect** operators or may be constructed using the **createGraphics** and **putField** operators. Binary images are often produced by one of the thresholding operators, **thresh**, **iThresh** or **localThresh**.

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_gFitLine(
    CorImage *In,
    CorObj *ROI,
    CorLine **Line
)
```

Headers

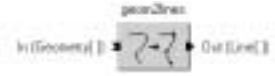
#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

geom2lines

Convert a vector of geometric objects to a line vector



Description

The **geom2lines** operator converts a vector of line, rectangle, polyline or polygon Geom objects into a vector of line segments. Input vector elements of other types are ignored. The line segments are output as a vector of Line data objects.

For polyline or polygon elements of the input vector, line segments are produced by determining if any vertices of the polyline are more than a specified **deviation** away from the line connecting its two endpoints. If not, the polyline endpoints are line segment endpoints. Otherwise, the polyline is split at the vertex farthest from the line and the algorithm is applied recursively to the two resulting polylines. The **deviation** is specified in pixels.

The Line objects produced by the operator contain the fields *p1* and *p2*, the two endpoints of the line; *length*, the line length; and *angle*, the angle between the line and the positive x axis in degrees. The **mergeLines** operator can be used to combine approximately collinear line segments with small gaps between them into longer lines.

Parameter Information

deviation Type: int
Default: 2

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_geom2lines(
    CorGeomVector *In,
    CorLineVector *Out,
    int deviation
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

getBoundingBox

Find bounding box of points, graphic or image

Description

The **getBoundingBox** operator finds the bounding box of an image, a set of points, a Graphic or Geometry object, or of a vector of Graphic or Geometry objects. The operator's output is a rectangle type Graphic object.

For image inputs, the bounding box is the minimum rectangle containing all non-zero pixels in the image ROI. The input image may be any image type.

The operator will accept vectors of Point, Real Point, Point Value, Graphic, Geometry, Edge, or Line objects or single Graphic, Geometry, Edge, or Line objects. The output is the minimum rectangle that contains the objects. In the case of text Graphic or Geometric objects only the text reference position (the lower left corner of the text string) is used to calculate the bounding box.

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_getBoundingBox(
    CorObj *In,
    CorGraphic **Out
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

getVertexPts

Get vertex points of a geometric object or point set

Description

The **getVertexPts** operator finds the vertices of a single Graphic, Geometry, Edge, or Line object or a vector of Graphic, Geometry, Edge, or Line objects. The output is a vector of Real Points.

For point, line, polyline, polygon, and text type geometric objects the operator produces the object's point list. In the case of text objects only the text reference position (the lower left corner of the text string) is used. For rectangles the operator produces the points corresponding to the upper left, upper right, lower right, and lower left corners. For circles the operator outputs the four points corresponding to the minimum and maximum x and y points on the circle. For arcs the operator produces the points corresponding to the minimum and maximum x and y points on the arc and the endpoints of the arc.

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_getVertexPts(
    CorObj *In,
    CorFpointVector *Out
)
```

Headers

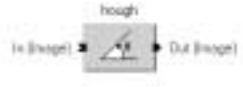
#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

hough

Hough transform



Description

The **hough** operator computes the forward or reverse Hough transform of the input image. The **direction** parameter specifies whether the *forward* or *reverse* transform is performed. The operator accepts unsigned 8 or 16 bit images as input and produces an unsigned 16 bit image as output.

The forward transform converts lines in a binary input image to points in output image. It generates a greyscale image output where each output pixel value represents the number of pixels on the corresponding line in the input image. In the output image the *x* axis represents the angle of the normal vector to the line in the input image with respect to the *x* axis (positive angle values indicate clockwise rotation). The angle range is specified by the **startAngle** and **endAngle** parameters, in increments specified by the **angleIncr** parameter. The angle parameters must be positive integers and the maximum angle range is 180 degrees.

The *y* direction represents the radial distance of the line from the center of the input image in image pixel units. The height of the transform image is approximately sqrt(W*W + H*H), where W is the width and H the height of the input image. Radial distance zero is at one-half the height of the Hough output image, and positive radial distances extend upward (negative *y*) from that point.

The reverse transform converts points in the input image to lines in the output image. It is not a true inverse in that when it is applied to a Hough tranformed image it does not reproduce the original image. The relationship of pixels in the transformed image to lines in the reverse transformed image is the inverse of that described for the forward transform. The **startAngle** parameter specifies the angle associated with the first column of the input image. The **angleIncr** parameter controls the angle increment associated with each pixel in the *x* direction.

The **accumulate** parameter controls how the output pixel values are assigned. In the **max** mode each output pixel is set to the maximum value of all associated pixels from the input image. The resulting image contains lines whose value gives an indication of the number of active pixels that were on that line in the original image. In the **sum** mode, each output pixel is assigned the sum of all associated pixels from the input image. This produces a scaled, blurred reconstruction of the original image. In the **incr** mode, the output pixels are incremented for each associated pixel in the input image. The pixel value gives an indication of the number of lines in the original image (points in the transformed image) that cross the pixel. This is most useful when applied to binarized transformed images in which non-zero pixels are sparse, such as might be produced by thresholding the transformed image. The inverse transformed image will always be larger than the original image, with both width and height of the image approximately equal to the diagonal length of the original. It can be resized to the original image space using the **matchSize** operator with the **sizeOp** parameter set to *center B on A.*

Parameter Information

direction Type: int
Default: 0
Values: forward: 0, reverse: 1

startAngle Type: int
Default: 0

endAngle Type: int
Default: 179

angleIncr Type: float
Default: 1

accumulate Type: int
Default: 0
Values: max: 0, sum: 1, incr: 2

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_hough(
```

```
    CorImage *In,
    CorImage *Out,
    int direction,
    int startAngle,
    int endAngle,
    float angleIncr,
    int accumulate
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

houghDir

Hough transform with direction

Description

Hough transform with direction

Parameter Information

tolerance Type: int
Default: 5

startAngle Type: int
Default: -128

endAngle Type: int
Default: 127

angleIncr Type: float
Default: 1

accumulate Type: int
Default: 0
Values: max: 0, sum: 1, incr: 2

degrees Type: int
Default: 0
Values: 360: 0, 256: 1

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_houghDir(
    CorImage *Magnitude,
    CorImage *Orientation,
    CorImage *Out,
    int tolerance,
    int startAngle,
    int endAngle,
    float angleIncr,
    int accumulate,
    int degrees
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

houghDirRoi

Hough transform with direction using ROI

Description

Hough transform with direction using ROI

Parameter Information

tolerance Type: int
Default: 5

startAngle Type: int
Default: -128

endAngle Type: int
Default: 127

angleIncr Type: float
Default: 1

rRange Type: int

Default: 0

rResolution Type: int
Default: 0
Values: 1: 0, 2: 1, 4: 2, 8: 3, 16: 4, 32: 5

degrees Type: int
Default: 0
Values: 360: 0, 256: 1

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_houghDirRoi(
    CorImage *Magnitude,
    CorImage *Orientation,
    CorObj *Roi,
    CorImage *Out,
    int tolerance,
    int startAngle,
    int endAngle,
    float angleIncr,
    int rRange,
    int rResolution,
    int degrees)
```

Headers

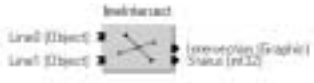
#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

lineIntersect

Find the intersection of two lines.



Description

The **lineIntersect** operator finds the intersection point of two lines or line segments. The **Line0** and **Line1** inputs must be line type geometric objects (Geometry, Graphic, Edge or Line).

The **extend** parameter specifies whether the the line inputs are considered to be finite line segments or infinite length lines extending through the endpoints.

The **Intersect** output is a graphic point that indicates the intersection of the input lines, if they intersect. The **Status** output indicates whether the lines actually intersect. The status value is 0 if the lines do not intersect, 1 if they do. In addition, the **Intersect** output point is colored green if the point is a valid intersection and red if it is not.

Parameter Information

extend Type: int
Default: 0
Values (bitwise OR): Line0: 1, Line1: 2

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_lineIntersect(
    CorObj *Line0,
    CorObj *Line1,
    CorGraphic **Intersection,
    int *Status,
    int extend
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

mergeLines

Merge approximately contiguous line segments

Description

The **mergeLines** operator combines line segments from a vector of Line objects into longer line segments. The input is a vector of Line data objects, typically produced by the **geom2lines** operator. The output is also a vector of Line objects.

Lines are merged if their angles are within a tolerance specified in degrees by the **angle** parameter and the endpoints of matching ends are within a distance of each other specified in pixels by the **gapSize** parameters. The operator can also reject line segments smaller than the **minLength** parameter value.

Parameter Information

gapSize Type: int
Default: 10

minLength Type: int
Default: 20

angle Type: float
Default: 10

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_mergeLines(
    CorLineVector *In,
    CorLineVector *Merged,
    int gapSize,
    int minLength,
    float angle
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

pix2pt

Convert pixel locations to points

Description

The **pix2pt** operator will take a binary image and produce a point vector describing the point locations of every non-zero pixel in the image ROI. The vector is limited in size by the **maxPts** parameter.

Parameter Information

maxPts Type: int
Default: 100

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_pix2pt(
    CorImage *In,
    CorPointVector *Points,
    int maxPts
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

reduceLines

Find the lines that best fit the sequence of the points

Description

The **reduceLines** operator produces approximations to polygons or polylines that contain fewer line segments than the originals. The input may be a polygon or polyline Geometry or Graphic object, a vector of polyline or polygon Geometry or Graphic objects, or a vector of Point or Fpoint objects. A vector of points is treated as if the points were endpoints in a single polyline. The output is the same type as the input except for the point vector input, which produces a polyline Geometry object. The polylines and polygons are approximated using a successive splitting approach. For a polyline, the initial approximation is a single segment polyline connecting the endpoints of the original polyline. If the original polyline is more than a specified error distance from the new polyline, the most distant vertex from the new polyline is found and added as a vertex of the new polyline. The process is repeated for the remaining vertices relative to the new polyline. The error distance is specified in pixels using the **max Deflection** parameter. The error distance can be either the maximum distance from any vertex to the new polyline or the mean distance from the new polyline to the original polyline. The type of distance measure used is specified by the **deflection Type** parameter. The mean distance is measured on only one side of the new polyline at a time.

The **adjust** parameter specifies which side of new polyline will be searched for vertices to add. Specifying **left** or **right** will allow each successive search to be limited to one side of the line. If the **adjust** parameter is set to **both** the operator will first consider the side with the greatest distance from the original estimate. The algorithm will be applied until the error distance on that side of the approximation is within the specified limit. It will then consider vertices on the other side of the new polyline. When the new polyline is within the error distance on that side, the first side may be considered again. This process continues until either the distance on both sides is below the error distance or it has switched sides the number of times specified in the **nIterations** parameter. Setting the **nIterations** parameter to zero will result in vertices only being added on the side that contains the maximum deviation from the line segment connecting the polyline endpoints.

The approach when the input is a polygon is similar, with the initial approximation containing two segments. The segments connect the starting vertex of the polygon to the most distant vertex and the most distance vertex to the original point. The algorithm then proceeds as for polylines.

When a single side adjustment is specified for polygons, **right** adjustment gives best results for polygons drawn in the counter-clockwise direction and **left** adjustment gives the best result with polygons drawn in the clockwise direction. Vertices in polygons created from perimeters using the **plotFeatures** operator are ordered clockwise, so the **left** setting usually provides the best results.

Parameter Information

max Deflection Type: int
Default: 100

deflection Type Type: int
Default: 0
Values: mean: 0, max: 1

adjust Type: int
Default: 0
Values: both: 0, left: 1, right: 2

nIterations Type: int
Default: 5

Demo iGraph

Operators\Geometry\convexHull.igr

C Prototype

```
CorOpRtn cor_reduceLines(
    CorObj *Points,
    CorObj *LinePoints,
    int max_Deflection,
    int deflection_Type,
    int adjust,
    int nIterations
)
```

Headers

#include "$(WITHOME)/h/wFit.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wFit.lib

Control

Flow control operators for WiT igraphs.

buf

Object buffer

Description

The **buf** operator passes its input object to its output. This operator is used primarily as a means to connect the output of an operator back to its input. Connecting outputs directly to the inputs of the same operator causes deadlock. This form of deadlock is corrected by using the **buf** operator between the output and input connections.

cCode

Dynamically compiled C code

Description

Dynamically compiled C code

clearObjs

clear data objects remaining in an igraph

Description

Igraphs that have loops and branches and operators with multiple inputs may have extra data objects remaining from previous iterations which can block proper execution of subsequent iterations. This is especially common when error conditions are encountered during execution. **clearObjs** can be used to clear all remaining data objects in an igraph. The output is the number of data objects freed.

Parameter Information

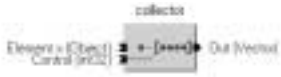
applyToLevels Type: int
Default: 0
Values: current: 0, current and lower: 1, lower only: 2

Demo iGraph

Operators\clearObjs

collector

Collect input objects and output a vector



Description

The **collector** operator collects a set of input objects of the same type and forms a vector as output. The objects which form the vector are collected from the top input port. The **Control** input port expects an integer object representing the **collector** state.

The number of objects collected for each vector may be specified using the **numToCollect** parameter or, if the **numToCollect** parameter is set to zero, may be controlled by the **Control** input. The **Control** input must be supplied each time an input object is received even if the vector size is specified.

In the case where **Control** input is used, if its value is zero the input object is appended to the vector and collection continues. If its value is not zero the **collector** sends a vector of collected objects and

resets itself. When the **ignoreLast** parameter is set to *yes*, the last object fed to the **collector** is not appended to the outgoing vector.

The **ignoreElement** parameter determines whether the input element is added to the current vector or consumed without being added. When **ignoreElement** is set explicitly it is always set to *no*. When used as an input parameter it allows conditional collection of elements based on a boolean value produced in the graph.

Collector is typically used in conjunction with **sequencer**, where the **Control** input is provided by the **sequencer**.

Parameter Information

status Type: int
Default: 0
Values: new: 0, append: 1

ignoreLast Type: int
Default: 0
Values: no: 0, yes: 1

numToCollect Type: int
Default: 0

numCollected Type: int
Default: 0

ignoreElement Type: int
Default: 0
Values: no: 0, yes: 1

elementTypes Type: int
Default: 0
Type: **choice**
same: 0
different: 1

If **elementTypes** is *same*, only objects of the same type are collected. Feeding different object types to **collector** will cause an error. If **elementTypes** is *different*, different object types can be collected.
Values: same: 0, different: 1

Demo iGraph

Operators\clearObjs

counterInit

Create or re-initialize up/down counter

Description

Normally a counter can be used without explicitly creating it. Such counters count from zero with a step increment of one every time **counterStep** executes. **counterInit** is used to create or re-initialize a counter with non-default settings, so that you can specify parameters such as the starting count, step size (including up or down counting), and whether the count should stop counting at a specified final value.

Counters are referenced by the **name** parameter, which refers to a global name. See chapter 'Operators/Special' in *User's Manual* for details.

See also:

counterReset, **counterStep**

Parameter Information

name Type: CorString
Default: "counter"
Type: **CorString**

The global name of the counter.

initial Type: int
Default: 0
Type: **int**

The initial value of the counter. The first time that **counterStep** is executed on a counter, the output count will be value of **initial**.

incre Type: int
Default: 1
Type: **int**

The amount that the counter value is incremented every time **counterStep** is

executed. If **incre** is negative, then the counter will count down.

hasFinal Type: int
Default: 0
Type: **choice**
no: 0
yes: 1

If **hasFinal** is *no*, the counter value is always incremented every time **counterStep** is executed. If **hasFinal** is *yes*, the counter only counts to, and including, the value specified by the **final** parameter.
Values: no: 0, yes: 1

final Type: int
Default: 0
Type: **int**

See **hasFinal**.

Demo iGraph

Operators\clearObjs

counterRecall

Recall current value of counter

Description

Recall current value of counter

Parameter Information

name Type: CorString
Default: "counter"

Demo iGraph

Operators\clearObjs

counterReset

Reset counter to initial value

Description

counterReset resets a counter to its initial value.

Counters are referenced by the **name** parameter, which refers to a global name. See chapter 'Operators/Special' in *User's Manual* for details.

See also:

counterInit, **counterStep**

Parameter Information

name Type: CorString
Default: "counter"

Demo iGraph

Operators\clearObjs

counterStep

Run counter for one step

Description

counterStep increments a counter by one step every time it executes. By default, a counter has an initial value of 0 and a step of 1, with no final value. Use **counterInit** to create or re-initialize a counter with non-default settings.

The first time **counterStep** is executed, the count output is the initial value of the counter. If the step size is negative, the counter counts down. If the counter has a final value, then the value remains at the final value after it has been reached. Otherwise, the counter is incremented indefinitely.

Counters are referenced by the **name** parameter, which refers to a global name. See chapter 'Operators/Special' in *User's Manual* for details.

See also:

counterReset, **counterStep**

Parameter Information

name Type: CorString
Default: "counter"

Demo iGraph

Operators\clearObjs

data2sync

Convert a data token to a sync token

Description

The **data2sync** operator takes an input object of any type and produces a sync token.

Demo iGraph

Operators\clearObjs

delay

Delay for a specified time

Description

The **delay** operator delays igraph execution for a number of milliseconds specified by its **msec** parameter.

Parameter Information

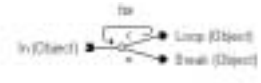
msec Type: int
Default: 1000

Demo iGraph

Operators\clearObjs

for

Repeat a set of operations a specified number of times



Description

The **for** operator is useful for executing a set of operators a fixed number of iterations. It has one standard integer parameter, **count**, and one special parameter **currentCount**. The **currentCount** parameter is initially set to zero and cannot be set by the user. Every time a token arrives at the input port, **currentCount** is incremented by one. If the resulting value of **currentCount** is less than the value of **count**, the token is passed to the top branch (labelled *Loop*), which most often would have a sequence of operators eventually sending a token back to the input of the **for** operator. When the **currentCount** value is equal to **count** the the input token is sent to the lower branch (labelled *Break*). As **currentCount** is incremented, its current value is interactively displayed on the igraph.

When you *run* the igraph again, the current value of **currentCount** will revert to zero.

See also:

for2, **for3**

Parameter Information

currentCount Type: int
Default: 0

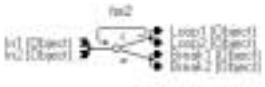
count Type: int
Default: 1

Demo iGraph

Operators\clearObjs

for2

Repeat for 2 inputs a set of operations a specified number of times



Description

Similar to the **for** operator, but controlling 2 objects with the same loop count.

See also:

for, **for3**

Parameter Information

currentCount Type: int
Default: 0

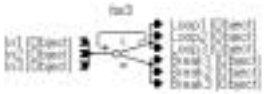
count Type: int
Default: 1

Demo iGraph

Operators\clearObjs

for3

Repeat for 3 inputs a set of operations a specified number of times



Description

Similar to the **for** operator, but controlling 3 objects with the same loop count.

See also:

for, **for2**

Parameter Information

currentCount Type: int
Default: 0

count Type: int
Default: 1

Demo iGraph

Operators\clearObjs

gate

Gate object data

Description

The **gate** operator allows objects to travel from input to output if the **Gate** input is present otherwise the input object is blocked. Both the **Gate** input and input object must be present before the **gate** operator executes.

Demo iGraph

Operators\clearObjs

goto

Send token to specified label

Description

The **goto** operator allows tokens to be sent to a distant location without a long link on the igraph. This is particularly useful when an igraph is very cluttered. The instance name of **label** is used to match the destination specified in the **label**

parameter of **goto**. A wild card * may be used to send an object to multiple **label** operators.

Parameter Information

label Type: CorString
Default: "label"

Demo iGraph

Operators\clearObjs

if

Conditional branch

Description

The **if** operator provides conditional branching ability in an igraph. It has one boolean parameter, which like all other parameters can be supplied from other igraph operators. If the condition is true, the input token is passed to the top branch (labelled with *TrueCond*). Otherwise the input token is passed to the bottom branch (labelled with *FalseCond*).

See also:

if2, **if3**, **if4**

Parameter Information

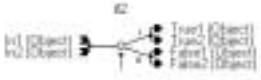
cond Type: int
Default: 0
Values: False: 0, True: 1

Demo iGraph

Operators\clearObjs

if2

Conditional branch for 2 inputs



Description

Similar to the **if** operator, but controlling 2 objects with the same condition.

See also:

if, **if3**, **if4**

Parameter Information

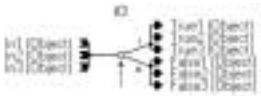
cond Type: int
Default: 0
Values: False: 0, True: 1

Demo iGraph

Operators\clearObjs

if3

Conditional branch for 3 inputs



Description

Similar to the **if** operator, but controlling 3 objects with the same condition.

See also:

if, **if2**, **if4**

Parameter Information

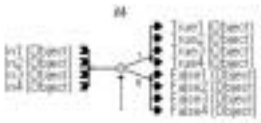
cond Type: int
Default: 0
Values: False: 0, True: 1

Demo iGraph

Operators\clearObjs

if4

Conditional branch for 4 inputs



Description

Similar to the **if** operator, but controlling 4 objects with the same condition.

See also:

if, **if2**, **if3**

Parameter Information

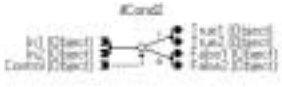
cond Type: int
Default: 0
Values: False: 0, True: 1

Demo iGraph

Operators\clearObjs

ifCond2

Conditional branch for 2 inputs with built-in test



Description

Similar to the **ifConditional** operator, but controlling 2 objects with the same condition.

See also:

ifConditional, **ifCond3**

Parameter Information

condition Type: int
Default: 0
Values: ==: 0, >: 1, <: 2, !=: 3, >=: 4, <=: 5, Empty: 6

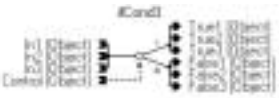
constant Type: CorString
Default: ""

Demo iGraph

Operators\clearObjs

ifCond3

Conditional branch for 3 inputs with built-in test



Description

Similar to the **ifConditional** operator, but controlling 3 objects with the same condition.

See also:

ifConditional, **ifCond2**

Parameter Information

condition Type: int
Default: 0
Values: ==: 0, >: 1, <: 2, !=: 3, >=: 4, <=: 5, Empty: 6

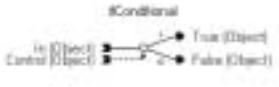
constant Type: CorString
Default: ""

Demo iGraph

Operators\clearObjs

ifConditional

Conditional branch with built-in test



Description

The **ifConditional** operator provides conditional branching ability in an igraph based on a comparison between two values. If the **condition** parameter is set to *Empty*, then the lower input can be a vector, image, or string. If the vector or image is empty, or if the string is NULL or empty, then the condition will be true. For all other values for *condition*, the lower input should be a numeric object (such as an integer or float). **ifConditional** compares it to the value set in the **constant** parameter. The type of comparison is chosen using the **condition** parameter. It may be one of ==, >, <, !=, >=, or <=.

If the condition is true, the object received at the top input port is passed to the top branch (labelled with *TrueCond*). Otherwise the input object is passed to the bottom branch (labelled with *FalseCond*).

See also:

ifCond2, **ifCond3**

Parameter Information

condition Type: int
Default: 0
Values: ==: 0, >: 1, <: 2, !=: 3, >=: 4, <=: 5, Empty: 6

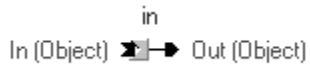
constant Type: CorString
Default: ""

Demo iGraph

Operators\clearObjs

in

Hierarchical operator input port



Description

The **in** operator is used to associate an input port of a super-node to an entry point in its sub-graph. The instance name of **in** is used as the name of the port in the super-node. Therefore, you should choose meaningful names for each instance of the **in** operator.

Demo iGraph

Operators\clearObjs

label

Goto operator destination

Description

The **label** operator serves as a destination position for the **goto** operator. The instance name of **label** is used to match the destination specified in the **label** parameter of **goto**.

Demo iGraph

Operators\clearObjs

memConst

Store constant objects for later recall

Description

Store constant objects for later recall

Parameter Information

name Type: CorString
Default: "mem"

value Type: CorObj

persist Type: int
Default: 0
Values: no: 0, yes: 1

Demo iGraph

Operators\clearObjs

memFree

Free previously stored objects

Description

Free memory previously allocated by a **memStore**, operator. Memory stored using **memStore** is usually freed automatically when a new igraph is loaded. Calling **memFree** explicitly is useful when an object is no longer needed and it takes up too much memory.

Objects stored in memory are referenced by the **name** parameter, which refers to a global name. See chapter 'Operators/Special' in *User's Manual* for details.

See also:

memStore, **memRecall**

Parameter Information

name Type: CorString
Default: "mem"

Demo iGraph

Operators\clearObjs

memRecall

Recall previously stored objects

Description

Recall memory previously allocated by a **memStore**, operator.

Objects stored in memory are referenced by the **name** parameter, which refers to a global name. See chapter 'Operators/Special' in *User's Manual* for details.

See also:

memStore, **memFree**

Parameter Information

name Type: CorString
Default: "mem"

Demo iGraph

Operators\clearObjs

memStore

Store objects for later recall

Description

Store an object in memory so that it can be recalled later anywhere in an igraph, as many times as required.

Objects stored in memory are referenced by the **name** parameter, which refers to a global name. See chapter 'Operators/Special' in *User's Manual* for details.

See also:

memFree, **memRecall**

Parameter Information

name Type: CorString

Default: "mem"
Type: **CorString**

The global name of the memory location.

persist Type: int
Default: 0
Type: **choice**
no: 0
yes: 1

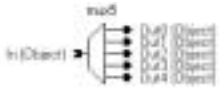
If **persist** is *no*, the memory will be freed when a new igraph is loaded. Otherwise, the memory will be valid even when a new igraph is loaded. This is useful when a large object needs to be read from disk and can be processed by multiple igraphs.
Values: no: 0, yes: 1

Demo iGraph

Operators\clearObjs

mux5

Multiplex input to 1 of 5 possible outputs



Description

Multiplex input to 1 of 5 possible outputs

Parameter Information

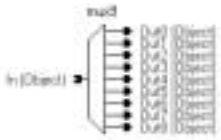
choice Type: int
Default: 0
Values: 0: 0, 1: 1, 2: 2, 3: 3, 4: 4

Demo iGraph

Operators\clearObjs

mux9

Multiplex input to 1 of 9 possible outputs



Description

Multiplex input to 1 of 9 possible outputs

Parameter Information

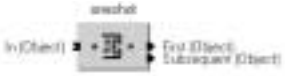
choice Type: int
Default: 0
Values: 0: 0, 1: 1, 2: 2, 3: 3, 4: 4, 5: 5, 6: 6, 7: 7, 8: 8

Demo iGraph

Operators\clearObjs

oneshot

Allow first and subsequent tokens to be routed differently



Description

The **oneshot** operator passes the first object it receives to the **First** output when in an armed (initial) state. After an one object has flowed through, the operator is in a triggered state and sends all subsequent inputs to the **Subsequent** port.

This operator is necessary to avoid some forms of igraph deadlock that can arise when using the for-loop or if-then-else operators. Using a **oneshot** also makes sense when you only want to do a particular igraph operation once, such as defining an area of interest.

Parameter Information

trigger Type: int
Default: 0
Values: armed: 0, disarmed: 1

Demo iGraph

Operators\clearObjs

out

Hierarchical operator output port

Description

The **out** operator is used to associated an output port of a super-node to an exit point on its sub-graph. The instance name of **out** is used as the name of the port in the super-node. Therefore, you should choose meaningful names for each instance of the **out** operator.

Demo iGraph

Operators\clearObjs

select5

Select 1 of 5 possible inputs for output

Description

Select 1 of 5 possible inputs for output

Parameter Information

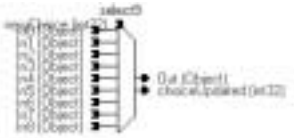
choice Type: int

Demo iGraph

Operators\clearObjs

select9

Select 1 of 9 possible inputs for output



Description

Select 1 of 9 possible inputs for output

Parameter Information

choice Type: int

Demo iGraph

Operators\clearObjs

sequencer

Output elements of a vector in sequence

Description

The **sequencer** operator dispatches the elements of a vector object received at its input port one by one to the **Element** output port along with an end condition flag from the **Control** output port. When the last element is sent, the end condition flag sent is set to true, otherwise it is false. The condition flag can be used by the **collector** operator (see also **collector**).

Parameter Information

count Type: int
Default: 0

Demo iGraph

Operators\clearObjs

start

Start an igraph

Description

The **start** operator produces a sync object. It is typically used as the starting point of an igraph, because most operators require at least one input.

Demo iGraph

Operators\clearObjs

stopDisable

Do not allow user to stop igraph

Description

Do not allow user to stop igraph

Demo iGraph

Operators\clearObjs

stopEnable

Enable user to stop igraph

Description

Enable user to stop igraph

Demo iGraph

Operators\clearObjs

vgate

Gate operator in vertical orientation

Description

The **vgate** operator allows objects to travel from input to output if the **Gate** input is present otherwise the input object is blocked. Both the **Gate** input and input object must be present before the **vgate** operator executes. This operator is the same as the **gate** but the input and outputs are positioned on the top and bottom of the icon and the **Gate** control is fed from the left side.

Demo iGraph

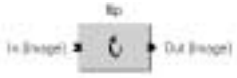
Operators\clearObjs

Geometry

The Geometry library supports spatial transformations of images and other objects. The library include operators that perform spatial transformations, such as rotation, shearing, scaling and perspective warping, on images and other objects and operators that perform spatial calibration functions.

flip

Perform a simple geometric transforms on an image



Description

The **flip** operator performs one of several common geometric transformations on its input image. These include flipping in *x* and *y* transpose, and rotations by multiples of 90 degrees.

The transformation type is specified by the **op** parameter:

```
flip-y:         x' = x,   y' = Y-y
flip-x:         x' = X-x, y' = y
x-pose:         x' = y,   y' = x
r-90  :         x' = y,   y' = X-x
r-180 :         x' = X-x, y' = Y-y
r-270 :         x' = Y-y, y' = x
```

where (x', y') is a pixel location in the output image, (x, y) is the location of the corresponding pixel in the input image, and X and Y are the maximum x and y pixel coordinates in the input image.

Parameter Information

op Type: int
Default: 0
Values: flip y: 0, flip x: 1, transpose: 2, rotate 90: 3, rotate 180: 4, rotate 270: 5

C Prototype

```
CorOpRtn cor_flip(
    CorImage *In,
    CorImage *Out,
    int op
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

getRigidBodyTransform

Produce rigid body transformation matrix for alignment

Description

The **getRigidBodyTransform** operator creates two 3x3 matrices for forward and inverse rigid body transformations that produce the best fit between the reference points input at the lower input port and the test points input at the upper port. The operator can be made to assume a one-to-one correspondence between the input point vectors or can search for the best fit between the two point sets.

The input points may be specified by vectors of Point, Fpoint or point type Graphic or Geometry objects. If the **correspondence** parameter is set to *1-1* both input vectors must contain exactly three points. This mode is used when the points in the test vector are known to be in the same order as the points in the reference vector.

If the **correspondence** parameter is set to *Best* the reference point vector must contain three points and the test point vector must contain three or more points. The operator will search for the permutation of three points from the test vector that gives the best fit to the reference points under a rigid body transformation. In the *Best* correspondence mode the user can select minimum and maximum rotation angles using the **minAngle** and **maxAngle** parameters. These parameters specify the limits on the angle by which the reference points are rotated before the fit to the test points is evaluated.

The output matrices can be used to transform images and graphical objects. The forward matrix, output at the center port, specifies the transformation that takes the reference points input at the lower input port to the test points input at the upper port. The reverse matrix, output at the lower port, is its inverse.

The error value output at the upper output port gives the error in pixels between the chosen test points and the transformed reference points. This value can be used to detect test point sets that do not produce a good match.

The **getRigidBodyTransform** operator is usually used to generate matrices for use with the **warp** operator. The matrices may also be used with the **warpFeatures** and **warpPerimeter** operators.

Parameter Information

correspondence Type: int
Default: 1
Values: 1-1: 0, Best: 1

minAngle Type: float
Default: -180

maxAngle Type: float
Default: 180

C Prototype

```
CorOpRtn cor_getRigidBodyTransform(
    CorVector *TestPts,
    CorVector *RefPts,
    float *Error,
    CorFloatVector *Forward,
    CorFloatVector *Reverse,
    int correspondence,
    float minAngle,
    float maxAngle
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

getWarpTransform

Calculate the warp conversion matrix and inverse

Description

The **getWarpTransform** operator creates two 3x3 matrices for forward and inverse perspective transformations that relate the input point sets. The output matrices can be used to transform images and graphical objects.

The forward matrix, output at the **FwdXform** port, specifies the transformation that takes the points input at the **From** (lower) input port to the points input at the **To** (upper) port. The reverse matrix, output at the **RvsXform** port, is its inverse.

The input points may be specified by vectors of Point, Fpoint or point type Graphic or Geometry objects. The inputs must contain the same number of points. There must be four or more points in the input vectors. If more than four points are specified the transformation is determined using a least square fit. The two sets of input points are matched pairwise in the order that they appear in the matrix.

Alternately, the upper input points may be specified by an image. In this case the points are the corners of the image in clockwise order from the upper left. If the upper input is an image, the lower input vector must contain four points.

The **getWarpTransform** operator is usually used to generate matrices for use with the **warp** operator. The matrices may also be used with the **warpFeatures** and **warpPerimeter** operators.

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_getWarpTransform(
    CorObj *To,
    CorObj *From,
    CorFloatVector *FwdXform,
    CorFloatVector *RvsXform
)
```

Headers

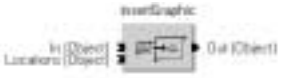
#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

insertGraphic

Move graphics to a new image position



Description

The **insertGraphic** operator will offset graphics or other geometric objects by an amount specified in the input graphic. This operator is primarily used to return geometric objects found in regions of interest extracted from an image using the **extract** operator to the original image coordinate system.

The **Locations** input receives a rectangle or point type graphic (or vector of graphics) that specifies the location of the origin of the coordinate system of the geometric objects received at the **In** input port. If a single graphic is received at the **Locations** input the geometric object may be a Graphic, Geom, Line, Edge, Point or Fpoint object or a vector of one of these types. If a vector is received at the **Locations** input a vector of the same size must be received at the **In** port. The elements of this vector may be single geometric objects or vectors of geometric objects, as described above. The elements of the **Locations** input vector are applied to the corresponding elements of the **In** input vector.

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_insertGraphic(
    CorObj *In,
    CorObj *Locations,
    CorObj *Out
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

matchSize

Make two images the same size by clipping or padding

Description

The **matchSize** operator takes two input images, **A** and **B**, offsets one image relative to the other, and pads or clips one or both images to produce two output images of the same width and height.

The **offset** parameter is used to specify the offset applied to image **B** relative to image **A**.

The dimensions of the output images are determined from the input images as specified by the **sizeOp** parameter:

```
  clip B        - B is clipped to fit
in A
  expand A      - A is expanded to
include B
  clip A and B  - A and B are clipped
to their intersection
  center B on A - B is centered on A
and then clipped to A
```

Clipping and expanding is performed after offsetting image **B**.

Values in the output images, **Aout** and **Bout**, are set to the values of the corresponding pixels in A and B, respectively, where they are defined and to zero elsewhere.

The **outputType** parameter allows the user to specify the type of WiT image produced. The *default* option causes a default output image type to be selected according to the following criteria.

```
  Input Image Types
Output Image Type
  - if either input is color
- output is color
  - else if either input is complex
- output is complex
  - else if either input is float
- output is float
  - else,
    - if either input is 16 bit
- output is 16 bit
    - if either input is signed
- output is signed
```

Color images are converted to other types by calculating a gray scale luminance image (equivalent to the Y channel of the Yuv color system), which is cast to the required type. Gray scale images are converted to color images by converting them to gray (R = G = B) RGB images. Complex images are converted by calculating the magnitudes of the complex values. Other image types are converted to complex by assigning the pixel gray levels (the luminance in the case of color images) to the real part of the corresponding complex pixel, the imaginary parts are all set to zero. When float image types are converted to an integer type, pixel values are rounded to the nearest integer value.

The **matchSize** operator can be used to prepare images for processing with the **fastAluOp**, which requires that images be the same size and offset.

Parameter Information

sizeOp Type: int
Default: 0
Values: clip B: 0, expand A: 1, clip A and B: 2, center B on A: 3

offset Type: CorPoint
Default: (0, 0)

outputType Type: int
Default: 0
Values: default: 0, 8-bit unsigned: 1, 8-bit signed: 2, 16-bit unsigned: 3, 16-bit signed: 4, float: 5, complex: 6, color: 7

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_matchSize(
    CorImage *A,
    CorImage *B,
    CorImage *Aout,
    CorImage *Bout,
    int sizeOp,
    CorPoint *offset,
    int outputType
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

move

Rotate an object by an arbitrary angle

Description

The **move** operator performs an arbitrary rotation and transformation on its input object. Rotation is executed first (*angle* parameter, in degrees counterclockwise), followed by translation (**shift** parameter, in pixels).

The rest of parameters is the same as in the **rotate** operator. Several of the parameters are used only when the input object is an image.

Parameter Information

angle Type: float
Default: 0

shift Type: CorPoint

sizeOp Type: int
Default: 0
Values: expand: 0, clip: 1

rotateAbout Type: int

Default: 0
Values: center: 0, user: 1

rotatePt Type: CorPoint
Default: (0, 0)

antiAlias Type: int
Default: 1
Values: no: 0, yes: 1

background Type: int
Default: 0
Values: auto: 0, user: 1

bgValue Type: float
Default: 0

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_move(
    CorObj *In,
    CorObj *Out,
    float angle,
    CorPoint *shift,
    int sizeOp,
    int rotateAbout,
    CorPoint *rotatePt,
    int antiAlias,
    int background,
    float bgValue)
```

Headers

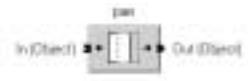
#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

pan

Pan an object



Description

The **pan** operator shifts the input object along the x-axis by the given amount. The **amount** paramater controls the number of pixels the object is shifted. A positive pan amount shifts the object to the right. Negative amounts shift the object to the left. In the case of the image pixels shifted off the right or left edges wrap around to the left or right sides, respectively.

Parameter Information

amount Type: int
Default: 10

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_pan(
    CorObj *In,
    CorObj *Out,
    int amount
)
```

Headers

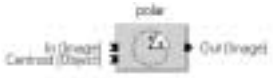
#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

polar

Transform image to polar representation



Description

The **polar** operator can transform an image to and from polar or log polar space. The **direction** parameter determines whether the input image is

transformed from polar to rectangular (*P->R*) or from rectangular to polar (*R->P*).

The polar coordinate space is centred at the point supplied at the lower input, which can be a Graphic, Geometry, Point or Real point object. The **type** parameter determines whether the space is polar or log polar.

When transforming from rectangular to polar, the transformation is applied over the radius range specified (in pixels) by the **minRadius** and **maxRadius** parameters and over the angular range specified (in degrees) by the **minAngle** and **maxAngle** parameters. The angles are calculated in degrees clockwise from the positive *x* axis. The number of pixels in the output image is specified with the **rBins** and **aBins** parameters for the radial (*x*) and angular (*y*) dimensions. Values outside the input image are set to zero.

When transforming from polar to rectangular, the input image is transformed into the region defined by the **minRadius**, **maxRadius**, **minAngle** and **maxAngle** parameters. When transforming a polar image created by another instance of the **polar** operator back into rectangular coordinates these parameters, and the **type** parameter should be set to the same value for both transformations. The **width** and **height** parameters set the width and height of the rectangular coordinate space output image.

Parameter Information

direction Type: int
Default: 0
Values: R->P: 0, P->R: 1

rBins Type: int
Default: 128

minRadius Type: float
Default: 0

maxRadius Type: float
Default: 127

aBins Type: int
Default: 360

minAngle Type: float
Default: 0

maxAngle Type: float
Default: 359

width Type: int
Default: 256

height Type: int
Default: 256

type Type: int
Default: 0
Values: Polar: 0, Log Polar: 1

Demo iGraph

Operators\Fit\polar.igr

C Prototype

```
CorOpRtn cor_polar(
    CorImage *In,
    CorObj *Centroid,
    CorImage *Out,
    int direction,
    int rBins,
    float minRadius,
    float maxRadius,
    int aBins,
    float minAngle,
    float maxAngle,
    int width,
    int height,
    int type)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

rotate

Rotate an object by an arbitrary angle

Description

The **rotate** operator performs an arbitrary rotation on its input object. The **angle** parameter defines the

angle in degrees where positive angles represent a rotation counter clockwise.

The **mode** parameter can be used to specify the size of the output image. In the *expand* mode the operator will produce an output image at least large enough to accomodate the entire rotated image, with the center pixel of the rotated image corresponding to the center point of the input image. The background area may extend farther than is necessary to contain the original rotated image when the input image is not square. In the *clip* mode the output image is clipped to the original image size and coordinate system. The output image in this mode can be considered a fixed window, behind which the input image is rotated about a specified point.

The center of rotation can be specified as the image center or as a user specified point using the **rotateAbout** parameter. Default center for the graphical object is (0,0). The user specified center of rotation is set with the **rotatePt** parameter. In the *clip* mode, the value of this parameter determines what portion of the image remains in the output image window. The effect in the *expand* mode is more subtle. The output image is enlarged to contain the entire rotated image, as before, and the output image center corresponds approximately to the center pixel of the input image, but the pixel specified by the **rotatePt** parameter corresponds exactly to a pixel in the output image.

When the **antiAliasing** parameter is set to *yes* a linear interpolation method is used to determine pixel values in the rotated image. When this parameter is set to *no* input pixel values are assigned directly to a pixel in the rotated image. This method is faster than the anti-alias method, but pixels are assigned with an accuracy of about +/- 1 pixel rather than the +/- 0.5 pixels that might be expected, due to the limitations of the rotation algorithm used. This may result in noticeable artifacts, particularly in rotation of thin lines.

The background regions in the output image (the regions that correspond to areas outside the input image) must be filled with an appropriate value. When the **background** parameter is set to **auto** the background value is computed as the average of the four corner pixels in the original image. When it is set to **user** the background value is set explicitly using the **bgValue** parameter.

Parameter Information

angle Type: float
Default: 0

sizeOp Type: int
Default: 0
Values: expand: 0, clip: 1

rotateAbout Type: int
Default: 0
Values: center: 0, user: 1

rotatePt Type: CorPoint
Default: (0, 0)

antiAlias Type: int
Default: 1
Values: no: 0, yes: 1

background Type: int
Default: 0
Values: auto: 0, user: 1

bgValue Type: float
Default: 0

Demo iGraph

Operators\Fit\polar.igr

C Prototype

```
CorOpRtn cor_rotate(
    CorObj *In,
    CorObj *Out,
    float angle,
    int sizeOp,
    int rotateAbout,
    CorPoint *rotatePt,
    int antiAlias,
    int background,
    float bgValue
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

scroll

Scroll an object

Description

The **scroll** operator shifts the object along the y-axis by the given amount. The **amount** paramater controls the number of pixels the object is shifted. A positive scroll amount shifts the object downwards. Negative amounts shift the object upwards. In the case of the image pixels shifted off the top or bottom edges wrap around to the bottom or top, respectively.

Parameter Information

amount Type: int
Default: 10

Demo iGraph

Operators\Fit\polar.igr

C Prototype

```
CorOpRtn cor_scroll(
    CorObj *In,
    CorObj *Out,
    int amount
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

shearX

Shear an image along the x-axis by an arbitrary angle

Description

The **shearX** operator performs a shear of the input image along the x-axis by the specified angular amount in the **angle** parameter. The angle is given in degrees where positive angles shear the image clockwise. Shearing constrains an image rotation to a single degree of freedom resulting in a stretching of the image along the x-axis about the given angle. The range of **angle** is [-90, 90].

Parameter Information

angle Type: float
Default: 10

Demo iGraph

Operators\Fit\polar.igr

C Prototype

```
CorOpRtn cor_shearX(
    CorImage *In,
    CorImage *Out,
    float angle
)
```

Headers

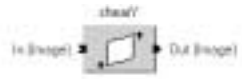
#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

shearY

Shear an image along the y-axis by an arbitrary angle



Description

The **shearY** operator performs a shear of the input image along the y-axis by the specified angular amount in the **angle** parameter. The angle is given in degrees where positive angles shear the image clockwise. Shearing constrains an image rotation to a single degree of freedom resulting in a stretching of the image along the y-axis about the given angle. The range of **angle** is [-90, 90].

Parameter Information

angle Type: float
Default: 10

Demo iGraph

Operators\Fit\polar.igr

C Prototype

```
CorOpRtn cor_shearY(
    CorImage *In,
    CorImage *Out,
    float angle
)
```

Headers

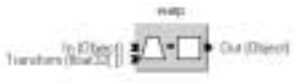
#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

warp

Apply perspective transform matrix to object



Description

The **warp** operator applies a 3x3 spatial transformation matrix to an image or graphical object.

Images are mapped to the transformed space using bilinear interpolation and are clipped to the size of the original input image. The operator will also accept or single objects of the types **Point, Real point, Graphic, Geometry, Line** or **Edge**. The length and angle fields of **Line** objects are adjusted to match the transformed endpoints. The direction, slope and level fields of **Edge** objects remain unchanged. Circles and rectangles are converted to polygons before transformation and the output objects are polygons. The starting position of text objects is transformed but the actual text is not distorted.

The **warp** operator is usually used with a matrix generated by the **getWarpTransform** operator.

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_warp(
    CorObj *In,
    CorFloatVector *Transform,
    CorObj *Out
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

zoomScale

Zoom an object by scaling x and y

Description

The **zoomScale** operator performs arbitrary scaling of the input object. The x and y scaling factors

specified using the **xscale** and **yscale** parameters, respectively.

Images are scaled by sampling the input image at points calculated from the scaling factors, no interpolation is performed. The output image is the same type the input image.

Graphical objects are scaled with respect to the origin (that is, the upper left corner of the image space), so a graphical object scaled by a number greater than one will become larger and move away from the upper left corner. Scaled graphical objects will retain their relative position when overlayed on similarly scaled images. The operator accepts vectors of graphical objects, such as those produced by **getData**, or single objects.

Parameter Information

xscale Type: float
Default: 0.5

yscale Type: float
Default: 0.5

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_zoomScale(
    CorObj *In,
    CorObj *Out,
    float xscale,
    float yscale
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

zoomSize

Zoom an image by setting width and height

Description

The **zoomSize** operator scales the input image to a specific image size. The output image size is specified using the **xsize** and **ysize** parameters. Zero size parameters have no scaling effect.

Images are scaled by sampling the input image at points calculated from the relative dimensions of the input and output images, no interpolation is performed. The output image is the same type as the input image.

Parameter Information

xsize Type: int
Default: 128

ysize Type: int
Default: 128

Demo iGraph

Operators\Fit\warp.igr

C Prototype

```
CorOpRtn cor_zoomSize(
    CorImage *In,
    CorImage *Out,
    int xsize,
    int ysize
)
```

Headers

#include "$(WITHOME)/h/wGeom.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wGeom.lib

Measurement

The Measurement library supports spatial measurement in images or geometric objects. The

library includes operators that calculate distances and angles between geometric objects; and operators that produce distance maps.

caliper

Measure the distance between two edges.

Description

The **caliper** operator measures the distance between two approximately parallel edges in an image. The operator searchs for a line edge near each end of a reference line. The line edge is found by fitting a line to point edges found crossing a number of short lines parallel to the reference line in the neighbourhood of the ends of the reference line. The distance between the line edges is measured using the intersection of the reference line with one or both line edges as measurement points.

The operator's inputs are a gray scale image and the reference line. The reference line must be a line geometric object (Geometry, Graphic, Line or Edge type object). The operator's outputs are an Edge vector containing the two edges found, a float value giving the distance between the measurement points on each edge, and a Graphic vector containing the two measurement points used to determine the distance.

The **measure** parameter is used to specify how the measurement points on the edge lines are determined. Edge line *E0* is the edge line near the first end-point of the reference line, edge line *E1* is the edge line near the second end-point of the reference line, point *P0* is the intersection of the reference line and *E0*, and point *P1* is the intersection of the reference line and *E1*. Setting **measure** to *P0-P1* sets the measurement points to the *P0* and *P1* intersections. Setting the parameter to *P0-E1 (perp to E0)* sets the measurement points to *P0* and the intersection of *E1* and a line through *P0* perpendicular to *E0*. Setting the parameter to *P0-E1 (shortest)* sets the measurement points to *P0* and the point on *E0* nearest to *P0*. Setting the parameter to *MidPoint* sets the measurement points to the intersection of the edge lines and a line through the mid-point of the reference line at an angle that is midway between perpendicular lines to the two edge lines.

The parameters on the **SearchBoxes** subpanel are used to set the box around the end-points of the reference line that will be searched for edges. The search box is a rectangle oriented so that its height is parallel to the reference line and its width is perpendicular to the reference line. A number of lines evenly spaced within the box and parallel to the reference line are searched for edges. The **boxWidth0**, **boxHeight0**, and **numPaths0** parameters set the search lines near the first end of the reference line and b>boxWidth1, **boxHeight1**, and **numPaths1** parameters set the search lines near the second end.

The parameters on the **Edges** subpanel control the edge search along the search lines. The **edgeType0** parameter can be used to direct the search to look for *rising*, *falling* or *unknown* edges. The edge type is relative to the direction from the end-point to the middle of the reference line. If the type is set to *unknown* the operator will chose the direction which produces the strongest edges. A minimum threshold can be set for edge slope, using **slopeThresh0**, and level change, using **levelThresh0**. The **edgeType1**, **slopeThresh1**, and **levelThresh1** parameters apply to the second end of the reference line. The search returns the strongest edge point on each search line that meets both threshold criteria. If no edge points are found at either end of the reference line an error condition occurs. The **subpixel** parameter is used to specify whether the edge point search uses interpolation to find a sub-pixel location for the edge points before fitting to the edge line.

The **subpixel** parameter

Parameter Information

measure	Type: int Default: 0 Values: P0-P1: 0, P0-E1 (perp to E0): 1, P0-E1 (shortest): 2, MidPoint: 3
boxWidth0	Type: int Default: 10

boxHeight0 Type: int
Default: 10

numPaths0 Type: int
Default: 3

boxWidth1 Type: int
Default: 20

boxHeight1 Type: int
Default: 20

numPaths1 Type: int
Default: 3

edgeType0 Type: int
Default: 2
Values: rising: 0, falling: 1, unknown: 2

slopeThresh0 Type: float
Default: 1

levelThresh0 Type: float
Default: 1

edgeType1 Type: int
Default: 2
Values: rising: 0, falling: 1, unknown: 2

slopeThresh1 Type: float
Default: 1

levelThresh1 Type: float
Default: 1

subpixel Type: int
Default: 1
Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_caliper(
    CorImage *i0,
    CorObj *RefLine,
    CorEdgeVector *Edges,
    float *Dist,
    CorGraphicVector *Points,
    int measure,
    int boxWidth0,
    int boxHeight0,
    int numPaths0,
    int boxWidth1,
    int boxHeight1,
    int numPaths1,
    int edgeType0,
    float slopeThresh0,
    float levelThresh0,
    int edgeType1,
    float slopeThresh1,
    float levelThresh1,
    int subpixel)
```

Headers

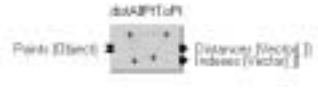
#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

distAllPtToPt

Find the distance between all pairs of points



Description

The **distAllPtToPt** operator calculates the distances between all (or a subset of) the pairs of points in the input point set. The input point set may be a vector of Point, Real Point, or Point Value objects, or a vector of point type Graphic or Geometry objects.

The operator outputs two vectors of vectors, the **Distances** vectors and the **Indexes** vectors. The output vectors contain one vector element for each point in the input vector. Each element of the **Distances** vector if a vector of Real numbers that contains the distances from the point in the corresponding element of the input vector to each other point in the input vector, sorted from the smallest to largest. The **Indexes** vector is made up of Integer vectors in which the elements are the indexes of the points in the input vector that produced the distance in the corresponding element of the **Distances** vector.

The maximum number of distances calculated for each point can be specified using the *maxDistances* parameter. When this parameter is set to a value greater than zero, at most that number of distances and indexes will be included in each element of the output vector. When this parameter is set to zero all distances will be produced.

Parameter Information

maxDistances Type: int
Default: 0

C Prototype

```
CorOpRtn cor_distAllPtToPt(
    CorObj *Points,
    CorVectorVector *Distances,
    CorVectorVector *Indexes,
    int maxDistances
)
```

Headers

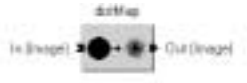
#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

distMap

Produce a distance map from a binary image



Description

The **distMap** operator converts a binary image to a distance map image, in which a pixel's value represents the distance of the pixel from object boundaries in the image.

The **method** parameter is used to specify the type of distance measure used by the operator. Two approximations to Euclidean distance are available, as well as two integer methods. The *Euclidean 3 x 3* and *Euclidean 5 x 5* methods use floating point masks to accurately determine the distance between pixels in 3x3 or 5x5 neighbourhoods, which are accumulated to approximate the Euclidean distance over larger regions. The 3x3 mask limits errors to under 8.0%, the 5x5 mask to under 2.4%. In the *City Block* method the distance is determined to the nearest edge in horizontal and vertical steps. In the *Chess Board* method diagonal steps are also allowed, and all steps are considered to be of unit length.

The **distFrom** parameter is used to specify whether the distance to each pixel is calculated from the nearest background pixel or the nearest foreground pixel. In the first case, all output image pixels corresponding to background (zero valued) pixels in the input image have a distance value of zero and output image pixels corresponding to foreground (non-zero valued) pixels in the input image contain the distance to the nearest background pixel. In the second case, the foreground pixels are set to zero and the background pixels contain the distance to the nearest foreground pixel.

Distance maps can also be produced directly from Graphic objects using the **grDistMap** operator.

Parameter Information

kernelType Type: int
Default: 0
Values: Euclidean 3 x 3: 0, Euclidean 5 x 5: 1, City Block: 2, Chess Board: 3

distFrom Type: int
Default: 0
Values: background: 0, foreground: 1

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_distMap(
    CorImage *In,
    CorImage *Out,
    int kernelType,
    int distFrom
)
```

Headers

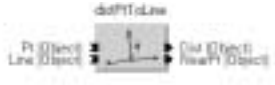
#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

distPtToLine

Measure the distance from point(s) to a line.



Description

The **distPtToLine** operator measures the distance from a point or points to a line. The **Pt** input may be a single point represented by a point type geometric object (Geometry, Graphic, or Edge object type) or a Point or Real Point object, or it may be a number of points represented by a vector of such objects. The **Line**input must a line type geometric object (Geometry, Graphic, or Line object type).

For a single input point, the **Dist** output is a float value that represents the shortest distance from the input point to the line and the **NearestPt** output is a Graphic object representing the point on the line nearest to the input point. For a vector of input points, the outputs are vectors of float and Graphic values that have a one-to-one correspondence to the input points.

If the **extendLine** parameter is set to *No* the distance and nearest point are calculated with respect to the line segment in the **Line** input. If this parameter is set to *Yes* the values are calculated with respect to an infinite length line through the segment endpoints.

If the **directional** parameter is set to *No* the distance values are all positive values indicating the distance of the input point from the line. If the **directional** parameter is set to *Yes* the distance values are positive on the right side of the input line and negative on the left.

Parameter Information

extendLine Type: int
Default: 0
Values: No: 0, Yes: 1

directional Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_distPtToLine(
    CorObj *Pt,
    CorObj *Line,
    CorObj *Dist,
    CorObj *NearPt,
    int extendLine,
    int directional
)
```

Headers

#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

getAngle

Compute the angles between points in a vector

Description

The **getAngle** operator calculates the angles between adjacent points in a vector with respect to a specified vertex point.

The vector of radial points is received at the top input, the vertex at the bottom input. The inputs may be a points, Real points, point type Graphics, point type Geometry objects, or Edge objects with a point type geometry. If the input vector contains *N* points, the output is a vector of *N-1* floating point values representing the angle in degrees between the lines connecting the vertex to points 0 and 1, to 1 and 2, ..., to *N-2* and *N-1*. A zero size vector is produced if the input vector contains fewer than two elements.

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_getAngle(
    CorVector *RadialPoints,
    CorObj *Vertex,
    CorFloatVector *Angles
)
```

Headers

#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

getDist

Compute the distances between points in a vector

Description

The **getDist** operator calculates the distances between adjacent points in a vector of points.

The input may be a vector of Points, Real points, point type Graphics, point type Geometry, or Edge objects with a point type geometry. If the input vector contains *N* points, the output is a vector of *N-1* floating point values representing the distance in pixels between points 0 and 1, 1 and 2, ..., *N-2* and *N-1*. A zero size vector is produced if the input vector contains fewer than two elements.

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_getDist(
    CorVector *Points,
    CorFloatVector *Distances
)
```

Headers

#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

grDistMap

Produce a distance map from a graphic object

Description

The **grDistMap** operator produces a distance map from a graphic object or vector of graphic objects. The output is a float image in which each pixel contains the minimum distance to a graphic object in the input. The size of the output image is specified using the *width* and *height* parameters.

The **fill** parameter determines whether rectangles, circles and polygons are considered to be filled. When this parameter is set to *No* distances are measured from the boundaries of the graphic, regardless of whether the pixels are inside or outside the graphic. When it is set to *Yes* pixels inside a graphic are set to zero. If **fill** is set to *Data*, a graphic is considered filled if its *fillColor.active* field is set.

In some cases, particularly for a large number of graphics and for polygons, a distance map can be created more quickly by rasterizing the graphics with the **rasterize** operator and creating the distance map from the resulting binary image using the **distMap** operator. This approach does, however, produce a less accurate distance map due both to

rasterization and approximations made in the image distance map algorithm.

Parameter Information

width Type: int
Default: 100

height Type: int
Default: 100

fill Type: int
Default: 1
Values: No: 0, Yes: 1, Data: 2

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_grDistMap(
    CorObj *In,
    CorImage *Out,
    int width,
    int height,
    int fill
)
```

Headers

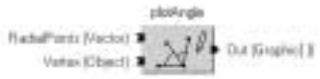
#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

plotAngle

Compute and plot the angles between points in a vector



Description

The **plotAngle** operator calculates the angles between adjacent points in a vector with respect to a specified vertex point and creates a vector of graphic objects which allow the angles to be displayed on an image.

The vector of radial points is received at the top input, the vertex at the bottom input. The inputs may be a Points, Real points, point type Graphics, point type Geometry objects, or Edge objects with a point type geometry. If the input vector contains *N* points, *N-1* angles are calculated for the lines connecting the vertex to points 0 and 1, to 1 and 2, ..., to *N-2* and *N-1*.

A vector of Graphics is created which includes the vertex and radial points and lines connecting them and the angle value in degrees. These may be displayed on an image using the **overlayData** operator.

The color of the graphical objects can be selected from a number of color combinations with the **color** parameter. The points and text are printed in the main color, the connecting lines are printed in the secondary color. The **font**, **fontSize** and **fontStyle** parameters control the output text. If the **font** parameter is set to *no text*, no text is produced.

Parameter Information

color Type: int
Default: 0
Values: red/yellow: 0, yellow/green: 1, aqua/blue: 2, white/yellow: 3, black/blue: 4

font Type: int
Default: 0
Values: helvetica: 0, times: 1, courier: 2, no text: 3

fontSize Type: int
Default: 12

fontStyle Type: int
Default: 0
Values: normal: 0, bold: 1, italic: 2, bold italic: 3

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_plotAngle(
    CorVector *RadialPoints,
    CorObj *Vertex,
    CorGraphicVector *Out,
    int color,
    int font,
    int fontSize,
    int fontStyle
)
```

Headers

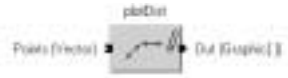
#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

plotDist

Compute and plot the distances between points in a vector



Description

The **plotDist** operator calculates the distances between adjacent points in a vector of points and creates a vector of graphic objects which allow the distances to be displayed on an image.

The input may be a vector of Points, Real points, point type Graphics, point type Geometry objects, or Edge objects with a point type geometry. If the input vector contains *N* points, *N-1* floating point values are calculated for the distances in pixels between points 0 and 1, 1 and 2, ..., *N-2* and *N-1*.

A vector of Graphics is created which includes the points and lines connecting them and the distance between points in pixels as text. These may be displayed on an image using the **overlayData** operator.

The color of the graphical objects can be selected from a number of color combinations with the **color** parameter. The points and text are printed in the main color, the connecting lines are printed in the secondary color. The **font**, **fontSize** and **fontStyle** parameters control the output text. If the **font** parameter is set to *no text*, no text is produced.

Parameter Information

color Type: int
Default: 0
Values: red/yellow: 0, yellow/green: 1, aqua/blue: 2, white/yellow: 3, black/blue: 4

font Type: int
Default: 0
Values: helvetica: 0, times: 1, courier: 2, no text: 3

fontSize Type: int
Default: 12

fontStyle Type: int
Default: 0
Values: normal: 0, bold: 1, italic: 2, bold italic: 3

Demo iGraph

Operators\Measurement\CircleCenters
Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_plotDist(
    CorVector *Points,
    CorGraphicVector *Out,
    int color,
    int font,
    int fontSize,
    int fontStyle
)
```

Headers

#include "$(WITHOME)/h/wMeas.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMeas.lib

Morphology

The Morphology library supports morphological and other non-linear neighbourhood operations on images. The library includes binary and grayscale erosion, dilation and related morphological operators; and median and rank operators.

bmedian

Binary median filter

Description

The **bmedian** operator performs median filtering on binary images. The operator sets a pixel in the output image true if the majority of the selected neighbourhood pixels are true, and false if they are not. The pixels to be used can be selected using a structuring element defined by the **kernel** parameter.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Parameter Information

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

C Prototype

```
CorOpRtn cor_bmedian(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_bmedian_consume(
    CorImage *In,
    CorIntImage *kernel,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

dilate

Morphological dilation

Description

The **dilate** operator performs binary or gray scale morphological dilation on images. Binary dilation tends to add pixels to the edges of objects in the image. Gray scale erosion sets each pixel to the maximum pixel value in its neighbourhood and is sometimes refered to as a maximum filter.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Binary or gray scale dilation is selected using the **type** parameter. The input for binary dilation must be an 8 bit unsigned image. The result is a binary 8 bit unsigned image. For gray scale dilation the input may be any integer or float gray scale image or color in the case **optimisation** is **speed**. The output image is a gray scale image of the same type as the input image.

The **kernelType** parameter is used to select the type of structuring element or neighbourhood specifying kernel used. The structuring element may be specified as a rectangular region, with the size of the region is given by the **width** and **height** parameters; or it may be specified as an arbitrary

region, in which case the neighbourhood is specified using the **kernel** parameter. Dilation by a rectangular structuring element is usually much faster than dilation by an arbitrary element, particularly for larger neighbourhoods. One common exception is dilation by 3x3 structuring elements, where the arbitrary kernel usually is faster.

Binary dilation tends to make objects larger, connecting discontinous objects and filling in holes. The kernel, either rectangular or arbitrary, specifies the structuring element which will control the dilation. The center of the kernel is always in row *height*/2 and column *width*/2. For each pixel *p* in the input image, if any pixel in the neighbourhood of *p*, as defined by the kernel dimensions, is on and the corresponding entry in the kernel is also on, then the output pixel corresponding to *p* will be set. In other words, the kernel defines a mask which is layed over the input image with its center aligned on a pixel at row *r* and column *c*. The output pixel at *r* and *c* will be set if any input pixel is set and the corresponding bit in the kernel mask is also set. For example,

```
Input:
0 0 0 0 0
0 1 1 0 0
0 1 1 1 0
0 0 1 1 0
0 0 0 0 0

1) Kernel: 0 1 1
   Output:
   0 0 0 0 0
   1 1 1 0 0
   1 1 1 1 0
   0 1 1 1 0
   0 0 0 0 0

2) Kernel: 1 1 0
   Output:
   0 0 0 0 0
   0 1 1 1 0
   0 1 1 1 1
   0 0 1 1 1
   0 0 0 0 0

3) Kernel: 1 1
           1 0
   Output:
   0 1 1 0 0
   1 1 1 1 0
   1 1 1 1 0
   0 1 1 1 0
   0 0 0 0 0
```

In the first example, the output is only grown to the left of the input object because the kernel, when aligned with any input pixel, will set the output only if either the pixel corresponding to kernel center is set, or the pixel one to the right of that input pixel is set. In a similar fashion, the second example grows the object to the right. The third example uses a kernel of size 2x2, with its center, being the top left bit in the kernel. The resulting output object has been grown to the left and top of the input object.

The implementation of dilation used in WiT is defined in the paper by Haralick, Sternberg and Zhuang, IEEE Transactions on Pattern Analysis and Machine Intelligence, July 1987. Border conditions are handled by assuming all pixels outside of the input image have zero value. Note that when the center of the kernel is zero, it is possible for dilation to clear an output pixel even if the input pixel is set.

Greyscale dilation is performed by computing the maximum value within every neighbourhood of the input image. As with binary dilation, only those pixels whose corresponding kernel bits are set are used to determine the local maxima.

Pixels beyond the image boundary are assumed to be the minimum value possible for the type of image being processed. This means that they will have no effect when dealing with a maximum calculation.

Given a grayscale image *I*, the following identity holds for **binary dilate** and **gray scale dilate**:

threshold(gray scale dilate(I)) = binary dilate(threshold(I))

Parameter Information

type	Type: int Default: 0 Values: Binary: 0, Grayscale: 1
kernelType	Type: int Default: 0 Values: Rectangular: 0, Arbitrary: 1
width	Type: int

Default: 7

height Type: int
Default: 7

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

C Prototype

```
CorOpRtn cor_dilate(
    CorImage *In,
    CorImage *Out,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_dilate_consume(
    CorImage *In,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
```

Headers

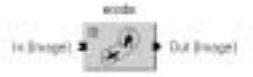
#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

erode

Morphological erosion



Description

The **erode** operator performs binary or gray scale morphological erosion on images. Binary erosion removes pixels from the edges of objects in the image. Gray scale erosion sets each pixel to the minimum pixel value in its neighbourhood and is sometimes refered to as a minimum filter.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Binary or gray scale erosion is selected using the **type** parameter. The input for binary erosion must be an 8 bit unsigned image. The result is a binary 8 bit unsigned image. For gray scale erosion the input may be any integer or float gray scale image or color in the case **optimisation** is **speed**. The output image is a gray scale image of the same type as the input image.

The **kernelType** parameter is used to select the type of structuring element or neighbourhood specifying kernel used. The structuring element may be specified as a rectangular region, with the size of the region is given by the **width** and **height** parameters; or it may be specified as an arbitrary region, in which case the neighbourhood is specified by the non-zero elements in the **kernel** array. Erosion by a rectangular structuring element is usually faster than erosion by an arbitrary element, particularly for larger neighbourhoods. One common exception is erosion by 3x3 structuring elements, where the arbitrary kernel usually is faster.

Binary erosion tends to make objects in the binary image smaller, separating objects that are touching and removing isolated pixels. The kernel, either rectangular or arbitrary, specifies the structuring element which will control the erosion. The center of the kernel is always in row *height*/2 and column *width*/2. For each pixel *p* in the input image, if every pixel in the neighbourhood of *p*, as defined by the kernel dimensions, is on and the corresponding entry in the kernel is also on, then the output pixel corresponding to *p* will be set. Otherwise, it will be cleared. In other words, the kernel defines a mask which is layed over the input image with its center aligned on a pixel at row *r* and column *c*. The output pixel at *r* and *c* will be set if every

combination input pixel is set and its corresponding bit in the kernel mask is also set. For example,

```
Input:
0 0 0 0 0
0 1 1 0 0
0 1 1 1 0
0 0 1 1 0
0 0 0 0 0

1) Kernel: 0 1 1
   Output:
   0 0 0 0 0
   0 1 0 0 0
   0 1 1 0 0
   0 0 1 0 0
   0 0 0 0 0

2) Kernel: 1 1 0
   Output:
   0 0 0 0 0
   0 0 1 0 0
   0 0 1 1 0
   0 0 0 1 0
   0 0 0 0 0

2) Kernel: 1 1
           1 0
   Output:
   0 0 0 0 0
   0 1 0 0 0
   0 0 1 0 0
   0 0 0 0 0
   0 0 0 0 0
```

In the first example, the output is only reduced on the right side of the input object because the kernel, when aligned with any input pixel, will set the output only if both the pixel corresponding to the kernel center is set and if the pixel one to the right of that input pixel is set. In a similar fashion, the second example reduces the object on the left side. The third example uses a kernel of size 2x2, with its center, being the top left bit in the kernel. The resulting output object has been reduced to only two pixels because only two set pixels in the input object have neighbours below and to the right which are both set. All other pixels are cleared.

The implementation of erosion used in WiT is defined in the paper by Haralick, Sternberg and Zhuang, IEEE Transactions on Pattern Analysis and Machine Intelligence, July 1987. Border conditions are handled by assuming all pixels outside of the input image have non-zero value. Note that when the center of the kernel is zero, it is possible for erosion to set an output pixel even if the input pixel is zero.

Greyscale erosion is performed by computing the minimum value within every neighbourhood of the input image. As with binary erosion the neighbourhhod may be either a rectangular region centred on the pixel or arbitrary pixels specified by the **kernel** parameter array. Pixels beyond the image boundary are assumed to be the maximum value possible for the type of image being processed. This means that they will have no effect when dealing with a minimum calculation.

Given a grayscale image *I*, the following identity holds for **binary erode** and **gray scale erode**:

threshold(gray scale erode(I)) = binary erode(threshold(I))

Parameter Information

type Type: int
Default: 0
Values: Binary: 0, Grayscale: 1

kernelType Type: int
Default: 0
Values: Rectangular: 0, Arbitrary: 1

width Type: int
Default: 7

height Type: int
Default: 7

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

C Prototype

```
CorOpRtn cor_erode(
    CorImage *In,
    CorImage *Out,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_erode_consume(
    CorImage *In,
```

```
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

hitOrMiss

Hit or miss filter

Description

The **hitOrMiss** operator performs a hit or miss type binary pattern matching operation on an image. If the pixels in the neighbourhood of a given pixel match the pattern of pixels specified in the kernel then the corresponding pixel in the output image is set to the image maximum, otherwise it is set to zero.

The **kernel** parameter allows the user to specify the pattern. Kernel elements set to 0 match 0 value pixels in the input image, kernel elements set to 1 (or any positive integer) match non-zero pixels in the input image, and kernel elements set to -1 (or any negative integer) match all pixel values in the input image.

The input and output of the **hitOrMiss** operator are both 8 bit unsigned images.

Parameter Information

structElem Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_hitOrMiss(
    CorImage *In,
    CorImage *Out,
    CorIntImage *structElem
)
CorOpRtn cor_hitOrMiss_consume(
    CorImage *In,
    CorIntImage *structElem
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

ldilate

Labeled image dilation

Description

The **ldilate** operator dilates labeled images, maintaining image pixel values in the dilated images. The effect of this operator is the equivalent to applying the **bdilate** binary dilation operator to the pixels at each distinct non-zero pixel value in the image and assigning the pixel value to the active pixels in the output image, except where a pixel would be assigned more than one distinct value, in which case it is set to zero. The result is that the regions in the image are dilated, with equal valued regions growing together and different valued regions remaining distinct. Zero valued pixels may or may not be maintained between adjacent regions of different values, depending on the size of the kernel (structuring element) and the distance between the edges of the regions in the input image.

Parameter Information

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_ldilate(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel
)
CorOpRtn cor_ldilate_consume(
    CorImage *In,
    CorIntImage *kernel
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

lerode

Labeled image erosion

Description

The **lerode** operator erodes labeled images, maintaining image pixel values in the eroded images. The effect of this operator is the equivalent to applying the **berode** binary erosion operator to the pixels at each distinct non-zero pixel value in the image and assigning the pixel value to the active pixels in the output image. The result is that the equal valued regions in the image are eroded, with adjacent regions with different pixel values being separated.

Parameter Information

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_lerode(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel
)
CorOpRtn cor_lerode_consume(
    CorImage *In,
    CorIntImage *kernel
)
```

Headers

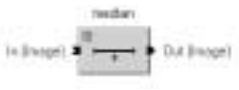
#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

median

Median filter



Description

The **median** operator performs median filtering on greyscale images. The operator sets each pixel in the output image to the median value, determined over all selected pixels, in the neighbourhood of that pixel. The pixels to be used are selected using a structuring element defined by the **kernel** parameter. For more on the use of the kernel, consult the documentation or help for the **berode** and **bdilate** operators.

The **median** operator is useful for removing isolated lines of pixels while preserving spatial

resolutions. Its performance is poor when the number of noise pixels in the neighborhood is greater than half the number of pixels in the neighborhood. Median filtering performs very well on images containing binary noise but performs poorly when the noise is Gaussian. For example, the kernel:

```
1 0 1
0 1 0
1 0 1
```

is very good at removing vertical and horizontal binary noise lines.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Parameter Information

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_median(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_median_consume(
    CorImage *In,
    CorIntImage *kernel,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

morphClose

Morphological closing

Description

The **morphClose** operator performs binary or gray scale morphological closing on images. Binary opening tends to fill small holes or gaps in larger objects, without making the larger objects larger. Binary closing is implemented by applying binary dilation followed by binary erosion to the image. Gray scale closing tends to increase reduce pixel values in small regions with low values relative to the surrounding area without increasing the value at the edges of large low valued regions. Gray scale closing is implemented by applying gray scale dilation followed by gray scale erosion to the image.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Binary or gray scale closing is selected using the **type** parameter. The input for binary closing must be an 8 bit unsigned image. The result is a binary 8 bit unsigned image. For gray scale closing the input may be any integer or float gray scale image or color in the case **optimisation** is **speed**. The output image is a gray scale image of the same type as the input image.

The **kernelType** parameter is used to select the type of structuring element or neighbourhood specifying kernel used. The structuring element may be specified as a rectangular region, with the size of the region is given by the **width** and **height** parameters; or it may be specified as an arbitrary

region, in which case the neighbourhood is specified using the **kernel** parameter as described in the **erode** or **dilate** documentation. Closing by a rectangular structuring element is usually faster than closing by an arbitrary element, particularly for larger neighbourhoods. One common exception is closing by 3x3 structuring elements, where the arbitrary kernel usually is faster.

Parameter Information

type Type: int
Default: 0
Values: Binary: 0, Grayscale: 1

kernelType Type: int
Default: 0
Values: Rectangular: 0, Arbitrary: 1

width Type: int
Default: 7

height Type: int
Default: 7

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_morphClose(
    CorImage *In,
    CorImage *Out,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_morphClose_consume(
    CorImage *In,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

morphGradient

Morphological gradient

Description

The **morphGradient** operator enhances edges in an image by subtracting the erosion of the input image from the dilation of the input image.

If the **type** parameter is set to *GrayScale*, the pixel values in the output image are the difference between the neighbourhood maximum and the neighbourhood minimum pixel values in the input. In the *GrayScale* mode the input image may be a gray scale or RGB image. The output image type is unsigned 8-bit for unsigned or signed 8-bit inputs; signed 16-bit for unsigned or signed inputs (saturation may occur); and the same type as the input for float or RGB inputs.

If the **type** parameter is set to *Binary*, pixels in the output image are non-zero if they are non-zero in the binary dilation of the input image and zero in the binary erosion of the input image. The input image may be an unsigned 8-bit, unsigned 16-bit image or RGB image. The output image is the same type as the input image.

For unsigned or signed 8-bit and float input images the **optimization** parameter may be set either to *preciseness* or to *speed*. For unsigned or signed 16-bit images the **optimization** parameter must be set to *preciseness* and for RGB images the **optimization** parameter must be set to *speed*.

The neighbourhood used for the dilation and erosion operations is specified by the **kernelType**, **width**, **height** and **kernel** parameters as described for the **erode** and **dilate** operators.

Parameter Information

type	Type: int Default: 1 Values: Binary: 0, Grayscale: 1
kernelType	Type: int Default: 1 Values: Rectangular: 0, Arbitrary: 1
width	Type: int Default: 7
height	Type: int Default: 7
kernel	Type: CorImage Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]
optimization	Type: int Default: 1 Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_morphGradient(
    CorImage *In,
    CorImage *Out,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_morphGradient_consume(
    CorImage *In,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

morphOpen

Morphological opening

Description

The **morphOpen** operator performs binary or gray scale morphological opening on images. Binary opening tends to remove small isolated pixels or small regions extending from larger objects, without making the larger objects smaller. Binary opening is implemented by applying binary erosion followed by binary dilation to the image. Gray scale opening tends to reduce pixel values in small high valued regions without reducing the value at the edges of large high valued regions. Gray scale opening is implemented by applying gray scale erosion followed by gray scale dilation to the image.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Binary or gray scale opening is selected using the **type** parameter. The input for binary opening must be an 8 bit unsigned image. The result is a binary 8 bit unsigned image. For gray scale opening the input may be any integer or float gray scale image or color in the case **optimisation** is **speed**. The output image is a gray scale image of the same type as the input image.

The **kernelType** parameter is used to select the type of structuring element or neighbourhood specifying kernel used. The structuring element may be specified as a rectangular region, with the size of the region is given by the **width** and **height** parameters; or it may be specified as an arbitrary region, in which case the neighbourhood is

specified using the **kernel** parameter as described in the **dilate** or **erode** operator documentation. Opening by a rectangular structuring element is usually faster than opening by an arbitrary element, particularly for larger neighbourhoods. One common exception is opening by 3x3 structuring elements, where the arbitrary kernel usually is faster.

Parameter Information

type Type: int
Default: 0
Values: Binary: 0, Grayscale: 1

kernelType Type: int
Default: 0
Values: Rectangular: 0, Arbitrary: 1

width Type: int
Default: 7

height Type: int
Default: 7

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_morphOpen(
    CorImage *In,
    CorImage *Out,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
CorOpRtn cor_morphOpen_consume(
    CorImage *In,
    int type,
    int kernelType,
    int width,
    int height,
    CorIntImage *kernel,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

outline

Binary outline filter

Description

The **outline** operator generates a one pixel wide outline of objects in the binary input image. The outline algorithm looks at every 3x3 neighborhood and based on white/black pixel arrangements, determines whether a pixel is a boundary pixel or a foreground/background pixel.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Parameter Information

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_outline(
    CorImage *In,
    CorImage *Out,
    int optimization
)
CorOpRtn cor_outline_consume(
    CorImage *In,
```

```
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

rank

Rank filter

Description

The **rank** operator performs rank filtering on greyscale images. The operator sets each pixel in the output image to the pixel value in the neighbourhood nearest to a specified percentile calculated over the neighbourhood.

The **rank** parameter sets the percentile value. The pixels to be used are selected using a structuring element defined by the **kernel** parameter. For more on the use of the kernel, consult the documentation or help for the **berode** and **bdilate** operators.

When the **optimization** parameter is set to *speed* and the kernel is rectangular (ie contains no zero entries) a faster, less precise algorithm is used. For signed or unsigned byte images the results vary only where the neighbourhood extends outside ROI boundary. For other image types, the rank is also computed at reduced precision in the *speed* mode.

The **rank** operator is a generalization of other gray scale morphology operators. With the **rank** parameter set to 50 the **rank** operator is equivalent to the **median** operator, set to 0 it is equivalent to the the **gerode** operator and set to 100 it is equivalent to the **gdilate** operator.

Parameter Information

kernel Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

rank Type: int
Default: 50
Values: 0 — 100

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\hitormiss.igr

C Prototype

```
CorOpRtn cor_rank_1(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel,
    int rank,
    int optimization
)
CorOpRtn cor_rank_1_consume(
    CorImage *In,
    CorIntImage *kernel,
    int rank,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

skeleton

Thin binary image with skeleton constraint

Description

The **skeleton** operator is used to remove pixels from objects in a binary input image until a single pixel

wide skeleton is reached. On each pass objects in the image are eroded by a one pixel wide boundary, provided the pixels are not part of a single pixel wide skeleton. After each execution of this operator, an output image is generated at the top output port along with a **pixelsRemoved** value at the bottom output port. This value represents the number of pixels removed from the image and is an integer object. When the **pixelsRemoved** value reaches zero the objects have reduced to a single pixel wide skeleton.

The **numPasses** parameter controls the number of erosion operations applied to the input image. If this value is set to zero, the image will be eroded until no more pixels are removed and the skeleton image is produced.

Single pixel wide skeletons can also be produced by applying the **skeleton** operator iteratively, using the **if** operator controlled by the value of **pixelsRemoved** output. The **if** *true* branch is connected to the skeleton operator input and the **if** *conditional* parameter port is connected to the **pixelsRemoved** output port. Skeletons will appear out the *false* branch when **pixelsRemoved** reaches zero. By setting a probe on the output of the skeleton operator, one can watch the image gradually collapse to its skeletal form.

Parameter Information

numPasses Type: int
Default: 1

Demo iGraph

Operators\Morphology\skeleton.igr

C Prototype

```
CorOpRtn cor_skeleton(
    CorImage *In,
    CorImage *Out,
    int *PixelsRemoved,
    int numPasses
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

thicken

Binary thickening filter

Description

The **thicken** operator performs a thickening type binary pattern matching operation on an image. If the pixels in the neighbourhood of a given pixel match the pattern of pixels specified in the kernel then the corresponding pixel in the output image is set to the image maximum, otherwise it is unchanged.

The **kernel** parameter allows the user to specify the pattern. Kernel elements set to 0 match 0 value pixels in the input image, kernel elements set to 1 (or any positive integer) match non-zero pixels in the input image, and kernel elements set to -1 (or any negative integer) match all pixel values in the input image.

The input and output of the **thicken** operator are both 8 bit unsigned images.

Parameter Information

structElem Type: CorImage
Default: [0, 0, 0, 0, 0, 0, 0, 0, 0]

Demo iGraph

Operators\Morphology\skeleton.igr

C Prototype

```
CorOpRtn cor_thicken(
    CorImage *In,
    CorImage *Out,
    CorIntImage *structElem
)
CorOpRtn cor_thicken_consume(
```

```
    CorImage *In,
    CorIntImage *structElem
)
```

Headers

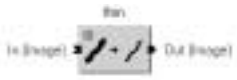
#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

thin

Binary thinning filter



Description

The **thin** operator performs a thinning type binary pattern matching operation on an image. If the pixels in the neighbourhood of a given pixel match the pattern of pixels specified in the kernel then the corresponding pixel in the output image is set to zero, otherwise it is unchanged.

The **kernel** parameter allows the user to specify the pattern. Kernel elements set to 0 match 0 value pixels in the input image, kernel elements set to 1 (or any positive integer) match non-zero pixels in the input image, and kernel elements set to -1 (or any negative integer) match all pixel values in the input image.

The input and output of the **thin** operator are both 8 bit unsigned images.

This operator could be executed in two modes. The user may choose the mode by using the **optimization** parameter. If the parameter value is **speed** then execution goes way faster, otherwise operator delivers more precise results.

Parameter Information

structElem Type: CorImage
Default: [1, 1, 1, 1, 1, 1, 1, 1, 1]

optimization Type: int
Default: 1
Values: preciseness: 0, speed: 1

Demo iGraph

Operators\Morphology\skeleton.igr

C Prototype

```
CorOpRtn cor_thin(
    CorImage *In,
    CorImage *Out,
    CorIntImage *structElem,
    int optimization
)
CorOpRtn cor_thin_consume(
    CorImage *In,
    CorIntImage *structElem,
    int optimization
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

tophat

Tophat filter

Description

The **tophat** operator finds pixels which exceed a threshold relative to specified pixels in their neighbourhood. The neighbourhood pixels that are considered are specified by the kernel parameter. Neighbourhood pixels that correspond to 1's in the kernel are active while those corresponding to 0's in the kernel are ignored.

A pixel in the output image is set if the value of the corresponding pixel in the input image is greater than or equal to the maximum of the active neighbourhood pixels plus the **threshold** for positive thresholds or less than or equal to the minimum of the active neighbourhood pixels plus the **threshold** for negative thresholds. All other pixels in the output image are set to zero. If the **overlay** parameter is turned on the set pixels are assigned the value of the corresponding pixel in the input image, otherwise the set pixels are assigned the maximum image value.

The **tophat** operator requires an 8 or 16 bit unsigned image as its input and produces an output image of the same type as the input.

Parameter Information

kernel Type: CorImage
Default: [0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 0]

threshold Type: float
Default: 10

overlay Type: int
Default: 0
Values: off: 0, on: 1

Demo iGraph

Operators\Morphology\skeleton.igr

C Prototype

```
CorOpRtn cor_tophat(
    CorImage *In,
    CorImage *Out,
    CorIntImage *kernel,
    float threshold,
    int overlay
)
CorOpRtn cor_tophat_consume(
    CorImage *In,
    CorIntImage *kernel,
    float threshold,
    int overlay
)
```

Headers

#include "$(WITHOME)/h/wMorpho.h"

Libraries

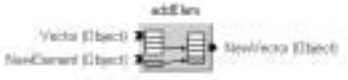
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMorpho.lib

Objects

The Objects library provides functions to manipulate WiT objects and handle elements in vectors and fields in compound objects. The library includes operators that create objects; operators that read and write to fields in compound objects; and operators that insert, extract or reorder elements of vectors.

addElem

Add an element to a vector



Description

The **addElem** operator appends the object at the **NewElement** input port to the vector at the **Vector** input port. The type of the object to be added must be the same as the type of objects currently stored in the input vector.

The position at which the element is added can be specified to be the first, the last or an intermediate element of the vector or list using the **method** parameter. If the **byElement** option is selected, then the **element** parameter is used to specify the position at which the element is added, with the first element indexed by zero. Selecting **byElement** with **element** set to zero is equivalent to selecting **First**.

Parameter Information

method Type: int
Default: 0
Values: first: 0, last: 1, byElement: 2

element Type: int
Default: 0

C Prototype

```
CorOpRtn cor_addElem(
    CorObj *Vector,
    CorObj *NewElement,
    CorObj *NewVector,
    int method,
    int element
)
```

Headers

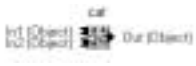
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

cat

Concatenate objects



Description

The **cat** operator concatenates two input objects. The objects must be either vectors, integers, files or strings, and both objects must be the same type. The nature of the concatenation depends on the type of the input objects.

If the input objects are vectors, the elements of the second vector (from the **In2** input port) are added to the end of the first vector (from the **In1** input port). The elements of the two vectors must be the same type. If integers are given, then the output is a Point, with the integer from the **In1** input port the *x* coordinate and the integer from the **In2** port the *y* coordinate. If strings or files are presented as inputs, then the output is a concatenated string. For example, you may want to build up a file name with using **splitDir**, **constant** and **cat**.

C Prototype

```
CorOpRtn cor_concat(
    CorObj *In1,
    CorObj *In2,
    CorObj *Out
)
```

Headers

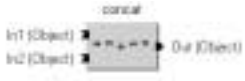
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

concat

Concatenate objects



Description

The **concat** operator concatenates two input objects. The objects must be either vectors, integers, files or strings, and both objects must be the same type. The nature of the concatenation depends on the type of the input objects.

If the input objects are vectors, the elements of the second vector (from the **In2** input port) are added to the end of the first vector (from the **In1** input port). The elements of the two vectors must be the same type. If integers are given, then the output is a Point, with the integer from the **In1** input port the *x* coordinate and the integer from the **In2** port the *y* coordinate. If strings or files are presented as inputs, then the output is a concatenated string. For example, you may want to build up a file name with using **splitDir**, **constant** and **concat**.

C Prototype

```
CorOpRtn cor_concat(
    CorObj *In1,
    CorObj *In2,
    CorObj *Out
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

const

Generates a basic constant object when triggered

Description

The **const** operator generates a constant object every time an input is received. If the *type* parameter is blank, the value and type of the object are determined from the **const** parameter based on these rules:

***constant* parameter**	**Type**
Only digits (no decimal point) e.g. 3048	int32
Only digits (with decimal point) e.g. 3.1416	float32
One quoted character, e.g. 'a'	char
First character is not a digit, e.g. abcde105	String
( )'s with integers for x and y, e.g. (5, 10)	Point

You can specify the type of the output object by setting the *type* parameter to the type you want. This also works for compound objects too. Examples:

***type* parameter**	***constant* parameter**	**Output object**
uint16	7	7
hex8	8	0x8
	cd	0xcd
	0x7A	0x7a
String	+ \"hello there\"	hello there
	+ \"I have \\\" quotes\"	I have " quotes
	-	NULL
Real point	(4.5, 6.2)	x=4.5, y=6.2
Complex	(4.5e-5, 6.2e3)	real=0.00045, imag=6200
RGB	(255, 128, 128, 0)	R=255, G=128, B=128

Other simple object types can be generated using the **cast** operator with the **concat** operator. More complex objects can be created using the **crObject** operator.

Parameter Information

constant Type: CorString
Default: ""

type Type: CorString
Default: ""

C Prototype

```
CorOpRtn cor_const(
    CorObj *Const,
    CorString constant,
    CorString type
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

crGraphic

Create a graphic object

Description

The **crGraphic** operator constructs a new graphic object any time it receives an input. The type of the new graphic is set by the **graphicType** parameter.

Graphic objects require a point list which identify the location of the object and in some cases other parameters of the object (e.g. radius of a circle). The point list for a graphic object is entered by selecting the **Edit** panel for the **points** parameter. This panel presents an array editor where each row in the array represents a point. The first column is the *x* coordinate and the second is the *y* coordinate.

A single point is required to specify a *Point* location. A single point is also used to designate the starting position for *Text*. Two endpoints are required for a *Line*. *Polyline* and *Polygon* types use a variable length list of points to designate vertices where at least one point is required.

A *Rectangle* is specified by two points representing the upper left and lower right corners of the rectangle. A *Circle* is specified by two points, with the first point the center of the circle and the *x* coordinate of the second point the radius. The *y* coordinate of the second point is not used.

An *Arc* object represents an elliptical arc. It requires four points in its point list. The first, second and fourth points specify the underlying ellipse or circle for the arc. The third point defines the part of the ellipse covered by the arc.

First point in the point list represents the center of the ellipse. The *x* coordinate of the second point is half the length of the major axis of the ellipse (typically called *a*) and the *y* coordinate is half the length of the minor axis of the ellipse (typically called *b*). If the *y* coordinate is set to zero, the underlying ellipse is a circle with the radius specified by the *x* coordinate of this point. The *x* coordinate of the fourth point is the angle of the major axis of the ellipse, clockwise from the x axis in degrees.

The *x* coordinate of the third point represents the angle of the starting point of the arc on the ellipse with respect to the major axis. The *y*coordinate represents the angle subtended by the arc. These angles values represent the angles after normalizing the ellipse to a circle.

An If the number of rows in the **points** array is less than the number of points required by the graphic object, the missing points will be set to *(0, 0)*. If the number of rows is greater than the number of points needed, the extra points will be ignored.

The color of the output graphics can be controlled using parameters on the **Color** subpanel. The drawing method can be specified using the **outline** and **fill** parameters. The outline and fill colors can be chosen with the **penR**, **penG** and **penB** parameters and **fillR**, **fillG** and **fillB** parameters. If **fill** alone is chosen, the filled object includes the outline. If both **outline** and **fill** are chosen the outline color is written over the fill color on the object outline.

When *Text* is selected, a text string can be entered using the **text** parameter of the **Text** subpanel. The font characteristics for the text can be set using the **font**, **fontSize** and **fontStyle** parameters.

Parameter Information

graphicType Type: int
Default: 0
Values: Point: 0, Line: 1, Polyline: 2, Polygon: 3, Rectangle: 4, Circle: 5, Text: 6, Arc: 7

points Type: CorImage
Default: [0, 0]

outline Type: int
Default: 1
Values: off: 0, on: 1

penR Type: int
Default: 255
Values: 0 — 255

penG Type: int
Default: 0
Values: 0 — 255

penB Type: int
Default: 0

Values: 0 — 255

fill Type: int
Default: 0
Values: off: 0, on: 1

fillR Type: int
Default: 0
Values: 0 — 255

fillG Type: int
Default: 0
Values: 0 — 255

fillB Type: int
Default: 0
Values: 0 — 255

text Type: CorString
Default: ""

font Type: int
Default: 0
Values: helvetica: 0, times: 1, courier: 2

fontSize Type: int
Default: 12

fontStyle Type: int
Default: 0
Values: normal: 0, bold: 1, italic: 2, bold italic: 3

C Prototype

```
CorOpRtn cor_crGraphic(
    CorObj *Graphic,
    int graphicType,
    CorIntImage *points,
    int outline,
    int penR,
    int penG,
    int penB,
    int fill,
    int fillR,
    int fillG,
    int fillB,
    CorString text,
    int font,
    int fontSize,
    int fontStyle)
```

Headers

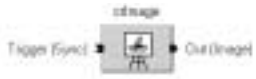
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

crImage

Create a image



Description

The **crImage** operator generates a new image every time an object is received at its input. Image values can be set to a constant or to a ramp in the *x* or *y* direction.

The image size is specified by the **width** and **height** parameters. The image type can be selected from among unsigned 8 or 16 bit integer image, float image or RGB color image using the **type** parameter.

The image values are set using the **fillType** parameter. Selecting the *fillval* option will set all image pixels to the value specified in the **fillval** parameter. The value will be clipped if it is outside the range of the selected image type. Selecting the *h-ramp* option will generate a ramp in the *x* direction. The pixel values increase linearly from 0 in the leftmost column of the image to a maximum at the rightmost column. The maximum value is 256 for 8-bit integer, float and RGB images and 65536 in 16-bit integer. A similar ramp is generated in the *y* direction when *v-ramp* is selected.

Parameter Information

width Type: int
Default: 100

height Type: int
Default: 100

type Type: int
Default: 0
Values: 8-bit: 0, 16-bit: 1, float: 2, color: 3

fillType Type: int

Default: 0
Values: fillval: 0, h-ramp: 1, v-ramp: 2

fillval Type: int
Default: 0

C Prototype

```
CorOpRtn cor_crImage(
    CorImage *Out,
    int width,
    int height,
    int type,
    int fillType,
    int fillval
)
```

Headers

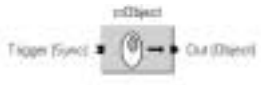
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

crObject

Create an object of any type



Description

The **crObject** operator creates an object of any type, including user created objects. The **value** parameter allows the specification of the type of object to be created and its value.

Parameter Information

value Type: CorObj

C Prototype

```
CorOpRtn cor_crObject(
    CorObj *Out,
    CorObj *value
)
```

Headers

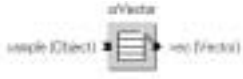
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

crVector

Create a vector of same type as input



Description

Create a vector of the same type as the input object. For example, if the input object is an integer, then the vector created will be a vector of integers. The number of elements is specified by the **num** parameter. All the elements are set to zero.

Parameter Information

num Type: int

C Prototype

```
CorOpRtn cor_crVector(
    CorObj *sample,
    CorVector *vec,
    int num
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

createRect

Create a rectangle graphic object

Description

The **createRect** operator creates a rectangular **Graphic** object from the coordinates specified by the **p1** and **p2** parameters. The two points, **p1** and **p2**, provide the coordinates for two vertices of a rectangle. All coordinates must be positive integers. This operator may be used with the **extract** operator to extracting an exact area-of-interest from an image, for example.

Parameter Information

p1 Type: CorPoint
Default: (0, 0)

p2 Type: CorPoint
Default: (64, 64)

C Prototype

```
CorOpRtn cor_createRect(
    CorGraphic **Rect,
    CorPoint *p1,
    CorPoint *p2
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

filter

Filter objects by type

Description

The **filter** operator takes input objects and outputs the same object to one of two output ports depending on whether the object type matches a set of specified types given by the parameters. If the input object equals any of the allowable types then it is passed to the top output (equal port) otherwise the it is sent to the bottom output (not equal port). The allowable set of types are determined by the parameters **type**, **user**, **image**, and **graphic**. The **type** parameter allows multiple selections, if the input object type matches any of the selected types it will be output at the equal port. If *image* or *Graphic* types are selected, the selection is further refined using the **image** or **graphic** parameters. These parameters also allow multiple selections.

If the object type does not appear in the **type** list then it can be specified by selecting the **user** type. A list of user types is specified by entering a string for the **user** parameter consisting of the appropriate object name. The object name may be either the object's display name (the name shown in the display of an object of that type by the **display** operator or a probe) or the programming type name. Type names that contain spaces must be enclosed in quotes (for example *"Real point"*). The operator will also accept the obsolete "OBJ_..." object name format. Multiple user object types can be specified by separating their names by spaces.

Parameter Information

type Type: int
Default: 0
Values (bitwise OR): byte: 1, ubyte: 2, short: 4, ushort: 8, int: 16, uint: 32, hex: 64, float: 128, double: 256, String: 512, Point: 1024, image: 2048, vector: 4096, linked list (obsolete): 8192, Graphic: 16384, Geometric: 32768, user: 65536, char: 131072, hex8: 262144, hex16: 524288, File: 1048576

user Type: CorString
Default: "OBJ_GENERIC"

image Type: int
Default: 0
Values (bitwise OR): unsigned 8 bit: 1, signed 8 bit: 2, unsigned 16 bit: 4, signed 16 bit: 8, float: 16, complex: 32, RGB: 64, HSV: 128, Yuv: 256

graphic Type: int
Default: 0
Values (bitwise OR): point: 1, line: 2, polyline: 4, polygon: 8, rectangle: 16,

circle: 32, text: 64, arc: 128

C Prototype

```
CorOpRtn cor_filter(
    CorObj *In,
    CorObj *Equal,
    CorObj *NotEqual,
    int type,
    CorString user,
    int image,
    int graphic
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

flattenVector

Convert vector of vectors to vector

Description

The **flattenVector** operator converts a 1-D object (vector) in which each of the elements is a 1-D object into a flat 1-D. If the **setNCols** parameter is set to *No*, the output is a single 1-D object formed by concatenating the elements of the input 1-D object.

If the **setNCols** parameter is set to *Yes*, and all element 1-D objects are the same length, a 2-D object is produced in which each element of the input becomes a row in the output.

Parameter Information

setNCols Type: int
Default: 0
Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_flattenVector(
    CorVector *In,
    CorObj *Out,
    int setNCols
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

ge

Extract an element from a vector

Description

ge performs the same function as **getElem**. **ge** has a small icon which makes it more convenient to use in large igraphs.

See Also

getElem

Parameter Information

method Type: int
Default: 0
Values: first: 0, last: 1, byElement: 2

element Type: int
Default: 0

C Prototype

```
CorOpRtn cor_getElem(
    CorObj *Vector,
    CorObj *newElement,
    CorObj *newVector,
    int method,
    int element
)
```

Headers

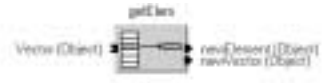
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

getElem

Extract an element from a vector



Description

The **getElem** operator copies an element from the input vector or linked list and outputs the extracted element and the remainder of the vector or list. The element to be extracted can be specified, using the **method** parameter, to be either the first, last or an intermediate element of the vector or list. If the *byElement* option is selected, then the **element** parameter is used to specify which element is extracted, with the first element indexed by zero. The extracted element is produced on the upper output port, the remainder of the vector or list on the lower output port.

Parameter Information

method Type: int
Default: 0
Values: first: 0, last: 1, byElement: 2

element Type: int
Default: 0

C Prototype

```
CorOpRtn cor_getElem(
    CorObj *Vector,
    CorObj *newElement,
    CorObj *newVector,
    int method,
    int element
)
```

Headers

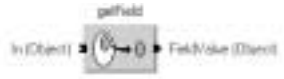
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

getField

Extract a field from input object



Description

The **getField** operator allows the user to extract a field from a complex object or vector of complex objects. Object types from which fields may be extracted include the built in types Point, WitImage, Vector and Llist; extended types, such as Fpoint, Graphic and Feature; and user defined types. The field to be extracted is specified by name in the **field** parameter, using a syntax similar to the *C* language.

Fields in the WiT built-in types that may be of use include: *x* and *y* in Point; *W* (image width), *H* (image height), *bpp* (bytes per pixel) and *type* in image; and *data*, *size*, *ncols* and *type* in vectors. The *data* field refers to the pointer to memory containing the elements and is most often used with an index value to specify one element in the vector. The field name *data[n]* specifies element *n* of the vector. An error occurs if there is no element *n* in the vector.

Field names of extended or user-defined types can be seen by viewing an object of the type using a probe or the **display** operator. For example, displaying a Feature object produces a list of the feature's fields; *id*, *xmin*, *xmax*, ...; and their values. The names as displayed (including case) can be used to access these fields.

Substructures embedded within structures can be specified using either "." or "->" notation. Fields can be nested to an arbitrary depth. For example, the Graphic object has a field called *geom*, which is itself a Geom object that includes the field *plist*. This field can be accessed by using *geom.plist* or *geom->plist* as the **field** parameter. The *plist* field is the vector of points that describe the graphic object. The number of elements in the *plist* vector can be extracted by specifying *geom.plist.size*. The coordinate values of a given point in the graphic object can be accessed using the vector notation described above. For example, *geom.plist.data[0].x* specifies the *x* coordinate of the first point in the vector.

The **getField** operator can also extract fields from the elements of a vector of complex objects and collect these fields into a vector of the field type for output. To specify this mode the **field** parameter is prefixed with a ".". For example, an integer vector of the size in pixels of objects in a binary image can be extracted directly from the vector of Feature structures produced by the **getFeatures** operator using the **field** parameter *.npixels*.

This syntax applies only to top level vectors and cannot be applied to vectors that are themselves fields of the input object. It is possible, for example, to form a vector of *x* coordinates from the first point in a vector of Graphic objects, using the field name *.geom.plist.data[0].x*. It is not possible, however, to extract all of the *x* coordinates of the points in a Graphic object using this syntax, since the *plist* vector is not at the top level. In this case two **getField** operators must be used. First the *plist* field must be extracted using the field name *geom.plist*. The *x* coordinates can then be extracted from this vector with the *.x* field name.

Parameter Information

field Type: CorString
Default: "xc"

C Prototype

```
CorOpRtn cor_getField(
    CorObj *In,
    CorObj *FieldValue,
    CorString field
)
```

Headers

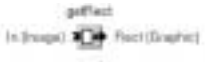
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

getRect

Extract image bounding box



Description

The **getRect** operator creates a graphic object describing a rectangle with the same dimension as the input image. The rectangle has a top, left corner of (0, 0) and a bottom, right corner of (W-1, H-1) where W and H are the width and height respectively of the input image.

C Prototype

```
CorOpRtn cor_getRect(
    CorImage *In,
    CorGraphic **Rect
)
```

Headers

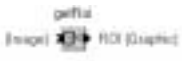
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

getRoi

Extract ROI from an image



Description

The **getRoi** operator extracts the image ROI from the input image and outputs the ROI as a rectangle Graphic. The color of the output rectangle can be set using the **red**, **green** and **blue** parameters.

Parameter Information

red Type: int
Default: 255

green Type: int
Default: 0

blue Type: int
Default: 0

C Prototype

```
CorOpRtn cor_getRoi(
    CorImage *i0,
    CorGraphic **ROI,
    int red,
    int green,
    int blue
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

getTiles

Convert an image to a vector of sub-images

Description

The **getTiles** operator decomposes an image into a vector of non-overlapping sub-images. The operator accepts any image type and produces a vector of images of the same type.

The **set** parameter value determines the grid used to divide the image into sub-images. It may be set to the divide the image by the *size* of the resulting sub-images or by the *number* of rows and columns into which the image is divided. When the parameter is set to *size* parameters are enabled to specify the **width** and **height** of the sub-images. When the parameter is set to *number* parameters are enabled to specify the number of columns (**nCols**) and number of rows (**nRows**) into which the image is divided.

The **remainder** parameter determines what happens when the image does not divide evenly into the specified size or number of subimages. In the *truncate* mode, the image is divided into equal size sub-images starting in the top left corner. Pixels on the right or bottom of the image that do not fit are dropped. Behaviour in the *fit* mode depends on the value of the **set** parameter. When it is set to *size*, any remainder pixels will be formed into a sub-image smaller than the specified size. In the *number* mode, the size of the last sub-image in the row or column will be adjusted to account for the remainder. In this case the last subimage may by larger or smaller than the other sub-images by up to half the specified number of columns or rows.

Images decomposed using the **getTiles** operator can be reassembled using the **tileImages** operator.

Parameter Information

set Type: int
Default: 0
Values: size: 0, number: 1

width Type: int
Default: 32

height Type: int
Default: 32

nCols Type: int
Default: 8

nRows Type: int
Default: 8

remainder Type: int
Default: 0
Values: truncate: 0, fit: 1

C Prototype

```
CorOpRtn cor_getTiles(
```

```
    CorImage *In,
    CorVector *Out,
    int set,
    int width,
    int height,
    int nCols,
    int nRows,
    int remainder
)
```

Headers

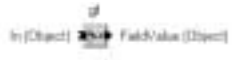
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

gf

Extract a field from input object



Description

gf performs the same function as **getField**. **gf** has a small icon which makes it more convenient to use in large igraphs.

See Also

getField

Parameter Information

field Type: CorString
Default: "xc"

C Prototype

```
CorOpRtn cor_getField(
    CorObj *In,
    CorObj *FieldValue,
    CorString field
)
```

Headers

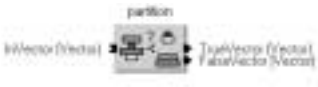
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

partition

Partition a vector of objects on a named field



Description

The **partition** operator allows the user to partition a vector of simple numeric objects or complex objects. Partition of complex objects is based on the value of a particular field within the object. The field must be one of the numeric or character basic types. The field is specified using the **field** parameter. If the elements of the input vector are simple numeric types, the the **field** parameter must be left empty.

The vector is partitioned by comparing the field value to the value specified by the **value** parameter. The type of comparison may be equal, greater than less than, not equal, greater than or equal, less than or equal, or a range of values as specified by the **condition** parameter. When the range comparison is used the **value** parameter specifies the lower bound of the range and a second parameter, the **hiValue** parameter, specifies the upper end of the range. The range is inclusive, so objects with field values equal to the the end point parameter values are included in the range.

Elements which meet the condition are collected in the *TrueVector*, which is output on the upper port, and those that do not are collected in the *FalseVector* which is output on the lower port.

The **output** parameter is normally set to *object*, which produces output vectors containing the the objects from the input vector. The **output** parameter may be set to *index* in which case the output vectors are integer vectors, where each element is an index into the input vector, rather than the object itself.

This is most often used with vectors of simple numeric objects.

Parameter Information

field Type: CorString
Default: "x"

value Type: float
Default: 30

hiValue Type: float
Default: 0

condition Type: int
Default: 2
Values: ==: 0, >: 1, <: 2, !=: 3, >=: 4, <=: 5, range: 6

output Type: int
Default: 0
Values: object: 0, index: 1

C Prototype

```
CorOpRtn cor_partition(
    CorVector *InVector,
    CorVector *TrueVector,
    CorVector *FalseVector,
    CorString field,
    float value,
    float hiValue,
    int condition,
    int output
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

pf

Insert a new field value into input object

Description

pf performs the same function as **putField**. **pf** has a small icon which makes it more convenient to use in large igraphs.

See Also

putField

Parameter Information

field Type: CorString
Default: "x"

C Prototype

```
CorOpRtn cor_putField(
    CorObj *In,
    CorObj *FieldValue,
    CorObj *Result,
    CorString field
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

putField

Insert a new field value into input object

Description

The **putField** operator allows the user to insert a new value into a particular field in a complex object or vector of complex objects. The operator's inputs are the object to be modified and the new field value. Object types that can be modified include the built in types Point, WitImage, Vector and Llist; extended types, such as Real point, Graphic and Feature; and user defined types. The field to be

modified is specified by name in the **field** parameter, using a syntax similar to the *C* language.

If the new field value is not the same type as the specified field in the complex object it will, if possible, be cast to that type. The valid casts and rules for casting are described in the **cast** operator help. When floating point values (floats, doubles or Real point) are cast to integer types by the **putField** operator the values are rounded to the nearest integer. When a value is cast to a type with a smaller range than the input type, the value is truncated if it is outside the range. If the input type cannot be cast to the field type an error occurs.

Fields in the WiT built-in types that may be of use include: *x* and *y* in Point; *W* (image width), *H* (image height), *bpp* (bytes per pixel) and *type* in image; and *data*, *size*, *ncols* and *type* in vectors. The *data* field refers to the pointer to memory containing the elements and is most often used with an index value to specify one element in the vector. The field name *data[n]* specifies element *n* of the vector. An error occurs if there is no element *n* in the vector.

Field names of extended or user-defined types can be seen by viewing an object of the type using a probe or the **display** operator. For example, displaying a Feature object produces a list of the feature's fields; *id*, *xmin*, *xmax*, ...; and their values. The names as displayed (including case) can be used to access these fields.

Substructures embedded within structures can be specified using either "." or "->" notation. Fields can be nested to an arbitrary depth. For example, the Graphic object has a field called *geom*, which is itself an object that includes the field *plist*. This field can be accessed by specifying *geom.plist* or *geom->plist* as the **field** parameter. The *plist* field is the vector of points that describe the graphic object. The number of elements in the *plist* vector can be replaced by specifying *geom.plist.size*. The coordinate values of a given point in the graphic object can be accessed using the vector notation described above. For example, *geom.plist.data[0].x* specifies the *x* coordinate of the first point in the vector.

The **putField** operator cannot allocate memory for an empty field. The most common instance in which this arises is when the *geom.text.data* field of a graphic object is accessed. If the input graphic is not a text graphic then it will generally have an empty *geom.text* field and a text string cannot be inserted directly into the *geom.text.data* field.

The **putField** operator can also be used to insert values into vectors of complex objects. To specify this mode the **field** parameter is prefixed with a ".". There are three cases to which this may be applied, depending on the nature of the input values. If the input to be modified is a vector of complex objects and the field value input is a vector of the field type, then the elements of the field value vector are inserted into corresponding elements of the complex object vector. In this case the two vectors must have the same number of elements. If the input to be modified is a vector of complex objects and the field value is a single object of the field type then a copy of that object is inserted into the specified field in each of the complex objects in the vector. If the input to be modified is a single complex object and the field value input is a vector of the field type then a vector of copies of the complex object is created and the field values are inserted into the corresponding elements in the vector.

Parameter Information

field Type: CorString
Default: "x"

C Prototype

```
CorOpRtn cor_putField(
    CorObj *In,
    CorObj *FieldValue,
    CorObj *Result,
    CorString field
)
```

Headers

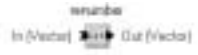
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

renumber

Sequentially number named fields



Description

The **renumber** operator sets the value of the specified field in each element vector of complex objects to a sequence number. The field is specified by the **field** parameter, and must be one of the numeric basic types or a string. The value assigned to the field in the first vector element is specified in the **from** parameter, and is incremented by one for each subsequent element.

Parameter Information

field Type: CorString
Default: "serial"

from Type: int
Default: 1

C Prototype

```
CorOpRtn cor_renumber(
    CorVector *In,
    CorVector *Out,
    CorString field,
    int from
)
```

Headers

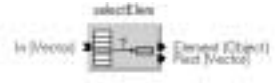
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

selectElem

Select an element based on the value of named field



Description

The **selectElem** operator allows the user to select the maximum or minimum element or the element with value nearest to a specified value from a vector of simple numeric objects or complex objects. Selection from a vector of complex objects is based on the value of a named field within the object, specified by the **field** parameter. The field must be one of the numeric or character basic types. If the elements of the input vector are simple numeric types, the the **field** parameter must be left empty.

The mode of operation is selected using the **mode** parameter. It may be set to *max*, *min* or *nearest*. When this parameter is set to *nearest*, the **value** parameter is used to specify the value to which the element or field value is compared.

The **output** parameter is normally set to *object*, in which case the **Element** output is the appropriate element from the input vector. The remaining vector elements are produced on the **Rest** output. The **output** parameter may also be set to *index*, in which case the output is the integer index into the input vector for the object, rather than the object itself. This mode is most often used when selecting from vectors of simple numeric objects.

Parameter Information

field Type: CorString
Default: "x"

mode Type: int
Default: 0
Values: max: 0, min: 1, nearest: 2

value Type: float
Default: 0

output Type: int
Default: 0
Values: object: 0, index: 1

C Prototype

```
CorOpRtn cor_selectElem(
    CorVector *In,
    CorObj *Element,
    CorVector *Rest,
    CorString field,
    int mode,
    float value,
    int output
```

)

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

setRoi

Set image ROI

Description

The **setRoi** operator sets the ROI of an image to the rectangle specified by the **ROI** parameter. The ROI parameter may be may a vector of two points or real points, representing the upper left and lower right corners of the rectangle; or it may be a rectangle graphic or geometry object; or it may be an image, in which case the parameter image's ROI is used. The graphic, geometry, and image type parameters are typically input parameters produced by other WiT operators. The ROI specified by the parameter will be clipped to fit the input image if it extends outside the image.

Parameter Information

ROI Type: CorObj
Default: "OBJ_B T CorVector CorFpoint 2 0 0 255 255 "

C Prototype

```
CorOpRtn cor_setRoi(
    CorImage *i0,
    CorImage *o0,
    CorObj *ROI
)
CorOpRtn cor_setRoi_consume(
    CorImage *i0,
    CorObj *ROI
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

shuffleVecExpr

Reorder a vector using a C-code like expression

Description

The **shuffleVecExpr** operator selects and rearranges the elements of an input vector based on a mapping specified by a C-code like expression. The input vector elements may be of any type. The **Out** output vector is made up of elements from the input object vector specified the expression. The **Indexes** output vector is an integer vector that gives the mapping from the input vector to the output vector.

The mapping from the input to output is specified by the **expression** parameter. This parameter is a string that uses a C-code like syntax to specify input vector indexes as a function of the output vector indexes. The symbol *A* is used to represent the output vector index in the expression. The function can be parameterized by a user supplied constant, given by the **userConstant** parameter, and by the length of the input vector. The symbol *K* is used to represent the user constant and the symbol *W* is used to represent the input vector length in the expression. The expression syntax is described in the operator help for the **calc** operator.

The calculations are performed using floating point arithmetic, with the final index value rounded to the nearest integer (*.5 rounded up). The *floor*, *ceil*, and *round* functions can be used in the expression to control truncation of the floating point values, if necessary. Calculated index values less than zero

are set to zero, and calculated index values greater than the maximum valid input index are set to the maximum valid input index.

Note that the expression is a function of the output indexes and the function resolves to an input index value. It is often more natural to think of the output index as a function of the input index, but the method used here allows the input to output mapping to be more general, allowing many to one mappings and subsets of the input, and also avoids problems with unspecified output vector elements.

The length of the output vector is specified by a second expression, given in the **lengthExpr** parameter. This expression may use the user constant, *K*, and input vector length, *W*. The index value *A* has no effect on the value of this expression, otherwise the syntax is the same as for the **expression** parameter. An integer value can be used to specify a constant length output vector.

The following examples give the **expression** and **lengthExpr** strings required for some common mappings.

First K elements (if K > input vector width the last element will be repeated to extend the output vector to K elements):

```
expression: A
lengthExpr: K
```

Last K elements:

```
expression: W - K + A
lengthExpr: K
```

Even elements:

```
expression: A * 2
lengthExpr: ceil(W / 2)
```

Odd elements:

```
expression: A * 2 + 1
lengthExpr: floor(W / 2)
```

All even elements followed by all odd elements:

```
expression: A <  W / 2 ?
   A * 2 :
   2 * (A - ceil(W / 2)) + 1
lengthExpr: W
```

Parameter Information

expression Type: CorString
Default: "A"

lengthExpr Type: CorString
Default: "W"

userConstant Type: double

C Prototype

```
CorOpRtn cor_shuffleVecExpr(
    CorVector *In,
    CorVector *Out,
    CorVector *Indexes,
    CorString expression,
    CorString lengthExpr,
    double userConstant
)
```

Headers

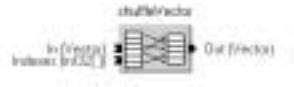
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

shuffleVector

Reorder a vector



Description

The **shuffleVector** operator selects and rearranges the elements of an input object vector based on the values of a input index vector of integers. The output is a vector made up of the elements from the input object vector at the positions specified in the input index vector. The output vector is same type as input object vector and the same size as the input index vector. There does not have to be a one to one (or onto) relationship between the index and object vectors. The operator may be used to extract a

subset of the object vector and index values may be repeated. Index values less than zero or greater than maximum object vector index result in an error.

The **shuffleVector** operator is most often used with the **sort** or **partition** with their **output** parameter set to *index*. In this mode these operators produce a vector of index values corresponding to the sorted object vector or the selected subset, respectively. The index values can then be used to sort or partition a vector related to the vector on which the operation was performed.

C Prototype

```
CorOpRtn cor_shuffleVector(
    CorVector *In,
    CorIntVector *Indexes,
    CorVector *Out
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

sortObj

Sort a vector of objects on a named field

Description

The **sortObj** operator allows the user to sort a vector of simple numeric objects or complex objects. Sorting of complex objects is based on the value of a particular field within the object. The field must be one of the numeric or character basic types. The field to be sorted on is specified using the **field** parameter. If the elements of the input vector are simple numeric types, the the **field** parameter must be left empty.

The vector can be sorted in *ascending* or *descending* order, as specified by the **direction** parameter.

The **output** parameter is normally set to *object*, which produces an output vector containing the the objects from the input vector in sorted order. The **output** parameter may be set to *index* in which case the output is an integer vector where each element is an index into the input vector for the object, rather than the object itself. This is most often used with vectors of simple numeric objects.

Typical examples of applications of this operator include sorting a vector of *Point* or *FPoint* objects on their *x* or *y* fields, sorting *Feature* vectors by size of the feature using the *npixels* or *boxarea* fields, or sorting a vector of images on their height (*H* field) or width (*W* field).

Parameter Information

field Type: CorString
Default: "x"

direction Type: int
Default: 0
Values: ascending: 0, descending: 1

output Type: int
Default: 0
Values: object: 0, index: 1

C Prototype

```
CorOpRtn cor_sortObj(
    CorVector *InVector,
    CorVector *SortedVector,
    CorString field,
    int direction,
    int output
)
```

Headers

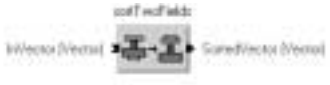
#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

sortTwoFields

Sorts a vector of complex objects based on the values of two fields



Description

The **sortTwoFields** operator allows the user to sort a vector of complex objects based on the values of two fields in the objects. The objects are sorted on the first field, and then bjects for which the first field values are equal (or within a tolerance range) are sorted on the second field value. A typical application of this operator is to sort *Feature* vectors derived from images of lines of text so that the lines are sorted in y and the characters in each line are sorted in x.

The first field to be sorted on is specified using the **field1** parameter. The **tolerance** parameter can be used to specify a range over which the first field values will be considered equal. The second field value is specified using the **field1** parameter. The fields must be one of the numeric or character basic types.

The vector can be sorted in *ascending* or *descending* order for each field, as specified by the **direction1** and **direction2** parameters.

The **output** parameter is normally set to *object*, which produces an output vector containing the the objects from the input vector in sorted order. The **output** parameter may be set to *index* in which case the output is an integer vector where each element is an index into the input vector for the object, rather than the object itself.

It should be noted that, in general, using the first field value with a non-zero tolerance range does not result in an ordering of the objects. That is, for three objects *a*, *b*, and *c* it is possible that $a < b$, $b < c$, and $c < a$. Heuristics are used that provide the expected result in cases where the first field values are clustered with some dependence on the second field value, such as lines of text characters under small rotations.

Parameter Information

field1 Type: CorString
Default: "y"

direction1 Type: int
Default: 0
Values: ascending: 0, descending: 1

tolerance Type: float

field2 Type: CorString
Default: "x"

direction2 Type: int
Default: 0
Values: ascending: 0, descending: 1

output Type: int
Default: 0
Values: object: 0, index: 1

C Prototype

```
CorOpRtn cor_sortTwoFields(
    CorVector *InVector,
    CorVector *SortedVector,
    CorString field1,
    int direction1,
    float tolerance,
    CorString field2,
    int direction2,
    int output
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

swapBytes

Swap byte order in two-byte images

Description

The **swapBytes** operator takes an image as input and outputs an image of the same type but has the low and high bytes/words swapped. The operator is useful when images are being processed on different architectures. On PCs, an ordinary C int variable is stored in memory starting from the least significant byte up to the most significant byte. On the other hand, Sun Workstations store the same variable in memory starting from the most significant byte down to the least significant byte.

For RGB and 8-bit images, **swapBytes** just outputs the same image as the input image. No swapping is necessary. For 16-bit images, the operator swaps the low and high bytes for each pixel. For float and complex images, the operator reverses the order of the four bytes for each pixel.

C Prototype

```
CorOpRtn cor_swapBytes(
    CorImage *In,
    CorImage *Out
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

tileImages

Display a vector of images as one image

Description

The **tileImages** operator converts a vector of images into one image. The resulting image is a grid of images having a number of columns and rows as denoted by the **tileColumns** and **tileRows** parameters. If either parameter is 0, then the operator determines the width and/or height of the grid image. The **spacing** parameter allows the user to place a band of zero-valued pixels between each image. The number of pixels in that band is given by the value of the parameter. Additionally, images from the vector can be placed in the top left corner of each grid area or in the center of the area. This may be useful when images in the vector are of varying sizes.

The tiled image size and spacing are calculated using the full size of the input images, even if the image ROIs are smaller than the images. Only the pixel values from within the input image ROIs are copied to the tiled image.

This operator is convenient for viewing vectors of related images, for example a series of slices through a 3D volume.

Parameter Information

tileColumns Type: int
Default: 0

tileRows Type: int
Default: 0

spacing Type: int
Default: 0

location Type: int
Default: 0
Values: top left: 0, center: 1

C Prototype

```
CorOpRtn cor_tileImages(
    CorImageVector *In,
    CorImage *Out,
    int tileColumns,
    int tileRows,
    int spacing,
    int location
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

vecRedim

Change the dimensions of a vector but retain element values

Description

The **vecRedim** operator changes the dimensions of a vector or image object while preserving all the element values. The number of elements in the input object must match the number of elements specified. If the **height** parameter is 0, then the output is a vector. If **height** is 1 or greater, the output is an image. If the **autoSet** parameter is set to **width**, **height** must be non-zero and the number of elements in the input object must be divisible by **height**. Similarly for **width**.

Parameter Information

autoSet Type: int
Default: 0
Values: none: 0, width: 1, height: 2

width Type: int
Default: 1

height Type: int
Default: 0

C Prototype

```
CorOpRtn cor_vecRedim(
    CorObj *In,
    CorObj *Out,
    int autoSet,
    int width,
    int height
)
```

Headers

#include "$(WITHOME)/h/wObjman.h"

Libraries

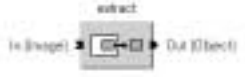
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wObjman.lib

Pixel Access

The Pixel Access library supports reading and writing pixel values from or to images. The library includes operators that set or get pixel values at points, rows, columns, arbitrary lines and rectangular regions of images.

extract

Extract a region of an image



Description

The **extract** operator extracts a rectangular subimage or images from the input image. Subimages are specified by the **subImage** parameter. If this parameter is a single Graphic or Geometry object, an image or a blob vector a single subimage is produced. If the parameter is a vector of Graphic or Geometry objects or a vector of images a vector of subimages is produced. For a Graphic or Geometry object the subimage produced will be the smallest rectangular region enclosing the object. For an image the subimage will correspond to the image ROI.

The **subImage** parameter is often supplied as an input parameter. Suitable input objects can be produced by operators such as **createRect**, which creates a single rectangle, or **getData**, which produces a vector of Graphics.

The subimages can be inserted back into the image after processing using the **insert** operator. Geometric objects, such as Graphics, Edges, Lines and Points, can be returned to the orginal image coordinates using the **insertGraphic** operator.

Parameter Information

subImage Type: CorObj
Default: "OBJ_B T CorGeom 4
CorFpoint 2 0 0 63 63 -"

C Prototype

```
CorOpRtn cor_extract_1(
    CorImage *In,
    CorObj *Out,
    CorObj *subImage
)
```

Headers

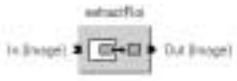
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

extractRoi

Extract an image's ROI



Description

The **extractRoi** operator extracts a sub-image of the input image corresponding to the input image's intrinsic ROI. The image ROI can be set using the **setRoi** operator.

C Prototype

```
CorOpRtn cor_extractRoi(
    CorImage *In,
    CorImage *Out
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

fill

Fill a region of an image with a value

Description

The **fill** operator fills a region in the input image with a pixel value specified by the **fillValue** parameter. The region to be filled is specified by the **mask** parameter. The **mask** parameter may be a Graphic or Geometric object or an 8 or 16 bit unsigned image; a vector of Graphic or Geometric objects or an 8 or 16 bit unsigned images; or a Blob vector. The **fill** parameter is used to specify if the *Foreground* areas (pixels inside the mask) or the *Background* areas (pixels outside the mask) are filled.

Parameter Information

mask Type: CorObj

fillValue Type: CorObj
Default: "OBJ_B T int 0"

fill Type: int
Default: 0
Values: Foreground: 0, Background: 1

C Prototype

```
CorOpRtn cor_fill_1(
    CorImage *In,
    CorImage *Out,
    CorObj *mask,
    CorObj *fillValue,
    int fill
)
CorOpRtn cor_fill_1_consume(
    CorImage *In,
    CorObj *mask,
    CorObj *fillValue,
    int fill
)
```

Headers

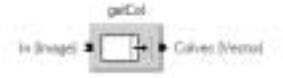
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

getCol

Get a column of pixels from an image



Description

The **getCol** operator retrieves the vector of pixel data corresponding to the column of pixels in the input image. The column is given by the **col** parameter.

Parameter Information

col Type: int
Default: 0

C Prototype

```
CorOpRtn cor_getCol(
    CorImage *In,
    CorVector *Colvec,
    int col
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

getPath

Get pixel values and coordinates of points on a path

Description

The **getPath** operator produces the floating point location of rasterized or equally spaced sample points along a path specified by a graphical object and determines the image values at the sample points.

The operator has two outputs, one corresponding to the path and the other to the image values on the path. The upper output is a vector of Fpoint objects that give the location of the sample points in pixel coordinates, as described below. The lower output is a vector of floating point values at the sample point locations in the image input at the upper input port.

The path is specified by a graphical object that is received on the lower input port. Any graphical object type other than text can be used. The path associated with rectangles, circles and polygons is the perimeter of the object. Point objects return a single sample point. The **operation** parameter specifies whether the path is rasterized or sampled at equally spaced points.

The *rasterize* option returns pixel locations corresponding to a single pixel width curve in the image, as would be used in rendering the graphic object. Each location correspond exactly to a pixel and no pixel appears more than once (except possibly in self-crossing polylines or polygons). It should be noted that the sampling distance is dependent on the orientation of the curve. For example, a horizontal line will have approximately 1.4 times as many sample points as a line of the same length at a 45 degree angle.

Selecting the *sample* option for the **operation** produces pixel locations corresponding to equally spaced samples along the graphical object. The distance between samples is specified using the **sampleSpacing** parameter, and is given in pixel units. For lines, polylines and polygons, equally spaced sample points are determined starting from the first end point of the graphical object. The last end point and intermediate segment end points will not necessarily be sample points. The path for a circle starts at the point *(x_c + r, y_c)* where *(x_c , y_c)* is the center of the circle and *r* is the radius, and proceeds clockwise around the circumference of the circle.

The equally spaced sample locations do not necessarily fall exactly on pixel centers. The method of assigning a value from the image to a

pixel location is controlled by the **sampling** parameter. If the *nearest* option is selected the value is that of the nearest pixel (that is, the pixel within which the sample point falls) If the *interpolate* option is selected, the value is determined by bilinear interpolation from the surrounding pixel values.

Parameter Information

operation Type: int
Default: 0
Values: rasterize: 0, sample: 1

sampling Type: int
Default: 0
Values: interpolate: 0, nearest: 1

sampleSpacing Type: float
Default: 1

C Prototype

```
CorOpRtn cor_getPath(
    CorImage *In,
    CorObj *Path,
    CorFpointVector *Points,
    CorFloatVector *Values,
    int operation,
    int sampling,
    float sampleSpacing
)
```

Headers

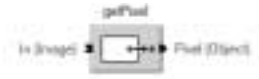
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

getPixel

Get a pixel value from an image



Description

The **getPixel** operator retrieves a single pixel of data corresponding to a pixel value in the input image. The pixel value is located by the (x, y) coordinate given in the **xy** parameter.

Parameter Information

xy Type: CorPoint
Default: (0, 0)

C Prototype

```
CorOpRtn cor_getPixel(
    CorImage *In,
    CorObj *Pixel,
    CorPoint *xy
)
```

Headers

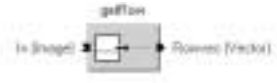
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

getRow

Get a row of pixels from an image



Description

The **getRow** operator retrieves the vector of pixel data corresponding to the row of pixels in the input image. The row is given in the **row** parameter.

Parameter Information

row Type: int
Default: 0

C Prototype

```
CorOpRtn cor_getRow(
    CorImage *In,
    CorVector *Rowvec,
    int row
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

getVector

Get pixel values along an arbitrary line segment

Description

The **getVector** operator retrieves the vector of pixel data from the input image corresponding to the vector defined by two end points, specified by the **start** and **end** parameters. The pixels are selected by rasterizing the line connecting the two end points, and consequently do not represent evenly spaced samples. Evenly spaced samples can be obtained using the **getPath** operator.

Parameter Information

start Type: CorPoint
Default: (0, 0)

end Type: CorPoint
Default: (0, 0)

C Prototype

```
CorOpRtn cor_getVector(
    CorImage *In,
    CorVector *Profile,
    CorPoint *start,
    CorPoint *end
)
```

Headers

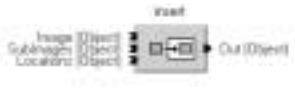
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

insert

Overlay an image on a larger image



Description

The **insert** operator overlays a subimage or subimages on larger images in specified locations. The main use of this operator is to insert subimages that have been extracted using the **extract** operator back into the original image. The graphic or vector of graphics used to extract the subimages can be used to insert the subimages.

A subimage or vector of subimages is input at the **SubImages** input port. A rectangle or point type graphic object or, in the case of a vector of subimages, a vector of graphic objects is input at the **Locations** input port. If these inputs are vectors they must contain the same number of elements. The **Image** input receives an image or vector of images. The subimages are offset to the position specified by the corresponding graphic and are written over the image. If a vector of images is received, then all of the subimages are written over each image in the vector.

If the **overlay** parameter is set to *Yes* the original image values will be written to pixels not covered by any subimage. In this case both the image and the subimage must be of the same type. If the **overlay** parameter is set to *No* these pixels are set to zero. Regions in the output image where subimages overlap will be set to the pixel values of the subimage that is later in the vector of subimages.

Parameter Information

overlay Type: int
Default: 1
Values: off: 0, on: 1

C Prototype

```
CorOpRtn cor_insert(
    CorObj *Image,
    CorObj *SubImages,
    CorObj *Locations,
    CorObj *Out,
    int overlay
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

putCol

Put values into a column of pixels in an image

Description

The **putCol** operator sets pixel values in a specified column of the input image to the corresponding values in the input vector. The column is given by the **col** parameter.

Parameter Information

column Type: int
Default: 0

C Prototype

```
CorOpRtn cor_putCol(
    CorImage *In,
    CorVector *ColumnData,
    CorImage *Out,
    int column
)
```

Headers

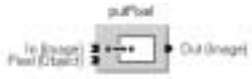
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

putPixel

Put a pixel value into an image



Description

The **putPixel** operator sets a single pixel in an image to a specified value. The pixel that is set to the new value is located by the (x, y) coordinate given in the **xy** parameter.

Parameter Information

xy Type: CorPoint
Default: (0, 0)

C Prototype

```
CorOpRtn cor_putPixel(
    CorImage *In,
    CorObj *Pixel,
    CorImage *Out,
    CorPoint *xy
)
```

Headers

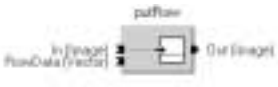
#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

putRow

Put values into a row of pixels in an image



Description

The **putRow** operator sets pixel values in a specified row of the input image to the corresponding values in the input vector. The row is given by the **row** parameter.

Parameter Information

row Type: int
Default: 0

C Prototype

```
CorOpRtn cor_putRow(
    CorImage *In,
    CorVector *RowData,
    CorImage *Out,
    int row
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

putVector

Put values into pixels along an arbitrary line segment

Description

The **putVector** operator inserts the values in the input vector into the input image pixels falling on an arbitrary line. The line in the image is specified by the **start** and **end** parameters. The pixels are selected by rasterizing the line connecting the two end points, and consequently do not represent evenly spaced samples.

Parameter Information

start Type: CorPoint
Default: (0, 0)

end Type: CorPoint
Default: (0, 0)

C Prototype

```
CorOpRtn cor_putVector(
    CorImage *In,
    CorVector *Profile,
    CorImage *Out,
    CorPoint *start,
    CorPoint *end
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

rasterize

Generate an image from graphical objects

Description

The **rasterize** operator rasterizes a vector of Graphic objects which describe a set of ROIs in an integer or float image. The operator will rasterize geometric objects; points, lines, rectangles, polylines, polygons and circles; but ignores text graphical objects. The graphical objects can be drawn in outline or filled (or both, using different colors) in color or grayscale either on a grayscale background image or a black background.

The **overlay** parameter determines if the output image is to be zeroed or set to the input image before rasterizing. When the parameter is set to *off*, the graphic objects are drawn on a black (zero valued) background. When set to *on*, the image is scaled to the 8-bit integer range (0 -- 255), as specified by the **rangeType** parameter, and the graphic objects are superimposed. The **rangeType**

parameter allows the user to map the image minimum and maximum by selecting *Actual*, the image type range minimum and maximum by selecting *Max* or a user specified minimum and maximum by selecting *User*. The *Max* range setting is not valid for floating point images, the actual image range values are used. Values outside the user specified range are clipped to the range when the *User* option is selected.

The graphical objects can be superimposed in *grayscale* or *color*, as specified by the **outType** parameter. The colors associated with the graphical object are specified on the **Color** subpanel. The source of the graphical object color is determined by the **useColor** parameter. If the parameter is set to *original* the colors are taken from the the color fields of the graphical object. A luminance value determined from the red, green and blue channel values is used for grayscale graphics in the original color mode. If **useColor** is set to *forced* the colors are specified using the operator's parameters. The **outline** and **fill** parameters are used to specify drawing the outline and filling the graphical object. Both parameters may be *on* in which case the outline is superimposed on the filled object. The pen color for object outlines and the fill color are specified using the *penval* and *pixval* parameters, respectively, for grayscale objects and using *penR, penG, penB* and *fillR, fillG, fillB* for color. (The inconsistency in parameter naming is required for back compatability.)

The output image is an 8 bit unsigned integer image in the grayscale mode and an RGB color image in the color mode. In the color mode, the background image produced when the *overlay* parameter is turned on is produced by setting the red, green and blue channels for each pixel to the scaled input image value. It may be necessary to select the *Private* colormap from the image properties panel to best display the color images.

In the grayscale mode, this operator is useful if the ROI set is to be used extensively since the rasterization step is done only once and eliminates on-the-fly ROI computation. The color mode is primarily for preparation of images for display.

Parameter Information

overlay Type: int
Default: 0
Values: off: 0, on: 1

rangeType Type: int
Default: 0
Values: Actual: 0, Max: 1, User: 2

min Type: float
Default: 0

max Type: float
Default: 255

outType Type: int
Default: 0
Values: grayscale: 0, color: 1

useColor Type: int
Default: 1
Values: original: 0, force: 1

outline Type: int
Default: 0
Values: off: 0, on: 1

penval Type: int
Default: 255
Values: 0 — 255

penR Type: int
Default: 255
Values: 0 — 255

penG Type: int
Default: 255
Values: 0 — 255

penB Type: int
Default: 0
Values: 0 — 255

fill Type: int
Default: 1
Values: off: 0, on: 1

pixval Type: int
Default: 255
Values: 0 — 255

fillR Type: int
Default: 255
Values: 0 — 255

fillG Type: int
Default: 255
Values: 0 — 255

fillB Type: int

Default: 0
Values: 0 — 255

C Prototype

```
CorOpRtn cor_rasterize(
    CorImage *Image,
    CorObj *Graphics,
    CorImage *Rasterized,
    int overlay,
    int rangeType,
    float min,
    float max,
    int outType,
    int useColor,
    int outline,
    int penval,
    int penR,
    int penG,
    int penB,
    int fill,
    int pixval,
    int fillR,
    int fillG,
    int fillB)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

sampleLine

Extract values along a line in the image

Description

The **sampleLine** operator extracts pixel values along a line in an image. The inputs to the operator are an integer or float image at the upper input port and line type graphic object at the **Line** input port.

Values are extracted from the input image at one pixel intervals along the specified line. The **lineWidth** parameter determines how many pixels on either side of the line are used to calculate these values. The pixel values are weighted by a linear decreasing function of their distance from the line. The **lineWidth** parameter value is the half value width of the linear weighting function. A **lineWidth** value of *0* gives nearest neighbour sampling and a value of *1* gives linear interpolation using the pixels nearest the line.

The **Points** output is a vector of real points corresponding to the sample locations on the line. The **Values** output is a vector of floats that correspond to the extracted value at each sample location on the line. The **P0** output is a real point that gives the location of the first sample point on the line. The **Incr** output is a real point with the x increment and y increment between sample points in its x and y fields, respectively.

Parameter Information

lineWidth Type: int
Default: 1

C Prototype

```
CorOpRtn cor_sampleLine(
    CorImage *In,
    CorGraphic *Line,
    CorFpointVector *Points,
    CorFloatVector *Values,
    CorFpoint **P0,
    CorFpoint **Incr,
    int lineWidth
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

zeroImage

Create a blank image

Description

The **zeroImage** operator produces an image of the same type and size as the input image, with all pixel values set to zero.

C Prototype

```
CorOpRtn cor_zeroImage(
    CorImage *In,
    CorImage *Out
)
CorOpRtn cor_zeroImage_consume(
    CorImage *In
)
```

Headers

#include "$(WITHOME)/h/wPixel.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPixel.lib

Pyramids

The Pyramid library provides support for multi-resolution image processing. The library includes operators that reduce or expand image size; operators that produce multi-scale pyramids from images and operators that reconstruct images from pyramids.

burt

Generate a pyramid using Burt method

Description

The **burt** operator generates a vector of *n* images I(i) such that image I(n) is the result of applying *n* reduce operations to the input image. All other images, I(i) where *i* ranges between 1 and *n-1*, are differences between the input image after *i-1* reduce operations and the expanded version of the input image after *i* reduce operations. Notationally:

```
    Let G[1] be the input image.
    Let G[i] denote an image sequence
where G[i] = reduce(G[i-1])
    Then I[i] = G[i] -
expand(reduce(G[i])).
    Unless i == n, then I[n] = G[n].
```

The **filter** parameter selects the type of gaussian filter to be applied. The effect of each filter is described in the WiT filter library during the discussion of the **gauss** operator. The **minsize** parameter defines the minimum size that an image G(i) can be before a reduce operation will not be performed and pyramid generation will terminate.

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

minsize Type: int
Default: 8

C Prototype

```
CorOpRtn cor_burt(
    CorImage *In,
    CorImageVector *Pyramid,
    int filter,
    int minsize
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

burtRecon

Reconstruct original image from a Burt pyramid

Description

The **burtRecon** operator reconstructs an original image from the Burt pyramid that was generated from it. This reconstruction should be exact, barring things like overflow during computation. Given that a Burt pyramid is a sequence of *n* images I(i), the process is to expand I(n), then add I(n-1). The result is expanded and then I(n-2) is added, etc. The **filter** parameter selects the type of gaussian filter to be applied. The effect of each filter is described in the WiT filter library during the discussion of the **gauss** operator. Care must be taken to insure that the filter used is the same one that was used to generated the pyramid, or reconstruction will not be exact.

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

final Type: int
Default: 0

start Type: int
Default: -1

C Prototype

```
CorOpRtn cor_burtRecon(
    CorImageVector *Pyramid,
    CorImage *Out,
    int filter,
    int final,
    int start
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

burtRecStep

One level reconstruction of a Burt pyramid

Description

The **burtRecStep** operator performs one iteration in the Burt reconstruction process. The **Gaussian** port input image is the gaussian image for the previous level, while the **Laplacian** port input image is the laplacian difference image for the current level. The output is the gaussian image for the current level. The **filter** parameter selects the type of gaussian filter to be applied. The effect of each filter is described in the WiT filter library during the discussion of the **gauss** operator. Care must be taken to insure that the filter used is the same one that was used to generated the pyramid, or reconstruction will not be exact.

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

C Prototype

```
CorOpRtn cor_burtRecStep(
    CorImage *Gaussian,
    CorImage *Laplacian,
    CorImage *Out,
    int filter
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

burtStep

Generate a new level in a Burt pyramid

Description

The **burtStep** operator performs one iteration in the generation of a Burt pyramid (see **burt**). The image output on the top port is equivalent to applying the **reduce** operator to the input image. The image output on the middle port is the difference between the input image and the expanded version of the reduced version of that image. The bottom output port is a flag which is set to 1 if this last iteration is the final step in a FSD pyramid generation. The flag is 0 otherwise. The final iteration occurs when the output image size is less than minimum size in at least one dimension. The **filter** parameter specifies the type of gaussian filter used during image reduction and expansion. The filters correspond to those provide by the **gauss** operator within the filter library. The **minsize** parameter denotes the minimum size of image that will be accepted as input to the operator.

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

minsize Type: int
Default: 8

C Prototype

```
CorOpRtn cor_burtStep(
    CorImage *In,
    CorImage *Gaussian,
    CorImage *Laplacian,
    int *Final,
    int filter,
    int minsize
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

decimate

Decimate an image

Description

The **decimate** operator takes an input image and reduces its size by half. The new image consists of every fourth pixel taken from the input image. The pixels used to compose the new image are taken from the decimation lattice defined by the **useRows** and **useColumns** parameters. These two parameters can be set to either even or odd indicating that pixels should be taken from the even or odd rows/columns of the input image. No filtering is performed by **decimate**.

Parameter Information

useRows Type: int
Default: 0
Values: Even: 0, Odd: 1

useColumns Type: int
Default: 0
Values: Even: 0, Odd: 1

C Prototype

```
CorOpRtn cor_decimate(
    CorImage *In,
    CorImage *Out,
    int useRows,
    int useColumns
)
```

Headers

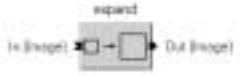
#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

expand

Expand and filter an image



Description

The **expand** operator increases the size of an input image by inserting a new row (column) of zero-valued pixels between each row (column) of the input image. The resulting image is then filtered using the gaussian filter specified by the **filter** parameter. The filters are described in detail in the **gauss** operator within the pyramid library. If the *None* option for filter type is indicated then no filtering is performed. The **outputWidth** and **outputHeight** parameters allow the user to specify the width and height of the output image. However, the values input are verified to assure that the resulting image will have an appropriate size. If the **reduce** operator is applied to an image I(i) and used to create an image I(i-1), then the output width and output height should be set to the dimensions of image I(i).

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

outputWidth Type: int
Default: 0

outputHeight Type: int
Default: 0

C Prototype

```
CorOpRtn cor_expand(
    CorImage *In,
    CorImage *Out,
    int filter,
    int outputWidth,
    int outputHeight
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

fsd

Generate a pyramid using FSD method

Description

The **fsd** operator generates two image sequences G(i) and L(i). The sequence G(i) that is output on the top port is a Gaussian pyramid and is identical to that which would be generated by the **gaussPyramid** operator. The sequence L(i) is a Laplacian pyramid and is output on the bottom port. Each image, L(i) is a difference between image G(i) and the filtered version of G(i). Notationally:

```
G[1] = input image
G[i] = reduce(G[i-1]) for i > 1.
L[i] = G[i] - gauss(G[i])
```

The **filter** parameter selects the type of gaussian filter to be applied. The effect of each filter is described in the WiT filter library during the discussion of the **gauss** operator. The **minsize** parameter defines the minimum size that an image G(i) can be before a reduce operation will not be performed and pyramid generation will terminate.

Parameter Information

filter Type: int
Default: 0
Values: 2x2: 0, 3x3: 1, 5x5: 2, 7x7: 3

minsize Type: int
Default: 8

C Prototype

```
CorOpRtn cor_fsd(
    CorImage *In,
    CorImageVector *Gaussian,
    CorImageVector *Laplacian,
    int filter,
    int minsize
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

fsdStep

Generate a new level in a FSD pyramid

Description

The **fsdStep** operator performs one iteration in the generation of a FSD pyramid (see **fsd**). The image output on the **Gaussian** port is equivalent to applying the **reduce** operator to the input image. The image output on the **Laplacian** port is the difference between the input image and the filtered version of that image. The **Final** output port is a flag which is set to 1 if this last iteration is the final step in a FSD pyramid generation. The flag is 0 otherwise. The final iteration occurs when the output image size is less than minimum size in at least one dimension. The **filter** parameter specifies the type of gaussian filter used during image reduction. The filters correspond to those provided by the **gauss** operator within the filter library. The **minsize** parameter denotes the minimum size of image that will be accepted as input to the operator.

Parameter Information

filter Type: int
Default: 0
Values: 2x2: 0, 3x3: 1, 5x5: 2, 7x7: 3

minsize Type: int
Default: 8

C Prototype

```
CorOpRtn cor_fsdStep(
    CorImage *In,
    CorImage *Gaussian,
    CorImage *Laplacian,
    int *Final,
    int filter,
    int minsize
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

gaussPyramid

Generate a gaussian pyramid

Description

The **gaussPyramid** operator generates a sequence of images corresponding to a gaussian pyramid. Each image G(i) is a reduction of image G(i-1). Notationally:

```
G[1] = input image
G[i] = reduce(G[i-1]) for i > 1.
```

The **filter** parameter selects the type of gaussian filter to be applied. The effect of each filter is described in the WiT filter library during the discussion of the **gauss** operator. The **minsize** parameter defines the minimum size that an image G(i) can be before a reduce operation will not be performed and pyramid generation will terminate.

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

minsize Type: int
Default: 8

C Prototype

```
CorOpRtn cor_gaussPyramid(
    CorImage *In,
    CorImageVector *Pyramid,
    int filter,
    int minsize
```

)

Headers

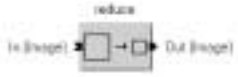
#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

reduce

Filter and decimate an image



Description

The **reduce** operator applies a filter to an input image and then decimates the resulting image by eliminating every other row and column. The **filter** parameter denotes which gaussian filter to use. The filters are discussed in more detail in the **gauss** operator within the filter library. The *None* option for filter indicates that no filtering will occur and that the input image will simply be decimated.

Parameter Information

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

C Prototype

```
CorOpRtn cor_reduce(
    CorImage *In,
    CorImage *Out,
    int filter
)
```

Headers

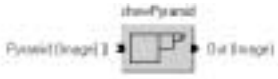
#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

showPyramid

Display all the images in a pyramid as one image



Description

The **showPyramid** operator takes an input image vector and creates a single image containing all elements within the vector. Component images can be ordered either horizontally, vertically, or in a spiral fashion as indicated by the **orientation** parameter. If a positive integer value *I* is specified for the **spacing** parameter, then a zero-valued band of pixels of width *I* will be placed between each component image within the composite image.

Parameter Information

orientation Type: int
Default: 0
Values: Horizontal: 0, Vertical: 1, Spiral: 2

spacing Type: int
Default: 0

C Prototype

```
CorOpRtn cor_showPyramid(
    CorImageVector *Pyramid,
    CorImage *Out,
    int orientation,
    int spacing
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

unDecimate

Expand image without filtering

Description

The **unDecimate** operator takes an input image and doubles its size. The data pixels from the input image are distributed throughout the output image in one of four possible decimation lattices. The lattice is specified by the **useRows** and **useColumns** parameters. These two parameters can be set to either even or odd indicating that pixels should be placed in the even or odd rows/columns of the input image. All other pixels not falling within the decimation lattice are set to zero-value. No filtering is performed by **unDecimate**.

Parameter Information

outputWidth Type: int
Default: 0

outputHeight Type: int
Default: 0

useRows Type: int
Default: 0
Values: Even: 0, Odd: 1

useColumns Type: int
Default: 0
Values: Even: 0, Odd: 1

borderWidth Type: int
Default: 0

C Prototype

```
CorOpRtn cor_unDecimate(
    CorImage *In,
    CorImage *Out,
    int outputWidth,
    int outputHeight,
    int useRows,
    int useColumns,
    int borderWidth
)
```

Headers

#include "$(WITHOME)/h/wPyramid.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wPyramid.lib

Segmentation

The Segmentation library produces binary or labeled images from grayscale source images. The library includes thresholding operators and other operators that divide an image into regions based on pixel values. It also includes operators that mark distinctive pixels in the image.

adaptThresh

Threshold an image relative to image mean pixel value

Description

The **adaptThresh** operator applies thresholding to a grayscale image using thresholds based on pixel values in the input image. For grayscale images the thresholds are applied directly to the values of image pixels. For color images the thresholds are applied to a luminence or intensity value for each pixel; the Y channel for Yuv images, the V channel for HSV images and a luminence value derived from all three channels (equivalent to the Y value) for RGB images.

The operator function is same as that of the **thresh** operator, except that values corresponding to the **lo** and **hi** parameters of the **thresh** operator are calculated from the image pixel values.

Each threshold value is set to the mean image pixel value plus an offset. The method of calculating the offsets is specified by the **offsetMethod** parameter. The low and high offset values are determined using the **loOffset** and **hiOffset** parameters, respectively.

When the **offsetMethod** parameter is set to *absolute* the **loOffset** and **hiOffset** parameter values are simply added to the mean value to determine the low and high threshold values. In the other modes the parameters are used as multiplying factors to determine the threshold offset values. In the *mean - min* mode the difference between the image mean pixel value and the image mimimum pixel value is multiplied by the parameter values and the resulting offset values are added to the image mean. In the *mean - min* mode the difference between the image maximum and the image mean is multiplied by the parameter values to determine the offsets. In the *standard deviation* mode the offsets are determined by multiplying the standard deviation of the image pixel values by the parameter values.

The low and high threshold values calculated for the image are output at the **LoThresh** and **HiThresh** outputs.

See the **thresh** operator for a description of the **invert**, **levels** and **result** parameters and the output images that result from various combinations of these parameters.

Parameter Information

offsetMethod Type: int
Default: 0
Values: absolute: 0, mean-min: 1, max-mean: 2, standard deviation: 3

loOffset Type: float
Default: 0

hiOffset Type: float
Default: 0

invert Type: int
Default: 0
Values: no: 0, yes: 1

levels Type: int
Default: 1
Values: double: 0, single: 1

result Type: int
Default: 1
Values: semi-threshold: 0, binary: 1

Demo iGraph

Operators\Segmentation\AdaptThresh

C Prototype

```
CorOpRtn cor_adaptThresh(
    CorImage *In,
    CorImage *Out,
    float *loThresh,
    float *hiThresh,
    int offsetMethod,
    float loOffset,
    float hiOffset,
    int invert,
    int levels,
    int result)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

colorThresh

Thresholds multi-channel images

Description

The **colorThresh** operator thresholds multi-channel images The operator produces a binary output image of all pixels with values that fall within (or outside) a specified volume in the image's color space. The operator accepts RGB, HSV, or Yuv images as input and produces an 8-bit unsigned image as output.

The type of color space volume is specified using the **type** parameter. When this parameter is set to *Level*, the color space volume is the region in which the pixel value in each channel is greater than the corresponding value among the **ch0 Low**, **ch1 Low**, and **ch2 Low** parameters,

When the **type** parameter is set to *Box* the volume is a rectangular box with axes parallel to the color space coordinate axes; when set to *Ellipsoid* the volume is an ellipsoid with axes parallel to the color

space coordinate axes; and when set to *Cylinder* the volume is an elliptical cylinder with the cylinder axis parallel to the channel 0 axis and the ellipse axes parallel to the channel 1 and channel 2 coordinate axes. For these types the size of the volume is specified by the **ch0 Low**, **ch0 High**, **ch1 Low**, **ch1 High**, **ch2 Low**, and **ch2 High** parameters, which give the minimum and maximum extent of the volume along the channel 0, channel 1, and channel 2 axes. If the input image is an HSV image the channel 1 volume wraps around at 255, so if **ch0 High** is less than **ch0 Low** the volume extends from **ch0 Low** to 255 and from 0 to **ch0 High**.

The **invert** parameter controls the value assigned to pixels in the output that correspond to input pixels with values in the color space volume. When the parameter is set to *No* these pixels are set to 255 and the remaining pixels are set to 0. When it is set to *Yes* these pixels are set to 0 and the remaining pixels are set to 255.

Parameter Information

type Type: int
Default: 0
Values: Level: 0, Box: 1, Ellipsoid: 2, Cylinder: 3

ch0 Low Type: int
Default: 0
Values: 0 — 255

ch0 High Type: int
Default: 255
Values: 0 — 255

ch1 Low Type: int
Default: 0
Values: 0 — 255

ch1 High Type: int
Default: 255
Values: 0 — 255

ch2 Low Type: int
Default: 0
Values: 0 — 255

ch2 High Type: int
Default: 255
Values: 0 — 255

invert Type: int
Default: 0
Values: No: 0, Yes: 1

Demo iGraph

Operators\Segmentation\ColorThresh
Operators\Segmentation\ColorThreshHSV

C Prototype

```
CorOpRtn cor_colorThresh(
    CorImage *In,
    CorImage *Out,
    int type,
    int ch0_Low,
    int ch0_High,
    int ch1_Low,
    int ch1_High,
    int ch2_Low,
    int ch2_High,
    int invert)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

kMeans

Automatically segment an image by pixel value

Description

The **kMeans** operator partitions an image into *k* clusters based on the pixel value. In the resulting partition, each pixel is closer in value to the mean value of the pixels in the cluster to which it belongs than it is to the mean of any other cluster. In general, there is not a unique partition that satisfies this condition, so the result may depend on choice of initial mean values for the iterative method.

The input to the operator is an integer or float image. The output image (at the top output port) is an unsigned 8 bit segmented image, with each pixel

assigned the label associated with its cluster. The labels are numbers from 0 to *k-1* ordered such that 0 represents the lowest value range and *k-1* the highest value range. The other three outputs are vectors of *k* numbers representing the mean, variance and number of pixels for each cluster.

The **initMeans** parameter is used to select from the two methods provided for specifying initial mean values. If *auto* is selected, then the number of clusters, *k* must be specified with the **numClusters** parameter. The operator will then automatically spread the initial means evenly over the range of values in the image. If *array* is selected, the initial mean values are specified by the **meanValues** array parameter. In this case, the number of clusters, *k* is set to the array size.

A maximum number of iterations is specified by the **maxIterations** parameter. The operator will continue until it converges to a local solution (that is, there is no further change in mean values) or the maximum number of iterations is reached.

As mentioned, there is not generally a unique kmeans partition. With inappropriate initial values, the resulting partition may not be what is expected. The vector outputs of the operator can be used to evaluate the quality of the solution and to help determine reasonable starting values. In the simplest case, the **mean** output from a model image can be provide the initial mean values for test images, either by connecting the output directly to the **meanValues** parameter port (with the parameter in *input* mode) or by entering the values using the array editor.

The **variance** and **number** outputs produce vectors representing the variance and number of pixels for each cluster. Depending on the application, a cluster with a large variance or small number of pixels relative to the other clusters may indicate a problem with the partion. In some cases these values could be used to modify the values in the **mean** vector to provide a new set of initial values.

Parameter Information

initMeans Type: int
Default: 1
Values: array: 0, auto: 1

meanValues Type: CorVector
Default: [0, 255]

numClusters Type: int
Default: 2

maxIterations Type: int
Default: 10000

Demo iGraph

Operators\Segmentation\KMeans

C Prototype

```
CorOpRtn cor_kMeans(
    CorImage *In,
    CorImage *Out,
    CorVector *Mean,
    CorVector *Variance,
    CorVector *Number,
    int initMeans,
    CorIntVector *meanValues,
    int numClusters,
    int maxIterations
)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

localAdaptThresh

Threshold an image relative to local mean pixel value

Description

The **localAdaptThresh** operator applies thresholding to a grayscale or color image using thresholds based on local pixel values in the input image. For grayscale images the thresholds are applied directly to the values of image pixels. For color images the thresholds are applied to a

luminence or intensity value for each pixel; the Y channel for Yuv images, the V channel for HSV images and a luminence value derived from all three channels (equivalent to the Y value) for RGB images.

The operator function is similar to that of the **thresh** operator, except that values corresponding to the **lo** and **hi** parameters of the **thresh** operator are calculated for each pixel in the image based on pixel values in the its neighbourhood.

Low and high threshold values are calculated for each pixel in the image. Each threshold value is set to the local mean pixel value plus an offset. The local mean is calculated over a rectangular region around the pixel whose size is specified by the **width** and **height** parameters.

The method of calculating the offsets is specified by the **offsetMethod** parameter. The low and high offset values are determined using the **loOffset** and **hiOffset** parameters, respectively.

When the **offsetMethod** parameter is set to *absolute* the **loOffset** and **hiOffset** parameter values are simply added to the local mean value to determine the low and high threshold values. In the other modes the parameters are used as multiplying factors to determine the threshold offset values. In the *mean - min* mode the difference between the local mean pixel value and the image mimimum pixel value is multiplied by the parameter values and the resulting offset values are added to the local mean. In the *max - mean* mode the difference between the image maximum and the local mean is multiplied by the parameter values to determine the offsets. In the *standard deviation* mode the offsets are determined by multiplying the standard deviation of the pixel values in the neighbourhood by the parameter values. Note that the *standard deviation* is calculated over the same neighbourhood as the local mean value, while the minimum and maximum used in the previous two modes described are the minimum and maximum over all pixel values in the image.

The **minOffsetBase** parameter is used in the *mean - min*, *max - mean* and *standard deviation* modes to help suppress noise problems in low signal regions of the image. The parameter value specifies the minimum value of the difference (in the first two modes) or the standard deviation used to calculate the offsets. The limit on the offset for a threshold can be determined by multiplying this value by the **loOffset** or **hiOffset** parameter value.

See the **thresh** operator for a description of the **invert**, **levels** and **result** parameters and the output images that result from various combinations of these parameters.

MMX acceleration is available for 8 bit unsigned input images in the *mean - min* mode when the **loOffset** is 0.5, 0.25, 0.125 or 0.0625, **invert** is *true*, **levels** is set to *single*, **result** is *binary*, the size of the kernel (**width** times **height**) is a power of two not greater than 256, and both **width** and **height** are greater than one.

Parameter Information

width	Type: int Default: 25
height	Type: int Default: 25
offsetMethod	Type: int Default: 0 Values: absolute: 0, mean-min: 1, max-mean: 2, standard deviation: 3
loOffset	Type: float Default: 0
hiOffset	Type: float Default: 0
minOffsetBase	Type: float Default: 0
invert	Type: int Default: 0 Values: no: 0, yes: 1
levels	Type: int Default: 1 Values: double: 0, single: 1
result	Type: int Default: 1 Values: semi-threshold: 0, binary: 1

Demo iGraph

Operators\Segmentation\LocalAdaptThresh

C Prototype

```
CorOpRtn cor_localAdaptThresh(
    CorImage *In,
    CorImage *Out,
    int width,
    int height,
    int offsetMethod,
    float loOffset,
    float hiOffset,
    float minOffsetBase,
    int invert,
    int levels,
    int result)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

localPeaks

Find local maxima or minima in images

Description

The **localPeaks** operator finds local maxima or minima in an image and produces a binary output image in which the non-zero pixels represent the maxima or minima found. The **peakType** parameter is used to specify either minima or maxima.

A local maximum may be a single pixel or a plateau. A single pixel maximum has a value greater than all adjacent pixels. A plateau is a contiguous group of pixels with equal value, where all pixels not in the group and adjacent to any pixel in the group have a value less than pixels in the group. The definition of local minima is similar, with values less than those of adjacent pixels.

The **connectivity** parameter is used to specify which pixels are considered adjacent to another pixel. If it is set to *4*, the four edge connected neighbours are considered the adjacent pixels. If it is set to *8*, the four diagonal neighbours are also included.

Parameter Information

peakType Type: int
Default: 1
Values: minima: 0, maxima: 1

connectivity Type: int
Default: 1
Values: 4: 0, 8: 1

Demo iGraph

Operators\Segmentation\LocalPeaks

C Prototype

```
CorOpRtn cor_localPeaks(
    CorImage *In,
    CorImage *Out,
    int peakType,
    int connectivity
)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

localThresh

Local thresholding using seed points

Description

The **localThresh** operator performs local thresholding for segmenting objects from a greyscale image. The top input port is connected to an 8-bit input image and the bottom input port is connected to a set of seed points from which region growing is to start. The seed input may be either a

binary image where the seed is a non-zero pixel value or a **getData** vector of points where each seed is an (x,y) location. The algorithm goes through the list of seeds, one by one, and attempts to grow the seed region by examining the seed's 8 neighbours recursively. A neighbour is region grown if its pixel value satisfies a threshold. The threshold is determined by the parameters **peakFraction** and **minContrast**. The idea here is to grow seed values into a region with pixels greater than a certain percentage of the seed pixel value. The **minContrast** constraint is involved to ensure the result of multiplying the seed value by the **peakFraction** to obtain a threshold will not go below/above a minimum noise level.

Note how the sign of **minContrast** determines whether a region is considered above or below a threshold. This technique for thresholding objects from a scene is ideal if the scene's background is not uniform. In other words each object to be segmented has a different background level. Global thresholding would either isolate too few objects or too much of the scene as a result of variation in the scene background.

This operator is often used after high-pass filtering an image, where there is a definite base level with which to measure contrast. The seed points can be generated by performing an edge detection followed by zero crossing detection, and then using the zero crossing points as seeds.

Parameter Information

peakFraction Type: float
Default: 50

minContrast Type: int
Default: 0

Demo iGraph

Operators\Segmentation\LocalThreshold

C Prototype

```
CorOpRtn cor_localThresh(
    CorImage *In,
    CorObj *Seed,
    CorImage *Out,
    float peakFraction,
    int minContrast
)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

thresh

Threshold an image in an interval

Description

The **thresh** operator takes a greyscale or color image and produces a binary or semi-binary image based on a specified threshold range. For grayscale images the thresholds are applied directly to the values of image pixels. For color images the thresholds are applied to a luminence or intensity value for each pixel; the Y channel for Yuv images, the V channel for HSV images and a luminence value derived from all three channels (equivalent to the Y value) for RGB images.

In the simplest use, set **invert** to *No* and **levels** to *single*. Then pixels which are equal to or above **lo** are turned 'on' and those below are turned 'off'. The **hi** parameter is not used when **levels** is set to *single*.

The value of 'on' and 'off' is controlled by the **result** parameter. If **result** is *binary*, the output is an 8-bit unsigned image with 'on' pixels set to 255 and and 'off' pixels set to 0. If **result** is *semi-threshold* the output image has the same type as the input image. 'On' pixels maintain their original values while 'off' pixels are set to the value specified by the **semiFillValue** parameter. For scalar input images this parameter should be set to a scalar value. If the value is outside the range of the input image type the value will be clipped. For color images the **semiFillValue**parameter can be set to a the same type as the input image or to a scalar value. If it is

set to a scalar the value is clipped to the unsigned byte range and applied to all channels.

If **levels** is *double* and **invert** is *No*, pixels in the range [lo, hi] (inclusive) are turned 'on', otherwise 'off'.

Setting the **invert** parameter to *Yes* causes the on and off ranges to be flipped. If **levels** is *single*, pixels equal to or above **lo** are 'off'. If **levels** is *double*, pixels in [lo, hi] (inclusive) are 'off'.

Parameter Information

lo	Type: float Default: 0
hi	Type: float Default: 255
invert	Type: int Default: 0 Values: no: 0, yes: 1
levels	Type: int Default: 1 Values: double: 0, single: 1
result	Type: int Default: 1 Values: semi-threshold: 0, binary: 1
semiFillColor	Type: CorObj Default: "OBJ_B T int 0"

Demo iGraph

Operators\Segmentation\Thresh
Operators\Segmentation\DoubleThresh

C Prototype

```
CorOpRtn cor_thresh_1(
    CorImage *In,
    CorImage *Out,
    float lo,
    float hi,
    int invert,
    int levels,
    int result,
    CorObj *semiFillColor
)
CorOpRtn cor_thresh_1_consume(
    CorImage *In,
    float lo,
    float hi,
    int invert,
    int levels,
    int result,
    CorObj *semiFillColor
)
```

Headers

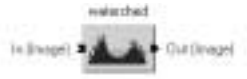
#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

watershed

Perform a watershed image segmentation



Description

The **watershed** operator segments an integer or floating point image into regions analogous to catchment basins in topographic elevation maps using the algorithm of Vincent and Soille (PAMI-13(6), 583--597; 1991).

Each region corresponds to a local image minimum and the surrounding basin, pixels for which there is a descending path to that minimum and to no other local minimum. Pixels that have a descending path to more than one local minimum are not included in any region, except in the case of ``plateaus''. Plateaus are flat areas of more than one pixel width between basins, these regions are divided according to their distance from the adjoining basins, with plateau pixels assigned to the region associated with the nearest basin. Pixels mid-way between two basins may not be assigned to a region.

The operator output is an unsigned 16 bit image in which the pixels of each region are given a distinct value (or label), from one to the number of regions. The pixels not assigned to any region are given a value of zero. It should be noted that these zero pixels do not necessarily form a continous dividing line between the regions.

The **connected** parameter controls the neighbourhood searched for descending paths from a pixel. It also affects the interpretation of distance when dividing plateau areas among regions. Setting this parameter to *4* will generate four connected basins and the distances on plateaus are "city block" distances, the distance measured moving in vertical and horizontal directions only. Selecting *8* will generate eight connected basins and use a "chess board" distance where all eight connected pixels are considered to be one unit length away.

Parameter Information

connected Type: int
Default: 1
Values: 4: 0, 8: 1

Demo iGraph

Operators\Segmentation\Watershed

C Prototype

```
CorOpRtn cor_watershed(
    CorImage *In,
    CorImage *Out,
    int connected
)
```

Headers

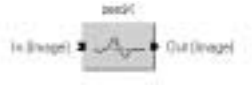
#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

zeroX

Zero crossing detector



Description

The **zeroX** operator finds zero crossings in the rows of a signed 8-bit integer, signed 16-bit integer, or float input image. One of three types of zero crossings may be found: *all*, *lo->hi*, or *hi->lo*. The operator produces a binary (unsigned 8-bit) image marking the locations of the zero crossings found in the input image.

A low to high transition occurs where a pixel value is greater than or equal to zero and the value of the preceding pixel in the row is less than zero, subject to the contrast test described below. Similarly, a high to low transition occurs where a pixel value is less than or equal to zero and the value of the preceding pixel in the row is greater than zero. When all zero crossings are desired, both low to high and high to low transitions are marked

A contrast test ensures that the amplitudes of the high and low pixel values defining the zero crossing are more than the value specified by the **contrast** parameter away from zero. The contrast test searches backward and forward from a potential zero crossing point to ensure the given contrast is present within the **zxwidth**.

For example, if *lo->hi* transitions are desired then for each such transition found, the algorithm will search backwards along the negative lobe (for not more than **zxwidth** pixels) for a pixel value more than the given contrast below zero. If this condition is met, then the algorithm searches forward along the positive lobe (for not more than **zxwidth** pixels) for a pixel greater than the given contrast. If this condition is met then the zero crossing is marked, otherwise it is rejected. When a zero crossing is marked, the search for zero crossings resumes from the pixel at which the forward search criterion was met. This means that zero crossings within the **zxwidth** range may be ignored.

Parameter Information

zxtype Type: int
Default: 0
Values: all: 0, lo->hi: 1, hi->lo: 2

contrast Type: int
Default: 1

zxwidth Type: int
Default: 1

Demo iGraph

Operators\Segmentation\ZeroCrossing

C Prototype

```
CorOpRtn cor_zeroX(
    CorImage *In,
    CorImage *Out,
    int zxtype,
    int contrast,
    int zxwidth
)
```

Headers

#include "$(WITHOME)/h/wSegment.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSegment.lib

Statistics

The Statistics library supports data reduction by the extraction or calculation of values based on the values in the input image or vector. The library includes operators that extract statistics from images or vectors; operators that extract image histograms; operators that extract projections from images; and some additional operators that process the extracted data.

backgnd

Compute an image background value

Description

The **backgnd** operator computes an approximate background intensity by taking the average pixel value from the four corners of the input image ROI. The output is a float background pixel value.

Demo iGraph

Operators\Statistics\BGSubtract

C Prototype

```
CorOpRtn cor_backgnd(
    CorImage *In,
    float *Background
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

bound

Determine extreme values in an image or vector

Description

The **bound** operator takes an input image or vector and returns the maximum and minimum values of the pixels or vector elements. Bounding values can be found for integer, float and complex images but not for color (RGB) images. For a complex image, the maximum and minimum of the base 10 logarithm of the magnitude of the complex pixel values are produced.

Vector bounding can only be performed on vectors of simple objects. Bounding values for vectors of vectors or vectors of images cannot be found using this operator.

Demo iGraph

Operators\Statistics\BoundThresh

C Prototype

```
CorOpRtn cor_bound(
    CorObj *In,
    double *Min,
    double *Max
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

countPix

Count the non-zero pixels in an image

Description

The **countPix** operator counts the non-zero pixels in the input image.

Demo iGraph

Operators\Statistics\CountPix

C Prototype

```
CorOpRtn cor_countPix(
    CorImage *In,
    int *Count
)
```

Headers

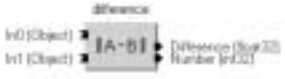
#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

difference

Measure the difference between two vectors or images



Description

The **difference** operator computes the difference between two images or vectors of numbers in one of several of ways. The various measures are based on pixel by pixel (or element by element) differences in the image (or vector).

The **measure** parameter specifies how the pixel or element value differences are used to produce a difference measure. Root mean square (RMS), average squared error, average absolute value of the error, euclidean distance, sum of squared errors, sum of absolute value of errors or maximum error may be selected.

Input images may be any of the standard WiT image types (unsigned 8-bit, signed 8-bit, unsigned 16-bit, signed 16-bit, float, complex, RGB, HSV, YUV). The difference measure is calculated over all pixels in the intersection of the input image ROIs. If the **useMask** parameter is set to *Yes* a mask specified by the **mask** parameter is applied, so that only pixels in the mask region and in the intersection of the ROIs of teh two input images are used to calculate the difference.

Input vector elements may be any of the types valid for images or unsigned 32-bit integer, signed 32-bit integer or double. The two input vectors must be the same size.

Parameter Information

measure Type: int
Default: 3
Values: RMS: 0, Mean Square Error: 1, Average Difference: 2, Euclidean Distance: 3, Sum of Squared Errors: 4, Sum of Differences: 5, Maximum: 6

useMask Type: int

Default: 0
Values: No: 0, Yes: 1

Mask Type: CorObj
Default: "OBJ_B T CorGeom 4
CorFpoint 2 0 0 99 99 -"

Demo iGraph

Operators\Filters\Variance
Operators\Filters\Entropy

C Prototype

```
CorOpRtn cor_difference(
    CorObj *In0,
    CorObj *In1,
    float *Difference,
    int *Number,
    int measure,
    int useMask,
    CorObj *Mask
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

getSlopeMaxima

Find local slope maxima in a vector

Description

The **getSlopeMaxima** operator finds local maxima and/or minima in a vector of scalar or point type values. The **Profile** input may be any integer or real scalar type vector or an integer or real point vector. The **direction** parameter determines if the operator looks for rising edges, falling edges, or both.

The **Slope** output is a vector that contains the calculated slope values. For scalar inputs this is a float vector. For point inputs this is a real point vector that contains the slope values in the *y* field and the *x* values from the **Profile** input the *x* field

The **SlopeMax** output is a vector of real point values that correspond to local slope extrema in the input that have an absolute value greater than the **threshold** parameter value. The *x* fields correspond to the position of the slope maximum/minimum and the *y* fields correspond to the maximum/minimum slope value. The **SlopeStart** and **SlopeEnd** outputs are vectors of real points that contain the location (in the *x* field) and profile value (in the *y* field) of the start and end of a continuous slope region in the profile. The start and end of the slope regions are defined as the zero crossing or local exteme value in the slope nearest to the slope maximum/minimum location.

The **Slope** output is a vector that contains the calculated slope values. For scalar inputs this is a float vector. For point inputs this is a real point vector that contains the slope values in the *y* field. The *x* field contains the *x* values from the **Profile** input.

The **interpolate** parameter can be used to specify the use of interpolation to more accurately determine the position of the maximum slope location. This is only applied to the location field (the *x* field) in the **MaxSlope** output. The maximum slope value and the position and value at the start and end of the slope are not interpolated.

Parameter Information

direction Type: int
Default: 0
Values: rising: 0, falling: 1, rising or falling: 2

threshold Type: float

interpolate Type: int
Default: 1
Values: No: 0, Yes: 1

Demo iGraph

Operators\Statistics\LocateInProj_Slope

C Prototype

```
CorOpRtn cor_getSlopeMaxima(
    CorVector *Profile,
    CorVector *Slope,
    CorFpointVector *SlopeMax,
    CorFpointVector *SlopeStart,
    CorFpointVector *SlopeEnd,
    int direction,
    float threshold,
    int interpolate
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

histCentroid

Compute the centroid of a histogram or numeric vector

Description

The **histCentroid** operator computes the centroid of a histogram or vector of numbers. Histograms are implemented as vectors of Real point objects, where the x field represents the value and the y field represents the frequency. The centroid of the histogram corresponds to the average of the pixel values that formed the image. When the centroid is calculated for numeric vectors, the element values correspond to frequency and the vector index corresponds to value.

Demo iGraph

Operators\Statistics\LocateInProj_Centroid

C Prototype

```
CorOpRtn cor_histCentroid(
    CorVector *Hist,
    float *Centroid
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

histPeaks

find histogram maxima or minima

Description

The **histPeaks** operator finds local maxima or minima in a histogram produced by the **histogram** or **histRoi** operator. The operator output is a vector of histogram entries (Real point objects) in which the x coordinate is the pixel value and the y coordinate is the frequency value associated with the maximum or minimum. The **type** parameter is used to specify whether the operator will find minima or maxima in the histogram.

The **vicinity** parameter is used to suppress multiple peaks in close proximity. If a higher peak is found in the **vicinity** of a local peak, the lower peak is suppressed. The higher peak may be suppressed by an even higher peak in its vicinity, which may not be in the vicinity of the lowest peak. In this case, only the highest peak is retained, even though the lowest peak is outside of its vicinity. The vicinity is expressed in pixel value units, corresponding to the x coordinate of the histogram entries.

Parameter Information

type Type: int
Default: 0
Values: minima: 0, maxima: 1

vicinity Type: float
Default: 1

Demo iGraph

Operators\Statistics\HistThresh

C Prototype

```
CorOpRtn cor_histPeaks(
    CorFpointVector *Hist,
    CorFpointVector *Peaks,
    int type,
    float vicinity
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

histogram

Compute a frequency distribution

Description

The **histogram** operator computes a frequency distribution of values in an integer or float input image. Either normal or cumulative histograms can be computed.

The **lo** and **hi** parameters determine the range of pixel values used in forming the histogram. This range is divided into equal size bins, with the number of bins specified by the **nbins** parameter. A bin frequency is determined by incrementing the bin for each image pixel whose value falls within the bin (or, in the case of a cumulative histogram, whose value is less than the bin maximum). A normal or cumulative histogram is selected using the **type** parameter.

The operator produces a vector of Real points. The first coordinate of the point is the bin boundary value and the second coordinate is the bin frequency. The vector may be viewed by connecting the **histogram** output to the **graph** operator for plotting.

If the **useMask** parameter is set to *No* the histograms are calculated using the entire image ROI. If the **useMask** parameter is set to *Yes* the histograms are calculated using pixels in the intersection of the image ROI and a mask specified by the **Mask** parameter. The mask can be specified by a Geometry or Graphic object or a binary image. The mask may also be specified by a vector of Geometry or Graphic objects, binary images or Blobs. In this case pixels may be counted more than once if the elements overlap in the image.

Parameter Information

type Type: int
Default: 0
Values: normal: 0, cumulative: 1

nbins Type: int
Default: 256

lo Type: float
Default: 0

hi Type: float
Default: 255

useMask Type: int
Default: 0
Values: No: 0, Yes: 1

Mask Type: CorObj
Default: "OBJ_B T CorGeom 4
CorFpoint 2 0 0 99 99 -"

Demo iGraph

Operators\Statistics\Histogram
Operators\Calculate\HistEqualize
Operators\Calculate\AddNoise

C Prototype

```
CorOpRtn cor_histogram_1(
    CorImage *In,
    CorFpointVector *Hist,
    int type,
    int nbins,
    float lo,
    float hi,
    int useMask,
    CorObj *Mask
```

)

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

projection

Compute row and column sums

Description

The **projection** operator produces row and column sums for the input image. The vector produced at the **Horizontal** output port contains the sums of the rows, the vector produced at the **Vertical** port contains the sums of the columns.

The output type can be selected with the **output** parameter. When this parameter is set to **Float**, the output vectors contain the pixel sums, with the first sum corresponding the the top row or leftmost column. When this parameter is set to **RealPoint**, the output vectors contain Real points with the pixel sums in the y field and the row (or column) number in the x field.

If the **useMask** parameter is set to *No* the projections are calculated using the entire image ROI. If the **useMask** parameter is set to *Yes* the projections are calculated using pixels in the intersection of the image ROI and a mask specified by the **Mask** parameter. The mask can be specified by a Geometry or Graphic object or by a binary image. The mask may also be specified by a vector of Geometry or Graphic objects, binary images or Blobs. In this case pixels may be counted more than once if the elements overlap in the image.

Parameter Information

output Type: int
Default: 0
Values: Float: 0, RealPoint: 1

useMask Type: int
Default: 0
Values: No: 0, Yes: 1

Mask Type: CorObj
Default: "OBJ_B T CorGeom 4
CorFpoint 2 0 0 99 99 -"

Demo iGraph

Operators\Statistics\Projection
Operators\Statistics\LocateInProj_Slope
Operators\Statistics\LocateInProj_Centroid

C Prototype

```
CorOpRtn cor_projection_1(
    CorImage *In,
    CorVector *Horizontal,
    CorVector *Vertical,
    int output,
    int useMask,
    CorObj *Mask
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

smoothHist

smooth a histogram

Description

The **smoothHist** operator smoothes a histogram produced by the **histogram** or **histRoi** operator. The output histogram frequency values are

smoothed by averaging the frequency values over a neighbourhood determined using **width** parameter. The width is specified in terms of the image pixel values (the x coordinates of the histogram entries) rather than number of bins. The width value is converted to the nearest odd number of bins based on the difference between the pixel values associated with the first two entries in the histogram. Consequently, the entries in the input histogram must be equally spaced in the pixel value (x) coordinate, as they are when produced by the **histogram** and **histRoi** operators.

Parameter Information

width Type: float
Default: 3

Demo iGraph

Operators\Statistics\HistThresh

C Prototype

```
CorOpRtn cor_smoothHist(
    CorFpointVector *Hist,
    CorFpointVector *SmoothedHist,
    float width
)
```

Headers

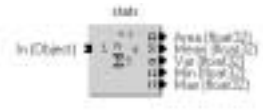
#include "$(WITHOME)/h/wStats.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

stats

Compute basic image statistics



Description

The **stats** operator derives basic statistics for an image or vector input. The operator accepts integer or float images and vectors of integer, unsigned integer, short, unsigned short, float or double type values. A geometric or image mask can be specified for image inputs.

The number of values, mean, standard deviation, minimum, and maximum of the image pixel values within the image ROI or of the vector element values are computed and produced on the top to bottom output ports, respectively.

If the input is an image and he **useMask** parameter is set to *Yes* the statistics are calculated using pixels in the intersection of the image ROI and a mask specified by the **Mask** parameter. The mask can be specified by a Geometry or Graphic object or by a binary image. The mask may also be specified by a vector of Geometry or Graphic objects, binary images or Blobs. In this case pixels may be counted more than once if the elements overlap in the image.

Parameter Information

useMask Type: int
Default: 0
Values: No: 0, Yes: 1

Mask Type: CorObj
Default: "OBJ_B T CorGeom 4
CorFpoint 2 0 0 99 99 -"

Demo iGraph

Operators\Statistics\Stats
Operators\Blobs\BlobStats

C Prototype

```
CorOpRtn cor_stats_1(
    CorObj *In,
    float *Area,
    float *Mean,
    float *Var,
    float *Min,
    float *Max,
    int useMask,
    CorObj *Mask
)
```

Headers

#include "$(WITHOME)/h/wStats.h"

Libraries

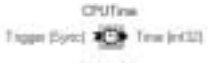
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wStats.lib

File IO

The File IO library supports writing to and reading from files. The library includes operators that read and write WiT objects; operators that read and write a number of image formats; and operators to support related functions.

CPUTime

Get the current CPU time



Description

Get the CPU time, typically to time sections of an igraph accurately.

Parameter Information

format Type: int
Default: 0
Values: milli: 0, micro: 1

C Prototype

```
CorOpRtn cor_CPUTime(
    int *Time,
    int format
)
```

Headers

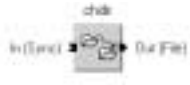
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

chdir

Change current object directory



Description

The **chdir** operator allows an executing igraph to change the object directory. This way you can use relative path names for operators which access the file system, such as **wrObj** and **wrImage**.

Parameter Information

filename Type: CorFile

C Prototype

```
CorOpRtn cor_chdir_1(
    CorFile *Out,
    CorFile filename
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

directory

Read a directory

Description

On receiving any object at its input, the **directory** operator forms a vector of strings representing the filenames that match a wildcard **filename** specifier in the current object directory. The **filename** specification is supplied in the property window and can consist of any valid regular expression, eg.

*.wit. If no matching filenames are found, the operator outputs an empty vector.

This operator is used as a method of sequencing a number of related objects from disk through an igraph (see also **sequencer**).

Parameter Information

filename Type: CorFile
Default: "*"

C Prototype

```
CorOpRtn cor_directory(
    CorStringVector *Filename,
    CorFile filename
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

exit

Exit WiT

Description

The **exit** operator causes WiT to exit when it receives any object at its input. If the **confirm** parameter is set to *no*, WiT will terminate immediately. If the parameter is set to *yes*, the user will be prompted before termination.

Parameter Information

confirm Type: int
Default: 0
Values: Yes: 0, No: 1

fileStatus

Check the status of a file

Description

The **fileStatus** operator reports the existence, size or time of last modification of a file. The name of the file to be tested is specified using the **filename** parameter.

The **request** parameter determines which of the three status values is reported. If it is set to *Exists* the operator will output a one if the file exists or a zero if it does not. If the **request** parameter is set to *Size* the operator will output the size of the file in bytes. If the named file does not exist the operator will output -1.

If the **request** parameter is set to *Time* the operator produces the time at which the specified file was last modified. The format of the output is controlled by the **format** parameter. The *Integer* format output is the number of seconds since a standard reference date. The *String* format output is the date and local time in the format:

Wed Nov 10 14:27:42 1999

If the file does not exist the output is -1 in the *Integer* format and an empty string in the *String* format.

Parameter Information

filename Type: CorFile
Default: "sample"

request Type: int
Default: 0
Values: Exists: 0, Size: 1, Time: 2

format Type: int
Default: 1
Values: String: 0, Integer: 1

C Prototype

```
CorOpRtn cor_fileStatus(
    CorObj *Status,
    CorFile filename,
    int request,
    int format
)
```

Headers

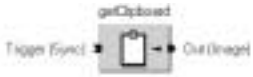
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

getClipboard

Get an image from the clipboard



Description

The **getClipboard** operator reads the current contents of the system clipboard when it receives any object at its input. If the current contents of the clipboard is a BMP format image **getClipboard** will read in the image and output it as a WiT color image. If the clipboard contains anything other than a BMP format image an error occurs.

C Prototype

```
CorOpRtn cor_getClipboard(
    CorImage *Out)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

getTime

Get the current date and time

Description

The **getTime** operator reports the current date and time when any token is received at the input. The format of the output is controlled by the **format** parameter. The *Integer* format output is the number of seconds since a standard reference date. The *String* format output is the date and local time in the format:

Wed Nov 10 14:27:42 1999

Parameter Information

format Type: int
Default: 0
Values: String: 0, Integer: 1

C Prototype

```
CorOpRtn cor_getTime(
    CorObj *Time,
    int format
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

mkdir

Create directory

Description

Create directory

Parameter Information

dirname Type: CorFile

force Type: int
Default: 0
Values: yes: 0, no: 1

C Prototype

```
CorOpRtn cor_mkdir(
    CorFile dirname,
    int force
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

playSound

Play a waveform sound file

Description

Play a waveform sound file

Parameter Information

filename Type: CorFile
Default: ""

type Type: int
Default: 0
Values: Asynchronously: 0, Synchronously: 1

loop Type: int
Default: 0
Values: off: 0, on: 1

nostop Type: int
Default: 0
Values: yes: 0, no: 1

C Prototype

```
CorOpRtn cor_playSound(
    CorFile filename,
    int type,
    int loop,
    int nostop
)
```

Headers

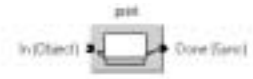
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

print

Print an object



Description

The **print** operator converts the input object to printer compatible format or text and then either sends it to the printer or saves it to a file.

image quality: If **high**, grayscale images are output in 256 (8-bit) grayscale. Color images are output in 256 grayscale or 24 bit/pixel format depending on **color** parameter. This allows the printer the freedom to use whatever halftone screen to produce the best results. On low-cost printers, the results may not look very good, but you can send the same file to a professional printer and obtain flawless images. Grayscale images require much more data to be transferred to the printer, and so may take more time to print, particularly if the link to the printer is serial. The images can be more difficult to photocopy too. If **draft** is chosen, the image is dithered with the resolution of the screen used. If you are using a monochrome display, the output

will have exactly the same number of dots as you see on the screen.

show frame: Enable or disable a frame around the object.

pagesize: This information allows the object to be centered on the printed page.

pagesize: This information allows the object to be centered on the printed page. If **custom** is chosen, the size must be specified in the **customSize** parameter.

customSize: Width and height of custom paper size. This is particularly useful if you want to make the object (using **fit** parameter) fit a known size.

orientation: **Landscape** means longer side of paper is horizontal (X-axis). **Portrait** means longer side of paper is vertical (Y-axis).

format: If **graphic**, the output is printer format. General objects are printed as printer encoded formatted text. An image always occupies one page, even if it may be clipped. A general object may span several printed pages. If **text**, the output is straight text (ASCII). Images are printed as hexadecimal values.

fit: If **Yes**, the object is scaled to exactly fit the page (determined by **pagesize** and **orientation**. If **No**, the scale specified in **scale** is used.

scale: The scale in printer points (1/72 inch) per pixel.

color: If **color** is chosen, color images are output.

print to: **Printer** - send to printer. **file** - save to file. **EPS** - save to file in EPS format. *name* - name of file for **file** or **EPS print to** setting. More information about printing can be found in the *User's Manual*.

Parameter Information

show frame Type: int
Default: 0
Values: yes: 0, no: 1

format Type: int
Default: 0
Values: graphic: 0, text: 1

fit Type: int
Default: 0
Values: no: 0, yes: 1

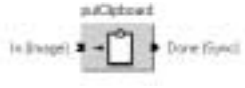
scale Type: float
Default: 1

print to Type: int
Default: 0
Values: printer: 0, file: 1

name Type: CorFile
Default: "witprint"

putClipboard

Put an image on the clipboard



Description

The **putClipboard** operator writes an eight bit unsigned or color WiT image to the system clipboard in BMP format. Images of other WiT types must first be converted to the eight bit unsigned type using the **castImage** operator before they are saved to the clipboard.

C Prototype

```
CorOpRtn cor_putClipboard(
    CorImage *In)
```

Headers

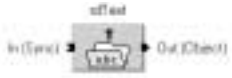
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

rdText

Read a text file and convert to WiT data objects



Description

Read a text file and convert to WiT data objects

Parameter Information

filename Type: CorFile
Default: "test.txt"

objType Type: int
Default: 0
Values: char: 0, int8: 1, int16: 2, int32: 3, long: 4, uint8: 5, uint16: 6, uint32: 7, ulong: 8, hex8: 9, hex16: 10, hex: 11, float: 12, double: 13, String: 14

array Type: int
Default: 0
Values: as image: 0, as vector of vectors: 1

multiLineStrings Type: int
Default: 0
Values: delimited: 0, whole file is one string: 1

C Prototype

```
CorOpRtn cor_rdText(
    CorObj *Out,
    CorFile filename,
    int objType,
    int array,
    int multiLineStrings
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

readImage

Read standard image format files

Description

The **readImage** operator reads an image file in one of a number of common image formats, including the WiT object format, or a raw image data file from disk The **filename** parameter is the name of the file. The object search path is used to search for the specified file.

The **type** parameter specifies the image format. Currently the following formats are supported:

GIF	Graphics Interchange Format (8-bit), no longer supported
PCX	PC PaintBrush (8-bit)
PBM	Portable Bitmap Format (PBM, PGM, PPM)
SUN	Sun Raster File Format
XBM	X Bitmap Format
TIFF	Tag Image File Format
BMP	Microsoft Windows Device Independent Bitmap Format
JPEG	Joint Photographers Expert Group
WiT	WiT object format (images only)
Raw	raw data of known size and type, possibly with a header of known length.
JPEG2000 JP2	JPEG 2000
JPEG2000 CodeStream	JPEG 2000 CodeStream

Besides these image format types, you can choose *Auto* to let the operator detect the image format type, where possible. Raw images cannot be detected using the *Auto* setting.

For PCX formats, **readImage** converts an image to a WiT RGB image if the image file contains color, otherwise a gray scale image is converted to an 8-bit gray scale WiT image.

For PBM format, **readImage** supports bit-mapped (PBM), gray scale (PGM), and color (PPM) types. Additionally, the operator interprets both ASCII text and raw formats.

For SUN format, both gray scale and color images (both pseudo or true color) are supported.

For XBM format, the operator ignores the hotspot location in an XBM file and creates an 8-bit gray scale WiT image. Color is not supported.

For TIFF format, **readImage** supports gray scale, palette, and RGB types.

For BMP format, **readImage** supports 1, 4, 8, and 24-bit image types. **readImage** converts an image to a WiT RGB image if the image file contains color, otherwise an 8-bit gray scale WiT image is produced.

For the JPEG format, the operator produces an unsigned 8-bit image for gray scale files. The operator produces a WiT RGB image for color images. The operator can handle JPEG color images in RGB, YCbCr, CMYK, and YCCK formats. Other formats will be passed without conversion, with the channel pixel values placed in the R, G and B channels of the output image.

In the *Raw* mode binary files representing color, greyscale, floating point, and complex data images may be read. The type and size of the image must be known. The type is specified using the *rawType* parameter.

In the case of color images, the raw data is represented by three files. Each file contains the raw data for one of the three color channels; red, green, or blue. Each file is named by the **filename** parameter suffixed with either the letter *r*, *g*, or *b*. For example, if the **filename** is given as *xx* then the files expected are *xx.r*, *xx.g*, and *xx.b*. Each raw data file is organized in row/column order given the **width** and **height** parameters. Floating point images are single precision and complex images are organized as real, complex single precision float pairs. The **offset** parameter is used to skip the given number of bytes into the file prior to extracting the data to accomodate header information.

Parameter Information

filename Type: CorFile
Default: "sample.wit"

type Type: int
Default: 0
Values: Auto: 0, GIF (obsolete): 1, PCX: 2, PBM: 3, SUN: 4, XBM: 5, TIFF: 6, BMP: 7, JPEG: 8, WiT: 9, Raw: 10, JPEG2000 JP2: 11, JPEG2000 CodeStream: 12

width Type: int
Default: 100

height Type: int
Default: 100

offset Type: int
Default: 0

rawType Type: int
Default: 0
Values: color: 0, 8-bit unsigned: 1, 8-bit signed: 2, 16-bit unsigned: 3, 16-bit signed: 4, float: 5, complex: 6

colorFormat Type: int
Default: 0
Values: packed: 0, banded: 1

padding Type: int
Default: 2
Values: none: 0, prepend: 1, append: 2

numberFiles Type: int
Default: 0
Values: 3: 0, 1: 1

order Type: int
Default: 1
Values: RGB: 0, BGR: 1

C Prototype

```
CorOpRtn cor_readImage(
    CorImage *Out,
    CorFile filename,
    int type,
    int width,
    int height,
```

```
    int offset,
    int rawType,
    int colorFormat,
    int padding,
    int numberFiles,
    int order)
```

Headers

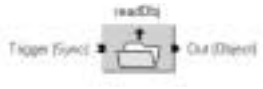
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

readObj

Read a WiT object



Description

The **readObj** operator reads a WiT object from disk when any object is received at its input. The name of the file to be read is specified by the **filename** parameter. The object search path is used to search for the specified file. The object file (".wit" file) may be in either the binary or text format produced by the **wrObj** operator.

Parameter Information

filename Type: CorFile
Default: "sample"

C Prototype

```
CorOpRtn cor_readObj(
    CorObj *Out,
    CorFile filename
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

ringBell

Generate a beep

Description

The **ringBell** operator sounds the system warning beep when an object is received at the input.

Parameter Information

bellType Type: int
Default: 0
Values: Sharp: 0, Low: 1

C Prototype

```
CorOpRtn cor_ringBell(
    int bellType)
```

Headers

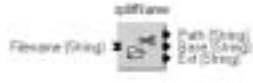
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

splitName

Split a string into path, base and extension



Description

The **splitName** operator takes a string **filename** as input. The **filename** should be an absolute path for a

file, in the form *path/base.ext*. The **Path** component is everything in front of the last slash (both '/' and " are accepted). If **filename** does not contain a slash, **Path** is set to NULL.

The **Base** component is everything after the last slash but in front of the last period ('.'), and **Ext** is everything after the last period. If there is no period, **Ext** is set to NULL.

C Prototype

```
CorOpRtn cor_splitName(
    CorString Filename,
    CorString *Path,
    CorString *Base,
    CorString *Ext
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

stopSound

Stop playing a waveform sound file

Description

Stop playing a waveform sound file

C Prototype

```
CorOpRtn cor_stopSound()
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

stopWatch

Time igraph operations

Description

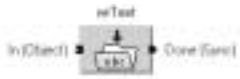
The **stopWatch** operator controls a global timer which can be used for timing igraph operation. The object received at the input initiates the **stopWatch** action and is passed through to the **Done** output port unchanged. The **stopWatch** action is controlled by the **reset** parameter. When the parameter is set to *Reset*, the timer is restarted and 0 is output from the **Time** output port. When the **reset** parameter is set to *Read*, the time in milliseconds since the last *Reset* is produced on the time output port and the timer continues. All **stopWatch** operators in an igraph affect the same global timer.

Parameter Information

reset Type: int
Default: 1
Values: Reset: 0, Read: 1

wrText

Write object as a text string



Description

The **wrText** operator writes an object to a file in a text format. The text can be written in a **labelled** or **unlabelled** format, as selected by the **format** parameter.

For non-image data, the **labelled** text is written to the file in the same format as that produced by the **display** operator. For images, only header information giving the image size and type is written.

In the **unlabelled** mode, the operator converts a simple WiT object, such as a number or string, or a vector with a simple object base type to a text string and writes the string to disk. Attempting to print images or complex data types in the **unlabelled** mode will result in an error. String objects are written as quoted character strings, all other objects are written in the string format produced by the **cast** operator (without quotes). Vectors are written as strings of comma separated values on a single line. If the elements of the vector are of String type, the individual elements are placed in quotation marks. The subvectors of a vector of vectors are printed in the same way, with each subvector on a single line.

The name of the file to which the string is written is specified by the **filename** parameter. The current directory is used unless an absolute path name is given.

The **fileMode** parameter may be set to **write** mode, in which the new value overwrites any existing data in the file, or **append** mode, in which the new value is added to the end of the existing data.

The text files produced by **wrText** cannot be read back into WiT. Files that can be read into WiT can be written in either binary or text format by the **wrObj** operator.

Parameter Information

filename Type: CorFile
Default: "test.txt"

format Type: int
Default: 0
Values: unlabelled: 0, labelled: 1

fileMode Type: int
Default: 1
Values: write: 0, append: 1

C Prototype

```
CorOpRtn cor_wrText(
    CorObj *In,
    CorFile filename,
    int format,
    int fileMode
)
```

Headers

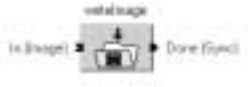
#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

writeImage

Write WiT image in a standard image file format



Description

The **writeImage** operator takes a WiT image, converts it to a file in a standard image format specified by the **filename** parameter. The **object** directory is used as the directory to write the file unless an absolute path name is given. The **type** parameter specifies the image format. Currently the following formats are supported:

GIF	Graphics Interchange Format (8-bit), no longer supported
PCX	PC PaintBrush (8-bit)
PBM	Portable Bitmap Format (PBM, PGM, PPM)
XBM	X Bitmap Format
TIFF	Tag Image File Format
BMP	Microsoft Windows Device Independent Bitmap Format
JPEG	Joint Photographers Expert Group
WiT	WiT object format (images only)
Raw	raw data of known size and type, possibly with a header of known length.

JPEG2000 JP2	JPEG 2000
JPEG2000 CodeStream	JPEG 2000 CodeStream

The **dataStorage** and **bitmap** options are only used for PBM formats and will be explained below. The **quality** parameter is used only for the JPEG format.

For PCX formats, **writeImage** does not support 16-bit images. The operator scales 16-bit images to 8-bit images before writing to disk. If a 24-bit color image has more that 256 colors, **writeImage** quantizes the colors in order to fit into the colormap. Color deterioration and longer processing time should be expected. However, the trade off is a much smaller file size.

For PBM format, **writeImage** converts a WiT image to bit-mapped (PBM), greyscale (PGM) or color (PPM) types depending on the type of the WiT image imported. You can specify raw bytes or ASCII text format with the **data storage** parameter. If you choose *yes* for the **bitmap** option, the operator will convert the input WiT image to a bit-mapped format by converting all non-zero pixels to off and all zero pixels to on no matter what the WiT image type is.

For XBM format, **writeImage** converts a WiT image to a bitmap by setting all non-zero pixels to 0 and all zero pixels to 1 and writes it to disk. Color is not supported for XBM format.

For TIFF format, **writeImage** converts a WiT RGB image to 24-bit RGB TIFF format and converts a greyscale image to greyscale format. **writeImage** will *not* use the colormap format.

For BMP format, **writeImage** does not support 16-bit images. The operator scales a 16-bit image to an 8-bit image before writing to disk. **writeImage** saves a color image using 24-bit format.

JPEG images are written as single-scan sequential JPEG files. All gray scale images stored in the JPEG format are scaled to 8-bit images before compression. The **quality** parameter controls the trade-off between speed/file size and compression losses. Lower values give faster compression and produce smaller files but result in greater compression losses. The quality values correspond to the 0..100 scale recommended by the Independent JPEG Group.

The raw image format is described in the **readImage** operator help page. Color images are written into three separate files corresponding to the red, green, and blue color channels. The three files are suffixed with the extension *r*, *g*, and *b*.

Parameter Information

filename Type: CorFile
Default: "sample.wit"

type Type: int
Default: 7
Values: GIF (obsolete): 0, PCX: 1, PBM: 2, XBM: 3, TIFF: 4, BMP: 5, JPEG: 6, WiT: 7, Raw: 8, JPEG2000 JP2: 9, JPEG2000 CodeStream: 10

dataStorage Type: int
Default: 0
Values: raw: 0, ascii: 1

bitmap Type: int
Default: 0
Values: no: 0, yes: 1

quality Type: int
Default: 75
Values: 0 — 100

witFormat Type: int
Default: 0
Values: binary: 0, text: 1, none: 2, display: 3

colorFormat Type: int
Default: 0
Values: packed: 0, banded: 1

padding Type: int
Default: 2
Values: none: 0, prepend: 1, append: 2

numberFiles Type: int
Default: 0
Values: 3: 0, 1: 1

order Type: int
Default: 1
Values: RGB: 0, BGR: 1

C Prototype

```
CorOpRtn cor_writeImage(
    CorImage *In,
    CorFile filename,
    int type,
    int dataStorage,
    int bitmap,
    int quality,
    int witFormat,
    int colorFormat,
    int padding,
    int numberFiles,
    int order)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

writeObj

Write a WiT object to disk

Description

The **writeObj** operator writes any WiT object to a file specified by the **filename** parameter. The current directory is used as the directory to write the file unless an absolute path name is given.

Files may be written in binary or text format as specified by the **format** parameter. The binary format is recommended for images and other large data objects because the resulting files are smaller. The text format files are useful when the objects are to be edited outside of WiT or when they must be read by other applications.

Parameter Information

filename Type: CorFile
Default: "outfile"

format Type: int
Default: 0
Values: binary: 0, text: 1, none: 2, display: 3

C Prototype

```
CorOpRtn cor_writeObj(
    CorObj *In,
    CorFile filename,
    int format
)
```

Headers

#include "$(WITHOME)/h/wSystem.h"

Libraries

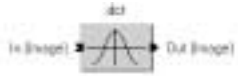
$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSystem.lib

Transforms

The Transforms library includes operators implementing the fast Fourier, fast Hadamard and discrete cosine transforms.

dct

Discrete cosine transform of an image



Description

The **dct** operator computes a forward or inverse discrete cosine transform of the input image. The transform is implemented using an FFT as an intermediate step.

The input image may be an integer or float image, it may not be complex or color (RGB). The operator's output is a float image with the size of the output image equal to that of the input image (regardless of the input image ROI size) rounded up to the nearest power of two in each dimension. Only pixels in the input image ROI are used in the DCT calculation. A

forward or inverse cosine is specified by the **dir** parameter.

Parameter Information

dir Type: int
Default: 0
Values: forward: 0, reverse: 1

Demo iGraph

Operators\Transforms\Transforms

C Prototype

```
CorOpRtn cor_dct(
    CorImage *In,
    CorImage *Out,
    int dir
)
```

Headers

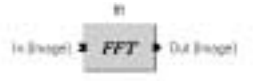
#include "$(WITHOME)/h/wXform.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wXform.lib

fft

Fast Fourier transform an image



Description

The **fft** operator computes the Fast Fourier transform of the input image. The input image may be a gray-scale (integer or float) or complex image. A forward or reverse FFT is specified by the **dir** parameter.

The **output** parameter is used to specify whether the output image is in the default format or in a user specified format. In the *Default* mode the forward transform produces a complex image and the reverse transform produces the real part of the reverse transformed image as a float image. (This is required for backward compatability.)

In the *User* mode the **outType** parameter is used to specify the output image format. When **outType** is set to *Complex* the transform is output in the WiT complex image format. The other settings produce a float image containing the *Real* part, *Imaginary* part, *Magnitude* or *Phase* of the transformed image.

The size of the output image is equal to that of the input image (regardless of the input image ROI size) rounded up to the nearest power of two in each dimension. Only pixels in the input image ROI are used in the FFT calculation. The forward FFT will shift the image origin to the centre of the image for presentation by the spectrum operator.

Parameter Information

dir Type: int
Default: 0
Values: forward: 0, reverse: 1

output Type: int
Default: 0
Values: Default: 0, User: 1

outType Type: int
Default: 0
Values: Complex: 0, Real: 1, Imaginary: 2, Magnitude: 3, Phase: 4

Demo iGraph

Operators\Transforms\Transforms
Operators\Transforms\FourierFilter
Operators\Transforms\CrossCorrelation

C Prototype

```
CorOpRtn cor_fft(
    CorImage *In,
    CorImage *Out,
    int dir,
    int output,
    int outType
)
```

Headers

#include "$(WITHOME)/h/wXform.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wXform.lib

fht

Fast Hadamard transform an image

Description

The **fht** operator computes the Fast Hadamard transform of the input image. A forward or inverse FHT is specified by the **dir** parameter. A forward FHT expects either an integer or float input image, and inverse FHT expects a float input image with both *x* and *y* dimensions a power of two. The output in either case is a float image. The size of the output image is equal to that of the input image (regardless of the input image ROI size) rounded up to the nearest power of two in each dimension. Only pixels in the input image ROI are used in the FHT calculation.

Parameter Information

dir Type: int
Default: 0
Values: forward: 0, reverse: 1

Demo iGraph

Operators\Transforms\Transforms

C Prototype

```
CorOpRtn cor_fht(
    CorImage *In,
    CorImage *Out,
    int dir
)
```

Headers

#include "$(WITHOME)/h/wXform.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wXform.lib

SmartMatrix

One and two dimensional bar code reading.

getBC412

Finds and decodes BC412 bar code

Description

The **getBC412** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for BC412 barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as light bars on a dark background.

Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode, including the check character. If no valid barcode is found, an empty string is output.

If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

checkSum
The **checkSum** parameter defines whether the bar code contains the check sum character.

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.

start and **stop**
The **start** and **stop** parameters define whether the bar code contains the start and stop characters.

Parameter Information

noise Type: int
Default: 5

checkSum Type: int
Default: 1
Values: No: 0, Yes: 1

start Type: int
Default: 1
Values: No: 0, Yes: 1

stop Type: int
Default: 1
Values: No: 0, Yes: 1

Demo iGraph

Operators\Matrix\BC412.igr

C Prototype

```
CorOpRtn cor_getBC412(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise,
    int checkSum,
    int start,
    int stop
)
```

Headers

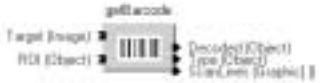
#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getBarcode

Finds and decodes any bar code



Description

Finds and decodes any bar code

Parameter Information

minSize Type: int
Default: 20

maxSize Type: int
Default: 40

invert Type: int
Default: 1
Values: No: 0, Yes: 1

noiseLev Type: int
Default: 20

threshold Type: int
Default: 10

barcodes Type: int
Default: 254
Values (bitwise OR): 412: 1, 128: 2, 39: 4, UPCa: 8, ITF: 16, EAN8: 32, EAN13: 64, UPCe: 128

checkSum Type: int
Default: 1
Values: No: 0, Yes: 1

timeout Type: int
Default: 100

Demo iGraph

Operators\Matrix\BC412.igr

C Prototype

```
CorOpRtn cor_getBarcode(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    CorObj *Type,
    CorGraphicVector *ScanLines,
    int minSize,
    int maxSize,
    int invert,
    int noiseLev,
    int threshold,
    int barcodes,
    int checkSum,
    int timeout)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getCCA

Finds and decodes Composite Component A of the RSS-14 bar code

Description

The **getCCA** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for

Composite Component-A of the RSS-14 barcodes. If a Composite Component is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.
Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid Composite Component is found, the output string contains the characters represented by the Composite Component. If no valid Composite Component is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a Composite Component in each ROI. The output is a vector of String objects. If a valid Composite Component is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid Composite Component is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.
type
The **type** parameter specifies the Composite Component barcode type. If parameter value is *regular* then Composite Component belongs to the RSS-14, RSS-14 Truncated, RSS-14 Stacked or RSS-14 Stacked Omnidirectional otherwise it belongs to RSS-14 Limited.

Parameter Information

noise Type: int
Default: 5

type Type: int
Default: 0
Values: regular: 0, limited: 1

Demo iGraph

Operators\Matrix\BC412.igr

C Prototype

```
CorOpRtn cor_getCCA(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise,
    int type
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getCodabar

Finds and decodes Codabar bar code

Description

The **getCodabar** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for Codabar barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.
Roi

A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode, including the check character. If no valid barcode is found, an empty string is output.

If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.
minLength
The **minLength** parameter specifies the minimum amount of characters in the decoded string.

Parameter Information

noise Type: int
Default: 5

minLength Type: int
Default: 0

Demo iGraph

Operators\Matrix\Codabar.igr

C Prototype

```
CorOpRtn cor_getCodabar(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise,
    int minLength
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getCode128

Finds and decodes Code128 bar code

Description

The **getCode128** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for Code128 barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.
Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode. If no valid barcode is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a

valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise

The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.

Parameter Information

noise Type: int
Default: 5

Demo iGraph

Operators\Matrix\Code128.igr

C Prototype

```
CorOpRtn cor_getCode128(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getCode39

Finds and decodes Code 39 bar code

Description

The **getCode39** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for Code39 barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target

The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.

Roi

A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded

If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode. If no valid barcode is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise

The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.

Parameter Information

noise Type: int
Default: 5

Demo iGraph

Operators\Matrix\Code39.igr

C Prototype

```
CorOpRtn cor_getCode39(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
```

```
    int noise
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getEAN13

Finds and decodes EAN-13 bar code

Description

The **getEAN13** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for EAN13 barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.

Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode. If no valid barcode is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.

Parameter Information

noise Type: int
Default: 5

Demo iGraph

Operators\Matrix\EAN13.igr

C Prototype

```
CorOpRtn cor_getEAN13(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getEAN8

Finds and decodes EAN-8 bar code

Description

The **getEAN8** operator accepts a binary or grayscale image and one or more rectangular

regions of interest (ROIs) then searches the ROIs for EAN8 barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.
Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode. If no valid barcode is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.

Parameter Information

noise Type: int
Default: 5

Demo iGraph

Operators\Matrix\EAN8.igr

C Prototype

```
CorOpRtn cor_getEAN8(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getECC200

Finds and decodes ECC-200 2D barcodes.

Description

The **getECC200** operator accepts a binary image and searches for ECC-200 barcodes. If a barcode is found then it is decoded to a string. If several codes are found, then several strings are generated as output.

Inputs

Target
The input image must be an unsigned 8-bit binary image, with the barcode represented as white bars or dots on a black background. The ECC-200 codes may be rotated, scaled or warped.

Outputs

Decoded
The **Decoded** output is a vector of String objects. If a valid barcode is found, the output vector contains a string with the characters represented by the barcode. If no valid barcode is found, an empty vector is output.
Info
The **Info** output provides a vector of vectors of graphics corresponding to each suspicious region found in the original image. This is sometimes useful for debugging.
Test

The **Test** output is an idealized image of the found ECC200 barcode.

Parameters

cellSize

The **cellSize** parameter determines the size of each cell comprising the 2D bar code given in pixels. This size must be bigger than the distance between two cells or dots in a barcode but smaller than the silent zone around the perimeter of the barcode.

Parameter Information

cellSize Type: int
Default: 10

Demo iGraph

Operators\Matrix\ECC200.igr

C Prototype

```
CorOpRtn cor_getECC200(
    CorImage *Target,
    CorStringVector *Decoded,
    CorImageVector *Test,
    CorGraphicVector *Info,
    int cellSize
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getECC200_1

Find and decode ECC-200 2D barcodes.

Description

The **getECC200_1** operator recognizes ECC200 barcode. See **getECC200** help for details. Differ from **getECC200** output of this operator is a vector of vectors of bytes rather then the vector of CorStrings.

Parameter Information

cellSize Type: int
Default: 10

moduleSize Type: int
Default: 10

Demo iGraph

Operators\Matrix\ECC200.igr

C Prototype

```
CorOpRtn cor_getECC200_1(
    CorImage *Target,
    CorVector *DecodedBin,
    CorGraphicVector *Info,
    int cellSize,
    int moduleSize
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getECC200_2

Find and decode ECC-200 2D barcodes.

Description

The **getECC200_1** operator recognises ECC200 barcode. See **getECC200** help for detales. Differ from **getECC200** this operator has two images as an inputs. One is a binary image for position finding and another is a grayscale image for the rest of the recognition tasks. Output of this operator is a vector of vectors of bytes rather then the vector of CorStrings.

Parameter Information

cellSize Type: int
Default: 10

Demo iGraph

Operators\Matrix\ECC200.igr

C Prototype

```
CorOpRtn cor_getECC200_2(
    CorImage *Target,
    CorImage *Binary,
    CorVector *DecodedBin,
    CorImageVector *Test,
    CorGraphicVector *Info,
    int cellSize
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getITF

Finds and decodes interleaved 2 of 5 bar code

Description

The **getITF** operator recognizes Interleaved 2 from 5 (ITF) barcode. See **getCode39** help for more details. Parameter **checkSum** defines whether checksum should be used.

Parameter Information

noise Type: int
Default: 5

checkSum Type: int
Default: 1
Values: No: 0, Yes: 1

Demo iGraph

Operators\Matrix\ITF.igr

C Prototype

```
CorOpRtn cor_getITF(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise,
    int checkSum
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getPOSTNET

Finds and decodes POSTNET bar code

Description

The **getPOSTNET** operator accepts a binary image and one or more rectangular regions of interest (ROIs) then searches the ROIs for POSTNET barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit binary image, with the barcode represented as dark bars on a light background.

Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode. If no valid barcode is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **MaxSize** parameter specifies the minimum length of the high bars in pixels.

Parameter Information

maxSize Type: int
Default: 40

timeout Type: int
Default: 100

Demo iGraph

Operators\Matrix\POSTNET.igr

C Prototype

```
CorOpRtn cor_getPOSTNET(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int maxSize,
    int timeout
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getPharmacode

Finds and decodes Code 39 bar code

Description

The **getPharmacode** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for Pharmacode barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.

Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.ROI must include silence zones on both sides of the barcode.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode, including the check character. If no valid barcode is found, an empty string is output.

If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.
type
The **type** parameter specifies the type of Pharmacode to be decoded.

Parameter Information

noise Type: int
Default: 5

type Type: int
Default: 0
Values: standard: 0, wide space: 1, complementary: 2

Demo iGraph

Operators\Matrix\Pharmacode.igr

C Prototype

```
CorOpRtn cor_getPharmacode(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise,
    int type
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getRSS14

Finds and decodes RSS-14 bar code

Description

The **getRSS14** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for the RSS-14 barcodes. If a Composite Component is found in a region, it is decoded to a string too.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.
Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid RSS14 is found, the output string contains the characters represented by the RSS14. If no valid RSS14 is found, an empty string is outputed. If the ROI is a vector of rectangles then the operator seeks for a RSS14 in each ROI. The output is a vector of String objects. If a valid RSS14 is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid RSS14 is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.
type
The **type** parameter specifies the RSS14 barcode type. If parameter value is *regular* then RSS14 belongs to the RSS-14, RSS-14 Truncated, RSS-14 Stacked or RSS-14 Stacked Omnidirectional otherwise it belongs to RSS-14 Limited.

Parameter Information

noise Type: int
Default: 5

type Type: int
Default: 0
Values: regular: 0, limited: 1

Demo iGraph

Operators\Matrix\POSTNET.igr

C Prototype

```
CorOpRtn cor_getRSS14(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise,
    int type
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getUPCa

Finds and decodes UPCa bar code

Description

The **getUPCa** operator accepts a binary or grayscale image and one or more rectangular regions of interest (ROIs) then searches the ROIs for UPC version A barcodes. If a barcode is found in a region, it is decoded to a string.

Inputs

Target
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as dark bars on a light background.

Roi
A single ROI may be specified by a rectangular Graphic or Geometry object. Multiple ROIs can be specified by a vector of Graphic or Geometry objects.

Outputs

Decoded
If the ROI is a single object then the output is a String object. If a valid barcode is found, the output string contains the characters represented by the barcode. If no valid barcode is found, an empty string is output. If the ROI is a vector of rectangles then the operator seeks for a barcode in each ROI. The output is a vector of String objects. If a valid barcode is found in a ROI, the corresponding element of the output vector contains the decoded string. If no valid barcode is found in a ROI, the corresponding output vector element is the empty string.

Parameters

noise
The **noise** parameter specifies the minimum low to high or high to low change in pixel value necessary to constitute the edge of bar.

Parameter Information

noise Type: int
Default: 5

Demo iGraph

Operators\Matrix\UPSa.igr

C Prototype

```
CorOpRtn cor_getUPCa(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

getUPCe

Finds and decodes UPCe bar code

Description

The **getUPCe** operator recognizes UPC-E barcode. See **getUPCa** help for details.

Parameter Information

noise Type: int
Default: 5

Demo iGraph

Operators\Matrix\UPSe.igr

C Prototype

```
CorOpRtn cor_getUPCe(
    CorImage *Target,
    CorObj *ROI,
    CorObj *Decoded,
    int noise
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

gradeECC200

Grades the quality of the ECC200 barcode

Description

The **gradeECC200** operator grades ECC200 barcode. It uses **getECC200** outputs and grayscale image of the ECC200 barcode as an inputs. See **getECC200** help for details.

Explanation of the outputs and parameters could be found in the ISO standard ISO_IEC_16022_2000. Parameter **dNom** stands for DNOM, parameter **dMax** stands for DMAX and parameter **dMin** stands for DMIN from this document. **cellSize** is the same as in the **getECC200**

Parameter Information

dNom Type: float
Default: 1

dMax Type: float
Default: 1.5

dMin Type: float
Default: 0.5

cellSize Type: int
Default: 10

Demo iGraph

Operators\Matrix\UPSe.igr

C Prototype

```
CorOpRtn cor_gradeECC200(
    CorImage *Target,
    CorStringVector *Decoded,
    CorImageVector *Test,
    CorGraphicVector *Info,
    int *Contrast,
    int *PrintGrowth,
    int *AxialNonunfrmty,
    int *UnusedErrCor,
    int *Overall,
    float dNom,
    float dMax,
    float dMin,
    int cellSize)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

warpMatrix

Finds and unwarps ECC-200 2D barcode

Description

The **warpMatrix** operator finds and extract images of the ECC-200 barcodes. If a barcode is found then it is extracted and warped to the rectangular image. If several barcodes were found, then several images are placed in the output vector.

Inputs

source
The input image must be an unsigned 8-bit grayscale image, with the barcode represented as white bars or dots on a black background. The ECC-200 codes may be rotated, scaled or warped.
binary
The input image must be an unsigned 8-bit binary image produced from the image mentioned above.

Outputs

unwarped
The **unwarped** output is a vector of images.
Info
The **Info** output provides a vector of graphics corresponding to each suspicious region found in the original image.
warpXform
The **warpXform** output is a transformation matrix for the found ECC200 barcode.

Parameters

cellSize
The **cellSize** parameter determines the size of each cell comprising the 2D bar code given in pixels. This size must be bigger than the distance between two cells or dots in a barcode but smaller than the silent zone around the perimeter of the barcode.

Parameter Information

cellSize Type: int
Default: 10

Demo iGraph

Operators\Matrix\UPSe.igr

C Prototype

```
CorOpRtn cor_warpMatrix(
    CorImage *Source,
    CorImage *Binary,
    CorImageVector *Unwarped,
    CorGraphicVector *Info,
    CorVector *WarpXform,
    int cellSize
)
```

Headers

#include "$(WITHOME)/h/wMatrix.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wMatrix.lib

SmartOCR

Character and text recognition.

ocrBin

Binarization using global thresholding

Description

The **ocrBin** operator binarizes a text image based on either a supplied threshold or a threshold calculated from the pixel values in the image.

Inputs

In
The input image may be any integer image type or a float image.

Outputs

Out
The operator produces a binary unsigned 8-bit image with white text on a black background.

Threshold
The threshold value used to binarize the image is output as a float value. This value may be used as an input parameter to subsequent applications of the **ocrBin** operator to maintain a consistent threshold level.

Parameters

background
The **background** parameter is set to *light* if the input image has a light background with dark text or to *dark* if the input image has a dark background with light text. Image pixels with a value below the threshold value are set true (non-zero), and those above the threshold as set false (zero) if the **background** has been specified as *light*. The opposite is true if the **background** has been specified as *dark*.

calcThresh
If the **calcThresh** parameter is set to *No* the threshold supplied in the **threshold** parameter is applied to the image directly. If the **calcThresh** parameter is set to *Yes* the threshold is calculated from the pixel values in the image.

threshold
The **threshold** parameter sets the threshold used when the **calcThresh** parameter is set to *No*.

threshFactor
When the **calcThresh** parameter is set to *Yes*, the threshold is based on the image mean and minimum pixel values and is controlled by the **threshFactor** parameter. The **threshFactor** parameter is usually set to a value between 0 and 1. A value of 1 will give the image mean as the threshold value. Lower values produce thresholds nearer the foreground value and usually result in thinning of the blobs in the binarized image.

Parameter Information

background Type: int
Default: 0
Values: light: 0, dark: 1

calcThresh Type: int
Default: 1
Values: No: 0, Yes: 1

threshold Type: float
Default: 0

threshFactor Type: float
Default: 0.7

C Prototype

```
CorOpRtn cor_ocrBin(
    CorImage *In,
    CorImage *Out,
    float *Threshold,
    int background,
    int calcThresh,
    float threshold,
    float threshFactor
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrEdit

Edit OCR parameters

Description

Parameter Information

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

C Prototype

```
CorOpRtn cor_ocrEdit(
    CorObj *In,
    CorOcrInfo **Out,
    int Placement,
    int X,
    int Y
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrGrayInit

Create a font model for use with ocrGrayRun

Description

The **ocrGrayInit** operator produces a gray-scale font model for use with the **ocrGrayRun** operator from a prepared font.

The input to this operator is an OCR font, usually produced by the **ocrMakeFont** operator. It includes a vector of images and a vector of label strings. The images are the model images used to identify characters in the font. The images in the vector must be the same type (the images vector will be correctly constructed if the **OcrFont** object is produced by the **ocrMakeFont** operator). The strings contain the labels associated with the corresponding character image.

The output is a vector of gray scale font models that is used by the **ocrGrayRun** operator as a model to identify characters.

C Prototype

```
CorOpRtn cor_ocrGrayInit_1(
    CorOcrFont *Font,
    CorFontModelGrayVector *FontModel
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrGrayRun

Perform optical character recognition on a gray-scale image

Description

The **ocrGrayRun** operator performs optical character recognition on a gray-scale image using a precalculated font model.

The inputs to the operator are a gray scale target image, a rectangle graphic or vector of rectangle graphics specifying the ROI, and a font model. Matches between the patterns and the image are evaluated by a statistical technique using pixel grayscale values. A two level strategy is used to speed up the search for matches. The operator produces the label string associated with the character found, its location, and a score indicating how well the character matched the model character.

Inputs

Target
The target image can be any gray scale WiT image: an unsigned or signed, eight or sixteen bit integer image; or a float image. The operator does not accept color or complex images.

ROI
The ROI or ROIs are a rectangle type Graphic object or a vector of rectangle type Graphic objects. The operator searches locations in the target image for which the character will be completely contained within an ROI rectangle. The ROI must be large enough to contain the pattern. An ROI specifying the entire image is produced by the **getRect** operator.

A single rectangle can be created using the **createRect** operator by specifying its corner points. The entire image can be specified using the **getRect** operator. A vector of ROIs can be created interactively using the **getData** operator.

FontModel
The font model is produced by the **ocrGrayInit** operator.

Outputs

Labels
The operator outputs the labels of characters found in the ROIs. If a single ROI is input, the operator outputs the labels as a vector of Strings, sorted on the x coordinate of the location of the match. If a vector of ROIs in input, the operator produces a vector of String vectors. The elements of this vector are the label vectors of the corresponding ROI in the input ROI vector.

Scores
The operator outputs a score of for each character character found that indicates the quality of the match with the model character. Scores range from 0 to 1, with 1 indicating a perfect match to the model character. The scores are output as a vector of float values or a vector of float vectors, depending on whether the input ROI is a single ROI or a vector of ROIs. The locations have a one-to-one correspondence with the label strings in the **Labels** output.

Locations
The operator also outputs the locations of the characters found in the target image as either a Real point vector or a vector of Real point vectors, depending on whether the input ROI is a single ROI or a vector of ROIs. The locations have a one-to-one correspondence with the label strings in the **Labels** output.

Parameters

maxMatches
The **maxMatches** parameter sets the maximum number of character matches that will be produced by the operator. The operator may produce fewer matches.

xVicinity and **yVicinity**
These parameters specify a minimum region around a character location in which matches with lower scores will be suppressed. Two matches will never be produced that are less than both **xVicinity** pixels apart in *x* and **yVicinity** pixels apart in *y*.

rejectThresh
The **rejectThresh** parameter is used to set a rejection threshold for character match scores, below which no characters will be considered. The parameter must be set to a value from zero to one, where zero indicates no match between the pattern and target and one indicates a perfect match. If no part of the target image matches the pattern sufficiently well, empty output vectors are produced.

acceptThresh
The **acceptThresh** parameter specifies an acceptance threshold above which a score value is always considered a valid match. If the maximum number of matches (specified by the **maxMatches** parameter) are found with match scores above the **acceptThresh** value, the search stops immediately. This parameter is used to control early termination of the search for improved speed.

relThresh
The **relThresh** parameter is used to set a relative rejection threshold for the matches. The relative rejection threshold is determined by multiplying the

parameter value by the match score of the best match found. This value is then applied like the normal rejection threshold.

minContrast

The **minContrast** parameter is used to specify the minimum contrast required in the target image to produce a match. This parameter is usually set to a value between zero and one, although values greater than one can be used if the target image has higher contrast than the model images.

The Candidates Sub-Panel

The **patFind** operator uses a two level seach strategy to speed up the matching process. First, a lower resolution search is performed over the entire ROI to find candidate matches. The candidate matches are then refined at full (and possibly subpixel) resolution. The parameters on the **Candidates** subpanel are used to control the low resolution search and candidate selection.

scale

The **scale** parameter is used to specify resolution reduction factor for the initial search for candidates. It can be set to powers of two from two to 32.

maxCandidates

The **maxCandidates** parameter specifies the maximum total number of candidates that will be considered in the first phase search. This maximum limit is applied **before** the **candsInVicinity** and **candRelThresh** parameters, which can further reduce the number of candidates passed to the second search phase.

candsInVicinity

The **candsInVicinity** parameter specifies the maximum number of candidates that are passed to the second phase from within any subregion of the image of a size specified by the **xVicinity** and **yVicinity** parameters.

candThresh

The **candThresh** parameter is used to set the rejection threshold for candidate matches.

candRelThresh

The **candRelThresh** parameter is used to set a relative rejection threshold for candidate matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best candidate match found. The relative threshold is used to restrict the number of candidates passed on to the second to those near the best in each region of the image.

output

The *Candidates* setting of of the **output** parameter allows the user to output the labels, scores and locations of the candidates, rather than those of the refined matches normally produced. The *Candidates* setting is usually used during development to help determine the best settings for the various parameters that control candidate selection.

Parameter Information

maxMatches	Type: int Default: 1
xVicinity	Type: int Default: 0
yVicinity	Type: int Default: 0
rejectThresh	Type: float Default: 0
acceptThresh	Type: float Default: 1
relThresh	Type: float Default: 0
minContrast	Type: float Default: 0.1
scale	Type: int Default: 1 Values: 2: 0, 4: 1, 8: 2, 16: 3, 32: 4
maxCandidates	Type: int Default: 400
candsInVicinity	Type: int Default: 4
candThreshold	Type: float Default: 0.5
candRelThresh	Type: float Default: 0.5
output	Type: int Default: 0

Values: Final Values: 0,
Candidates: 1

C Prototype

```
CorOpRtn cor_ocrGrayRun_1(
    CorImage *Target,
    CorObj *ROI,
    CorFontModelGrayVector *FontModel,
    CorVector *Labels,
    CorVector *Scores,
    CorVector *Locations,
    int maxMatches,
    int xVicinity,
    int yVicinity,
    float rejectThresh,
    float acceptThresh,
    float relThresh,
    float minContrast,
    int scale,
    int maxCandidates,
    int candsInVicinity,
    float candThreshold,
    float candRelThresh,
    int output)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrLocalBin

Binarization using local thresholding

Description

The **ocrLocalBin** operator binarizes a text image based a threshold calculated for each pixel from the pixel values in its neighbourhood.

Inputs

In
The input image may be any integer image type or a float image.

Outputs

Out
The operator produces a binary unsigned 8-bit image with white text on a black background.

Parameters

background
The **background** parameter is set to *light* if the input image has a light background with dark text or to *dark* if the input image has a dark background with light text. Image pixels with a value below the threshold value are set true (non-zero), and those above the threshold as set false (zero) if the **background** has been specified as *light*. The opposite is true if the **background** has been specified as *dark*.

width and **height**
The **width** and **height** parameters control the size of the size of the neighbourhood used to calculate the threshold for each pixel value.

threshFactor
The threshold at each pixel is calculated based on the **threshFactor** parameter and the mean, maximum and minimum pixel value in the neighbourhood of the pixel. The **threshFactor** parameter is usually set to a value between 0 and 1. A value of 1 will give the local mean as the threshold value. Lower values produce thresholds nearer the foreground value and usually result in thinning of the blobs in the binarized image.

Parameter Information

background Type: int
Default: 0
Values: light: 0, dark: 1

width Type: int
Default: 25

height Type: int
Default: 25

threshFactor Type: float
Default: 0.7

C Prototype

```
CorOpRtn cor_ocrLocalBin(
    CorImage *In,
    CorImage *Out,
```

```
    int background,
    int width,
    int height,
    float threshFactor
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrMakeFont

Extract font characters from an image

Description

The **ocrMakeFont** operator adds characters from an example image to an **OcrFont** object. The regions corresponding to new characters in the example image are specified by graphic ROIs and the operator's parameters.

The input image must an integer or float gray-scale image type. The **ROI** input must be either a **Graphic** or **Geom** object or a vector of **Graphic** or **Geom** objects. The graphics may be rectangle or point type.

The ROI is a rectangle whose size may be specified by the **width** and **height** parameters. The ROI rectangle is centered at the point location for point graphics or at the center of the rectangle for rectangle graphics. Note that in this case the rectangle graphic is not used directly as the ROI. If the **width** (**height**) parameter is set to 0 and the input graphic is a rectangle, the width (height) of the ROI will be set to the rectangle's width (height). The ROI will be the input graphic rectangle if both **width** and **height** are set to 0.

The region of the image specied by the ROI is extracted and used as a model image for the font. If the ROI extends outside the input image the parts of the model image that fall outside the input image are assigned a background value calculated by averaging the corner pixels in the overlapping part of the ROI.

The label value of the **Graphic** object is used as the the label associated with the model. If the the label field of the graphic is empty an empty string is used as the label for the corresponding model image. If the ROI is specified with **Geom** objects, its index number in the input vector is used as a label (0 if a single **Geom**). Duplicate labels are allowed.

If the **Font** input is an **OcrFont** type object, the new model images and their corresponding labels are added to the font. In all other cases a new font is created.

The characters (model images and labels) in the font will be sorted alphabetically by label if the **sortByLabel** parameter is set to *Yes*. If it is set to *No*, new characters will be appended to the characters in the existing font (if any) in the order of the corresponding ROIs in the input vector.

The operator's output is an **OcrFont** type object that can be used by a **ocrGrayInit** or **ocrPerimInit** operator to create a font model for use with the **ocrGrayRun** or **ocrPerimRun** operator.

The **ocrGrayRun** operator will run faster if all of the model images are the same size, so when preparing a gray-scale font the **width** and **height** parameters may be set to non-zero values, which will force the images to be the specified size. When preparing a font for the **ocrPerimInit** operator the input image must be a binary image.

Parameter Information

width Type: int
Default: 64

height Type: int
Default: 64

sortByLabel Type: int
Default: 1
Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_ocrMakeFont(
    CorImage *In,
    CorObj *ROI,
    CorObj *Font,
    CorOcrFont **NewFont,
    int width,
    int height,
    int sortByLabel
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrMakeSemiFont

Create an OcrFont for SEMI OCR-A characters

Description

The **ocrMakeSemiFont** operator produces a scaled font based on the SEMI standard. The operator's output is an **OcrFont** type object that can be used by a **ocrGrayInit** or **ocrPerimInit** operator to create a font model for use with the **ocrGrayRun** or **ocrPerimRun** operator. The operator can produce gray-scale font images (for use with the **ocrGrayInit** operator) or binary font images (for use with the **ocrPerimInit** operator).

Parameters

style
: The **style** parameter is used to specify whether the characters produced are made up of solid lines or a 5x9 dot-matrix.

width and **height**
: These parameters specify the size of the characters produced. The width and height are measured in pixels from center to center of the strokes or dots that make up the characters.

clearZone
: The **clearZone** parameter is used to specify the size of the empty space between characters in the font.

strokeWidth
: The **strokeWidth** parameter specifies the width of the strokes or dots that make up the characters in the font.

outType
: The **outType** parameter is used to specify whether the images in the output font are gray-scale or binary. Gray scale images may only be used with used with the **ocrGrayInit** operator. Binary images may be used with either the **ocrGrayInit** or **octPerimInit**.

thresh
: The **thresh** parameter is used to specify a threshold value for binary font images. It is given as a percent of the full scale value.

invert
: If the **invert** parameter is set to *No* gray-scale characters are light on a dark background. If it is set to *Yes* gray-scale characters are dark on a light background.

filter
: This parameter allows gaussian smoothing to be applied to the font images. The user can specify no smoothing or a gaussian filter of up to 7x7 pixels to be applied to the font images. For binary images, the smoothing is applied before thresholding.

charSet
: When the **charSet** parameter is set to *All* the output font includes the digits, upper case characters and the characters "-" and ".". When it is set to *Alpha-numeric* it contains the digits and upper case letters. When it is set to *Digits* it contains only the digits.

Parameter Information

style
: Type: int
Default: 1
Values: Point: 0, Line: 1

width
: Type: float
Default: 20

height Type: float
Default: 40

clearZone Type: float
Default: 10

strokeWidth Type: float
Default: 5

outType Type: int
Default: 1
Values: binary: 0, gray-scale: 1

threshold Type: int
Default: 50
Values: 0 — 100

invert Type: int
Default: 1
Values: No: 0, Yes: 1

filter Type: int
Default: 0
Values: None: 0, 2x2: 1, 3x3: 2, 5x5: 3, 7x7: 4

charSet Type: int
Default: 1
Values: All: 0, Alpha-numeric: 1, Digits: 2

C Prototype

```
CorOpRtn cor_ocrMakeSemiFont(
    CorOcrFont **Out,
    int style,
    float width,
    float height,
    float clearZone,
    float strokeWidth,
    int outType,
    int threshold,
    int invert,
    int filter,
    int charSet)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrPerimInit

Create a font model for use with ocrPerimRun

Description

The **ocrPerimInit** operator produces a binary font model for use with the **ocrPerimRun** operator from a prepared font.

The input to this operator is an **OcrFont** type object. The **OcrFont** object is usually produced by the **ocrMakeFont** operator. It includes a vector of images and a vector of strings. The images are the model images used to identify characters in the font. The strings contain the labels associated with the corresponding character image.

The output is a **FontModel** object that is used by the **ocrPerimRun** operator as a model to identify characters. It is recommended that the **FontModel** object only be used as internally to igraphs or programs, and that fonts are stored externally in the form of the **OcrFont** object.

Parameter Information

samples Type: int
Default: 3
Values: 8: 0, 16: 1, 32: 2, 64: 3, 128: 4, 256: 5

C Prototype

```
CorOpRtn cor_ocrPerimInit(
    CorOcrFont *Font,
    CorFontModel **FontModel,
    int samples
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrPerimRun

Perform optical character recognition using character perimeters

Description

The **ocrPerimRun** operator performs optical character recognition on a binary image using a precalculated font model. The operator matches specified blobs (connected sets of pixels) in the target image to characters in the font model. Matching between the blobs and the font model characters is based on the blobs' perimeters. Consequently, in order to perform effective matching the characters in the binary image must be separated and complete.

Inputs

Target
The target image must be a binary image. Binary images can be produced by the **ocrBin**, **ocrRoiBin** and **ocrLocalBin** operators.

ROI
The object that specifies the blobs of interest can be a region of interest (ROI) or vector of ROIs in the image or a vector of Blob features.

The ROI or ROIs are a rectangle type Graphic object or a vector of rectangle type Graphic objects. A single rectangle can be created using the **createRect** operator by specifying its corner points. The entire image can be specified using the **getRect** operator. A vector of ROIs can be created interactively using the **getData** operator.

If a vector of Blob features is used they must include the Blob perimeter data. The Blob feature vector can be created by applying the **getBlobs**, **getFeatures** and **getPerimeter** operators to a binary image.

FontModel
The precalculated font model is created using the **ocrPerimInit** operator. The font model should be based on a clean, representative example of the font. The font model contains the matching features associated with each model character as well as a label that represents the character. More than one entry in the font model may have the same label. Such cases represent variations in the shape of a character. The font model can be modified using the **ocrModify** operator.

Outputs

Labels
The operator outputs the labels of characters that match blobs in the input image. If a single ROI is input, the operator outputs the labels as a vector of Strings, sorted on the x coordinate of the location of the match. If a vector of ROIs in input, the operator produces a vector of String vectors. The elements of this vector are the label vectors of the corresponding ROI in the input ROI vector.

Scores
The operator outputs a score of for each character character found that indicates the quality of the match with the model character. Scores range from 0 to 1, with 1 indicating a perfect match to the model character. The scores are output as a vector of float values or a vector of float vectors, depending on whether the input ROI is a single ROI or a vector of ROIs. The locations have a one-to-one correspondence with the label strings in the **Labels** output.

Locations
The operator also outputs the locations of the characters found in the target image as either a Real point vector or a vector of Real point vectors, depending on whether the input ROI is a single ROI or a vector of ROIs. The locations have a one-to-one correspondence with the label strings in the **Labels** output.

Parameters

rotation
The **rotation** parameter controls the degree of rotational invariance allowed in the match between the model and the

blobs. This parameter may be used to specify rotationally *Invariant* or *Non-Invariant* matching or matching over a *Range* of angles.

In the *Invariant* mode, the operator uses a set of features that is invariant under rotation and reflection to match the blobs to the font model. In this mode of operation rotated characters can be matched to model characters very quickly. It is not possible to reliably distinguish between characters that are very nearly rotated or reflected versions of other characters. For example, the characters "6" and "9" exhibit this problem in many fonts.

The *Non-Invariant* mode of operation adds rotation and reflection sensitive features to the match criteria, allowing the operator to distinguish between problem characters when the approximate orientation of the characters is known. The weighting of rotation sensitive features relative to the invariant features is controlled by the **sensitivity** parameter.

The *Range* mode allows the user to specify the angular range through which the characters in the image may be rotated. The range of angles is specified by the **minAngle** and **maxAngle** parameters. The angle range is used to limit the rotation of the rotation sensitive features before matching rather than to reject matches in which the best fit is rotated outside the range. This means that characters that are rotated outside the specified range by a small amount may still be considered matches. This mode of operation is somewhat slower than the other two modes. The **featuresUsed** parameter can be used in this mode to speed up matching.

sensitivity
The **sensitivity** parameter controls the sensitivity of matching to rotation when **rotation** parameter is set to *Non-Invariant*. The parameter controls the relative weight of rotation sensitive and rotation invariant features used. The parameter is set to a value from 0 to 1, where 0 specifies rotation invariant features only and 1 specifies rotation sensitive features only. Lower values of this parameter tend to allow greater tolerance for rotation in the image, however it is difficult to quantify and may vary among the different characters in the font. Lower values also tend to provide more robust discrimination between characters with simple perimeter shapes, particularly those exhibiting some symmetry. Consequently, this parameter is usually set to the lowest value that provides reliable discrimination between rotated or reflected character pairs.
minAngle and **maxAngle**
These parameters specify the angular range in the *Range* **rotation** mode. The parameter values are given in degrees and are not limited in range (negative values and values greater than 360 are valid). The angles are evaluated modulo 360, so a **minAngle** value of 0 and a **maxAngle** value of 370 will give a 10 degree range, not a 370 degree range. The exception to this is when the values indicate the same angle. If the actual parameter values are the same the angle range is 0, if the actual parameter values are different by a multiple of 360 the range is 360 degrees.
featuresUsed
The **featuresUsed** parameter controls the fraction of the feature set used in the *Range* mode. The parameter must be set to a value from 0 to 1. Settings of or near 0 will result in the use of minimal feature set. All the features will be used when the parameter is set to 1. Lower values increase the operator's speed but also reduce the ability to discriminate between different characters.
scaleInvariant
When this parameter is set to *Yes* the operator automatically normalizes the characters for scale. It should be noted that very small characters can suffer from pixellization effects that can distort the shape of the character perimeter.

When set to *No* the operator limits the range of scale corrections that can be applied to the characters from the image. The range of scales is specified by the **minScale** and **maxScale** parameters. As with the rotation range, the scale range is limited before matching, so characters for which the best match is outside the scale range may be considered a match if the scale limited match is sufficiently good.

minScale and **maxScale**
These parameters specify the minimum and maximum value of the scale correction factor applied to information extracted from the image when the **scaleInvariant** parameter is set to *No*.
threshold
The **threshold** parameter allows the specification of a minimum acceptable match quality. This parameter is set to a value from 0 to 1, where a setting of zero means that every blob will be assigned some matching character from the font and a setting of 1 requires a perfect match. The treatment of blobs for which sufficiently good match is not found is controlled by the **ignoreNoMatch** and **noMatchLabel** parameters.
ignoreNoMatch
When this parameter is set to *Yes* image blobs that do not match a character in the font model (that is, those for which the best match quality falls below the **threshold** value) are ignored. When the parameter is set to *No* such blobs are assigned the label specified in the **noMatchLabel** parameter.
noMatchLabel
The **noMatchLabel** String parameter specifies the label that is assigned to blobs that do not match a character in the font model when the **ignoreNoMatch** parameter is set to *No*.
selection
The **selection** parameter determines whether a minimum and/or maximum width, height and number of pixels will be specified for blobs extracted from the image ROIs. When *Min size* is selected, the minimum values are set using the **minWidth**, **minHeight** and **minPixels** parameters. When *Max size* is selected, the maximum values are set using the **maxWidth**, **maxHeight** and **maxPixels** parameters.

A blob must meet all the criteria to be selected. Blobs outside the ranges are always ignored. Blob selection is not affected by the **ignoreNoMatch** parameter setting. Blobs that do not meet the selection criteria are not compared to the model font characters, so selection is usually a more efficient way of eliminating extraneous small or large blobs than using a limited scale range.

minWidth and **minHeight**
These parameters specify the minimum blob width and height in pixels when the *Min size* choice of the **selection** parameter is activated.
maxWidth and **maxHeight**
These parameters specify the maximum blob width and height in pixels when the *Max size* choice of the **selection** parameter is activated.

Parameter Information

rotation	Type: int Default: 0 Values: Invariant: 0, Non-Invariant: 1, Range: 2
sensitivity	Type: float Default: 0.5
minAngle	Type: float Default: -5
maxAngle	Type: float Default: 5
featuresUsed	Type: float Default: 0.5
scaleInvariant	Type: int Default: 1 Values: No: 0, Yes: 1
minScale	Type: float Default: 0.5
maxScale	Type: float Default: 2
threshold	Type: float

Default: 0

ignoreNoMatch Type: int
Default: 0
Values: No: 0, Yes: 1

noMatchLabel Type: CorString
Default: "?"

selection Type: int
Default: 0
Values (bitwise OR): Max size: 1, Min size: 2

minWidth Type: int
Default: 0

maxWidth Type: int
Default: 0

minHeight Type: int
Default: 0

maxHeight Type: int
Default: 0

minPixels Type: int
Default: 4

maxPixels Type: int
Default: 0

C Prototype

```
CorOpRtn cor_ocrPerimRun(
    CorImage *Target,
    CorObj *ROI,
    CorFontModel *FontModel,
    CorVector *Labels,
    CorVector *Scores,
    CorVector *Locations,
    int rotation,
    float sensitivity,
    float minAngle,
    float maxAngle,
    float featuresUsed,
    int scaleInvariant,
    float minScale,
    float maxScale,
    float threshold,
    int ignoreNoMatch,
    CorString noMatchLabel,
    int selection,
    int minWidth,
    int maxWidth,
    int minHeight,
    int maxHeight,
    int minPixels,
    int maxPixels)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrPlotFont

Create graphic representation of the font from the font model

Description

The **ocrPlotFont** operator creates a graphic representation of the sampled perimeters used to extract features from the font model.

Inputs

FontModel
The input to the operator is a font model created by the **ocrInitialize** operator.

Outputs

Perimeters
The output is a vector of polygon Graphic objects in which each element represents one character in the font. The vertices of a polygon represent the sample points of the character perimeter. The label field of a Graphic contains the label associated with the character in the font model. The serial field contains the character's index number, which may be required by the **ocrModify** operator.

Parameters

width and **height**
The **width** and **height** parameters specify the minimum width and height of the space in which each reconstructed character graphic is centered. The width of the space is set to the greater of the maximum character width in the font model and the value of the **width** parameter and the height is set to the

greater of the maximum character height and the value of the **height** parameter.

offset
The positioning of the polygons is controlled by the **offset** parameter. When **offset** is set to *None*, each polygon is positioned so that it is centred on an image the size of the reconstructed character space as described above.

When the **offset** parameter is set to *Tile* the character polygons are positioned in rows suitable for overlay on a single image. Each character is centered on a tile the size of the reconstructed image space.

When the **offset** parameter is set to *Original* the character polygons are placed in the position of the character in the original binary image from which the perimeter was derived.

cols
The number of polygons in each row in the tiled offset mode is set by the **cols** parameter. If the **cols** parameter is set to 0 the polygons are positioned so that the number of rows and columns are approximately equal.

Parameter Information

width Type: int
Default: 0

height Type: int
Default: 0

offset Type: int
Default: 2
Values: None: 0, Tile: 1, Original: 2

cols Type: int
Default: 0

C Prototype

```
CorOpRtn cor_ocrPlotFont(
    CorFontModel *FontModel,
    CorGraphicVector *Perimeters,
    int width,
    int height,
    int offset,
    int cols
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrRoiBin

Binarization using ROI based thresholding

Description

The **ocrRoiBin** operator binarizes regions of interest (ROIs) in a text image based on either supplied thresholds or thresholds calculated from the pixel values in the ROIs.

Inputs

In
The input image may be any integer image type or a float image.

ROIs
The ROIs input can either a single rectangle Graphic or Geometry type object or a vector of rectangle Graphic or Geometry objects.

Outputs

Out
The operator produces a binary unsigned 8-bit image with white text on a black background within the ROIs and black background outside the ROIs.

Threshold
The operator outputs a vector of float values that holds the thresholds used in the ROIs. A vector of thresholds is often calculated in an initialization step or in a first pass for a set of ROIs. The vector is then supplied as an input parameter for subsequent applications of the **ocrRoiBin** operator.

Parameters

background

The **background** parameter is set to *light* if the input image has a light background with dark text or to *dark* if the input image has a dark background with light text. Image pixels with a value below the threshold value are set true (non-zero), and those above the threshold as set false (zero) if the **background** has been specified as *light*. The opposite is true if the **background** has been specified as *dark*.

calcThresh

If the **calcThresh** parameter is set to *No* the thresholds supplied in the **threshold** parameter are applied to the image ROIs directly. If the **calcThresh** parameter is set to *Yes* the thresholds are calculated from the pixel values in each ROI.

thresholds

The **threshold** parameter is a vector of float values that set the thresholds used when the **calcThresh** parameter is set to *No*. The float vector must be the same size as the **ROIs** vector.

threshFactor

When the **calcThresh** parameter is set to *Yes*, the threshold for each ROI is based on the mean and minimum pixel values in the ROI and is controlled by the **threshFactor** parameter. The **threshFactor** parameter is usually set to a value between 0 and 1. A value of 1 will give the ROI mean as the threshold value. Lower values produce thresholds nearer the foreground value in the ROI and usually result in thinning of the blobs in the binarized image.

Parameter Information

background Type: int
Default: 0
Values: light: 0, dark: 1

calcThresh Type: int
Default: 1
Values: No: 0, Yes: 1

thresholds Type: CorVector

threshFactor Type: float
Default: 0.7

C Prototype

```
CorOpRtn cor_ocrRoiBin(
    CorImage *In,
    CorObj *ROI,
    CorImage *Out,
    CorFloatVector *Thresholds,
    int background,
    int calcThresh,
    CorFloatVector *thresholds,
    float threshFactor
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrRun

Recognize characters in an image

Description

See SmartOCR manual for details.

C Prototype

```
CorOpRtn cor_ocrRun(
    CorImage *Image,
    CorOcrInfo *Info,
    CorString *Result,
    CorStringVector *Characters,
    CorFloatVector *Scores,
    CorFpointVector *Locations,
    CorGraphicVector *Gfx
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

ocrSelectFont

Select a subset of a font's characters

Description

The **ocrSelectFont** operator selects a subset of characters from from a **OcrFont** object based on their labels. Characters in the input font with labels that match one of the strings in the **labels** parameter are collected into an **OcrFont** that is output at the **Selected** output. All characters that do not match one of these strings collected into an **OcrFont** that is output at the **Remaining** output. Label matching is case sensitive.

The **OcrFont** models are usually produced by the **ocrMakeFont** operator and are used by the **ocrGrayInit** operator to produce font models for the **ocrGrayRun** operator.

Parameter Information

labels Type: CorVector

C Prototype

```
CorOpRtn cor_ocrSelectFont(
    CorOcrFont *InFont,
    CorOcrFont **Selected,
    CorOcrFont **Remaining,
    CorStringVector *labels
)
```

Headers

#include "$(WITHOME)/h/wOcr.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wOcr.lib

SmartSearch

Fast and accurate pattern search.

patFind1

Find a pattern or patterns

Description

The **patFind1** operator locates the best match or matches to one or more patterns in a rectangular region of interest (ROI) of the target image. The inputs to the operator are a gray scale target image, a rectangle graphic specifying the ROI, and a pattern model, which may use tiled pattern images and/or binary masks. Matches between the patterns and the image are evaluated by a statistical technique using pixel grayscale values. A two level strategy is used to speed up the search for matches. The operator produces the location, match score, and pattern index number of the match or matches meeting criteria specified by the operator's parameters.

Inputs

Target
The target image can be any gray scale WiT image: an unsigned or signed, eight or sixteen bit integer image; or a float image. The operator does not accept color or complex images.

ROI
The ROI must be a rectangle type Graphic object. The operator searches locations in the target image for which the pattern will be completely contained within the ROI. The ROI must be large enough to contain the pattern. An ROI specifying the entire image is produced by the **getRect** operator.

PatModel
The pattern model is produced by the **patInit1** operator from a pattern image or vector of images. The pattern may be broken into equal sized rectangular tiles and/or may incorporate an arbitrary binary mask, as described in the **patInit1** operator documentation.

Outputs

Locations

The match locations are produced as a vector of Real points giving the x and y coordinates of the location in the matching region in the target image corresponding to the center pixel in the pattern image. For even dimension (width or height) pattern images, the center pixel location is rounded up to the next integer value. Only the best match at each location is reported. The matches are sorted in order of descending score.

Scores

The match scores corresponding to the locations in the Locations output vector are produced as a vector of float values.

Indexes

The **Indexes** output is a vector of integers in which each element is the index number of the pattern in the **PatModel** that produced the match at the corresponding location in the **Locations** output vector.

Parameters

rejectThresh

The **rejectThresh** parameter is used to set a rejection threshold for match scores, below which no matches will be considered. The parameter must be set to a value from zero to one, where zero indicates no correlation between the pattern and target and one indicates a perfect match. If no part of the target image matches the pattern sufficiently well, empty output vectors are produced.

acceptThresh

The **acceptThresh** parameter specifies an acceptance threshold above which a score value is always considered a valid match. If the maximum number of matches (specified by the **maxMatches** parameter) are found with match scores above the **acceptThresh** value, the search stops immediately. This parameter is used to control early termination of the search for improved speed.

minContrast

The **minContrast** parameter is used to specify the minimum contrast required in the target image to produce a match. The parameter specifies the minimum standard deviation of the pixel values in a possible match region relative to the standard deviation of pixel values in the pattern model image. This parameter is usually set to a value between zero and one, although values greater than one can be used if the target image has higher contrast than the model images.

maxTilesOmitted

If the pattern model breaks the pattern images into multiple tiles, the **maxTilesOmitted** parameter allows the operator to omit some of the tiles while calculating the best matching score. The operator will use the best score for a location that omits at most the number of tiles specified by this parameter. The operator will always use at least one tile to calculate the best score. Setting this parameter to a value greater than zero provides some tolerance to partially occluded or damaged target regions.

localSearch

The **localSearch** parameter specifies the method used to search the local neighbourhoods of candidates found in the low resolution search. When the parameter is set to *Fast* a binary hill-climbing method is used. The hill-climbing method can get stuck in local a maximum, in particular when the target and pattern model images contain fine regular patterns. To prevent this occuring the parameter can be set to *All*, in which case an exhaustive search of the neighbourhood is performed. The exhaustive search is slower for large candidate search scale factors.

subPixel

The **subPixel** parameter allows the match locations to be refined to subpixel precision. The pattern model must have been prepared using the subpixel mode of the **patInit** operator.

resolution

The **resolution** parameter specifies the resolution of the subpixel refinement of the match locations. The resolution can be specified in powers of two from "2" (half pixel) to "64" (1/64 pixel); This parameter is only used when the **subPixel** parameter is set to *Yes*.

The Candidates Sub-Panel

The **patFind** operator uses a two level seach strategy to speed up the matching process. First, a lower resolution search is performed over the entire ROI to find candidate matches. The candidate matches are then refined at full (and possibly subpixel) resolution. The parameters on the **Candidates** subpanel are used to control the low resolution search and candidate selection.

scale

The **scale** parameter is used to specify resolution reduction factor for the initial search for candidates. It can be set to powers of two from two to 32.

maxCandidates

The **maxCandidates** parameter specifies the maximum number of candidates that will be passed to the second phase of the search. This should usually be greater than the number of matches required in the second phase.

candidateThresh

The **candidateThresh** parameter is used to set the rejection threshold for candidate matches.

candidateRelThresh

The **candidateRelThresh** parameter is used to set a relative rejection threshold for candidate matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best candidate match found. This value is then applied like the normal rejection threshold. The relative threshold is used to restrict the candidates passed on to the second to those near the best.

applyPatterns

The **applyPatterns** parameter is only meaningful when more than one pattern model is applied. When the parameter is set to *All* all patterns in the input pattern vector are compared to the target image in both phases of the search. When the parameter is set to *Sample* the pattern vector is sampled as specified by the **patSampling** parameter for the candidate search. The second phase of the search will then only use patterns within the sampling distance of the pattern that produced the candidate match.

patSampling

The **patSampling** parameter specifies the sample spacing in the pattern vector for the candidate search when **applyPatterns** is set to *Sample*.

The best setting for the **applyPatterns** and **patSampling** parameters depends on the structure of the variation in the pattern vector. The *All* setting produces a more robust search but takes longer than a sampled search. This mode is most appropriate when the structure of the variation within the pattern vector is unknown or unpredictable. The *Sample* setting may often be used to speed up the search when the structure is known.

If the patterns are distinguishable at low resolution **patSampling** should be set to "1". In this case, all patterns are evaluated at low resolution, but only the best candidate pattern is refined. If the patterns are very similar at low resolution the parameter should be set to the size of the pattern vector. This will result in an initial search with one representative pattern, followed by refinement with all patterns. Intermediate values of this parameter are appropriate when the patterns change in some incremental way across the vector, so that patterns are more like patterns nearby in the vector than they are like more distant patterns. Typical examples include patterns produced by vectors of rotated images (such as those produced by the **patRotate** operator) or vectors of scale images (such as those produced by the **patScale** operator).

output

The *Candidates* setting of of the **output** parameter allows the user to output the locations, match scores and pattern indexes of the candidates, rather than those of the refined matches normally produced. The *Candidates* setting is usually used during development to help determine the best settings for the various parameters that control candidate selection.

The MultipleMatches Sub-Panel
The **MultipleMatches** sub-panel includes parameters that control the output when multiple matches are required.
maxMatches
The **maxMatches** parameter sets the maximum number of matches that will be produced by the operator. The operator may produce fewer matches.
relThresh
The **relThresh** parameter is used to set a relative rejection threshold for the matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best match found. This value is then applied like the normal rejection threshold.
xVicinity and **yVicinity**
These parameters specify a minimum region around a match location in which matches with lower match scores will be suppressed. Two matches will never be produced that are less than both **xVicinity** pixels apart in *x* and **yVicinity** pixels apart in *y*.

Parameter Information

rejectThresh Type: float
Default: 0

acceptThresh Type: float
Default: 1

minContrast Type: float
Default: 0

maxTilesOmitted Type: int
Default: 0

localSearch Type: int
Default: 0
Values: Fast: 0, All: 1

subPixel Type: int
Default: 0
Values: No: 0, Yes: 1

resolution Type: int
Default: 3
Values: 2: 0, 4: 1, 8: 2, 16: 3, 32: 4, 64: 5

scale Type: int
Default: 2
Values: 2: 0, 4: 1, 8: 2, 16: 3, 32: 4

maxCandidates Type: int
Default: 4

candidateThreshold Type: float
Default: 0.5

candidateRelThresh Type: float
Default: 0

applyPatterns Type: int
Default: 0
Values: All: 0, Sample: 1

patSampling Type: int
Default: 1

output Type: int
Default: 0
Values: Final Values: 0, Candidates: 1

maxMatches Type: int
Default: 1

relThresh Type: float
Default: 0

xVicinity Type: int
Default: 0

yVicinity Type: int
Default: 0

C Prototype

```
CorOpRtn cor_patFind1(
    CorImage *Target,
    CorGraphic *ROI,
    CorPatModel1 *PatModel,
    CorFpointVector *Locations,
    CorFloatVector *Scores,
    CorIntVector *Indexes,
    float rejectThresh,
    float acceptThresh,
    float minContrast,
    int maxTilesOmitted,
    int localSearch,
    int subPixel,
    int resolution,
    int scale,
    int maxCandidates,
    float candidateThreshold,
    float candidateRelThresh,
    int applyPatterns,
    int patSampling,
    int output,
    int maxMatches,
    float relThresh,
    int xVicinity,
    int yVicinity)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patFind2D1

Find one of a 2D array of patterns

Description

The **patFind2D** operator locates the best match or matches to patterns from a 2D array of pattern variations. The inputs to the operator are a gray scale target image, a rectangle graphic specifying the ROI, and a vector of pattern models, which may use tiled pattern images and/or binary masks. A rectangular region of interest (ROI) of the target image is searched for the pattern matches. Matches between the patterns and the image are evaluated by a statistical technique using pixel grayscale values. A two level strategy is used to speed up the search. The operator outputs the location, match score, and pattern index of the match or matches meeting criteria specified by the operator's parameters.

Inputs

Target
The target image can be any gray scale WiT image: an unsigned or signed, eight or sixteen bit integer image; or a float image. The operator does not accept color or complex images.
ROI
The ROI must be a rectangle type Graphic object. The operator searches locations in the target image for which the pattern will be completely contained within the ROI. The ROI must be large enough to contain the pattern. An ROI specifying the entire image is produced by the **getRect** operator.
PatModel
The vector of pattern models is produced by the **patInit2D1** operator from from a vector of image vectors.

The input pattern models in either dimension may represent variations on a pattern or different basic patterns. A typical example is an input vector in which each pattern model vector represents a different scaling of a pattern image and each pattern model within a vector represents a different rotation of the scaled image. (The **patRotateScale** operator and the **patInit2D1** operator can be used together to produce a vector of pattern model vectors in this format from a single image.) When applicable, the pattern models should be more closely related within each pattern model vector than they are across the vector of vectors. For example, each vector in the top level vector might represent a different character, while the pattern models within a vector represent various forms or degraded versions of that vector's character.

The patterns may be broken into equal sized rectangular tiles and/or may incorporate an arbitrary binary mask, as described in the **patInit2D1** operator documentation.

Outputs

Locations
The match locations are produced as a vector of Real points giving the x and y coordinates of the location in the matching region in the target image corresponding to the center pixel in the pattern image. For even dimension (width or height) pattern images, the center pixel location is rounded up to the next integer value. Only the best match at each location is reported. The matches are sorted in order of descending score.
Scores

The match scores corresponding to the locations in the Locations output vector are produced as a vector of float values.

Indexes1 and **Indexes2**

The **Indexes1** output is a vector of integers in which each element is the index number indicating which pattern model in the **PatModel** input vector contained the pattern that produced the corresponding match. The elements of the **Indexes2** integer vector indicate which pattern within that model produced the match. Together these index values identify the matching pattern in the 2-D array.

Parameters

rejectThresh

The **rejectThresh** parameter is used to set a rejection threshold for match scores below which no matches will be considered. The parameter must be set to a value from zero to one, where zero indicates no correlation between the pattern and target and one indicates a perfect match. If no part of the target image matches the pattern sufficiently well, empty output vectors are produced.

acceptThresh

The **acceptThresh** parameter specifies an acceptance threshold above which a score value is always considered a valid match. If the maximum number of matches (specified by the **maxMatches** parameter) are found with match scores above the **acceptThresh** value, the search stops immediately. This parameter is used to control early termination of the search for improved speed.

minContrast

The **minContrast** parameter is used to specify the minimum contrast required in the target image to produce a match. The parameter specifies the minimum standard deviation of the pixel values in a possible match region relative to the standard deviation of pixel values in the pattern model image. This parameter is usually set to a value between zero and one, although values greater than one can be used if the target image has higher contrast than the model images.

maxTilesOmitted

If the pattern model breaks the pattern images into multiple tiles, the **maxTilesOmitted** parameter allows the operator to omit some of the tiles while calculating the best matching score. The operator will use the best score for a location that omits at most the number of tiles specified by this parameter. The operator will always use at least one tile to calculate the best score. Setting this parameter to a value greater than zero provides some tolerance to partially occluded or damaged target regions.

localSearch

The **localSearch** parameter specifies the method used to search the local neighbourhoods of candidates found in the low resolution search. When the parameter is set to *Fast* a binary hill-climbing method is used. The hill-climbing method can get stuck in local a maximum, in particular when the target and pattern model images contain fine regular patterns. To prevent this occuring the parameter can be set to *All*, in which case an exhaustive search of the neighbourhood is performed. The exhaustive search is slower for large candidate search scale factors.

subPixel

The **subPixel** parameter allows the match locations to be refined to subpixel precision. The pattern model must have been prepared using the subpixel mode of the **patInit** operator.

resolution

The **resolution** parameter specifies the resolution of the subpixel refinement of the match locations. The resolution can be specified in powers of two from "2" (half pixel) to "64" (1/64 pixel); This parameter is only used when the **subPixel** parameter is set to *Yes*.

The Candidates Sub-Panel

The **patFind** operator uses a two level seach strategy to speed up the matching process. First, a lower resolution search is performed over the entire ROI to find candidate matches. The candidate matches are then refined at full (and possibly subpixel) resolution. The parameters on the **Candidates** subpanel

are used to control the low resolution search and candidate selection.

scale

The **scale** parameter is used to specify resolution reduction factor for the initial search for candidates. It can be set to powers of two from two to 32.

maxCandidates

The **maxCandidates** parameter specifies the maximum number of candidates that will be passed to the second phase of the search. This should usually be greater than the number of matches required in the second phase.

candidateThresh

The **candidateThresh** parameter is used to set the rejection threshold for candidate matches.

candidateRelThresh

The **candidateRelThresh** parameter is used to set a relative rejection threshold for candidate matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best candidate match found. This value is then applied like the normal rejection threshold. The relative threshold is used to restrict the candidates passed on to the second to those near the best.

applyPatterns

The **applyPatterns** parameter is only meaningful when more than one pattern model is applied. When the parameter is set to *All* all patterns in the input are compared to the target image in both phases of the search. When the parameter is set to *Sample* the input vector of pattern vectors is sampled in both dimensions, as specified by the **patSampling1** and **patSampling2** parameters for the candidate search. The second phase of the search will then only use pattern vectors or patterns within the corresponding sampling distance of the vector or pattern that produced the candidate match.

patSampling1

The **patSampling1** parameter specifies the sample spacing in the vector of pattern vectors for the candidate search when **applyPatterns** is set to *Sample*.

patSampling2

The **patSampling2** parameter specifies the sample spacing within each vector of pattern vectors for the candidate search when **applyPatterns** is set to *Sample*.

output

The *Candidates* setting of of the **output** parameter allows the user to output the locations, match scores and pattern indexes of the candidates, rather than those of the refined matches normally produced. The *Candidates* setting is usually used during development to help determine the best settings for the various parameters that control candidate selection.

The MultipleMatches Sub-Panel

The **MultipleMatches** sub-panel includes parameters that control the output when multiple matches are required.

maxMatches

The **maxMatches** parameter sets the maximum number of matches that will be produced by the operator. The operator may produce fewer matches.

relThresh

The **relThresh** parameter is used to set a relative rejection threshold for the matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best match found. This value is then applied like the normal rejection threshold.

xVicinity and **yVicinity**

These parameters specify a minimum region around a match location in which matches with lower match scores will be suppressed. Two matches will never be produced that are less than both **xVicinity** pixels apart in *x* and **yVicinity** pixels apart in *y*.

Parameter Information

rejectThresh	Type: float Default: 0
acceptThresh	Type: float Default: 1
minContrast	Type: float Default: 0
maxTilesOmitted	Type: int Default: 0

localSearch Type: int
Default: 0
Values: Fast: 0, All: 1

subPixel Type: int
Default: 0
Values: No: 0, Yes: 1

resolution Type: int
Default: 3
Values: 2: 0, 4: 1, 8: 2, 16: 3, 32: 4, 64: 5

scale Type: int
Default: 2
Values: 2: 0, 4: 1, 8: 2, 16: 3, 32: 4

maxCandidates Type: int
Default: 4

candidateThreshold Type: float
Default: 0.5

candidateRelThresh Type: float
Default: 0.75

applyPatterns Type: int
Default: 0
Values: All: 0, Sample: 1

patSampling1 Type: int
Default: 1

patSampling2 Type: int
Default: 1

output Type: int
Default: 0
Values: Final Values: 0, Candidates: 1

maxMatches Type: int
Default: 1

relThresh Type: float
Default: 0

xVicinity Type: int
Default: 0

yVicinity Type: int
Default: 0

C Prototype

```
CorOpRtn cor_patFind2D1(
    CorImage *Target,
    CorGraphic *ROI,
    CorPatModel1Vector *PatModels,
    CorFpointVector *Locations,
    CorFloatVector *Scores,
    CorIntVector *Indexes1,
    CorIntVector *Indexes2,
    float rejectThresh,
    float acceptThresh,
    float minContrast,
    int maxTilesOmitted,
    int localSearch,
    int subPixel,
    int resolution,
    int scale,
    int maxCandidates,
    float candidateThreshold,
    float candidateRelThresh,
    int applyPatterns,
    int patSampling1,
    int patSampling2,
    int output,
    int maxMatches,
    float relThresh,
    int xVicinity,
    int yVicinity)
```

Headers

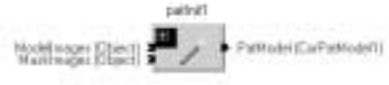
#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patInit1

Initialize pattern from image or image vector



Description

The **patInit1** operator prepares a pattern model from an image or vector of images for use with the pattern matching operators **patFind1**, **patLocal1**, and **patRoi1**.

The pattern model images may be broken up into equal sized rectangular subimages or tiles. The pattern matching operators can optionally use a subset of the tiles when calculating match scores to improve the robustness of matching of partially occluded or damaged target images. Tiled model images can also be used to maintain precision in

large (greater than 256x256) model images by suppressing the automatic scaling that is applied to large model images.

The operator can also incorporate binary mask images into the pattern model. Only pixels in the model and target images that correspond to non-zero pixels in the mask image will be used in the calculation of matching scores.

Inputs

ModelImages
The input may be either a single gray scale image or a vector of gray scale images. If a vector of images is used, all images in the vector must be the same size and type. Vectors of rotated or scaled versions of the same image can be produced by the **patRotate** and **patScale** operators. These image vectors can be used as input to **patInit** to allow prepare a model for searches for rotated or scaled patterns in the target.

MaskImages
When the **mask** parameter is set to *Yes*, the input may be either a single unsigned 8-bit image or a vector of unsigned 8-bit images. The number of images and the size of each the images must be the same as the ModelImages.

When the **mask** parameter is set to *No* the input is ignored.

Outputs

PatModel
The operator produces a PatModel object that includes models of each image in the input image set. The pattern model enables the pattern matching operators to quickly search the image for matches to the patterns represented by the input image set.

Parameters

subPixel
If the **subPixel** parameter is set to *Yes* coefficients required for subpixel pattern matching will be calculated and included in the pattern model. These coefficients must be precalculated by the **patInit** operator in order to use the pattern models for subpixel resolution matching.

mask
If the **mask** parameter is set to *Yes* the MaskImages input will be used to create a masked pattern model in which only pixels corresponding to non-zero pixels in the mask image will be used to calculate the match score.

If it is set to *No* all pixels in the model image and corresponding region of the target image will be used in the score calculation.

tileCols and **tileRows**
If the **tileCols** and **tileRows** parameters are used to set the number of tiles into which the model image is divided horizontally and vertically. The model image is not tiled when both parameters are set to 1.

The image will be broken into the equal size tiles. If the number of pixels in the model image does not divide evenly by the number of tiles, remaining pixels on the right and/or bottom of the model image will be dropped.

colorMode
The **colorMode** parameter controls the normalization of color images.

When this parameter is set to *brightness* the model image and target image are converted to gray scale images (corresponding to the Y channel of the CIE Yuv color space) and the match score is calculated using the gray scale pixel values.

The other color space modes are not yet implemented.

If the model image is not a color image the parameter value is is ignored and the color mode is automatically set to *brightness*.

Parameter Information

subPixel Type: int
Default: 0
Values: No: 0, Yes: 1

mask Type: int
Default: 0
Values: No: 0, Yes: 1

tileCols Type: int
Default: 1

tileRows Type: int
Default: 1

colorMode Type: int
Default: 0
Values: brightness: 0, fixColor: 1, varyColor: 2

C Prototype

```
CorOpRtn cor_patInit1(
    CorObj *ModelImages,
    CorObj *MaskImages,
    CorPatModel1 **PatModel,
    int subPixel,
    int mask,
    int tileCols,
    int tileRows,
    int colorMode
)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patInit2D1

Initialize 2D array of patterns

Description

The **patInit2D1** operator prepares an array of pattern models from a vector of image vectors for use with the **patFind2D1** operator. These operators facilitate searching for patterns with two distinct types of variation; for example rotated and scaled versions of a single pattern or rotated versions of each of several different patterns.

The pattern model images may be broken up into equal sized rectangular subimages or tiles. The pattern matching operators can optionally use a subset of the tiles when calculating match scores to improve the robustness of matching of partially occluded or damaged target images. Tiled model images can also be used to maintain precision in large (greater than 256x256) model images by suppressing the automatic scaling that is applied to large model images.

The operator can also incorporate binary mask images into the pattern model. Only pixels in the model and target images that correspond to non-zero pixels in the mask image will be used in the calculation of matching scores.

Inputs

ModelImages
The input must be a vector of image vectors. All images within an image vector must be the same size, but the image size may vary among the image vectors. The images must all be gray scale image of the same image type.

The input images (and the resulting pattern models) in either dimension may represent variations on a pattern or different basic patterns. A typical example is an input vector in which each image vector represents a different scaling of a pattern image and each image within a vector represents a different rotation of the scaled image. (The **patRotateScale** operator produces a vector of image vectors in this format from a single image.) When applicable, the images should be more closely related within each image vector than they are across the vector of vectors. For example, each image vector in the top level vector might represent a different character, while the images within a vector represent various

forms or degraded versions of that vector's character.

MaskImages
When the **mask** parameter is set to *Yes*, the input must be a vector of image vectors in which the images are unsigned 8-bit images. The number of images and the size of each the images must be the same as the corresponding ModelImages.

When the **mask** parameter is set to *No* the input is ignored.

Outputs

PatModels
The operator produces a vector of PatModel objects. Each element of the vector includes models for the images in one of the image vector elements of the input vector of vectors.

Parameters

subPixel
If the **subPixel** parameter is set to *Yes* coefficients required for subpixel pattern matching will be calculated and included in the pattern model. These coefficients must be precalculated by the **patInit2D** operator in order to use the pattern models for subpixel resolution matching.

mask
If the **mask** parameter is set to *Yes* the MaskImages input will be used to create a masked pattern model in which only pixels corresponding to non-zero pixels in the mask image will be used to calculate the match score.

If it is set to *No* all pixels in the model image and corresponding region of the target image will be used in the score calculation.

tileCols and **tileRows**
If the **tileCols** and **tileRows** parameters are used to set the number of tiles into which the model image is divided horizontally and vertically. The model image is not tiled when both parameters are set to 1.

The image will be broken into the equal size tiles. If the number of pixels in the model image does not divide evenly by the number of tiles, remaining pixels on the right and/or bottom of the model image will be dropped.

colorMode
The **colorMode** parameter controls the normalization of color images.

When this parameter is set to *brightness* the model image and target image are converted to gray scale images (corresponding to the Y channel of the CIE Yuv color space) and the match score is calculated using the gray scale pixel values.

The other color space modes are not yet implemented.

If the model image is not a color image the parameter value is is ignored and the color mode is automatically set to *brightness*.

Parameter Information

subPixel Type: int
Default: 0
Values: No: 0, Yes: 1

mask Type: int
Default: 0
Values: No: 0, Yes: 1

tileCols Type: int
Default: 1

tileRows Type: int
Default: 1

colorMode Type: int
Default: 0
Values: brightness: 0, fixColor: 1, varyColor: 2

C Prototype

```
CorOpRtn cor_patInit2D1(
    CorVector *ModelImages,
    CorVector *MaskImages,
    CorVector *PatModels,
    int subPixel,
```

```
    int mask,
    int tileCols,
    int tileRows,
    int colorMode
)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patInterpolate

Sub-pixel shift an image using interpolation

Description

The **patInterpolate** operator shifts the input image by non-integer amounts in *x* and *y* using bicubic interpolation.

Inputs

In
The input must be a gray scale integer or float image. Color and complex images are not supported by this operator.

Outputs

Out
The output image is the same size and type as the input image. Pixels in rows and columns outside the shifted input image are set to zero.

Parameters

dx and **dy**
The **dx** and **dy** parameters specify the amount of shift in the *x* and *y* directions respectively. A positive value of **dx** shifts the input image to the left and a positive value of **dy** shifts the input image up.

method
The **method** parameter allows the user to choose one of two interpolation methods. If the parameter is set to *Derivatives* the operator uses the values and derivatives at the four pixels surrounding each interpolation point to determine the value at the interpolation point. The derivatives are calculated from pixel value differences. If the parameter is set to *Lagrange* the operator fits third order polynomials to pixel values in the neighbourhood of the interpolation point to obtain a value.

Parameter Information

dx Type: float
Default: 0.5

dy Type: float
Default: 0.5

method Type: int
Default: 0
Values: Derivatives: 0, Lagrange: 1, BiLinear: 2

C Prototype

```
CorOpRtn cor_patInterpolate(
    CorImage *In,
    CorImage *Out,
    float dx,
    float dy,
    int method
)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patLocal1

Find a pattern in point neighbourhoods

Description

The **patLocal** operator locates the best match or matches to one or more patterns in the neighbourhood of specified points in the target image. Matches between the patterns and the image are evaluated by a statistical technique using pixel grayscale values.

The inputs to the operator are a gray scale target image, a vector of points, and a vector of pattern models, which may use tiled pattern images and/or binary masks. The size of the neighbourhood is specified by a parameter. The operator outputs the location, match score, and pattern element number of the match or matches meeting criteria specified by the operator's parameters.

Inputs

Target
The target image can be any gray scale WiT image: an unsigned or signed, eight or sixteen bit integer image; or a float image. The operator does not accept color or complex images.

ROI
The ROI is a vector of Real Points. The operator searches the neighbourhood surrounding each point in the image. The size of the neighbourhood is specified by the **range** parameter.

PatModel
The pattern model is produced by the **patInit1** operator from a pattern image or vector of images. The pattern may be broken into equal sized rectangular tiles and/or may incorporate an arbitrary binary mask, as described in the **patInit1** operator documentation.

Outputs

Locations
The match locations are produced as a vector of Real points giving the x and y coordinates of the location in the matching region in the target image corresponding to the center pixel in the pattern image. For even dimension (width or height) pattern images, the center pixel location is rounded up to the next integer value. Only the best match at each location is reported. The matches are sorted in order of descending score.

Scores
The match scores corresponding to the locations in the Locations output vector are produced as a vector of float values.

Indexes
The **Indexes** output is a vector of integers in which each element is the index number of the pattern in the **PatModel** that produced the match at the corresponding location in the **Locations** output vector.

Parameters

scale
The **scale** parameter is used to specify resolution reduction factor for the search. It can be set to powers of two from one to 32.

range
The **range** parameter specifieds the size of the neighbourhood searched around each input point. The search will extend at most the specified number of pixels in the *x* and *y* directions. It can be set to powers of two from one to 32.

rejectThresh
The **rejectThresh** parameter is used to set a rejection threshold for match scores below which no matches will be considered. The parameter must be set to a value from zero to one, where zero indicates no correlation between the pattern and target and one indicates a perfect match. If no part of the target image matches the pattern sufficiently well, empty output vectors are produced.

acceptThresh
The **acceptThresh** parameter specifies an acceptance threshold above which a match score value is always considered a valid match. If the maximum number of matches (specified by the **maxMatches** parameter) are found with match score above the **acceptThresh** value, the search stops immediately. This parameter is used to control early termination of the search for improved speed.

minContrast
The **minContrast** parameter is used to specify the minimum contrast required in the target image to produce a match. The

parameter specifies the minimum standard deviation of the pixel values in a possible match region relative to the standard deviation of pixel values in the pattern model image. This parameter is usually set to a value between zero and one, although values greater than one can be used if the target image has higher contrast than the model images.

maxTilesOmitted

If the pattern model breaks the pattern images into multiple tiles, the **maxTilesOmitted** parameter allows the operator to omit some of the tiles while calculating the best matching score. The operator will use the best score for a location that omits at most the number of tiles specified by this parameter. The operator will always use at least one tile to calculate the best score. Setting this parameter to a value greater than zero provides some tolerance to partially occluded or damaged target regions.

localSearch

The **localSearch** parameter specifies the method used to search the local neighbourhoods. When the parameter is set to *Fast* a binary hill-climbing method is used. The hill-climbing method can get stuck in local a maximum, in particular when the target and pattern model images contain fine regular patterns. To prevent this occuring the parameter can be set to *All*, in which case an exhaustive search of the neighbourhood is performed. The exhaustive search is slower for large search ranges.

The MultipleMatches Sub-Panel

The **MultipleMatches** sub-panel includes parameters that control the output when multiple matches are required.

maxMatches

The **maxMatches** parameter sets the maximum number of matches that will be produced by the operator. The operator may produce fewer matches.

relThresh

The **relThresh** parameter is used to set a relative rejection threshold for the matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best match found. This value is then applied like the normal rejection threshold.

selectMode

The **selectMode** parameter controls how the operator treats multiple matches that may correspond to the same target. When this parameter is set to *Location*, any matches found within the range specified by the **xVicinity** and **yVicinity** parameters are considered duplicates. When it is set to *Pattern* any matches that correspond to the same element in the pattern model vector are considered duplicates. When it is set to *LocAndPat* matches that are within the vicinity and correspond to the same element in the pattern vector are considered duplicates. Only the best match of a set of duplicate matches is kept.

xVicinity and **yVicinity**

These parameters specify a minimum region around a match location in which matches with lower match scores will be suppressed when the location is being used to select matches. Two matches will never be produced that are less than both **xVicinity** pixels apart in *x* and **yVicinity** pixels apart in *y* when the **selectMode** parameter is set to *Location* or *Both*.

The MultiplePatterns Sub-Panel

The **MultiplePatterns** sub-panel includes parameters that control the output when multiple pattern models are used.

applyPatterns

The **applyPatterns** parameter is only meaningful when more than one pattern model is applied. When the parameter is set to *All* all patterns in the input pattern vector are compared to the target image in both phases of the search. When the parameter is set to *Sample* the pattern vector is sampled as specified by the **patSampling** parameter for the candidate search. A range of adjacent pattern models can be selected by setting the parameter to *Range*, in which case the elements used are specified by the **patCenter** and **patRange** parameters.

patSampling

The **patSampling** parameter specifies the sample spacing in the pattern vector for

the search when **applyPatterns** is set to *Sample*.
patCenter and **patRange**
The **patCenter** and **patRange** parameters specify elements selected from the pattern vector for the search when **applyPatterns** is set to *Range*. The **patCenter** parameter is a vector of integers that must be the same length as the input point vector. The elements of the parameter vector are indexes into the input pattern model vector that indicate the center of the range of patterns for the corresponding input point. A contiguous group of 2 * **patRange** - 1 elements of the pattern vector, centered on the **patCenter** element, are used in the search.

Parameter Information

scale Type: int
Default: 2
Values: 1: 0, 2: 1, 4: 2, 8: 3, 16: 4, 32: 5

range Type: int
Default: 3
Values: 2: 0, 4: 1, 8: 2, 16: 3, 32: 4

rejectThresh Type: float
Default: 0

acceptThresh Type: float
Default: 1

minContrast Type: float
Default: 0

maxTilesOmitted Type: int
Default: 0

localSearch Type: int
Default: 0
Values: Fast: 0, All: 1

maxMatches Type: int
Default: 1

relThresh Type: float
Default: 0

selectMode Type: int
Default: 0
Values: LocAndPat: 0, Location: 1, Pattern: 2

xVicinity Type: int
Default: 0

yVicinity Type: int
Default: 0

applyPatterns Type: int
Default: 0
Values: All: 0, Sample: 1, Range: 2

patSampling Type: int
Default: 1

patCenter Type: CorVector

patRange Type: int
Default: 1

C Prototype

```
CorOpRtn cor_patLocal1(
    CorImage *Target,
    CorFpointVector *ROI,
    CorPatModel1 *PatModel,
    CorFpointVector *Locations,
    CorFloatVector *Scores,
    CorIntVector *Indexes,
    int scale,
    int range,
    float rejectThresh,
    float acceptThresh,
    float minContrast,
    int maxTilesOmitted,
    int localSearch,
    int maxMatches,
    float relThresh,
    int selectMode,
    int xVicinity,
    int yVicinity,
    int applyPatterns,
    int patSampling,
    CorIntVector *patCenter,
    int patRange)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patRoi1

Find a pattern in a rectangular region of interest

Description

The **patRoi** operator locates the best match or matches to one or more patterns in a rectangular region of interest (ROI) of the target image. Matches between the patterns and the image are evaluated by a statistical technique using pixel grayscale values.

The inputs to the operator are a gray scale target image, a rectangle graphic specifying the ROI, and a vector of pattern models, which may use tiled pattern images and/or binary masks. The operator outputs the location, match value, and pattern element number of the match or matches meeting criteria specified by the operator's parameters. The operator can search at reduced resolution to increase speed.

Inputs

Target
The target image can be any gray scale WiT image: an unsigned or signed, eight or sixteen bit integer image; or a float image. The operator does not accept color or complex images.

ROI
The ROI must be a rectangle type Graphic object. The operator searches locations in the target image for which the pattern will be completely contained within the ROI. The ROI must be large enough to contain the pattern. An ROI specifying the entire image is produced by the **getRect** operator.

PatModel
The pattern model is produced by the **patInit1** operator from a pattern image or vector of images. The pattern may be broken into equal sized rectangular tiles and/or may incorporate an arbitrary binary mask, as described in the **patInit1** operator documentation.

Outputs

Locations
The match locations are produced as a vector of Real points giving the x and y coordinates of the location in the matching region in the target image corresponding to the center pixel in the pattern image. For even dimension (width or height) pattern images, the center pixel location is rounded up to the next integer value. Only the best match at each location is reported. The matches are sorted in order of descending score.

Scores
The match scores corresponding to the locations in the Locations output vector are produced as a vector of float values.

Indexes
The **Indexes** output is a vector of integers in which each element is the index number of the pattern in the **PatModel** that produced the match at the corresponding location in the **Locations** output vector.

Parameters

scale
The **scale** parameter is used to specify resolution reduction factor for the search. It can be set to powers of two from one to 32.

rejectThresh
The **rejectThresh** parameter is used to set a rejection threshold for match scores below which no matches will be considered. The parameter must be set to a value from zero to one, where zero indicates no correlation between the pattern and target and one indicates a perfect match. If no part of the target image matches the pattern sufficiently well, empty output vectors are produced.

minContrast
The **minContrast** parameter is used to specify the minimum contrast required in the target image to produce a match. The parameter specifies the minimum standard deviation of the pixel values in a possible match region relative to the standard deviation of pixel values in the pattern model image. This parameter is usually set to a value between zero and one, although values greater than one can be used if the target image has higher contrast than the model images.

maxTilesOmitted
If the pattern model breaks the pattern images into multiple tiles, the

maxTilesOmitted parameter allows the operator to omit some of the tiles while calculating the best matching score. The operator will use the best score for a location that omits at most the number of tiles specified by this parameter. The operator will always use at least one tile to calculate the best score. Setting this parameter to a value greater than zero provides some tolerance to partially occluded or damaged target regions.

The MultipleMatches Sub-Panel

The **MultipleMatches** sub-panel includes parameters that control the output when multiple matches are required.

maxMatches

The **maxMatches** parameter sets the maximum number of matches that will be produced by the operator. The operator may produce fewer matches.

relThresh

The **relThresh** parameter is used to set a relative rejection threshold for the matches. The relative rejection threshold is determined by multiplying the parameter value by the match score of the best match found. This value is then applied like the normal rejection threshold.

selectMode

The **selectMode** parameter controls how the operator treats multiple matches that may correspond to the same target. When this parameter is set to *Location*, any matches found within the range specified by the **xVicinity** and **yVicinity** parameters are considered duplicates. When it is set to *Pattern* any matches that correspond to the same element in the pattern model vector are considered duplicates. When it is set to *LocAndPat* matches that are within the vicinity and correspond to the same element in the pattern vector are considered duplicates. Only the best match of a set of duplicate matches is kept.

xVicinity and **yVicinity**

These parameters specify a minimum region around a match location in which matches with lower match score will be suppressed when the location is being used to select matches. Two matches will never be produced that are less than both **xVicinity** pixels apart in *x* and **yVicinity** pixels apart in *y* when the **selectMode** parameter is set to *Location* or *Both*.

The MultiplePatterns Sub-Panel

The **MultiplePatterns** sub-panel includes parameters that control the output when multiple pattern models are used.

applyPatterns

The **applyPatterns** parameter is only meaningful when more than one pattern model is applied. When the parameter is set to *All* all patterns in the input pattern vector are compared to the target image in both phases of the search. When the parameter is set to *Sample* the pattern vector is sampled as specified by the **patSampling** parameter for the candidate search. A range of adjacent pattern models can be selected by setting the parameter to *Range*, in which case the elements used are specified by the **patCenter** and **patRange** parameters. Finally, the user can specify arbitrary pattern models by setting this parameter to *Select* and specifying the patterns using the **patIndexes** parameter.

patSampling

The **patSampling** parameter specifies the sample spacing in the pattern vector for the search when **applyPatterns** is set to *Sample*.

patCenter and **patRange**

The **patCenter** and **patRange** parameters specify elements selected from the pattern vector for the search when **applyPatterns** is set to *Range*. A contiguous group of 2 * **patRange** - 1 elements centered on element **patCenter** are used in the search.

Parameter Information

scale	Type: int Default: 2 Values: 1: 0, 2: 1, 4: 2, 8: 3, 16: 4, 32: 5
rejectThresh	Type: float Default: 0
minContrast	Type: float Default: 0
maxTilesOmitted	Type: int Default: 0

maxMatches Type: int
Default: 1

relThresh Type: float
Default: 0

selectMode Type: int
Default: 0
Values: LocAndPat: 0, Location: 1, Pattern: 2

xVicinity Type: int
Default: 0

yVicinity Type: int
Default: 0

applyPatterns Type: int
Default: 0
Values: All: 0, Sample: 1, Range: 2

patSampling Type: int
Default: 1

patCenter Type: int
Default: 0

patRange Type: int
Default: 1

C Prototype

```
CorOpRtn cor_patRoi1(
    CorImage *Target,
    CorGraphic *ROI,
    CorPatModel1 *PatModel,
    CorFpointVector *Locations,
    CorFloatVector *Scores,
    CorIntVector *Indexes,
    int scale,
    float rejectThresh,
    float minContrast,
    int maxTilesOmitted,
    int maxMatches,
    float relThresh,
    int selectMode,
    int xVicinity,
    int yVicinity,
    int applyPatterns,
    int patSampling,
    int patCenter,
    int patRange)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patRotate

Rotate a pattern image through a range of angles

Description

The **patRotate** operator creates a vector of rotated versions of the input image. The input image is rotated about its center pixel in increments specified by the operator's parameters to produce the images in the output image vector.

This operator can be used to produce a vector of images for input into the **patInit** operator. The resulting pattern model vector can then be used to search for rotated patterns using the **patFind** operator.

Inputs

In
The input image can be a gray scale or color image, complex images are not currently supported by this operator.

Outputs

Rotated
The output is a vector of rotated versions of the input image. The number of rotated images, the rotation angles and the image sizes are controlled by the parameters as described below. The images in the output vector are of the same type as the input image. Note that vectors color images produced by this operator cannot be used as input to the **patInit** operator.

Params
The **Params** output is a four element float vector that contains the transformation parameters applied to the images in output vector. The first element is the minimum scale factor, the second is the scale increment, the third is the minimum

rotation angle and the fourth is the angle increment. For the **patRotate** operator the first value is always 1.0 and the second is always 0.

Parameters

startAngle, **endAngle** and **angleIncr**
The input image is rotated by angles from **startAngle** up to the largest angle less than or equal to **endAngle** in increments of **angleIncr**. The value of **startAngle** must be less than or equal to the value of **endAngle** and **angleIncr** must zero.

width and **height**
The **width** and **height** parameters control the size of the output image. When a parameter is set to a non-zero value the corresponding dimension of the output image is set to the parameter value, up to a maximum of the corresponding dimension in the input image. When a parameter is set to zero, the corresponding output dimension is the same size as the dimension in the input image. A reduced size image is centered on the original image.

The **width** and **height** parameters may be used to reduce the size of the rotated output images so that the corners of the image contain valid image data. When regions from outside the input image are rotated into the field of view of an output image, the pixels are set to the average of the four corner pixels of the input image.

Parameter Information

minAngle Type: float
Default: 0

maxAngle Type: float
Default: 0

angleIncr Type: float
Default: 1

width Type: int
Default: 0

height Type: int
Default: 0

C Prototype

```
CorOpRtn cor_patRotate(
    CorImage *In,
    CorImageVector *Rotated,
    CorFloatVector *Params,
    float minAngle,
    float maxAngle,
    float angleIncr,
    int width,
    int height
)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patScale

Rescale a pattern image through a range of sizes

Description

The **patScale** operator creates a vector of scaled versions of the input image. The input image is scaled in increments specified by the operator's parameters to produce the images in the output image vector.

This operator can be used to produce a vector of images for input into the **patInit** operator. The resulting pattern model vector can then be used to search for scaled patterns using the **patFind** operator.

Inputs

In
The input image can be a gray scale or color image, complex images are not currently supported by this operator.

Outputs

Scaled
The output is a vector of scaled versions of the input image. The number of scaled images, the scale factors and the image sizes are controlled by the parameters as

described below. The images in the output vector are of the same type as the input image. Note that vectors color images produced by this operator cannot be used as input to the **patInit** operator. The scaled images are produced by pixel sampling relative to the center pixel in the image with no interpolation or smoothing.

Params

The **Params** output is a four element float vector that contains the transformation parameters applied to the images in output vector. The first element is the minimum scale factor, the second is the scale increment, the third is the minimum rotation angle and the fourth is the angle increment. For the **patScale** operator the last two values are always 0.

Parameters

minScale, **maxScale** and **scaleIncr**

The input image is scaled by factors from **minScale** up to the largest value less than or equal to **maxScale** in increments of **scaleIncr**. The value of **minScale** must be less than or equal to the value of **maxScale** and **scaleIncr** must be greater than zero.

width and **height**

The **width** and **height** parameters control the size of the output image. When a parameter is set to a non-zero value the corresponding dimension of the output image is set to the parameter value, from a minimum of the corresponding dimension of the smallest scaled output image to a maximum of the corresponding dimension in the largest scaled image. When a parameter is set to zero, the corresponding output dimension is the size of the scaled image in that dimension.

When either of these parameters is set to zero the resulting image vector will contain images of different sizes and cannot be used directly as input to the **patInit** operator. The **width** and **height** parameters may be used to fix the size of the images in the output vector. Pixels in a fixed size output image that are outside the boundaries of the scaled input image are set to the average of the four corner pixels of the input image.

Parameter Information

minScale Type: float
Default: 1

maxScale Type: float
Default: 1

scaleIncr Type: float
Default: 0.1

width Type: int
Default: 0

height Type: int
Default: 0

C Prototype

```
CorOpRtn cor_patScale(
    CorImage *In,
    CorImageVector *Scaled,
    CorFloatVector *Params,
    float minScale,
    float maxScale,
    float scaleIncr,
    int width,
    int height
)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

patScaleRotate

Rotate and scale a pattern image through ranges of values

Description

The **patRotate** operator creates a vector of image vectors representing scaled and rotated versions of the input image. The input image is scaled in increments specified by the operator's parameters. Each scaled image is rotated as specified by the

parameters to produce a vector of images. These vectors of rotated images are collected to produce the output vector of image vectors.

This operator can be used to produce a vector of image vectors for input into the **patInit2D** operator. The resulting pattern model vector can then be used to search for scaled, rotated patterns using the **patFind2D** operator.

Inputs

In
The input image can be a gray scale or color image, complex images are not currently supported by this operator.

Outputs

Transformed
The input image is first scaled then each scaled image is rotated to produce a vector of images. These vectors of rotated images are collected to produce the output vector of image vectors. The number of scaled image vectors and their scale factors, the number of rotated images in each vector and their rotation angles and the image sizes are controlled by the parameters as described below. The images in the vectors are of the same type as the input image.

Params
The **Params** output is a four element float vector that contains the transformation parameters applied to the images in output vector. The first element is the minimum scale factor, the second is the scale increment, the third is the minimum rotation angle and the fourth is the angle increment.

Parameters

minScale, **maxScale** and **scaleIncr**
The input image is scaled by factors from **minScale** up to the largest angle less than or equal to **maxScale** in increments of **scaleIncr**. The value of **minScale** must be less than or equal to the value of **maxScale** and **scaleIncr** must be greater than zero.

startAngle, **endAngle** and **angleIncr**
Each scaled image is rotated by angles from **startAngle** up to the largest angle less than or equal to **endAngle** in increments of **angleIncr**. The value of **startAngle** must be less than or equal to the value of **endAngle** and **angleIncr** must greater than zero.

width and **height**
The **width** and **height** parameters control the size of the images in the output vectors. If the **width** or **height** parameter is set to a non-zero value the corresponding dimension of the output image is set to the parameter value scaled by the scaling factor for that image, up to a maximum of the corresponding dimension in the scaled input image. When a parameter is set to zero, the corresponding output dimension is the same as the dimension in the scaled input image.

The image size is the same within each image vector in the output, since all rotations of a scaled image are the same size. The image size will vary among the image vectors in the output, with the relative size of the images in a vector proportional to the scaling factor associated with that vector.

Parameter Information

minScale Type: float
Default: 1

maxScale Type: float
Default: 1

scaleIncr Type: float
Default: 0.1

minAngle Type: float
Default: 0

maxAngle Type: float
Default: 0

angleIncr Type: float
Default: 1

width Type: int
Default: 0

height Type: int
Default: 0

C Prototype

```
CorOpRtn cor_patScaleRotate(
    CorImage *In,
```

```
    CorVector *Transformed,
    CorFloatVector *Params,
    float minScale,
    float maxScale,
    float scaleIncr,
    float minAngle,
    float maxAngle,
    float angleIncr,
    int width,
    int height)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

searchEdit

Edit search parameters

Description

Edit search parameters

Parameter Information

Placement Type: int
Default: 0
Values (bitwise OR): Fix position: 1

X Type: int
Default: 0

Y Type: int
Default: 0

C Prototype

```
CorOpRtn cor_searchEdit(
    CorObj *In,
    CorSearchInfo **Out,
    int Placement,
    int X,
    int Y
)
```

Headers

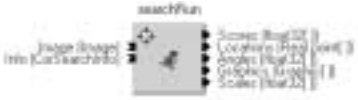
#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

searchRun

Search for patterns in an image



Description

See *User's Manual* for details.

C Prototype

```
CorOpRtn cor_searchRun1(
    CorImage *Image,
    CorSearchInfo *Info,
    CorFpointVector *Locations,
    CorFloatVector *Scores,
    CorFloatVector *Scales,
    CorFloatVector *Angles,
    CorGraphicVector *Graphics
)
```

Headers

#include "$(WITHOME)/h/wSearch.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSearch.lib

SmartWeb

Continuous web and line scan camera specific functions.

webClusterFeatures

Consolidate clusters of features in a stream of images

Description

The **webClusterFeatures** operator groups Features from the input vector that correspond to clusters of blobs in a stream of input image. The Features for each cluster are merged to produce a single Feature in which the field values are calculated over all blobs of the cluster.

When used with Feature vectors produced by the **webGetBlobs** operator, the **webClusterFeatures** operator allows the clusters of blobs to extend across several images in a sequence of images representing vertically adjacent blocks in a larger image space.

A blob is assigned to a cluster when a circle or ellipse derived from the its best fit ellipse overlaps a similar ellipse from some other blob in a cluster. The size of the circle or ellipse is controlled by the operator's parameters.

Inputs

In
The **In** input is a vector of Features produced by the **getFeatures** operator. For this operator, the Features are typically based on blobs extracted by the **webGetBlobs** operator.

Outputs

Out
The **Out** output is a vector of Features representing values calculated over the clusters found in the input Feature vector. Since these Features do not represent contiguous blobs in original image, they cannot be used as input to the **webGetPerimeter** or **getPerimeter** operators.

Parameters

yOffset
The **yOffset** value is used with the **blockHeight** parameter value to determine if a cluster should be released when the **reset** parameter is set to *No* (or is a zero if it is an input parameter). Any cluster whose minimum y value would be below the **yOffset** value if it were extended into the next block will be released.

If the clustered features are going to be used with images produced by the **webWaterfall** operator then this parameter should be an input parameter connected to the **Offset** output of the **webWaterfall** operator.

blockHeight
The **blockHeight** parameter is used with the **yOffset** parameter to control the release of clusters of Features. This parameter should be set to the height of the images from which the Features were extracted. The operator expects these images to be the same height.

reset
When the **reset** parameter is set to *Yes* the operator forces all clusters accumulated to be output. If the **reset** parameter is set to *No* the operator will output clusters that could extend beyond the **yOffset** value if grouped with a Feature from the next input vector. All other clusters will be held to determine if they will be extended into subsequent images.

The **reset** parameter should always be set to the same value as the **reset** parameter of the **webGetBlobs** operator that generated the blobs that produced the Features.

resetId
When the **resetId** parameter is set to *No* the the Feature id number will be saved by the operator so that the id of the first Feature produced the next time the operator fires will follow the last id among the current output Features. When it is set to *Yes*, the operator will reset the

Feature id to zero after the current Features are produced.

mode

The **mode** parameter setting specifies whether a circle or ellipse will be used to determine if two Features are near each other.

aScale, bScale, aOffset, bOffset

These parameters are used with the best fit ellipse axes to determine the size of the circle or ellipse used. In the *circle* mode the circle's diameter is given by:

```
diameter = major * aScale +
aOffset
```

In the *ellipse* mode the ellipse's extended major and minor axes are given by:

```
extended major = major *
aScale + aOffset
```

```
extended minor = minor *
bScale + bOffset
```

where major is the length of the major axis of the best fit ellipse and minor is the length of its minor axis. The circle or ellipse is centered at at the Feature centroid.

Parameter Information

yOffset Type: int
Default: 0

blockHeight Type: int
Default: 32

clear Type: int
Default: 0

resetId Type: int
Default: 0

mode Type: int
Default: 1
Values: Circle: 0, Ellipse: 1

aScale Type: float
Default: 1

bScale Type: float
Default: 1

aOffset Type: float
Default: 0

bOffset Type: float
Default: 0

C Prototype

```
CorOpRtn cor_webClusterFeatures(
    CorFeatureVector *In,
    CorFeatureVector *Out,
    int yOffset,
    int blockHeight,
    int clear,
    int resetId,
    int mode,
    float aScale,
    float bScale,
    float aOffset,
    float bOffset)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webGetBlobFeatsRoi

Get Blobs and Blob features from ROIs in a stream of line scan images

Description

The **webGetBlobFeatsRoi** operator performs pixel connectivity analysis within rectangular regions of interest on a stream of binary or labeled images. The operator extracts run-lengths from the image and outputs both a set of features describing each contiguous region and the run lengths organized into blobs (in the form of a Blob vector). Images in the sequence are treated as if the last line of the previous image is adjacent to the first line of the current image and the first line of the next image is adjacent to the last line of the current image, allowing blobs to extend across more than one

image. Blobs are output when they do not reach the bottom of the current image and so cannot extend into the next image in the sequence. Blobs that reach the bottom row of the current image are usually saved by the operator to see if they extend into the next image in the sequence. The operator can be forced to output these blobs using the **reset** parameter.

The operator is approximately equivalent to applying the **getBlobFeaturesRoi** operator to an image formed by concatenating the images in the stream into a single image. The difference is that this operator provides parameters to reset the operator's state and to limit the maximum height of the blobs produced and perimeters cannot be extracted by this operator.

Inputs

BinaryImage

The **BinaryImage** input must be an 8 or 16 bit unsigned image. The images may be interpreted as either binary images, such as those produced by the **thresh** operator, or labeled images, such as those produced by the **kMeans** operator. All images received by an instance of the operator must be the same size and type.

ROI

The **ROI** input must be single rectangle graphic or a vector of rectangle graphics. The y coordinates of the rectangular ROI are specified relative the the frame of reference of the stream of images, rather than that of the individual input images.

ROI

The **ROI** input must be single rectangle graphic or a vector of rectangle graphics. The y coordinates of the rectangular ROI are specified relative the the frame of reference of the stream of images, rather than that of the individual input images.

Outputs

BlobFeatures

The **BlobFeatures** output is a Blob feature vector. Each element of the vector contains information related to one contiguous region in the input image. This information includes such things as the number of pixels in the region and its centroid. The Blob feature structure comprises the following fields.

Field Name	Description
id	Unique blob identifier
npixels	Number of pixels in the blob
xmin	Minimum x-coordinate of blob (left edge)
xmax	Maximum x-coordinate of blob (right edge)
ymin	Minimum y-coordinate of blob (top edge)
ymax	Maximum y-coordinate of blob (bottom edge)
sumx	Sum of all x-coordinates
sumy	Sum of all y-coordinates
sumxsq	Sum of all x-coordinates squared
sumysq	Sum of all y-coordinates squared
sumxy	Sum of all x-coordinates*y-coordinates
perimx	X-coordinate of a pixel on the blob perimeter (lower right corner)
perimy	Y-coordinate of a pixel on the blob perimeter (lower right corner)
xc	X-coordinate of blob centroid (sumx/n)
yc	Y-coordinate of blob centroid (sumy/n)
angle	Angle of best fit ellipse major axis (clockwise from x axis)
major	Length of best fit ellipse major axis
minor	Length of best fit ellipse minor axis
axratio	minor/major
xdiff	xmax-xmin+1
ydiff	ymax-ymin+1

boxarea	xdiff*ydiff
bxaratio	npixels/boxarea
perim	Perimeter data for blob (must run the getPerimeter operator to fill in this structure)

Blobs

The **Blobs** output is a vector of Blob objects. Each Blob object contains a single run-length. The run-lengths are grouped into contiguous regions. Within each group the run-lengths are sorted by increasing line number and then by the x location of the end of the run. The groups are sorted on the last run-length in the group. The operator keeps a running line count, the run-lengths and information derived from them are referenced to the beginning of the first image in the sequence of images.

Parameters

connected

The connectivity of the output blobs is specified by the **connected** parameter. When this parameter is set to *4* pixels that share a common edge are considered to be connected, so each pixel has four neighbours. When it is set to *8* pixels that touch corner to corner are also considered connected, so each pixel has eight neighbours.

type

The **type** parameter determines how the input image will be interpreted. When it is set to *binary* all non-zero pixels are considered to be equivalent and the run-lengths will represent runs of non-zero pixels. When it is set to *labeled* pixels with the same value are considered equivalent and run-lengths represent runs of equal valued non-zero pixels.

maxBlobHeight

The **maxBlobHeight** parameter sets an upper limit on the height of blobs produced by the operator. When the information derived using the **webGetBlobFeatsRoi** operator is used with images produced by the **webWaterfall** operator, the **maxBlobHeight** value should be less than the **height** parameter value of the **webWaterfall** operator by at least the height of the images in the input image stream to ensure that the blobs are contained within a single waterfall image.

reset

The **reset** parameter can be used to release all active blobs and reset the running line count to zero at the end of the current image. When a reset function is required this parameter is usually used as an input parameter. When a zero is received the blobs are built up as usual. When a one is received, all blobs in the current image are output (even if they reach the bottom of the image) and after processing for the current image is complete the starting line number is reset to zero. The **webLineCounter** operator can be used to provide the required control signals. When no reset function is required, this parameter is set to *No*. In this mode, the line count will continually increase as images are received until the graph stops. Blobs which reach the bottom of the last image processed will not be output by the operator.

resetBlobId

The blob id number can be set to zero with the **resetBlobId** parameter, This will set the next blob id to zero after processing the current image. This parameter is usually set to *No* or used as an input parameter. It may be tied to the **reset** parameter when both are input parameters, in which case a new set of id numbers will be started every time the operator is reset.

Parameter Information

type	Type: int Default: 0 Values: binary: 0, labeled: 1
connected	Type: int Default: 1 Values: 4: 0, 8: 1
maxBlobHeight	Type: int Default: 0
reset	Type: int Default: 0 Values: No: 0, Yes: 1

resetBlobId Type: int
Default: 0
Values: No: 0, Yes: 1

minPixels Type: int
Default: 0

minWidth Type: int
Default: 0

minHeight Type: int
Default: 0

C Prototype

```
CorOpRtn cor_webGetBlobFeatsRoi(
    CorImage *In,
    CorObj *ROI,
    CorFeatureVector *BlobFeatures,
    CorBlobVector *Blobs,
    int type,
    int connected,
    int maxBlobHeight,
    int reset,
    int resetBlobId,
    int minPixels,
    int minWidth,
    int minHeight)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webGetBlobFeatures

Get Blobs and Blob features from a stream of line scan images

Description

The **webGetBlobFeatures** operator performs pixel connectivity analysis on a stream of binary or labeled images. The operator extracts run-lengths from the image and outputs both a set of features describing each contiguous region and the run lengths organized into blobs (in the form of a Blob vector). Images in the sequence are treated as if the last line of the previous image is adjacent to the first line of the current image and the first line of the next image is adjacent to the last line of the current image, allowing blobs to extend across more than one image. Blobs are output when they do not reach the bottom of the current image and so cannot extend into the next image in the sequence. Blobs that reach the bottom row of the current image are usually saved by the operator to see if they extend into the next image in the sequence. The operator can be forced to output these blobs using the **reset** parameter.

The operator is approximately equivalent to applying the **getBlobFeatures** operator to an image formed by concatenating the images in the stream into a single image. The difference is that this operator provides parameters to reset the operator's state and to limit the maximum height of the blobs produced and perimeters cannot be extracted by this operator.

Inputs

BinaryImage
The **BinaryImage** input must be an 8 or 16 bit unsigned image. The images may be interpreted as either binary images, such as those produced by the **thresh** operator, or labeled images, such as those produced by the **kMeans** operator. All images received by an instance of the operator must be the same size and type.

Outputs

BlobFeatures
The **BlobFeatures** output is a Blob feature vector. Each element of the vector contains information related to one contiguous region in the input image. This information includes such things as the number of pixels in the region and its centroid. The Blob feature structure comprises the following fields.

Field Name	Description
id	Unique blob identifier
npixels	Number of pixels in the blob
xmin	Minimum x-coordinate of blob (left edge)

xmax	Maximum x-coordinate of blob (right edge)
ymin	Minimum y-coordinate of blob (top edge)
ymax	Maximum y-coordinate of blob (bottom edge)
sumx	Sum of all x-coordinates
sumy	Sum of all y-coordinates
sumxsq	Sum of all x-coordinates squared
sumysq	Sum of all y-coordinates squared
sumxy	Sum of all x-coordinates*y-coordinates
perimx	X-coordinate of a pixel on the blob perimeter (lower right corner)
perimy	Y-coordinate of a pixel on the blob perimeter (lower right corner)
xc	X-coordinate of blob centroid (sumx/n)
yc	Y-coordinate of blob centroid (sumy/n)
angle	Angle of best fit ellipse major axis (clockwise from x axis)
major	Length of best fit ellipse major axis
minor	Length of best fit ellipse minor axis
axratio	minor/major
xdiff	xmax-xmin+1
ydiff	ymax-ymin+1
boxarea	xdiff*ydiff
bxaratio	npixels/boxarea
perim	Perimeter data for blob (must run the getPerimeter operator to fill in this structure)

Blobs

The **Blobs** output is a vector of Blob objects. Each Blob object contains a single run-length. The run-lengths are grouped into contiguous regions. Within each group the run-lengths are sorted by increasing line number and then by the x location of the end of the run. The groups are sorted on the last run-length in the group. The operator keeps a running line count, the run-lengths and information derived from them are referenced to the beginning of the first image in the sequence of images.

Parameters

connected

The connectivity of the output blobs is specified by the **connected** parameter. When this parameter is set to *4* pixels that share a common edge are considered to be connected, so each pixel has four neighbours. When it is set to *8* pixels that touch corner to corner are also considered connected, so each pixel has eight neighbours.

type

The **type** parameter determines how the input image will be interpreted. When it is set to *binary* all non-zero pixels are considered to be equivalent and the run-lengths will represent runs of non-zero pixels. When it is set to *labeled* pixels with the same value are considered equivalent and run-lengths represent runs of equal valued non-zero pixels.

maxBlobHeight

The **maxBlobHeight** parameter sets an upper limit on the height of blobs produced by the operator. When the information derived using the **webGetBlobFeatures** operator is used with images produced by the **webWaterfall** operator, the **maxBlobHeight** value should be less than the **height** parameter value of the **webWaterfall** operator by at least the height of the images in the input image stream to ensure that the blobs are contained within a single waterfall image.

reset

The **reset** parameter can be used to release all active blobs and reset the running line count to zero at the end of

the current image. When a reset function is required this parameter is usually used as an input parameter. When a zero is received the blobs are built up as usual. When a one is received, all blobs in the current image are output (even if they reach the bottom of the image) and after processing for the current image is complete the starting line number is reset to zero. The **webLineCounter** operator can be used to provide the required control signals. When no reset function is required, this parameter is set to *No*. In this mode, the line count will continually increase as images are received until the graph stops. Blobs which reach the bottom of the last image processed will not be output by the operator.

resetBlobId

The blob id number can be set to zero with the **resetBlobId** parameter, This will set the next blob id to zero after processing the current image. This parameter is usually set to *No* or used as an input parameter. It may be tied to the **reset** parameter when both are input parameters, in which case a new set of id numbers will be started every time the operator is reset.

Parameter Information

type Type: int
Default: 0
Values: binary: 0, labeled: 1

connected Type: int
Default: 1
Values: 4: 0, 8: 1

maxBlobHeight Type: int
Default: 0

reset Type: int
Default: 0
Values: No: 0, Yes: 1

resetBlobId Type: int
Default: 0
Values: No: 0, Yes: 1

minPixels Type: int
Default: 0

minWidth Type: int
Default: 0

minHeight Type: int
Default: 0

C Prototype

```
CorOpRtn cor_webGetBlobFeatures(
    CorImage *In,
    CorFeatureVector *BlobFeatures,
    CorBlobVector *Blobs,
    int type,
    int connected,
    int maxBlobHeight,
    int reset,
    int resetBlobId,
    int minPixels,
    int minWidth,
    int minHeight)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webGetBlobs

Run-length encode blobs in a stream of line scan images

Description

The **webGetBlobs** operator performs pixel connectivity analysis on a stream of binary or labeled images. The operator extracts run-lengths from the image and outputs them in a vector in which run-lengths from each contiguous set of pixels in the image are grouped together and given a distinct id number. Images in the sequence are treated as if the last line of the previous image is adjacent to the first line of the current image and the first line of the next image is adjacent to the last line of the current image, allowing blobs to extend across more than one image. Blobs are output when they do not reach the bottom of the current image and so cannot extend into the next image in the sequence. Blobs that reach the bottom row of the

current image are usually saved by the operator to see if they extend into the next image in the sequence. The operator can be forced to output these blobs using the **reset** parameter.

The operator is approximately equivalent to applying the **getBlobs** operator to an image formed by concatenating the images in the stream into a single image. The difference is that this operator provides parameters to reset the operator's state and to limit the maximum height of the blobs produced.

Inputs

BinaryImage

The **BinaryImage** input must be an 8 or 16 bit unsigned image. The images may be interpreted as either binary images, such as those produced by the **thresh** operator, or labeled images, such as those produced by the **kMeans** operator. All images received by an instance of the operator must be the same size and type.

Outputs

Blobs

The **Blobs** output is a vector of Blob objects. Each Blob object contains a single run-length. The run-lengths are grouped into contiguous regions. Within each group the run-lengths are sorted by increasing line number and then by the x location of the end of the run. The groups are sorted on the last run-length in the group. The operator keeps a running line count, the run-lengths and information derived from them are referenced to the beginning of the first image in the sequence of images.

Parameters

connected

The connectivity of the output blobs is specified by the **connected** parameter. When this parameter is set to *4* pixels that share a common edge are considered to be connected, so each pixel has four neighbours. When it is set to *8* pixels that touch corner to corner are also considered connected, so each pixel has eight neighbours.

type

The **type** parameter determines how the input image will be interpreted. When it is set to *binary* all non-zero pixels are considered to be equivalent and the run-lengths will represent runs of non-zero pixels. When it is set to *labeled* pixels with the same value are considered equivalent and run-lengths represent runs of equal valued non-zero pixels.

maxBlobHeight

The **maxBlobHeight** parameter sets an upper limit on the height of blobs produced by the operator. When the information derived using the **webGetBlobs** operator is used with images produced by the **webWaterfall** operator, the **maxBlobHeight** value should be less than the **height** parameter value of the **webWaterfall** operator by at least the height of the images in the input image stream to ensure that the blobs are contained within a single waterfall image.

reset

The **reset** parameter can be used to release all active blobs and reset the running line count to zero at the end of the current image. When a reset function is required this parameter is usually used as an input parameter. When a zero is received the blobs are built up as usual. When a one is received, all blobs in the current image are output (even if they reach the bottom of the image) and after processing for the current image is complete the starting line number is reset to zero. The **webLineCounter** operator can be used to provide the required control signals. When no reset function is required, this parameter is set to *No*. In this mode, the line count will continually increase as images are received until the graph stops. Blobs which reach the bottom of the last image processed will not be output by the operator.

resetBlobId

The blob id number can be set to zero with the **resetBlobId** parameter, This will set the next blob id to zero after processing the current image. This parameter is usually set to *No* or used as an input parameter. It may be tied to the **reset** parameter when both are input parameters, in which case a new set of id numbers will be started every time the operator is reset.

Parameter Information

connected Type: int
Default: 1
Values: 4: 0, 8: 1

type Type: int
Default: 0
Values: binary: 0, labeled: 1

maxBlobHeight Type: int
Default: 0

reset Type: int
Default: 0
Values: No: 0, Yes: 1

resetBlobId Type: int
Default: 0
Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_webGetBlobs(
    CorImage *BinaryImage,
    CorBlobVector *Blobs,
    int connected,
    int type,
    int maxBlobHeight,
    int reset,
    int resetBlobId
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webGetBlobsRoi

Run-length encode blobs in ROIs in a stream of line scan images

Description

The **webGetBlobsRoi** operator performs pixel connectivity analysis within rectangular regions of interest on a stream of binary or labeled images. The operator extracts run-lengths from the image and outputs them in a vector in which run-lengths from each contiguous set of pixels in the image are grouped together and given a distinct id number. Images in the sequence are treated as if the last line of the previous image is adjacent to the first line of the current image and the first line of the next image is adjacent to the last line of the current image, allowing blobs to extend across more than one image. Blobs are output when they do not reach the bottom of the current image and so cannot extend into the next image in the sequence. Blobs that reach the bottom row of the current image are usually saved by the operator to see if they extend into the next image in the sequence. The operator can be forced to output these blobs using its parameters.

The operator is approximately equivalent to applying the **getBlobsROI** operator to an image formed by concatenating the images in the stream into a single image. The difference is that this operator provides parameters to reset the operator's state and to limit the maximum height of the blobs produced.

Inputs

BinaryImage
The **BinaryImage** input must be an 8 or 16 bit unsigned image. The images may be interpreted as either binary images, such as those produced by the **thresh** operator, or labeled images, such as those produced by the **kMeans** operator. All images received by an instance of the operator must be the same size and type.

ROI
The **ROI** input must be single rectangle graphic or a vector of rectangle graphics. The y coordinates of the rectangular ROI are specified relative the the frame of reference of the stream of images, rather than that of the individual input images.

Outputs

Blobs
The **Blobs** output is a vector of Blob objects. Each Blob object contains a single run-length. The run-lengths are grouped into contiguous regions. Within each group the run-lengths are sorted by increasing line number and then by the x

location of the end of the run. The groups are sorted on the last run-length in the group. The operator keeps a running line count, the run-lengths and information derived from them are referenced to the beginning of the first image in the sequence of images.

Parameters

connected
The connectivity of the output blobs is specified by the **connected** parameter. When this parameter is set to *4* pixels that share a common edge are considered to be connected, so each pixel has four neighbours. When it is set to *8* pixels that touch corner to corner are also considered connected, so each pixel has eight neighbours.

type
The **type** parameter determines how the input image will be interpreted. When it is set to *binary* all non-zero pixels are considered to be equivalent and the run-lengths will represent runs of non-zero pixels. When it is set to *labeled* pixels with the same value are considered equivalent and run-lengths represent runs of equal valued non-zero pixels.

maxBlobHeight
The **maxBlobHeight** parameter sets an upper limit on the height of blobs produced by the operator. When the information derived using the **webGetBlobs** operator is used with images produced by the **webWaterfall** operator, the **maxBlobHeight** value should be less than the **height** parameter value of the **webWaterfall** operator by at least the height of the images in the input image stream to ensure that the blobs are contained within a single waterfall image.

reset
The **reset** parameter can be used to release all active blobs and reset the running line count to zero at the end of the current image. When a reset function is required this parameter is usually used as an input parameter. When a zero is received the blobs are built up as usual. When a one is received, all blobs in the current image are output (even if they reach the bottom of the image) and after processing for the current image is complete the starting line number is reset to zero. The **webLineCounter** operator can be used to provide the required control signals. When no reset function is required, this parameter is set to *No*. In this mode, the line count will continually increase as images are received until the graph stops. Blobs which reach the bottom of the last image processed will not be output by the operator.

resetBlobId
The blob id number can be set to zero with the **resetBlobId** parameter, This will set the next blob id to zero after processing the current image. This parameter is usually set to *No* or used as an input parameter. It may be tied to the **reset** parameter when both are input parameters, in which case a new set of id numbers will be started every time the operator is reset.

Parameter Information

connected	Type: int Default: 1 Values: 4: 0, 8: 1
type	Type: int Default: 0 Values: binary: 0, labeled: 1
maxBlobHeight	Type: int Default: 0
reset	Type: int Default: 0 Values: No: 0, Yes: 1
resetBlobId	Type: int Default: 0 Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_webGetBlobsRoi(
    CorImage *BinaryImage,
    CorObj *ROI,
    CorBlobVector *Blobs,
    int connected,
    int type,
    int maxBlobHeight,
    int reset,
    int resetBlobId
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webGetPerimeter

Find perimeter given a feature in a waterfall image

Description

The **webGetPerimeter** operator determines the perimeter related data corresponding to an input Feature vector and an input image from a frame of reference shifted in y relative to the Features. The perimeter is determined for each element in the input vector by tracing equivalent valued boundary pixels in the input image.

This operator is typically used to calculate perimeters for Feature vectors generated from blobs extracted by the **webGetBlobs** operator using images from the input stream or images produced by the **webWaterfall** operator. In these cases, the first row of image does not, in general, represent the first row of the image space in which the Feature field values are determined. The offset between the two image spaces is specified by the **yOffset** parameter.

Inputs

In
The **In** input is a vector of Features produced by the **getFeatures** operator. The Features are usually derived from blobs produced by the **webGetBlobs** operator.

BinaryImage
The **BinaryImage** input must be an unsigned eight or sixteen bit binary or labeled image. In a binary image all non-zero connected pixels are considered to belong to the same connected blob. In a labeled image equal valued non-zero connected pixels belong to the same blob. The input image is usually produced from an original image in a stream of images processed by the web operators or from the output of the **webWatershed** operator.

Outputs

Out
The output Feature vector is a duplicate of the input Feature vector with the Feature perimeter data set added to each element. The perimeter data set values are in the frame of reference of the original feature set. The perimeter fields are defined as follows:

Field Name	Description
perimLength	Total length of perimeter (# of points) around object
maxDeltaX	Max. distance along x-axis from x-centroid
minDeltaX	Min. distance along x-axis from x-centroid
maxDeltaY	Max. distance along y-axis from y-centroid
minDeltaY	Min. distance along y-axis from y-centroid
sumRadius	Sum of radial distances of each perimeter point from centroid
sumRadiusSqrd	Sum of radial distances squared
maxRadiusSqrd	Max. radial distance squared
minRadiusSqrd	Min. radial distance squared
maxRadDeltaX	Max. distance along x-axis from x-centroid at max. radial point
maxRadDeltaY	Max. distance along y-axis from y-centroid at max. radial point

minRadDeltaX	Min. distance along x-axis from x-centroid at max. radial point
minRadDeltaY	Min. distance along y-axis from y-centroid at max. radial point
maxLength	Max. length of perimeter
minLength	Min. length of perimeter
maxWidth	Max. width of perimeter
minWidth	Min. width of perimeter
points	Point vector containing all perimeter points

Parameters

yOffset
The **yOffset** parameter specifies the line number of the first line in the input image relative to the frame of reference of the input Features. This parameter is typically used as an input parameter. The line number offset outputs of operators such as **webWaterfall** and **webLineCounter** may be used to provide the input value.

connected
The **connected** parameter can be used to specify whether the perimeter pixels should be eight connected, where diagonal neighbours are considered to be touching, or four connected, where they are not.

type
The **type** parameter is used to to specify whether the input image is considered a binary image, in which case non-zero regions will be traced, or a labeled image, in which case equal valued non-zero regions will be traced. The **connected** and **type** parameters should be set to the same values as the **connected** and **type** parameters on the **webGetBlobs** operator that was used to generate the input feature vector. If they are not, the operator may have trouble correctly tracing the perimeter.

Parameter Information

yOffset Type: int
Default: 0

connected Type: int
Default: 1
Values: 4: 0, 8: 1

type Type: int
Default: 0
Values: binary: 0, labeled: 1

C Prototype

```
CorOpRtn cor_webGetPerimeter(
    CorFeatureVector *In,
    CorImage *BinaryImage,
    CorFeatureVector *Out,
    int yOffset,
    int connected,
    int type
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webLabelBlob

Rasterize/binarize/outline blobs in a waterfall image

Description

The **webLabelBlob** operator produces images from Blob vectors. The image may be produced in a frame of reference that is shifted in y by a specified amount. The image produced may be a binary image or a labeled image of the blobs in the input vector or a binary outline of the blobs in the the input vector. The original image that was fed to getBlobs is required at the top input to create the correct output image size.

Inputs

BlobSource
The **BlobSource** input must be an image. This image defines size of the output

image and is usually the image from which the blobs were extracted.

Blobs

The **Blobs** input must be a blob vector. For this operator the blob vector is usually produced by the **webGetBlobs** operator.

Outputs

LabeledImage

The output image is an unsigned eight bit image the same size as the input image. The content of the image is determined by the setting of the **labelType** parameter.

Parameters

offset

The value in the **offset** parameter is subtracted from the row number of the run-lengths in the Blob vector before the output images are produced, so the images appear shifted up by that amount in the output image.

labelType

The **labelType** parameter determines how the output image is formed. If it is set to *greyscale* the output is a labeled image in which each blob is assigned a distinct non-zero value. The *binary* and *outline* settings produce binary images of the filled blobs and blob outlines, respectively. The blobs are assigned the value of their label when this parameter is set to *label value*. The final setting may be used when the *labeled* mode of the **webGetBlobs** (or **getBlobs**) operator is used to produce the input blobs.

Parameter Information

yOffset Type: int
Default: 0

labelType Type: int
Default: 0
Values: greyscale: 0, binary: 1, outline: 2, label values: 3

C Prototype

```
CorOpRtn cor_webLabelBlob(
    CorImage *BlobSource,
    CorBlobVector *Blobs,
    CorImage *LabeledImage,
    int yOffset,
    int labelType
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webLineCounter

Provide parameters and control signals for streams of images

Description

The **webLineCounter** operator provides control parameters and signals for the web operators. This operator is used where each image in a stream of images represents a vertically adjacent blocks from a larger image space composed of a known number of blocks. The larger image space may represent a distinct long image or may be part of an effectively continuous image that is broken up for convenience.

The operator produces the size of the current image in the stream, the line number of the first line of the current image in the larger image space and a control signal that indicates an image represents the last image the current large image space.

Inputs

In

The operator takes an image or an integer value as input.

Outputs

BlockSize

The height of the input image or the value of the input integer is output at the block **BlockSize** output.

YOffset

The line number of the first line of the image, relative to the first image of the current large image space, is produced at the **YOffset** output.

Reset
A one is produced on the **Reset** output when the last image each group of input images of the size specified in the **blocksPerImage** parameter is received. A zero is produced when any other image is received.

Parameters

blocksPerImage
The **blocksPerImage** parameter specifies the number of images that make up the larger image space. After receiving this number of images the YOffset line counter is reset. The operator also produces a reset signal (1) at the reset output.

Parameter Information

blocksPerImage Type: int
Default: 32

C Prototype

```
CorOpRtn cor_webLineCounter(
    CorObj *In,
    int *BlockSize,
    int *YOffset,
    int *Reset,
    int blocksPerImage
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webPlotFeatures

Convert feature vectors to graphic descriptions in waterfall image

Description

The **webPlotFeatures** operator converts the input feature vector element or feature vector generated from blobs in one frame of reference into a graphic object or vector of graphic objects in a frame of reference with a different y origin. This operator is typically used to transform features produced by the **webGetBlobs** operator into the frame of reference of the images in the original input image stream or of images produced by the **webWaterfall** operator.

Inputs

Features
The input must be a Feature object or a vector of Feature objects.

Outputs

Graphics
The output is a Graphic (for a single Feature input) or a vector of Graphics (for a vector of Features input) derived from the information in the Features. An output Graphic may be a point representing the blob centroid; a rectangle representing the bounding box; a line representing the major axis of the best fit ellipse; or a polygon representing the perimeter. The output graphic is offset by subtracting the amount specified in the **offset** parameter from the y coordinate of each point.

Parameters

featureType
The type of feature for viewing is specified by the **featureType** parameter and can be one of centroids, ellipse axes, bounding boxes, or perimeters. In order to plot perimeters, input feature vector must have been previously passed through the **webGetPerimeter** operator.

offset
The **offset** parameter specifies the line number of the first line in the frame of reference of the output graphics relative to the frame of reference of the input Features. This parameter is typically used as an input parameter. The line number offset outputs of operators such as **webWaterfall** and **webLineCounter** may be used to provide the input value.

The **Color** subpanel
The color of the output graphics can be controlled using parameters on the **Color**

subpanel. If the **colors** parameter is set to custom the remaining parameters can be used to specify whether the output graphics are outlines or filled graphic objects and to specify the color of the objects. The default graphics are yellow outlines. The label field of each graphic object is set to the id number of the associated element of the feature vector.

Parameter Information

featureType Type: int
Default: 0
Values: centroids: 0, major axis: 1, bbox: 2, perimeter: 3

yOffset Type: int
Default: 0

colors Type: int
Default: 0
Values: default: 0, custom: 1

outline Type: int
Default: 0
Values: off: 0, on: 1

penR Type: int
Default: 0
Values: 0 — 255

penG Type: int
Default: 0
Values: 0 — 255

penB Type: int
Default: 0
Values: 0 — 255

fill Type: int
Default: 0
Values: off: 0, on: 1

fillR Type: int
Default: 0
Values: 0 — 255

fillG Type: int
Default: 0
Values: 0 — 255

fillB Type: int
Default: 0
Values: 0 — 255

C Prototype

```
CorOpRtn cor_webPlotFeatures(
    CorObj *Features,
    CorObj *Graphics,
    int featureType,
    int yOffset,
    int colors,
    int outline,
    int penR,
    int penG,
    int penB,
    int fill,
    int fillR,
    int fillG,
    int fillB)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webRealign

Align images from multiple line scan cameras

Description

The **webRealign** operator corrects alignment errors in a sequence of images created by horizontally concatenating images produced by a number of side-by-side cameras. The images in the sequence represent vertically adjacent blocks in the imaged space.

The two alignment errors handled by the operator are overlap in field of horizontal field of view between adjacent cameras and vertical misalignment of the cameras. The non-overlapping columns from each camera and the vertical offset associated with each camera are specified using the operators parameters.

The operator uses rows of previous images in the stream to correctly align pixels in the rows of the offset portions of the images.

Inputs

In

The input image is assumed to be a composite image in which the images from several side-by-side cameras are concatenated into a single wide image. The image width must be a multiple of the number of cameras (specified implicitly in the operator parameters). All images in a stream of images received by an instance of the operator must be the same size and type.

Outputs

Out

The output image is formed by concatenating the portions of the input image specified in the **validRange** parameter vector. These portions are offset vertically by the amounts specified in the **offset** parameter vector. The images can only be offset downward from the top of the image. The offset spaces are filled with the lines from the bottom of the corresponding portion of previous images. These spaces are filled with zero valued pixels in the first image in the sequence.

Offset

The **Offset** output is an integer value that gives the line number of the first row of the output image, relative to the first row in the first camera image in the sequence of images.

Parameters

validRange

The **validRange** parameter is used to specify the start and end pixel for the valid, non-overlapping horizontal range for each camera. The number of elements in this Point vector implicitly specifies the number of cameras. The start and end values must be within the portion of the image captured by the corresponding camera.

offset

The **offset** parameter is a vector of integers in which each element represents vertical offset of the corresponding region in the input image. The vector must contain the same number of entries as the **validRange** parameter vector.

reset

The **reset** parameter is used to reset the line count to zero. When no reset function is required the parameter should be set to *No*. When the reset function is required the parameter is used as an input parameter. When a zero is received the line count is incremented as usual. When a one is received the line count is reset to reference the first row of the next image received after processing the current image.

clear

The **clear** parameter blanks the image rows stored from previous images in the stream after processing the current image. This parameter is also used as an input parameter when it is required. When a one is received the next image in the stream will have blank (zero-valued) pixels in offset regions.

Parameter Information

validRange	Type: CorVector
offset	Type: CorVector
reset	Type: int Default: 0 Values: No: 0, Yes: 1
clear	Type: int Default: 0 Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_webRealign(
    CorImage *In,
    CorImage *Out,
    int *Offset,
    CorPointVector *validRange,
    CorIntVector *offset,
    int reset,
    int clear
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webRowExtend

Extend images in a stream for neighbourhood operations

Description

The **webRowExtend** extends an image from a stream of images by prepending rows from preceding images and appending a specified number of rows from subsequent images. The operator is applied to images in a stream that represent vertically adjacent blocks from a single image space so that neighbourhood image processing methods (such as filtering) will produce correct results at the top and bottom of the images.

Images extended in this manner can be returned to their original size using the **webRowRemove** operator.

Inputs

In
The input images in a stream must be the same size and type.

Outputs

Out
The output images are the same width and type as the input images. The height of the output image is the height of the input images plus two times the number of specified number of rows.

The output image has the appropriate number of rows from the current image appended to the bottom of the image. In the usual case where the height of the input image is greater than the number of rows added, this results in a delay of one image as the stream passes through this operator. The first output image will only contain the top rows of the first input image in the stream and most of the last image will not be output.

Parameters

rows
The **rows** parameter specifies the number of rows by which an image is extended at the top and bottom.

Parameter Information

rows Type: int
Default: 2

C Prototype

```
CorOpRtn cor_webRowExtend(
    CorImage *In,
    CorImage *Out,
    int rows
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webRowRemove

Remove rows from the top and bottom of images

Description

The **webRowRemove** operator strips a specified number of rows from the top and bottom of the input image. This operator is usually used following the **webRowExtend** operator to return the extended images to their original size.

Inputs

In
The input images may be any type. The image height must be greater than twice the number of rows specified for removal.

Outputs

Out
The output image contains the rows of the input image that remain after the specified

number of rows are removed from the top and bottom.

Parameters

rows
The **rows** parameter specifies the number of rows to be removed from the top and bottom of the image.

Parameter Information

rows Type: int
Default: 2

C Prototype

```
CorOpRtn cor_webRowRemove(
    CorImage *In,
    CorImage *Out,
    int rows
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webScrollGraphics

Subtract from one or a vector of Graphics

Description

The **webScrollGraphics** operator takes a Graphic or vector of Graphics and subtracts the specified offset value from the y coordinates of all points in the graphic.

This operator is typically used to transform graphics produced using the output of the **webGetBlobs** operator into the frame of reference of the images produced by the **webWaterfall** operator. In this case the offset value is taken from the **o1** output of the **webWaterfall** operator. The transformed graphics can then used with the waterfall image for overlay display or extraction of regions of interest. It can also be used to convert the graphics to the frame of reference of images from the original image stream by feeding the image stream into the **webLineCounter** operator and using its **yOffset** output to control the offset.

Inputs

InGraphics
The input is a Graphic or vector of Graphics.

Outputs

ScrolledGraphics
The output is the input Graphic or Graphic vector with the offset value subtracted from the y value of each point.

Parameters

offset
The **offset** parameter specifies the amount subtracted from the y coordinates of all input graphics. When this operator is used with other web operators this is usually an input parameter.

Parameter Information

offset Type: int
Default: 0

C Prototype

```
CorOpRtn cor_webScrollGraphics(
    CorObj *InGraphics,
    CorObj *ScrolledGraphics,
    int offset
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

webWaterfall

Create a waterfall image from a stream of images

Description

The **webWaterfall** operator appends the input image to the bottom of an image produced by appending previously received images and outputs a specified number of rows from the bottom of the new image. If the input images are vertically adjacent blocks from a single imaged space the **webWaterfall** output images can be viewed as a moving window into the image space.

Inputs

ImageBlock
The stream of images input to an instance of the **webWaterfall** operator must all be of the same size and type. The input image height must be less than the height specified for the output image.

Outputs

Waterfall
The output images are of the same width and type as the input images. The output image height is specified by a parameter. The top rows of images for which the total number of rows received has not yet reached the specified height are blank (zero-valued).

Offset
The **Offset** output is the line number of the first row of the current output image, relative to the start of the first image in the sequence. This value is negative for the initial image(s) in a sequence.

Parameters

height
The **height** parameter specifies the height of the output image. It must be greater than the height of the images in the input image stream.

reset
When the reset function is not required, the **reset** parameter is set to *No*. If the reset function is required, the **reset** parameter is used as an input parameter. Sending a zero to the input parameter results in normal operation. Sending a one (setting the parameter to *Yes*) will clear the previous stored images after producing the current output image. The next execution of the operator will produce an image with its top rows blank. The line count is also reset after the current execution.

Parameter Information

height Type: int
Default: 256

reset Type: int
Default: 0
Values: No: 0, Yes: 1

C Prototype

```
CorOpRtn cor_webWaterfall(
    CorImage *Block,
    CorImage *Waterfall,
    int *Offset,
    int height,
    int reset
)
```

Headers

#include "$(WITHOME)/h/wWeb.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wWeb.lib

Frame Grabber and Hardware

SerialIO

The SerialIO library contains operators for reading from and writing to PC serial ports.

openSerial

Open a serial port

Description

The **openSerial** operator opens a serial port for reading and writing. The input object is passed through to the output unchanged. The port configuration and timeouts can be set using the operator's parameters.

The **port** parameter is used to select the input port to be opened. The port parameter value 0 corresponds to the COM1 port, parameter value 1 corresponds to COM2, and so on. Once a port has been opened the **readSerial** and **writeSerial** operators can be used to read from and write to the port. An open port will remain open until it is closed by the **closeSerial** operator or WiT is exited. Ports are not automatically closed when an igraph stops running. If the specified port is already open, it will be closed and reopened using the operator's parameter values.

When the **configurePort** parameter is set to *Yes*, the serial link is configured using the **baudRate**, **parity**, **stopBits** and **dataBits** parameters. When it is set to *No* the existing system settings are used.

Read timeouts can be specified using the **rdTimeOutMult**, **rdTimeOutConst**, and **rdIntervalTimeOut** parameters. Write timeouts can be specified by setting the **wrTimeOutMult** and **wrTimeOutConst** parameters. Timeout parameter values are in milliseconds. No timeout is set if the parameter value is zero.

Parameter Information

port	Type: int Default: 1
configurePort	Type: int Default: 0 Values: No: 0, Yes: 1
baudRate	Type: int Default: 9600
parity	Type: int Default: 0 Values: none: 0, odd: 1, even: 2, mark: 3, space: 4
stopBits	Type: int Default: 0 Values: 1: 0, 1.5: 1, 2: 2
dataBits	Type: int Default: 3 Values: 5: 0, 6: 1, 7: 2, 8: 3
setTimeOuts	Type: int Default: 0 Values: No: 0, Yes: 1
rdTimeOutMult	Type: int Default: 0
rdTimeOutConst	Type: int Default: 0
rdIntervalTimeOut	Type: int Default: 0
wrTimeOutMult	Type: int Default: 0
wrTimeOutConst	Type: int Default: 0

C Prototype

```
CorOpRtn cor_openSerial(
```

```
    CorObj *In,
    CorObj *Out,
    int port,
    int configurePort,
    int baudRate,
    int parity,
    int stopBits,
    int dataBits,
    int setTimeOuts,
    int rdTimeOutMult,
    int rdTimeOutConst,
    int rdIntervalTimeOut,
    int wrTimeOutMult,
    int wrTimeOutConst)
```

Headers

#include "$(WITHOME)/h/wSerial.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSerial.lib

closeSerial

Close a serial port

Description

The **closeSerial** operator closes a serial port that has been previously opened for reading and writing. The input object is passed through to the output unchanged.

The **port** parameter is used to specify the input port to be closed. The port parameter value 0 corresponds to the COM1 port, parameter value 1 corresponds to COM2, and so on. If the specified port is not open the operator does nothing. Ports are not automatically closed when an igraph stops running.

Parameter Information

port Type: int
Default: 1

C Prototype

```
CorOpRtn cor_closeSerial(
    CorObj *In,
    CorObj *Out,
    int port
)
```

Headers

#include "$(WITHOME)/h/wSerial.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSerial.lib

readSerial

Read a string from a serial port

Description

The **readSerial** operator reads characters from a previously opened serial port when it receives any input object. The type of output is specified by the **output** parameter. When this parameter is set to *String* the operator produces a WiT string. When it is set to *CharVector* a vector of characters is produced. The vector of characters output may be necessary when a null character is expected in the data to avoid treating the null character as an end of string marker.

The **port** parameter specifies the serial port to be read. The port parameter value 0 corresponds to the COM1 port, parameter value 1 corresponds to COM2, and so on. The port must have previously been opened using the **openSerial** operator. Attempting to read a port that has not been opened results in an error.

The maximum number of characters to be read can be set using the **maxChars** parameter. The operator will wait until the specified number of characters have been read or until a read timeout is reached.

Timeouts are set when the port is opened by the **openSerial** operator.

Parameter Information

port Type: int
Default: 1

maxChars Type: int
Default: 1

output Type: int
Default: 0
Values: String: 0, CharVector: 1

C Prototype

```
CorOpRtn cor_readSerial(
    CorObj *Data,
    int port,
    int maxChars,
    int output
)
```

Headers

#include "$(WITHOME)/h/wSerial.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSerial.lib

writeSerial

Write to a serial port

Description

The **writeSerial** operator writes the input string or characters to a previously opened serial port.

The **port** parameter specifies the serial port written to. The port parameter value 0 corresponds to the COM1 port, parameter value 1 corresponds to COM2, and so on. The port must have previously been opened using the **openSerial** operator. Attempting to write to a port that has not been opened results in an error.

The input may be a string or a vector of characters (WiT types char, byte and ubyte will all be accepted). The operator will write characters from the input to the port until all the characters have been written or until a write timeout is reached. Timeouts are set when the port is opened by the **openSerial** operator. The operator outputs the number of characters successfully written to the port.

Parameter Information

port Type: int
Default: 1

C Prototype

```
CorOpRtn cor_writeSerial(
    CorObj *Data,
    int *NumWritten,
    int port
)
```

Headers

#include "$(WITHOME)/h/wSerial.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wSerial.lib

Video Acquisition

acqColorkey

Set color key index for live video passthrough

Description

The **acqColorkey** operator is available for frame grabbers that support live video display and color keying. Any pixel set to the color key value becomes a live video pixel, otherwise the actual pixel value is displayed. This is how graphics, text or images can be drawn on a live video window to

report results with the live video data shown "underneath". Depending on the VGA color depth, the colorkey parameters are set differently. If you are using 256 colors, then only the **red** parameter is used to select an index into the colormap which will be used for the color key value. If you are using more than 256 colors, then the all parameters are used to set an RGB value to act as the colorkey value.

Parameter Information

red Type: int
Default: 100

green Type: int
Default: 255

blue Type: int
Default: 50

C Prototype

```
CorOpRtn acqColorkey(
    int red,
    int green,
    int blue
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqCounterRead

Read current value of acquisition event counter

Description

The **acqCounterRead** operator reads the value of the hardware acquisition event counter, if available. The **acqCounterReset** operator must execute at least once before **acqCounterRead** executes for the first time.

C Prototype

```
CorOpRtn acqCounterRead(
    int *Count)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqCounterReset

Reset acquisition event counter

Description

The first time the **acqCounterReset** operator executes, it initializes the hardware acquisition event counter (if available) and resets the count to zero. Subsequent executions simply reset the count to zero. This operator must be executed at least once before executing **acqCounterRead**.

C Prototype

```
CorOpRtn acqCounterReset()
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqDisplay

Draw an image on the video window

Description

Draw an image on the video window

C Prototype

```
CorOpRtn acqDisplay(
    CorImage *In)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqExposure

Set the exposure duration of a camera's electronic shutter

Description

The **acqExposure** operator is used to set the amount of exposure required by the camera during a frame grab by the **acquire** operator. The **duration** parameter specifies the exposure in units particular to the frame grabber (usually either milliseconds or microseconds).

Parameter Information

duration Type: uint
Default: 16667

C Prototype

```
CorOpRtn acqExposure(
    uint duration)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqFrameTrigger

Control a frame grabber's frame trigger mode

Description

The **acqFrameTrigger** operator is used to control the trigger state of the currently selected frame grabber. When the **source** is set to **Internal**, the **acquire** operator will grab an image from the connected camera based on triggering from an internal generator on the frame grabber board. If the **source** is **External**, the **acquire** operator will block until the frame grabber board receives an external trigger input to start a grab. If the **source** is **None**, the board will send no frame trigger signals to the camera.

Parameter Information

source Type: int
Default: 1
Values: None: 0, Internal: 1, External: 2

C Prototype

```
CorOpRtn acqFrameTrigger(
    int source)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqHue

Set video hue and saturation on frame grabber

Description

The **acqHue** operator is available for frame grabbers that support color acquisition. This operator is used to set the **hue** and **saturation** used by the **acquire** operator. The range of these parameters is expressed as a percentage between 0 and 100.

Parameter Information

hue Type: int
Default: 50
Values: 0 — 100

saturation Type: int
Default: 50
Values: 0 — 100

C Prototype

```
CorOpRtn acqHue(
    int hue,
    int saturation
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqIoRead

Read from external I/O on frame grabber

Description

The **acqIoRead** operator is used to read a digital I/O lines from a selected port which may be available on the frame grabber card.

The **port** parameter is used to select which port to read from. The operator's output is an integer which can be interpreted as a bit-field, where a bit value of 1 indicates that the corresponding line is "on" or "high", and a value of 0 indicates that the line is "off" or "low".

See the description of the **acqIoSetup** operator for more information on the use of hardware I/O.

Parameter Information

port Type: uint
Default: 1

C Prototype

```
CorOpRtn acqIoRead(
    uint *Bits,
    uint port
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqIoRelease

Release external I/O resources on frame grabber

Description

The **acqIoRelease** operator is used to release the hardware resources used to read or write I/O lines on a frame grabber. See the help for **acqIoSetup** for more information on the use of frame grabber I/O lines.

Parameter Information

port Type: uint
Default: 0

C Prototype

```
CorOpRtn acqIoRelease(
    uint port)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqIoSetup

Configure external I/O on frame grabber

Description

The **acqIoSetup** operator is used to configure the hardware resources necessary to read and/or write to I/O lines available on a frame grabber.

The **port** parameter selects which port to configure. A port is a collection of 1 or more I/O lines (commonly 8 or 16) that are read or written in a single operation. Normally a particular port has read-only or write-only lines. For example, port #0 may be read-only, while port #1 may be write-only. The number of available ports, the number of lines per port, and the direction of the lines, are all hardware dependent characteristics. See the documentation for your frame grabber for details.

The **direction** parameter controls whether the lines chosen by the **bits** parameter, of the selected port, are to be configured for input (reading) or output (writing).

The **bits** parameter controls which lines of the selected port are to be configured. The value of **bits** is interpreted as a bit field: the lines corresponding to the "on" bits are the ones to be configured. For example, if the value of **bits** is 170 (bit pattern 10101010) then every other line is to be configured (for reading or writing, depending on the value of the **direction** parameter). If the hardware supports ports which can have lines for both reading and writing, the **acqIoSetup** operator can be executed twice, once to configure the read lines, and once for the write lines. Normally all lines in a port are read-only or write-only lines. In this case the **bits** parameter should be set to the value corresponding to a bit pattern of all 1's. For example, a port with 8 lines would use a value of 255 for **bits**.

Parameter Information

port Type: uint
Default: 0

bits Type: uint
Default: 255

direction Type: int
Default: 0
Values: Read: 0, Write: 1

C Prototype

```
CorOpRtn acqIoSetup(
    uint port,
    uint bits,
    int direction
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqIoWrite

Write to external I/O on frame grabber

Description

The **acqIoWrite** operator supports frame grabbers that have digital I/O output capability. This operator

is used to set output lines on a digital output port given the **port** and **bits** pattern.

The **mask** parameter controls which lines will be set. Those lines whose corresponding bit in the mask are 1, will be written to. Lines whose corresponding bit in the mask are 0 will not be affected by the execution of the operator.

The **acqIoWrite** operator has two modes, controlled by the **mode** parameter. In "immediate" mode, the output lines selected by **mask** are immediately set to the values given by **bits**, and the operator returns. The lines remain in that state until subsequent execution of another **acqIoWrite** or **acqIoRelease** operator. In "delayed" mode the bahavior is more complex.

"Delayed" mode operates in conjuntion with a hardware event counter, available on some frame grabber boards. When the operator executes the output lines selected by the **mode** parameter are immediately set to the complement of the value given by the **bits** parameter, and the operator returns. When the hardware counter value reaches the value given by the **count** parameter, the selected output lines are switched to the values given by **bits**, and remain so until the hardware counter value is equal to **count** + **duration**. At that time the selected output lines are switched back to the values they had before **count** was reached.

The **acqIoSetup** operator may be executed before acqIoWrite to configure the hardware appropriately. If this is not done, then the configuration will occur the first time **acqIoWrite** is executed (which may incur a performance penalty).

See the help for the **acqIoSetup** operator for more information on I/O support.

Parameter Information

port Type: uint
Default: 0

mask Type: uint
Default: 255

bits Type: uint
Default: 255

mode Type: int
Default: 0
Values: immediate: 0, delayed: 1

count Type: uint
Default: 0

duration Type: uint
Default: 1

C Prototype

```
CorOpRtn acqIoWrite(
    uint port,
    uint mask,
    uint bits,
    int mode,
    uint count,
    uint duration
)
```

Headers

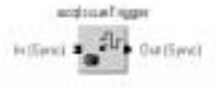
#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqIssueTrigger

emulate a trigger



Description

Issue a trigger internally. This is especially useful when using the frame grabber emulator to emulate externally triggered acquisition.

Demo iGraph

Operators\Video Acquisition\trigger

C Prototype

```
CorOpRtn acqIssueTrigger()
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqLineTrigger

Control a frame grabber's line trigger mode

Description

The **acqLineTrigger** operator is used to control the line trigger method for a linescan camera attached to the currently selected frame grabber. When the **source** is set to **Internal**, the frame grabber board will generate line sync signals for the camera, at a fixed line rate. If the **source** is **External** or **Encoder**, the board will generate line sync signals for the camera based on an external line trigger signal supplied to the board. If the **source** is "None", the board will send no line sync signals to the camera. If the source is **Encoder**, then the **dropCount** parameter determines how many encoder pulses are ignored before the board sends a line sync signal to the camera. For example, if dropCount=7, then the camera will acquire a single line for every 8th encoder pulse.

Parameter Information

source Type: int
Default: 1
Values: None: 0, Internal: 1, External: 2, Encoder: 3

dropCount Type: int
Default: 0

Demo iGraph

Operators\Video Acquisition\trigger

C Prototype

```
CorOpRtn acqLineTrigger(
    int source,
    int dropCount
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqLive

Turn on/off live video display

Description

The **acqLive** operator is supported for frame grabbers that can display live video. When the **enable** parameter is turned on, live video will be presented in a window for display. The live window will be closed automatically when an igraph stops execution or when this operator is run again with the **enable** parameter set off.

Parameter Information

enable Type: int
Default: 0
Values: no: 0, yes: 1

Demo iGraph

Operators\Video Acquisition\trigger

C Prototype

```
CorOpRtn acqLive(
    int enable)
```

Headers

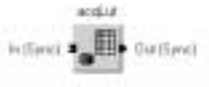
#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqLut

Load an input LUT on frame grabber



Description

The **acqLut** operator is used to load a hardware lookup table which may be available on the frame grabber. The input is a Vector of integers which holds the values of the lookup table to be loaded. The **lutGen** operator can be used to generate many common lookup tables.

Parameter Information

lutNumber Type: int
Default: 0

lut Type: CorVector
Default: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255]

Demo iGraph

Operators\Video Acquisition\trigger

C Prototype

```
CorOpRtn acqLut(
    int lutNumber,
    CorIntVector *lut
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqOverlay

Overlay image or graphics on video window

Description

The **acqOverlay** operator is available on frame grabbers which support live video display. This operator takes an image or Graphic vector as input, and draws the data to the live video display window at the specified **x** and **y** offset. Typically, the **acqLive** operator is used first to bring up the live video window then the **acqOverlay** operator is used to display results. The **acqOverlay** operator can only handle Graphic objects of type point, circle, rectangle, text, and line.

Parameter Information

x Type: int
Default: 0

y Type: int
Default: 0

Demo iGraph

Operators\Video Acquisition\trigger

C Prototype

```
CorOpRtn acqOverlay(
    CorObj *In,
    int x,
    int y
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqRgbBrightness

Set video offset and gain for RGB frame grabber

Description

The **acqRgbBrightness** operator sets the contrast (gain) and brightness (offset) of the red, green, and blue bands of a color image acquired with the acquire operator. The parameters are given as a value between 0 and 100 where 0 is the minimum and 100 is the maximum value available on the frame grabber hardware in use.

Parameter Information

rBrightness Type: int
Default: 50
Values: 0 — 100

gBrightness Type: int
Default: 50
Values: 0 — 100

bBrightness Type: int
Default: 50
Values: 0 — 100

rContrast Type: int
Default: 50
Values: 0 — 100

gContrast Type: int
Default: 50
Values: 0 — 100

bContrast Type: int
Default: 50
Values: 0 — 100

Demo iGraph

Operators\Video Acquisition\trigger

C Prototype

```
CorOpRtn acqRgbBrightness(
    int rBrightness,
    int gBrightness,
    int bBrightness,
    int rContrast,
    int gContrast,
    int bContrast
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqSetup

Setup hardware dependent settings

Description

The **acqSetup** operator executes device dependent setup for controlling subsequent acquisitions.

The following applies only to servers that support the CAB ("Coreco Auxilliary Bus"):

acqSetup commits hardware resources that are required for single frame acquisition mode. Normally, it is not necessary to execute this operator explicitly, since it is called implicitly by the **acquire** operator if required.

For acquisition to the CAB it is necessary to execute **acqSetup** once, after all **cabSetup** operators have executed, but before any **cabStart** operators have executed. See the help for any of the CAB operators for more information.

acqSetup may also be used to ensure that the first execution of **acquire** not incur the overhead necessary to set up the hardware. This operator should not be used if **acqStart** is also executed.

C Prototype

```
CorOpRtn acqSetup()
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqSize

Set input window on frame grabber

Description

The **acqSize** operator is used to set a region of interest for transfer from a frame grabber to host. The frame grabber must support a hardware ROI transfer capability. This operator can be used to transfer a limited region and thereby increase transfer performance. The **w**, **h**, **x**, and **y** parameters are used to set the width, height, and origin offset of the region of interest relative to the camera image.

Parameter Information

x Type: int
Default: 0

y Type: int
Default: 0

w Type: int
Default: 256

h Type: int
Default: 256

C Prototype

```
CorOpRtn acqSize(
    int x,
    int y,
    int w,
    int h
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqSnapCount

Set frame grabber's acquisition snap count.

Description

The **acqSnapCount** operator controls the number of frames acquired by a frame grabber for each frame delivered by the frame grabber to WiT. This is only available for certain frame grabbers. The value should not normally be modified at run-time. It may be necessary to change the snap count after loading certain sophisticated custom pixel processor designs.

Parameter Information

snapCount Type: uint
Default: 1

C Prototype

```
CorOpRtn acqSnapCount(
    uint snapCount)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqSource

Switch input source on frame grabber

Description

The **acqSource** operator is used to switch the video input source from one camera to another for the current frame grabber. The **source** parameter specifies the desired input channel. Input channels begin at zero.

Parameter Information

source Type: int
Default: 0

C Prototype

```
CorOpRtn acqSource(
    int source)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqStart

Start ping-pong acquisition on frame grabber

Description

The **acqStart** operator configures the current frame grabber for continuous acquisition, and starts frame transfer to a circular queue of image buffers. This is a generalization of so-called "ping-pong" buffering, in which uses two buffers only. For some hardware the queue size is fixed, while for others the **queueSize** parameter can be used to set the number of image buffers in the queue. If the queue size is user-modifiable, then the number of buffers in the queue is limited only by available memory.

After **acqStart** has executed, the **acquire** operator immediately returns the image from the head of the queue (unless the queue is empty, in which case it waits for a frame as usual). This allows processing to proceed in parallel with the transfer of image data to memory. As long as the average processing time per frame does not exceed the interval between frames delivered by the frame grabber, then no frames are dropped (as long as the queue is large enough). Clearly, if there is great variability in the time taken to process individual frames then the queue needs to be larger. If the frame grabber delivers frames quickly enough to fill the queue, then subsequent frames will be dropped. In this case, the next **acquire** operator will return (in the

"dropped" output) the number of frames dropped since the previous execution of **acquire**.

Normally, **acqStart** is called once, and then a loop is entered in which **acquire** is called repeatedly to deliver single frames for processing. Operators that configure the acquisition (for example, **acqSize**, **pproCustom**) should not be called after **acqStart**.

Continuous transfer is stopped automatically when an igraph stops. Alternatively, the transfers can be stopped explicitly using the **acqStop** operator.

Parameter Information

queueSize Type: int
Default: 2

C Prototype

```
CorOpRtn acqStart(
    int queueSize)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqStop

Stop ping-pong acquisition on frame grabber

Description

The **acqStop** operator halts continuous mode image transfer for a frame grabber. See the help for the **acqStart** operator for more information on continuous mode acquisition.

C Prototype

```
CorOpRtn acqStop()
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqSwitchGrab

Grab up to 4 cameras setup for switching

Description

The **acqSwitchGrab** operator grabs images from several cameras on the currently installed frame grabber. Typically, the Frame Grabber tool in WiT is used to configure the frame grabber for switched acquisition using 2, 3, or 4 cameras that are constantly being multiplexed between frames or fields. All cameras must be genlocked with the same synchronization to ensure switching is reliable. This operator supports up to 4 image outputs when 4 camera switching is enabled. For 2 camera switching, only the top 2 outputs are used. For 3 camera switching, only the top 3 outputs are used.

C Prototype

```
CorOpRtn acqSwitchGrab(
    CorImage *Camera1,
    CorImage *Camera2,
    CorImage *Camera3,
    CorImage *Camera4
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqWriteLut

Write an input LUT on frame grabber

Description

Write an input LUT on frame grabber

Parameter Information

filename Type: CorFile
Default: "sampleLut"

C Prototype

```
CorOpRtn acqWriteLut(
    CorIntVector *Lut,
    CorFile filename
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acqZoom

Set hardware scale on frame grabber

Description

The **acqZoom** operator is used to scale an image in hardware as it is being grabbed using the **acquire** operator. The amount of scaling is determined by the **x** and **y** parameters. A positive integer is used to magnify the image whereas a negative integer is used to reduce the image. For example, setting the parameters to -2 will cause the image to be reduced to half its size whereas a setting of 2 will cause the image to be magnified by double its size.

Parameter Information

x Type: int
Default: 1

y Type: int
Default: 1

C Prototype

```
CorOpRtn acqZoom(
    int x,
    int y
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acquire

Acquire an image from a frame grabber

Description

The **acquire** operator grabs an image from the currently installed frame grabber. Typically, the Frame Grabber tool in WiT is used to configure the frame grabber for acquisition then the **acquire** operator is used to grab images in an igraph. The **frames** parameter determines the number of images to grab. If **frames** is set to one, then a single WiT image is output. If **frames** is greater than one, then a sequence of images is grabbed and output as a vector of WiT images. In this case, the **delay** parameter sets the number of milliseconds between image grabs in the sequence. The bottom output of the operator reports the number of missed frames since the last **acquire**. This output is meaningful only when **acqStart** has been used to start continuous acquisition (it is 0 otherwise). This

allows tracking the number of missed frames in the event the processing load on the CPU(s) prevents the acquire operator from being executed often enough to keep up with the frame rate.

Parameter Information

frames Type: int
Default: 1

delay Type: int
Default: 0

C Prototype

```
CorOpRtn acquire(
    CorObj *Out,
    int *Dropped,
    int frames,
    int delay
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

acquireStamped

Acquire an image from a frame grabber, with current counter value

Description

The **acquireStamped** operator is identical to the **acquire** operator in all respects, except that it also returns the value of the hardware event counter at the moment the frame was acquired.

The **acqCounterReset** operator must be executed at least once before **acquireStamped** executes for the first time, in order to initialize the counter.

Parameter Information

frames Type: int
Default: 1

delay Type: int
Default: 0

C Prototype

```
CorOpRtn acquireStamped(
    CorObj *Count,
    CorObj *Out,
    int *Dropped,
    int frames,
    int delay
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

brightness

Set video offset and gain on frame grabber

Description

The **brightness** operator sets the contrast and brightness of an image acquired with the **acquire** operator. The parameters are given as a percentage between 0 and 100 where 0 is the darkest and 100 is the brightest or greatest amount of contrast.

Parameter Information

brightness Type: int
Default: 50
Values: 0 — 100

gain Type: int
Default: 50
Values: 0 — 100

C Prototype

```
CorOpRtn brightness(
    int brightness,
    int gain
)
```

Headers

#include "$(WITHOME)/h/wVideo.h"

Libraries

$(WITHOME)/lib/wObj.lib
$(WITHOME)/lib/wVideo.lib

Coreco Imaging Contact Information

Sales Information

Web site: www.imaging.com
Email: info@corecoimaging.com

Technical Support

Voice: (604) 435-2587 ext 9
Email: wit@corecoimaging.com

Corporate Headquarters

Coreco Imaging Inc.
7075 Place Robert-Joncas, Suite 142
St. Laurent
Quebec H4M 2Z2
Canada

Tel: (514) 333-1301
Fax: (514) 333-1388

US Sales Office

Coreco Imaging Inc.
900 Middlesex Turnpike
Building 8, Floor #2
Billerica, MA 01821
USA

Tel: (781) 275-2700
Fax: (781) 275-9590