Full Dynamic Range Tools

Photography in a new dimension

User manual, version 2.6

Andreas Schömann
Manfred Schömann

Full Dynamic Range Tools: Photography in a new dimension: : User manual, version 2.6

by Andreas Schömann and Manfred Schömann

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Part I. General considerations

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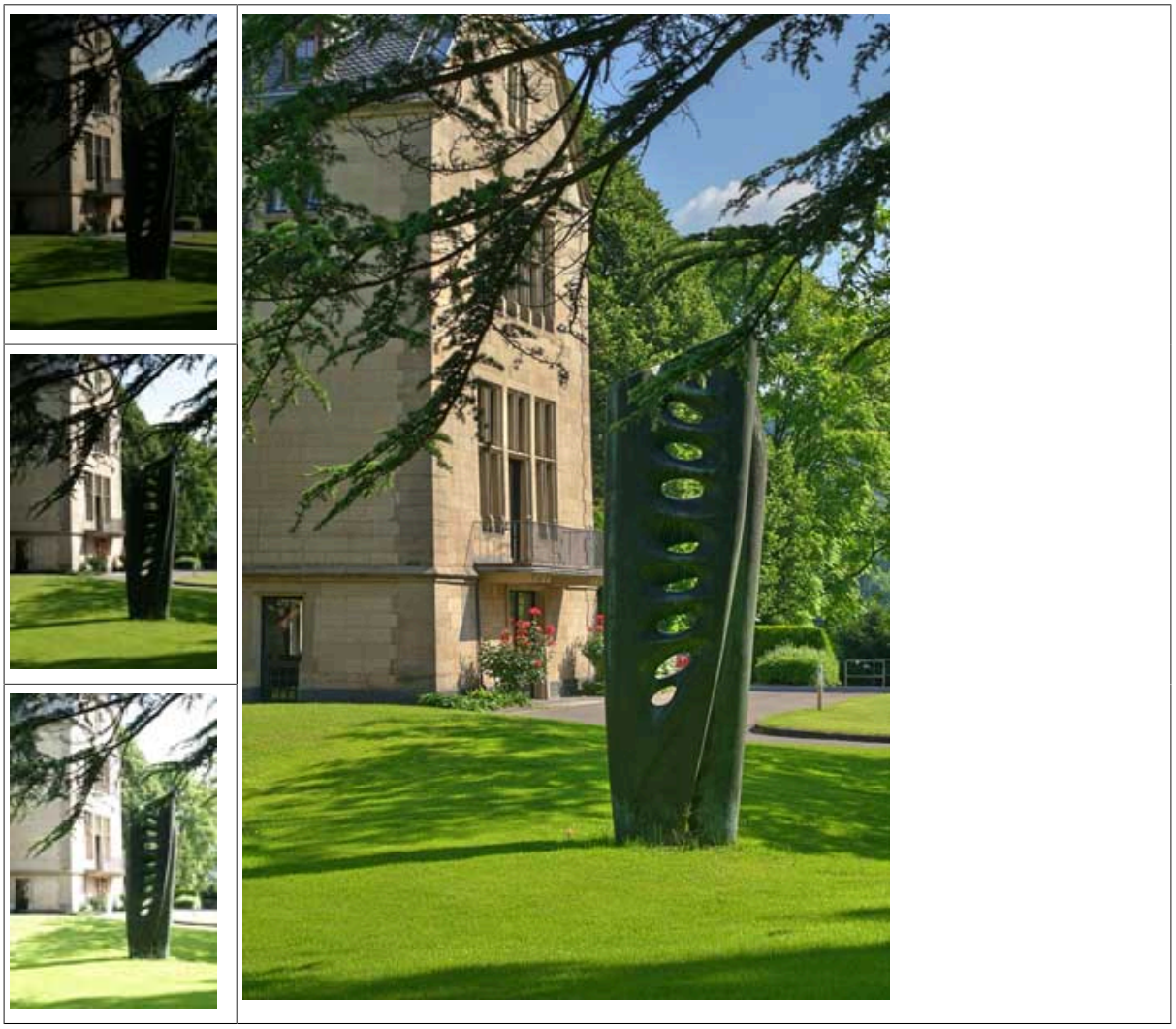
Chapter 1. Preface HDR photography

1. HDR photography - why and what for

Digital photography is fun. Digital photography would be even more fun without those reiterative exposure problems. Annoyingly they occur especially in situations, where light is most beautiful - for instance on days with crystal clear air, cloudless sky and bright sunshine. Digital cameras simply can't cope with the very intensive interplay of light and shadow. Consequences are overexposure in light image areas and/or strong noise in dark areas. "Correct" exposure is often impossible.

Cause for this nuisance is the technical imperfection of todays digital cameras. A thing the human eye manages effortlessly - the clean visualization of even the greatest intensity differences without "overexposure" or "noise" - is utterly impossible for a digital camera.



The following consideration shows a way out of this unsatisfying situation: what is impossible with one image, can be accomplished with several, differently exposed images. This way all areas of a scene are present optimally exposed, though in different images. The "only" thing one needs to do now is to combine these photos to a single image in a way that lets overexposure and noise disappear.

Such an image is named HDRI (High Dynamic Range Image). An HDRI comprises all information contained in the images of an exposure series. Normal output devices like monitor or printer can not reproduce the information content of an HDR image in a natural looking way. An other step - named Tone Mapping - is needed to make

this possible. Tone Mapping converts an HDRI to an LDRI (Low Dynamic Range Image) preserving all relevant details of the scene. The LDRI can then be displayed using monitors and printers.

The figure to the left shows an example for such an exposure series and the tone mapped result obtained with FDRTools.

2. Natural and creative HDR image processing

Result of a dramatising image processing with FDRTools

The tone mapped image resulting from combining three images as shown above looks quite natural. However, achieving dramatising effects with FDRTools is also possible. The premium tone mapping method named *Compressor* with ease converts boring looking scenes into exciting images.

But there is more to merging images than just scene HDRI and TM. FDRTools offers a method named *Creative*. *Creative* allows for mixing images with completely differing content thus broadening the possibilities of HDR imaging and supporting creative photography.

3. Preparing exposure series

One of the essential functions of FDRTools is to merge the images of an exposure series into a so called HDR image. When doing such an exposure series you should observe the following:

1. The camera must not jiggle while taking the exposure series. Therefore the following is recommended:

- Mount your camera to a tripod and look out for save stand of the tripod.
- If you have a cable release you should use it.
- If your camera has a so called mirror lock-up function you should use it.

2. Pay attention that your exposure series covers the whole dynamic range of the scene. In the brightest picture all detail of the darkest areas should be clearly visible. Contrary in the darkest picture all detail of the brightest areas should be clearly visible.

3. The images of an exposure series should have exposure differences between two and four EV or f-stops. Using the Automatic Exposure Bracketing functionality that most digital cameras possess can be beneficial.

4. To alter the exposure value vary the exposure time. Keep the aperture value constant.

5. All images of an exposure series should be taken with identical white balance setting.

6. We recommend to use RAW format whenever your camera supports this.

Chapter 2. Quick start guide

1. Purpose

This is the first in a series of tutorials that explain how to use FDRTools. Quick start guide is for all photographers who have never used FDRTools before. Processing an exposure series and getting a result from it is demonstrated by means of a series of provided images. You can find further and more detailed information in the complete manual.

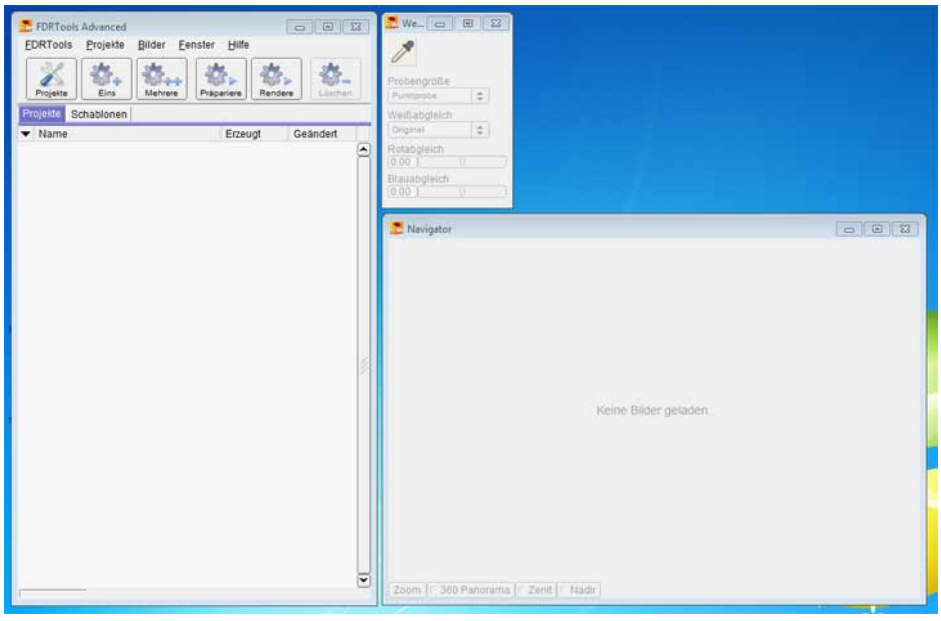
2. Installation

The installation procedure depends on the used operating system:

- **Windows**: Double click the downloaded installer file. An assistant will guide you through the installation process. A link to the executable will be created on your desktop.
- **OS X**: When the download has finished a Finder window opens up showing the FDRTools folder. Drag the folder to your preferred destination. You will find the executable FDRTools within the folder FDRTools.

3. Starting the program

FDRTools is started like any normal Windows or Mac program. When starting it the first time the user interface looks like this:



FDRTools user interface on initial start

Please note that FDRTools' user interface consists of several windows:

- Main window - hosts all functionality modules; loading of source images, processing exposure series and saving results.
- Navigator/Preview window - for displaying and processing of HDR and tone mapped results.
- Tools window - displays tools for individual image processing.

- Exif Info window - displays Exif and other metadata information evtl. available with an image.

Main, Navigator/Preview windows are the most important ones. They should always be visible. You may show or hide individual windows via the *Windows* menu.

4. Processing a single image

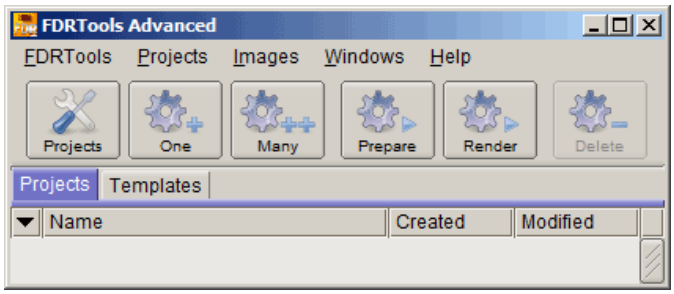
FDRTools were developped primarily for processing series of images but allow for processing a single image also, whereas it doesn't matter whether the image is a "real" HDR image, a RAW iamge, a TIFF file or a JPEG.

It is often intended to obtain a dramatising or even alienating effect when tone mapping a single image. The following section demonstrates how you can achieve this "HDR effect".

We provide a series of images for this tutorial that you can download from http://www.fdrtools.com/examples/tutorial.zip. Extract these images to a directory of your choice.

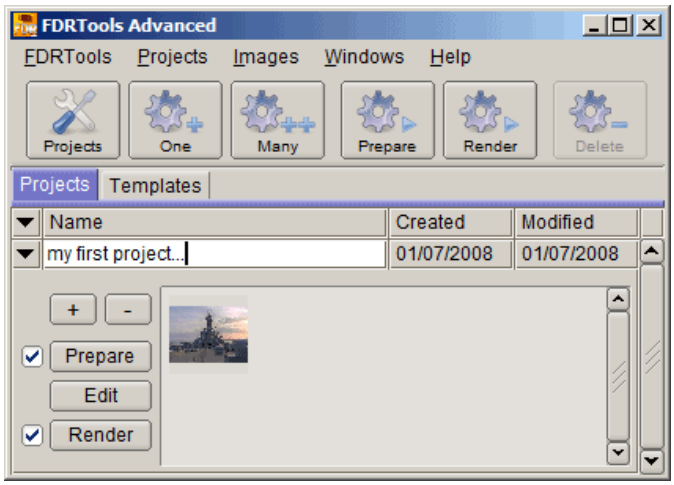
5. Starting a project

FDRTools start in project management view. A project consists of one or several images and the accompanying processing settings. Projects are saved when exiting the program and are reloaded with the next program start.



FDRTools main window - project management view

By pressing the *One* button we are now going to create a single new project. The file choosing dialog shows up. Navigate to the directory with the example images and choose data type *Generic TIFF*. Choose the image battleship.tif and press the *Open* button. A project is created.



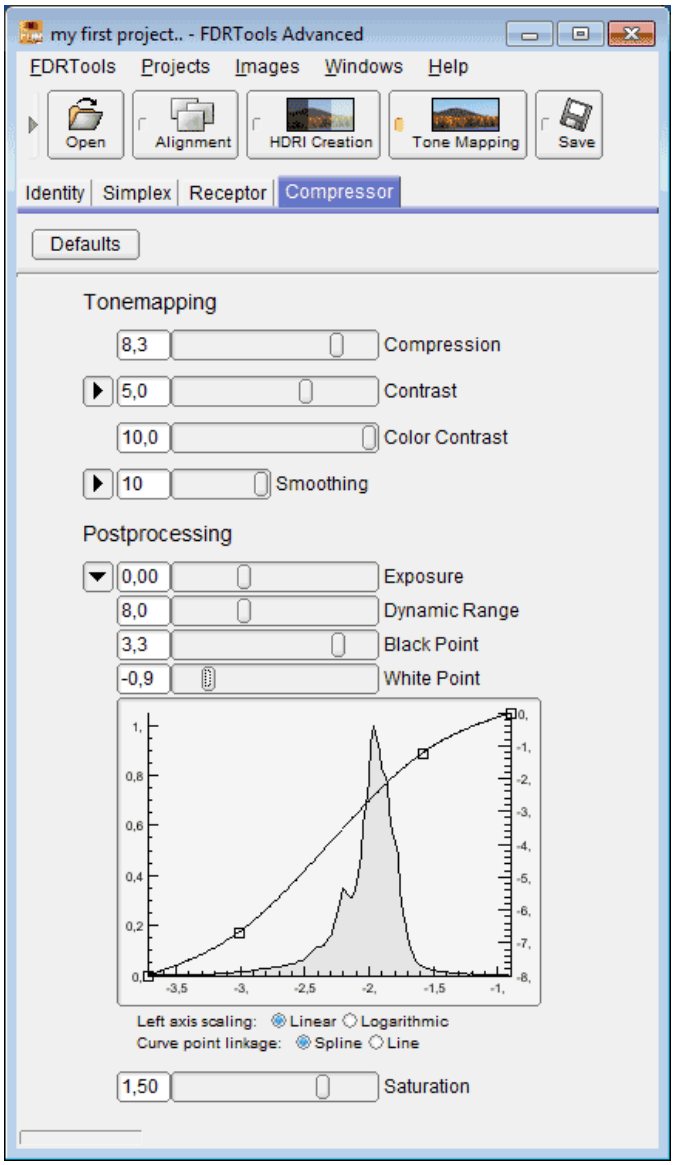
FDRTools main window - project overview with a single project

You should give a speaking name to your project as can be seen in the example project. By pressing the *Edit* button the program switches to the editor view, at the same time hiding the project view.

5.1. Processing and Tone Mapping

The toolbar functions *Alignment* and *HDRI Creation* have a meaning only when processing a series of images; they are not of interest at this point. Switch to the *Tone Mapping* module straight away.

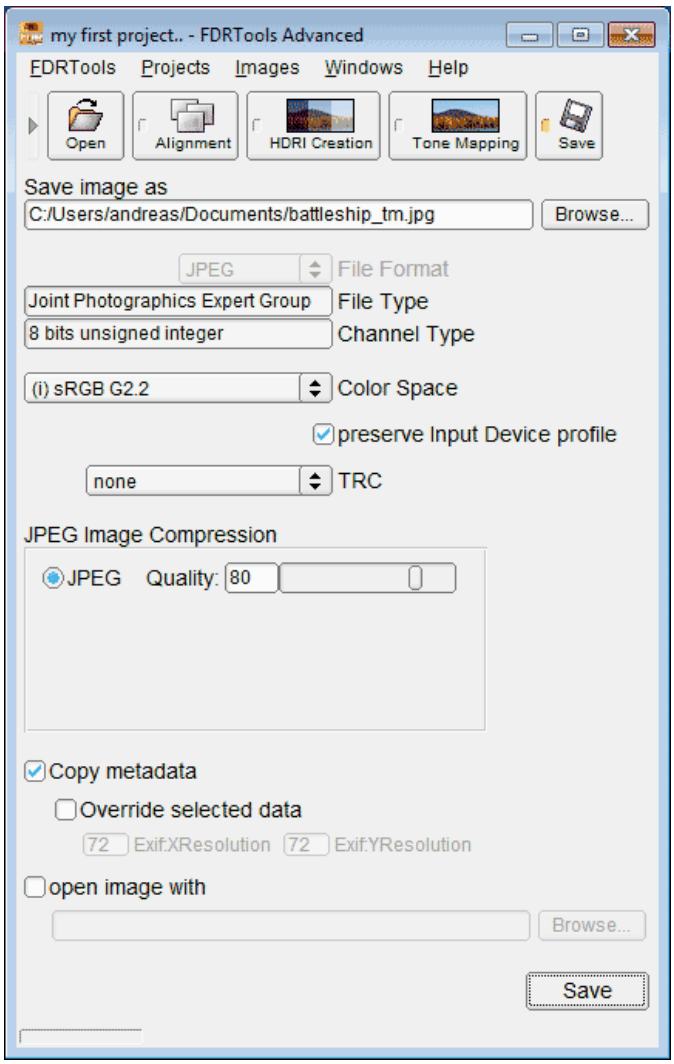
FDRTools offer four tone mapping methods. By far the most important tone mapper is named *Compressor*. It allows for contrast enhancing as well as dramatising effects. The other methods are useful primarily with exposure series.



FDRTools main window - processing a single image

5.2. Saving the result

Images -> Save as... saves the result. First you determine the file format that shall be used to save the resulting image. Here we have chosen 'JPEG'. Name the result and confirm. Now the *Save image* dialog shows up. Start the image generation by pressing the *Save* button.



The Save image dialog

5.3. Result

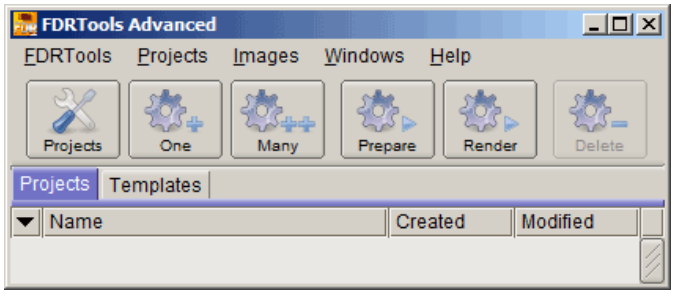
The result

5.4. Processing an image series

For this tutorial we provide a set of images that you can get from http://www.fdrtools.com/examples/tutorial.zip. Extract the images to a directory of your choice.

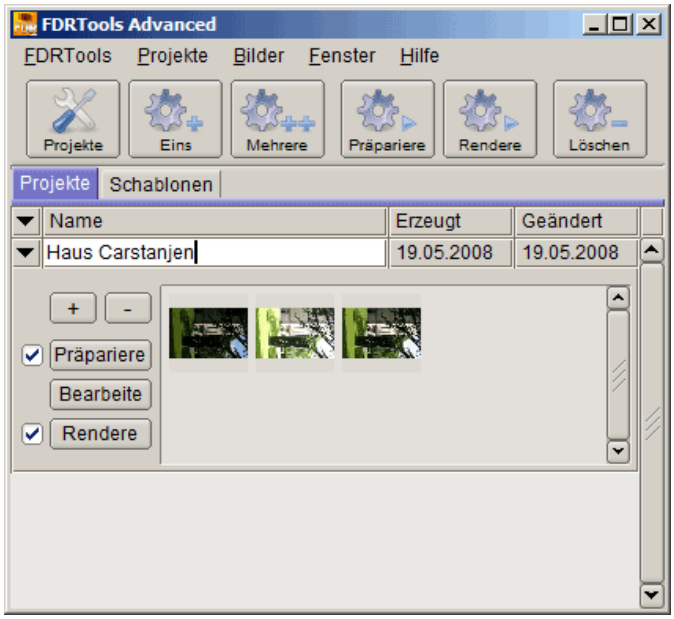
5.5. Starting a project

FDRTools start in project management view. A project consists of one or several images and the accompanying processing settings. Projects are saved when exiting the program and are reloaded with the next program start.



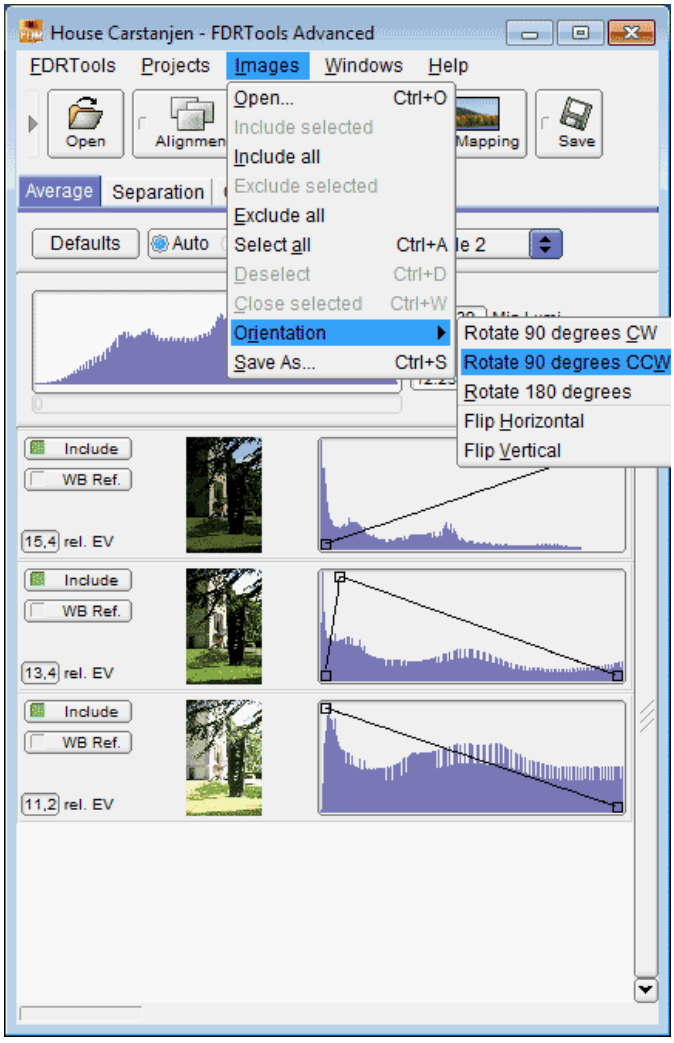
FDRTools main window - project management view

By pressing the *One* button we are now going to create a single new project. The file choosing dialog shows up. Navigate to the directory with the example images and choose data type *Generic JPEG*. Choose images 0.jpg to 2.jpg and press the *Open* button. A project is created.



FDRTools main window - project overview

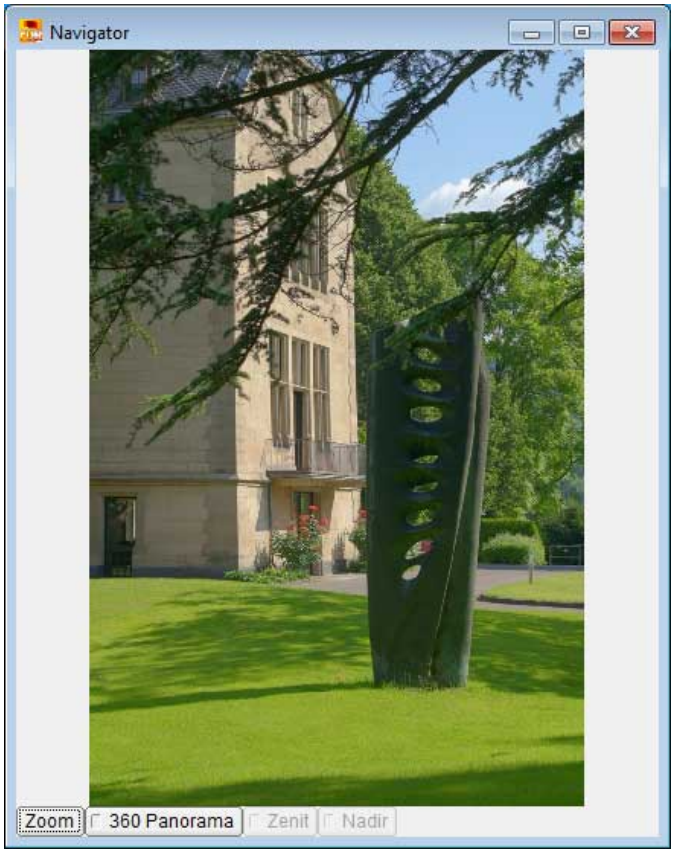
Press the *Edit* button to open the project with the editor. The exposure series is loaded to the editor for processing. Choose *Images -> Orientation -> Rotate 90 degrees CCW* to give the images the right orientation.



FDRTools main window - project editor view

5.6. Intermediate result

The images are processed automatically using default parameters. The intermediate result is then shown in the Navigator window.



FDRTools Navigator window

5.7. Optimisation

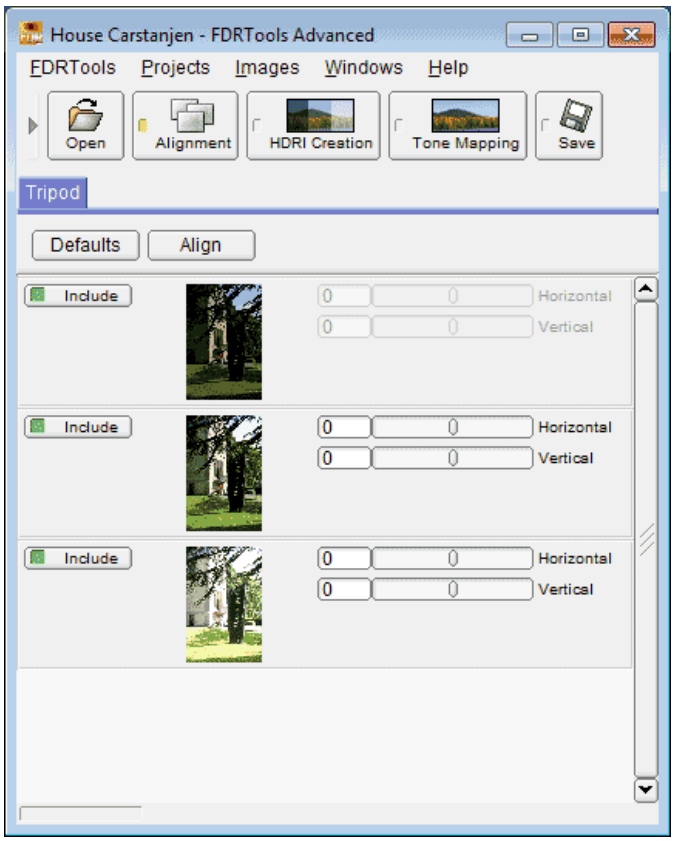
Automatic processing comprises the following steps:

- Alignment
- HDRI Creation
- Tone Mapping

When automatic processing is finished you can refine the settings and adapt the result to your taste.

5.8. Alignment

When taking bracketed exposures there is a chance that the single exposures are somewhat misaligned, even if you use a tripod. This can be caused by wind, shutter vibration or micro movements of the tripod. Module *Alignment* helps in correcting such shifts.



Alignment module Tripod

The example series was captured using a tripod. Automatic alignment can not detect horizontal or vertical shifts hence there is nothing to align here. This is not always the case. Often there will be positive or negative numbers visible in the image alignment layers of the *Tripod* module.

You can adapt the results of automatic alignment if necessary. The results of changed alignment parameters are displayed in the Navigator window.

5.9. HDRI Creation

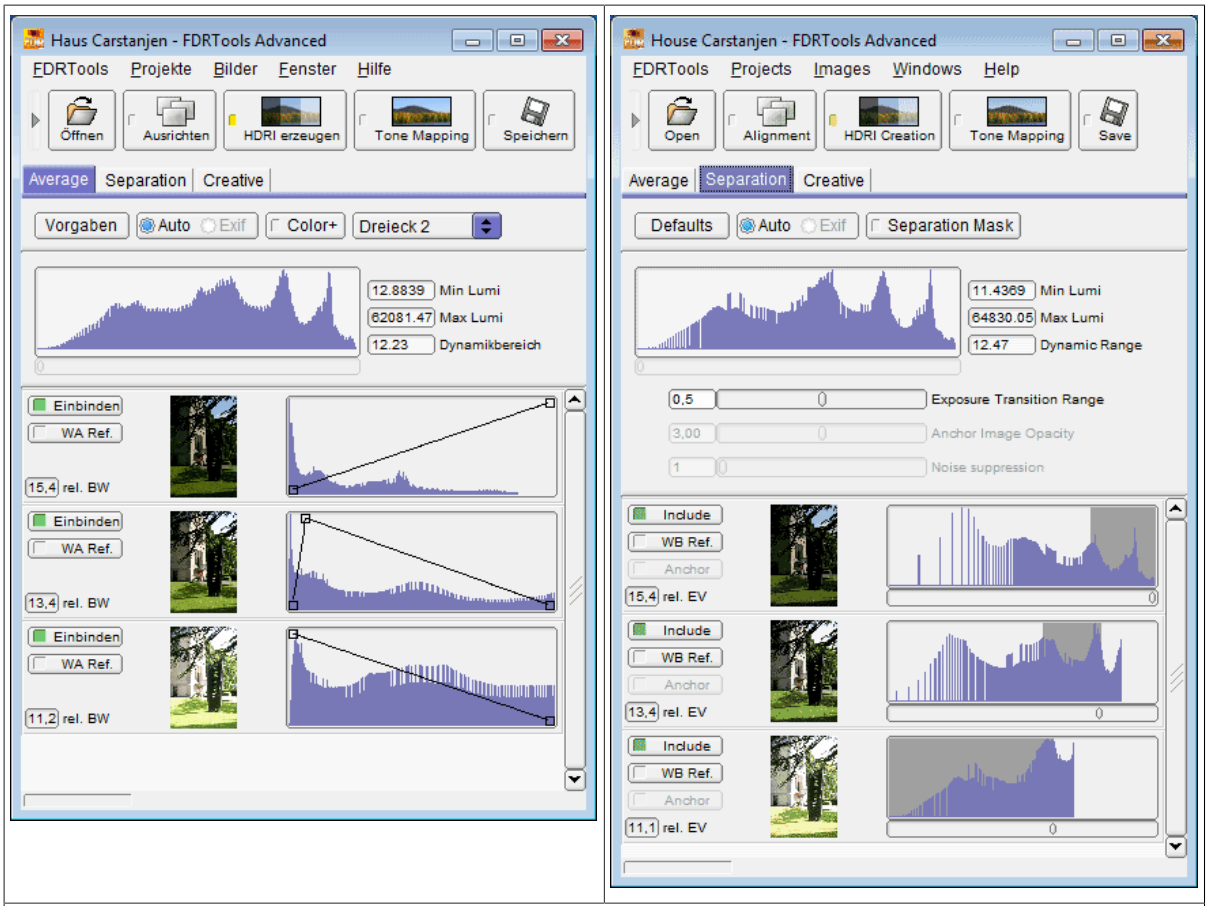
HDRI Creation serves to the merging of differently exposed photos to one homogeneous image, the HDRI (high dynamic range image).

FDRTools offer several methods for HDRI Creation named *Average*, *Separation* and *Creative*, each of which is specialised in some aspects.

The *Average* method is the method of choice as long as the scene has no moving objects like people, cars etc.

The *Separation* method in many cases allows to avoid so called "ghosts" caused by moving objects and can reduce artefacts caused by slightly misaligned images. *Separation* also yields optimal results in the shadow and highlight regions of a scene.

While *Average* and *Separation* are specialised in merging exposure series of a statically illuminated scene, the *Creative* method allows for seamless merging of any kind of imagery, especially images with changing lighting in terms of position, intensity and spectrum of the light sources. The result of the blending procedure can be steered in a very flexible way. See chapter Chapter 7 for more information on *Creative*.

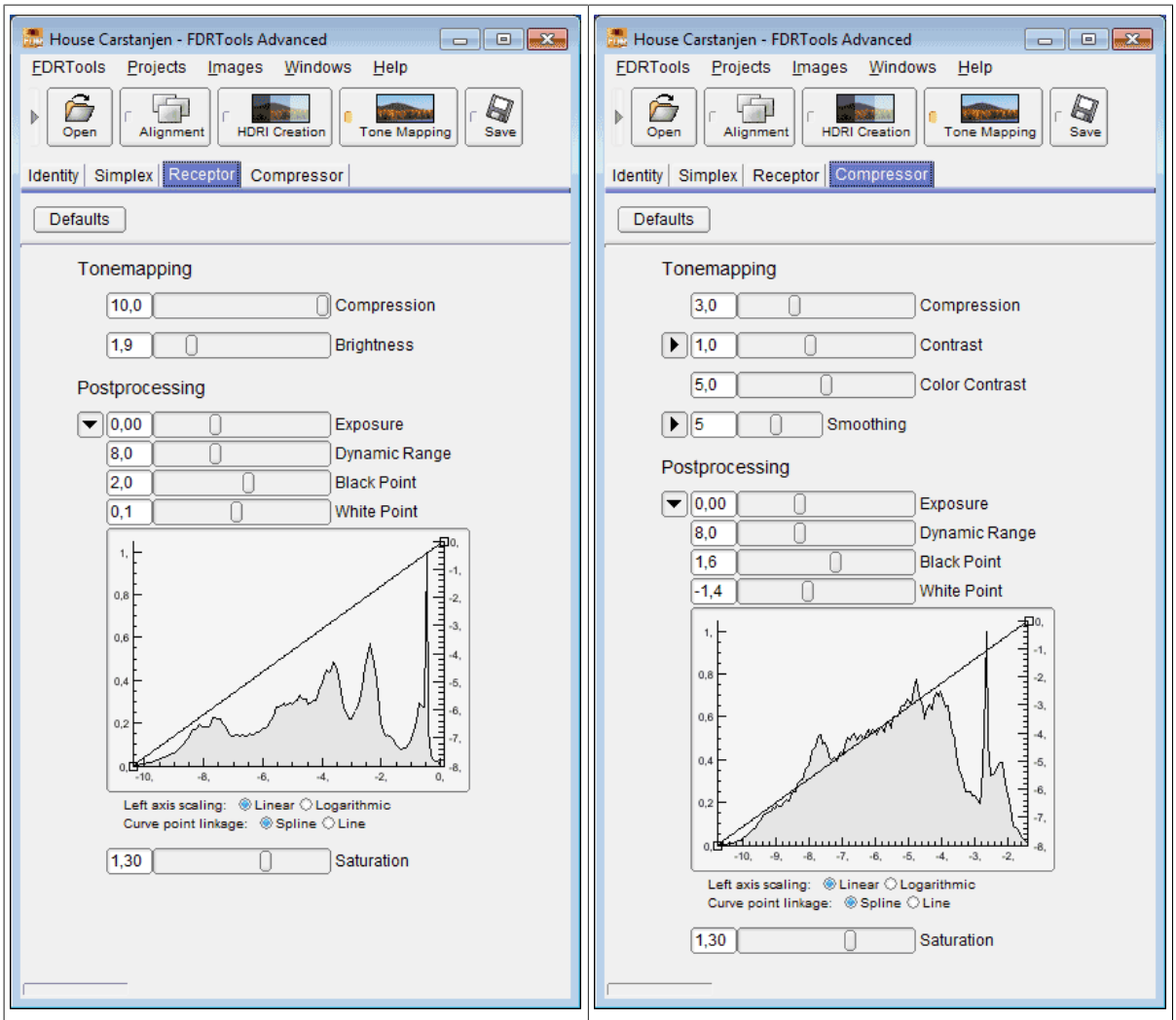


The HDRI Creation dialog

5.10. Tone Mapping

By compressing tonal values Tone Mapping maps a HDR image with high dynamic range to an image with a dynamic range that can be reproduced completely on any monitor or printer. Lots of tone mapping methods have been invented, each of them producing characteristic results.

In the main window choose the *Tone Mapping* dialog and then one of the methods *Receptor* or *Compressor*. For this tutorial the parameters were adjusted as follows:



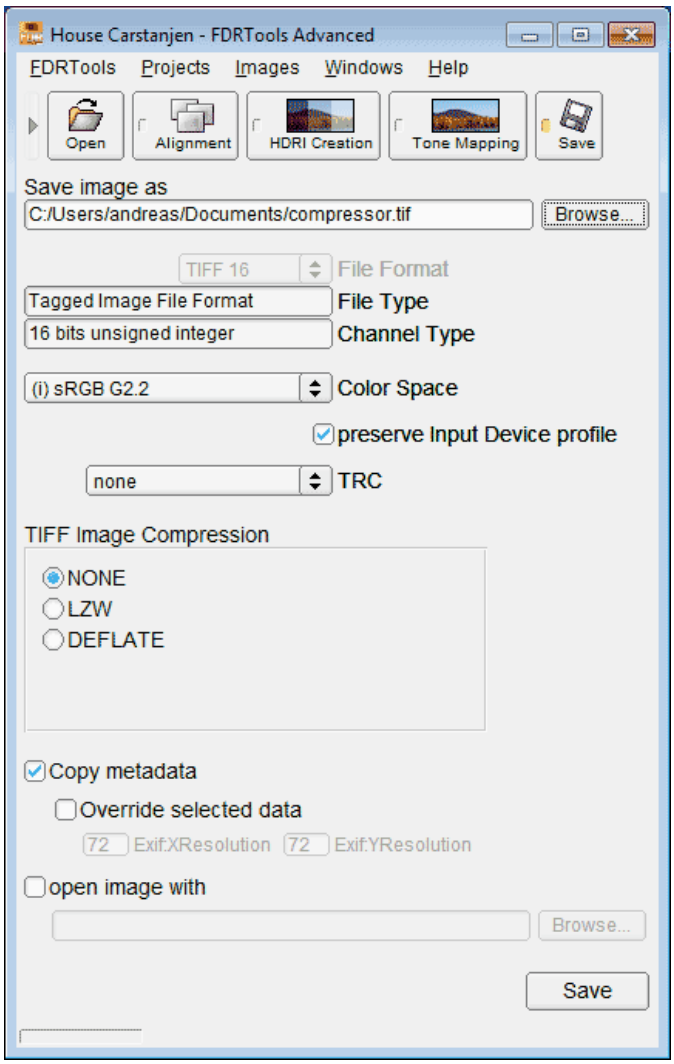
The Tone Mapping dialog

The tone mapped image is displayed in the Navigator window.

By means of tonal value compression we have converted an HDR image into a contrasty image that shows all details of the scene and is suited for display on conventional media like monitor or photographic paper.

6. Saving the result

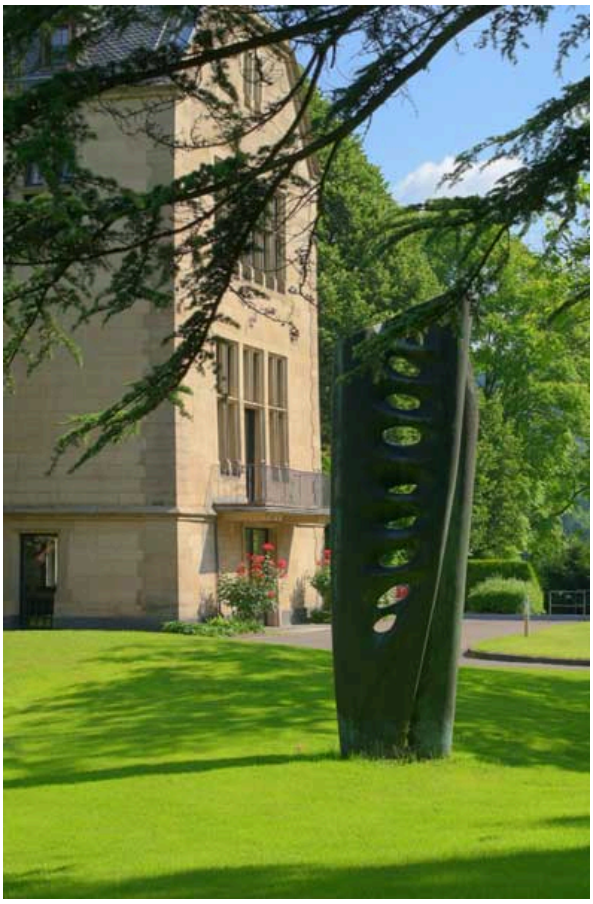
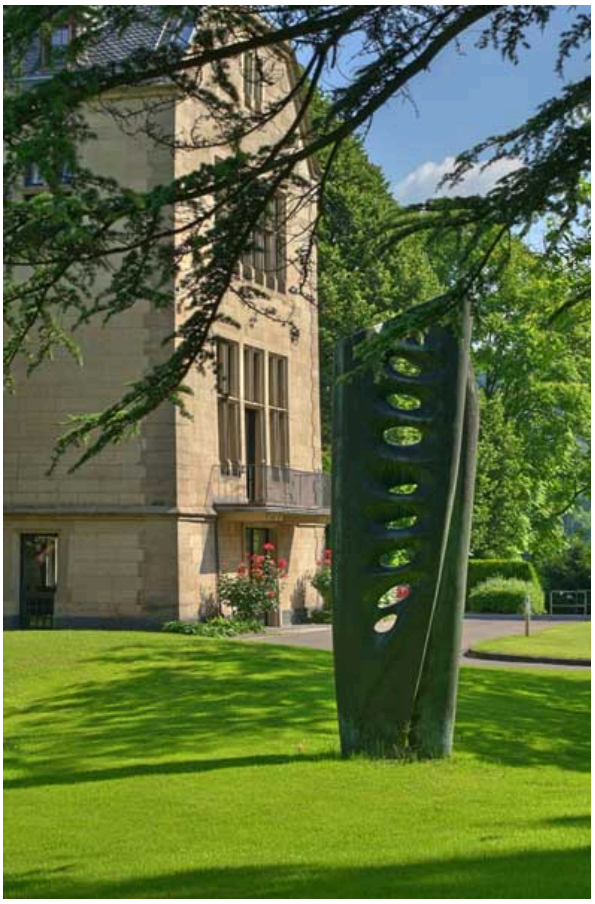
Images -> Save as... saves the result. First you determine the file format that shall be used to save the resulting image. Here we have chosen 'TIFF 16'. Name the result and press the *Save* button. Now the *Save image* dialog shows up. Start the image generation by pressing the *Save* button.



The Save image dialog

7. Result

The following images show the results. Both images were created using the *Average* HDR creation method and then tone mapped with methods *Receptor* resp. *Compressor*

	
Resultat Receptor	Resultat Compressor

Chapter 3. Workflow overview

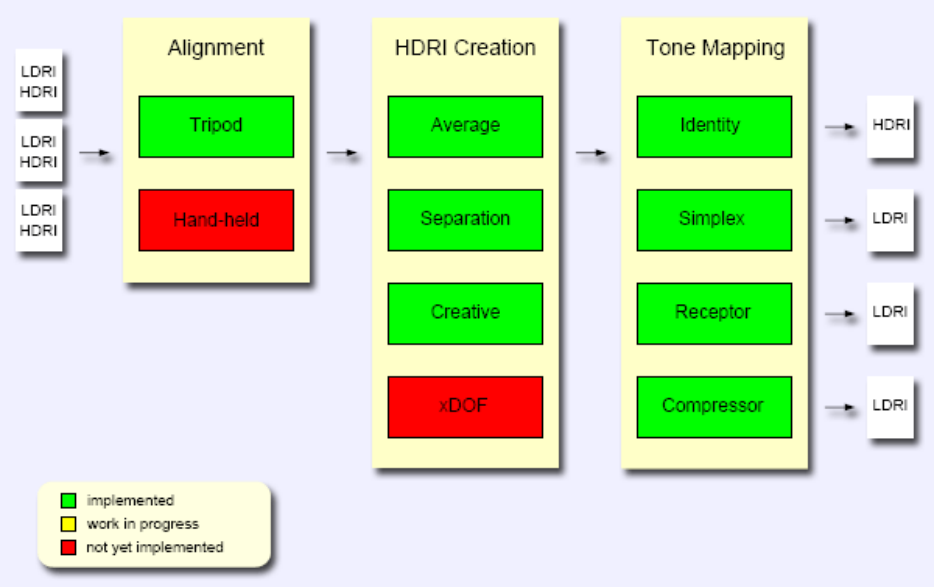
1. Project management

Probably you want to optimise not only one but many scenes using HDR techniques. FDRTools help you to keep track of your HDR activities. By means of a *Project* all images of a bracketed series, the HDRI creation parameters, tone mapping settings and everything else needed to remember your work are integrated and saved for later use. The component that helps you keep track of your work on several projects is called *Project Manager*.

2. Processing a single project

Working on a single project comprises several steps. The component that you use to process your bracketed images is named *Project Editor*.

The following figure provides a view over the principal workflow when editing a project. It shows the essential participating modules within the functional groups. The diagram shows the status quo of planning and realisation. Modules colored in green are implemented, yellow modules are currently under construction and red modules are not yet implemented.



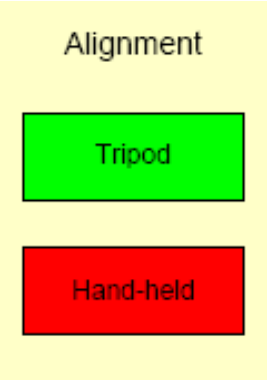
Abläufe und Module in den FDRTools

2.1. Importing images

Editing a bracketed series of images starts with loading images. This always starts a project, either explicitly via the project manager or implicitly when using the *Images -> Open* menu to enter the image editor immediately. By using the latter option and discarding any unsaved results you may bypass project management if you don't need it.

2.2. Alignment

Merging several, differently exposed images implicates a couple of problems. One of these problems which arises already when taking the images is the movement of the camera itself. If the camera jiggles then the exposures won't fit exactly together. Instead they are slightly displaced yielding an unpleasant blurry look of the combined image. Camera movement is nearly unavoidable. Only mounting the camera to a tripod and using an accurate shooting technique can avoid jiggling in most cases.



Module zur Ausrichtung von Bildern

2.2.1. Tripod

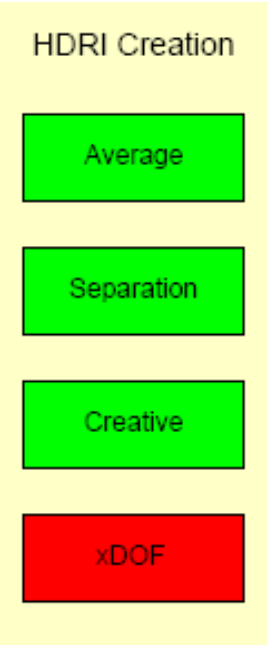
This is a method for registering of photos that were taken using a tripod. It allows to compensate for slight vibrations of the camera.

2.2.2. Hand-held

Combining photos taken freehand requires more elaborated correction measures. In principal all possible degrees of freedom of a camera must be taken into consideration, i.e. all movements of the camera during the image taking session must be reconstructed from the photos. Methodically this happens via the recognition and localisation of identical features among the photos. This information then allows to translate, rotate and zoom the images accordingly.

2.3. Creating HDR images

Normally each image of an exposure series has a different exposure. Hence the images have different brightness. These differences must be calculated and each pixel of the resulting HDR image must be optimally exposed. Overexposure and noise must be avoided. Moving objects like persons, cars and plants moved by the wind pose a serious problem when combining several temporally successive photos.



Module zur HDRI-Erzegung

2.3.1. Average

This is an optimal method for creating an HDR image from several, differently exposed images of a static scene. There should not be any moving objects in the scene.

2.3.2. Separation

This method allows to separate a scene into several intensity areas. The resulting HDR pixels of such an area are taken exactly from one source image. Thus it is possible to treat moving objects proper and avoid blur or ghost objects in many cases.

2.3.3. Creative

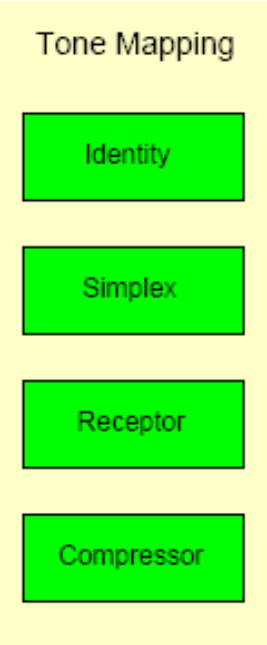
Creative allows to blend images with differing content. You can combine images with different exposure, aperture or focus settings or combinations of these, images taken under different lighting conditions like dusk and dawn photos, flashed images or even images with totally different content. Creative works similiar to layer composition in Photoshop or GIMP but without the limited intensity range (8 or 16 bits per channel). Hence Creative is categorised as HDR creation method.

2.3.4. xDOF

xDOF combines differently focused photos into an HDR image with greater depth of focus. In contrast to the *Creative* module - that allows to select contrasty regions from the source images and thus yields the effect of greater depth of focus - *xDOF* implements a specialised algorithm for this task.

2.4. Tone Mapping

A (well done) HDR image should only have well exposed pixels, i.e. there should not be any overexposed or noisy pixels. However, an HDR image can't be displayed properly on common media like monitors or photographic prints. It is therefore necessary to compress the dynamic range of such an HDR image. FDRTools provides you with three differing methods to accomplish this tone mapping process.



Module zur Tonemapping

2.4.1. Identity

This method does an identity mapping. The result of this method hence is the HDR image itself. This method is used to inspect and save the HDR image.

2.4.2. Simplex

This is a simple tone mapper that is used to get a fast overview of the image. A disadvantage is that it yields poor image contrast.

2.4.3. Receptor

This method uses one of the several available global algorithms for the purpose of tonal range compression. Global means that the same formula is applied to all the pixels of an image.

2.4.4. Compressor

This method acts locally. That means: the algorithm investigates the surrounding of a pixel and from this information calculates an optimal compression value. This method is computational expensive but delivers quite contrasty and natural acting results.

2.5. Exporting images

Merging an exposure series in general results in two images: an HDRI (high dynamic range image) and an LDRI (low dynamic range image). By switching the appropriate tone mapper you can select either of them. A subsequent save operation then saves the selected image.

Chapter 4. Project management

1. Use cases

FDRTools start in a project management mode. The motivation for using projects is as follows: projects comprise all images of the exposure series and accompanying parameter settings of the project editor into a unit. Projects are saved at program exit and reloaded with the next program start. Projects are useful for:

- Processing of a "days work", i.e. the whole bunch of exposure series one shoots on a photo tour.
- Processing of HDR panoramas. Here each angle of view results in an exposure series.
- in general: for saving and reloading parameter settings of an exposure series.

2. Workflow

The (recommended) workflow consists of four steps:

1. Creation of projects.
2. (Optional) Automated preparation of all the projects for interactive processing.
3. Interactive processing of the single projects.
4. Automated rendering of all the projects to create the HDR and (tone mapped) LDR images.

Motivation: the complete processing of an exposure series consisting of several RAW images is rather time-consuming: loading the images, interactive evaluation of the HDR and tone mapping settings and especially the rendering of the results take some time. In order to minimise waiting times for the user it makes sense to separate automatable working steps from interactive working steps. This separation is supported by FDRTools' project manager when adopting the recommended workflow.

3. Elements of a project

A project comprises the images of an exposure series and the accompanying parameter settings from the project editor into one unit. You can create single projects or several projects in one go, see Section 4. Projects can be named and show thumbnail images.

Projects have a name. When a project is created its name is derived from the project images. This automatically created name may be changed at any time. A project shows thumbnails of the project images and has several buttons.

Elements of a project

The buttons have the following functions:

- RAW images are "developed" and saved in a compressed format.
- Thumbnails are (if available) extracted and saved.
- Metadata are extracted and saved. You can get an excerpt of the metadata if you move the mouse over the thumbnail.

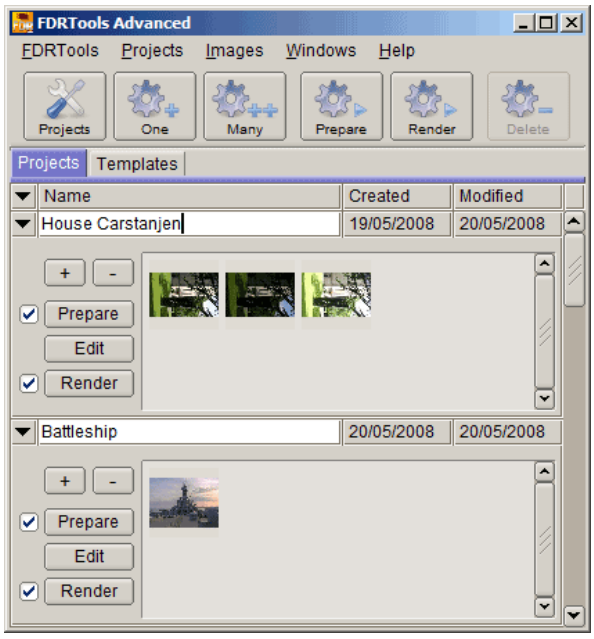
In a further step images are aligned with the *Tripod* method.

- "+" - Adding of images. Opens the file choosing dialog.
- "-" - Removing of images. Removes selected images from the project. Clicking a thumbnail selects the image. (Note: removing an image from the project does not delete the original image from the harddisk.)
- "Prepare" - Preparing of a project. Motivation: loading several RAW files can be tedious. The point in preparing is to speed up loading and processing of images. Preparing extracts data from the original images and saves them to the Section 5.1. In detail the following data is saved:
- "Edit" - Editing of a project. This opens the project in the editor. (Note: the project editor lies "above" the project manager: when opening a project for editing the program switches into editor view at the same time hiding the project manager. The program returns to project view if the project is closed either via menu *Projects -> Close active* or alternatively by clicking the Close button of the window.
- "Render" - Rendering of a project. This renders the HDR and (tone mapped) LDR images in full image size. For that purpose the source images are loaded to the editor, the processing parameters - saved in the project - are set and finally the rendered images are saved.

Remark: Thumbnails may be moved among projects via drag & drop. This is necessary to correct wrong allocations that may evtl. result from creating projects via the "Many" button.

4. Overview project management

FDRTools start in a project managment view. Here projects can be created, edited, rendered and deleted again. The buttons of the toolbar allow the following actions:



Overview project management

- "Projects" - Allows to configure project management preferences.
- "One" - Creates a single project. The file choosing dialog opens up. Upon finishing file selection a project is created.
- "Many" - Creates projects by grouping related images from a selection of images. Images may be grouped by number or by their difference in creation time.
- "Prepare" - Preparing of marked projects. This is a batch process preparing all marked projects in one go. (Note: currently the process can be started but not paused. Depending on the number of projects running time can be quite long. The "Include in next run" flag of finished projects is cleared.)

- "Render" - Rendering of marked projects. This is a batch process rendering all marked projects in one go. Rendering means: HDR image and (tone mapped) LDR image are calculated in full size and saved in the Section 5.1. (Note: currently the process can be started but not paused. Depending on the number of projects running time can be quite long. The "Include in next run" flag of finished projects is cleared.)

- "Delete" - Deletion of selected projects. Projects remain in the project view until you decide to delete them. In order to delete projects select them with a mouse click and then press the "Delete" button. (Note: deleting a project does not delete the source images from the harddisk.)

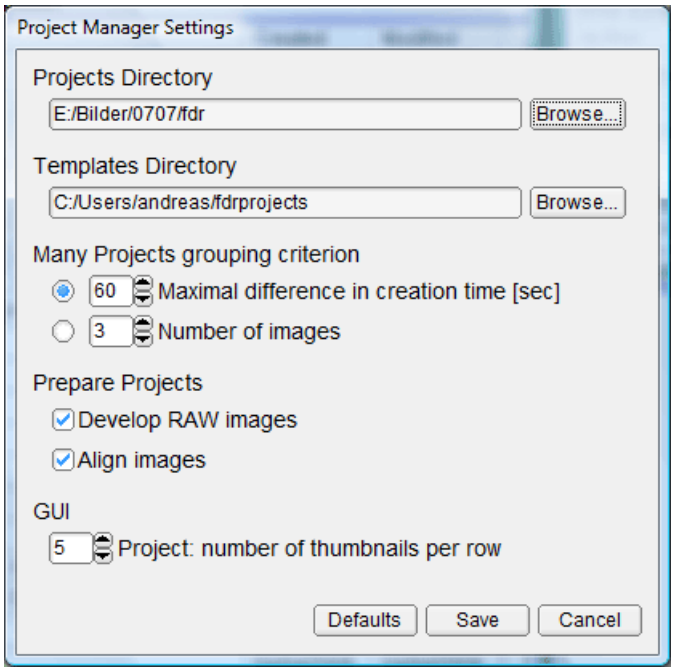
5. Dialog "Project Manager Settings"

The Project Manager manages Projects and Templates. Templates in principle are Projects too. They differ from "ordinary" Projects in that

- they can be stored in a separate directory, and

- there is a function allowing to copy parameter settings from the Template to ordinary Projects.

The data belonging to Projects and Templates is stored in directories. You can determine where in the file system the Projects and Templates shall be stored. You can store Projects and Templates in as many places you like and set the directories in this dialog:



Dialog "Project Manager Settings"

5.1. Project Directory

The Project data is stored in this directory. In detail the following files are stored:

- File .fdrprojects: contains all projects and their parameter settings.

- File .fdrimages: contains a list of all images related to the projects.

- The image data that is extracted during project preparation, in form of coded files, e.g. 2B5E6CC3C459DA7FD4EC0ACBE7CC5443.

- The HDR and (tone mapped) LDR images that emerge from rendering projects. Naming follows the scheme: *Project name.type.ext*. HDR images are of type *hdr*, LDR images are accordingly named *ldr*. *ext* denominates the extension of the used image format, e.g. tif.

5.2. Templates Directory

The Template data is stored here. Templates are contained in the file .fdrtemplate. Alle files have the same structure as their Project data counterparts.

5.3. Many Projects grouping criterion

Projects may be created manually or from a larger set of images in an automated way. For automated generation the images must be grouped somehow so that images belonging together form a project. Images are grouped according to one out of two possible criteria:

- the maximum difference in shooting times.
- the number of images.

5.4. Prepare Projects

When there are many projects to process one can save some time if automatable calculations are performed **before** the actual editing is done. This comprises e.g. the development of RAW images and the alignment of images - although automatic alignment of course delivers an approximate solution only. Currently these two steps are supported. Other precalculations are thinkable but not yet realised.

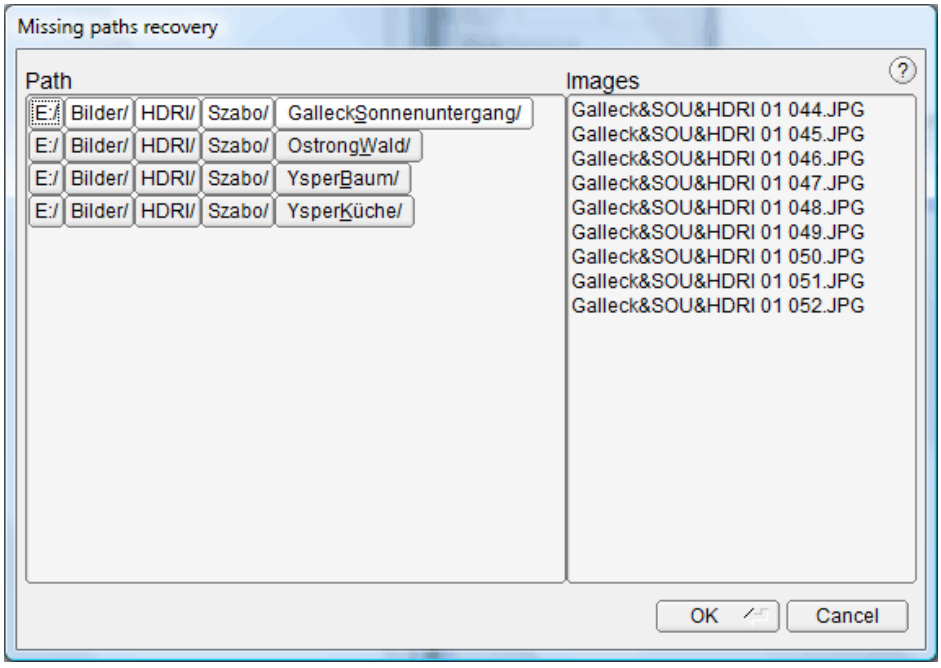
5.5. GUI

For the thumbnail browser within a project you can set the number of thumbnails per row.

6. Dialog "Missing paths recovery"

If you see this dialog it means that FDRTools while loading projects could not find all related image files.

How is this possible? When creating a project FDRTools remembers where the accompanying images can be found in the file system. The image paths are saved in the project files. Without this information it would not be possible to edit a project because the images must be loaded in order to edit a project. Now if you move these image files within the file system - be it because you want to rearrange your images or because you want to archive images on external storage media - this invalidates the image paths stored in the project files and FDRTools can not retrieve the image files any more. The projects are unusable in this state. In order to make the projects usable again the incorrect image paths must be recovered. The dialog supports you in performing the recovery.



Dialog "Missing paths recovery"

The left side of the dialog shows all the missing directories and the right side lists all the image files that are expected to reside in the missing directory (move the mouse over the directories to show the accompanying image file names). The directories are decomposed into their elements, the "path nodes". The path nodes are selectable.

To recover a path you replace the non existing part of the directory path with the correct, existing path, assisted by the dialog.

How does the recovery work? Let's assume you have moved the folder "E:/Bilder/HDRI/Szabo/" with all its subfolders to "D:/Bilder/" some time after you created projects with images from these directories. Now FDRTools is unable to find the (original) directories and you will see the dialog as shown in the figure. To recover the missing paths choose one of them and click the path node that you have moved, in our example this is "Szabo/". The dialog for choosing a folder opens up. Navigate to the existing path - in our example this is "D:/Bilder/Szabo" - and confirm your selection. Now FDRTools replaces the path "E:/Bilder/HDRI/Szabo/" with "D:/Bilder/Szabo" and checks if the expected image files are there. If so the now corrected path is removed from the list.

Moreover all paths which have "E:/Bilder/HDRI/Szabo/" as part of their path and can be recovered by replacing it with "D:/Bilder/Szabo" are also removed from the list. So in the example in fact all the missing paths are recovered by replacing "E:/Bilder/HDRI/Szabo/" with "D:/Bilder/Szabo".

You can close the dialog at any time via the "OK" button. If you have not recovered all missing paths the affected projects will be visible in the project browser, yet they will be deactivated and thus be unusable. You may then delete the unusable projects or recover them the next time you start FDRTools.

Part II. Processing a single project

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Chapter 5. Loading images

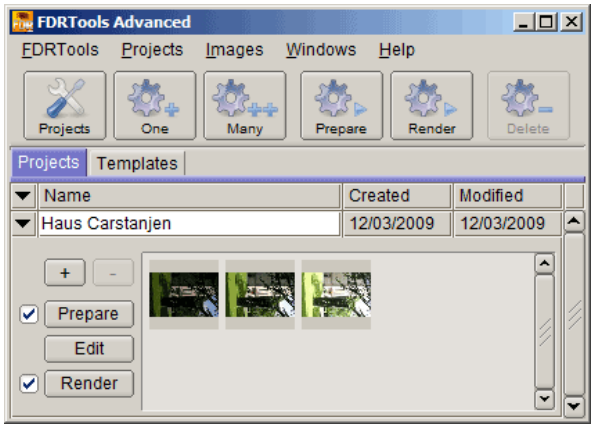
1. General

There are several ways to load images to the program. Some of them are general methods, some of them are connected to project view, some of them are connected to editor view.

1. Drag&Drop images to the program icon. This starts FDRTools and loads the images.

2. Use the menu entry *Images -> Open*. This creates a new project, switches to project editor view and loads the images.

2. Loading in project view



Loading of images in project view

1. Create a project via the "One" and "Many" buttons of the toolbar. This opens the file chooser dialog where you can select the images. Later on you can add additional images using the "+" button.

2. Drap&Drop images to the thumbnail browser of a project. This adds the image to the project.

3. Drap&Drop images to the project browser area. This creates a new project.

3. Loading in editor view

Loading of images in editor view

1. Use the "Open" toolbar button to add images to the active project.

2. Drag&Drop image to the image layer browser of one of the Alignment modules like *Tripod*.

3. Drag&Drop image to the image layer browser of one of the HDRI creation modules like *Average* etc.

Chapter 6. Aligning images

1. Problem

Merging several images into an HDR image works satisfyingly only if the source images are exactly aligned. Chapter "Preface HDR photography" explains how to prepare an exposure series using a tripod. But even if you follow the advice closely you may find that sometimes your images are not perfectly aligned.

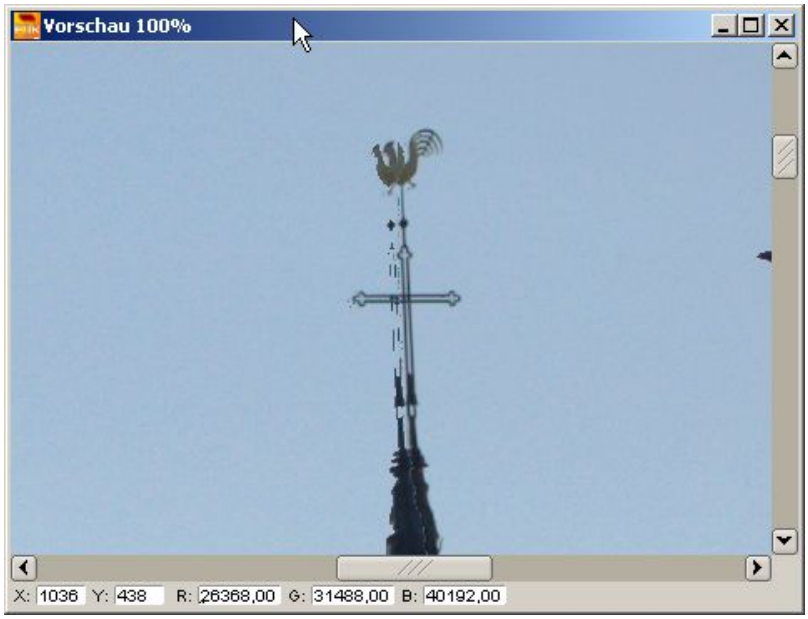
2. Module Tripod

While avoiding misalignemts by careful shooting is the best strategy for getting perfect results minor misalignemts from horizontal and vertical shifts can be corrected satisfyingly using automated alignment algorithm *Tripod*. Use this method for photos taken with the camera mounted to a tripod. This method is not suited for alignment of hand-held images.

Tripod method dialog

Start image alignment by pressing the "Align" button.

Generally *Tripod* works quite reliable yielding very good results. However, scenes with moving objects covering large areas of the scene can be problematic, often requiring manual intervention. The figure to the left shows an exposure series that shows severe horizontal and vertical shifts. The scene has moving objects (flag, car, person).



Preview window

Inspecting the resulting image using the Preview reveals that the images are not yet perfectly aligned. Here the area around the steeple shows some horizontal and vertical shift.

Manual correction is best done in an image by image manner. First right click into the layer browser. This opens a pop-up menu, choose "Exclude all" from the menu. All layers are excluded from processing yielding a black result. Now "Include" image by image, starting with the first and second image, and then alternately adjusting the shift sliders and including the next image until all images are properly aligned.

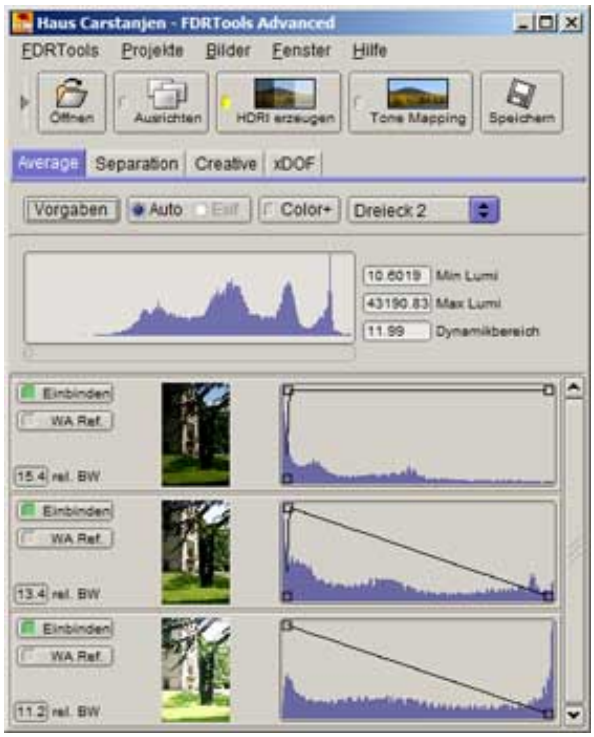
Chapter 7. Creating HDR images

1. Preliminary note

This chapter tells how you can create an image with high dynamic range - a so called HDRI - from a series of differently exposed photos. FDRTools implement several methods for HDRI creation. Each method covers an other aspect of this subject. You can switch among the methods by choosing one of the tabs *Average*, *Separation* or *Creative* in the HDRI Creation module.

2. HDR method Average

Average calculates the HDR image as a weighted sum of the source images. This is simple and works automatically but has the disadvantage of creating so called 'ghosts' with moving objects. Ghosts are e.g. persons moving through the scene and showing up in several photos. When mixing the photos these persons then also show up several times in the resulting HDR image. Not all moving objects yield visible ghost artefacts. Scenes with moving clouds or water are normally noncritical as the ghost artefacts do not catch the viewer's eye.



The Average dialog

Controls and buttons impacting all images are located in the upper part of the dialog:

Button 'Defaults'. Resets all parameters to their default values.

Switch 'Exposure info'. *Average* needs to know about the exposure of the source images. With setting "Auto" the relative exposure values of the source images are calculated from the pixel data of the source images. With setting "Exif" the exposure value is extracted from the image EXIF data, provided embedded EXIF data is available.

Switch 'Color+'. Activating this switch can vitalise colors with nonlinear images like JPEGs. *Color+* has no effect with linear images like RAWs.

Menu 'Weighting curves'. The menu allows to assign preset weighting curves to the image layers. These curves are meaningful with nonlinear images like JPEGs. The form of the weighting curve impacts colors and contrast of the resulting HDR image. According to present experience 'Triangle 2' yields best results and hence is

the default curve. With linear images (e.g. RAWs) colors and contrast do not depend on the form of the weighting curves.Below these controls there is a histogram display. The histogram displays the intensity spectrum of the resulting HDR image. To the right are the measured values for minimal and maximal luminance. Below is the image dynamic range in EV units, calculated from minimal and maximal luminance. Note: the stated dynamic range value is an estimation, calculated from the pixels of the Navigator image.Below the histogram display the source images are listed as layers. The following parameters steer the influence of a layer on the result:

Switch 'Include'. When activated (green) the layer is included in the calculation of the result, otherwise the layer is ignored.

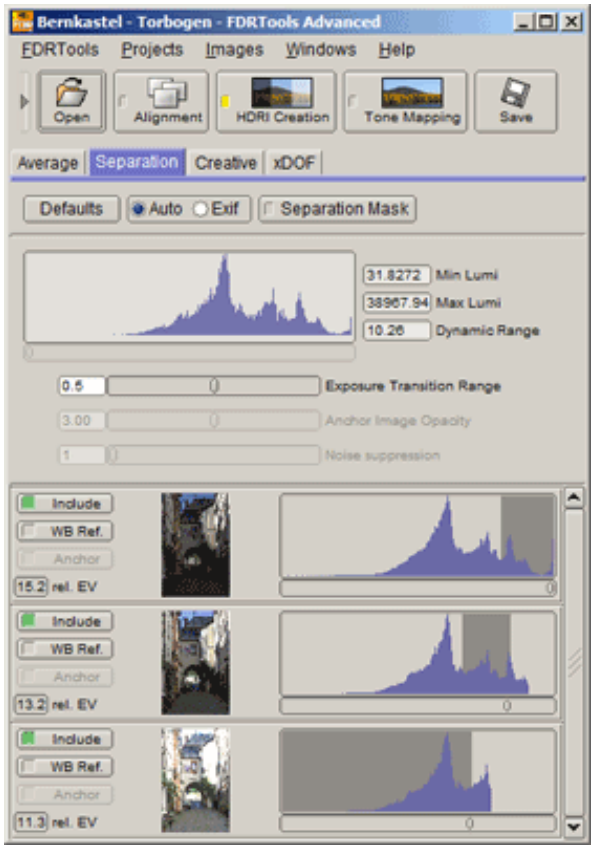
Switch 'WA Ref.'. Specifies a white balance reference image. When specifying an image as white balance reference the program tries to adapt the white balance of the other images to the white balance of the reference image.

Weighting curve 'Intensity'. Weighting of the intensity is adjustable per layer. The form of the curve can be adapted by adding/removing and moving knots.Hint: modification of a weighting curve can be synchronised among layers. To do this select the layers to synchronise and then modify the curve of one of the selected layers.

rel. EV. The relative exposure value of an image is displayed here as an information.

3. HDR method Separation

Separation - unlike the *Average* method - does not mix the pixels of the source images. Instead the image is assembled from several intensity ranges. Each source image contributes one intensity range. All resulting pixels within this intensity range emanate from the respective source image - an exception to this rule is the exposure transition range, see below. Separating the intensity areas allows to suppress 'ghosts' in scenes with moving onjects in a simple yet often successful manner. Further it allows optimal suppression of noise. Both aspects are described in more detail below.



The Separation dialog

Controls and buttons impacting all images are located in the upper part of the dialog:

Button 'Defaults'. Resets all parameters to their default values.

Switch 'Exposure info'. *Average* needs to know about the exposure of the source images. With setting "Auto" the relative exposure values of the source images are calculated from the pixel data of the source images. With setting "Exif" (available only with RAW images) the exposure value is extracted from the Exif data.

Switch 'Separation mask'. Highlights the intensity areas of the selected layers that contribute to the HDR image, see example below.Below these controls there is a histogram display. The histogram displays the intensity spectrum of the resulting HDR image. To the right are the measured values for minimal and maximal luminance. Below is the image dynamic range in EV units, calculated from minimal and maximal luminance. Note: the stated dynamic range value is an estimation, calculated from the pixels of the Navigator image.

Slider 'Exposure Transition Range'. If visible seams should show up along the separation boundaries then this switch allows to specify an intensity area where pixels are blended.

Slider 'Anchor Image Opacity'. not yet implemented correct.

Regler 'Noise suppression'. not yet implemented correct.

Below these sliders the source images are listed as layers. The following parameters steer the influence of a layer on the result:

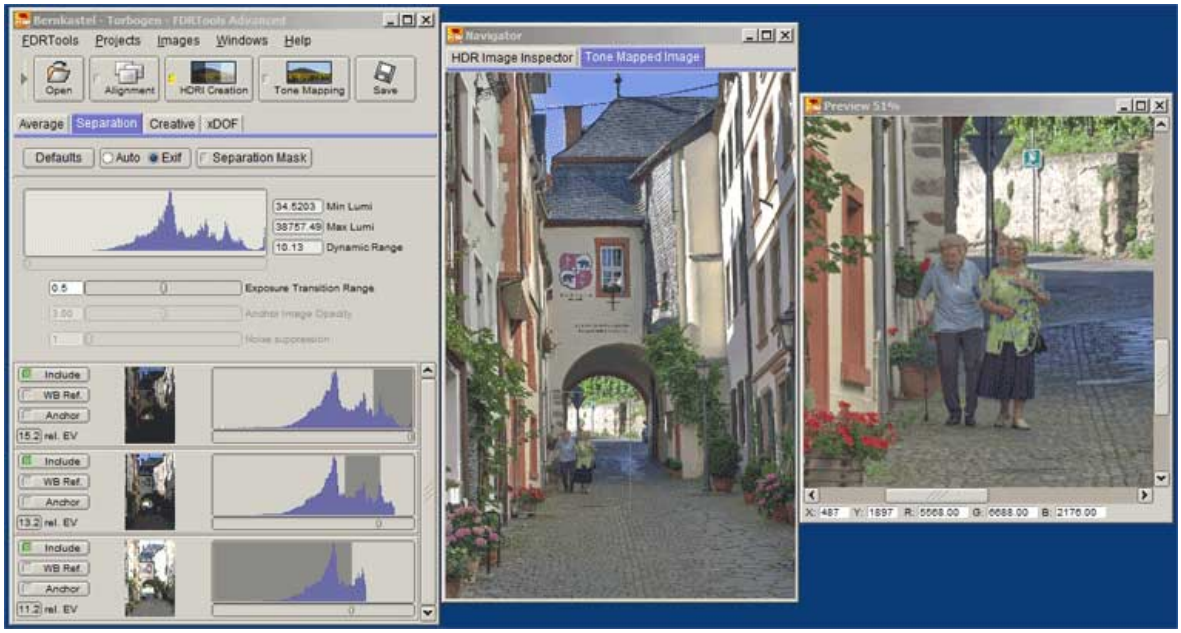
Switch 'Include'. When activated (green) the layer is included in the calculation of the result, otherwise the layer is ignored.

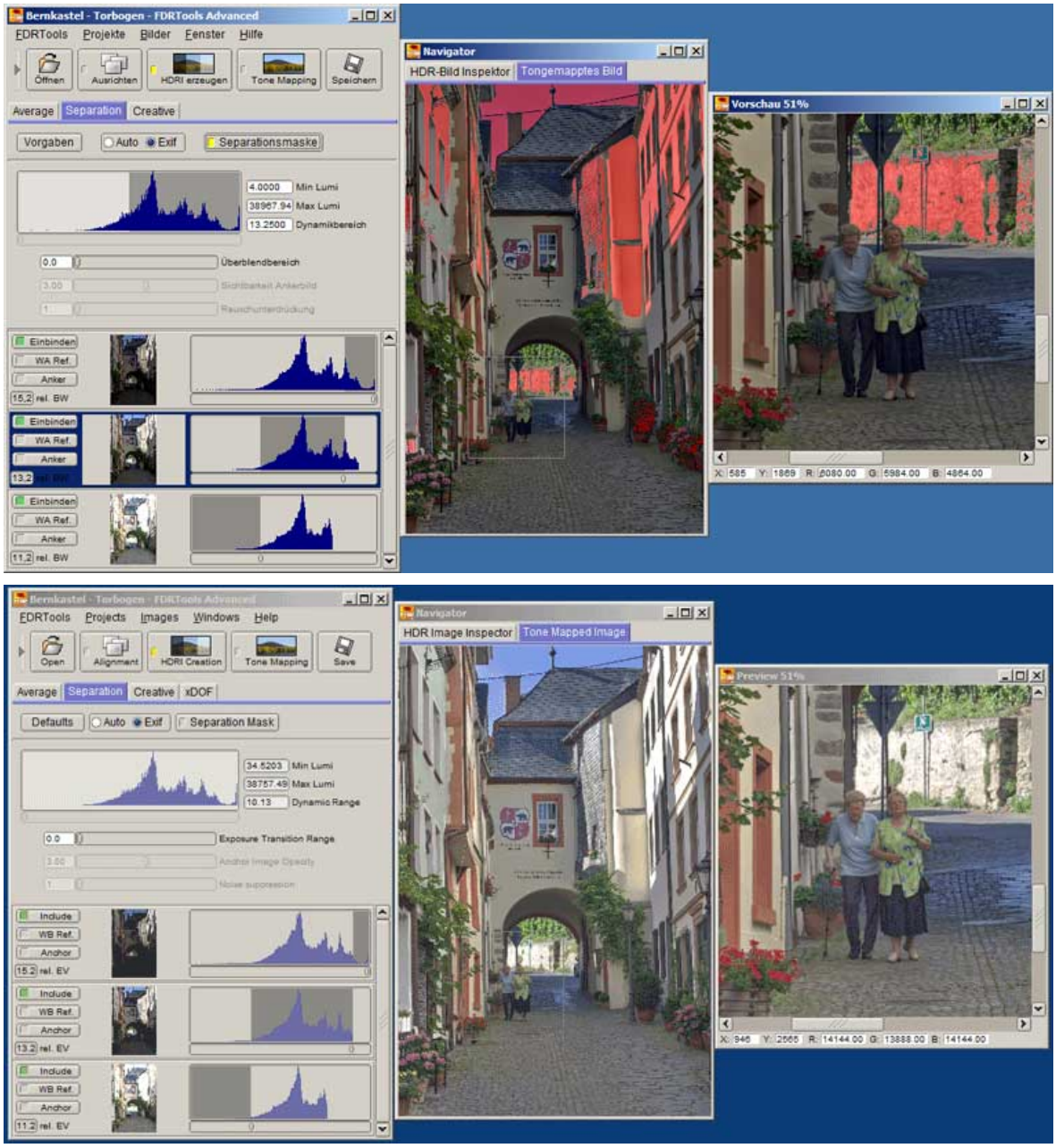
Switch 'WA Ref.'. Specifies a white balance reference image. When specifying an image as white balance reference the program tries to adapt the white balance of the other images to the white balance of the reference image.

Switch 'Anchor'. not yet implemented correct.

rel. EV. The relative exposure value of an image is displayed here as an information.

Slider 'Separation'. The slider is below the histogram and - in conjunction with the slider of the following layer - specifies the intensity area that this image contributes to the HDR image. The contributed area is highlighted in dark grey in the histogram. The following example shows how to use the separation sliders. The scene shows a typical use case for this method: separation is easy and effective if the scene is easily separable into several intensity areas and the moving objects are each completely within the respective intensity area. In this case two areas can be distinguished: the sky with the sunlit house walls and the shadowy area where two ladies are walking. Both ladies are complete in the shadowy area.

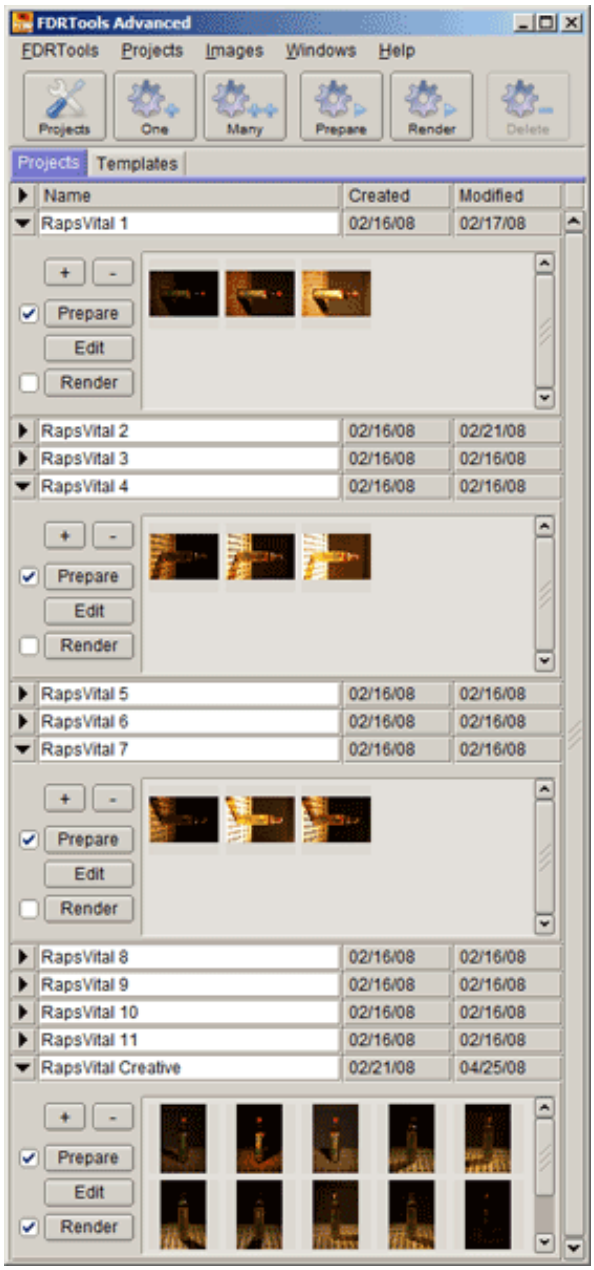




Separation example
'Defaults' shows the 'ghosts' caused by the moving persons. Separation now means to take the light areas from the first image while the shadowy areas - with the ladies - are taken from the second image and evtl. very dark areas from the third image. To accomplish this one simply has to move the slider of the bottom image to the left until the ghost artefacts are gone, see 'Separated without mask'. 'Separated with mask' shows which pixels are adopted from the middle (selected) image. Areas that are not adopted are colored red. The separation mask is a good aid when adjusting the sliders.This example also reveals a side effect of the separation. The photos were taken freehand and hence are slightly misaligned. The alignment function has corrected the horizontal and vertical shift but more complex contributions like rotation etc. have not been corrected. This can be seen when toggling between 'Defaults' and 'Separated without mask': the buildings move slightly between the two views. Here the separation reduces visible seams because seams form only along the separation boundaries. This positive trait often hides 'slight jitters' or at least makes them less noticeable.

4. HDR method Creative

Creative is a method for the creation of HDR images from arbitrary image material. The process can be steered with a couple of parameters and hence is quite flexible. The essential difference to *Average* and *Separation* is that images with differing light sources (position, intensity, color spectrum) can be mixed. This allows for interesting effects.



Project consisting of 11 exposure series

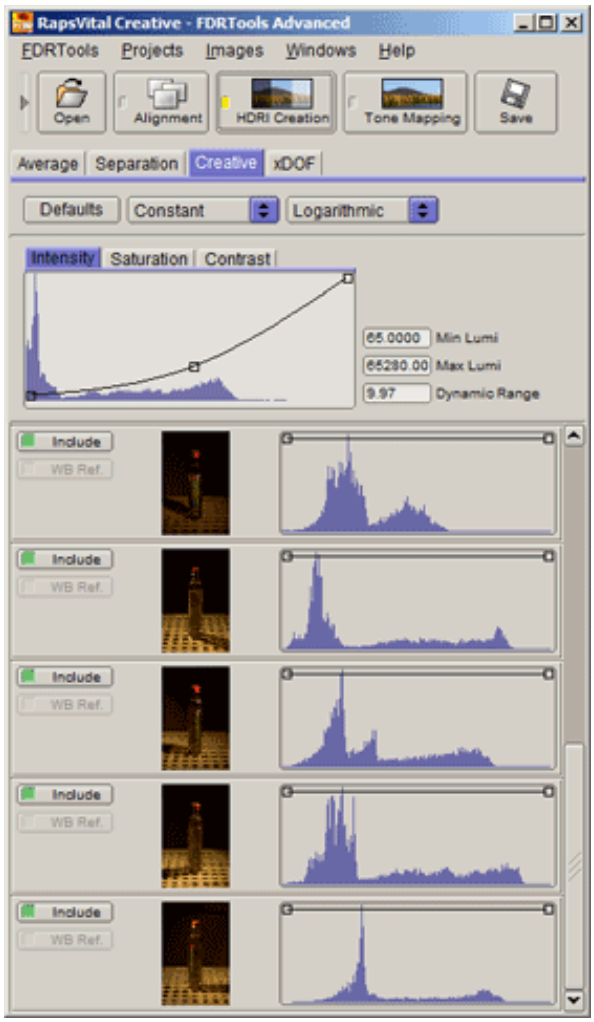
In the following example an object is illuminated from different directions. For each of the directions a HDR image is created and these HDRs are then merged with the *Creative* method. The result shows an object that acts quite 3-dimensional and does not cast shadows though it obviously has been illuminated.

The figure to the left shows the project. The object (a cooking oil bottle) is spot-illuminated from on high. The spot is then moved around the object in steps and an exposure series +2, 0, -2 EV is taken at each position. Then a HDR image is created from each of the exposure series. Thus 11 HDR images are produced in total, see the projects *RapsVital 1* to *RapsVital 11*. The figure exemplarily shows the images for three of the eleven positions.

The HDR images of the several positions are now combined to the new project *RapsVital Creative*. The project is opened with the editor and the *Creative* method is chosen for HDR creation. The intensity curve is adapted as shown in order to remove remains of shadows. Changes to other parameters are not necessary. Finally the image is tone mapped with the *Compressor* method and the result is saved.

Hint: for best results with method *Creative* you should use high quality image material. That is to say: the images should neither be noisy nor overexposed. For this reason a HDR image is created at each position in the example before merging them with *Creative*.

Hint: you should use HDR images for mixing images with *Creative* but not tone mapped LDR images. While that works too the quality of the resulting image is not optimal.



The Creative dialog

In principle *Creative* is used like methods *Average* and *Separation*. Controls and buttons impacting all images are located in the upper part of the dialog:

Button 'Defaults'. Resets all parameters to their default values.

Menu 'Weighting curves'. The menu allows to assign preset weighting curves to the image layers.

Menu 'Histogram scaling'. The scaling of layer histograms can be 'linear' or 'logarithmic'.

Sliders 'Intensity', 'Saturation', 'Contrast'. When merging the source images the attributes 'Intensity', 'Saturation' and 'Contrast' are weighted for each pixel in order to form the resulting image. A curve is used to adjust the weighting values. The example shows the weighting curve for 'Intensity'. It is adjusted in order to assign a low weight to the shadows and higher weights with growing intensity. Such a curve prefers highlights while shadows

are suppressed. The parameters 'Saturation' and 'Contrast' are adjusted analogous via a curve.The browser below lists the source images as layers. The following parameters steer the influence of a layer on the result:

Switch 'Include'. When activated (green) the layer is included in the calculation of the result, otherwise the layer is ignored.

Switch 'WA Ref.'. Not implemented yet.

Weighting curve 'Intensity'. Weighting of the intensity is adjustable per layer. The form of the curve can be adapted by adding/removing and moving knots. The resulting weight is equal to the sum of the weights of each layer, multiplied with the global intensity weighting value (see above).Hint: modification of a weighting curve can be synchronised among layers. To do this select the layers to synchronise and then modify the curve of one of the selected layers.

Migratory light source compared to stationary light source

The figure to the left shows the resulting image compared to one of the original positions.(Both images were created with the *Compressor* tone mapper and then slightly postprocessed in an image editing application: curve and sharpening).When looking at the image emanating from the migratory light source one notices that the object does not cast a shadow. That looks strange because the object was obviously illuminated as the traces of the spot light at the bottleneck and the closure show.The direct comparison to the 'normal' image - shot with stationary light source - shows some differences. The regions lit by the spot are especially bright and hence contrasty while contours lying in the shadow are dark and hard to recognize. The migratory light source in contrast illuminates all contours of the object and makes them clearly visible. This makes the object look '3-dimensional'.Differences in the footprint can be noticed just as clear. Illuminated from one direction the footprint appears unfamiliar while with illumation from all sides the structure emerges very clear.The object is clearly silhouetted against background and footprint and seems to 'levitate'. This effect is exaggerated by choosing a large aperture (2.0).

Chapter 8. Tone Mapping and Postprocessing

1. Tone Mapping

The contrast ratio of commercially available monitors is somewhere between 100:1 and 1000:1 - paper is even worse in this respect. This is by far lower than the contrast ratios of many real scenes which can easily reach 10,000:1 to 1,000,000:1. If an HDR image is composed from an exposure series properly capturing the full dynamic range of the scene this means that the HDR image can not be reproduced in a natural way on a normal monitor. As a consequence the dynamic range of an HDR image must somehow be mapped to the limited range of a monitor. This process is called 'tone mapping'.

1.1. Global and local methods

Doing this 'tone mapping' in a simple manner would loose the natural contrast and details of a scene - the resulting image would look flat and dull. In the recent past many different tone mapping algorithms were invented because it turned out that developing a method that produces fine looking results for all thinkable types of scenes is not easy.

Tone mappers can be categorised into 'global' and 'local' acting methods. Global tone mappers work in a rather simple and computational efficient way. The resulting tonal value of a pixel is computed by applying a 'global' formula. In contrast local tone mappers handle each pixel by looking at surrounding pixels. This is computationally more expensive but in general produces better results in terms of local contrast and detail reproduction. Local tone mapping algorithms usually also allow for more influence on the "look" of the tone mapped result.

1.2. Natural and creative Tone Mapping

Usually the goal of tone mapping is to produce a natural looking LDR (low dynamic range) image from an HDR image that may be displayed on LDR media. However, tone mapping algorithms - and here especially local tone mappers - like other forms of digital image manipulation also allow for "creative" manipulation of HDR images resulting in quite expressive looking results. When exaggerated, tone mapping can even produce unsightly results. The following figure shows a scene that has been tone mapped in two ways: while the image to the left looks quite natural the right hand side image creates a dramatising effect.

Natural vs. dramatising tone mapping

1.3. Tone Mapping and panorama photography

HDR imaging and tone mapping techniques are especially important in panorama photography. This is because the large field of view captured in a panorama often results in huge intensity differences caused by strong light sources (e.g. sun) in the scene. As a consequence the captured scene becomes a HDR scene and should be handled

accordingly. When tone mapping a panorama with a local tone mapping algorithm the projection of the panorama should be taken into account in order to avoid wrong results at the horizontal and vertical boundaries.

2. Tone Mapping in FDRTools

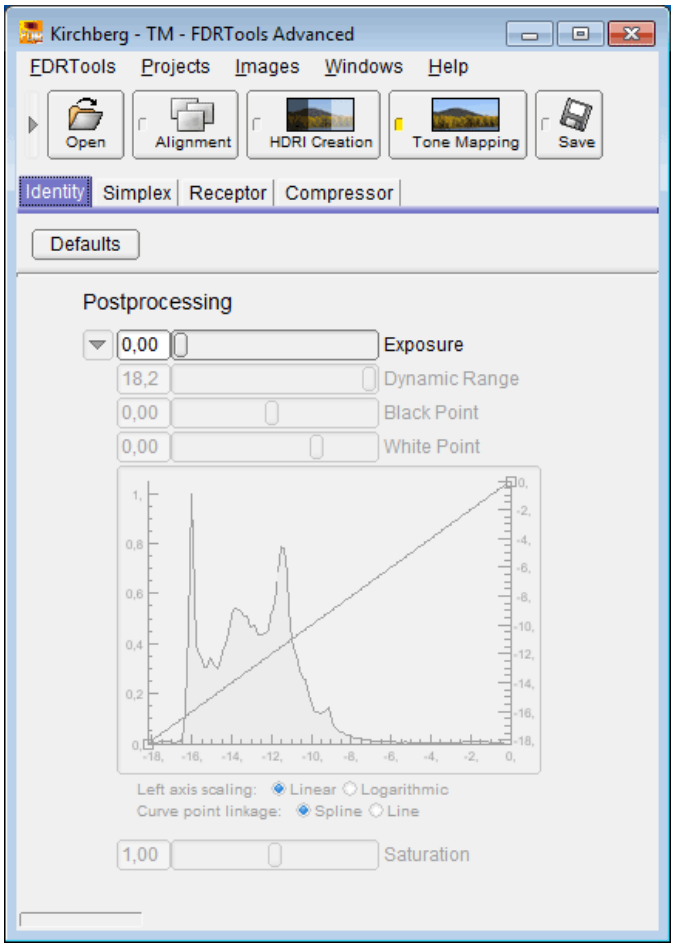
FDRTools implements four differing tone mapping methods.

Three of them are global methods and one is a local acting method named *Compressor*. While the global methods allow for basic tone mapping only the local *Compressor* algorithm is a capable and flexible tone mapper producing images with remarkable local contrast and fine detail.

You can switch between the methods by choosing the tabs *Identity*, *Simplex*, *Receptor*, or *Compressor* in the "Tone Mapping" module.

2.1. TM method Identity

Identity does an identity mapping. This means the HDR image is mapped to itself. One may ask what could be the use of such a method. Well, *Identity* is used to display and inspect the HDR image. While *Identity* has all the controls of the *Simplex* method only one slider is active. However, displaying the other controls makes clear how *Identity* differs from *Simplex*.



The Identity dialog

Button 'Defaults'. Resets all parameters to their default values.

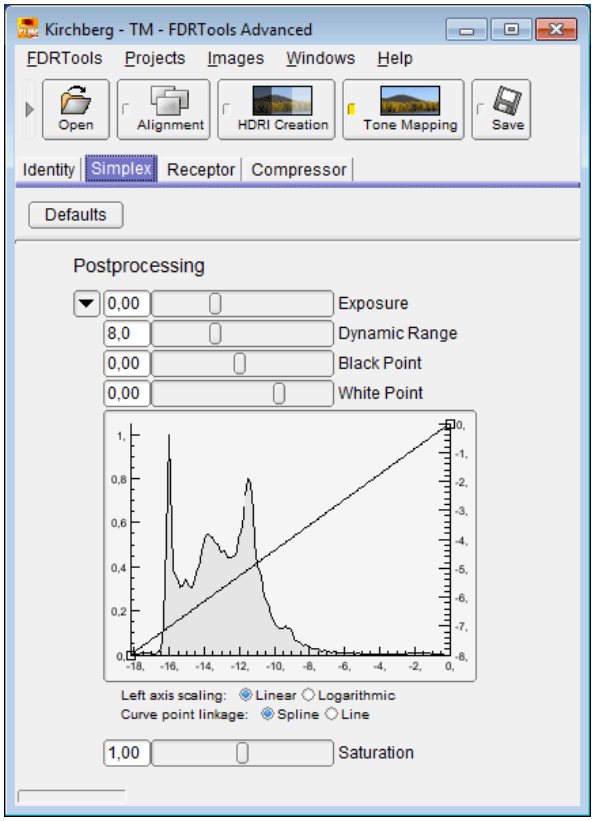
2.1.1. Postprocessing

Slider 'Exposure'. Shifts the output EV range up/down. This corresponds to changing the exposure settings of a camera.

For a description of the other Postprocessing controls see *Simplex*
.

2.2. TM method Simplex

Simplex implements the simplest possible tone mapping algorithm: the HDR image is linearly mapped to the output EV range. Though this method attenuates contrast and details it works fast. It is suited to get an overview of the scene and is useful when editing the HDR image, e.g. with manual alignment.



The Simplex dialog

Button 'Defaults'. Resets all parameters to their default values.

Postprocessing (applies to all tone mappers).

Slider 'Exposure'. Shifts the output EV range up/down. This corresponds to changing the exposure settings of a camera.

Slider 'Dynamic Range'. Widens/narrows the output EV range. Use this to adapt to the dynamic range of the output device.

Slider 'Black Point'. Widens/narrows the left end of the input EV range.

Slider 'White Point'. Widens/narrows the right end of the input EV range.

Curve and Histogram. The curve maps the EV range of the tone mapped image (bottom axis) to an adjustable output EV range (right axis). Adjusting the curve using knots you can achieve sophisticated mappings. Add a knot via left mouse click. Remove a knot by dragging the knot outside the borders of the control.The default setting for the curve does the following: the left knot maps the darkest pixel of the tone mapped image to -8 while the right knot maps the brightest pixel to 0. The output values are a measure of the output dynamic range and are in log base 2 units or EV or f-stops. In effect this means that the white point with value 0 has 256 times the luminance of the black point with value -8.The tone mapped histogram is displayed behind the curve. It is obtained from the luminance channel of the tone mapped image. The histogram is a visual aid for adjusting black point and white

point.Note: the left axis scaling is a measure of the number of entries per histogram bin. It is of informational value only.

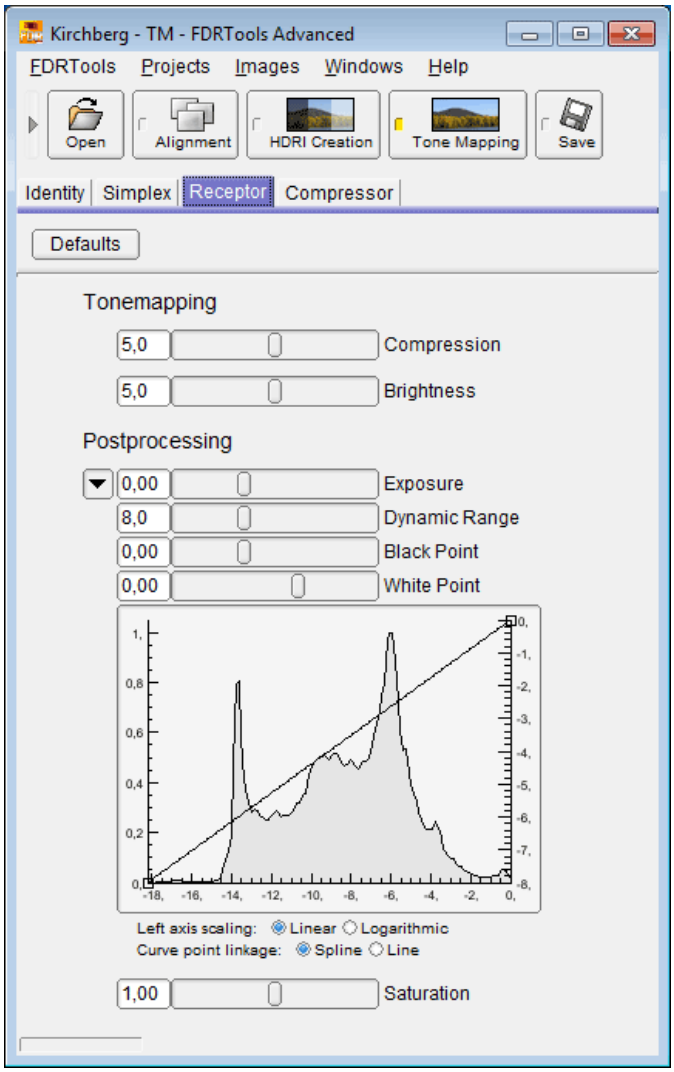
Switch 'Left axis scaling'. The scaling of the left-hand axis can be changed from linear to logarithmic. This alleviates the perception of the histogram tails.

Switch 'Curve point linkage'. The curve knots may be linked via splines (smooth curve) or via lines.

Slider 'Saturation'. Is used to adjust the color saturation.

2.3. TM method Receptor

Receptor mapping works by logarithmising the HDR image. The strength of the compression depends on the intensity of a pixel. Highlights are compressed more than shadows.



The Receptor dialog

Button 'Defaults'. Resets all parameters to their default values.

2.3.1. Tone Mapping

Switch Compression. Regulates the dynamic compression.

Switch Brightness. Regulates the image brightness.

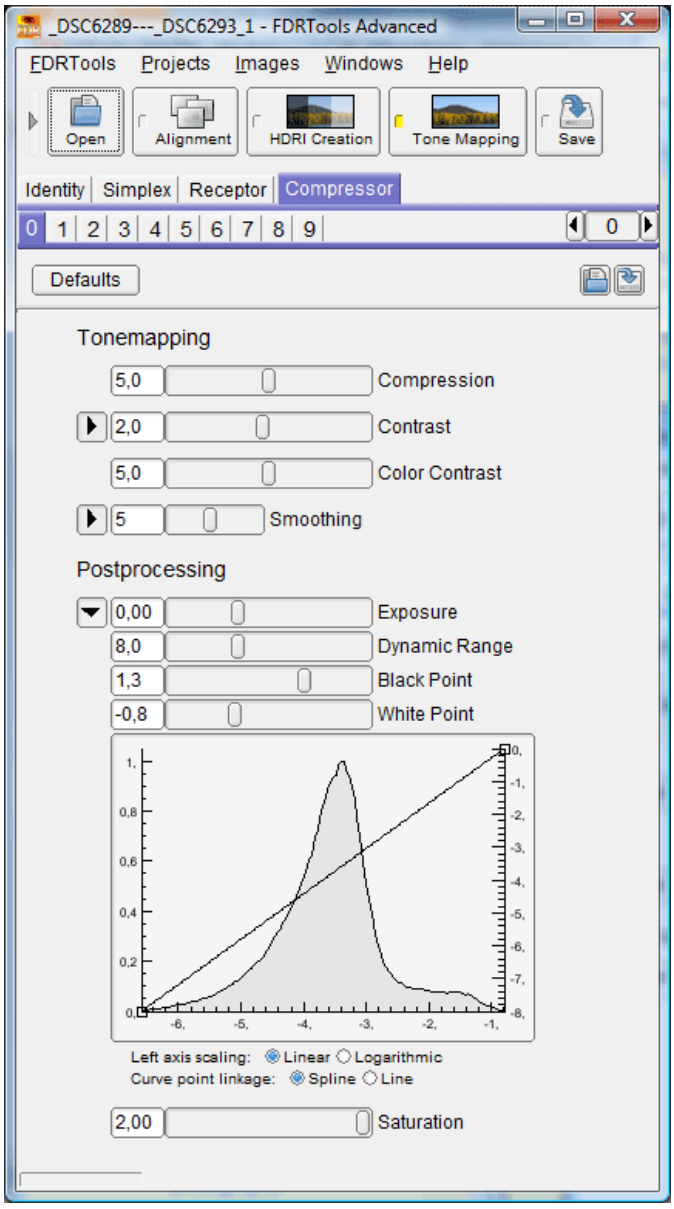
For a description of the Postprocessing controls see *Simplex*

.

2.4. TM method Compressor

The *Compressor* algorithm works as follows: the intensity of each pixel is regulated individually and depends on the intensities of neighbouring pixels. If neighbouring pixels differ strongly in their respective intensity, e.g. in the surroundings of a strong light source, then these differences are strongly attenuated. Where the differences are small, e.g. in shadowy areas, there is little or no attenuation, evtl. the difference is even increased. As a result the dynamic range of the HDR image is strongly reduced while local tonal value differences are preserved. Local contrast and thus the perceptibility of details are considerably improved compared to global tone mapping methods like *Simplex* or *Receptor* .

History. Parameter changes are recorded by a history module. The user interface to the history module is a panel placed below the Compressor tab. It consists of ten tabs - the so called "branches" - and a counter with arrowed buttons. Each parameter change increments the counter and the change is saved in the active branch. The arrowed buttons allow to browse the history of the active branch. Selecting a different branch switches to the history of that branch or - if that branch has no history yet - the history is started with the current set of parameters. This way up to ten history branches can be maintained and compared with each other. A history branch can be reset by browsing backwards until the counter shows -1.



Der Compressor-Dialog

Button 'Defaults'. Resets all parameters to their default values.

Button 'Load state'. Opens a file choosing dialog that allows to load a state saved at an earlier time.

Button 'Save state'. Opens a file choosing dialog that allows to save the current state, that is the entirety of all parameter settings.

2.4.1. Tone Mapping

Slider Compression. Regulates the strength of tonal range compression. More likely affects local contrast.

Slider Contrast. Substantially affects the contrast of the image. Low values result in smooth transitions - the image will look blurred. High values yield strong local contrasts - the image will look sharp. Should the image look dirty or should unwanted seams show up (blue skies are especially damageable), then the value is adjusted too high. Clicking the toggle button to the left opens two additional controls named *Frequency* and *Luminance*:

Curve Contrast->Frequency. Lets you control the contrast with respect to frequency bands. The x-axis ranges over the frequency components beginning with lowest frequencies. Low frequencies stand for large scale features while high frequencies stand for fine details. Adjusting the Frequency curve you can influence blurriness and sharpness respectively.

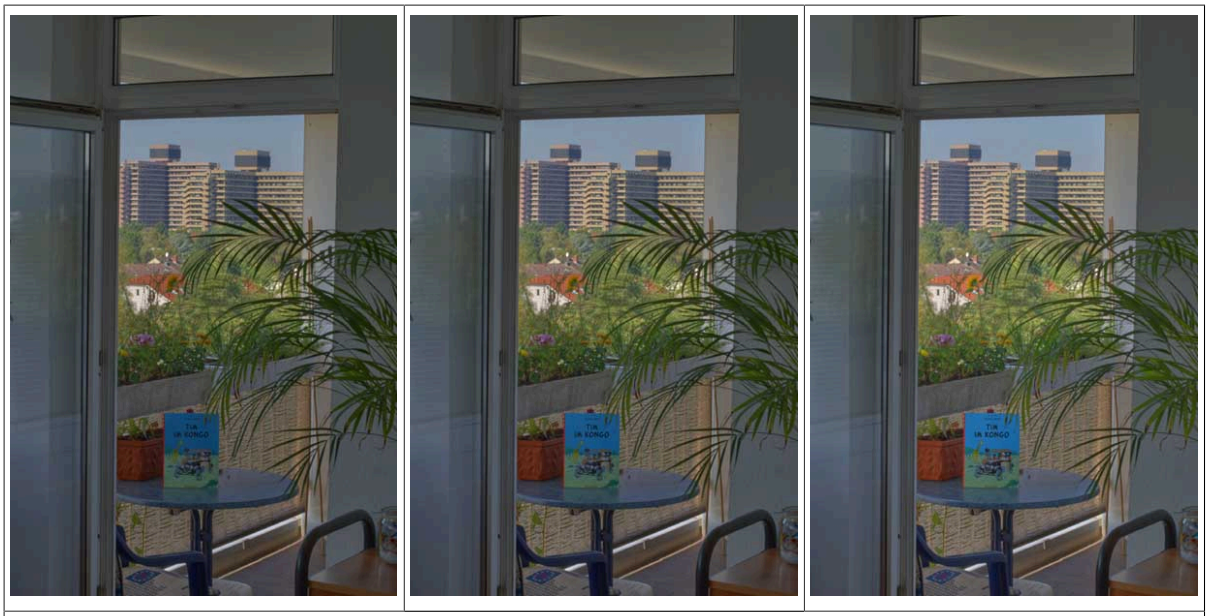
Curve Contrast->Luminance. Lets you control the contrast with respect to pixel luminance. The x-axis ranges over the pixel luminance beginning with lowest luminance. Low luminace stands for "dark" pixels while high luminance stands for "light" pixels. Adjusting the Luminance curve you can influence contrast in dark areas and light areas respectively.

Slider Color Contrast. Regulates the contrast of colored regions. This is best demonstrated with an example image, see fig. *Compressor Color Contrast*. Note that the brightness of colored regions varies considerably with the slider value while the effect on grey regions is negligible.

Slider Smoothing. Regulates the definition of image details. Low values yield less defined details, especially large scale details are less defined. High values result in well defined image details - the result will have smooth transitions. Using an analogy to painting one could also describe the effect of this slider as regulating the covering application of paint. Clicking the toggle button to the left opens an additional control:

Curve Smoothing->Frequency. This curve lets you control Smoothing with respect to frequency bands. The x-axis ranges over the frequency components beginning with lowest frequencies. Low frequencies stand for large scale features while high frequencies stand for fine details.

For a description of the Postprocessing controls see *Simplex*
.



Compressor Color Contrast

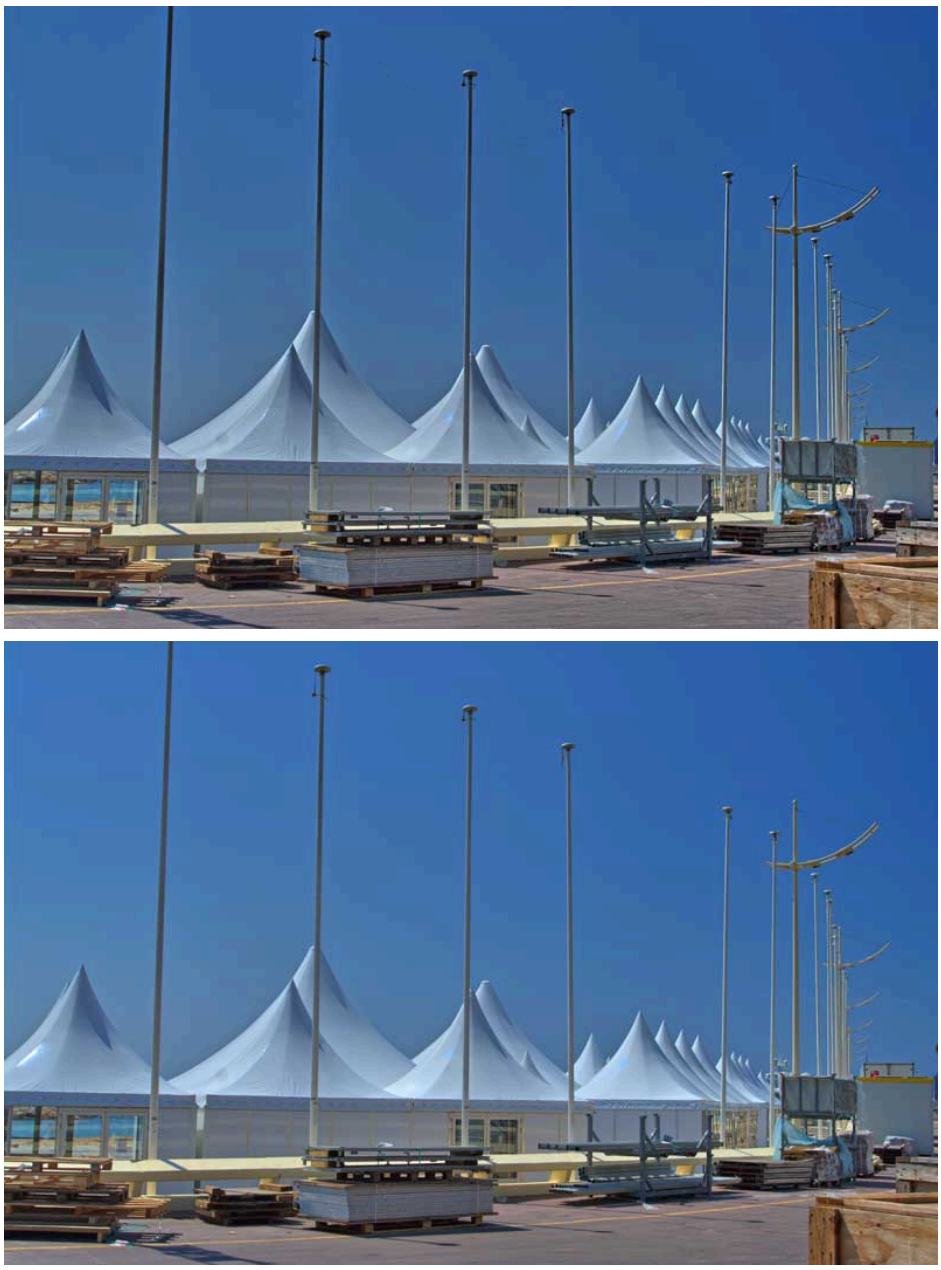
2.4.2. How to avoid "halos" and "spots"

The *Compressor* tone mapper sometimes produces so called "halos" and/or "spots". Halos are seams along edges appearing unnaturally bright. Spots are regions appearing unnatural dark or bright. Spots result in a patchy illuminated image look. It depends on the scene and the *Compressor* parameter settings whether such artefacts appear or not.

If you encounter halos in a tone mapped image you can remove them by adjusting the *Frequency* components of the *Contrast* parameter.

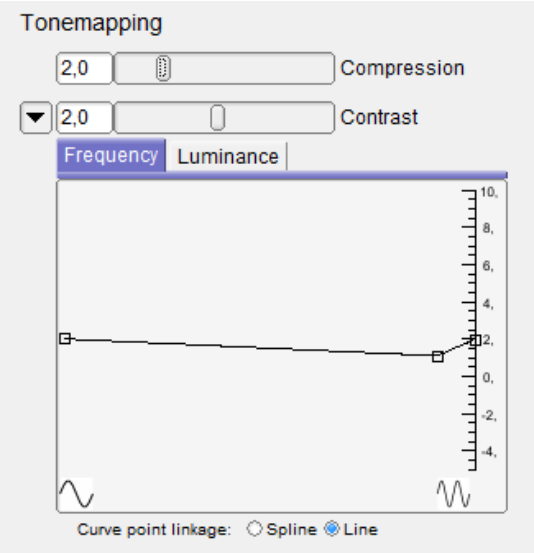
If you encounter spots in a tone mapped image you can remove them by lowering the *Compression* parameter value.

Look at the following image comparison. The first image shows the *Simplex* result. The second image shows the result of using the *Compressor* default settings. You can here perceive slight halos along the pylons and moreover dark looking spots inside the pylons. The third image results from properly adjusting the *Compressor* parameters.



Compressor halos and spots (image by courtesy of Alessandro de Simone)

How to adjust the Compressor parameters: in general lower the *Compression* value until the spots disappear but keep it as high as possible in order to achieve good details and contrast. Adjust the *Contrast->Frequency* curve as shown below (to access the *Contrast->Frequency* option click the arrow button left to the *Contrast* slider). Set the 'Curve point linkage' option to 'Line'. The intention is to lower the impact of frequency components that are responsible for the halos.

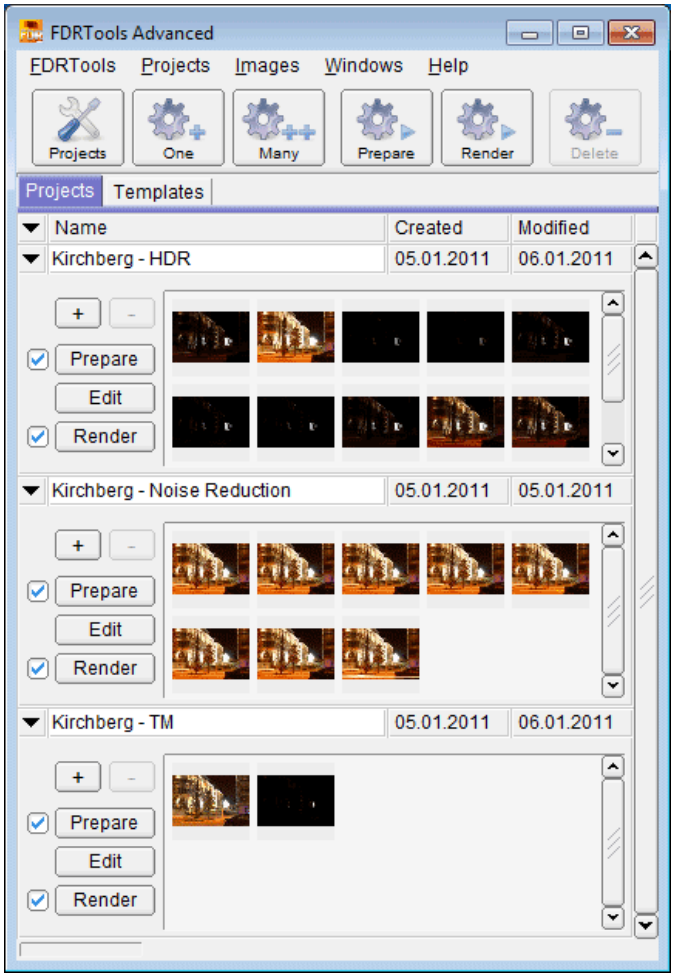


The relevant Compressor parameters

3. Example: Night Shot

The following example clarifies the characteristics of the tone mapping algorithms. It is a night scene. Night scenes are especially hard to handle because usually they are high dynamic range and prone to noise. Nearly always there are very dark areas that can hardly be exposed free from noise. Noise is a problem when tone mapping with *Compressor*. *Compressor* does not distinguish noisy pixels from "clean" pixels. Therefore noisy pixels gain contrast too and hence gain perceptibility. For this reason the tone mapping example deals not only with tone mapping itself but also with the preparation, namely the creation of a noise-free HDR image.

3.1. HDR image



Night shot - projects

The possibly strong noise in night scenes is caused by a low signal-to-noise ratio in very dark image areas like the night sky. Even quite long exposure does not yield a measurable signal because there is simply not enough light - the background noise of the camera electronics prevails. Noise can be fought in several ways. The cleanest way - because image quality is preserved - is the following method. Dark image areas emit light also, albeit very little. In order to get a sufficiently strong signal one has to expose longer. There are two ways to expose for an arbitrary long time:

1. Make a single exposure of the required exposure time. As many cameras are limited in their maximal exposure time external equipment is necessary, e.g. a remote control release.

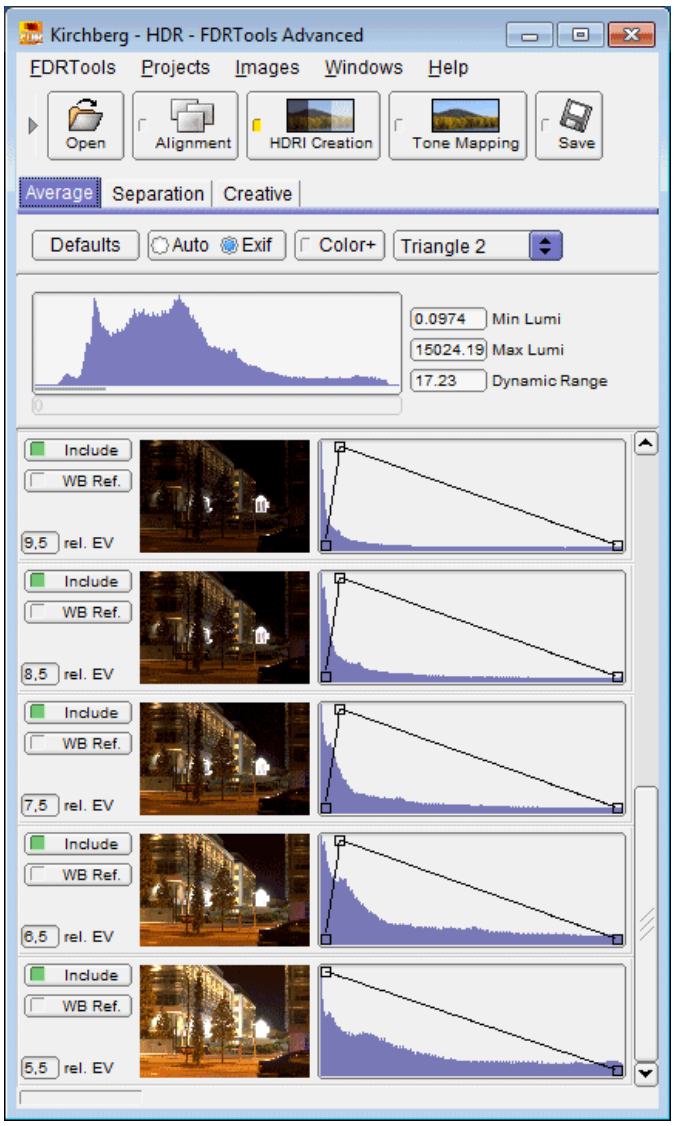
2. Cumulating the required exposure time via a series of N identical exposed photos. The images of the series are then merged using the HDR method *Average*, see below. The result matches a single photo of N times the exposure time. Advantage of this method: disturbing factors like cars passing the scene can be removed by excluding the respective photo.

For the implementation of this method three projects are defined:

1. "Kirchberg - HDR" is the usual exposure series. The resulting HDR image is not noise-free.

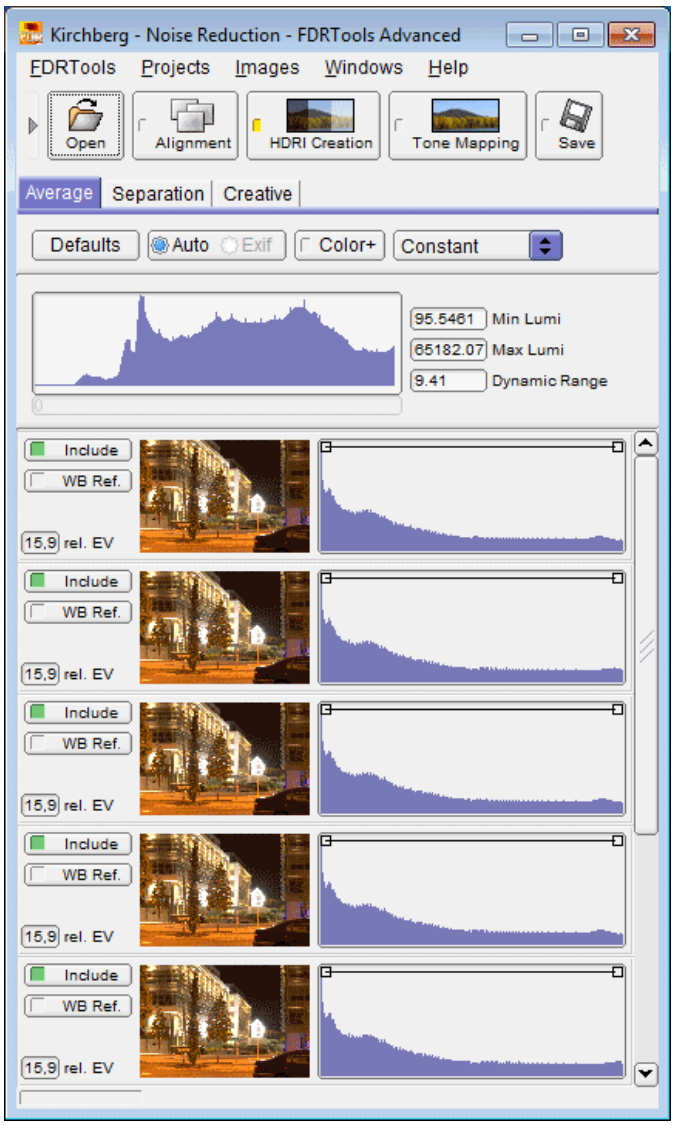
2. "Kirchberg - Noise reduction" is a series of images with identical exposure time combined into a long time exposure.

3. "Kirchberg - TM" is the unification of the previous images into the noise-free HDR.



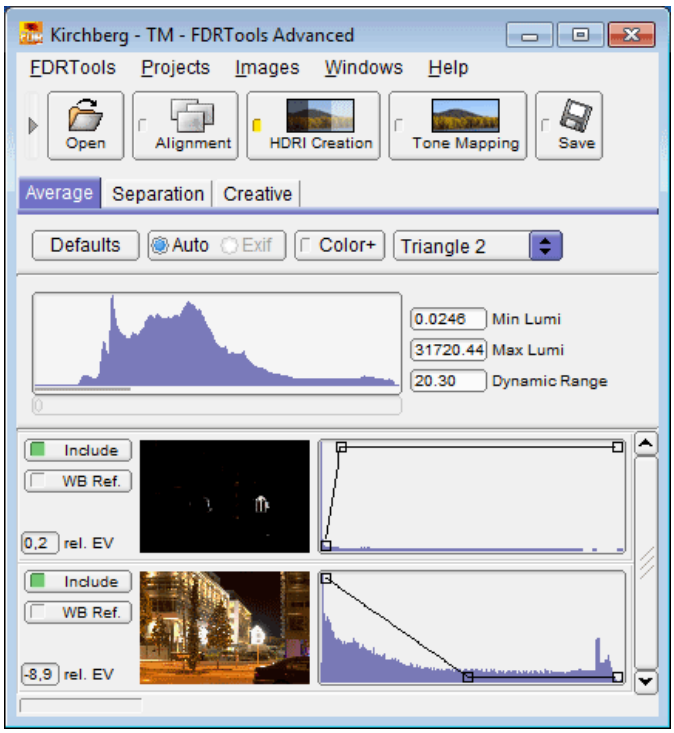
First part of the project - the HDR image

The figure to the left shows the first part of the HDR image, an exposure series consisting of 11 exposures with exposure times ranging from 1/100 of a second to 10 seconds. The resulting HDR image is not noise-free. Longer exposure times are realised with a second exposure series, see below.



Second part - long time exposure

The figure to the left shows the second part of the HDR image. This series comprises 8 photos, each of them exposed for 10 seconds. The 8 images correspond to a single photo with an 80 seconds exposure time. This in turn means a difference of 3 EV or f-stops compared to a single photo. The photos are merged with the HDR method *Average*. The pixels are weighted using weighting curve "Constant" which means that the resulting value of a pixel is calculated as the sum of the pixel values from all images divided by the number of images.



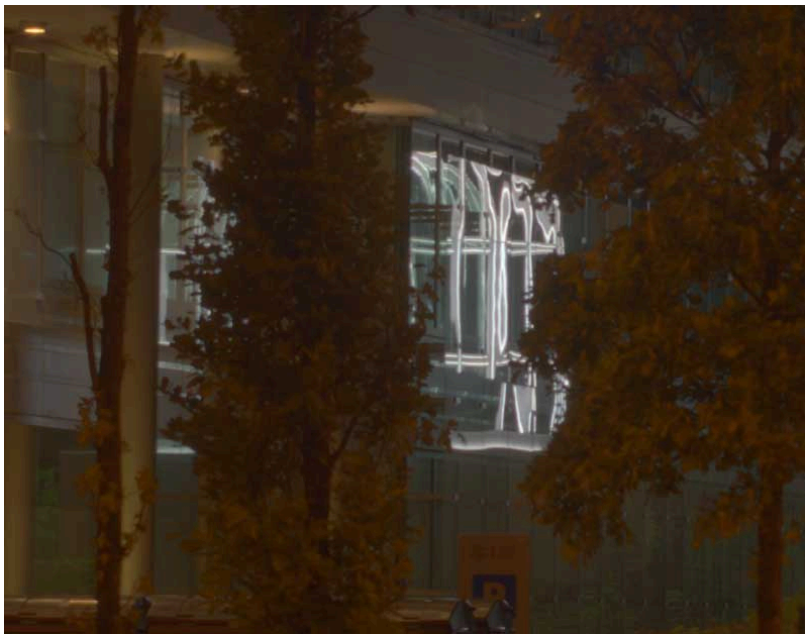
Third part - the final noise-free HDR image

The figure to the left shows the third part, the final HDR image, consisting of the HDR images from the two previous projects. The HDR image is nois-free and is tone mapped.

3.2. Tone Mapping

The following figures show the results achieved with the different tone mappers applied to the HDR image. The first figure shows the overview, the second figure a detail of the scene. In order to make the results of the algorithms comparable the intensity of the brightest feature in the scene - an illuminated cage - is adjusted so that the intensity is about the same for all tone mappers. Note that the intention of this example is not to produce the best looking result but to show the differences between the tone mappers.

Overview



Detail

While the *Simplex* result is noise-free and does not show overexposed pixels, it is rather dark and shows poor contrast. It is not easy to discern fine detail.

Receptor creates a brighter image. The reason for this is a stronger compression of the highlights and linked to it a spreading of dark and medium tonal values. As a consequence the contrast in the highlights decreases: the reflection of the illuminated cage appears brighter but less detailed compared to *Simplex*. On the other hand the contrast increases in the lower and medium tonal value ranges.

Compressor yields a well-balanced result. All areas of the scene are sufficiently bright. Even details of the wheelhouse of the car in the front (see the overview image) are recognizable. However, good contrast and hence details are preserved over the full tonal value spectrum. The resulting image looks quite natural.

Chapter 9. Saving the results

1. HDR File Formats

A HDR image is an attempt to reconstruct the intensities of the real scene like our eye would recognize them. An (optimal) HDR image therefore comprises the full dynamic range of a scene in uncompressed form. In general a HDR image can not be saved lossless in a 8-bit data format. Lossless storage in general requires a floating point data format.

FDRTools supports the floating point formats OpenEXR, RGBE and TIFF FP (floating point). We recommend the OpenEXR data format for the saving of HDR images.

2. LDR File Formats

Tone mapping compresses the dynamic range of a scene in a way that the resulting image can be saved in an ordinary 8-bit or 16-bit integer data format. Such formats like JPEG are denoted as LDR (low dynamic range) formats. The most important ones are TIFF 16-bit and JPEG. Because FDRTools is not designed to be a full-fledged image editor the resulting LDR images are in general further processed in an external image editing application. To this end it is recommended to save tone mapped images in a lossless data format.

FDRTools supports several 8-bit and 16-bit integer formats. We recommend the 16-bit TIFF format for the saving of tone mapped images.

3. Save Image dialog

When exiting FDRTools the projects with all relevant project details are saved automatically. When starting FDRTools again the projects are also loaded automatically again.

The results from processing a scene, namely HDR image and tone mapped image - are saved explicitly. This is done from within the project editor. By choosing one of the tone mapping modules you decide which type will be saved. Choose *Identity* if you intend to save the HDR image. Choose *Simplex*, *Receptor* or *Compressor* to save the LDR image, see Tone Mapping in FDRTools Section 2.

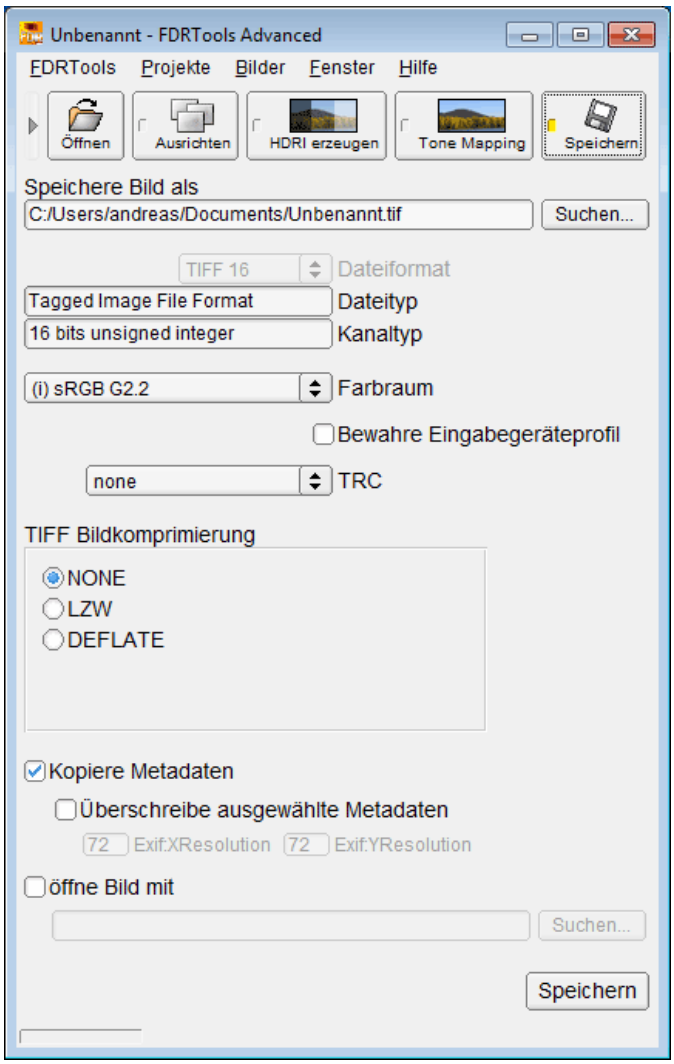
The Saving Image dialog is displayed by pressing the "Save" button in the task bar or by choosing the menu entry *Images -> Save as...*

The figure below shows the Save Image dialog. Use the "Browse" button to browse the file system and choose file path, file name and data type. The fields underneath show the parameters of the output device (for a description see FDRTools -> Preferences -> Output Device) and image format settings (for a description see FDRTools -> Preferences -> File Formats).

Copy metadata. Check this box to copy metadata from the (darkest) source image to the resulting image - provided the target data type supports this. You may override selected metadata. Currently you may change "Exif:XResolution" and "Exif:YResolution". Set both fields to the same value to give the resulting image a certain "image resolution". Note that changing metadata has no impact on image quality.

open image with. You may specify an external application that shall be used for further editing of the image. The external application is started and the image handed over to it automatically. For HDR images external editing is useful only if the external application can handle floating point images.

Save. Starts the saving process.

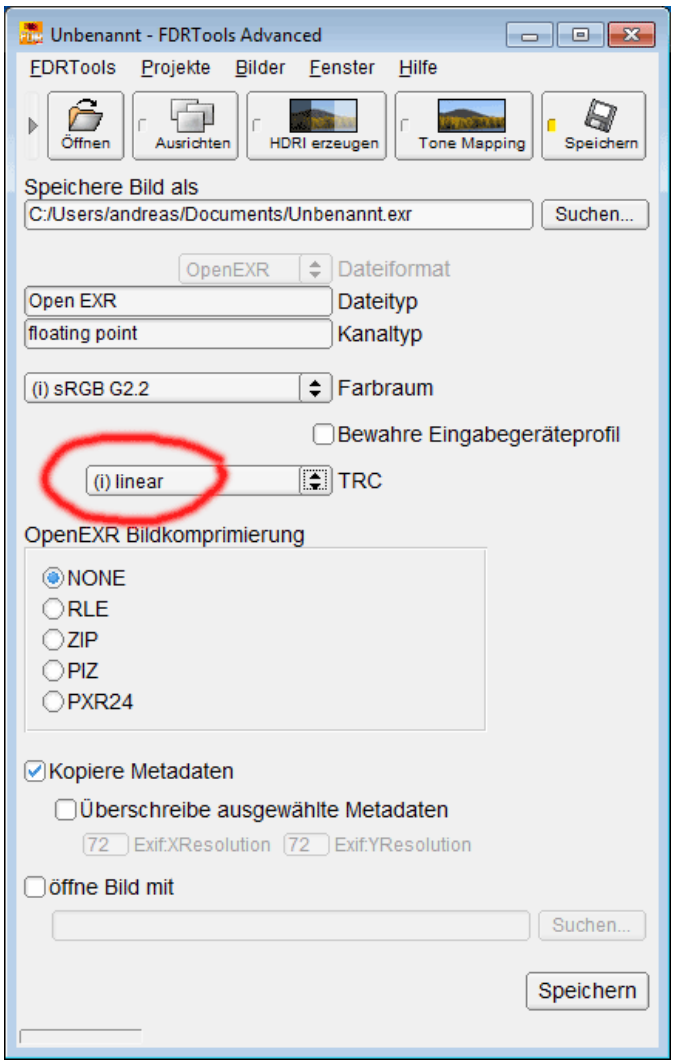


Saving a result in the project editor

4. Saving the HDR Image

As already mentioned the HDR image is displayed via the tone mapping module *Identity*. Once you have chosen *Identity* as tone mapper make sure the Exposure slider is set to 0. Now press the "Save" button in the task bar or choose the menu entry *Images -> Save as...*

HDR images should be saved as floating point data. Possible data types are: RGBE, OpenEXR and TIFF FP. Now before starting the saving there is one more thing to consider: HDR images should be saved as "linear" light. To do this set the "TRC" menu button to "(i) linear" (an alternative would be to choose a linear color profile like "(i) Wide Gamut RGB G1.0"). Now save the image. Note: saving HDR images is not interesting for the "normal" user. However, if you save HDR images on a regular basis it is recommended to create a custom Parameter Set (see FDRTools -> Preferences -> Devices) to make sure the right settings are chosen automatically.



Saving the HDR image

Part III. Specific topics

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Chapter 10. Navigator and Preview

1. Navigator

The *Navigator* provides an overview of the resulting image. The user interface elements:

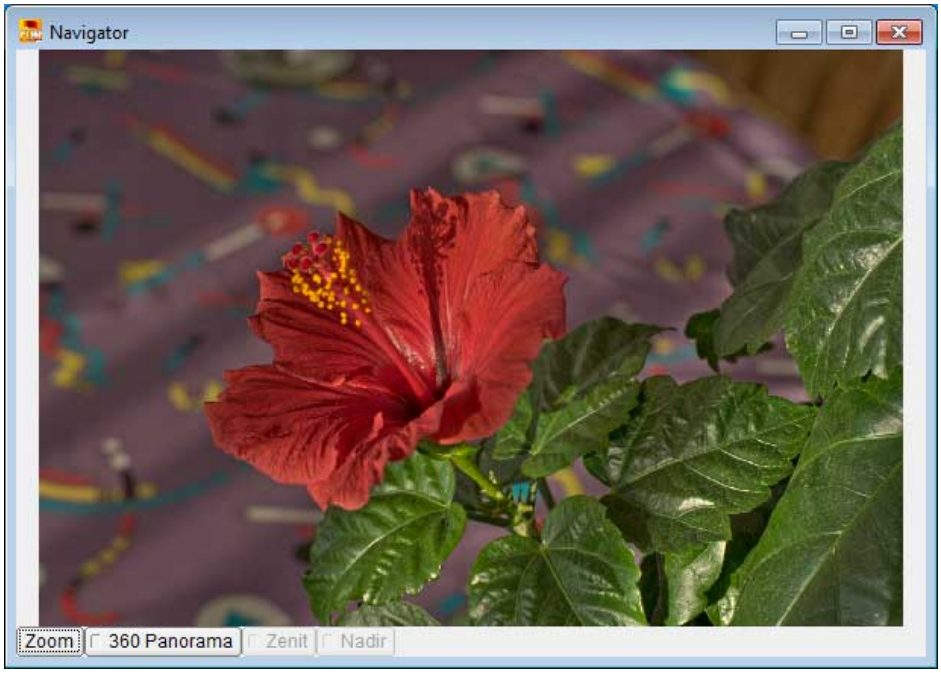
Image area. Clicking the left mouse button within the image area switches from Navigator to Preview mode. The spot below the mouse pointer will be shown centered in Preview.

Button 'Zoom'. Clicking the 'Zoom' button switches from Navigator to Preview mode.

Switch '360 Panorama'. Activate this switch if the image is a 360° panorama (cylindrical or spherical). The panorama must be in the so called *equirectangular* projection. This is a common form of projection in panorama photography; for more details see Panorama Tools.

Switch 'Zenith'. Activate this switch if the panorama has a *zenith*.

Switch 'Nadir'. Activate this switch if the panorama has a *nadir*.



Navigator

2. Preview

The *Preview* allows to inspect the image in detail. The user interface elements:

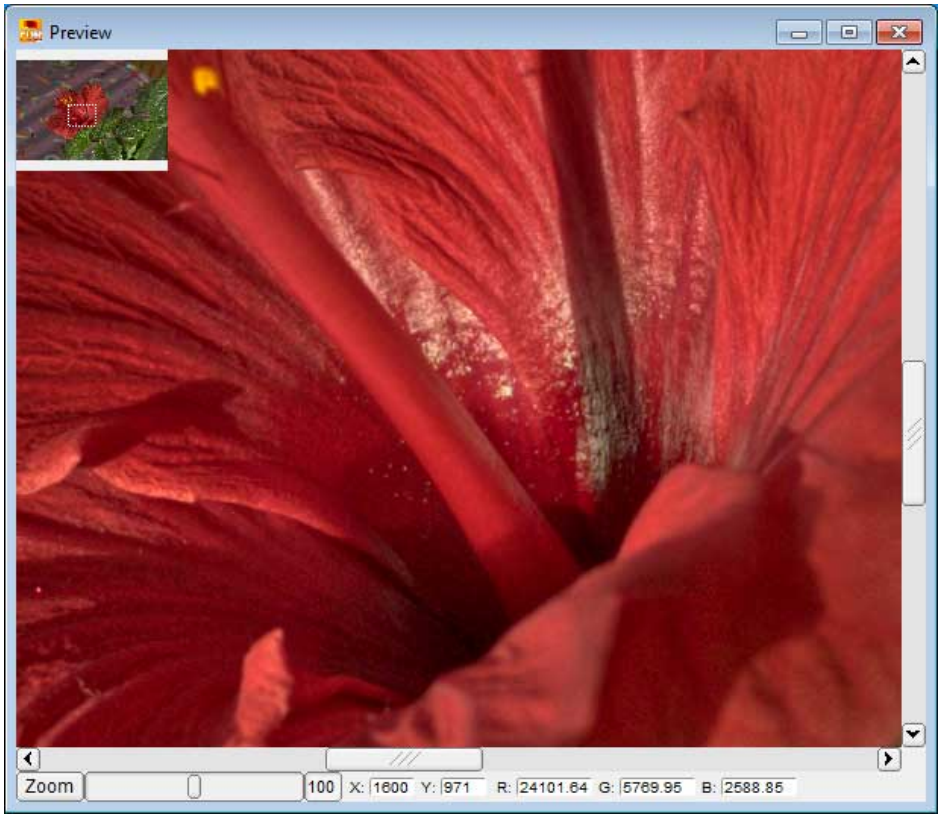
Image area. Clicking the left mouse button within the image area switches from Preview to Navigator mode. In the top left corner there is a small Navigator showing the currently displayed detail. Clicking the left mouse button within the small Navigator shifts the displayed image detail. If you need to inspect the image pixels in the upper left corner - which are hidden by the Navigator - you can toggle the visibility of the small Navigator by clicking the right mouse button.

Button 'Zoom'. Clicking the 'Zoom' button switches from Preview to Navigator mode.

Slider 'Zoom Scaling'. Sets the zoom level of the displayed image detail. The zoom level may alternatively be controlled via the mousewheel.

Output fields 'X' and 'Y'. Displays the current mouse coordinates.

Output fields 'R', 'G' and 'B'. Displays the RGB values of the pixel at the current mouse coordinates.



Preview

Chapter 11. Tools

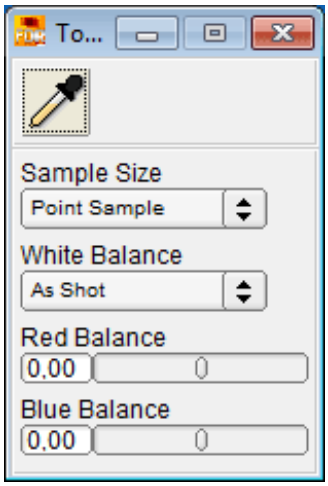
1. White Balance Tool

Click the button with the pipette icon to toggle the *White Balance* tool. Move the cursor over the image area. Clicking the pipette in the image area of Navigator or Preview measures the color value of this spot. The white balance correction then adjusts red and blue channels so that the spot is "neutral grey" which means that the color channels red, green and blue have the same value.

Option Button 'Sample Size'. The area of the measured spot is variable. It can be a single pixel or a quadrat of sizes 3 or 5 respectively.

Option Button 'White Balance'. 'Custom' indicates that white balance has been adjusted. 'As Shot' resets the red and blue channels to their defaults.

Sliders Red/Blue Balance. As an alternative to the pipette you can use sliders to manually adjust the red and blue channel correction values.



Tools window

Chapter 12. Preferences

1. Preliminary note

Preferences allow you to influence several functions of the program and to configure them according to your wishes. All parameters have reasonable default values, hence a configuration is not a must.

2. Devices

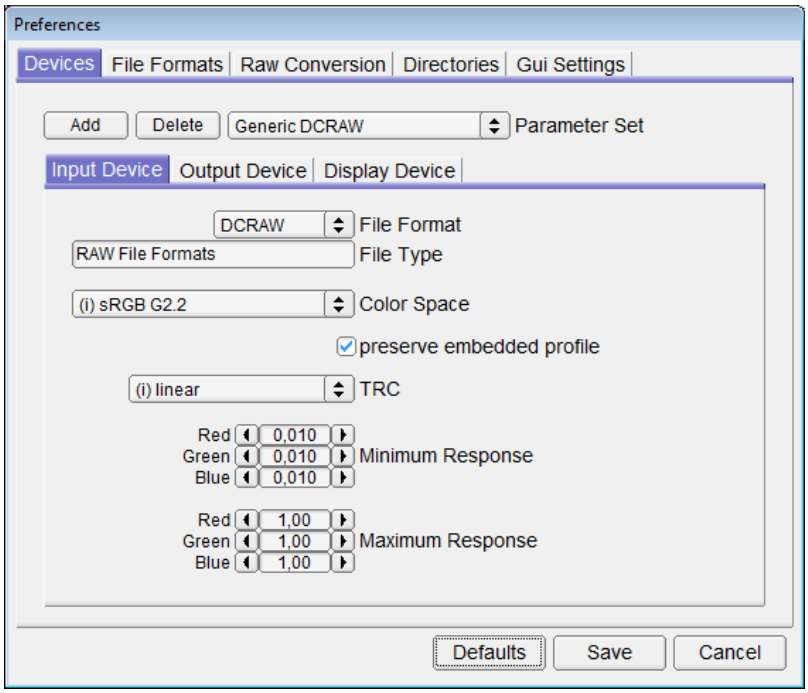
FDRTools processes images from differing devices/sources. Here you can configure the characteristics that matter in the context of merging images.

Add, Delete, Parameter Set. A Parameter Set comprises the settings for input device, output device and display device in one set. The important cases are covered by presets like *Generic JPEG*. This guarantees that everything works even without the definition of custom Parameter Sets. Creation of a new parameter set is recommended if

- a device shall be used whose characteristics (like color space) are not embedded in the image files produced by the device.
- a device shall be measured, e.g. TRC.

The user chooses the right Parameter Set in the file chooser when loading images. Instead of the usual data formats like JPEG, TIFF etc. you will find the configured Parameter Sets like *Generic JPEG*, *Generic TIFF* etc.Note: Use of self defined Parameter Sets is deactivated by default. You can avtivate the switch *Show custom Input Devices in Open Image(s) dialog* in the Gui settings dialog in order to use self defined Parameter Sets.

3. Input device



Dialog input device

File Format. File format (RAW, JPEG etc.) delivered by the Input Device.

File Type. A textual description of the File Format.

Color Space. Describes the color space of the Input Device. Choices are the ICC profiles that FDRTools finds in the directory configured at ICC profiles directory .

preserve embedded profile. The value configured at 'Color Space' is overridden if a color space - in the form of an ICC profile - is embedded in the image file.Note: for RAW image files this parameter has a special meaning: since RAW files have no ICC profile embedded one could think that the *preserve embedded profile* parameter has no effect. However, FDRTools relies on dcraw (a well known RAW converter) to decode RAW files and to convert the image data from the native color space to a usable RGB color space. This color space is adjustable and it was decided to use WideGamut RGB. In addition it was decided that this color space, namely WideGamut RGB, shall be considered the "embedded" color space of a RAW file. This definition is of course somewhat arbitrary but nevertheless makes sense. The bottom line is: activating the *preserve embedded profile* parameter means that the converted RAW image will be in WideGamut RGB space.

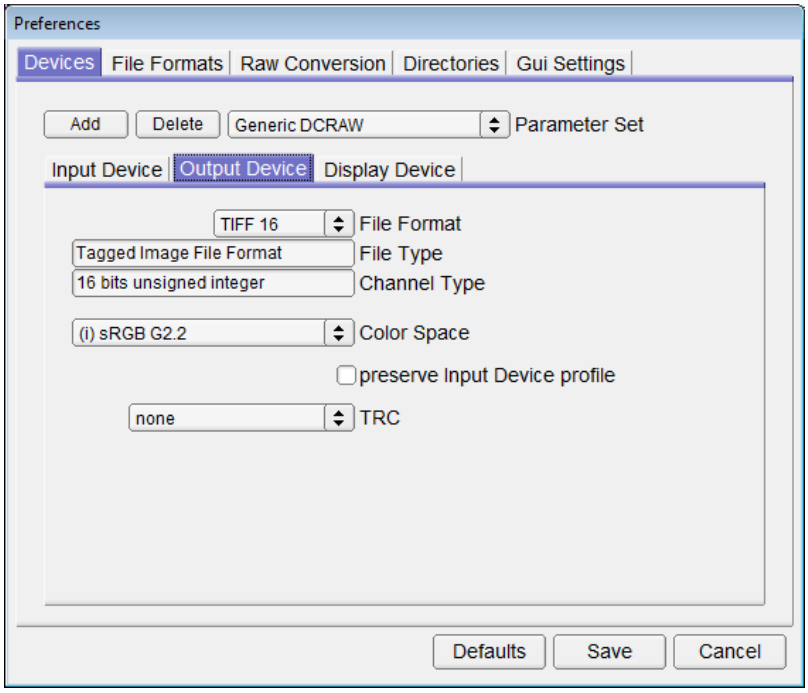
TRC. FDRTools supports measuring the 'Transfer Response Curve' of the input device. Such TRCs are contained in ICC profiles also but these are quite imprecise and not suited for accurate linearisation of image data. In order to get properly linearised image data for further processing in FDRTools measuring the TRC is reasonable. Notes:

- Measuring a TRC is not a must. FDRTools creates very good HDR images without a TRC.
- Measuring a TRC makes sense only with nonlinear image data (like e.g. JPEG images). RAW images are linear by nature hence a TRC is not necessary.
- The TRC profiling function is currently only available in the older version 1.8.3.

Minimum Response. Here you can configure the minimum response value of an input device that shall be utilised for HDR image creation. The range [0, 1] is internally mapped to the file formats value range. This setting is part of the Input device profile and is normally set by the Profiler application.

Maximum Response. Here you can configure the maximum response value of an input device that shall be utilised for HDR image creation. The range [0, 1] is internally mapped to the file formats value range. This setting is part of the Input device profile and is normally set by the Profiler application.Note: this switch is currently inactive.

4. Output Device



Dialog output device

File Format. File format of the tone mapped image.

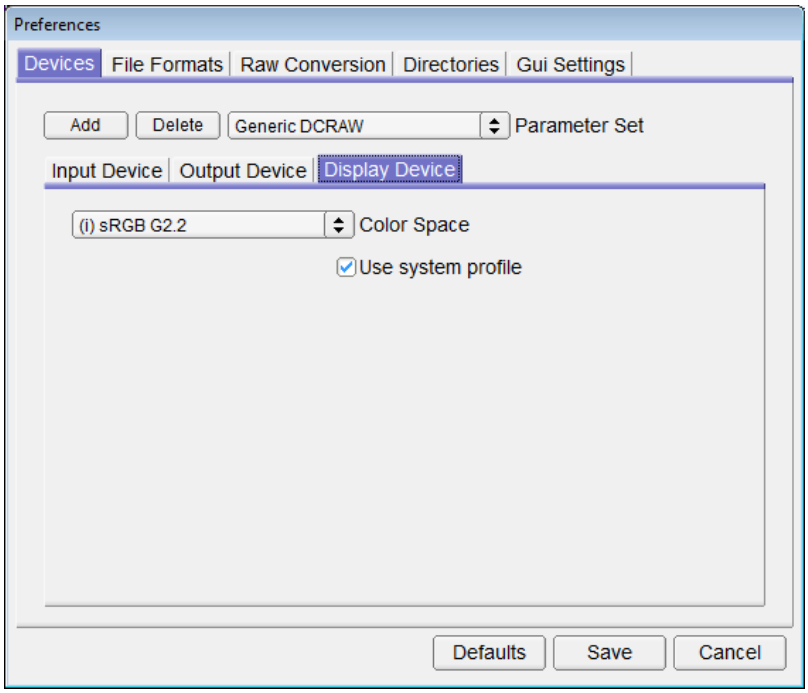
File Type. A textual description of the File Format.

Channel Type. A textual description of the channel type.

Color Space. Describes the color space of the tone mapped image. Choices are the ICC profiles that FDRTools finds in the folder configured at ICC Profiles Directory.

preserve Input Device profile. The tone mapped image is not saved in the color space configured at *Color Space*. Instead the color space configured at Input Device is adopted.Note: be aware of the special meaning that activating this parameter has for RAW images if *Input Device -> preserve embedded profile* is also activated, see explanation above!

5. Display device

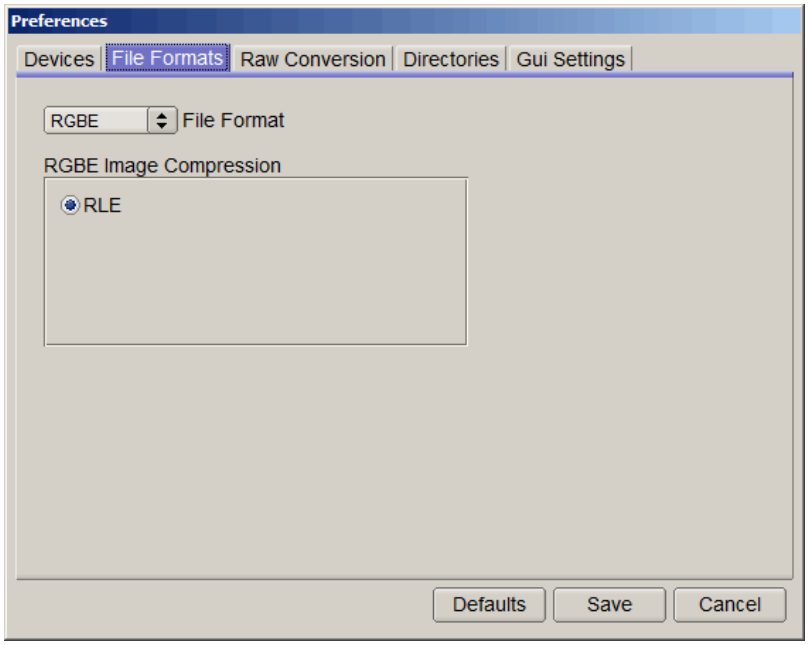


Dialog display device

Color Space. Describes the color space of the display device.

Use system profile. Use the system display profile (if available). This overrides the manually configured profile above.

6. File Formats

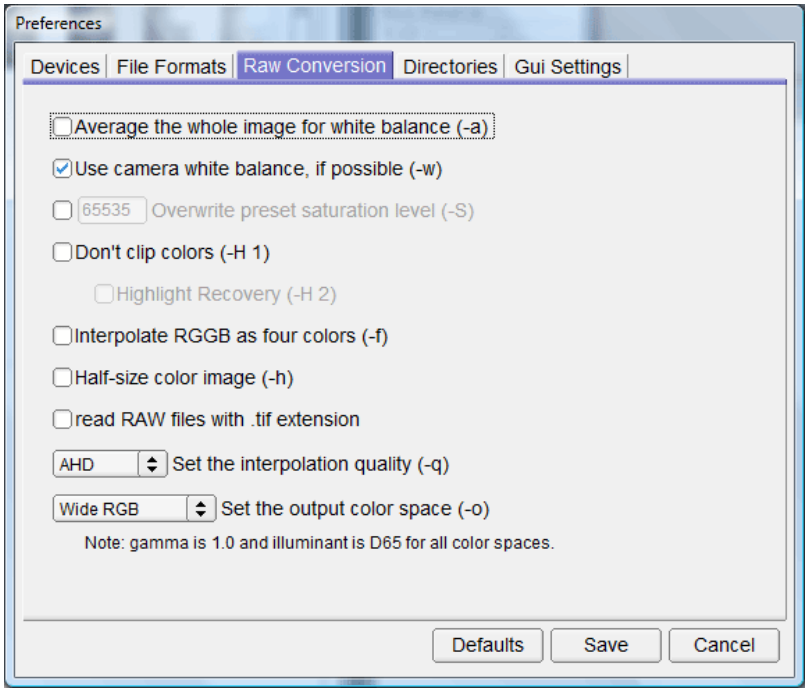


Dialog file formats

File Format. A file format supported by FDRTools.

Image Compression. A compression scheme supported by the selected file format.

7. Raw Conversion



Dialog raw conversion

Average the whole image for white balance. Calculates the white balance correction factors by averaging the whole image. In general this method is not recommended.

Use camera white balance, if possible. Utilizes the values calculated by the camera, if available.

Overwrite preset saturation level. DCRAW has internal presets for the overexposure limits. Beyond these values a color channel is regarded "saturated".In general the preset values are right. However, certain camera models seem to show a strong variation of the saturation levels among individual cameras. One example is the Canon 40D. If the true saturation value of the camera is below the preset value this results in "pink colored highlights". In this case the saturation value can be lowered manually until the pink highlights disappear. More information is available from Guillermo Luijk [http://www.guillermoluijk.com/tutorial/dcraw/index_en.htm]

Don't clip colors. Usually the highlights are clipped to the saturation value. This can be switched off. This normally results in pink colored highlights, see also FAQ [http://fdrtools.com/faq_e.php#105].

Highlight Recovery. With unclipped highlights it is possible to recover details from useable information within the unsaturated red channel. This method makes sense only in case of an emergency, e.g. if only a single RAW image is available. An exposure series is always preferable and yields optimal quality.

Interpolate RGGB as four colors. This option is required by certain camera models.

Half-size color image. Four pixels are combined into one. This results in an image of half width and height, accelerating RAW decoding and further processing within FDRTools.

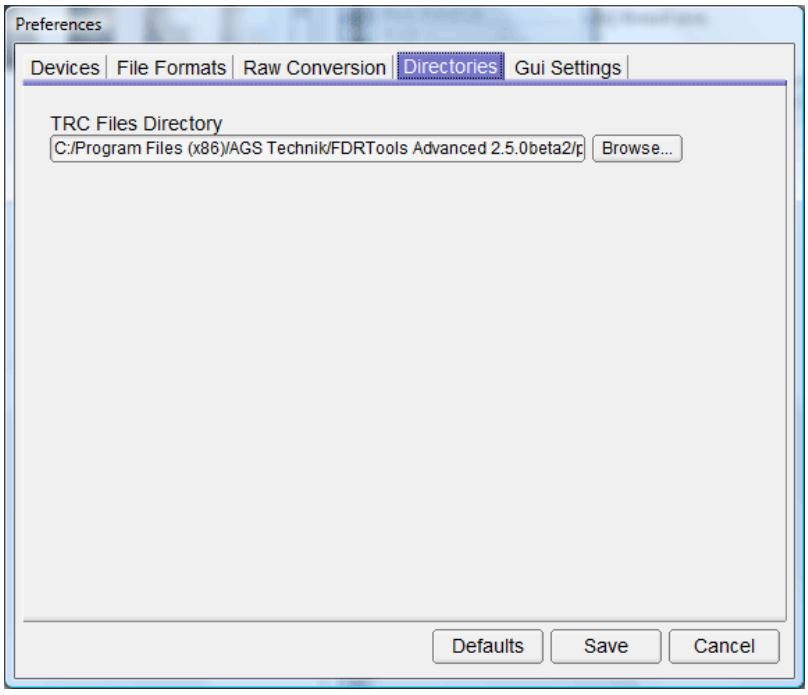
read RAW files with .tif extension. CAUTION: this option adds TIFF to the list of file extensions recognized by DCRAW. Do not check this unless your camera produces RAW files with .tif extension like the Canon 1Ds. Reading 'normal' TIFFs with this option enabled may yield unexpected results!

Set the interpolation quality.

- Bilinear - fast, suboptimal quality
- VNG - "Variable Number of Gradients" interpolation
- PPG - "Patterned Pixel Grouping" interpolation
- AHD - "Adaptive Homogeneity Directed" interpolation (Default)

Set the output color space. During "development" RAW images are converted from a camera specific color space to a device independent color space. Set this color space here. The default value is "Wide Gamut RGB".

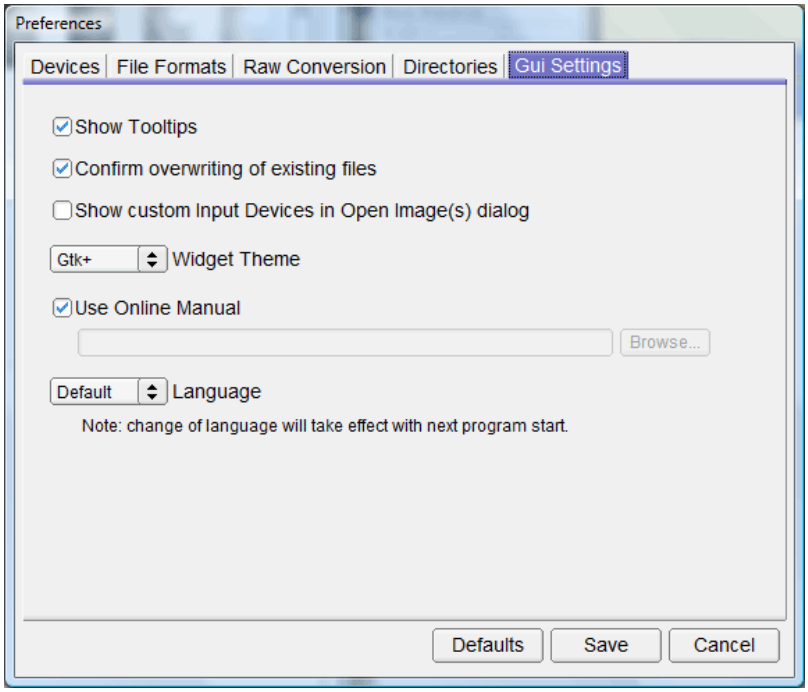
8. Directories



Dialog Directories

TRC Files directory. FDRTools looks this directory for TRC files.

9. Gui Settings



Dialog GUI settings

Show Tooltips. Show a help text if the mouse is moved over a Gui element.

Confirm overwriting of existing files. Protects against unintended overwriting when saving an image.

Show custom Input Devices in Open Image(s) dialog. This switch activates the use of custom Parameter Sets within the file choosing dialog.

Widget Theme. The look of the Gui elements can be adjusted via "themes".

Use Online Manual. With active switch the program uses the online HTML manual from the FDRTools website. If you wish to read "offline" you may also use a HTML manual that is saved locally on your computer. Note that the HTML manual is not part of the software. If you want to use this option go to download pages of the FDRTools web site, load the HTML manual (ZIP archive) down to your computer, unpack the archive somewhere on your computer and navigate to this place via the "Browse..." button.

Language. Sets the language used to display texts in the program. Changing the language setting will take effect with the next program start. The default language is taken from operating system settings.