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[54] DETERMINATION OF AMBIENT LIGHT LEVEL CHANGES IN VISUAL IMAGES

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[22] Filed: Sep. 11, 1990

[51] Int. Cl.[5] G06K 9/00

[52] U.S. Cl. 382/1; 382/37; 382/4; 358/105

[58] Field of Search 382/1, 4, 2, 37, 38, 382/39, 42; 358/105, 108, 109, 101

[56] References Cited

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4,408,224	10/1983	Yoshida	358/108
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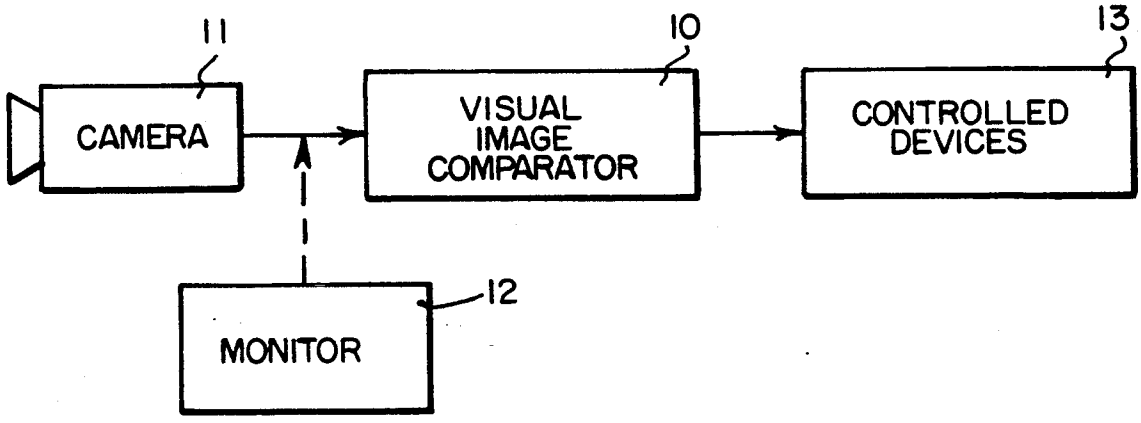
Primary Examiner—Michael Razavi

[57] ABSTRACT

A visual image comparison method is provided, including the steps of: obtaining a first digital representation of a first visual image, where the first digital representation comprises a first plurality of pixels, and each pixel has a gray scale indicative of light intensity; obtaining a second digital representation of a second visual image, where the second digital representation comprises a second plurality of pixels, and each pixel has a gray scale indicative of light intensity; and selectively making a first predetermined number of comparisons of corresponding pixels from the first and second digital representations to determine whether a difference in ambient light intensity exists between the first and second visual images, and, selectively making a second predetermined number of comparisons of corresponding pixels from the first and second digital representations if and only if no difference in ambient light intensity exists between the first and second visual images, and indicating an alarm condition when a percentage of the second predetermined number of comparisons result in pixels having a difference in gray scale of a predetermined amount. Apparatus is also described for the purpose of implementing the method.

3 Claims, 7 Drawing Sheets

Microfiche Appendix Included
(1 Microfiche, 21 Pages)



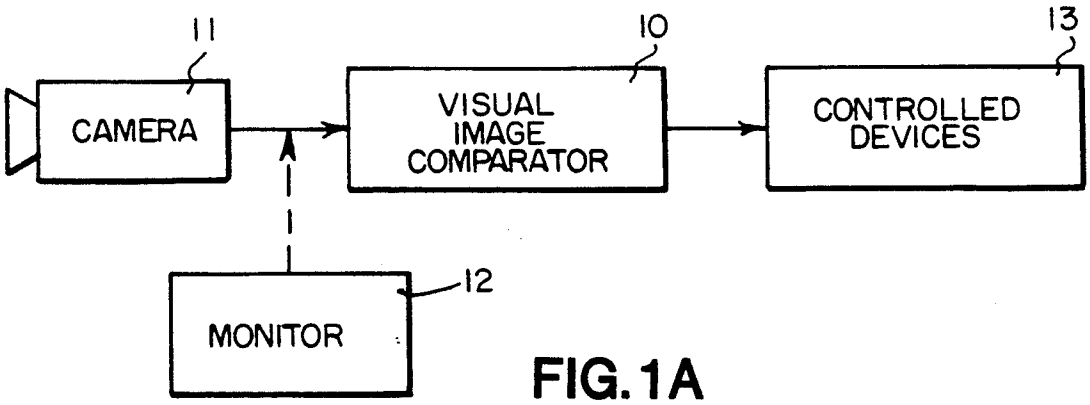

11
CAMERA
10
VISUAL IMAGE COMPARATOR
13
CONTROLLED DEVICES
12
MONITOR

FIG. 1A

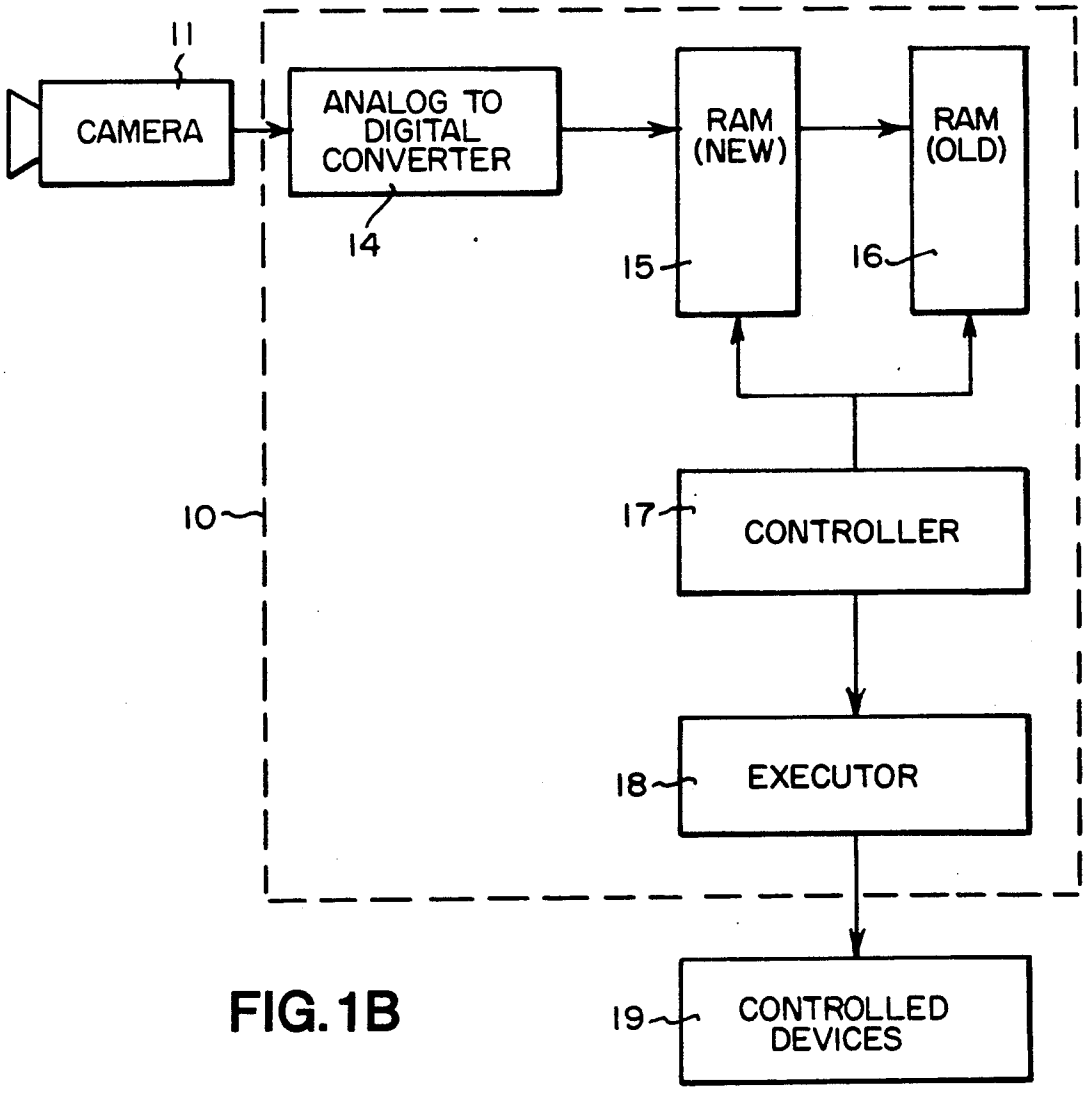

11
CAMERA
ANALOG TO DIGITAL CONVERTER
14
RAM (NEW)
15
RAM (OLD)
16
10
17
CONTROLLER
18
EXECUTOR
19
CONTROLLED DEVICES

FIG. 1B

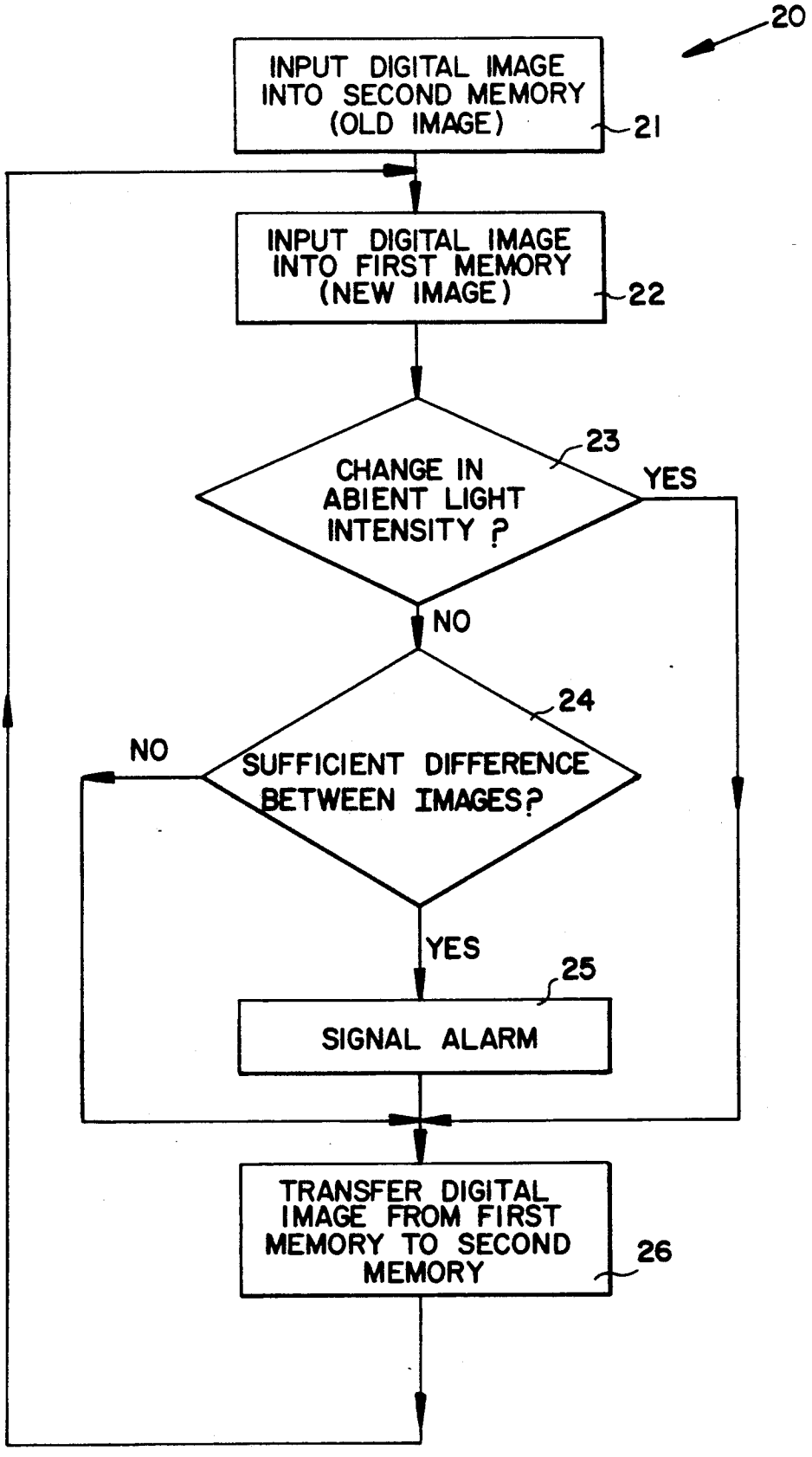

20
INPUT DIGITAL IMAGE INTO SECOND MEMORY (OLD IMAGE)
21
INPUT DIGITAL IMAGE INTO FIRST MEMORY (NEW IMAGE)
22
CHANGE IN ABIENT LIGHT INTENSITY ?
23
YES
NO
SUFFICIENT DIFFERENCE BETWEEN IMAGES?
24
NO
YES
SIGNAL ALARM
25
TRANSFER DIGITAL IMAGE FROM FIRST MEMORY TO SECOND MEMORY
26

FIG.2

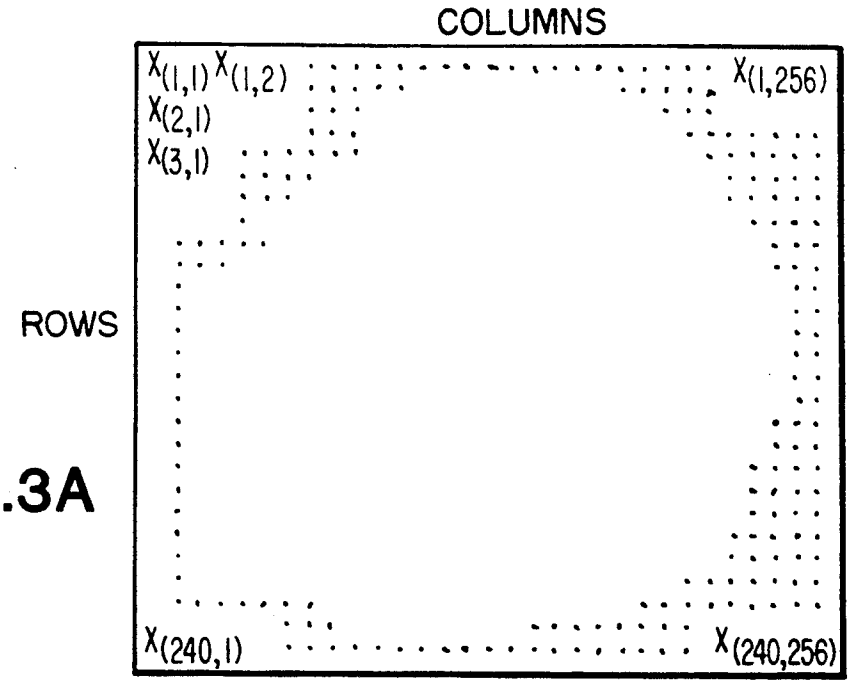

COLUMNS
X(1,1)
X(1,2)
X(1,256)
X(2,1)
X(3,1)
ROWS
X(240,1)
X(240,256)

FIG.3A

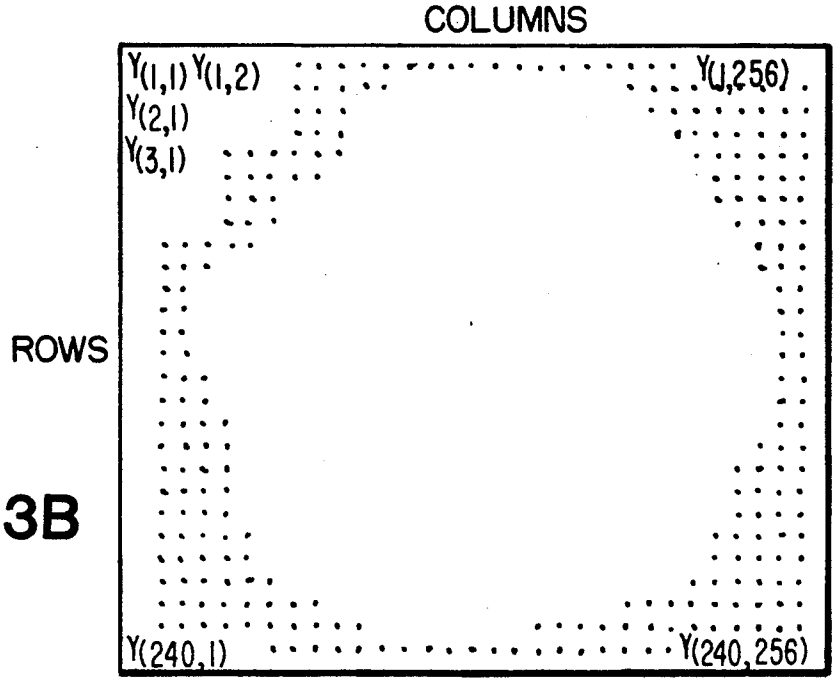

COLUMNS
Y(1,1)
Y(1,2)
Y(1,256)
Y(2,1)
Y(3,1)
ROWS
Y(240,1)
Y(240,256)

FIG.3B

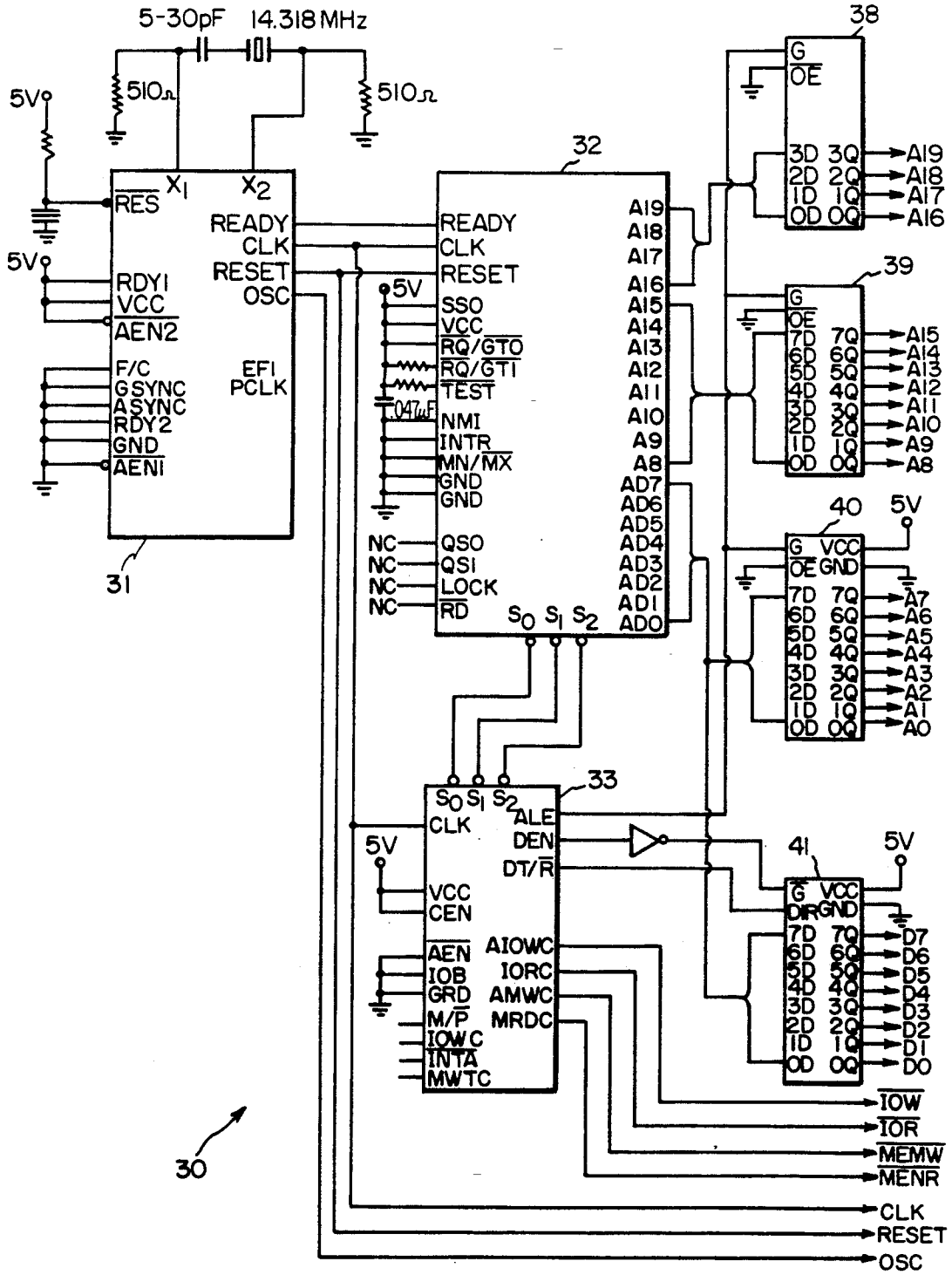

5-30pF
14.318 MHz
510Ω
510Ω
5V
X1
X2
RES
READY
CLK
RESET
OSC
RDY1
VCC
AEN2
F/C
GSYNC
ASYNC
RDY2
GND
AEN1
EFI
PCLK
31
32
READY
CLK
RESET
5V
SSO
VCC
RQ/GTO
RQ/GTI
TEST
.047μF
NMI
INTR
MN/MX
GND
GND
NC
NC
NC
NC
QSO
QSI
LOCK
RD
S0 S1 S2
A19
A18
A17
A16
A15
A14
A13
A12
A11
A10
A9
A8
AD7
AD6
AD5
AD4
AD3
AD2
AD1
AD0
38
G
OE
3D 3Q
2D 2Q
1D 1Q
0D 0Q
A19
A18
A17
A16
39
A15
A14
A13
A12
A11
A10
A9
A8
40
VCC
GND
A7
A6
A5
A4
A3
A2
A1
A0
33
S0 S1 S2
CLK
ALE
DEN
DT/R
VCC
CEN
AEN
IOB
GRD
M/IO
IOWC
INTA
MWTC
AIOWC
IORC
AMWC
MRDC
41
DIR
D7
D6
D5
D4
D3
D2
D1
D0
IOW
IOR
MEMW
MENR
CLK
RESET
OSC
30

FIG.4A

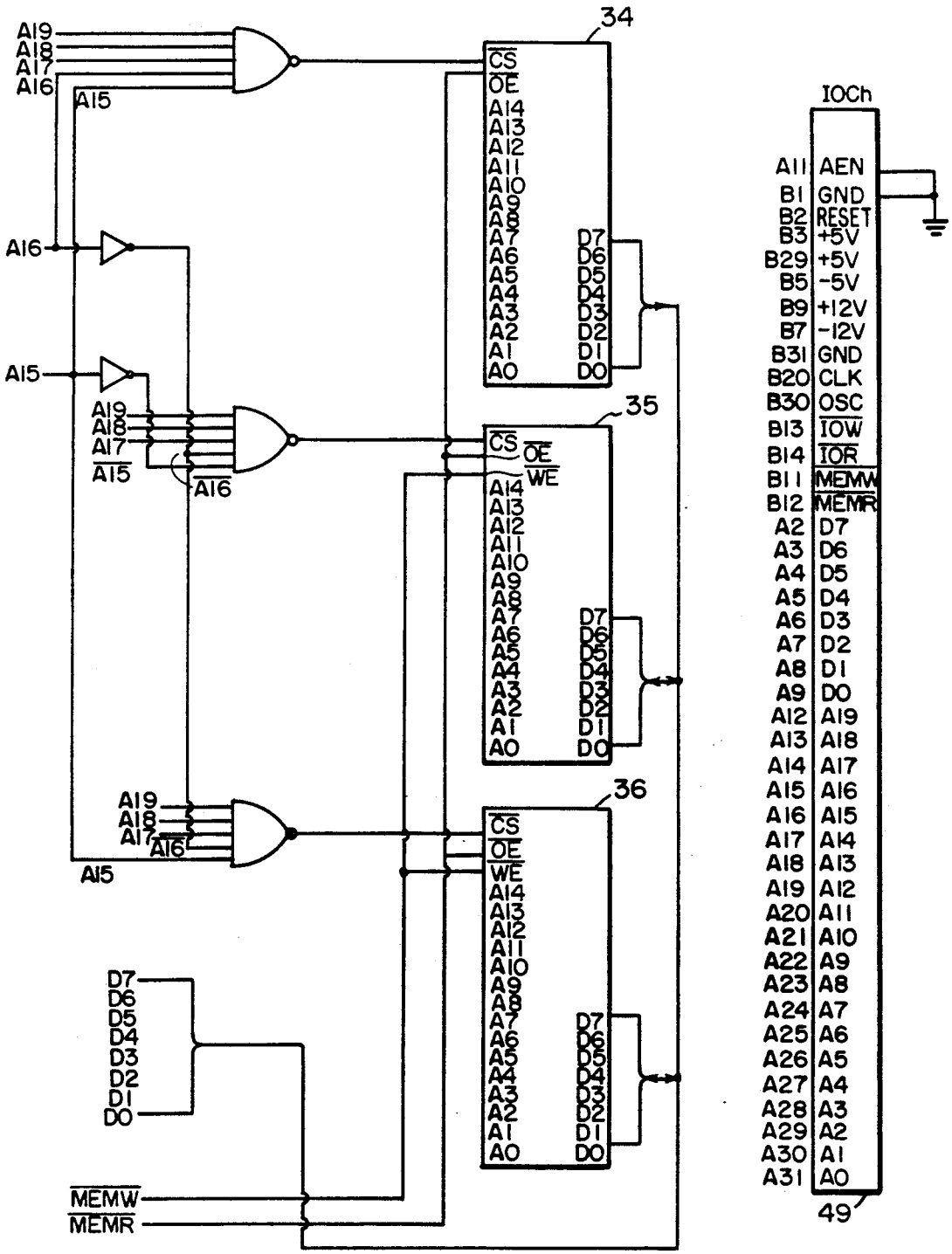

34
35
36
49
IOCh
A19
A18
A17
A16
A15
A14
A13
A12
A11
A10
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
D7
D6
D5
D4
D3
D2
D1
D0
CS
OE
WE
MEMW
MEMR
AEN
GND
RESET
+5V
-5V
+12V
-12V
CLK
OSC
IOW
IOR

FIG.4B

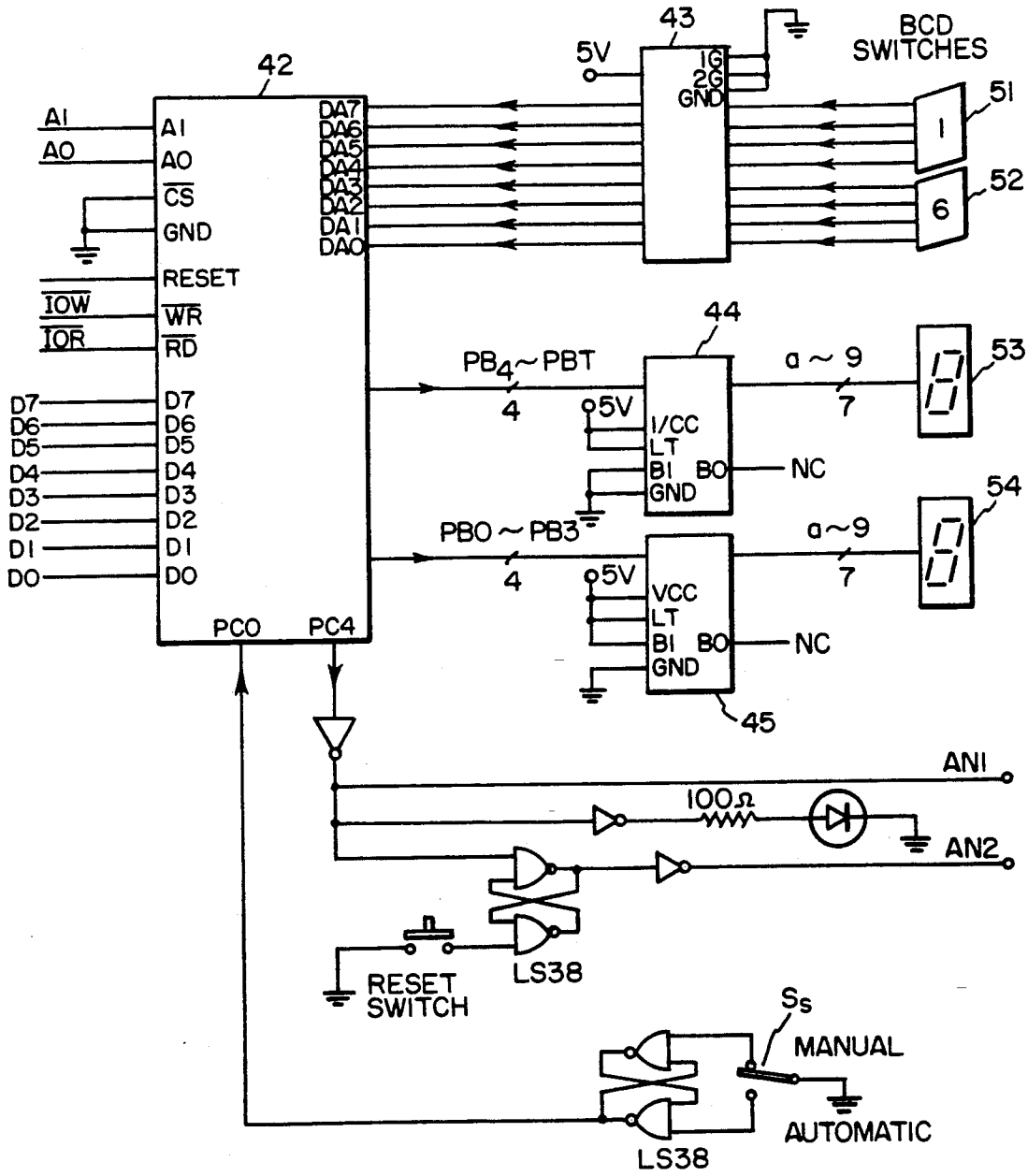

42
43
5V
BCD SWITCHES
51
52
44
53
54
45
A1
A0
CS
GND
RESET
IOW
IOR
WR
RD
D7
D6
D5
D4
D3
D2
D1
D0
DA7
DA6
DA5
DA4
DA3
DA2
DA1
DA0
1G
2G
GND
PB4~PBT
PBO~PB3
4
7
a~9
1/CC
LT
BI
BO
NC
VCC
PC0
PC4
AN1
AN2
100Ω
RESET SWITCH
LS38
Ss
MANUAL
AUTOMATIC

FIG.4C

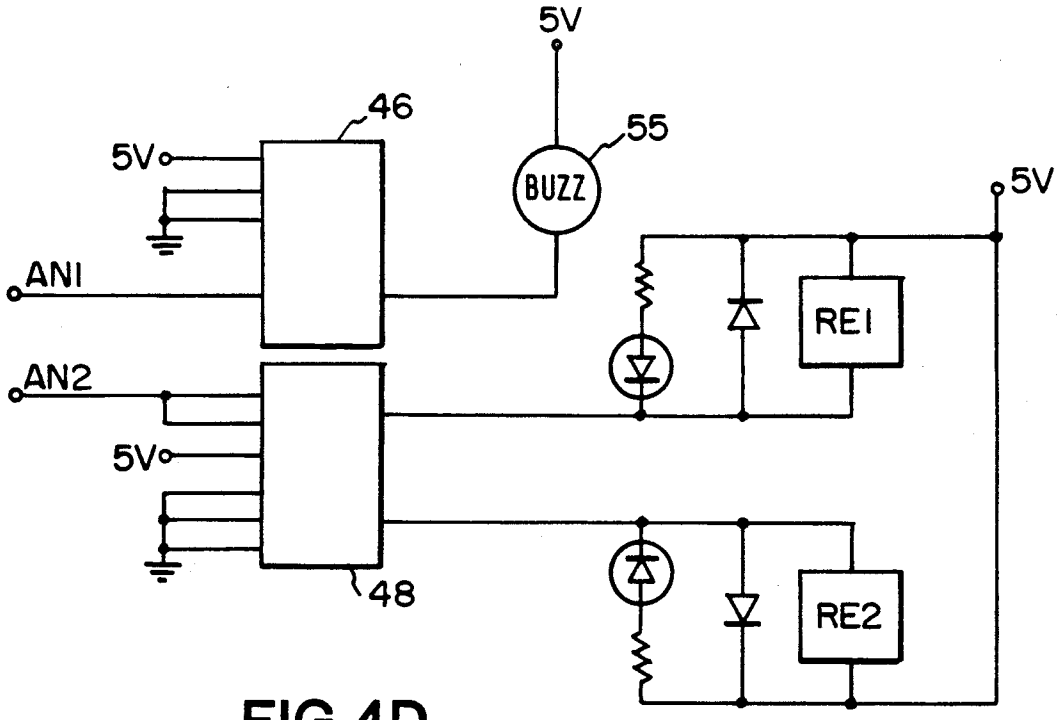

5V
46
55
5V
BUZZ
5V
ANI
AN2
RE1
5V
RE2
48

FIG.4D

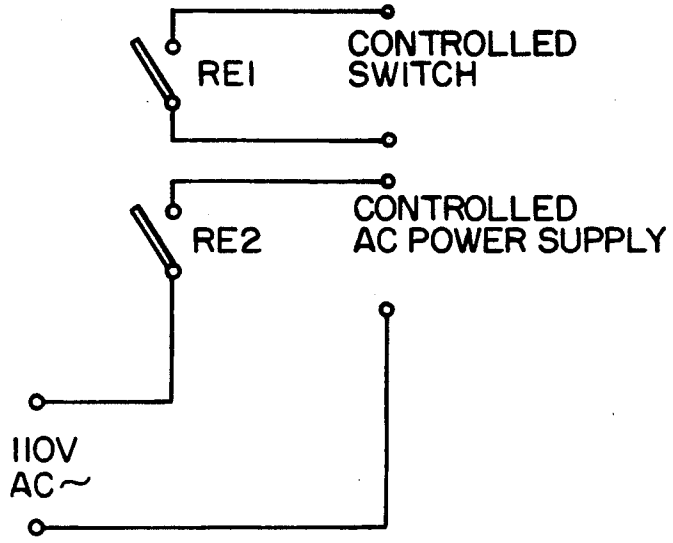

RE1
CONTROLLED
SWITCH
RE2
CONTROLLED
AC POWER SUPPLY
110V
AC~

FIG.4E

DETERMINATION OF AMBIENT LIGHT LEVEL CHANGES IN VISUAL IMAGES

In accordance with 37 C.F.R. 1.96, a microfiche appendix is to be considered a portion of the entire "written description" of this invention in conformance with 35 U.S.C. 112. The appendix includes one microfiche having 21 data frames.

BACKGROUND OF THE INVENTION

The present invention relates generally to video surveillance methods and apparatus and, more particularly, to automatic surveillance systems which detect changes in a field of view over time and indicate an alarm condition accordingly.

The use of video cameras at remote locations for surveillance by video monitors is well known. In some circumstances, constant human supervision or monitoring is required. A typical example of this manual surveillance method would be the remote placement of cameras in a retail store to detect shoplifting; another example would be a camera in a bank activated during working hours to monitor a robbery attempt. Many security systems typically employ a plurality of video cameras situated throughout a facility, with a central monitoring location where a human guard keeps watch. These manual systems are predecessors within the field of the present invention.

Human interaction in surveillance is extremely expensive. In some circumstances, then, it is economical and desirable to replace the human observer with an automatic surveillance system, or at least to alleviate the guard from the burden of constant supervision, freeing him to perform other useful work. Automatic surveillance systems have evolved, therefore, to handle situations which do not require constant human supervision. An example of this application would be the monitoring of an empty room at night, where an automatic system would sense the entry of an intruder and sound an alarm. It may be desired to monitor an outdoor parking lot, or perhaps the entrance or exit of a building. Other applications include monitoring products or workpieces on an assembly line, etc. In a multitude of applications, automatic surveillance methods and systems are more economical and even more reliable than systems requiring constant human interaction.

A common problem encountered by all automatic surveillance systems, both indoor and outdoor, involves false alarms triggered by changes in ambient light intensity. For example, in monitoring an outdoor scene such as a parking lot, a cloud passing overhead may substantially affect ambient light conditions and trigger a false alarm. Even in indoor applications, many offices employ automatic light dimming circuits which dim the lights in the evening, causing problems for automatic surveillance systems.

Attempts to solve the false triggering problem are well documented in the art. One well-known technique involves the use of automatic exposure lenses or cameras to compensate for ambient light intensity variations. Unfortunately, this method is limited to only small variations in intensity. Another alleged solution is proposed by Yoshida in U.S. Pat. No. 4,408,224 (Oct. 4, 1983). Yoshida broadly discloses a surveillance method which includes the comparison of two digitized video image signals taken of a "place scenery" at different points in time. To solve the problem caused by changes in ambient light, Yoshida suggests displacing the capturing of the two video images in time by an amount which is negligible with respect to the ambient changes in brightness. For example, Yoshida suggests that displacing the capture of the images by 15 seconds to 1 minute is suitable to overcome the effects of gradually changing brightness. Unfortunately, this attempt to solve the problem is limited in its usefulness in that it is dependent upon the rate of change of the ambient light intensity. While one time setting may be suitable for slowly changing intensity levels (such as might occur at sunset, dawn, etc.), this same time setting may be unsuitable for rapid changes (such as clouds passing overhead during a thunderstorm, or sudden dimming of lights in an office, etc.).

What is needed, then, is a surveillance system which is not only immune to false alarms caused by changes in ambient light conditions, but also functions independently of the speed with which these ambient changes occur.

SUMMARY OF THE INVENTION

A visual image comparison method is provided, including the steps of obtaining a first digital representation of a first visual image, where the first digital representation comprises a first matrix having a plurality of pixels, and each pixel has a gray scale value indicative of light intensity; obtaining a second digital representation of a second visual image, where the second digital representation comprises a second matrix having a plurality of pixels, and each pixel has a gray scale value indicative of light intensity; and selectively making a first predetermined number of comparisons of corresponding pixels from the first and second digital representations to determine whether a difference in ambient light intensity exists between the first and second visual images, and, selectively making a second predetermined number of comparisons of corresponding pixels from the first and second digital representations if and only if no difference in ambient light intensity exists between the first and second visual images, and indicating an alarm condition when a percentage of the second predetermined number of comparisons result in pixels having a difference in gray scale of a predetermined amount. The first and second visual images can be images obtained at different locations simultaneously, images taken of a single location at different times, or images obtained at different locations at different times. An apparatus is also provided to implement the method of the invention.

A primary object of the invention is to provide a visual image comparison method which functions independently of ambient changes in light intensity between the visual images being compared.

A secondary object is to provide a visual image comparison method which functions independently of the time rate of change of ambient light intensity between a first and second visual image being compared.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a general block diagram of a video surveillance apparatus which utilizes the present invention.

FIG. 1B is a general block diagram similar to FIG. 1A but expanded to show the major elements of the visual image comparator.

FIG. 2 is a flow diagram illustrating the general method of the invention.

FIG. 3A represents a first digital representation of a first visual image, and FIG. 3B represents a second digital representation of a second visual image, which two images are compared by the present invention.

FIGS. 4A–4E illustrate a schematic circuit diagram of an alternative embodiment of the invention which utilizes a dedicated "hard" circuit.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is a visual image comparison system which enables automatic surveillance of a location over time, or simultaneous monitoring of two or more identical or nearly identical objects. The system described herein may be used in homes, museums, stores, offices, and other commercial establishments as well as in hotels, airports, and other special places requiring security measures. The invention may also find applications in industry such as, for example, the monitoring of a workpiece on an assembly line. In addition to security surveillance applications, the system may also be used to compare two visual images (fingerprints, etc.) simultaneously to determine if the images are the same or nearly the same.

The system is used in conjunction with a video camera or other means of providing an analog visual image. A visual image comparator method and apparatus analyzes the analog visual images and sounds an alarm if a sufficient difference exists between two different images.

The apparatus of the invention is outlined in block form in FIG. 1A to show how the invention interacts with auxiliary equipment. Visual image comparator (VIC) **10** represents the present invention, which operates on visual images provided by video camera **11** or, alternatively, by optional video monitor **12**. When a change in non-ambient light intensity or when motion occurs within the field of view of camera **11** (or within monitor **12**), VIC **10** signals an alarm, represented by controlled devices **13** in FIG. 1A. Controlled devices **13** may be any device capable of indicating an alarm (bell, whistle, buzzer, light, etc.) or it may even comprise a video monitor which automatically displays the changing video image when a change occurs. For example, in one application contemplated by the inventors, a video camera is focused on the entrance to a residence. As someone approaches the entrance, the motion is detected by the system. The system may be programmed to display the video camera image on a television set (or to display the image as a "picture-within-a-picture" on the television) to indicate the arrival of a visitor. When the television set is turned off, the system may be programmed to turn on lights or sound audible alarms, etc. (or to turn the television on to display the changing video image). In yet another application, the camera might be focused on an infant's crib to monitor the baby at sleep. If the infant awakens, moves or becomes distressed, the parents can be alerted accordingly.

A preferred embodiment of the invention which shows VIC **10** in more detail is shown conceptually in FIG. 1B. VIC **10** includes A/D converter **14**, $RAM_{(NEW)}$ **15**, $RAM_{(OLD)}$ **16**, controller **17** and executor **18**. A/D converter **14** converts the analog video signal provided by camera **14** into digitized signals. The digital representation of a first visual image so obtained is then stored in $RAM_{(NEW)}$ **15**, which is a random access memory. At a subsequent instant in time, a new image signal is obtained. The digital representation stored in $RAM_{(NEW)}$ **15** is transferred to $RAM_{(OLD)}$ **16**, and the new digital image is stored in $RAM_{(NEW)}$ **15**. Controller **17** controls the transferring of the old image from $RAM_{(NEW)}$ **15** to $RAM_{(OLD)}$ **16** and then compares the old and new images. If a sufficient difference exists between the images, controller **17** sends an alarm signal to executor **18**. Executor **18** activates various auxiliary alarm devices as discussed previously.

In the preferred embodiment depicted in FIG. 1B, both the old and new digitally represented images are stored in separate memories prior to comparison. It should be readily apparent, however, that it is also possible to compare temporally displaced images by only storing the earlier image in memory and then comparing a present or new image to the old in real time, eliminating the need for one of the memories. It is also possible to compare two distinct images simultaneously received by two video cameras at the same time, eliminating both memories. For example, one camera could be focused on an image (such as a fingerprint) while a second camera scans other images looking for a match. An inverter circuit connected to controller **17** or executor **18** would sound an alarm only when a match is found. Similarly, on an assembly line, one camera could be focused on a static image of a workpiece as it should appear at a certain step in assembly, while a second camera is timed to monitor workpieces on the actual assembly line. If the two images don't match, a suitable warning would be given to indicate a possible product defect.

Adverting once again to the preferred embodiment depicted in FIG. 1B, it should be noted that VIC **10** may be implemented in apparatus form in one of at least two ways. In a first embodiment, VIC **10** may comprise software run by a conventional computer such as an IBM PC® or compatible computer. In a second embodiment, VIC **10** may comprise a dedicated circuit specially designed to implement the method of the invention. In either case, the method of comparison is the same, and this method is described herebelow:

The Visual Image Comparison Method

The present invention broadly comprises a visual image comparison method, comprising the steps of: obtaining a first digital representation of a first visual image comprising a first plurality of pixels, where each pixel has a gray scale indicative of light intensity; obtaining a second digital representation of a second visual image comprising a second plurality of pixels, where each pixel has a gray scale indicative of light intensity; selectively making a first predetermined number of comparisons of corresponding pixels from the first and second digital representations to determine whether a difference in ambient light intensity exists between the first and second visual images, and, selectively making a second predetermined number of comparisons of corresponding pixels from the first and second digital representations if and only if no difference in ambient light intensity exists between the first and second visual images, and indicating an alarm condition when a percentage of the second predetermined number of comparisons result in pixels having a difference in gray scale of a predetermined amount.

FIG. **2** illustrates by flow diagram the general method of the invention. To begin the process, it is assumed that a frame of digitized data representative of a second visual image is already stored in a second memory (box **21**). A new image is then digitized and a

new frame of digitized data is stored in a first memory (box **22**). The new and old digital representations of first and second visual images, respectively, are then compared (box **23**). A decision is made as to whether a difference in ambient light intensity exists between the two images. Such a difference would occur, for example, if the sun suddenly disappeared behind a cloud; if a tree branch was moved by the wind in front of the camera lens; at sunset or sunrise, or if the lights in a room were turned on or off, etc. In other words, such a change would likely be distributed somewhat throughout the entire visual field. The essence of the invention is to distinguish between such ambient intensity changes, and other changes, such as might be caused by someone or something entering or leaving the visual field. The invention will indicate an alarm condition for the latter condition, but will not sound a false alarm for the former condition.

If an ambient intensity difference is found to exist in box **23**, control is passed to box **26**, where the digital image previously stored in the first memory is transferred to the second memory (and the image previously stored in the second memory is erased). The method then proceeds back to box **22** where a new image is obtained and stored and the process repeated.

If, on the other hand, no ambient intensity change or difference is detected, control passes directly to box **24**, where a second comparison is done between the first and second visual images. If a sufficient difference exists between the two images, an alarm is indicated (box **25**). Otherwise, control passes to box **26** and the process repeats as described above.

It is the unique method used to compare old and new images which enables the present invention to operate independently of changes in ambient light intensity. This comparison is best understood with reference to FIGS. **3A** and **3B**.

FIG. **3A** represents a first digital representation of a first visual image. The representation comprises a plurality of pixels $X_{(1,1)}$, $X_{(1,2)}$, $X_{(1,3)}$, . . . , $X_{(240,256)}$, where each pixel has an associated gray scale indicative of brightness or light intensity. For example, an individual pixel may have a gray scale, G, ranging from 0 to 63, where 0 indicates black and 63 indicates white, or from 0 to 255, where 0 indicates black and 255 indicates white depending on the interface board used.

Similarly, FIG. **3B** represents a second digital representation of a second visual image, such as that of an image obtained at a later point in time than the first image mentioned previously. The second representation comprises a plurality of pixels $Y_{(1,1)}$, $Y_{(1,2)}$, $Y_{(1,3)}$, . . . , $Y_{(240,256)}$, where each pixel has an associated gray scale as discussed above.

The comparison method of the invention functions by comparing digital representations of corresponding pixels of the first and second images. For example, $X_{(3,1)}$ and $Y_{(3,1)}$ are corresponding pixels. There are three variables which factor into the comparison process as follows:

1. The total number of comparisons of corresponding pixels from each image. (Determined by J, the number of pixels to jump over when making comparisons from each image).
2. The number of comparisons, N, which must yield a difference in gray scale in order to signify an alarm condition.
3. The magnitude, K, of the gray scale difference necessary within a given pixel-pair to signify an alarm condition.

It can be readily appreciated that a comparison of each pixel of the first image with its corresponding pixel of the second image would be extremely time consuming if all 61,440 pixels of each image were compared. Obviously, comparison processing time is related to the number of pixels compared. For example, in a software-driven embodiment of the invention, a comparison of 20,480 pixels (skipping every third pixel) takes approximately 0.71 seconds of processing time, whereas comparing 8,777 pixels (skipping every seventh pixel) takes approximately 0.43 seconds.

Fortunately, it is unnecessary to compare each and every pixel to achieve a system which functions independently of changes in ambient light intensity. Moreover, the number of comparisons needed, the percentage of those comparisons which must show a difference, the spatial distribution of the pixels compared, and the magnitude of the gray difference between pixels being compared are variables dependent upon whether the comparison is being done to determine a change in ambient light intensity, or to determine an alarm condition.

The first comparison of the method determines whether a difference in ambient light intensity exists between the first and second visual images. In a preferred embodiment, experiments indicate that, for an image comprising 61,440 pixels, as few as 1,536 pixels need be compared (skipping every 40th pixel, i.e., $J=40$) and yet still achieve accurate and reliable results. In other words, it is only necessary to compare approximately 2% to about 4% of the total image, assuming that the compared pixels are distributed throughout the image. Of course, more pixels could be compared, but this would increase processing time. The processing time required to compare 1,536 pixels is less than 0.3 seconds.

Experiments also indicate that, for $J=25$–40, N may be in the approximate range of $N=90$–110 to achieve accurate results. In other words, approximately 3% to about 8% of the compared pixel-pairs must exceed the predetermined K value (magnitude of gray difference) in order to indicate a difference in ambient light intensity.

Finally, in making the ambient light comparison, experiments indicate that a low K value is preferred (e.g., $K=2$ or 3) since the change in ambient light may be very small. This is the magnitude, K, of the gray scale difference within a given pixel-pair comparison necessary to signify an alarm condition. For example, if one pixel has a gray scale of 21 and its corresponding pixel has a gray scale of 27, then the gray scale difference is said to be 6 (27−21). The value of K selected affects the sensitivity of the system. The lower the value of K, the more sensitive the system. In a system such as the preferred embodiment where each pixel has a gray scale range from 0 to 63, a K value of 2 to 3 is a difference equivalent to 3%–5% of the total gray scale.

Once again, experimental data suggest that values of $K=2$ or 3 ensure reliable operation in nearly all ambient light conditions. This is not to say that other values of K will not be suitable, only that values of $K=2$ or 3 are preferred. In fact, other values of K have been proven to achieve suitable results, depending upon the ambient light conditions. Obviously, the method will still work

satisfactorily with larger K values, but will simply be less sensitive to changes in ambient light intensity.

Also, it is noted that, in a preferred embodiment, the pixels compared are uniformly distributed throughout the images (i.e., every 25th pixel, every 40th pixel, etc.). This is not to imply that uniform distribution is absolutely necessary, although it is preferred. In checking for ambient light differences, it is necessary, however, that compared pixels be distributed widely throughout the images.

Summarizing, then, in a preferred embodiment, the first comparison to determine if a difference in ambient light intensity exists between the first and second images is preferably made with K=2 or 3, N=90–110, and J=25–40. These ranges are intended to be guidelines and approximations, and it is not intended or implied that other combinations of J, K and N will not work satisfactorily, only that satisfactory results have been obtained when the variables are selected within these ranges.

In the second comparison, or so-called common surveillance mode, a different range of the variables are utilized to determine if an alarm condition exists. It has been determined experimentally that N=2 or 3 achieves satisfactory results when J=3–7. While other values of N may also work, it has been found that N=1 often results in false alarms, and high values of N result in low surveillance sensitivities which may not detect small moving objects within the visual field. Similarly, although larger values of J may work satisfactorily, as J increases small moving objects may not be detected.

In a preferred embodiment, the K value in the second comparison is determined by the average gray scale value of the ambient (AGA) according to Table I below. The average gray scale value of the ambient is determined by adding all of the individual gray scales values (G's) of each considered pixel and then dividing this total by the number of pixels considered.

TABLE I

AGA	1	2	3	4	5	6	7	8	9	10
K	1	2	4	7	9	12	14	16	16	16
AGA	11	12	13	14	15	16	17	18	19	20
K	16	16	16	16	16	16	17	17	17	17
AGA	21	22	23	24	25	26	27	28	29	30
K	18	18	18	18	18	19	19	19	19	19
AGA	31	32	33	34	35	36	37	38	39	40
K	20	20	20	20	21	21	21	22	22	22
AGA	41	42	43	44	45	46	47	48	49	50
K	23	23	23	24	24	24	24	25	25	25
AGA	51	52	53	54	55	56	57	58	59	60
K	26	26	26	27	27	27	28	28	29	29
AGA	61	62	63							
K	30	31	32							

Although K is determined automatically in the preferred embodiment, a less sophisticated embodiment is possible, where K is determined manually and by trial and error by the system operator. For example, if surveillance of an indoor room having a constant ambient light intensity is desired, the operator may manually set the sensitivity level and experiment with persons or objects moving in and out of the visual field until satisfactory results are obtained.

Obviously, increasing the number of pixels compared is one way of increasing the reliability of the system, but at the cost of increasing processing time. Another method of improving reliability without necessarily increasing processing time, is in the selection of the number of comparisons which must indicate a difference in gray scale in order to signify an alarm condition. Moreover, it is not necessary to actually make all the planned comparisons if, for example, a sequence of early comparisons indicate a problem. For instance, if 2,458 comparisons are to be made, but only 90 comparisons indicating a difference are required to signal an alarm, then the processing can stop as soon as the 90th comparison indicating a difference is reached. This may occur at any time (i.e., on the 2,450th comparison or even on the 90th comparison, etc.). This manner of processing ensures reliability by preventing false alarms while minimizing processing time.

A First Physical Embodiment For Implementing The Method

In a first embodiment, the method of the invention may be implemented using a software driven system of a personal computer, such as an IBM-PC or equivalent. The software necessary to implement the system is included in the microfiche appendix. Also required in a video imaging interface for converting the analog video signal to digital signals for processing by the computer. In a preferred software driven embodiment, a Model DT2803 "Frame Grabber" was used as the video interface (available from Data Translation, Inc., 100 Locke Drive, Marlborough, Massachusetts 01752-1192). Of course, any commercially available equivalent video imaging interface could be used in lieu of the DT2803.

The DT2803 Frame Grabber is a single-board, microprocessor-based video imaging interface, suitable for use with the IBM personal computer series (IBM PC/AT/XT) and functionally IBM-compatible personal computers. This video interface provides real-time 6-bit digitization of an RS-170/RS-330/NTSC or CCIR/PAL compatible input signal. The DT2803 plugs into the PC backplane, and includes a video imaging input analog to digital converter and look-up tables, a 64 kilobyte frame-store memory, a video imaging output digital to analog converter and look-up tables, and microprocessor and control logic. For a more complete description of the capabilities and operation of the video imaging interface, the reader is referred to the User Manual for the DT2803 Low-Cost Frame Grabber, available as Document UM-03286A, copyright 1985, by Data Translation, Inc. This document is incorporated herein by reference as representative of the general state of the art with respect to video imaging interfaces.

The software included in the microfiche appendix is self-executing. After booting up the computer and loading the software, the user merely types the word "ALARMS" on the keyboard and then follows the self-explanatory menu driven instructions for setting the system sensitivity. If desired, the user can omit setting sensitivity levels, in which case the levels are automatically set by the software.

In the software driven embodiment, video camera **11** provides analog video signals to analog-to-digital converter **14** (DT2803), and the digital signals are then processed by the computer as previously described. When an abnormal or alarm condition is detected by the system, the software sounds an audible alarm through the internal speaker of the computer. With minor software modification, the system can also be programmed to sound an external alarm. For this purpose, an additional output port interface board is required, such as DT2801, also available from Data Translation, Inc.

Commercially available equivalent interfaces are also suitable.

A Second Physical Embodiment For Implementing The Method

FIGS. **4A–4E** represent a second physical embodiment for implementing the method of the invention. This second embodiment is a hard or dedicated circuit designed specifically to implement the method of the invention.

Dedicated circuit **30** comprises I/O channel socket **49**, which interconnects with an image processing interface board (e.g., DT2803, available from Data Translation, Inc., or equivalent) to accept digitized video signals which are stored in the 64 k random access memory (RAM) on the board. RAMs **35** and **36** are used to store the old frame image signals for later comparison with the new signals stored in memory on the interface board. RAMs **35** and **36** comprise 64 k of memory (43256-10L, or equivalent). Erasable programmable read-only memory (EPROM) 34 (27C256-20, or equivalent) is used to store the control program, similar to ALARM-U or ALARM-S used in the first embodiment. Central processing unit **32** (8088 or equivalent) controls the operations of the entire circuit. Latches **38**, **39** and **40** (74LS373 or equivalent) are used to latch the address signals **A0**, **A1**, . . . **A19**, and send them to the appropriate chips as required. Bus transceiver **41** (74LS245 or equivalent) is used to transmit and receive data signals. Clock generator **31** (8284 or equivalent) produces CLK and OSC signals to synchronize the whole system. Programmable input/output interface chip **42** (8255A or equivalent) is used to input the manual sensitivity setting (using BCD switches **51** and **52** and octad driver **43** [74LS244 or equivalent]) and to output the sensitivity display (via 7 segment decoder/-drivers **44** and **45** [74ls47 or equivalent] to displays **53** and **54**, respectively) and to send out alarm signals AN1 and AN2 which can drive buzzer **55** via driver **46** (74563 or equivalent) or other alarm devices via relays **RE1** and **RE2** driven by driver **48** (74563 or equivalent). The reset switch is used to reset the relays and sensitivity switch S_5 is used to select either manual sensitivity (selected by BCD switches **51** or **52**) or automatic sensitivity (selected by the software).

While the form of the apparatus used to implement the method of the invention as described herein constitutes a preferred embodiment of this invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention as defined in the claims.

What is claimed is:

1. A visual image comparison method for automated video surveillance, comprising the steps of:

a. obtaining a first digital representation of a first visual image, said first digital representation comprising a first plurality of pixels, wherein each pixel has a gray scale indicative of light intensity;

b. obtaining a second digital representation of a second visual image, said second digital representation comprising a second plurality of pixels, wherein each pixel has a gray scale indicative of light intensity;

c. selectively making a first predetermined number of first comparisons of corresponding remotely displaced pixels from said first and second digital representations to determine whether a difference in ambient light intensity exists between said first and second visual images, wherein said difference in ambient light intensity is defined to exist when a first percentage of said first predetermined number of first remotely displaced comparisons result in pixels having a difference in gray scale of a first predetermined amount; and,

d. selectively making a second predetermined number of second comparisons of corresponding near neighboring pixels from said first and second digital representations if and only if no significant difference in ambient light intensity exists between said first and second visual images,

e. and indicating an alarm condition when a second percentage of said second predetermined number of second near neighboring comparisons result in pixels having a difference in gray scale of a second predetermined amount.

2. A method as described in claim **1** wherein said second predetermined amount of difference in gray scale is defined as "K2" and K2 is determined automatically based on an average gray scale value of ambient light within the visual images being compared in said first comparison, wherein said average gray scale value is defined as "AGA", and wherein the average gray scale of the ambient is determined by adding all of the individual gray scales values (G's) of each considered pixel and then dividing this total by the number of pixels considered wherein K2 is determined according to Table I herebelow:

TABLE I

AGA	1	2	3	4	5	6	7	8	9	10
K2	1	2	4	7	9	12	14	16	16	16
AGA	11	12	13	14	15	16	17	18	19	20
K2	16	16	16	16	16	16	17	17	17	17
AGA	21	22	23	24	25	26	27	28	29	30
K2	18	18	18	18	18	19	19	19	19	19
AGA	31	32	33	34	35	36	37	38	39	40
K2	20	20	20	20	21	21	21	21	21	21
AGA	51	52	53	54	55	56	57	58	59	60
K2	26	26	26	27	27	27	28	28	29	29
AGA	61	62	63							
K2	30	31	32							

3. A visual comparison apparatus, comprising:

a. means for obtaining a first digital representation of a first visual image, said first digital representation comprising a first plurality of pixels, wherein each pixel has a gray scale indicative of light intensity;

b. means for obtaining a second digital representation of a second visual image, said second digital representation comprising a second plurality of pixels, wherein each pixel has a gray scale indicative of light intensity;

c. means for selectively making a first predetermined number of first remotely displaced comparisons of corresponding pixels from said first and second digital representations to determine whether a difference in ambient light intensity exists between said first and second visual images, wherein said difference in ambient light intensity is defined to exist when a first percentage of said first predetermined number of first remotely displaced comparisons result in pixels having a difference in gray scale of a first predetermined amount; and,

d. means for selectively making a second predetermined number of second comparisons of corresponding near neighboring pixels from said first and second digital representations if and only if no

significant difference in ambient light intensity is found to exist,

e. and indicating an alarm condition when a second percentage of said second predetermined number of second near neighboring comparisons result in pixels having a difference in gray scale of a second predetermined amount.

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