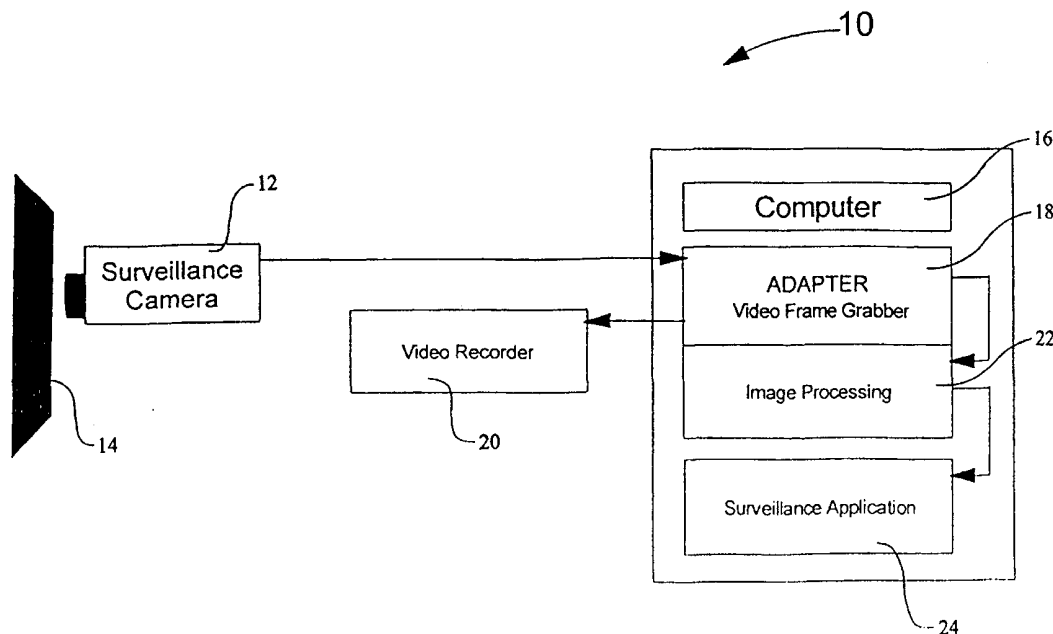




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(54) Title: SYSTEM AND METHOD FOR MONITORING VISIBLE CHANGES



(57) Abstract

A method for monitoring a field of view (14) for visible changes is disclosed. A first image is taken in a predetermined manner of the field of view to be monitored, and then an array divides the first image into a plurality of cells (36). A second image is taken in the predetermined manner of the field of view to be monitored. The array is also applied to the second image, dividing the second image (38) into the plurality of cells. Predetermined groups of cells of the second image are then compared to the same groups of cells of the first image, and the number of the groups of cells that changed from the first image to the second image is computed. In some situations only certain groups of cells are compared.

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EE	Estonia						

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Description

System and Method for Monitoring Visible Changes

5 Background of the Invention

1. Field of the Invention

The present invention relates generally to methods and apparatus for video or other photographic security systems.

10

2. Description of Related Art

Security systems using video cameras have been in use for many years. United States patent number 5,099,322 shows a system for detecting scene changes using a video security system. United States patent number 5,471, 239 show the system for using video frame compression and numerical comparison to detect scene changes.

15

Summary of the Invention

In a method for monitoring a field of view for visible changes, according to the present invention, a first image is taken in a predetermined manner of the field of view to be monitored, and then an array divides the first image into a plurality of cells. The first image divided by the array is then stored, and a second image is taken in the predetermined manner of the field of view to be monitored. The array is also applied to the second image, dividing the second image into the plurality of cells. Cells are combined into predetermined groups. The groups could be individual cells, which is to say groups of one cell each. The groups could be rows of cells or columns of cells or rectangular groupings which in effect create larger cells. The predetermined groups of cells of the second image are then compared to

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the same groups of cells of the first image, and the number of the groups of cells that changed from the first image to the second image is computed. In some situations only certain groups of cells are compared. If a parrot is moving around in a cage, then the cells or the groups of cells which might show the parrot are not compared, or if there are several ceiling fans which are moving, then the cells or the groups of cells which show the ceiling fans might not be compared. There are also other ways of handling these problems which are also described.

In one preferred form of the method, each cell of the first image is given a numerical value based upon the information in each cell, and each cell of the second image is also given a numerical value based upon the information in each cell. Each group of cells is also given a numerical value based on the numerical value of the cells within the group. The simplest method is to make the numerical value of each group equal to the sum of the numerical values of the cells within the group, but manipulation would work as long as the numerical value of the group changes when the numerical value of its cells change. Computing how many groups of the cells changed from the first image to the second image is simply a matter of computing the difference between the numerical value of each group of cells in the second image and in the first image.

In one arrangement, each cell is a single picture element, known as a pixel. A pixel has a its own brightness ranging from 0 for black to a maximum value, typically 255, for white, and the numerical value of each cell is the brightness of the pixel. There is still a brightness number for color images, but color scales could also be used. The numerical value of each group of cells is determined by an image algorithm, which in one preferred form is simply taking the sum of the brightness for the pixels in the group. In one such arrangement, the predetermined groups of cells comprises a single group.

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In one method according to the present invention, the number of the groups of cells which changed in numerical value by more than a predetermined amount is also computed.

5 One method, according to the present invention, also includes the step of comparing the number of the groups of cells that changed from the first image to the second image to a predetermined number. If the parrot moving in its cage, or a cat climbing on the furniture is small enough to never be in more than the predetermined number groups of cells, then if more than the predetermined number groups of cells changed, then it was not caused by the parrot or the cat.

10 Another method, according to the present invention, for monitoring a field of view for visible changes, includes the steps of taking a sequence of video images in a predetermined manner of the field of view to be monitored, creating a sequence of images, and creating an array which divides each of the images into a plurality of cells. Each image divided by the array is stored and the groups of cells of each
15 image are compared to the same groups of cells of the other images. Again, this could just be predetermined groups of cells which are less than all of the groups of cells. It is then computed if there is a cyclical change in any of the predetermined groups of cells during the sequence. This cyclical change could be the rotation of a ceiling fan or the movement of a flower arrangement caused by the blowing of an air
20 conditioner. Similar to that already described, each cell of each image is given a numerical value based upon the information in that cell, and each group of cells is given a numerical value based upon the numerical value of the cells within that group, and computing if there is a cyclical change in any of the predetermined groups of cells during the sequence becomes computing if there is a cyclical change
25 in any of the numerical values of the predetermined groups of cells during the sequence. In a preferred form, the number of the predetermined groups of cells that changed from one image of the sequence to the next image of the sequence and was not part of a cyclical change is computed.

These and other objects, advantages and features of this invention will be apparent from the following description taken with reference to the accompanying drawing, wherein is shown a preferred embodiment of the invention.

5 Brief Description of the Drawing

FIGURE 1 is a block diagram representation of a system for monitoring a field of view for visible changes in accordance with a present invention:

FIGURE 2 is a flow diagram of a method for monitoring a field of view for visible changes in accordance with the present invention:

10 FIGURE 3 is a representation of a first image and array in accordance with the present invention:

FIGURE 4 is a representation of a second image and array in accordance with a present invention:

15 FIGURE 5 is an alternative representation of a second image and array in accordance with present invention; and

FIGURE 6 is a representation of the first image and array of Figure 3 showing the use of a preferred algorithm.

Description of the Preferred Embodiment

20 Referring now to the drawing, and in particular to Figure 1, a system according to the present invention is referred to generally by reference to 10. Surveillance camera 12 can be in a fixed position and angle with respect to field of view 14 to be monitored, although this is not necessary, and can even work with a fixed lens so that any image that it takes of field of view 14 will be identical except
25 for changes in field of view 14 itself. Images from video camera 12 are fed to computer 16 where they are input as video images via video image grabber 18. Video image grabber 18 can be anything compatible with the particular video camera, such as a 256 gray scale or a red, green, blue (RGB) scale adapter. The

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video images are transmitted from video image grabber 18 to both video recorder 20 and image processor 22. Once each image has been processed, the information about that image is made available to the surveillance application program 24. Video recorder 20 can be a video cassette recorder (VCR) or a digital versatile disk (DVD, formerly "digital video disk") or some other kind of recorder.

5 Referring also to Figure 2, Figure 3, Figure 4 and Figure 5, method for monitoring a field of view for visible changes, according to the present invention, is referred to generally by reference in 26. After the video image grabber 18 is initialized 28, a first or benchmark image 30 is taken by video camera 12 in a
10 predetermined manner of the field of view 14 to be monitored, which is read 32, and then an array 34, which can be a matrix or grid or other array, divides the first image into a plurality of cells 36. The first image divided by the array is then stored, and a second image 38 is taken in the predetermined manner of the field of view to be monitored, which is captured 40. Array 34 is also applied to the second image,
15 dividing the second image into the plurality of cells. The cells of each row R2-1 through R2-10 of the second image are grouped and the cells of each row R1-1 through R1-10 of the first image are grouped 42. The rows of the second image are then compared to the rows of the first image, and the number of the rows that changed from the first image to the second image is computed. This could, of
20 course, be done using columns rather than rows, and in a preferred form, rows and columns are alternately compared. In some situations only certain groups are compared. If a parrot is moving around in a cage, then the cells which might show the parrot are not compared, or if there are several ceiling fans which are moving, then the cells which show the ceiling fans might not be compared by the comparison
25 algorithm. There are also other ways of handling these problems which are also shown. In the situation illustrated in Figure 4, a cat 46 has moved into field of view 14 explained the first image and the second image. Cat 46 can occupy up to three rows. The compare against standard 44 portion of the program can simply be

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instructed to ignore changes in no more than three rows so that the cat will not give a false alarm. Referring now to figure 5, an alternative second image is referred to by reference number 48. In this case, a human being 50 has entered field of view 14. Human being 50 occupies all ten rows so that there is no danger in the present invention of thus taking human being 50 for cat 46 for vice versa. If columns were used in this case, the man could take two to three columns as could the cat. Alternating comparisons of rows and columns, or comparing both, avoids mistakes from such situations.

Figure 5 could, of course, be the first image and Figure 3 be the second image, in which case, the present system would detect human being 50 leaving field of vision 14. In such a case, since human being 50 occupies the same space as he moves, he can move within the image without triggering an alarm, depending on the comparison algorithm used.

In one preferred form of the method, each cell of the first image is given a numerical value based upon the information in each cell, and each cell of the second image is also given a numerical value based upon the information in each cell. Computing how many groups of the cells changed from the first image to the second image is simply a matter of computing the difference between the numerical value of each cell in the second image and in the first image.

In a preferred arrangement, each cell comprises a pixel, the numerical value of each cell comprises the brightness of the pixel; and the numerical value of each group of cells comprises the sum of the brightness for the pixels in the group. In an arrangement wherein the predetermined groups of cells comprises a single group, the comparison number is a single number that can be quickly calculated since it is simply the sum of the pixel brightness numbers. Then the single number is compared for the first image and the second image. This can be implemented with a minimum of computer power, making it easy to monitor many different cameras. In another arrangement, each group of cells is a row of cells, wherein a single number

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can be obtained by a sum of row sums. It would work the same for columns. Once again, a sum of row sums could be used alternately with a row of column sums or both sum of row sums and column sums, again obtaining a single number for comparison, would work as well.

5 In a more general sense, if we define "image mass" as anything which can be measured about an image, such as the sum of the brightness numbers for all of the pixels, then a preferred form of the present invention is to compare the image mass of the first image with the image mass of the second image. Such a system makes it possible for a guard station to operate with a single monitor, television or other
10 video screen. Whenever a significant change is detected, then the monitor, television or other video screen is switched to that camera where the change was detected, while sounding an audible alarm at the guard station to alert the guard that a change has been detected. Besides relieving the tedium of monitoring many different sites where nothing is happening, it would simplify monitoring so that
15 many different sites could actually be monitored at a police station. Once the alarm has been sounded, then whoever is monitoring the site can display both the benchmark image and the image which changed enough to trigger the alarm in addition to the current image, both of which are stored on video recorder 20 or can view a live image directly from surveillance camera 12. If it appears to be a false
20 alarm, then the person monitoring the site can reset a new benchmark from the computer.

In one method according to the present invention, the number of the cells or groups of cells and which changed in numerical value by more than a predetermined amount is also computed.

25 One method, according to the present invention, also includes the step of comparing 44 the number of the groups of cells that changed from the first image to the second image to a predetermined number. If the parrot moving in its cage, or a cat climbing on the furniture is small enough to never be in more than the

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predetermined number of groups of cells, then if more than the predetermined number of groups of cells changed, then it was not caused by the parrot or the cat.

Another method, according to the present invention, for monitoring a field of view for visible changes, includes the steps of taking a sequence of video images in a predetermined manner of the field of view to be monitored, creating a sequence of images, and creating an array which divides each of the images into a plurality of cells. Each image divided by the array is stored and groups of the cells of each image are compared to the same groups of cells of the other images. Again, this could just be predetermined groups of cells which add to less than all of the cells. It is then computed if there is a cyclical change in any of the predetermined groups of cells during the sequence. This cyclical change could be the rotation of a ceiling fan or the movement of a flower arrangement caused by the blowing of an air conditioner. Similar to that already described, each cell of each image is given a numerical value based upon the information in that cell, and computing if there is a cyclical change in any of the predetermined groups of cells during the sequence becomes computing if there is a cyclical change in any of the numerical values of the predetermined groups of cells during the sequence. In a preferred form, the number of the predetermined cells that changed from one image of the sequence to the next image of the sequence and was not part of a cyclical change is computed.

Referring now specifically to Figure 6, one image algorithm according to the present invention sums rows or columns of cells by assigning each cell a unique numerical value. In the case illustrated, the cells are numbered from left to right beginning at the top. The value of each cell is added to the value of a row or column if a visible item, other than background such as wallpaper, occupies part of that cell. For the field of view illustrated, a table occupies cells 41.

42, 43, 51, 52, 53, 61, 62, 63, 71 and 72. A bookcase occupies cells 4, 5, 6, 14, 15, 16, 24, 25, 26, 34, 35, 36, 44, 45, 46, 54, 55, 56, 64, 65 and 66. A chair occupies cells 39, 48, 49, 50, 58, 59, 60, 68, 69, 70, 78, 79 and 80. The value of groups, where a group

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is a row, far from the top: 15, 45, 75, 144, 408, 498, 588, 380, zero and zero. This algorithm has several advantages over using image compression. The algorithm is very simple, for each cell has affixed value which uses that value when the cell is occupied and a value of zero when that cell is not occupied. The value of a row is
5 equal to the sum of the occupied cell numbers in that row. Similarly, the value of a column would be the sum of the occupied cell numbers in that column. The sum of row sums or the sum of column sums is the number 2153 shown in the lower right corner. As before, sum of row sums could be alternated with row of column sums or the two could be added together, in which case the number in the lower right corner
10 would be doubled.

From the foregoing it will be seen that this invention is well adapted to attain all of the ends and objectives hereinabove set forth, together with other advantages which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility
15 and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the figures of the accompanying drawings is to be interpreted as
20 illustrative and not in a limiting sense.

The Claims

1. A method for monitoring a field of view for visible changes, comprising in combination the steps of:
 - 5 taking a first image in a predetermined manner of the field of view to be monitored:
 - dividing the first image into a plurality of cells;
 - taking a second image in the predetermined manner of the field of view to be monitored after creating the first image;
 - 10 dividing the second image into the plurality of cells; and
 - comparing predetermined groups of cells of the second image to the same predetermined groups of cells of the first image.

2. A method according to Claim 1, further comprising the steps of:
 - 15 giving each cell of the first image a numerical value based upon the information in each cell:
 - giving each cell of the second image a numerical value based upon the information in each cell;
 - giving each group of cells a numerical value based upon the
 - 20 numerical value of the cells within that group; and
 - wherein comparing predetermined groups of cells of the second image to the same predetermined groups of cells in the first image comprises computing the difference between the numerical values of each group of cells in the second image and in the first image.

- 25 3. A method according to Claim 2 wherein:
 - each cell comprises a pixel; and
 - the numerical value of each cell comprises the brightness of the pixel.

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4. A method according to Claim 3 wherein the numerical value of each group of cells comprises the sum of the brightness for the pixels in the group.
5. A method according to Claim 4 wherein the predetermined groups of cells comprises a single group.
6. A method for monitoring a field of view for visible changes, comprising in combination the steps of:
 - 10 taking a sequence of images in a predetermined manner of the field of view to be monitored:
 - dividing each of the images into a plurality of cells;
 - comparing a plurality of predetermined groups of cells of each image to the same groups of cells of the other images; and
 - 15 computing if there is a cyclical change in any of the predetermined groups of cells during the sequence.
7. A method according to Claim 6, further comprising the steps of:
 - 20 giving each cell of each image a numerical value based upon the information in that cell;
 - giving each group of cells of each image a numerical value based upon the numerical value of the cells within that group; and
 - wherein computing if there is a cyclical change in any of the predetermined groups of cells during the sequence comprises computing if
 - 25 there is a cyclical change in any of the numerical values of the predetermined groups of cells during the sequence.
8. A method according to Claim 7, wherein:

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each cell comprises a pixel;
the numerical value of each cell comprises the brightness of the pixel;
and
the numerical value of each group of cells comprises the sum of the
5 brightness for the pixels in the group.

9. A method according to Claim 8. wherein the predetermined groups of cells
comprises a single group.

10 10. A method for monitoring a field of view for visible changes, comprising in
combination the steps of:
taking a first image in a predetermined manner of the field of view to
be monitored:
dividing the first image into a plurality of areas;
15 taking a second image in the predetermined manner of the field of
view to be monitored after creating the first image:
dividing the second image into the plurality of areas:
comparing predetermined areas of the second image to the same areas
of the first image: and
20 computing the number of the predetermined areas that changed from
the first image to the second image.

11. A method according to Claim 10. further comprising the steps of:
giving each area of the first image a numerical value based upon the
25 information in each area:
giving each area of the second image a numerical value based upon
the information in each area: and

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wherein computing the number of the predetermined areas that changed from the first image to the second image comprises computing the difference between the numerical values of each area in the second image and in the first image.

5

12. A method according to Claim 11 further comprising the step of computing the number of the predetermined areas that changed in numerical value by more than a predetermined amount.

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13. A method according to Claim 11 further comprising the step of computing the number of the predetermined areas that changed in numerical value by more than a predetermined amount.

15

14. A method according to Claim 10 further comprising the step of comparing the number of the predetermined areas that changed from the first image to the second image to a predetermined number.

20

15. A method according to Claim 14, further comprising the steps of:
giving each area of the first image a numerical value based upon the information in each area:

giving each area of the second image a numerical value based upon the information in each area: and

25

wherein computing the number of the predetermined areas that changed from the first image to the second image comprises computing the difference between the numerical values of each areas in the second image and in the first image.

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16. A method according to Claim 15 further comprising the step of computing the number of the predetermined areas that changed in numerical value by more than a predetermined amount.
- 5 17. A method for monitoring a field of view for visible changes, comprising in combination the steps of:
- taking a sequence of images in a predetermined manner of the field of view to be monitored;
 - dividing each of the images into an identical plurality of areas;
 - 10 comparing a plurality of predetermined areas of each image to the same areas of the other images;
 - computing if there is a cyclical change in any of the predetermined areas during the sequence.
- 15 18. A method according to Claim 17, further comprising the steps of:
- giving each area of each image a numerical value based upon the information in that area; and
 - wherein computing if there is a cyclical change in any of the predetermined areas during the sequence comprises computing if there is a
 - 20 cyclical change in any of the numerical values of the predetermined areas during the sequence.
19. A method according to Claim 18, further comprising the step of computing the number of the predetermined areas that changed from one image of the sequence to the next image of the sequence and was not part of a cyclical
- 25 change.

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20. A method according to Claim 17. further comprising the step of computing the number of the predetermined areas that changed from one image of the sequence to the next image of the sequence and was not part of a cyclical change.
- 5
21. A method for monitoring a field of view for visible changes. comprising in combination the steps of:
- taking a first image in a predetermined manner of the field of view to be monitored;
 - 10 determining the image mass of the first image;
 - taking a second image in the predetermined manner of the field of view to be monitored after creating the first image;
 - determining the image mass of the second image; and
 - 15 comparing the image mass of the first image to the image mass of the second image.
22. A method for monitoring a field of view for visible changes. comprising in combination the steps of:
- 20 taking a sequence of images in a predetermined manner of the field of view to be monitored;
 - determining the image mass of each of the images in the sequence;
 - comparing the image mass of the images in the sequence to each other:
 - 25 computing if there is a cyclical change in the image mass of the images in the sequence.

Fig. 1

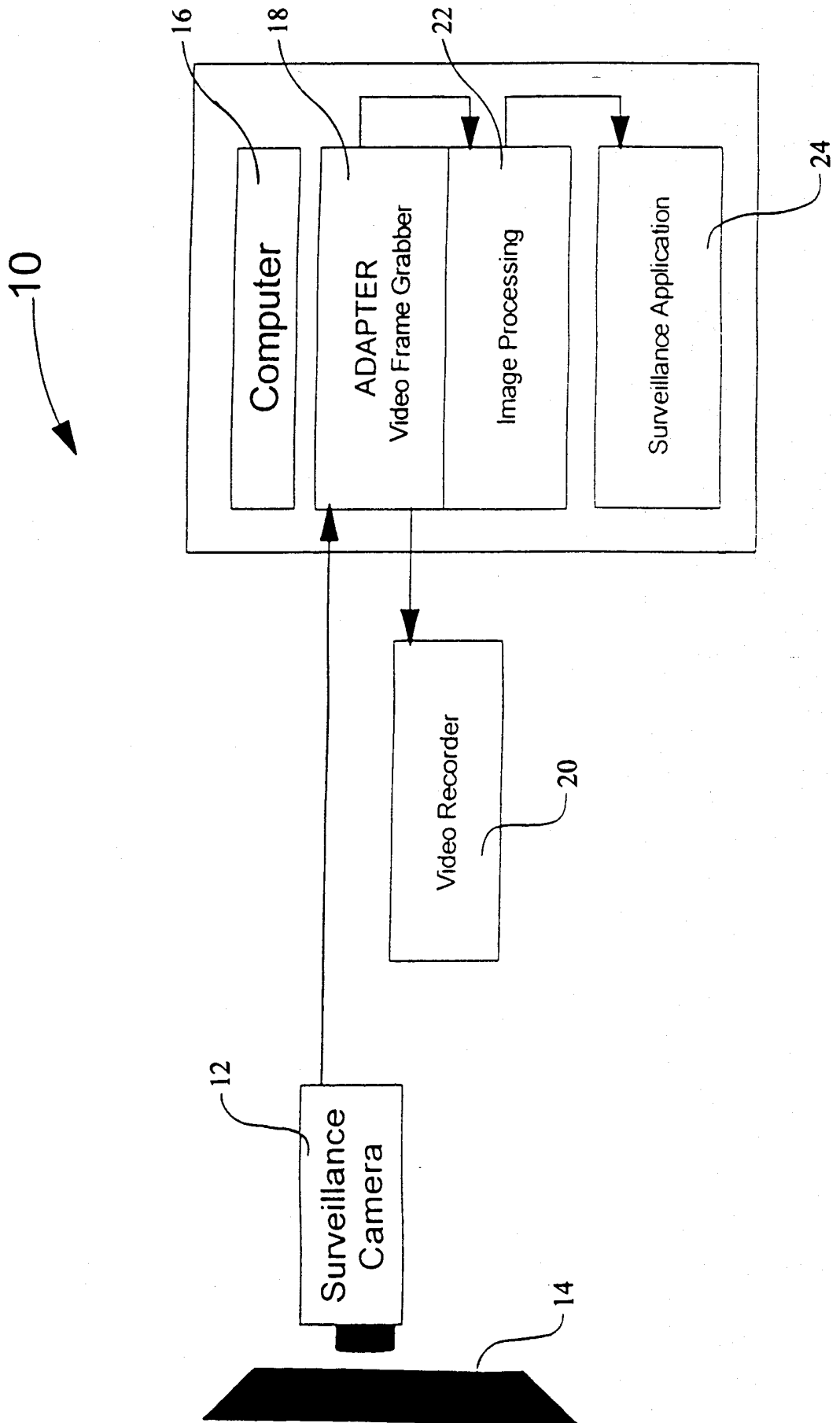
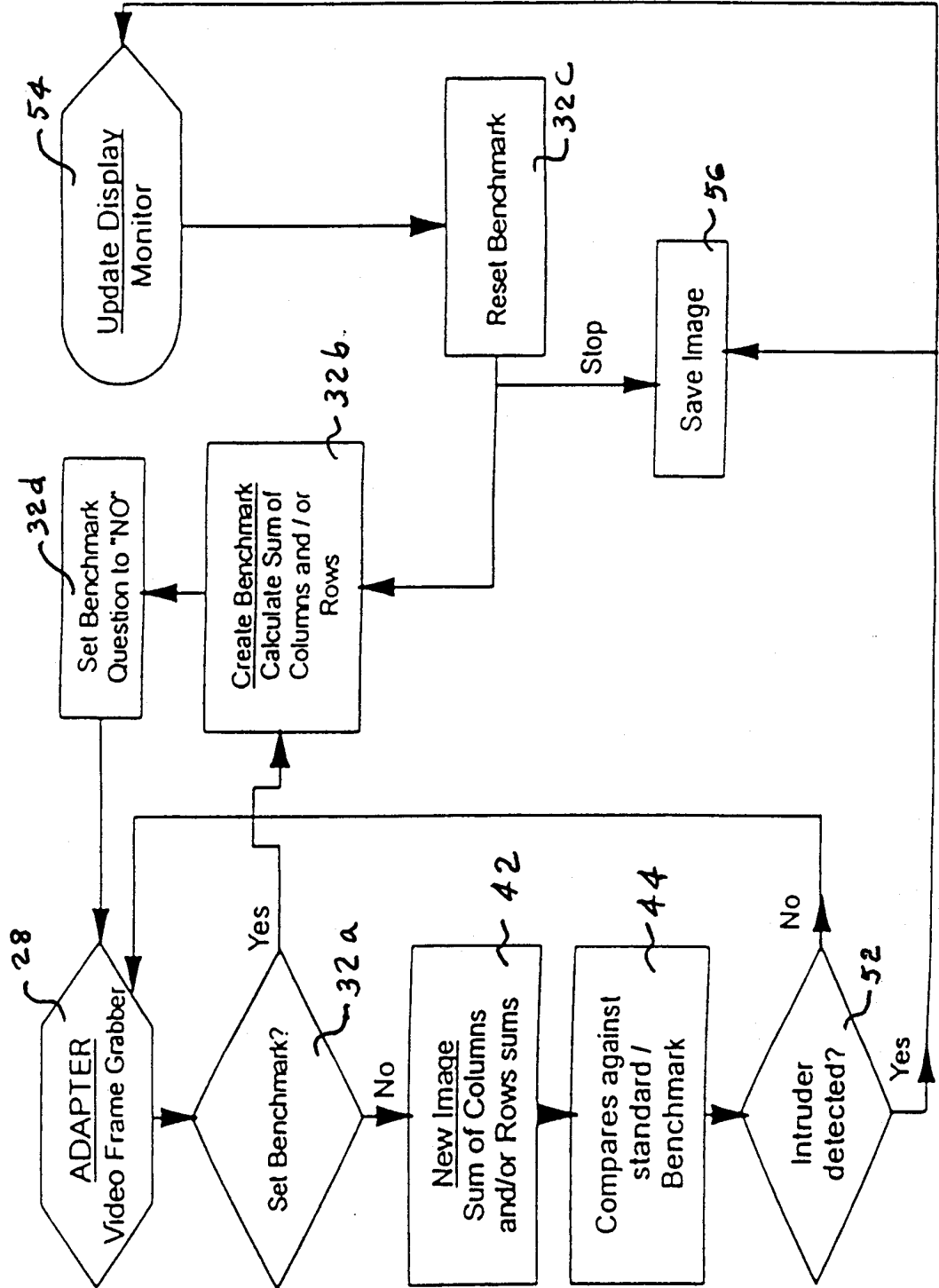


Fig. 2



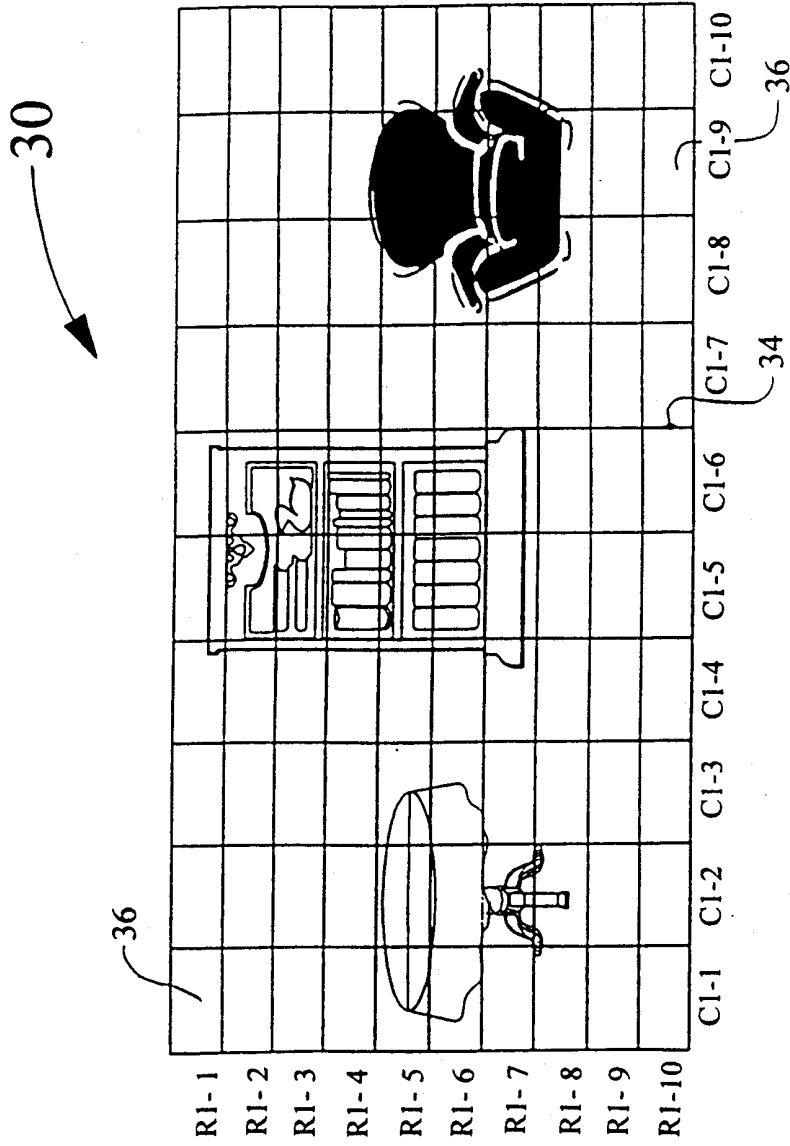


Fig. 3

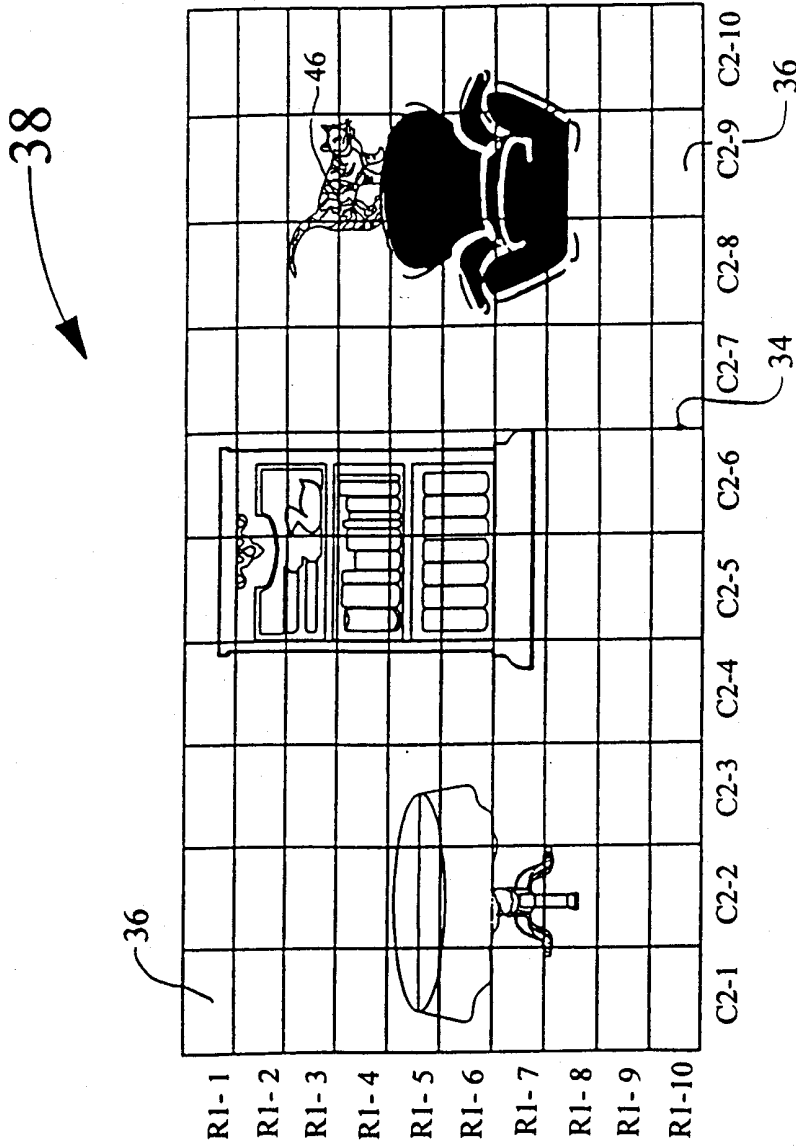


Fig. 4

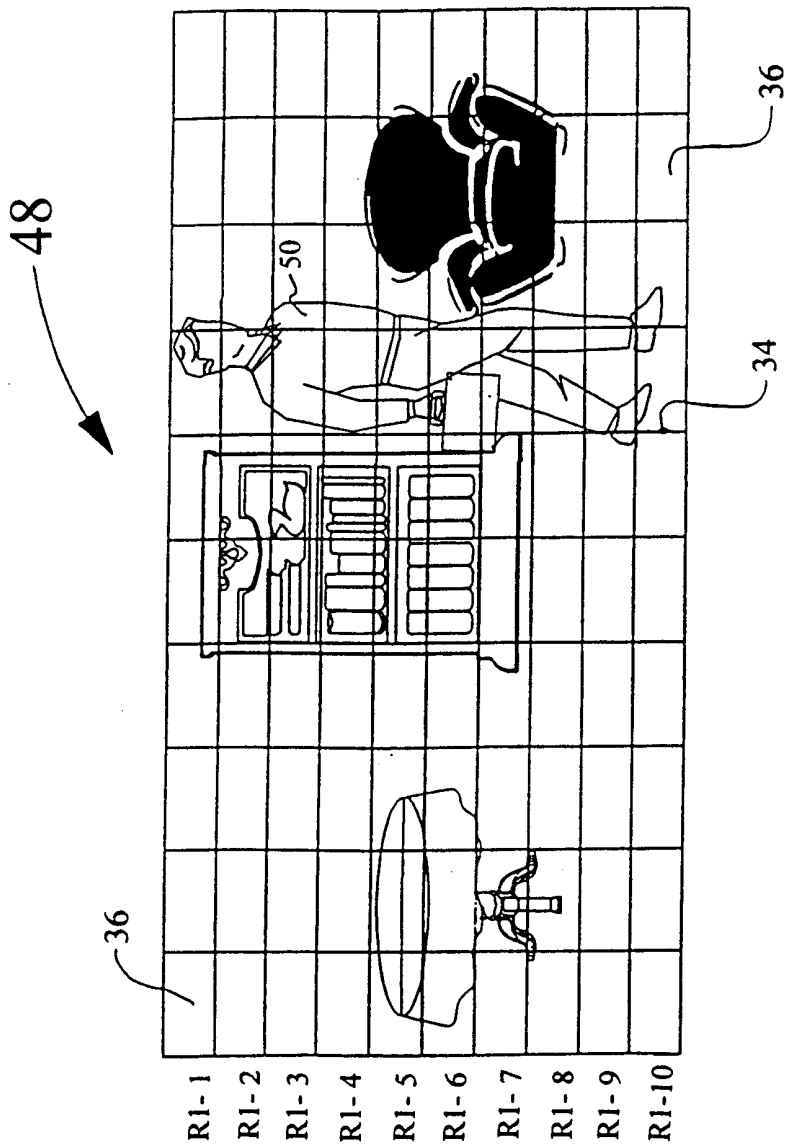


Fig. 5

1	2	3	4	5	6	7	8	9	10	= 15
11	12	13	14	15	16	17	18	19	20	= 45
21	22	23	24	25	26	27	28	29	30	= 75
31	32	33	34	35	36	37	38	39	40	=144
41	42	43	44	45	46	47	48	49	50	=408
51	52	53	54	55	56	57	58	59	60	=498
61	62	63	64	65	66	67	68	69	70	=588
71	72	73	74	75	76	77	78	79	80	=380
81	82	83	84	85	86	87	88	89	90	= 0
91	92	93	94	95	96	97	98	99	100	= 0
=224	=228	=159	=238	=245	=252	=0	=252	=295	=260	2153

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/04906

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06K 9/00
US CL : 382/103

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/103, 107, 236; 348/169

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST, IEBE
pixel, cell, compare, group, alarm, human, intruder, movement, motion, change

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,864,630 A (COSATTO et al.) 26 January 1999, col. 6, lines 35-55, fig. 1d, elements 250, 260, 270.	1-22
Y	US 5,109,435 A (LO et al.) 28 April 1992, col. 2, lines 30-65, fig. 5C-G.	1-22
Y	US 4,493,420 A (DENNIS) 15 January 1985, col. 8, lines 20-50, fig. 7.	1-22
Y	US 5,323,470 A (KARA et al.) 21 June 1994, col.2, lines 15-45.	1-22
A	US 5,815,590 A (BUTTNER et al.) 29 September 1998, col. 2, lines 40-60.	1-22

 Further documents are listed in the continuation of Box C.
 See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/04906

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,375,177 A (VAIDYANATHAN et al.) 20 December 1994, col. 2, lines 30-55, fig. 33, elements 16, 24.	1-22