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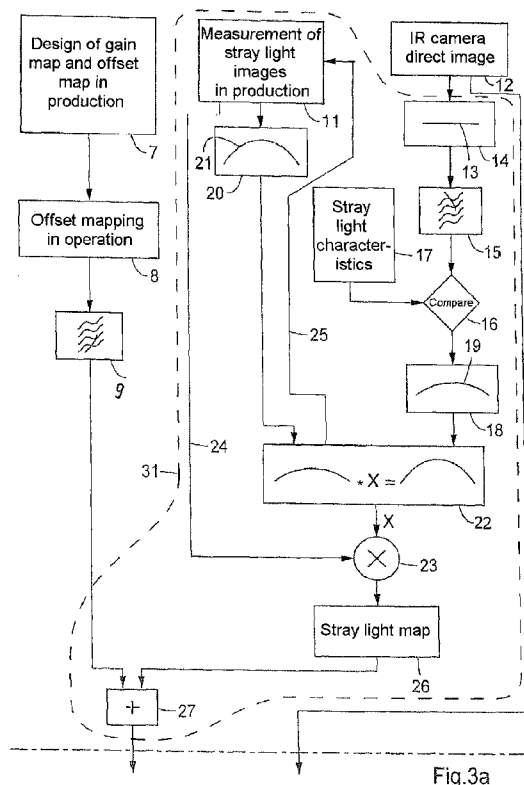
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(54) Title: PROCESS FOR STRAY LIGHT COMPENSATION OF AN IR CAMERA



(57) **Abstract:** The invention relates to a process for stray light compensation of an IR camera. According to the process, it is included that: a) stray light images are measured in production for at least two different camera temperatures against flat radiators and stored (11), b) the stray light is measured directly in image during operation for a selection, such as one or more lines, a few points or the whole image (14) and the made selection is low-pass filtered (15), c) corresponding selections are made in the stray light images (21), d) the selection from the stray light is matched against corresponding selections in the stray light images by calculating the factor which makes the most points from the selections coincide (22), e) image during operation is compensated with calculated factor of matched stray light image (23-29).



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Process for stray light compensation of an IR cameraTechnical field

- 5 The present invention relates to a process for stray light compensation of an IR camera.

Background

- 10 A common way of offset-calibrating an IR camera is to calibrate against an insertable spade. An example of a realization comprising a spade is described in US 2002/0162963 A1.

- 15 One problem with IR cameras provided with a spade and, in particular, with uncooled IR cameras is spatial noise ("fix pattern noise", FPN) should the camera, and in particular the spade, not have the same temperature as the scene which the camera is viewing. Moreover, the
20 spade with associated transport mechanisms constitutes a significant part of the production cost of the camera.

- In order to get around the problem of a warm spade, it
25 has previously been known to use the scene temperature in the calibration without being affected by objects in the scene. For this, it is necessary to be able to make a so-called NUC (Non Uniformity Correction). This requires the camera to be able to be directed towards a
30 plane surface which has the same temperature as the scene. A surface which can be used in certain cases has been the sky.

- It is also known to offset-calibrate an IR camera by
35 moving one or more lenses in the camera in order to defocus the scene as much as possible and make the calibration against this almost uniform scene. The use of defocusing in connection with offset calibration is described, inter alia, in FR 2 928 462 A1. According to

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the said document, lenses are moved in the optical path for calibration by defocusing.

An offset calibration against the defocused scene
5 removes, inter alia, the high-frequency noise and corrects for the characteristics of integral detectors. On the other hand, there remain problems with the stray light, since stray light in the defocused state looks different from in the focused state. This results in
10 the addition of a new stray light, originating from the defocused state, to the stray light in the focused state.

Summary of the invention

15

One object of the invention is to provide a process which can compensate for low-frequency noise in the form of stray light in the camera.

20 The object of the invention is achieved by a process characterized in that:

- a) stray light images are measured in production for at least two different camera temperatures against flat radiators and stored,
- 25 b) the stray light is measured directly in image during operation for a selection, such as one or more lines, a few points or the whole image and the made selection is low-pass filtered,
- c) corresponding selections are made in the stray
30 light images,
- d) the selection from the stray light is matched against corresponding selections in the stray light images by calculating the factor which makes the most points from the selections coincide,
- 35 e) image during operation is compensated with calculated factor of matched stray light image.

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The process serves to ensure that low-frequency scene content does not destroy the measurements and that very noise-free images can be generated.

5 According to one refinement of the process, it is proposed that points in the selection from the stray light which deviate from the stray light form according to the selection in the stray light images are eliminated. Stray light has a characteristic form which
10 means that deviant forms can be identified and excluded. Examples of deviant forms can be square notches, steep peaks and the like. By first removing parts which deviate from the stray light form, a subsequent matching is facilitated and a more effective
15 stray light compensation is achieved.

According to another refinement of the process, it is proposed that the selection directly in image is constituted by the two diagonal lines of the image. By
20 making a diagonal selection, the image is covered from corner to corner and a very representative selection is obtained under normal conditions without needing to manage excessively large quantities of data, which facilitates compensation virtually in real time.

25 According to an alternative to the process according to the previous paragraph, the selection directly in image is constituted by at least one horizontal line and at least one vertical line in the image. This selection
30 too covers the image in an advantageous manner without the need to manage excessive quantities of data.

The calculation of the factor which makes the most points from the selections coincide is advantageously
35 conducted using the least squares method. Other calculation methods can also be applied, however.

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According to another refinement of the process, in which an offset map is made during operation against a defocused scene or against a spade, low-pass noise is eliminated by virtue of the fact that the offset map is
5 high-pass filtered and that the offset map is compensated with calculated factor of matched stray light image. The high-pass filtering prevents the addition of new stray light emanating from calibration against defocused scene or against spade.

10

According to a further refinement of the process, the low-frequency noise is compensated to a still higher degree by virtue of the fact that offset maps are generated in production for compensation of low-
15 frequency noise in the detector.

The stray light compensation can be carried out separately in operation or can be coordinated with other activities. A preferred refinement of the process
20 is to carry out the stray light compensation in connection with offset calibration in operation.

The stray light compensation can be carried out, for example, in combination with optical NUC or spade-based
25 NUC.

Stray light images which are measured in production should be made for at least two camera temperatures. It is especially proposed that stray light images are
30 measured in production for at least three camera temperatures, of which one camera temperature corresponds to room temperature and at least one camera temperature is lower and at least one camera temperature is higher than the room temperature.

35

Brief description of the drawings

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The invention according to the specified processes will be further described below with reference to the appended drawings, in which:

5 Figure 1 shows schematically a detector matrix to be housed in an IR camera,

Figure 2 shows schematically a memory circuit.

10 Figures 3a and 3b illustrate in a block flow diagram an example of a process according to the invention for the compensation of stray light and thus also for the management of other noise. The transition between Figure 3a and Figure 3b is shown in the drawings by
15 means of a dash-dotted line.

Detailed description of embodiments

Detectors incorporated in a detector matrix of an IR
20 camera do not behave equally but have variations in amplification and offset. In order to manage these variations, so-called gain and offset maps are recorded and stored preferably already in production. With the aid of the gain map, corrections are made during
25 operation for amplification variations of the individual detectors in a matrix. Correspondingly, the offset map is used, during operation, for the parallel displacement of the detector signals of integral detectors such that the amplification curves of the
30 detectors substantially coincide. In order to further clarify the principles behind gain and offset mapping, reference is made to our published US patent application US 2011/0164139 A1.

35 In Figure 1 is schematically illustrated a detector matrix 1 housed in an IR camera which has merely been outlined in box form with dashed lines. The detector matrix 1 comprises rows and columns of detectors 2, the

gain and offset maps of which, after having been recorded in production, have been stored and have here been illustrated in Figure 2 with a memory circuit 4 accommodating the gain map 5 and offset map 6. In addition, there is space for storage of stray light images, as will be described in greater detail in different context below. Even though the memory circuit has been shown as a separate unit, maps and stray light images can be stored separately. Acting as the memory circuit can be any type of memory which is suitable in this context and, for example, types of memory which are suited to interactions with microprocessors.

With reference to a schematic flow diagram shown in Figures 3a and 3b, the principles for stray light compensation, and therewith associated mapping, are now described. In order to more clearly mark the stray light compensating part, it has been ringed by means of a dashed loop 31.

In connection with the production of an IR camera 3, gain and offset maps 5, 6 are expediently recorded. The block 7 in Figure 3 illustrates this mapping in production. Furthermore, offset mapping is carried out during normal operation of the IR camera. This is illustrated by block 8. The offset mapping can be carried out according to the principle for optical NUC, i.e. by defocusing the scene shown by the IR camera, for example by moving optical elements such as lenses, and carrying out the mapping against the defocused scene having high uniformity. Another possible principle is spade-based NUC, where a spade-like object is introduced into the ray path in the recording of an offset map.

In order to eliminate low-frequency contributions from the scene and from the optics in the defocused state, according to block 9 a high-pass filtering is carried

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out. An offset map which from the noise aspect can favourably manage the high-frequency noise is thereby produced.

5 In order to manage stray light, stray light images are measured in production for different temperatures against flat radiators and stored in a memory, such as the memory 4 shown in Figure 2 having a section 10 for stray light images. The procedure for measuring stray
10 light images is illustrated in Figure 3a with the block 11. The stray light measurement calls for measurement at at least two temperatures. It can be expedient to cover a temperature range of perhaps 40 degrees, with measuring points of, for example, +10 degrees and +35
15 degrees. In order to increase the accuracy, measurement can be realized at more than two measuring points, which, in particular, would be likely to give a more effective stray light compensation out in the edges of an image. It is especially proposed to locate a
20 measuring point at room temperature.

A block 12 illustrates an image in the IR camera 3, which image is accessible during operation.

25 In order to establish the magnitude of the stray light, a matching of stored stray light images takes place, block 11, with the particular direct image, block 12, according to the principles described below.

30 Starting from the particular direct image, a selection is first made. The selection can be made such that one or more lines in the image, a few points or the whole of the image are processed. By limiting the selection to some lines or a few points, the calculation time can
35 be kept down. It is especially proposed to choose the two diagonals in the image. Other suitable choices can be some parallel lines and some horizontal lines.

For the sake of clarity, a selection which is constituted by a single horizontal line 13 shown in a block 14 in order to show the principle behind the stray light compensation is described below. Such a horizontal line, like other selection examples, also contains scene content which has nothing to do with the stray light. In order to separate the stray light information from the rest of the image, a low-pass filtering of the horizontal line, see block 15, is first carried out. After this, it can be checked whether the low-pass filtered line has a form which coincides with the form for stray light. Points which markedly deviate, for example square notches or steep peaks, are eliminated. A block 16 indicates a comparison between the low-pass filtered horizontal line and characteristics for a stray light form acquired from block 17. After low-pass filtering and elimination of any points, a line 19 is obtained, which line can have a curve shape schematically shown in the block 18.

Stray light images which have been taken during the production phase have previously been stored. The block 11 makes such images available and a corresponding line 21 in the stray light images is produced and exemplified schematically in block 20.

A line 19 representing part of the direct image of the IR camera and lines 21 representing known curves from stray light images now exist. In a block 22, the curve shape of the line 19 is matched against the curve shapes of the lines 21 by calculating the factor X which makes the most pixels from the curves coincide. The calculation can be conducted by means of the least squares method. Block 22 illustrates the equation set-up and supplies the calculated factor X . The block 22 can also include the conductance of a reasonability assessment of the calculated factor X .

The produced factor X is next multiplied by the stray light image which best corresponds to the line 19, see block 23. A connection 24 here shows that the stray
5 light image can be fetched from the block 11, and a connection 25 indicates the particular stray light image. As a result of the multiplication, a stray light map, marked by a block 26, is obtained. This stray light map is placed in a block 27 together with an
10 offset map generated in block 8 and high-pass filtered in block 9, to form a map 28 which is applied in a block 29 to the direct image of the IR camera represented by block 12, resulting in a finished image, block 30, compensated for stray light and other, both
15 low-frequency and high-frequency noise.

The invention is not limited to the processes described as examples above, but can be subject to modifications within the scope of the following patent claims.

Patent claims

1. Process for stray light compensation of an IR camera, **characterized in that**:
- 5 a) stray light images are measured in production for at least two different camera temperatures against flat radiators and stored,
- b) the stray light is measured directly in image during operation for a selection, such as one or more
- 10 lines, a few points or the whole image and the made selection is low-pass filtered,
- c) corresponding selections are made in the stray light images,
- d) the selection from the stray light is matched
- 15 against corresponding selections in the stray light images by calculating the factor which makes the most points from the selections coincide,
- e) image during operation is compensated with calculated factor of matched stray light image.
- 20
2. Process according to Patent Claim 1, **characterized in that** points in the selection from the stray light which deviate from the stray light form according to the selection in the stray light images are eliminated.
- 25
3. Process according to any one of the preceding patent claims **characterized in that** the selection directly in image is constituted by the two diagonal lines of the image.
- 30
4. Process according to any one of the preceding patent claims 1-2, **characterized in that** the selection directly in image is constituted by at least one horizontal line and at least one vertical line in the
- 35 image.

5. Process according to any one of the preceding patent claims, **characterized in that** the factor is calculated by means of the least squares method.

5 6. Process according to any one of the preceding patent claims, wherein an offset map is made during operation against a defocused scene or against a spade, **characterized in that** the offset map is high-pass filtered and that the offset map is compensated with
10 calculated factor of matched stray light image.

7. Process according to any one of the preceding patent claims, **characterized in that** offset maps are generated in production for compensation of low-
15 frequency noise in the detector.

8. Process according to any one of Patent Claims 6 or 7, **characterized in that** the stray light compensation is carried out in connection with offset calibration in
20 operation.

9. Process according to any one of the preceding Patent Claims 6-8, **characterized in that** the stray light compensation is carried out in combination with
25 optical NUC.

10. Process according to any one of the preceding Patent Claims 6-8, **characterized in that** the stray light compensation is carried out in combination with a
30 spade-based NUC.

11. Process according to any one of the preceding patent claims, **characterized in that** stray light images are measured in production for at least three camera
35 temperatures, of which one camera temperature corresponds to room temperature and at least one camera temperature is lower and at least one camera temperature is higher than the room temperature.

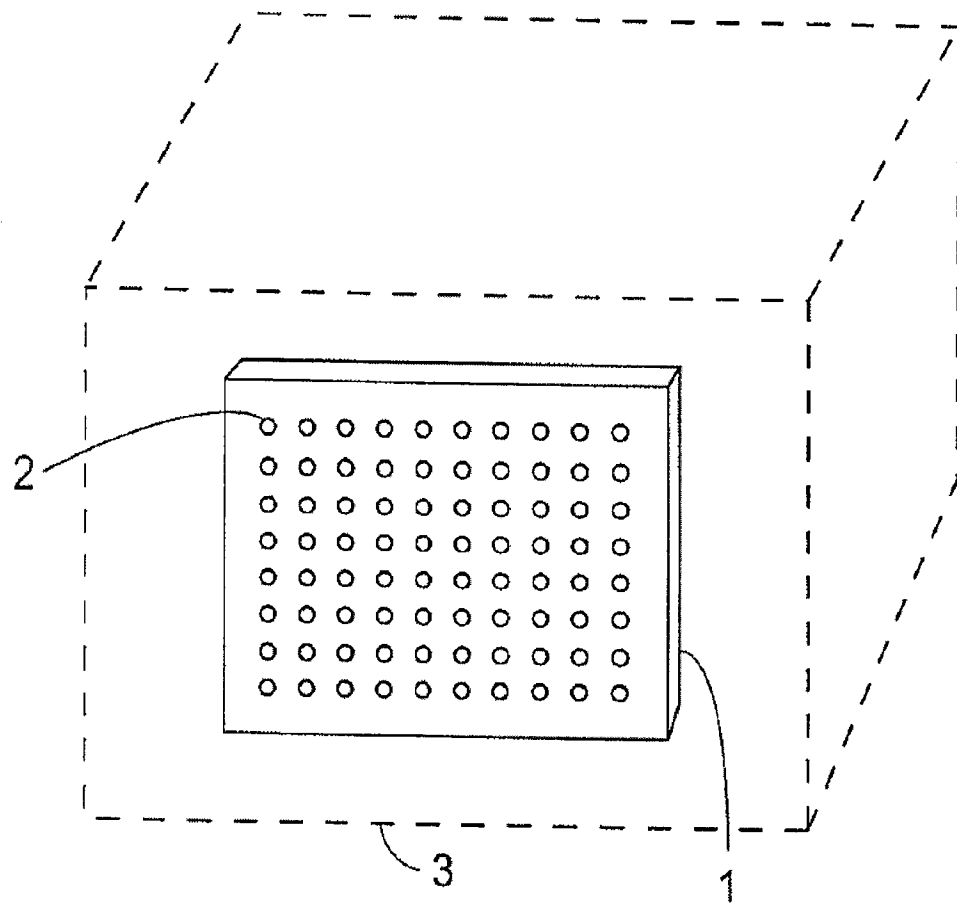


Fig.1

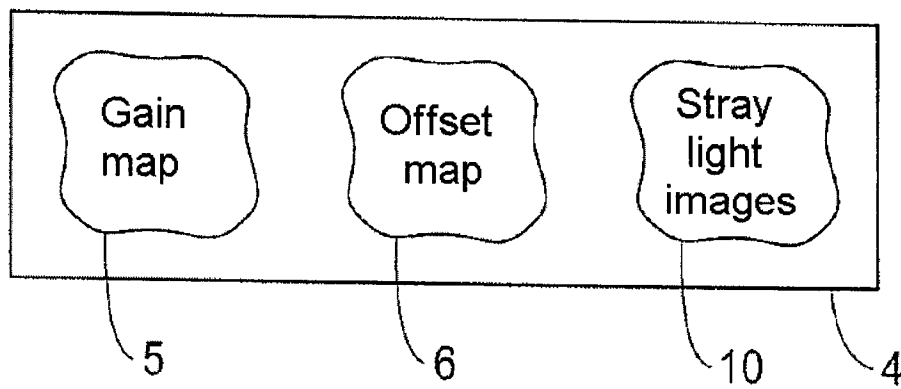


Fig.2

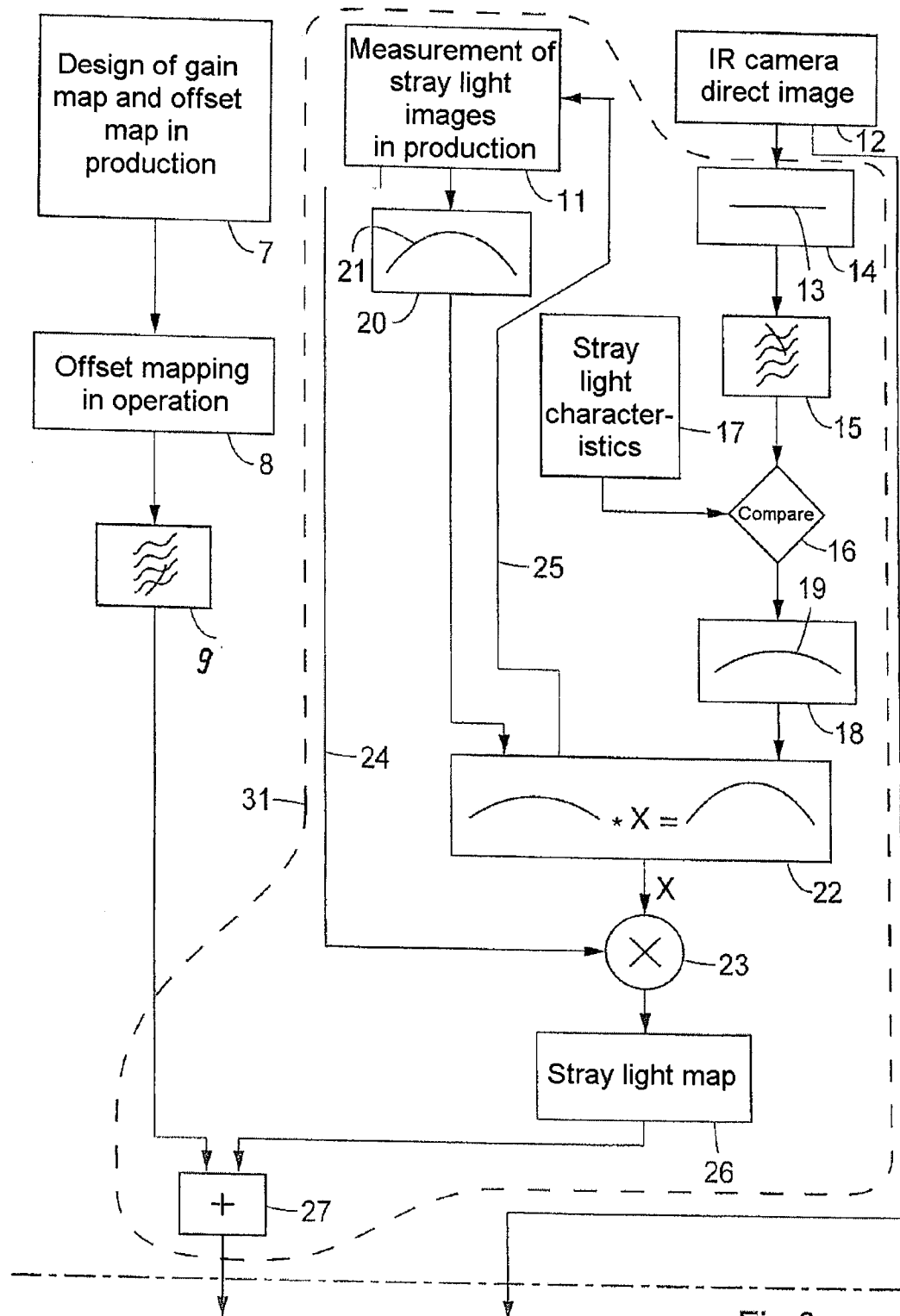


Fig.3a

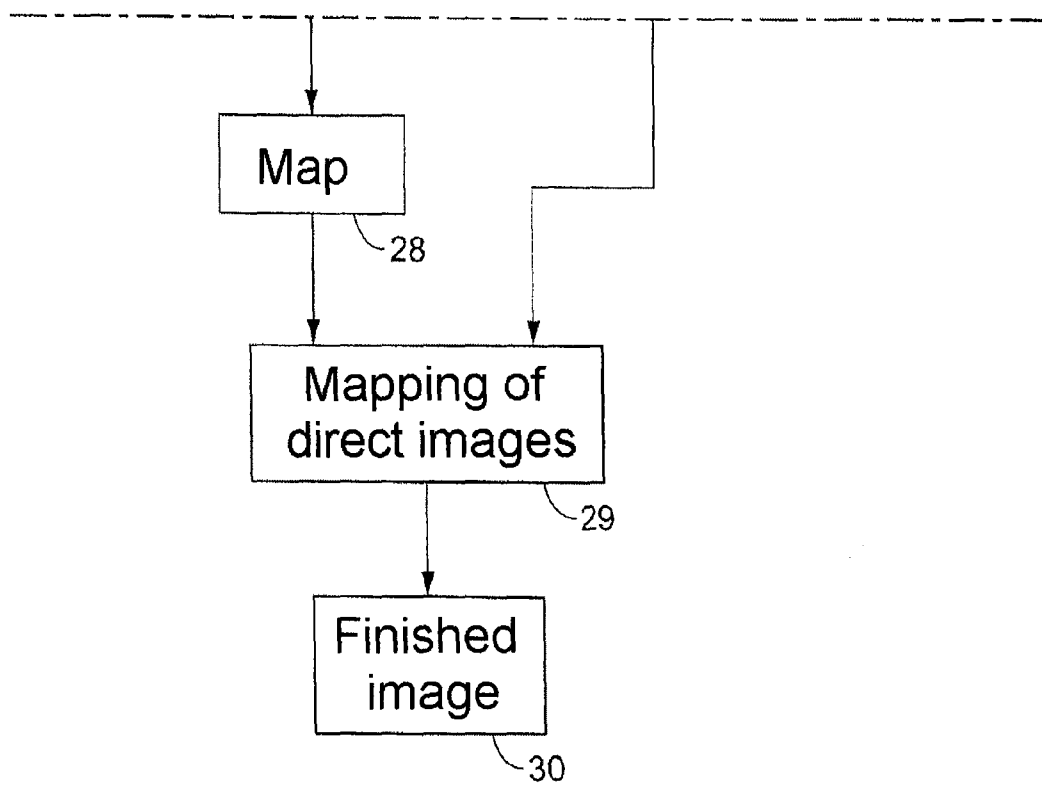


Fig.3b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/000136

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: G01J, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20030169345 A1 (RYKOWSKI RONALD F ET AL), 11 September 2003 (2003-09-11); abstract; paragraphs [0024]-[0032]; figures 1-2 --	1-11
A	US 20090059210 A1 (ZONG YUQIN ET AL), 5 March 2009 (2009-03-05); abstract; paragraphs [0012]-[0017], [0030]-[0031] --	1-11
A	US 20060279632 A1 (ANDERSON SHANE M), 14 December 2006 (2006-12-14); abstract; paragraphs [0015]-[0019] --	1-11

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

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“&” document member of the same patent family

Date of the actual completion of the international search

15-02-2013

Date of mailing of the international search report

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Name and mailing address of the ISA/SE

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/000136

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20070247672 A1 (NGUYEN HUGH P), 25 October 2007 (2007-10-25); abstract; paragraphs [0020]-[0035]; figures 5-10 --	1-11
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Continuation of: second sheet**International Patent Classification (IPC)*****H04N 5/365*** (2011.01)***H04N 5/217*** (2011.01)***H04N 5/33*** (2006.01)***H04N 5/357*** (2011.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

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