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(71) Applicant (for all designated States except US): THOM-SON LICENSING [FR/FR]; 46 Quai A. Le Gallo, F-92100 Boulogne-Billancourt (FR).

(72) Inventors; and
(75) Inventors/Applicants (for US only): THEBAULT, Cédric [FR/DE]; Oberestr. 8, 78050 VS-villingen (DE). WEITBRUCH, Sébastien [FR/DE]; Im Wolfacker 25, 78078 Kappel (DE). CORREA, Carlos [PT/DE]; Deuten-bergring 16, 78056 Villingen-Schwenningen (DE).

(74) Agent: LINDEMANN, Robert; Deutsche Thomson OHG, European Patent Operations, Karl-Wiechert-Allee 74, 30625 Hannover (DE).

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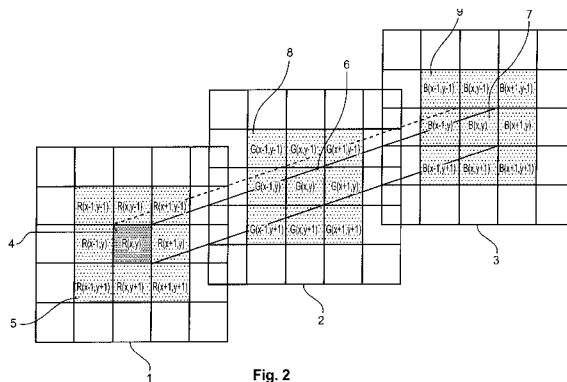

Fig. 2

(57) Abstract: CMOS image sensors are usually suffering from fixed pattern noise and random defect pixels. However, for economical reasons and in order to increase the manufacturing yield, some random defective pixels are usually accepted even for professional devices. In this case, the defect pixels are usually corrected by signal processing. A processing device (15) for correcting of at least one defect pixel value of an image sensor unit is proposed, the image sensor unit comprising at least a first and a second pixel array (1, 2, 3), wherein the image sensor unit is embodied to project the same image onto each pixel array (1, 2, 3), the processing device (15) comprising at least a first and a second input channel (11, 12, 13) for receiving pixel values of the first and the second pixel array, respectively, wherein the processing device (15) is operable to exchange the defect pixel value by a corrected pixel value, wherein the corrected pixel value is estimated by evaluating the values of neighbouring pixels of the defect pixel of the same pixel array, wherein the corrected pixel value is estimated by evaluating values of a corresponding pixel and its neighbouring pixels of the second pixel array at the same location as the defect pixel of the first pixel array in respect to the projected image.

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Processing device for correcting defect pixel values of an image sensor unit, image sensor unit with the processing device and method

The invention relates to a processing device for correcting defect pixel values of an image sensor unit, the image sensor unit and a respective method and, more specifically, to a processing device for correcting of at least one defect pixel value of an image sensor, the image sensor comprising at least a first and a second pixel array, wherein the image sensor unit is embodied to project the same image onto each pixel array, the processing device comprising at least a first and a second input channel for receiving pixel values of the first and the second pixel array, respectively, wherein the processing device is operable to exchange the defect pixel value by a corrected pixel value, wherein the corrected pixel value is estimated by evaluating the values of neighbouring pixels of the defect pixel of the same pixel array, and to the said image sensor and the method.

Image sensors comprise one or more pixel arrays on which an image is projected. For grey-scale images sensors (black-and-white image sensors) one pixel array is sufficient. Colour image sensors usually require more than one pixel array, more precisely, they usually require three pixel arrays, whereby each pixel array is responsible for receiving the information of a colour component of the image. In this connection 3-chip image sensors are known having one chip per colour, whereby the spread of the original incoming image towards these three chips is done by means of prisms and colour filters.

One possible realisation of the image sensor is the so-called CMOS-sensor, which can be produced in the standard CMOS process, which allows integrating on a single chip also other circuits, such as analogue to digital

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converters (ADC), digital controller for read-out from the CMOS-sensor and sometimes also digital signal processing cores for signal post-processing.

The advantages of the CMOS image sensors are that they use low supply voltages and that they can be fabricated at low cost due to the possible integration of the other circuits on one single chip.

But CMOS image sensors are often suffering from fixed pattern noise and random defect pixels, whereby the pixel defects in an imager are seen as spot noise. In a CMOS image sensor for example, the white spots on a dark portion of the image are due to pixels with excessive leakage current and the dark spots on a white portion of the image due to either a particle covering the pixel or a defect in the pixel electronics causing the pixel to be insensitive. Defect pixels are mainly created during manufacturing, some more can occur with time. This spot noise strongly degrades image quality. However, for economical reasons and in order to increase the manufacturing yield, some random defective pixels are usually accepted even for professional devices. In this case, the defect pixels are corrected by signal processing.

It is a general desire in the art to improve the correcting of the defect pixel values of images sensors in order to enhance image quality.

This object is achieved by a processing device with the features of claim 1, by an image sensor unit with the features of claim 15 and by a method with the features of claim 21. Advantageous or preferred embodiments of the invention are disclosed in the dependent claims, the description and the figures.

According to the invention, a processing device is presented, which is capable to correct at least one defect pixel value of an image sensor unit. In general the processing device allows to correct the values of especially bonded or clustered areas of defect pixels, but it is preferred that the processing device is embodied to correct a bonded area with only one single defect pixel as

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sensor units with larger clustered areas of defect pixels are preferably sorted out during fabrication.

The image sensor unit is of based on any technology like CMOS or CCD and comprises at least two two-dimensional pixel arrays for sensing impinging light, the pixel arrays being arranged on one or more chips. The image sensor unit is realised so that an incoming image is projected in parallel onto the at least two pixel arrays, wherein the at least two pixel areas receive the same spatial image sections. The expression "image" is herein used as a two-dimensional array of light intensity and may be but is not restricted to a real image.

The processing device shows corresponding to the at least two pixel arrays a respective number of input channels for receiving the read-out values from the at least two pixel arrays.

In general the processing device is adapted to exchange the at least one defect pixel by a corrected value in order to correct the defect pixel value. The corrected pixel value is generated by evaluating the values of the neighbouring pixels of the same pixel array as the defect pixel and – according to the invention – by evaluating the values of a corresponding pixel and its neighbouring pixels of the second pixel and optionally of a third pixel array, wherein the corresponding pixel is positioned at the same location as the defect pixel with respect to the projected image. The expression neighbouring pixel is directed to pixels, which are positioned adjacently and/or in the surrounding and/or as direct neighbours to the defect pixels or to the corresponding pixel, respectively.

One finding of the invention is that using of information of the neighbourhood of the defect pixel in one pixel array combined with the information of the pixels at the same location but in the other array or arrays allows to recreate the missing information of the defect pixel with only very few

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or as less artefacts as possible. Especially in view of real images there is usually a lot of similitude between the information from the various pixel arrays, so that structural or statistical features are at least similar at the same locations in the various pixel arrays. Thus using information of the corresponding pixels in the other arrays is a way of improving the quality of the corrected pixel value.

In a preferred embodiment, the processing device comprises a third input channel for receiving pixel values of a third pixel field of the image sensor. This embodiment allows the processing device to cooperate with image sensor units having three pixel arrays, whereby each of the pixel arrays is embodied to receive one colour component of the incoming image. A wide-spread colour distribution and thus a preferred realisation is the RGB-colour scheme. However, the invention is in general not restricted to the RGB-distribution but can handle any kind of image sensors units with multiple pixel fields.

In yet a further preferred embodiment of the invention the processing device is adapted to evaluate the values of the neighbouring pixels of the defect pixel by directional interpolation operations, i.e. interpolation operations which are direction optimised. Directional interpolation operations are characterised in that various directional interpolation operations results in various interpolation values due to the structural features of the values of the neighbouring pixel values of the defect pixel. In one possible realisation the interpolation operations are performed along lines, whereby the lines are arranged in a vertical (column), horizontal (row), first diagonal and/or second diagonal direction. In a very simple and thus advantageous realisation, the directional interpolations are performed as an average operation between the values of the next and diametrically lying neighbours of the defect pixel. One possible advantage of employing the directional interpolation operations is that thin structures and the like of the image are not degraded.

In a possible development of the invention the processing device is adapted to use values of the corresponding pixel and its neighbouring pixels of

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the second and optionally of the third pixel array to derive a confidence value for each of the directional interpolation operation results, the confidence value being a quantity for the quality of the respective directional interpolation operation. Furthermore the processing device is operable to evaluate the values
5   of the neighbouring pixels of the defect pixels and/or the results of the directional interpolation operations in a weighted manner.

In order to improve the significance of the confidence value it is preferred that the confidence values are derived by a directional evaluation of the values
10   of the corresponding pixel and its neighbouring pixels. Especially the confidence values are derived by a line-wise evaluation, whereby the lines are parallel or congruent to the lines of the corresponding or respective directional interpolation operation.

15   In a possible practical realisation the confidence values are derived by calculating the mean value between the two next neighbours of the corresponding pixel, which are lying diametrically on a line parallel or congruent to the line of the directional interpolation operation. In a next step, the mean value is subtracted from the value of the corresponding pixel. In an optional
20   further step the result of the respective interpolation operation is added.

For estimating the corrected pixel value the processing device is preferably adapted to combine the various directional interpolation results in dependence on the corresponding confidence value, for example in a weighted
25   manner.

A further subject-matter of the invention is a image sensor unit with the features of claims 10. The images sensor unit comprises three pixel arrays, which are preferably distributed on three chips, so that the image sensor unit is
30   a 3-chip camera having one chip per colour. The image sensor unit comprises or is connected with means for spreading an original incoming image into three partial images, each representing one colour component, red-green-blue

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(RGB), of the original image. The means for spreading are preferably realised as a combination of prisms and colour filters. As a result the same image region is projected onto each pixel array.

5   According to the invention the image sensor unit comprises the processing device as claimed in the preceding claims and/or as described above.

           In a preferred embodiment, the image sensor unit is based on CMOS-technology, so that the pixel arrays are arrays of basic pixel cells manufactured
10   in CMOS-technology each comprising for example a photodiode and three transistors. Optionally the processing unit is also manufactured in CMOS-technology and/or arranged as an additional circuit on one of the pixel array chips and/or on another chip.

15   From a structural point of view, the processing device and/or the image sensor unit comprises a plurality of directional interpolators for interpolating the defect pixel value. In this connection it is preferred that the directional interpolators comprise also means for calculating the confidence values.

20   In an optional realisation, the processing device and/or the image sensor unit comprises a soft switch block, which is operable to mix the results of the interpolation operation depending on the respective confidence values to calculate the corrected pixel value.

25   A replacement switch block is optionally provided, wherein the replacement switch block is operable to exchange or replace the defect pixel value with the corrected pixel value.

           Furthermore means for detecting defect pixel and/or defect pixel values
30   are implemented in the processing unit and/or the image sensor unit.

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Yet a further subject-matter of the invention is a method for correcting defect pixel values with the features of claim 16, which is preferably carried out on the processing device and/or the images sensor unit of the preceding claims or description. The method comprises the steps of calculating directional

5   interpolation values of a defect pixel value by evaluating neighbouring pixel values, the neighbouring pixels being arranged in the surrounding of the defect pixel in a same first pixel array; estimating a confidence value for each interpolated value by evaluating the values of a corresponding pixel and its neighbouring pixels, the corresponding pixel being arranged at the same image

10   location in a second pixel array; mixing the interpolated values in dependence on the confidence values in order to generate a corrected pixel value and exchanging the defect pixel value with the corrected pixel value.

Further features, advantages and/or effects of the invention are disclosed

15   by the following detailed description of preferred embodiments of the invention and the figures, which show:

Fig. 1   a flow-diagram as an embodiment of a method according to the invention;

20

Fig. 2   a schematic illustration of three pixel arrays of a 3-chip-camera for defining some expressions in connection with the method in figure 1;

25   Fig. 3 to 6   schematic illustrations for explaining the interpolation step and the calculation of confidence value step in figure 1;

Fig. 7   a schematic block diagram of a processing device as an embodiment of the invention, which can be used in

30   connection with the method in figure 1;

Fig. 8   a more detailed schematic block diagram of one of the
              defect_pixel_correction blocks in figure 7;

Fig. 9   a more detailed schematic block diagram of one of the
              interpolator blocks in figure 8;

Fig. 10   a more detailed schematic block diagram of the soft_switch
              block in figure 8;

Fig. 11   a more detailed schematic block diagram of one of the
              single_switch blocks in figure 10;

Fig. 12   a more detailed schematic block diagram of the
              replacement_switch block in figure 8.

In the following description the same or the like reference numerals
designate the same or the like parts.

Figure 1 is a flow diagram illustrating a method for correcting a defect pixel
value of an image sensor as a first embodiment of the invention. The method is
carried out in connection with a 3-chip-CMOS camera (not shown), whereby the
colour components of an incoming image are distributed, for example by means
of prisms and colour filters, onto three chips, each carrying a pixel array with a
two-dimensional field of basic pixel cells, which comprise a light sensitive
element, like a photodiode, and a basic readout circuit with for example three
transistors.

Due to the manufacturing process or during life time, some of the basic
pixel cells are or become defective and create spot noise on the output image of
the 3-chip-CMOS camera. Roughly spoken, two different types of spot noise
often occur, which are dead/dark pixels due to a particle covering the pixel or a

defect in the pixel electronics, causing the pixel to be insensitive, and leaking pixels, which are white spots on a dark portion of the image due to pixels with excessive leakage current.

5   The objective of the method as illustrated in figure 1 is to interpolate such defect pixels in order to deliver an output image free of visible defects out of the 3-chip-CMOS camera. This is achieved by using information of the neighbourhood of a defect pixel for one colour combined with the information of the pixels at the same location but in the other colours in order to recreate the
10   missing information of the defect pixel.

        Reference is now made to figure 2 showing schematically a first, a second and third pixel array 1, 2 and 3, each representing one of the chips of the 3-chip-CMOS camera. The first pixel array 1 is adapted to receive the red
15   component, the second pixel array 2 is adapted to receive the green component and the third pixel array is adapted to receive the blue component from an incoming original image, which is split up in its RGB-components. Now and in the following it is assumed that the pixel at the position $R(x,y)$ in the first pixel array is a defect pixel 4. However, each other pixel in each other pixel array
20   could be used in an analogue manner.

        For matter of definition the pixels surrounding the defect pixel 4 in the same first pixel array 1 are named neighbouring pixels 5 and are referenced by the positions from $R(x-1, y-1)$ to $R(x+1, y+1)$. The pixels of the other two pixel
25   arrays 2, 3 at the same location are named corresponding pixels 6, 7 and are referenced by the positions $G(x,y)$ and $B(x,y)$ respectively. The pixels surrounding the corresponding pixels 6,7 are named neighbouring pixels 8, 9, respectively, and are defined in an analogue manner as the neighbouring pixels 5.

30
        The expression that pixels of various pixel arrays are at the same location means that these pixels together form a RGB-image point of an output image.

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Returning now to figure 1, the first step 100 of the method is the calculation of directional interpolation values for the defect pixel 4 by evaluating the neighbouring pixels 5. For the calculation of the directional interpolation

5   values the four main directions are evaluated, which are according to fig. 3 a vertical interpolation, according to fig. 4 a horizontal interpolation, according to fig. 5 a first diagonal interpolation and according to fig. 6 a second diagonal interpolation. Each directional interpolation is carried out by calculating the mean value of the values of two pixels of the neighbouring pixels 5, whereby the

10   said two pixels lay on a line of the respective main direction and surround the defect pixel 5. For the vertical direction the mean value of the pixels with the positions R(x,y-1) and R(x,y+1) is calculated as the directional interpolation value.

15   In a second step 200 a confidence value for each directional interpolation value is estimated by evaluating the values of the corresponding pixels 6, 7 and the neighbouring pixels 8, 9 of the second and third pixel array 2, 3. As an example the confidence value for the vertical interpolation value is estimated by the formula:

20

$$\text{vert\_confidence} = \text{abs}(G(x,y)-(G(x,y-1)+G(x,y+1))/2) + \text{abs}(B(x,y)-(B(x,y-1)+B(x,y+1))/2) + \text{abs}(R(x,y-1)-R(x,y+1))/2)).$$

The confidence values concerning the other main directions are calculated

25   in an analogue manner. The smaller the value of vert_confidence is, the bigger the confidence in the interpolated value in this direction.

In a third step 300 the results of the directional interpolation operation are mixed in a weighted manner in dependence on the confidence values. This

30   operation is also performed to avoid blinking pixels. The mixing operation is performed stepwise, whereby in a first step two directional interpolation values are mixed, respectively, and in a second step the resulting two intermediate

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values are mixed. As a result of the mixing operation a corrected pixel value is output. For details of the mixing operation, reference is made to fig. 10 and fig. 11.

5   In a fourth step 400, the defect pixel value is replaced by the corrected pixel value, so that the output image comprises instead of defect pixel values the estimated corrected pixel values thus improving significantly the quality of the output image.

10   Fig. 7 shows a first embodiment of a processing device 10 as a schematic block diagram. The processing device is for example realised in CMOS-technology and is part of the above-mentioned three-chip-camera. The processing device 10 comprises three input channels 11, 12, 13, whereby the first input channel 11 is adapted for receiving the red pixel values of the first
15   pixel array 1, the second input channel 12 is adapted for receiving the green pixel values of the second pixel array 2 and the third input channel 13 is adapted for receiving the blue pixel values of the third pixel array 3. Each of the channels is divided in an information section, for example Red_in[11:0], for receiving 12-Bit pixel values and in an error section, for example Red_defect
20   ,for receiving a 1-Bit value (this signal is equal to 1 when the corresponding pixel is defect, to 0 otherwise) for a defect pixel.

       The input signals are sent to a pixel_distribution block 14, which is basically a memory. Next the pixel values are guided to one of the
25   defect_pixel_correction blocks 15, 16, 17, whereby each block receives 26 pixel values for generating corrected pixel values. The red_defect_pixel_correction block 15 for example receives in the situation of figure 2 the 8 values of the neighbouring pixels 5, 8 and 9, respectively (i.e. 24 values) and the 2 values of the corresponding pixels 6 and 7 (i.e. 2 values). As already explained in
30   connection with figure 1, the defect pixel value(s), for example defect pixel 4, are replaced by the corrected pixel values and sent to output channels 18, 19 and 20 of the processing device 10, whereby the signals of the output channels

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18, 19 and 20 show instead of defect pixels values the replaced corrected pixel values.

Figure 8 shows the red_defect_pixel_correction block 15 in a more
5   detailed schematic block diagram. The green_defect_pixel_correction block 16 and the blue_defect_pixel_correction block 17 are constructed in an analogue manner.

The red_defect_pixel_correction block 15 is composed by four identical
10   direction_interpolator blocks 21, 22, 23, 24, which generate interpolation values for the respective direction, and confidence values corresponding to the confidence to the interpolation values as explained in connection with figures 3 to 6. A soft_switch 25 mixes the different interpolation values depending on the confidence values especially in order to avoid blinking pixels. A
15   replacement_switch block 26 only switches between the input value and the corrected value depending on the red_defect(x,y) bit.

Figure 9 illustrates the verticular_interpolator block 21 in a more detailed presentation also as a block diagram. The other interpolators 22, 23, 24 are -
20   besides the inputs – identical or analogue, so that by means of example only the red_vertical_interpolator is described. The verticular_interpolator block 21 generates an interpolation value vert_interpolation [11:0], which is an average between two neighbour pixels (see also figure 3) in the interpolation direction. A vert_confidence [13:0] value is calculated by the formula as already explained
25   above. In order to save some operations, some results can be shared by the different direction_interpolator blocks 21, 22, 23, 24: For example if the interpolation values of Red_vertical_interpolator, Green_vertical_interpolator and Blue_vertical_interpolator are calculated, these values can be used for the computation of Red_vertical_confidence. Also the value abs(G(x,y)-(G(x,y-
30   1)+G(x,y+1))/2) can be used for the computation of Red_vertical_confidence and the computation of Blue_vertical_confidence. So only one of the values abs(G(x,y)-(G(x,y-1)+G(x,y+1))/2) and abs(B(x,y)-(B(x,y-1)+B(x,y+1))/2) could

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be computed in this block. For example if abs(G(x,y)-(G(x,y-1)+G(x,y+1))/2) should be computed (which is equal to abs(G(x,y)-Green_vertical_interpolation)), the value of abs(B(x,y)-(B(x,y-1)+B(x,y+1))/2) can be used, which is computed in the Green_vertical_interpolator. The output

5 values of the verticular_interpolator block 21 and the other interpolators 22, 23, 24 are fed into the soft_switch 25, which is shown in detail in figure 10.

The soft_switch 25 in figure 10 merges or mixes the interpolated values from the interpolators 21, 22, 23, 24 in dependence on the confidence values.

10 The mixing operation is done stepwise, whereby in a first step in a first single switch block 27 the interpolated values from the vertical interpolator 21 and from the diagonal1_interpolator 22 are mixed. In a second single switch block 28 parallel to the first single switch block 27 the interpolated values from the horizontal_interpolator 21 and from the diagonal2_interpolator 22 are mixed.

15 Each of the single switch_blocks 27 and 28 generates an intermediate interpolated value and an intermediate confidence value, which are guided into a third single switch block 29. The third single switch 29 mixes the intermediate interpolated into the corrected pixel value interpolated_pixel [11:0], which is then guided to the replacement switch block 26. The mixing operation in the

20 single_switch blocks 27, 28 and 29 is explained by means of example for the first single_switch block 27 in connection with figure 11.

As shown in the schematic block diagram in figure 11, the first single_switch block 27 receives the value vert_interpolation [11:0] from the

25 vertical interpolator 21, the respective confidence value vert_confidence [13:0], the value diag1_interpolation [11:0] from the diagonal1_interpolator 22 and the respective confidence value diag1_confidence [13:0] as input values. As output values, the first single_switch block generates an intermediate interpolated value vert_diag1_interpolated_pixel[11:0] and a respective confidence value

30 vert_diag1_confidence[13:0].

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The intermediate interpolated value vert_diag1_interpolated_pixel is equal to the median value of:

vert_interpolation,

diag1_interpolation and

5   (Vert_interpolation+diag1_interpolation)/2 – sign(vert_interpolation - diag1_interpolation)*(vert_confidence-diag1_confidence)

(the median of 3 values is the value which lies between the other two)

This means that the intermediate interpolated value

10   vert_diag1_interpolated_pixel lies between the two input values (vert_interpolation and diag1_interpolation). If the two confidence values are equal this intermediate interpolated value is equal to the average of these two input values, otherwise the intermediate interpolated value is closer (or equal) to the input value having the smaller confidence value.

15

vert_diag1_confidence is equal to the minimum of the two confidence values. (The third single switch block 29 does not need this computation since this value will not be used).

20   The replacement switch block 29 receives the corrected pixel value interpolated_pixel [11:0] or in the discussed example red_interpolated_pixel[11:0] as an input value. Additionally the read out value of the pixel in question is and the error section red_defect (x,y) of the input channel 11 are defined as input value. In dependence on the error signal

25   red_defect (x,y), the replacement switch block 29 gives out the uncorrected pixel value (in case red_defect (x,y)=0, i.e. no defect pixel) or the corrected pixel value red_interpolated_pixel[11:0] (in case red_defect (x,y)=01, i.e. defect pixel).

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Claims

1. Apparatus (15) for correcting of at least one defect pixel value of an image sensor unit,

    the image sensor unit comprising at least a first and a second pixel array (1, 2, 3), wherein the image sensor unit is arranged to project representations of substantially the same image onto each pixel array (1, 2, 3),

    the apparatus (15) comprising at least a first and a second input channel (11, 12, 13) for receiving pixel values of the first and the second pixel array, respectively,

    wherein the apparatus (15) is operable to replace a defect pixel value of the first pixel array with a corrected pixel value, wherein the corrected pixel value is determined from the values of neighbouring pixels of the defect pixel of the first pixel array,

    wherein

    the corrected pixel value is determined from values of a corresponding pixel and its neighbouring pixels of the second pixel array at the same pixel location as the defect pixel of the first pixel array with respect to the projected image,

    characterized in that

    the value of the corresponding pixel (6, 7) and/or the values of its neighbouring pixels (8, 9) are used to derive a confidence value for evaluating the values of the neighbouring pixels (5) of the defect pixel (4) in a weighted manner.

2. Apparatus (15) according to claim 1, further comprising a third input channel (13) for receiving pixel values of a third pixel array of the image sensor unit.

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3. Apparatus (15) according to claim 1 or 2, characterized in that the apparatus is adapted to evaluate the values of the neighbouring pixels of the defect pixel by directional interpolations, wherein the directional interpolation operations are performed along lines, whereby the lines are arranged in a vertical, horizontal, first diagonal and/or second diagonal direction resulting in various directional interpolation operation results for the defect pixel value.

4. Apparatus (15) according to claim 3, characterized in that the value of the corresponding pixel (6, 7) and/or the values of its neighbouring pixels (8, 9) are used to derive the confidence value for each of the directional interpolation operation results, the confidence value being a quantity for the quality of the respective directional interpolation.

5. Apparatus (15) according to one of the preceding claims 3 or 4, characterized in that that the confidence values are derived by a line-wise evaluation, whereby the lines are parallel or congruent to the lines of the corresponding or respective directional interpolation operation.

6. Apparatus (15) according to one of the preceding claims 3 to 5, characterized in that the confidence values are derived by calculating the mean value between the two next neighbours of the corresponding pixel, which are lying diametrically on a line parallel or congruent to the line of the directional interpolation operation and by subtracting the mean value from the value of the corresponding pixel.

7. Apparatus (15) according to one of the preceding claims 3 to 6, characterized in that the confidence values are used for evaluating the values of the neighbouring pixels (5) and thus the various directional interpolation operation results of the defect pixel (4) in the weighted manner.

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8. Apparatus (15) according to one of the preceding claims 3 to 7, characterized in that the directional interpolation results are mixed in dependence on the confidence value in order to generate the corrected pixel value.

5

9. Apparatus (15) according to one of the preceding claims claim 2 to 8, characterised in that the three input channels (11, 12, 13) represent three colour channels, preferably receiving pixel values corresponding to red, green and blue components of an image.

10

10. Apparatus (15) according to one of the preceding claims, characterized in that determining the corrected pixel from the neighbouring pixels (5) of the defect pixel (4) comprises interpolation operations, which are direction optimised.

15

11. Apparatus (15) according toone of the preceding claims 3 to 10, characterized in that the interpolation operations comprise an interpolation in a vertical, in a horizontal, in a first diagonal and/or in a second diagonal direction.

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12. Apparatus (15) according to one of the preceding claims 3 to 11, characterised in that the confidence values are derived in dependence on the interpolation directions.

25 13. Apparatus (15) according to one of the preceding claims 3 to 12, characterised in that for each interpolation direction one of the confidence values is derived, wherein the respective confidence value represents the difference of the values of the corresponding pixel and the neighbouring pixel of the corresponding pixel in the interpolation direction.

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14. Apparatus (15) according to one of the preceding claims 3 to 13 , characterised in that the results of the interpolation operation in the

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various interpolation directions are combined in dependence of the respective confidence values.

15.   Image sensor unit comprising a first, a second and a third pixel array (1, 2, 3), wherein the image sensor is adapted to project the same image region onto each of the three pixel arrays, characterised by comprising the apparatus according to one of the preceding claims.

16.   Image sensor unit according to claim 15, characterised by the pixel arrays being of the CMOS-sensor type.

17.   Image sensor unit according to claim 15 or 16, further comprising a plurality of directional interpolators (21, 22, 23, 24) for interpolating the defect pixel value.

18.   Image sensor unit according to claim 17, characterised in that the directional interpolators (21, 22, 23, 24) are operable to calculate the confidence values.

19.   Image sensor unit according to claim 17 or 18, characterised by a soft switch block (25) operable to mix the results of the directional interpolators (21, 22, 23, 24) depending on the respective confidence values in order to generate the corrected pixel value.

20.   Image sensor unit according to one of claims 15 to 19, characterised by a replacement switch block (26) operable to replace the defect pixel value with the corrected pixel value.

21.   Method for correcting defect pixel values of a first pixel array of an image sensor unit, characterised by the steps of:
        - interpolating a value for the defect pixel in various interpolation directions from the neighbouring pixels of the defect pixel of the first pixel array,

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- determining a confidence value for each interpolating direction by evaluating a corresponding pixel and its neighbouring pixels of at least a second pixel array, the corresponding pixel being arranged at the same location as the defect pixel with respect to an image projected onto the pixel arrays,

- mixing the results of the interpolations in the various directions in a weighted manner depending on the respective confidence values and thus generating a corrected pixel value,

- replacing the defect pixel value with the corrected pixel value.
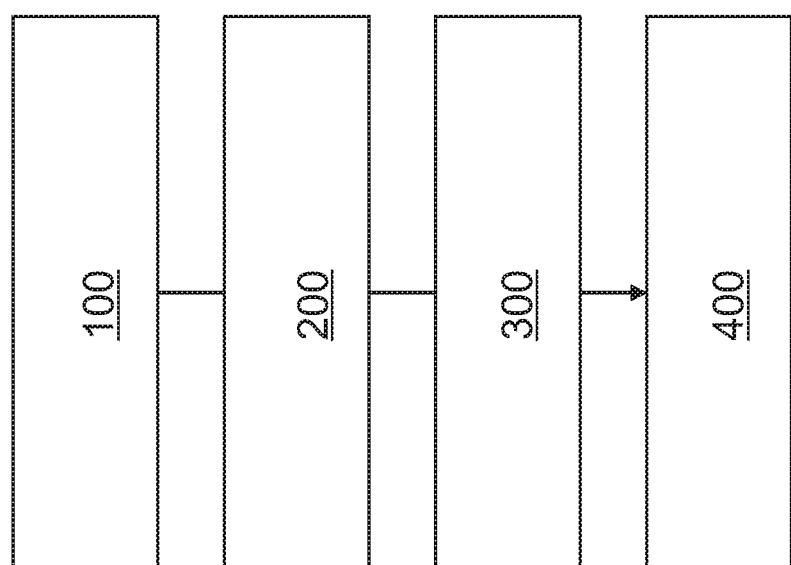
Fig. 1

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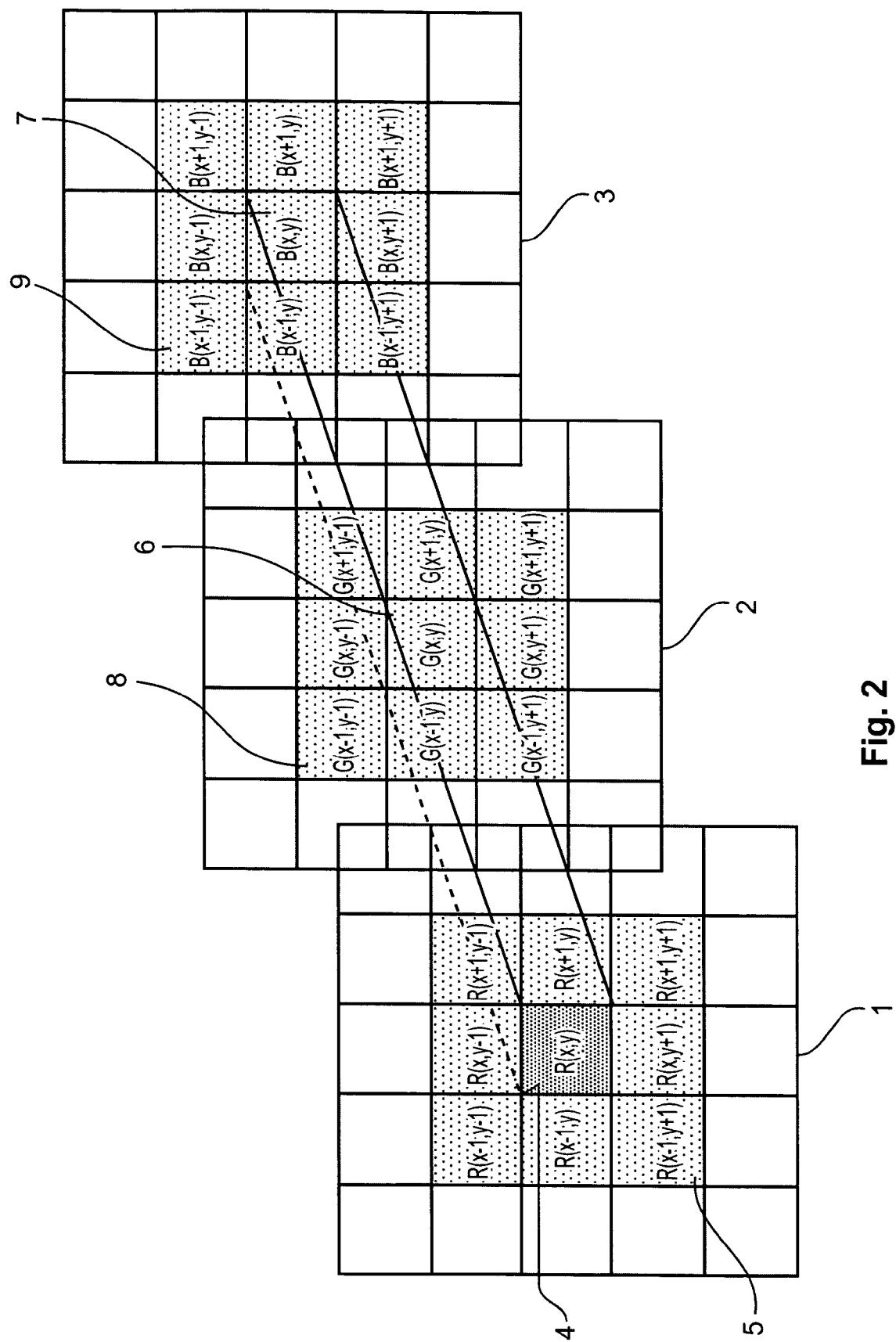
Fig. 2
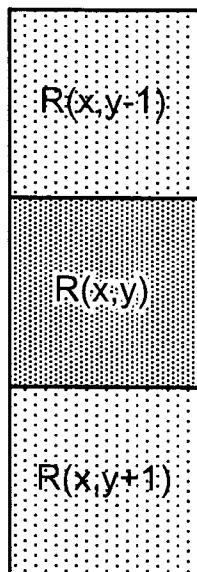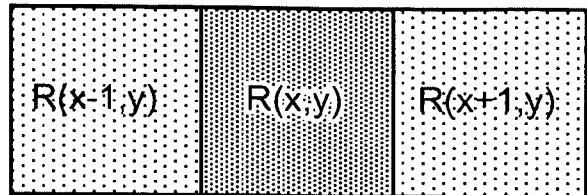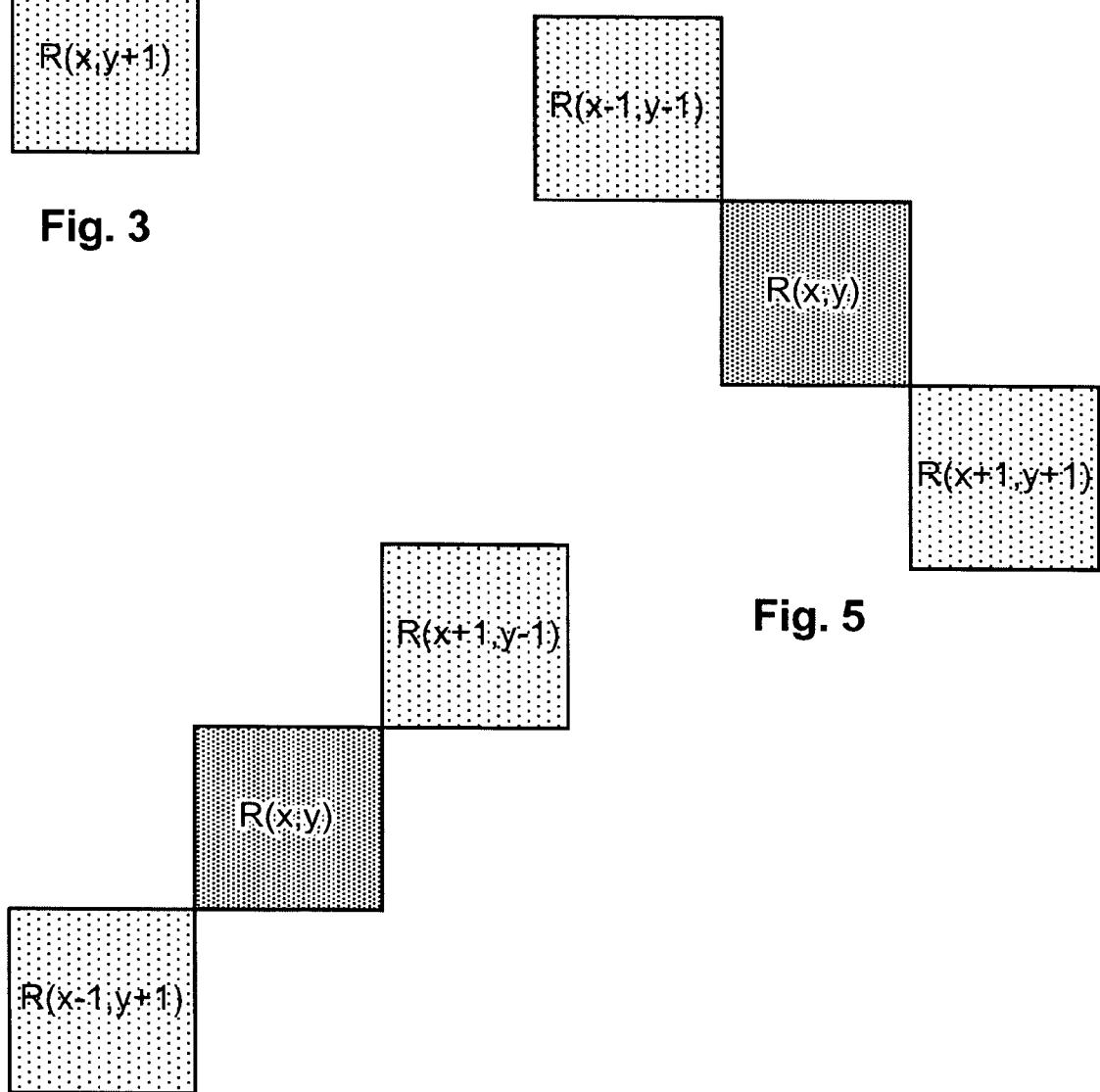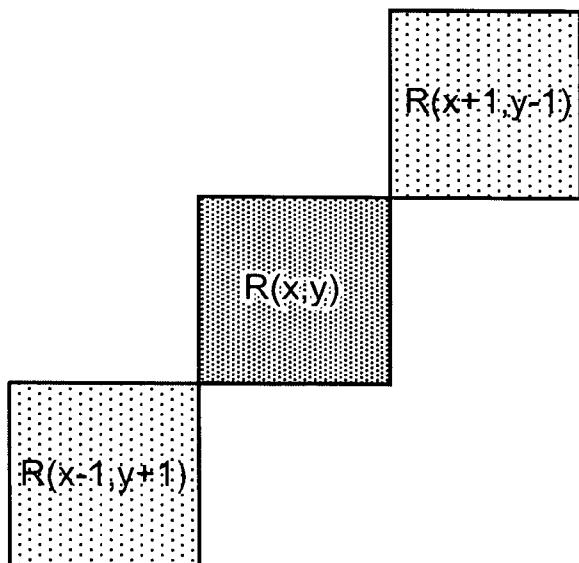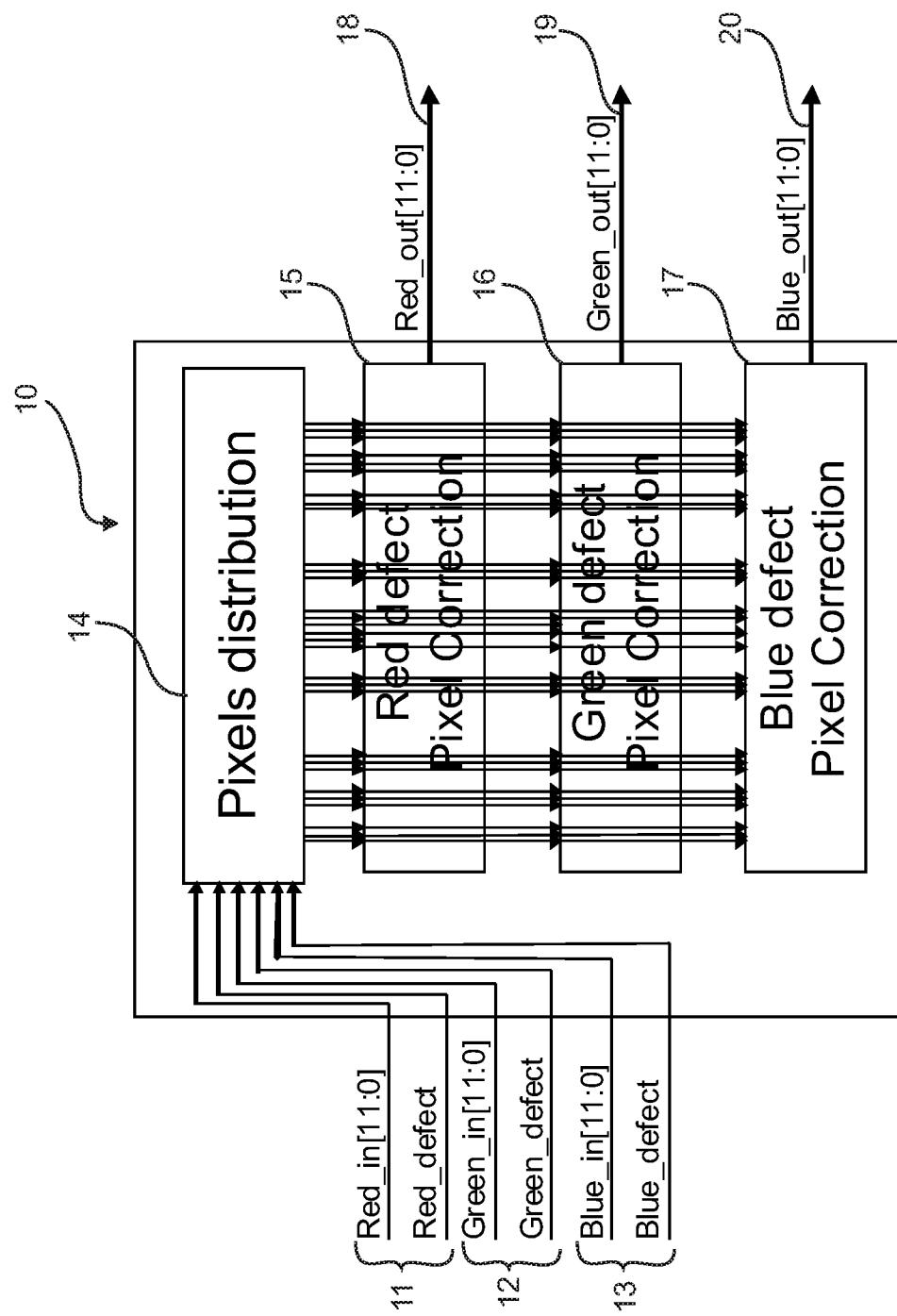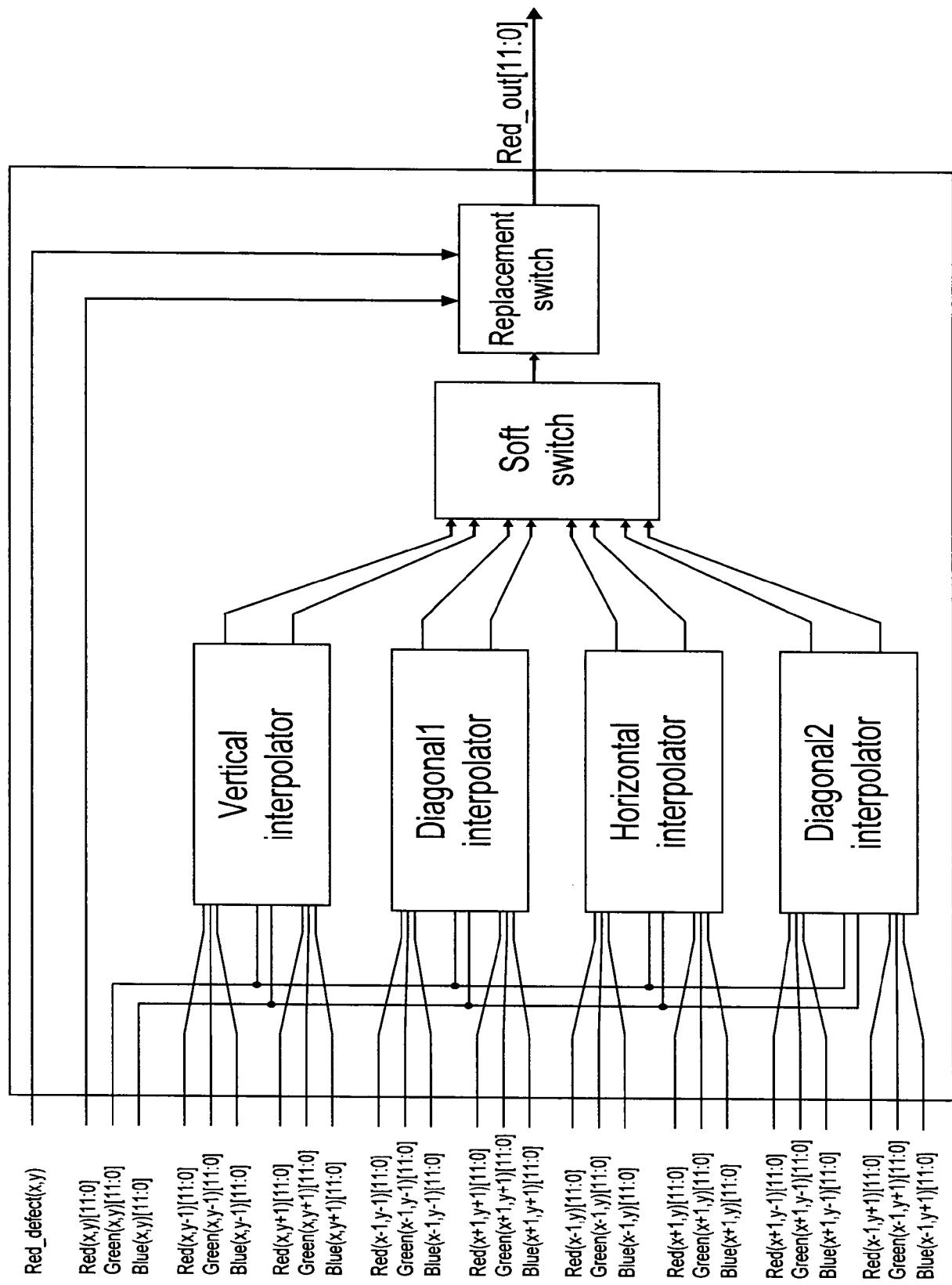
R(x,y-1)

R(x,y)

R(x,y+1)

Fig. 3

| R(x-1,y) | R(x,y) | R(x+1,y) |

Fig. 4

R(x-1,y-1)

R(x,y)

R(x+1,y+1)

Fig. 5

R(x+1,y-1)

R(x,y)

R(x-1,y+1)

Fig. 6

Fig. 7

Fig. 8

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Red(x,y-1)[11:0]

Green(x,y-1)[11:0]

Blue(x,y-1)[11:0]

Green(x,y)[11:0]

Blue(x,y)[11:0]

Red(x,y+1)[11:0]

Green(x,y+1)[11:0]

Blue(x,y+1)[11:0]

Vert_interpolation = (Red(x,y-1)+Red(x,y+1))/2

Vert_confidence = abs(G(x,y)-(G(x,y-1)+G(x,y+1))/2)
+ abs(B(x,y)-(B(x,y-1)+B(x,y+1))/2)
+ abs(R(x,y-1)-R(x,y+1))/2

Vert_interpolation[11:0]

Vert_confidence[13:0]

Fig. 9

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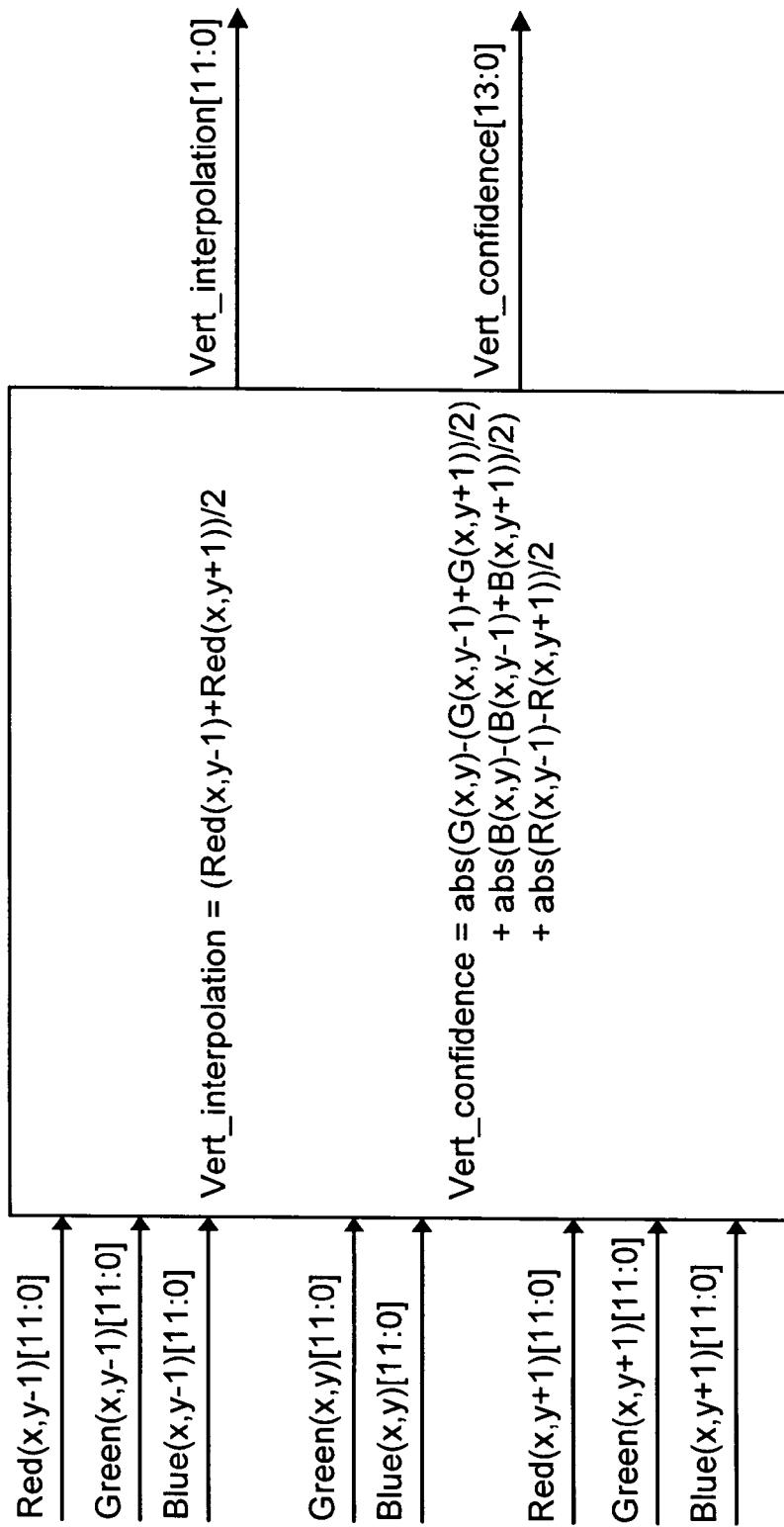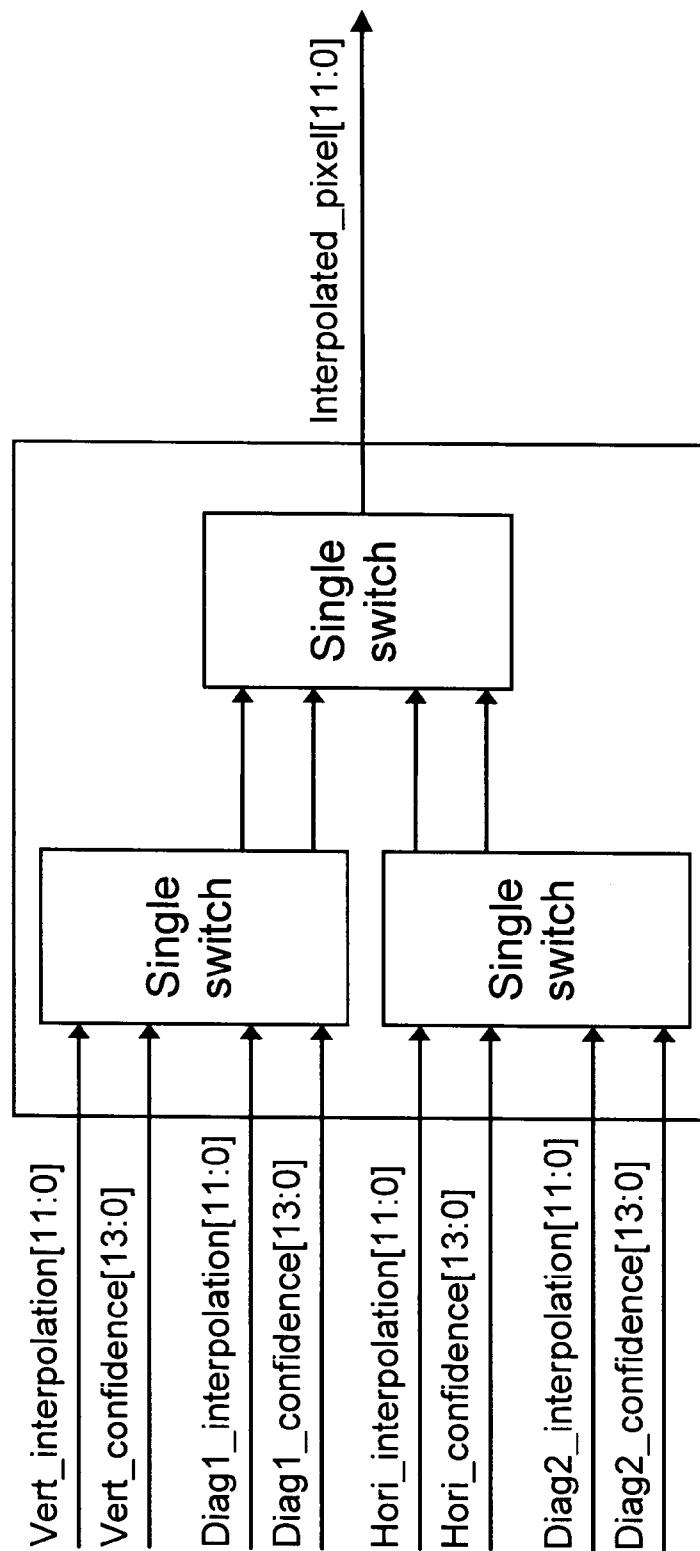
Fig. 10
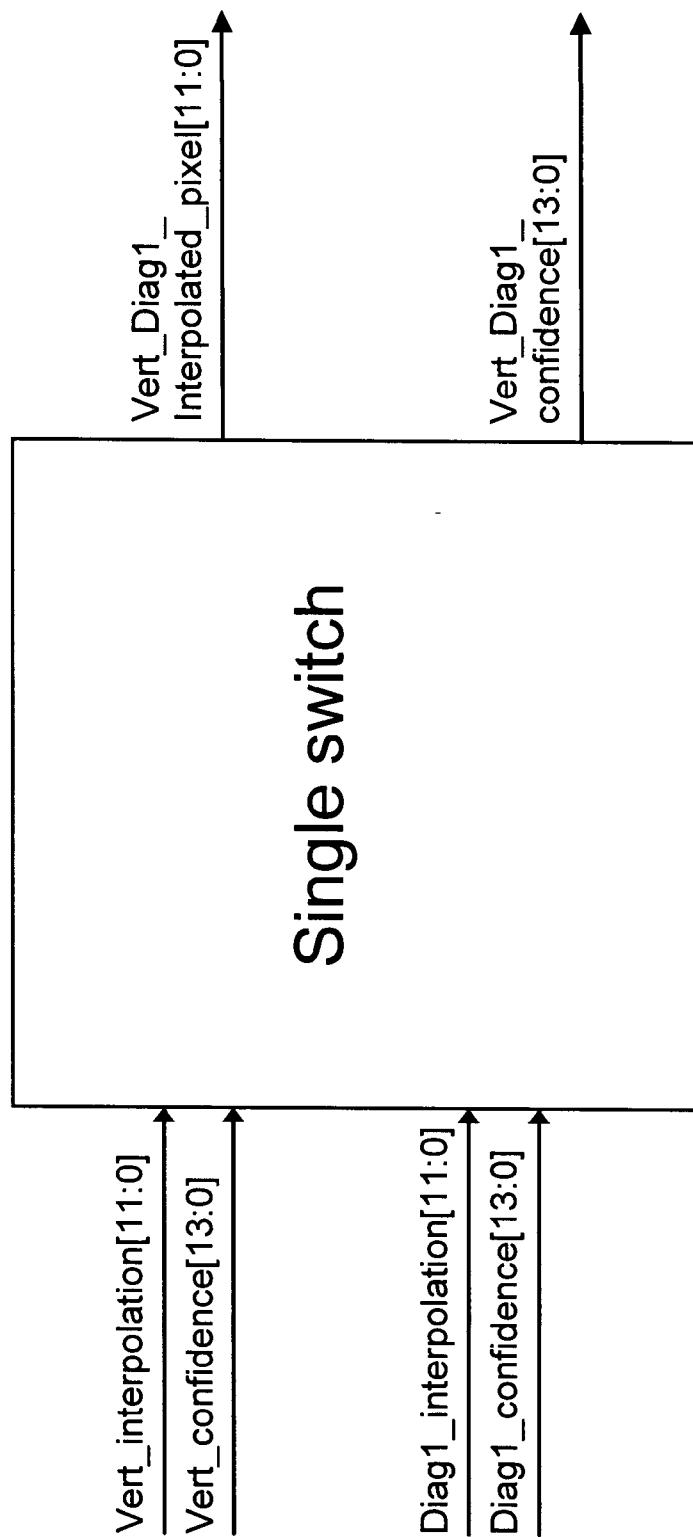
Fig. 11

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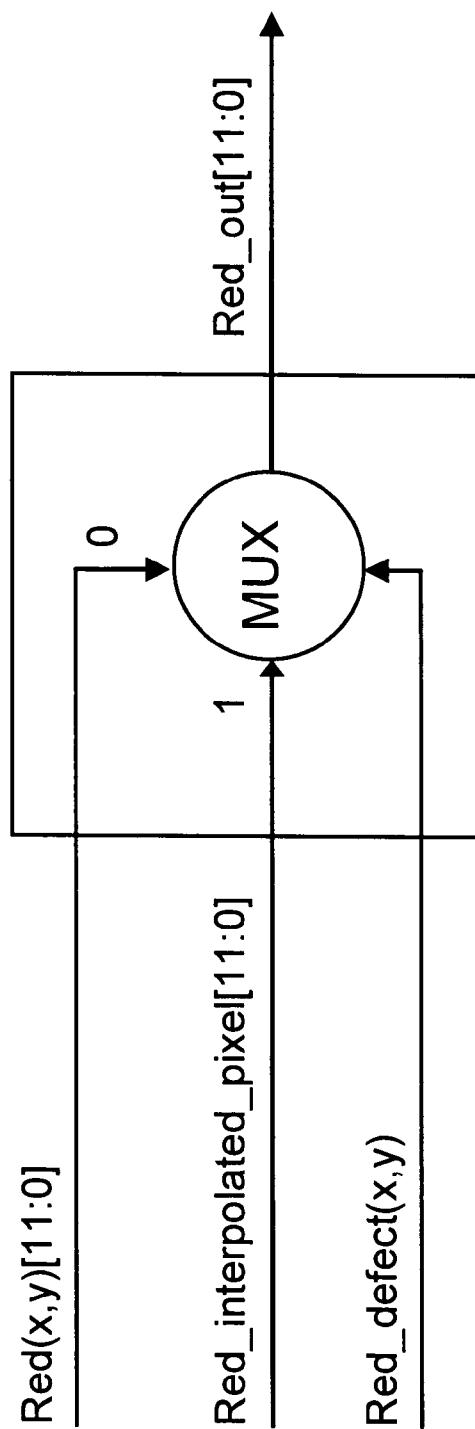
Fig. 12

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N5/217   H04N9/04   H04N9/09

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)
H04N   G06T

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

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

EPO-Internal

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| X | Further documents are listed in the continuation of Box C. | | X | 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
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"P" document published prior to the international filing date but later than the priority date claimed

"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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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 September 2008	07/10/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Wentzel, Jürgen

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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