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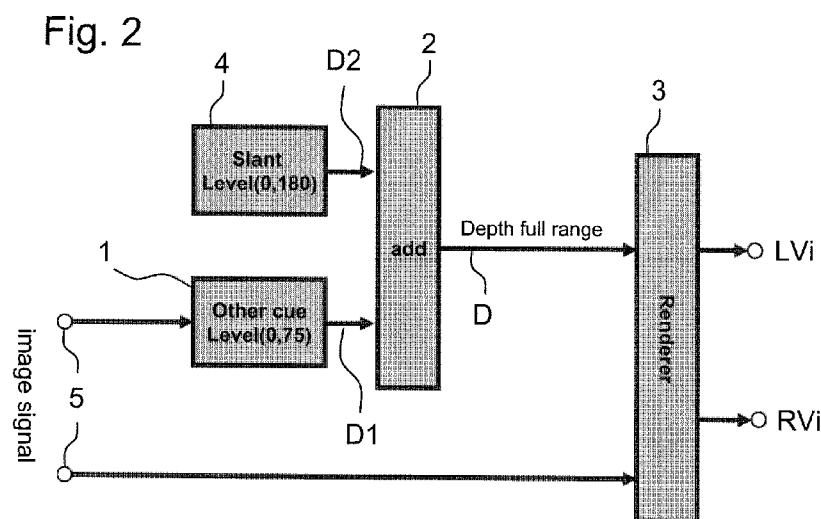
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(54) Title: METHOD FOR GENERATING OF A DEPTH MAP, METHOD FOR CONVERTING A TWO-DIMENSIONAL IMAGE SEQUENCE AND DEVICE FOR GENERATING A STEREOSCOPIC IMAGE



(57) Abstract: A method for generating a depth map from two-dimensional image data comprises providing an image signal comprising two-dimensional image data and processing the image signal to obtain a processed image signal, said processed image signal comprising frequency portions above a first cut-off frequency and below a second cut-off frequency.

Description

Method for generation of a depth map, method for converting a two-dimensional image sequence and device for generating a stereoscopic image

The present invention is related to a method for generating a depth map from a two-dimensional image data and to a method for converting a two-dimensional image sequence into an image sequence creating a stereoscopic view (or multi-view) for an observer. The invention is also related to a device for generating a stereoscopic image or image sequence from a two-dimensional image or image sequence.

BACKGROUND OF THE INVENTION

Modern televisions are recently becoming capable to display three-dimensional content to a viewer. As such, so called 3D-TVs display a video sequence or images, where objects can be shown to appear to project out of the screen and/or behind the screen. The basic concept underlying a three-dimensional presentation is the stereoscopic nature of the human visual system. That is, when two slightly shifted two-dimensional images are shown separately to the observer's left and right eye. The human visual system can perceive a depth based on such displacement of objects in both images. In the following the term three-dimensional view or image correspond to such stereoscopic view.

A number of conventional display technologies exist presenting separate and shifted images to the person's different eyes to create a three-dimensional view of a scene. For example, glasses based on technologies include line-interleaved

polarized displays used with passive polarized glasses and high repetition rate capable displays used with active shutter glasses. Repetition rates up to 200 Hz and more allow a smooth presentation of a stereoscopic view in a movie.

However, image content that is shot in original three-dimensional systems, e.g. with a stereo left/right camera is very limited up to now. On the other hand, most content including TV movies, TV shows to live sports events are often shot and available as 2D that is a single two-dimensional view. To enjoy the capability of a television capable of employing stereoscopic views, such original available two-dimensional content has to be converted to a three-dimensional presentation in real time.

For this purpose, 2D-to-3D conversion often comprises two steps. In a first step, a depth map is generated based on the two-dimensional video or image sequence that is to be converted. Such depth map defines the relative depth for each pixel in the image. In a subsequent step, the depth map is used together with the original image to generate a multiple images with different viewing angles, corresponding, for instance, to the left and right image of a stereoscopic view. In such process, each pixel is shifted based on the depth map values.

Due to different two-dimensional content available, the requirements for creating a depth map may vary significantly, finally resulting in different impressions of the stereoscopic view depending on the original two-dimensional image sequence.

SUMMARY OF THE INVENTION

In an embodiment, the invention is a method for generating a depth map from a two-dimensional image data wherein an image signal comprising two-dimensional image data is provided and processed to obtain a processed image signal. That processed image signal comprises frequency portions above a first cut-off frequency and below a second cut-off frequency.

Such process image with mid and some high frequency portions may represent a depth map.

In an embodiment, the method for generating a depth map generally employs a band pass filtering of two-dimensional image data to obtain mid and high frequency portion of the two-dimensional image data. Such frequency portion corresponds to coarse and fine details of the two-dimensional image data. Such details and frequency portion correspond to a depth map, which is spatiotemporal stable and in which small depth discontinuities are reduced.

In a further aspect, the proposed method employs filtering the image signal to obtain a filtered signal, said filtered signal comprising frequency portions of the image data above the first cut-off frequency and processing the filtered signal to obtain an output signal, corresponding to the depth map comprising frequency portions of the image data below the second cut-off frequency.

Such processing of the image signal may comprise blurring the two-dimensional data and particularly blurring the image data after the image data has been processed by applying the image signal to a high-pass filter.

In an embodiment, filtering the image signal comprises to filter the image signal using a high-pass filter, said filter comprising the first cut-off frequency depending on the pixel aperture size of the filter.

To further reduce computing time and complexity, the image signal may also be processed by downscaling the two-dimensional image data to obtain an image signal with down-scaled image data and then filtering the image signal with the down-scaled image data to obtain the filtered signal.

Further, the filtered image signal can be downscaled to obtain a downscaled filtered image signal and then further processed. Downscaling the filtered signal may reduce computing time and effort.

Another aspect of the invention is related to a method for generating a depth map from a two-dimensional image wherein the image data comprising image information for a plurality of pixels is provided to a high-pass filter. The filtered image data comprising frequency portions above a first cut-off frequency is applied to a blur filter to obtain a blur filtered image data. The blur filtered image data is output as a depth map.

In a different aspect, the method also comprises the step of filtering provided image data with a pre-filter to obtain pre-filtered image data, that pre-filtered image data comprising frequency portions below a third cut-off frequency. The third cut-off frequency is higher than the first cut-off frequency. Pre-filtering the image data, particularly by a low-pass filter, reduces high frequency portions of the image data. To reduce computational effort, the two-dimensional im-

age data can be down-scaled to obtain an image with down-scaled image data before applying the down-scaled image data to the high-pass filter.

In another aspect, the filtered image data can be down-scaled by a first factor in x-direction and a second factor in y-direction before applying the now down-scaled filtered image to the blur filter. After blurring the filtered and down-scaled image data, the data is up-scaled again by the inverse first factor in x-direction and the inverse second factor in y-direction. After each filter step, the filtered image data may be remapped, preferably soft-clipped to a pre-defined amplitude range.

In another embodiment, a method for converting a two-dimensional image sequence into an image sequence creating a stereoscopic view for an observer. The method comprises the step of generating a first depth map from the two-dimensional image sequence in accordance with one of the depth map generation methods described herein. Further, a background depth map using a pre-determined depth scheme is generated. Then, the first and second depth maps are combined to generate a combined image depth map. The stereoscopic view of a two-dimensional image sequence is generated using the combined image depth map and the two-dimensional image sequence.

While the first depth map includes the information about foreground objects, the background depth map may comprise a scheme with a slant or ramp corresponding to a static depth profile.

In a further aspect, depth values of at least one of the first depth map and the background depth map may be remapped

to a pre-determined level range, said level range smaller than a level range of the combined image depth map. Combining the first depth map and the background depth map may comprise adding the first depth map to the background depth map and particularly the respective depth values of the first depth map to the background depth map.

The method can be implemented in a semiconductor circuitry, for instance a digital signal processor or other programmable hardware.

In an embodiment, a device for generating a stereoscopic view of an image sequence comprises an input to receive two-dimensional image data, the data comprising image information for a plurality of pixels and an image processing unit configured to generate an image depth map from the two-dimensional image data. The processing unit may comprise a high-pass filter unit coupled to the input to obtain medium and high frequency portions from the received two-dimensional image data, a blur filter unit coupled downstream to the high-pass filter to blur the medium and high frequency portions. The device also comprises a 3D-generating unit coupled to the image processing unit. The 3D-generating unit is configured to generate the stereoscopic image or image sequence.

In an aspect, the image processing unit comprises a depth map generator configured to generate the background depth map having a pre-determined depth profile. Further, the image processing unit comprises a depth map combiner coupled to the blur filter unit and the depth map generator. The combiner is configured to add the background depth map and the blurred medium and high frequency portions to provide the image depth map.

Additional features and embodiments of the present invention will be evident in view of the following detailed description of the invention in accordance with the accompanying drawings.

A brief description of the drawings

FIG. 1 is a schematic diagram of the generation process of a stereoscopic view.

FIG. 2 shows an embodiment of the device according to an aspect of the present invention.

Figs 3A to 3D illustrate an example of an image, a generated first depth map, a background depth map and a combined depth map.

FIG. 4 illustrates an embodiment of the image depth map generator according to the present invention.

FIG. 5 is a more detailed view of the image depth map generator in accordance with an embodiment of the present invention.

FIG. 6 illustrates a method for generating a depth map and the corresponding depth map generator.

FIG. 7 shows another embodiment of an image depth map generator and respective method steps to generate a depth map in accordance with the embodiment.

FIG. 8 illustrates a further example of the depth map generation process according to the present invention.

FIG. 9 illustrates yet another embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The following embodiments illustrate various aspects of the present invention showing method steps and corresponding hardware elements combined. Elements with similar or same functionalities have the same reference signs. It is noted that the various elements and method steps can be implemented in dedicated hardware or implemented in software loaded in a programmable processing unit, like a digital signal processor, a field programming gate array or similar hardware circuitry. As such the units illustrated in the embodiment can be program modules or software functions executed in a processor or hardware circuitry. For example, the TriMedia processor family and its successors can be used for this purpose. Combinations of dedicated hardware as well as software are also possible.

The various aspects can also be combined in different ways without limiting the invention to the precise forms disclosed. Variations and modifications of the embodiments described herein will be apparent to one of ordinary skill in the art in light of the below disclosure. The scope of the invention is to be defined by the claims appended hereto and by their equivalents. Further, while the present invention will be explained using TV signals, it will be noted that the present invention is not restricted thereto. It may also be noted that different filters or technologies can be used and

still remain within the spirit and scope of the present invention.

Figure 1 illustrates the principle of generating a stereoscopic view of two-dimensional image data according to the present invention. The two-dimensional image data M, in this case a single picture of an image sequence is processed to generate a depth map D from the image information. Image information may comprise color, chrominance and/or luminance values, but is not restricted thereto.

The depth map provides information about the relative depth for each pixel within image M. For instance, objects in the foreground are brighter, as they appear to be closer to the viewer, while objects in the background are darker, because it is assumed such objects are farther away from the viewer.

The stereoscopic left view LV and right view RV can be generated from the generated image depth map D and the original image information. In the example image M may be used for the right view RV of the stereoscopic views. For generating the left view LV, each pixel of image M is phase shifted depending on the depth value of the respective pixel in depth map D. It can be seen that brighter objects in the depth map are stronger shifted, while dark objects, appearing in the background and farther away from the viewer are only marginal shifted.

Figure 2 illustrates a device for generating a stereoscopic view from a two-dimensional image or image sequence. The image as illustrated in Figure 2a in form of an image signal is applied to the device at input terminal 5. The image in Fig-

ure 2a comprises a plurality of pixels, each pixel carrying colour information as mentioned above.

For generating the depth map D as seen in Figure 1, the image signal is applied to an image adaptive depth map generator 1. The depth map generator 1 extract mid and high frequency portions of the image signal and provides depth value for each pixel within the image. In other word the image is processed and mid and high frequency portions, up to some cut-off frequency is extracted, representing depth map D1. Various embodiments of the depth map generator 1 will be explained later in greater detail with respect to Figures 3 to 8.

The depth map D1 created by the depth map generator 1 comprises, for each pixel of the image applied to input 5, a specific depth value. These values lay within a predetermined level range 0 to 75 out of 255 possible values as illustrated in Figure 2b. Depth map D1 in figure 2b reflects depth information about the various objects within the image of Figure 2a.

In addition to the depth information, the device according to the present invention further comprises a background depth generator 4 configured to generate depth map D2 with a predetermined depth profile. In this example, the depth profile comprises a linear increase of depth values starting with the bottom-most pixel with value 0 to the topmost pixel with value 180. The resulting depth map is shown in figure 2c.

The reason for the linear increase or slant is given by the assumption that objects in the foreground are normally arranged in the bottom area of an image, while background ob-

jects and background in particular can be seen in the rear and as such appear in to top area of the image.

Both depth maps D1 and D2 are applied to combiner 2, which adds depth map D1 from generator 1 to the background depth map provided by background generator 4. The resulting depth map Di illustrated in Figure 2d comprises the full depth range with possible values from 0 to 255, wherein 255 corresponds to the brightest and therefore assumed closest object. The combination of background depth map D2 with predetermined depth values and depth map D1 adaptively generated allow a slight depth separation of objects from the environment.

Generated depth map D1 by combiner 2 is applied together with the image at input 5 to the 3D-generation unit 3. 3D-generation unit 3 uses the image information at input 5 to generate a first image of a stereoscopic view and outputs the image at one of its output terminal LVi and RVi, respectively. In addition, it uses the depth information from depth map Di to shift each pixel of the two-dimensional image depending on the depth value. The resulting phase-shifted image is provided at the respective other output for the stereoscopic view of the image at input 5.

In the example, the sum of both depth levels of depth maps D1 and D2 gives the full range depth map Di with a level range from 0 to 255. It is possible to do some remapping or scaling in the one of the depth map generators 1, 4 to provide additional headroom in the slant for other cue values, like for instance from depth map generator 1. Alternatively or in addition, combiner 2 may also be configured to provide some soft clipping to the depth values of generator 4 and 1, re-

spectively, to allow for the full range of the combined depth map.

Figure 3 illustrates depth map generator 1 and the respective method steps for generating a depth map in greater detail. The image data or image signal representing pixel information is applied to input terminal 5. In the example, the image has a resolution of 1920x1080 pixels at a frame rate of 60 frames per second, with colour information of 8 bits per pixel. This information corresponds to a full HD image sequence.

To create a depth map from the two-dimensional image, wherein details of the objects are kept at the same depth level and object break-ups are reduced, several filters and elements are used.

In the embodiment, high frequency portions of the image signal, that is a fast variation of luminance or chrominance values, are pre-filtered and removed using a 5x5 box filter. Pre-Filter unit 10 basically acts as a low pass filter with a very high cut-off frequency to ensure removal of all high frequency portions. The values 1, 4, 6, 4, 1 represent approximation values of Gaussian filter coefficients also corresponding to a convolution filter with a matrix having those values as coefficients.

The low pass filtered signal is then applied to a second filter to derive the course and remaining high frequency portions. For this purpose, pre-filter unit 10 is coupled to filter unit 11. Filter unit 11 comprises a box filter 110 implemented as a 17x17 box filter and soft clipper 111. A small filter like a 3x3 or 5x5 filter resulting in a very low cut-off frequency may not provide enough details of the objects in the image. On the other hand, box filters with very large

aperture, such as 20% of the image size, may pass all frequencies so that objects may break up into different pieces. Consequently, medium sized box filters with aperture sizes from 0.5% to 12% of the input resolution of the image are used, as they provide enough details of the object and temporal stability. While in unit 11 of this example a 17x17 box filter is used, other aperture sizes like 21x21 to 101x101 may be suitable as well.

The image data filtered this way is then applied to a soft clipping unit 111 to remap the filtered results to a predefined amplitude range. As soft-clipping requires information about the amplitude range, soft clipper 111 is also coupled to input of filter unit 11 to receive the pre-filtered image data applied to box filter 110. The soft clipping together with the filtering process prevents undesired large discontinuities in the depth map which may not be perceived well in a stereoscopic view.

The output of unit 11 is a high resolution filtered image with mid and some high frequency portions only.

In the next step, the filtered image is blurred with a very large blur filter to make the resulting depth map spatiotemporal stable and to smoothen out all small depth discontinuities in the depth map. As the smoothing operation using a very large (e.g., 120x90) box filter 122 takes relatively high computational effort when applied to a HD resolution picture, the filtered image signal at the input of filter unit 12 is downsampled using downscaler 120 with adjustable downscaling factors X and Y. The downscaling process will reduce computing time in the subsequent stages without significantly disturbing the depth map generation process.

The process of downscaling, then blurring and then upscaling is the operation to filter the signal with second cut-off frequency with the frequency portions above the second cut-off frequency are being reduced.

As we want to blur mid/high-frequency portions of the original HD signal using large blur filters (e.g., 120x90), the downscale process can be done using large downscale factors, like for instance X=40 in x-direction and Y=30 in y-direction. After downscaling the resulting image data, now 48x36 pixels with 8-bit pixel information, is normalized to a specific level range by re-mapper 121. Re-mapper 121 remaps the amplitude of every input pixel to a determined level range with values from 0 to 50. Then, the downscaled filtered and normalized image data is blurred by applying the image data to a box filter. The box filter may comprise an aperture size of 3x3.

Finally, the now downscaled and filtered image data will be up-scaled to the original resolution using interpolator 123. In this example, a bilinear interpolation with the inverse factors of downscaler 120 is applied to the downscaled image data resulting in the original HD resolution of the filtered image. The resulting image data corresponds to the depth map with a level range basically predetermined by re-mapper 121.

The method illustrated in Figure 3 is image adaptive as it produces different depth maps for each image applied at input 5. It uses the image properties and particularly mid and high frequency portions in contrast to a motion-based method. Therefore, it can be applied to all kinds of different image contents.

Figure 4 illustrates the depth map generation circuitry with generators 1, 4 and combiner 2. Depth map generator 1 provides a depth map representing various objects in the image, whereby the generated depth map has a level range of 0 to 50 due to re-mapper 121 and filter unit 12. At the same time, a slant depth map is provided from background depth map generator 4 and unit 40. A predetermined depth scheme is used, starting with the highest value at the bottom of the depth map decreasing the depth map values with increasing height of the depth map. Such static depth map generated by unit 40 may be sufficient for a specific content, in which foreground objects are arranged in the lower part of the image while background and background objects are arranged in the upper part.

The level range for the static depth profile is from 0 to 180, for the depth map generated by depth map generator it is 0 to 50. This gives additional headroom for the total level range of the depth map to improve depth separation of objects from the environment.

Both depth maps are added in combiner 3 to provide the combined depth map which is then applied to the 3D generation unit.

Several different embodiments and filter operations are possible for depth map generator 1. Figure 5 shows yet another example of a depth map generator according to the present invention. In this embodiment, filter 11a is used to directly derive the medium and high frequency portions out of the image data applied to input terminal 5. Box filter 110 comprises an adjustable aperture size to process images with various resolutions. The aperture size is selected depending on the resolution of the image applied to input 5. If an im-

age sequence with a smaller resolution is applied to input, the aperture size may be chosen differently. For instance, an image resolution of 720x576, corresponding to normal DVD resolution, may require an aperture size of 6x6. Other resolutions may include EDTV, PAL, PAL-WIDE, NTSC, HDTV, but are not limited thereto. Depending on the image resolution, the aperture size may be selected accordingly. In addition the content may influence the adjustment factor to the extent that an action movie with huge motion may require different aperture size than a news report with little or almost no motion.

The filtered image data is clipped and normalized to a specific level range in clipper 111 connected downstream to box filter 110. Soft clipper 111 uses the input image signal as a reference to re-map the amplitude of the box filtered signal to a specific level range. The results are provided to second filter unit 12 with a downscaler 120, re-mapper 121, blurring box filter 122 and interpolator 123. The filtered image signal provided by unit 11 is down-scaled by downscaler 120 to reduce computing time in filter unit 12. Again downscaler 120 and up-scaler 123 each comprise an adjustment input to adjust the factor. The values X and Y for down- and up-scaling are selected depending on the resolution of the image applied to input 5. If an image sequence with a smaller resolution is applied to input, the downscale factors may be chosen differently. For an image resolution of 720x576, the factors may be chosen to be X=15 and Y=16, resulting in a 48x36 downsampled image as well.

Second filter unit 12 applies a low pass filter using box filter 122 on the normalized and downsampled image signal. The normalized and blurred filtered image signal at output of a box filter 122 is applied to a bilinear interpolator for up-scaling to the original HD image resolution. The resulting depth map is a blurred and high pass filtered version of the original image.

It is possible to apply the high pass filtered image at the output of first filter unit 11a directly to re-mapper 121 and blur filter 122 without downscaling at the costs of increased computing effort.

A further embodiment to reduce computing time and effort is illustrated in Figure 6.

In this embodiment, downscaler 10a is connected upstream to high pass filter unit 11b and blur filter unit 12. Downscaler 10a with scaler unit 101 receives image data from input terminal 5 and provides downsampled image data. Particularly the image with HD resolution is downsampled by a factor of 4, giving a 480x270 downsampled image applied to high pass 11b. High pass filter 11b comprises a 5x5 box Gaussian filter 130. As the image is already downsampled, the aperture size of the box of the Gaussian filter can be smaller while achieving spatio-temporal stability. Again, the filtered signal is applied to a soft clipper for remapping the pixel amplitudes to a predetermined level range.

Second filter unit 12 also comprises a down- and up-scaler, respectively. Due to the downscaling by downscaler 10a, the factors for downscaler 124 are smaller as well. Depending on the scaling factor of downscaler 101 in pre-filter 10a, the

output of high pass 11b can be coupled directly to re-mapper 121 and the blur filter 122 without an additional downscaling process in unit 12. After normalizing the downscaled and filtered image data, the data is blurred and then applied to interpolator 123. A bilinear interpolator 123 takes the downscaling operation of downscaler 124 and 101 into account to provide a depth map with the HD resolution as illustrated.

Figures 7 and 8 illustrate further embodiments of an image map generator and the respective method steps. In these embodiments, different filter operations are used to derive the medium and high frequency portions of the image signal. For instance, Figure 7 illustrates to apply a bilinear filtering with an aperture size of 0.5 to 12% of the image resolution to the image signal. In Figure 8 a Gaussian filter 115 is used a high pass in first filter unit 8. In these two embodiment the filters 114, 115, and the downscaler 120 as well as the up-scaler 123 are adjustable depending on the resolution of the image sequence applied to input 5.

The present invention employs an image adaptive method to generate a depth map out of a two-dimensional image sequence. Therefore, different depth map are generated for each varying image. The method uses image properties, namely high and mid frequency portions, which are always present in the image. As a result, the method can be used irrespectively of the content and overcomes the problem of motion based methods in cases where no motion or only arbitrary motion is present. The combination of a more static depth scheme together with the depth map generation method according to the present invention improves the 3D impression of a viewer in outdoor scenes as well as in close-ups and indoor scenes.

REFERENCE LIST

- M image, single frame of an image sequence
- D depth map
- D1 first or foreground depth map
- D2 background depth map
- Di combined depth map
- LV left view of a stereoscopic view
- RV right view of a stereoscopic view
- 1 depth map generator
- 2 depth map combiner
- 3 3D-generation unit
- 4 background depth map generator
- 5 input terminal
- 10 pre-filter unit
- 10a downscaler
- 11 first filter unit
- 12 second filter unit
- 101 downscaler
- 110 box filter
- 111 soft-clipper, re-mapper
- 112 input
- 114 bilateral filter with adjustable aperture size
- 115 gaussian filter
- 120 downscaler
- 121 re-mapper
- 122 blur filter, box filter
- 123 up-scaler, interpolator

Claims

1. Method for generating a depth map from two-dimensional image data, the depth map defining a relative depth of each pixel in the two-dimensional image data, the method comprising:
 - providing an image signal comprising two-dimensional image data;
 - processing the image signal to obtain a processed image signal, said processed image signal comprising frequency portions above a first cut-off frequency and below a second cut-off frequency.
2. The method of claim 1, wherein processing the image signal comprises obtaining coarse and fine details of the two-dimensional image data.
3. The method according to any of claims 1 to 2, wherein processing the image signal comprises:
 - filtering the image signal to obtain a filtered signal, said filtered signal comprising frequency portions of the image data above the first cut-off frequency;
 - processing the filtered signal to obtain an output signal comprising frequency portions of the image data below the second cut-off frequency.
4. The method of claim 3, wherein processing the filtered signal comprises blurring two-dimensional image data.
5. The method of claim 3, wherein filtering the image signal comprises:

- applying the image signal to a high-pass filter, said filter comprising the first cut-off frequency depending on the pixel aperture size of the filter.

5 6. The method according to claim 5, wherein the aperture size of the high-pass filter depends on the image content of the two-dimensional image data.

10 7. The method according to claim 3, wherein filtering the image signal comprises:

- filtering the image signal using a non-linear filter, particularly a bilateral filter.

15 8. The method according to any of claims 3 to 7, wherein processing the image signal comprises:

- downscaling the two-dimensional image data to obtain an image signal with downsampled image data and then
- filtering said image signal with downsampled image data to obtain the filtered signal.

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9. The method according to any of claims 3 to 7, wherein processing the image signal comprises:

- filtering the image signal with a pre-filter to obtain a pre-filtered signal, said pre-filtered signal comprising frequency portions of the image data below a third cut-off frequency, said third cut-off frequency being higher than the first cut-off frequency.

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10. The method according to any of claims 1 to 9, wherein processing the image signal comprises

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- remapping an amplitude of the filtered signal to a pre-defined amplitude range.

11. The method according to claim 10, wherein remapping comprises soft-clipping of the filtered signal.

12. The method according to any of claims 3 to 11, wherein
5 processing the filtered signal comprises:

- downscaling the filtered signal;
- applying the downscaled signal to a filter with a low pass characteristic, particularly a blur filter;
- up-scaling the downscaled filtered signal.

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13. The method according to claim 12, wherein up-scaling the filtered and downscaled signal comprises bilinear, bicubic or stairstep interpolating the downscaled filtered image signal.

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14. The method according to any of claims 3 to 12, wherein processing the filtered signal comprises normalizing the filtered signal or normalizing the downscaled filtered signal.

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15. Method for generating a depth map from a two-dimensional image, the depth map defining a depth value of each pixel in the two-dimensional image, the method comprising:

- providing image data comprising image information for a
25 plurality of pixels;
- applying the image data to a high-pass filter to obtain filtered image data comprising frequency portions above a first cut-off frequency;
- applying the filtered image data to a blur filter to ob-
30 tain blurred filtered image data;
- outputting the blurred filtered image data as the depth map.

16. The method according to claim 15, further comprising:

- filtering the provided image data with a pre-filter to obtain pre-filtered image data, said pre-filtered image data comprising frequency portions below a third cut-off frequency, said third cut-off frequency being higher than the first cut-off frequency.

17. The method according to claim 15, wherein further comprising:

- downscaling the two-dimensional image data to obtain an image with downscaled image data and then
- applying the image data to the high-pass filter.

18. The method of claim 15, wherein the high-pass filter comprises a block aperture size in the range of 0,5 % to 12 % of the number of the pixels in the image data.

19. The method according to any of claims 15 to 18, further comprising:

- remapping, preferably soft-clipping, the filtered image data, to a pre-defined amplitude range.

20. The method according to any of claims 15 to 19, further comprising:

- downscaling the filtered image data by a first factor in x-direction and a second factor in y-direction and
- up-scaling blurred filtered image data by the inverse first factor in x-direction and the inverse second factor in y-direction.

21. The method according to claim 20, wherein first and second factor are different.

22. The method according to any of claims 15 to 21, wherein a applying the filtered image data to a blur filter comprises:

- normalizing the downscaled and/or filtered image data to a pre-defined amplitude range;
- applying the downscaled and/or filtered image data a blur filter;
- up-scaling the blurred filtered image data.

23. The method according to claim 22, wherein up-scaling the blurred filtered image data comprises:

- bilinear, bicubic or stairstep interpolating the blurred image signal.

24. Method for converting a two-dimensional image sequence into an image sequence creating a stereoscopic view for an observer, comprising:

- generating a first depth map from the two-dimensional image sequence in accordance with any method of the preceding claims;
- generating a background depth map from the two-dimensional image sequence using a pre-determined depth scheme ;
- combining the first depth map and the background depth map to generate a combined image depth map;
- generating the image sequence for the stereoscopic view using the combined image depth map and the two-dimensional image sequence.

25. The method according to claim 24, wherein the pre-determined depth scheme comprises a slant or ramp corresponding to static depth profile.

26. The method according to any of claims 24 to 25, comprising:

- remapping depth values of at least one of the first depth map and the background depth map to a pre-determined level range, said level range smaller than a level range of the combined image depth map.

27. The method according to any of claims 24 to 26, wherein

- each of the first, background and the image depth map comprise a respective level range, wherein the sum of the first level range and the background level range is smaller than the full depth range.

28. The method according to claim 27, wherein the second

level range is greater than the first level range.

29. The method according to any of claims 24 to 28, wherein

combining the first depth map and the background depth map comprises adding the first depth map to the background depth map.

30. Device for generating a stereoscopic image or image sequence from a two-dimensional image or image sequence, comprising:

- an input to receive two-dimensional image data, the data comprising image information for a plurality of pixels;
- an image processing unit configured to generate an image depth map from the two-dimensional image data, said processing unit comprising:
 - a high-pass filter unit coupled to the input to obtain medium and high frequency portions from the received two-dimensional image data;

- a blur filter unit coupled downstream to the high-pass filter to blur the medium and high frequency portions from the two-dimensional image data;
- a 3D-generating unit coupled to the image processing unit and configured to generate the stereoscopic image or image sequence from the two-dimensional image data and the image depth map provided by the image processing unit.

31. The device according to claim 30, wherein the image processing unit further comprises:

- a depth map generator configured to generate a background depth map having a pre-determined depth profile;
- a depth map combiner coupled to the blur filter unit and the depth map generator and configured to add the background depth map and the blurred medium and high frequency portions to provide the image depth map.

32. The device according to claim 31, wherein

- the background depth map comprises a background level range;
 - the image depth map comprises an image level range; and
- wherein a sum of the background level range and a level range of the blurred medium and high frequency portions is smaller than the full depth level range.

25

33. The device according to any of claims 31 to 32, wherein the depth map combiner comprises:

- re-mapper configured to receive the background depth map and/or the blurred medium and high frequency portions to normalize each to a respective level range.

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34. The device according to any of claims 30 to 33, wherein the high-pass filter unit comprises:

- a clipping unit coupled downstream to an high-pass filter and configured to limit the medium and high frequency portions from the two-dimensional image data to a pre-determined maximum value.

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35. The device according to claim 34, wherein the clipping unit comprises a soft-clipper.

36. The device according to any of claims 30 to 35, wherein
10 the blur filter unit further comprises:

- a down-scaler coupled to the high-pass filter unit and configured to downscale the medium and high frequency portions from the received two-dimensional image data;
- a filter coupled to the down-scaler and configured to blur
15 the downscaled signal;
- an up-scaler coupled to the filter and configured to interpolate the blurred downscaled signal.

37. The device according to claim 36, wherein

- 20 - the down-scaler is configured to downscale the medium and high frequency portions from the received two-dimensional image data by a first factor in a first direction and a second factor in a second direction.

25 38. The device according to claim 37, wherein

- the up-scaler is configured to upscale the blurred down-scaled signal by the inverse first factor in the first direction and the inverse second factor in the second direction.

30

39. The device according to claim 37, wherein first factor and second factor are different.

40. The device according to any of claims 36 to 39, wherein the blur filter unit further comprises a re-mapper arranged between the down-scaler and the filter and configured to normalize the downscaled medium and high frequency portions to a predetermined level range.

41. The device according to any of claims 36 to 39, wherein at least one of the following units:

- image processing unit,
- 10 - high-pass filter unit,
- blur filter unit,
- down-scaler,
- up-scaler,
- filter,
- 15 - clipping unit

is implemented in one or more software functions, said software functions stored in a memory and being adapted to be executed by a processor.

Fig. 1

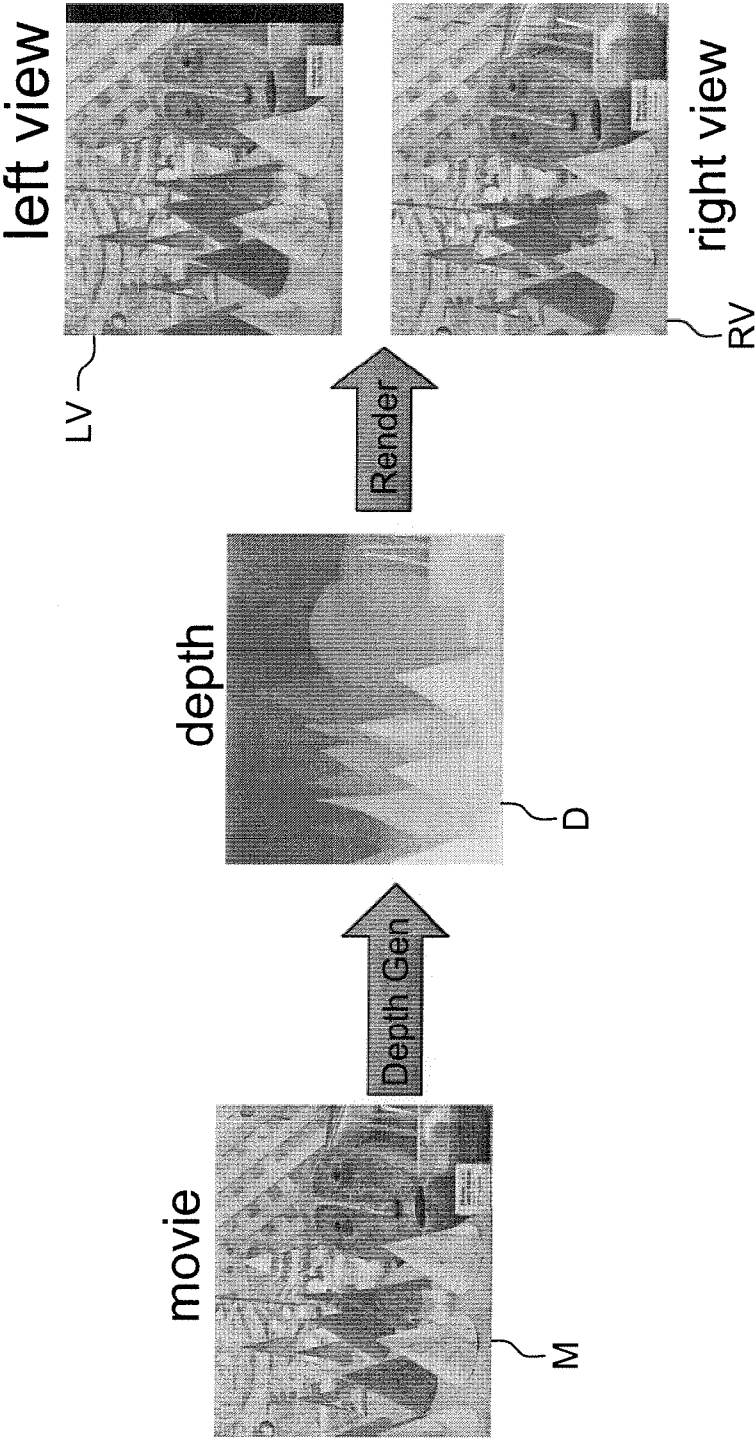


Fig. 2

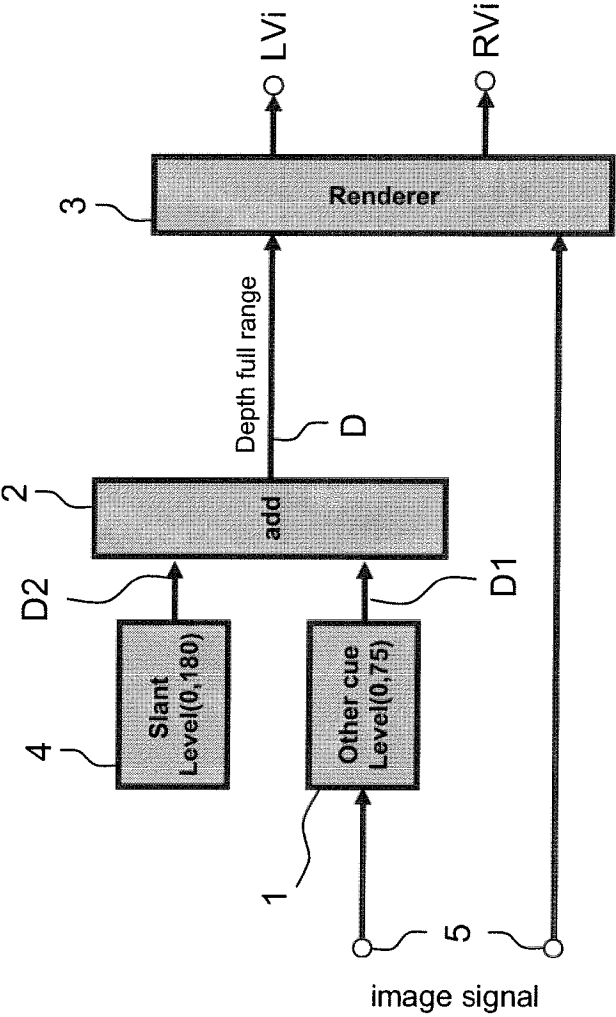


Fig. 3a

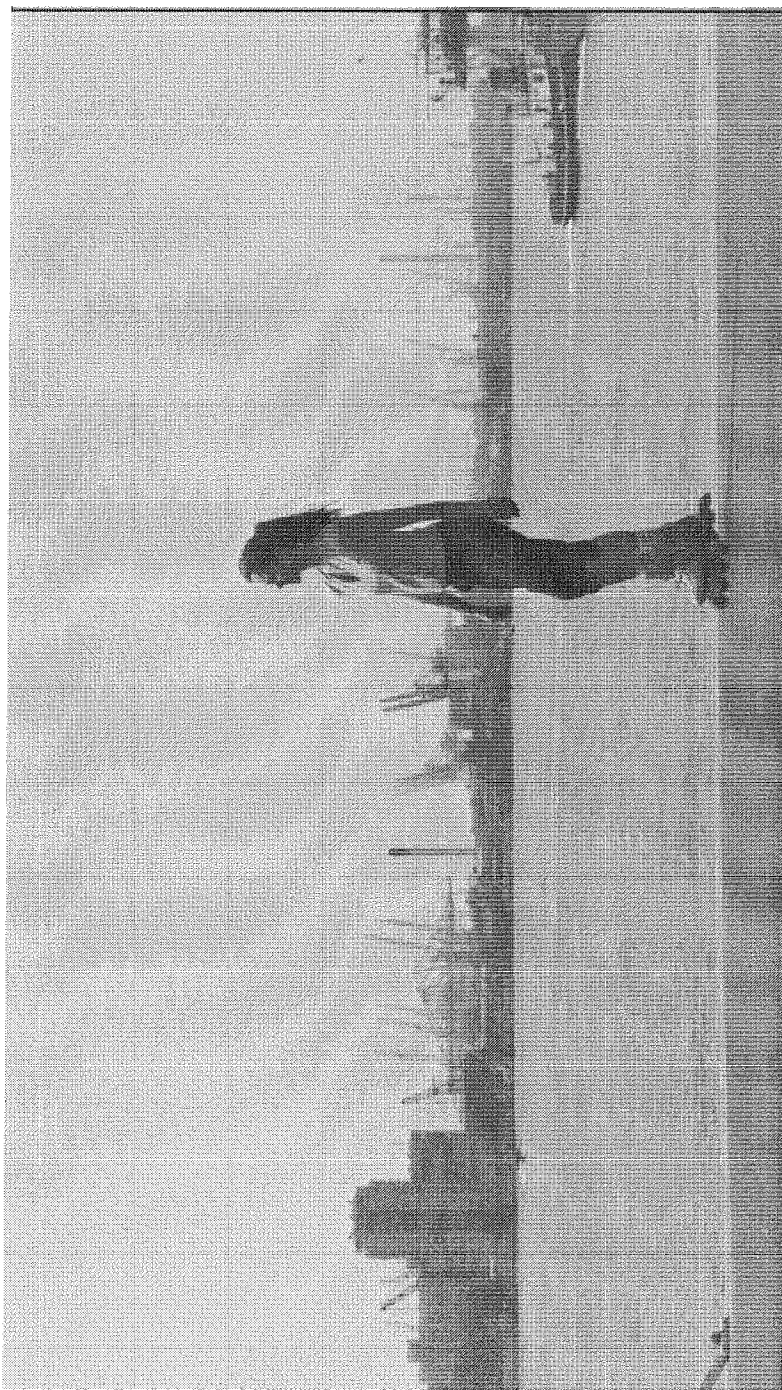


Fig. 3b

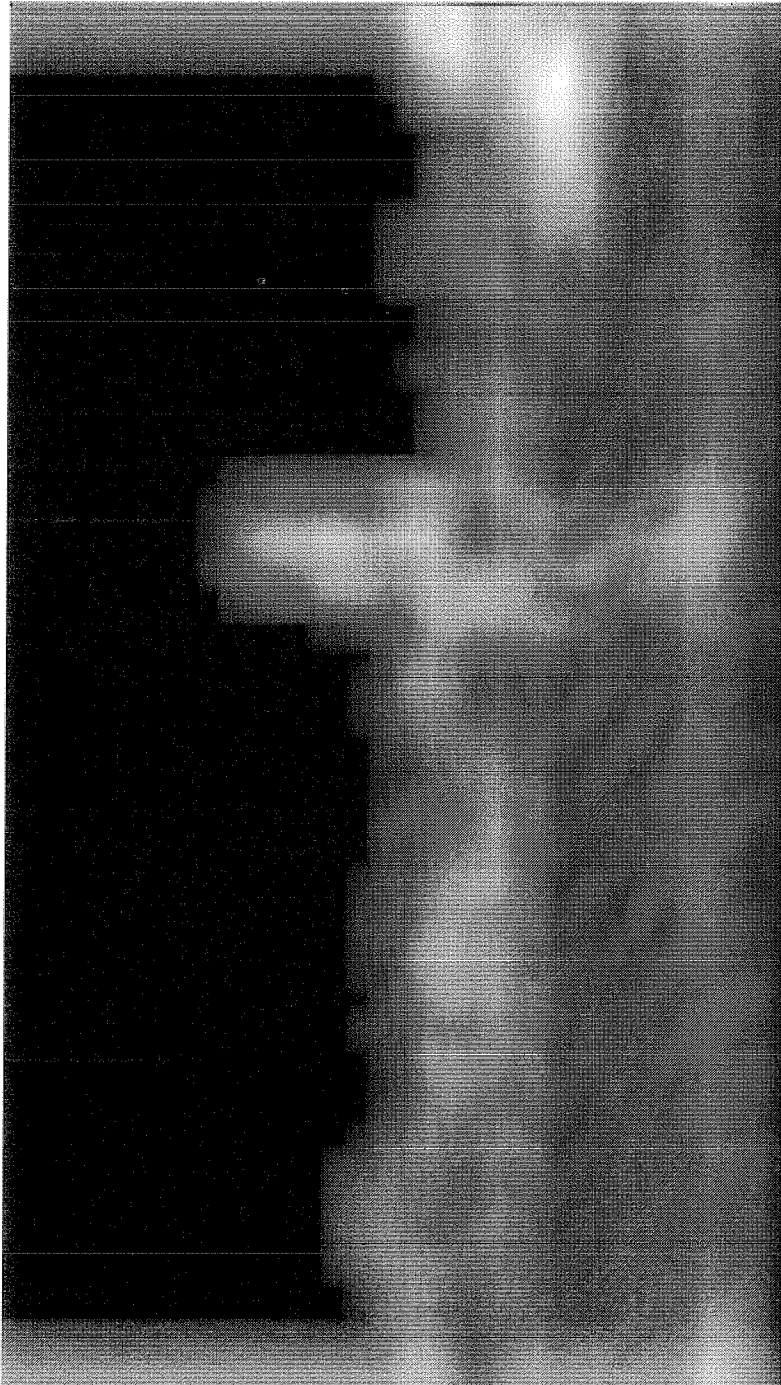


Fig. 3c

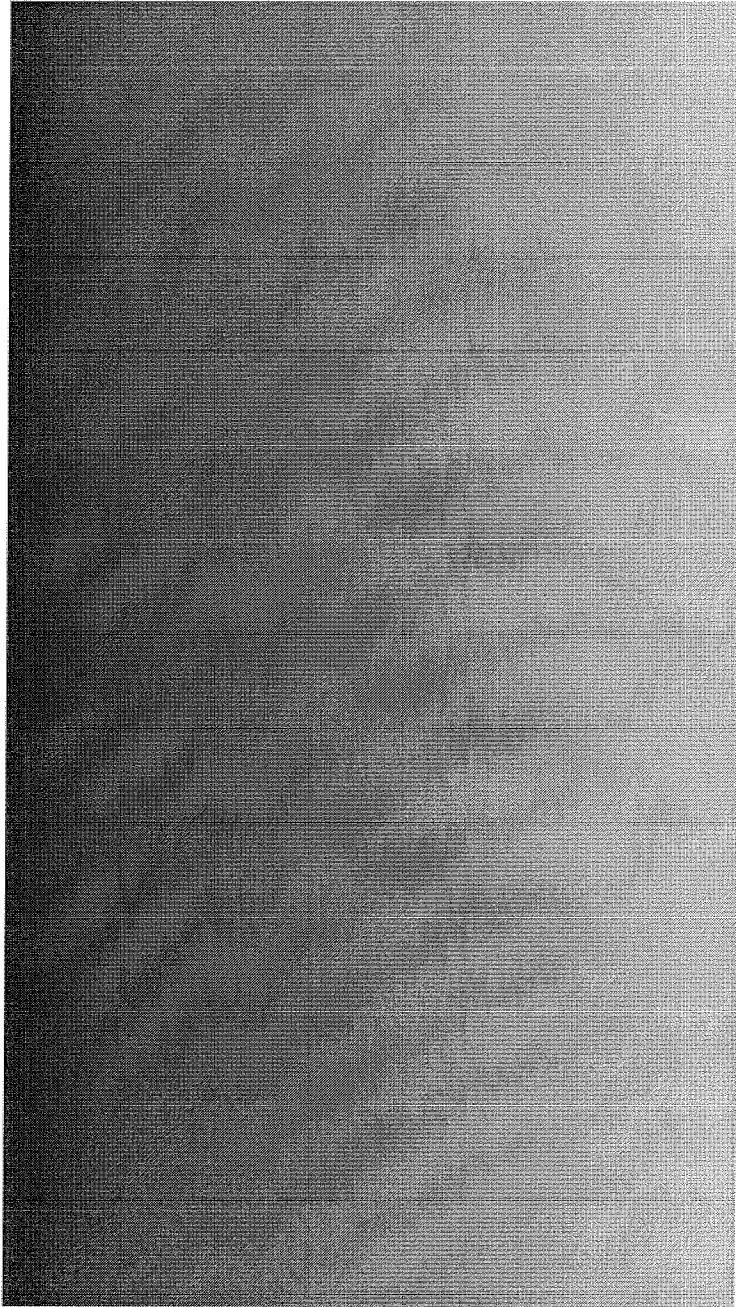


Fig. 3d

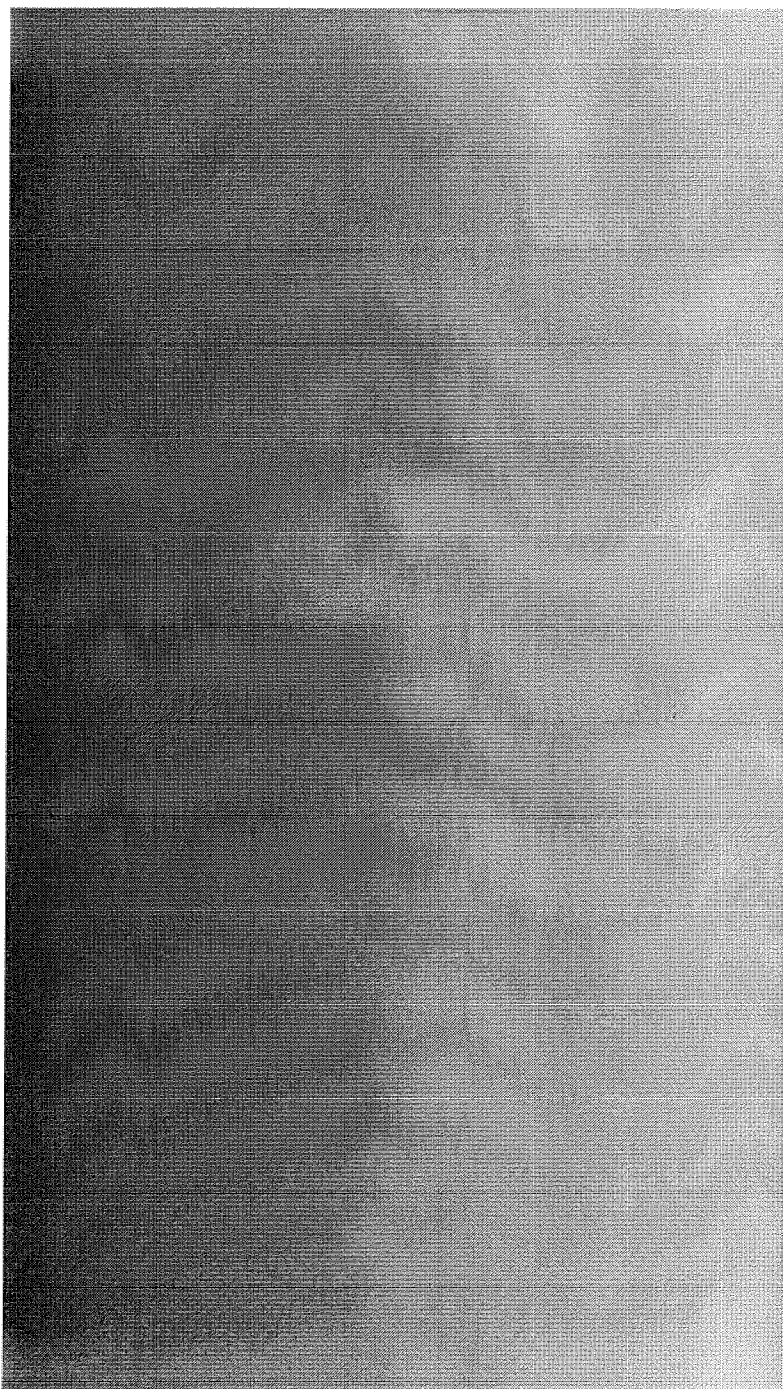


Fig. 4

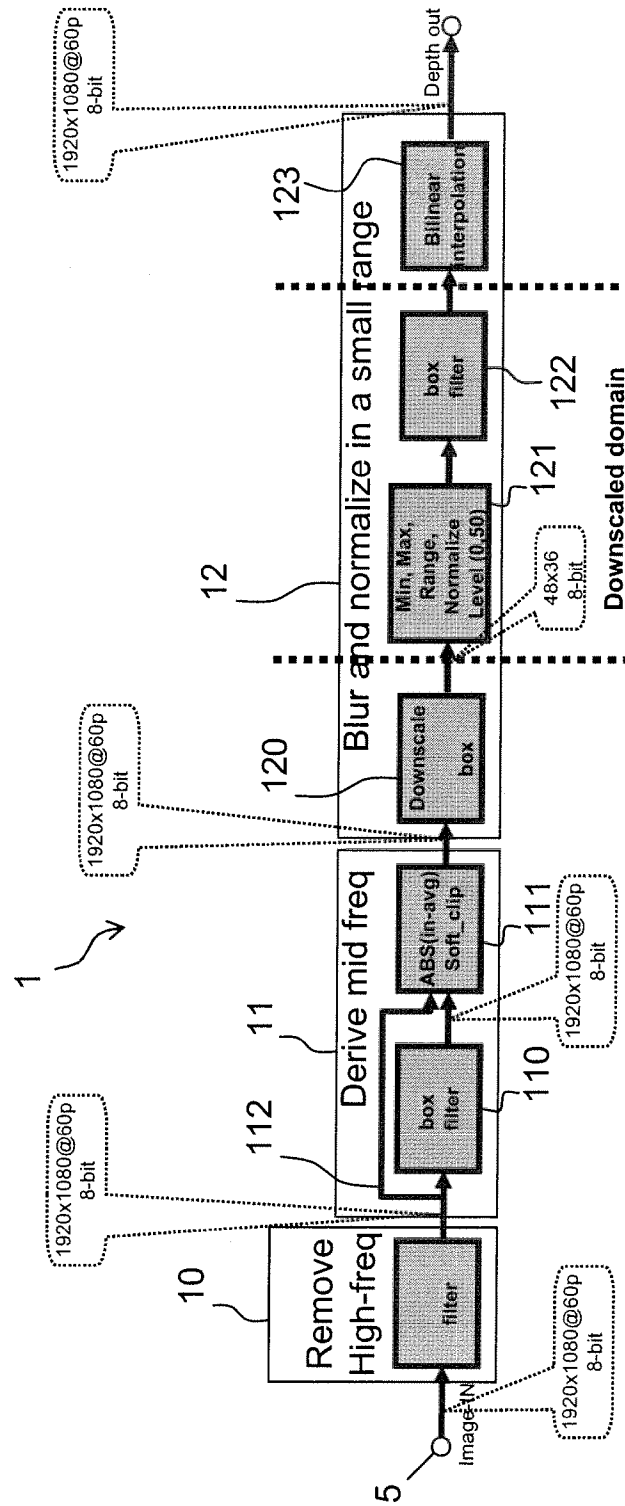


Fig. 5

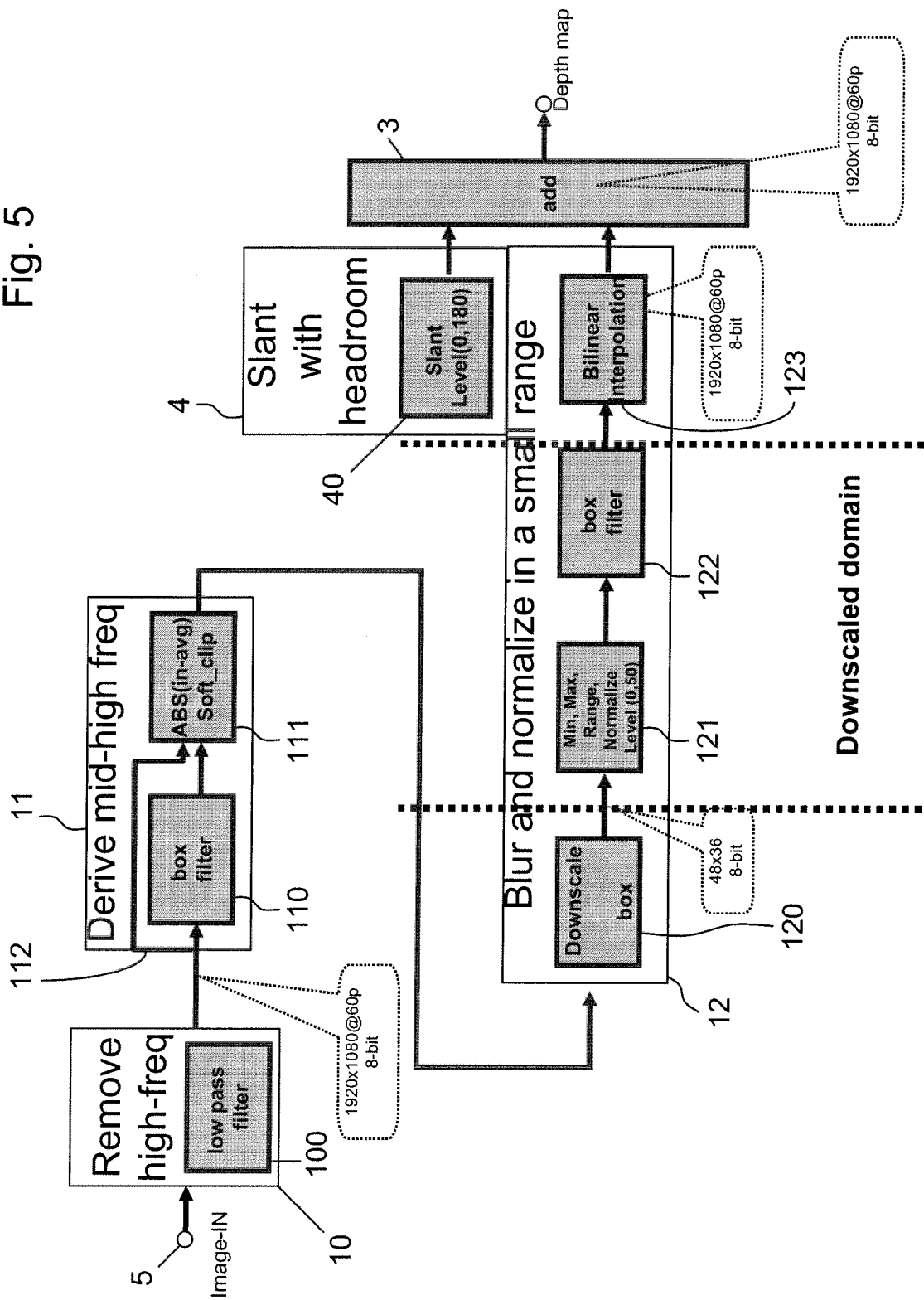


Fig. 6

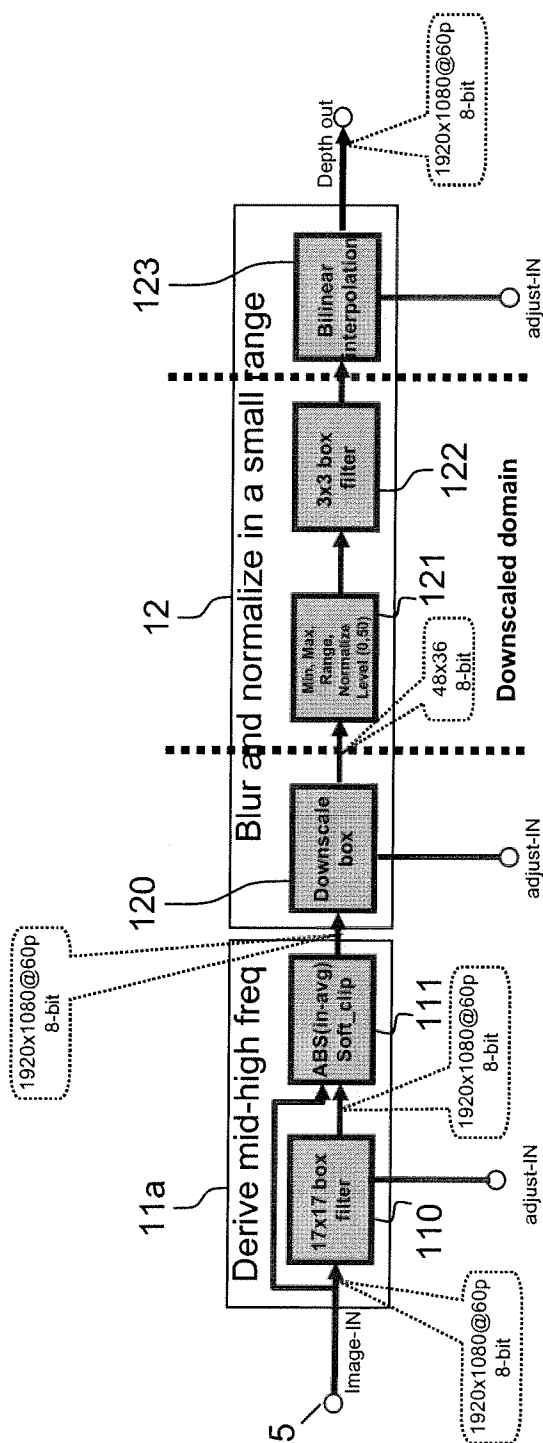


Fig. 7

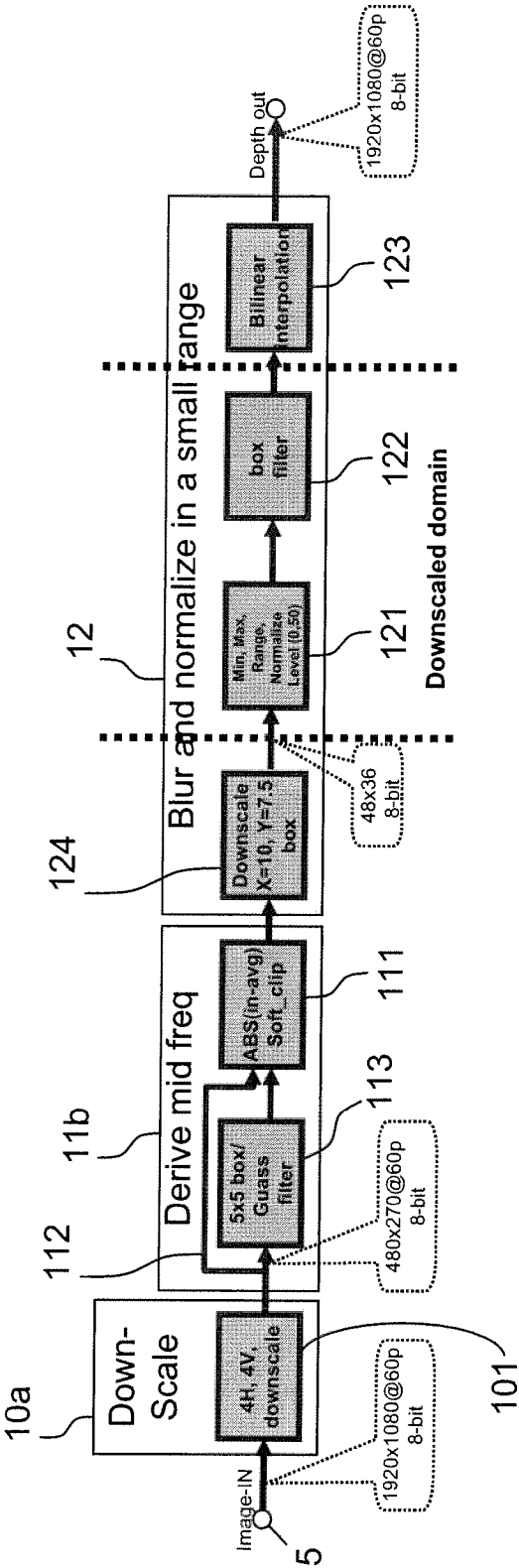


Fig. 8

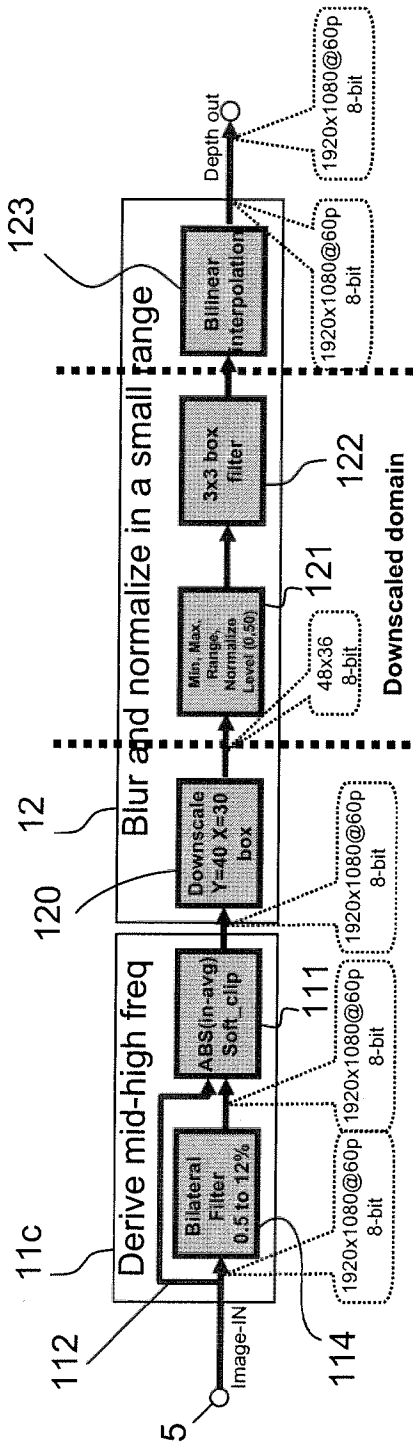
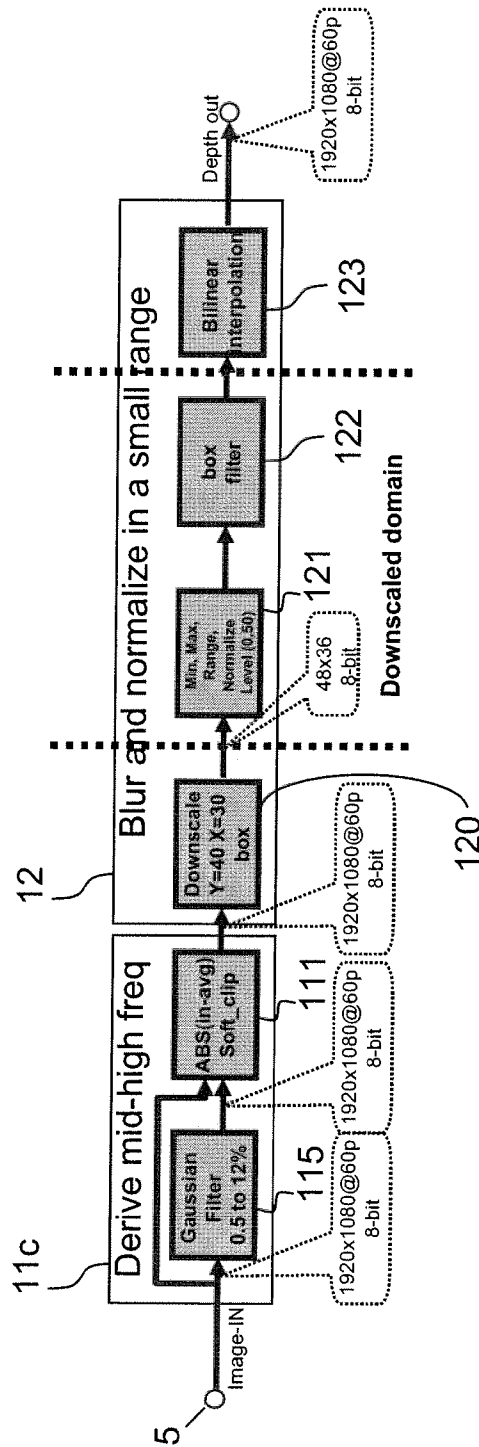


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/061519

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T7/00 H04N13/00
ADD.

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)
G06T H04N

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, COMPENDEX, INSPEC, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/062351 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; BOUGHORBEL FAYCAL [NL]) 29 May 2008 (2008-05-29) page 1, line 1 - page 2, line 6 page 7, line 9 - page 14, line 5 figures 4, 5	1-41
A	----- EP 2 184 713 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]) 12 May 2010 (2010-05-12) abstract paragraph [0031] - paragraph [0045] figures 4,5 ----- -/-	1-41



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

13 April 2011

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26/04/2011

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/061519

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2006/061569 A1 (YAMADA KUNIO [JP]) 23 March 2006 (2006-03-23) abstract -----	1-41

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2010/061519

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