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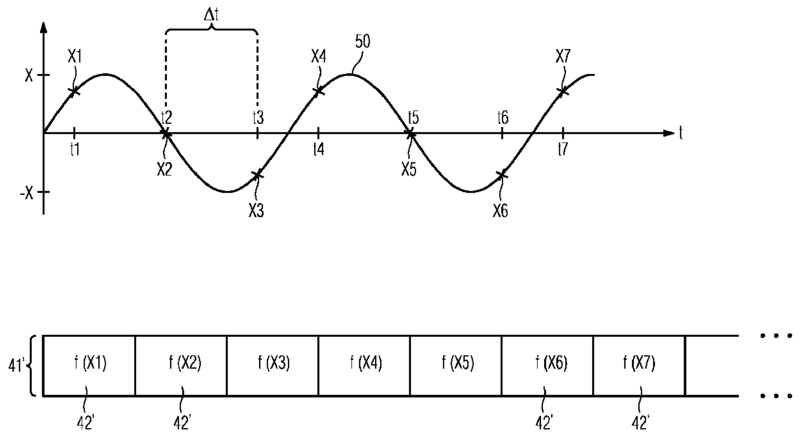

FIG. 7

(57) Abstract: The present invention is related to a method and an apparatus for line-based motion estimation in video image data, especially for field rate up-conversion in consecutive frames/fields of a motion picture, comprising the steps of: providing a video signal comprising video image data of a several video lines or part of these video lines of a frame or a field; performing the motion estimation by line -based detecting and analysing the video image data and by deriving motion vectors depending on the detected motion; wherein the motion estimation employs a matching process for testing and up-dating the different lines within a field or frame and wherein matching process is different for the first line of the frame or field compared to the other lines of the same frame or field. The present invention is further related to TV-set, a computer program product and a data carrier comprising a computer program.

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Method and apparatus for line-based motion estimation in video image data

FIELD OF THE INVENTION

The present invention is related to a method and an apparatus for line-based motion estimation in video image data and especially for line-based field rate up-conversion motion estimation video image data. The present invention is further related to a TV-set, a computer program product and a data carrier comprising a computer program.

TECHNICAL BACKGROUND OF THE INVENTION

The present invention relates to a line-based motion estimation and motion compensation device and more particularly to a motion estimation and motion compensation device that estimates motion vectors and performs motion compensated predictions of an interlaced/non interlaced sequence of chrominance sub-sampled/non sub-sampled video frames/fields.

Hereinafter, the present invention and its underlying problem is described with regard to the processing of a video signal for line-based motion estimation and motion compensation within a video processing apparatus such as a microprocessor or microcontroller having line memory devices, whereas, it should be noted, that the present invention is not restricted to this application, but can also be used for other video processing apparatus.

The market introduction of TV-sets based on 100/120 Hz frame rate or even higher required the development of reliable Field / Frame Rate Up-conversion (FRU) techniques to remove artefacts within a picture such as large area flickers and line flickers. Standard FRU methods, which interpolate the missing image fields to be displayed on Displays without performing an estimation and compensation of the motion of moving objects in successive image fields are satisfactory in many applications, especially with regard to a better quality of the image and with regard to the reduction of the above-mentioned artefacts. However, many pictures contain moving objects, like persons, subtitles and the like, which cause so-called motion judders.

This problem is better understood by referring to Figure 1, wherein the motion trajectory of the moving objects (white squares) in the original image fields (i.e. transmitted and received image fields) is supposed to be straight-lined. If the missing fields/frames result from interpolation by means of the above mentioned standard FRU methods (i.e. without motion estimation and compensation), the motion of the moving object in the interpolated fields (dark grey squares) is not at a position as expected by the observer (dotted squares). Such artefacts are visible and induce a blurring effect especially of fast moving objects. These blurring effects typically reduce the quality of the displayed images significantly.

In order to avoid such blurring effects and to reduce artefacts several methods for motion estimation and motion compensation - or shortly MEMC - are proposed. This MEMC provides the detecting of a moving part or object within the received image fields and then the interpolation of the missing fields according to the estimated motion by incorporating the missing object or part in an estimated field.

Figure 2 shows schematically the change of the position of a moving object between two successive image fields. Between two successive received image fields/frames, the moving objects will have changed their position, e. g. object MO which is in the previous field/frame T in position A is then in the current field/frame T+1 then in position B. This means, that a motion exists from the previous field/frame T to the current field/frame T+1. This motion of an object in successive image fields/frames can be represented by a so-called motion vector. The motion vector AB represents the motion of the object MO from position A in the previous field T to position B in the current field/frame T+1. This motion vector AB typically has a horizontal and a vertical vector component. Starting from point A in the previous field T and applying this motion vector AB to the object MO the object MO is then translated in position B in the current field/frame T+1. The missing position I of the object MO in the missing field/frame T+1/2 that has to be interpolated must be calculated by the interpolation of the previous field T and the current field T+1 taken account of the respective positions A, B of the moving object MO. If the object MO does not change its position between the previous field/frame and the current field/frame, e. g. if A and B are the same, position I in the missing field is obtained by the translation of A with a motion vector |AB|/2. In this manner the missing field T+1/2 is interpolated with a moving object in the right position with the consequence that blurring effects are effectively avoided.

One major problem in line-based MEMC is the first, highest line within a frame or field on the screen. For the first line MEMC turns out to be rather difficult especially with regard to test and up-date processes incorporated in the MEMC.

For the line-based motion estimation it is very advantageous that the motion vector will converge quickly for the real motion in the scene. Therefore, for the different lines of a frame or a field a testing and/or updating process is accomplished. In each of the lines of a field or a frame an elected motion vector is used to test the motion vector of the line above for updating reasons. However this testing and up-dating process is not possible for the first line within a frame or a field since there does not exist any line above the first line which can be used for up-dating and testing purposes. This leads to a blurring/judder effect in the upper part of the picture.

OBJECT AND SUMMARY OF THE INVENTION

The present invention is, therefore, based on the object to provide a better and especially more reliable possibility to select motion vectors especially for the first line of a field or a frame in line-based motion estimation implementations.

In accordance with the present invention, a method comprising the features of claim 1 and/or an apparatus comprising the features of claim 10 and/or a TV-set comprising the features of claim 12 and/or a computer program product comprising the features of claim 13 and/or a data carrier comprising the features of claim 14 is/are provided.

Accordingly, it is provided:

- A method for line-based motion estimation in video image data, especially for field rate up-conversion in consecutive frames/fields of a motion picture, comprising the steps of: providing a video signal comprising video image data of a several video lines or part of these video lines of a frame or a field; performing the motion estimation by line-based detecting and analysing the video image data and by deriving motion vectors depending on the detected motion; wherein the motion estimation employs a matching process for testing and up-dating the different lines within a field or a frame and wherein the matching process is different for the first line of the frame or field compared to the other lines of the same frame or field.

An apparatus for line-based motion estimation in video image data, especially for line-based motion estimated and compensated field/frame rate up-conversion in consecutive frames or fields of a motion picture, wherein the apparatus is configured to perform a method according to the present invention.

A TV-set comprising: an analogue or digital input terminal to provide a video input signal; a device to generate a line-based video signal out of the line-based video input signal comprising video image data of a video line or part of the video line of the picture; an apparatus to perform a line-based motion estimation and a motion compensation according to the present invention and to provide a motion compensated image output signal; a screen to display a motion compensated picture using the motion compensated image output signal.

A computer program product comprising a code, said code being configured to implement a method according to the present invention.

A data carrier comprising a computer program product ac-cording to the present invention.

During the process of motion estimation several motion vectors are calculated which are suitable for being used in a subsequent motion compensation process. For up-dating purposes the different motion vectors within a line are used for testing the motion vectors of the line above. The basic idea on the present invention is now that for testing and up-dating the first line within a frame or a field is treated differently compared to the other lines of the same frame or field. Here, especially a regular oscillating function having a predefine magnitude may be applied for the testing and up-dating of the motion vectors of the first line. By applying this kind of predefined functions it is surprisingly possible to provide an easy and nevertheless effective testing and up-dating process for the motion vectors within the first line. Blurring and/or Judder effects as a result of not or badly tested motion vectors within the first line do not occur or at least are reduced significantly.

This update method supports also the fast convergine of the vector field after scene changes has occured. Furthermore, the quick finding of the global motion vector speeds up significantly.

The present invention describes also a method for motion estimation and motion compensation which operates only in one direction and therefore performs the motion estimation and motion compensation operations using at least one single line buffer memory, the so-called line memory. This offers the possibility to reduce the chip embedded memory to one single line memory for the previous and one single line memory for the current field or frame. This advantageously enables significant silicon area reducing and cost saving implementations.

Advantages, embodiments and further developments of the present invention can be found in the further subclaims and in the following description, referring to the drawings.

In a preferred embodiment for the first line of each frame or field the selected motion vectors are loaded with a predefined vector value which varies according to a predefined function from pixel to pixel wherein the predefined function has a predefined magnitude.

In a preferred embodiment a regular oscillating function, especially a saw tooth function and/or a sinusoidal function and/or a triangle function, is used for the determination of the pixel-wise motion vectors of the first line.

In a preferred embodiment for the other lines of a frame or field the matching process is done by testing motion vectors of the corresponding pixels of the corresponding line above the line to be tested.

In a preferred embodiment a variation of at least one selected motion vector is performed in order to set up the process of motion estimation and/or to follow a deviation from the constant motion.

In a preferred embodiment the method comprises the steps of: performing the motion estimation by detecting and analysing the video image data and by deriving a motion vector depending on the detected motion, wherein the motion vector contains only motion data for motion of an object in one direction and especially in the horizontal direction; using the motion vector for motion compensation to interpolate a picture.

In a preferred embodiment for the matching process the luminance profile and/or chrominance profile is/are used as matching parameter.

In a preferred embodiment a SAD-based method and/or an ADRC-based method is/are employed for the comparison of the luminance and/or chrominance values.

In a preferred embodiment the motion vector contains only motion data for motion of an object in one direction and especially in the horizontal direction.

In a preferred embodiment the apparatus is an integrated circuit and/or is implemented within a microcontroller or a microprocessor.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings. The invention will be described in greater detail hereinafter, by way of non-limiting examples, with reference to the embodiments shown in the drawings, in which:

Figure 1 shows the result of a standard (i.e. non motion compensated) FRU method;

Figure 2 shows the change of position of a moving object between two consecutive received image fields;

Figure 3 show the motion estimation principle for the line-based motion estimation by means of a current frame/field and the corresponding previous frame/field;

Figure 4 shows a block diagram of a first embodiment of a line-based MEMC system according to the present invention;

Figure 5 shows an example to illustrate the matching process of the motion estimation;

Figure 6shows an illustration of a field of several lines to illustrate the method for testing and up-dating motion vectors within the first line according to the present invention;

Figure 7shows a detailed example for the process of up-dating motion vectors within the first line according to the present invention;

Figure 8 shows a block diagram illustrating an embodiment of the line-based motion estimation according to the present invention;

Figure 9 shows a block diagram of a second embodiment of a line-based MEMC system according to the present invention using the line memories assigned to the de-interlacer device also for the motion estimation device.

In all figures of the drawings elements, features and signals which are the same or at least have the same functionality have been provided with the same reference symbols, descriptions and abbreviations unless explicitly stated otherwise.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE PRESENT INVENTION

In the following description of the present invention first of all a short overview of the motion estimation and motion compensation is presented.

The MEMC method consists mainly of two sections, the motion estimation and the motion compensation method. The motion estimation performs the measurement of the motion and derives the velocity of the displayed regions in pixel per picture (i.e. field or frame). Also the direction of the motion will be indicated by a positive or negative sign. These measured motion information is described in the form of a motion vector. The motion vector is used for the motion compensation to interpolate the picture at the temporal accurate position and to avoid so-called judder effects and/or so-called motion blurring effects.

Figure 3 shows the motion estimation principle for the line-based motion estimation by means of a current picture (field or frame) 10 (n) and the corresponding previous picture 11 (n-1). According to the temporal positions the motion vector 12, 13 will be split by its length into two parts, where the first vector part 12 points into the previous picture 11 and the second vector part 13 points into the current picture 10. For the interpolation of a missing picture 14 (n-1/2) between the current and the previous pictures 10, 11 pixels 15 from both temporal pictures 10, 11 are taken into account for the compensation. In line-based MEMC only the pixels 15 within the same line 16 are used at the same time and the MEMC is performed for a single line 16 of a field or frame only. For this kind of MEMC the pixels 15 of the current picture 10 are compared with the corresponding pixels 15 of the previous picture 11 to estimate and compensate the corresponding pixels 15 of the missing picture 14.

Figure 4 shows a block diagram of a line-based MEMC system according to the present invention. The MEMC system is denoted by reference number 20. The MEMC system 20 comprises an input terminal 21, a bus 22, two line memories 23, 24, a motion estimation device 25, a motion compensation device 26 and an output terminal 27. It is assumed that the bus 22 is an external bus 22 and especially an external memory bus 22. However, it may also be possible, that the bus 22 is an internal bus 22. At the input side the bus 22 is connected to an external memory 28 device such as a SDRAM, a DDR-RAM, etc. Image data to be displayed in a panel 29 such as a plasma- or LCD-panel or a CRT-screen is stored in this external memory 28. Via the input terminal 21 and the memory bus 22 this image data X1, X1' is transferred to both line memories 23, 24. According to the present invention only two line memories 23, 24 are needed whereas the first line memory 23 is used for buffering image data X1 of the previous picture and the other line memory 24 is used for storing the image data X1' of the current picture.

A line memory 23, 24 as used in the present patent application indicates an embedded memory of a size of one video line of a frame or a field or at least less of the incoming video signal stream or actually processing video signal stream. A field denotes a video image or picture which comprises either odd or even lines. A frame denotes a video image comprising of the complete video information for one picture, i.e. of a field for the odd lines and the corresponding field for the even lines. A line denotes a full horizontal row within a field of one video picture or at least a part of this row.

Both of the line memories 23, 24 are coupled - on their output sides – to the motion estimation device 25 and to the motion compensation device 26. This enables the image data X1, X1' stored in the line memories 23, 24 to be transferred to the motion estimation device 25 and to the motion compensation device 26, respectively. In Figure 4 the corresponding data signals to the motion estimation device 25 are denoted by X2, X2' and the corresponding data signals motion compensation device 26 are denoted by X3, X3'.

The motion estimation device 25 generates a motion vector signal X4 out of the image data X2, X2' stored in the line memories 23, 24 by employing a matching process. This vector signal X4 is transferred to the motion compensation device 26. The motion compensation device 26 performs a motion compensation using the image data X3, X3' stored in the line memories 23, 24 and applying the vector data X4 to this image data X3, X3'. At the output terminal 27, the motion compensation device 27 provides a video signal X5 which comprises information for a motion compensated picture. This video signal X5 is transferred via the output terminal 27 to a display 29, such as a LCD-panel 29 or the like.

With regard to Figure 5, hereinafter the operation of the motion estimation device 25 is described in more detail:

For the motion estimation a matching process is employed to select a corresponding series of pixels 32 which fits best to a given amount of pixels 30. For this selection a given amount of pixels 30 of a line of a current frame/field around the centre pixel 31 for which the motion shall be determined is taken from a line memory 24 of the current frame/field 32. Hereinafter this given amount of pixels 30 is denoted to as series of pixels 30. In the present embodiment a series of pixels 30 comprises 9 single pixels 33. It is self-understood that a series can also comprise a greater or a smaller amount of pixels 33.

For the selection the luminance profile of the pixels 33 is used as the matching parameter. Luminance is a photometric measure of the density of luminous intensity in a given direction. It describes the amount of light that passes through or is emitted from a particular area, and falls within a given solid angle. Thus, luminance is the photometric measure of the brightness in a frame/field of a motion picture. If the luminance is high, the picture is bright and if it is low the picture is dark. Thus, luminance is the black and white part of the picture.

This luminance profile is used to find out that series of e.g. nine pixels 34 (there can be used even more or less pixels for the matching process, depending on the quality) out of the previous frame/field 35 which fits best with the series of nine pixels 30 of the current frame/field 32. In the embodiment of Figure 5 the luminance profile of the series of nine pixels 30 of the current frame/field 32 are compared with the luminance profiles of several corresponding series of nine pixels 34 of the previous frame/field 35. In order to derive the true motion the series of nine pixels 30 will be shifted over the search range in the horizontal direction 36. It is assumed that that series of nine pixels 34 of the previous frame/field 35 which shows the best luminance profile matching (with the series of nine pixels 30 of the current frame/field 32) is the correct series of pixels. These series of pixels 30, 34 are then used for the computation of the motion vector.

A typical value for the search range is, e.g. 64 pixels (+31…-32). However, it may also be possible to use less than 64 pixels, however, then the quality of the result of this comparison is increasingly going down. On the other hand it is also possible to use more than 64 pixels. Then the quality of the selection result is going up, however, this needs more computational effort. Therefore, typically a trade-off which provides an optimization between best quality of the selection result and simultaneously a minimum computation effort is employed.

In a preferred embodiment for each selected motion vector 37 a single matching process is performed in the way described above. This matching process is performed by assigning a quality degree and/or a failure degree for each series of pixels 30. Then, a quality-degree and/or a failure degree are assigned to each one of those series of pixels 30 which are undergoing the matching process. Those series of pixels 30 having the highest quality-degrees and/or the lowest failure degrees are selected as most probable series of pixels. These series of pixels 30 are then used for computing the motion vectors for the horizontal motion. Typically, but not necessarily a SAD method (SAD = sum of absolute difference) and/or ADRC method is used for the comparison of the luminance and/or chrominance values.

Using pre-selected motion vector samples for the motion estimation:

Assuming the motion of an object in the scene will be constant from frame to frame (or field to field) and the object is larger than a series of pixels (e.g. the above mentioned 9 pixels), then the matching process can then be performed more efficiently if a set 38 of pre-selected motion vectors 37 – the so-called motion vector samples 37 - are checked for a matching of the luminance profile (see Figure 5). For example, one selected motion vector 37 can be taken from the neighbouring pixel. A second selected motion vector can be taken from the previous line, if the already estimated motion vectors are stored in a vector memory specially designed for the different motion vector samples.

The zero-vector which indicates no motion of the object is typically one of the most used motion vector samples. This zero-vector is used in order to more efficiently detect regions within a picture showing no motion. In principle the amount of pre-selected motion vectors 37 which will taken into account depend strongly on what kind of motion vector quality is desired.

Variation of selected motion vectors:

In order to set up the process of motion estimation and to follow the deviation from the constant motion, a variation of certain pre-selected motion vectors is required for test operation purposes. That means that for pre-selected motion vector samples a certain amount of motion will be added or subtracted. This can be done by applying a variance with different amount of motion speed to these motion vectors. The tested implementation checks between odd pixels and even pixels alternating an update of +/-1 pixels and +/-4 pixels on the previously determined motion vector. The selection of the variance is adjustable and variable as required or as the need arises and depends e.g. on the resolution of the incoming video signal.

Treatment of motion vectors of the first line:

For the line-based motion estimation it is very advantageous that the motion vector will converge quickly for the real motion in the scene. Therefore, the selection of the tested motion vectors is treated differently for the first line of a frame or field. For the first line of a frame or field testing is not possible in the normal way since a line above the first line which is needed for testing does not exist. In the first line of each field/frame the selected motion vectors which normally test the motion vectors of the line above are loaded with vector values, which e.g. vary according to a triangle function from pixel to pixel. The triangle function oscillates between an adjustable minimum value and an adjustable maximum value. For that purpose also other regular oscillating functions e.g. a saw tooth function, a sinusoidal function, and the like may be employed for the determination of the motion vector of the first line.

Figure 6 shows an illustration of a field/frame of several lines to illustrate the method for testing and up-dating motion vectors within the first line according to the present invention. In Figure 6 the field is denoted by reference number 40. It should be noted, that instead a field 40 a method according to the present invention is also working for a frame or part of the frame or field.

In the embodiment shown in Figure 6 the frame/field 40 comprises several lines 41 whereas the first, highest line is denoted by reference number 41'. Every line 41, 41' comprises a plurality of pixels 42, 42', whereas the pixels within the first line 41' are denoted by reference numbers 42'. During the motion estimation for every pixel 42, 42' within the different lines 41, 41' a motion vector is calculated, for example on the basis of a SAD-method, ADRC-method or the like as sketched above.

These motion vectors are then used for the line-based motion compensation. For the process of testing and up-dating a motion vector which is assigned to a specific pixel 42 within the corresponding line 41 is tested on the basis of the corresponding motion vector of the pixel 42 on the line 41 directly above. An example of this process is described in Figure 6 on the basis of the three lines 41a to 41c in the middle part of the field 40. Here, the motion vector A assigned to the pixel 42a is used for testing the motion vector B in the pixel 42b of the subjacent line 41b. Therefore, the motion vector B is tested on the basis of the above motion vector A. Further, this motion vector B can be then used to test the motion vector C in the pixel 42c of the subjacent line 41c. This testing and up-dating process is employed for all lines of the field 40.

However, for the first line 41' a testing and up-dating process as described above is not possible since there is no existing line above the first line 41'. For testing and up-dating purposes of the different motion vectors in the pixels 42' of this first line 41' a predefined function having a predefined magnitude and characteristics is employed for testing the motion vectors assigned to the different pixels 42' of the first line 41'.

This is shown with regard to figure 7 of the drawing. Figure 7 shows a detailed example for the process of up-dating motion vectors within the first line according to the present invention.

The predefined function may be most preferably a regular oscillating function. In Figure 7 this oscillating function is a Sinus-function 50 oscillating between the amplitudes X and -X. For predefined points of time t1 - t7 the corresponding values X1 - X7 of the Sinus-function 50 are determined from pixel 42' to pixel 42'. To determine the different values 51 of the Sinus-function 50 the duration Δt between two points of time t1 - t7 should be constant.

The determined values X1 - X7 which are each assigned to different pixels 42' within a line 41' are then used for testing and up-dating the corresponding motion vectors within the corresponding pixels 42'. The motion vectors of these pixels are then loaded with a specific value f(X1) - f(X7) which advantageously is a function of the determined values X1 - X7.

Instead of using a Sinus-function 50 it is also possible to use any other triangle-function or a saw tooth-function for the determination of the values X1 - X7 to test the motion vectors in the first line 41'.

<u>The matching process</u>:

In a preferred embodiment the matching process assigns a failure value to each tested motion vector. In another embodiment this value may be also a quality value. It might also be possible to evaluate as well a failure value and a quality value for the matching process. Preferably, the sum of the absolute difference (SAD) is used as the failure value or to at least derive the failure value. Ideally, to find the optimal motion vector a failure value of zero is needed. However, typically the failure value is different from zero. Therefore, the motion vector corresponding with the lowest failure value is then selected as the most probably motion vector representing the motion of an object in the local scene.

Attenuation of the vector selection, vector damping:

In a preferred embodiment a damping value is used which depends on the vector attenuation of the different motion vectors. This enables to control the motion vectors with equal failure values and/or to furnish the motion vector selection process with a certain direction.

Vector memory:

The different motion vectors are advantageously stored in a vector memory. These motion vectors can be then – if required - fetched from the vector memory for further processing and/or for the motion estimation of the next pixels.

The motion estimation process forms a recursive process. Therefore, the size of this vector memory mainly depends on the desired quality level of the matching process. In one embodiment, the tested implementation comprises only one line of a vector memory. In this vector memory every second motion vector will be stored alternately, in order that an access of the motion vectors from the measured line above is possible.

Robustness improvement by providing a vector histogram:

In a preferred embodiment a motion vector histogram is calculated in order to create a highly reliable and homogeneous field of motion vectors. This vector histogram allows a vector majority ranking to derive most and less used motion vectors in an actual scene.

Figure 8 shows a block diagram illustrating an embodiment of the line-based motion estimation according to the present invention as described above and as implemented in a motion estimation device 25 as shown in Figure 4.

The motion estimation device 25 comprises a matching device 80, a cost/quality function device 81 and a vector selector device 82, which are arranged in series connection between the input side 83 of the motion estimation device 25 where the image data signals X1, X1' stored in the both line memories 23, 24 are provided and the output side 84 of the motion estimation device 25 where the motion vector signal X4 in present. In the device elements 80-82 a matching process and a vector selection as described with regard to Figure 5 is implemented.

The motion estimation device 25 further comprises a vector quality device 85 which is connected on the one hand to the input side 83 and on the other hand to the output side 84. The vector quality device 85 generates a quality signal X6 comprising an information of the vector quality out of the image data signals X1, X1' and the motion vector signal X4.

The motion estimation device 25 further comprises a vector histogram device 86 and a vector majority device 87 which are arranged in series connection in a feedback path between the output side 84 and the matching device 80. Here, in the device elements 86, 87 a vector histogram is generated to provide a ranking of most and less used vectors in the actual scene.

The motion estimation device 25 may further comprise a further line memory 88 to store the motion vector data X4 and/or the data X6 for the vector quality.

The motion estimation device 25 further comprises a vector sample device 89. This vector sample device 89 is also arranged in the feedback path and is connected at its input side with the line memory 88, the vector majority device 87 and advantageously with a further device 90. This further device 90 performs a variation of the motion vector samples by using a special signal having a certain magnitude, e.g. a sinusoidal signal, a saw tooth signal or the like. This certain signal is then used for a testing and/or matching process and/or an up-dating process of the first line of a frame or field. However, it might also be possible to randomly up-date different lines of the frame or field. On its output side, the vector sample device 89 is connected at its output side to the matching device 80.

The motion estimation device 25 further comprises a vertical motion estimation device 91. For vertical motions the above described one-dimensional motion estimation algorithm is not able to compensate fully motion in the vertical direction. However, the occurrence of vertical motions can be used to reduce the compensation in same regions of the picture by splitting the picture into different regions to derive vertical motion for each region. In this case the luminance values of the lines in the different region of the same picture will be summed up and stored individually for each line of this picture. This results in an accumulated vertical profile for different regions of the same picture. Then, the whole picture can be divided into smaller regions to derive a vertical motion for each of these regions. This vertical motion estimation process is performed in the vertical motion estimation device 91 which is connected to the input side 83 and which provides at its output side a sector based vertical motion index X7.

Thus, the vertical MEMC as sketched above can be performed independently of horizontal MEMC and also in combination with the horizontal MEMC, wherein the combination can be performed in dependence on a certain situation or the motions present, respectively. Further, such a methodology allows an implementation of vertical MEMC, which does not need large amounts of additional memory capacity to analyze data of consecutive frames/fields being the case in the most methodologies of the prior art.

The motion estimation device 25 further comprises a vector damping device 92. In this damping device 92 a damping value as described above may be used to damp vector samples of the vector sample device 89 and to provide damped vector samples to the vector selector 82.

Figure 9 shows a block diagram of a second embodiment of a line-based MEMC system according to the present invention using the line memories assigned to the de-interlacer device also for the motion estimation device.

Unlike the first embodiment in Figure 4 a de-interlacer device 113 is arranged between the line memories 110, 111, 112 and the motion compensation device 26. The de-interlacer device 113 is typically used to convert a field represented by video data stream into a full frame which is then also represented by another video data stream.

On-chip solutions for video processing which are memory-based have already existing internal line buffers 110-112 – the so-called line memories 110-112 - which carry video data from the previous and current field or frame. These line buffers 110-112 can be located e. g. within temporal noise reductions or de-interlacing units 113 which operate motion adaptive. With the proposed line-based MEMC these line buffers can be reused additionally for the motion estimation. For that purpose and in order to reduce motion judder artefacts from movie sources, a movie detector which indicates the current interpolated sequence of pull-down mode is used. A line buffer selector transfers the video signal data to the motion estimation device according to the previous and the current video input signal. This technique allows using already existing memory resources also for motion estimation which also prevents additional bandwidth for the temporal up-conversion process. Therefore, the chip area for the motion estimation and the motion compensation can be reduced to a minimum.

The de-interlacer device 113 uses in this embodiment three line memories 110, 111, 112 coupled on their input side to the memory bus 22 and providing at their output side line data. The amount of line memories for the deinterlacer can vary, that is there can be more or less than three line-memories. This line data provided by the line memories 110, 111, 112 is processed within the de-interlacer device and then provided to the motion compensation device 26. According to the present invention, these line memories 110, 111, 112 are additionally used also for the motion estimation device 25. For this purpose, the system 20 additionally comprises a selector device 114, where a movie sequence X0 is provided to this selector device 114. This movie sequence X0 may be then stored in an external memory 28 via the memory bus 22 and can be read out from this external memory 28 through the line memories 110, 111, 112. For an operation, this data stored in the line memories 110, 111, 112 of the de-interlacer device 113 can be also used for MEMC. For this purpose the data stored in the line memories 110, 111, 112 is then provided as well to the motion estimation device 25 and the motion compensation 26 device.

While embodiments and applications of this invention have been shown and described above, it should be apparent to those skilled in the art, that many more modifications (than mentioned above) are possible without departing from the inventive concept described herein. The invention, therefore, is not restricted except in the spirit of the appending claims. It is therefore intended that the foregoing detailed description is to be regarded as illustrative rather than limiting and that it is understood that it is the following claims including all equivalents described in these claims that are intended to define the spirit and the scope of this invention. Nor is anything in the foregoing description intended to disavow the scope of the invention as claimed or any equivalents thereof. It is self understood that the above mentioned numerical data is merely illustrative and may be adapted to best provide an optimized blurring effect.

Finally, it should be noted that the aforementioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be capable of designing many alternative embodiments without departing from the scope of the invention as defined by the appended claims. In the claims, any reference signs placed in parentheses shall not be construed as limiting the claims. The word "comprising" and "comprises", and the like, does not exclude the presence of elements or steps other than those listed in any claim or the specification as a whole. The singular reference of an element does not exclude the plural reference of such elements and vice-versa. In a device claim enumerating several means, several of these means may be embodied by one and the same item of software or hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage

CLAIMS:

1. Method for line-based motion estimation in video image data, especially for field rate up-conversion in consecutive frames of a motion picture, comprising the steps of:

- providing a video signal (X1, X1') comprising video image data of a several video lines or part of these video lines of a frame or a field;

- performing the motion estimation by line-based detecting and analysing the video image data and by deriving motion vectors depending on the detected motion;

- wherein the motion estimation employs a matching process for testing and up-dating the different lines within a field or a frame and wherein the matching process is different for the first line of the frame or field compared to the other lines of the same frame or field.

2. Method according to claim 1,

wherein for the first line (41') of each frame or field (40) the selected motion vectors are loaded with a predefined vector value which varies according to a predefined function (50) from pixel to pixel (42') wherein the predefined function (40) has a predefined magnitude (X).

3. Method according to claim 1,

wherein a regular oscillating function (50), especially a saw tooth function and/or a sinusoidal function (50) and/or a triangle function, is/are used for the determination of the pixel-wise motion vectors of the first line (41').

4. Method according to claim 1,

wherein for the other lines (41) of a frame (40) or field the matching process is done by testing motion vectors of the corresponding pixels (42) of the corresponding line (41) above the line (41) to be tested.

5. Method according to claim 1,

wherein a variation of at least one selected motion vector is performed in order to set up the process of motion estimation and/or to follow a deviation from the constant motion.

6. Method according to claim 1,

- wherein the method comprises the steps of:

- performing the motion estimation by detecting and analysing the video image data and by deriving a motion vector depending on the detected motion;

- using the motion vector for motion compensation to interpolate a picture (14).

7. Method according to claim 1,

wherein for the matching process the luminance profile and/or chrominance profile is/are used as matching parameter.

8. Method according to claim 1,

wherein a SAD-based method and/or an ADRC-based method is/are employed for the comparison of the luminance and/or chrominance values.

9. Method according to claim 1,

wherein the motion vector contains only motion data for motion of an object in one direction and especially in the horizontal direction.

10. Apparatus (20) for line-based motion estimation in video image data, especially for line-based motion estimated and compensated field rate up-conversion in consecutive frames or fields of a motion picture, wherein the apparatus (20) is configured to perform a method according to cording to claim 1.

11. Apparatus according to claim 10,

wherein the apparatus is an integrated circuit (20) and/or is implemented within a microcontroller or a microprocessor.

12. TV-set comprising:

- an analogue or digital input terminal to provide a video input signal;

- a device to generate a line-based video signal (X1, X1') out of the video input signal comprising line-based video image data;

- an apparatus (20) to perform a line-based motion estimation according to claim 1 and to provide a motion compensated image output signal (X5, X5');

- a screen to display a motion compensated picture using the motion compensated image output signal (X5, X5').

13. A computer program product comprising a code, said code being configured to implement a method according to claim 1.

14. A data carrier comprising a computer program product ac-cording to claim 13.

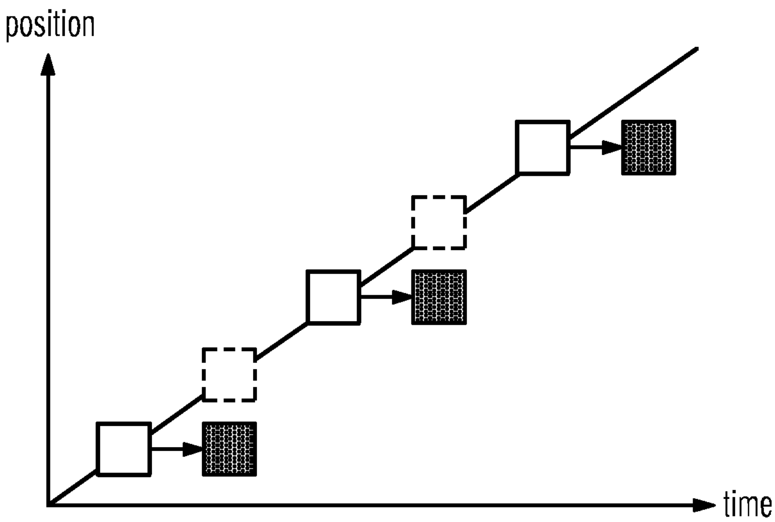

FIG. 1

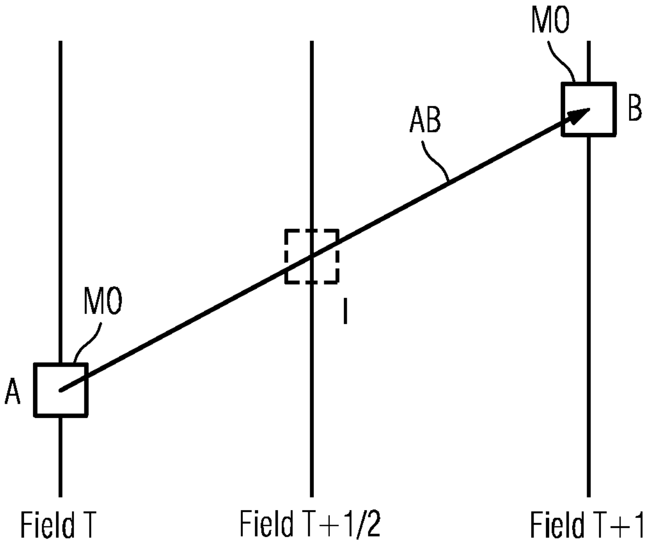

FIG. 2

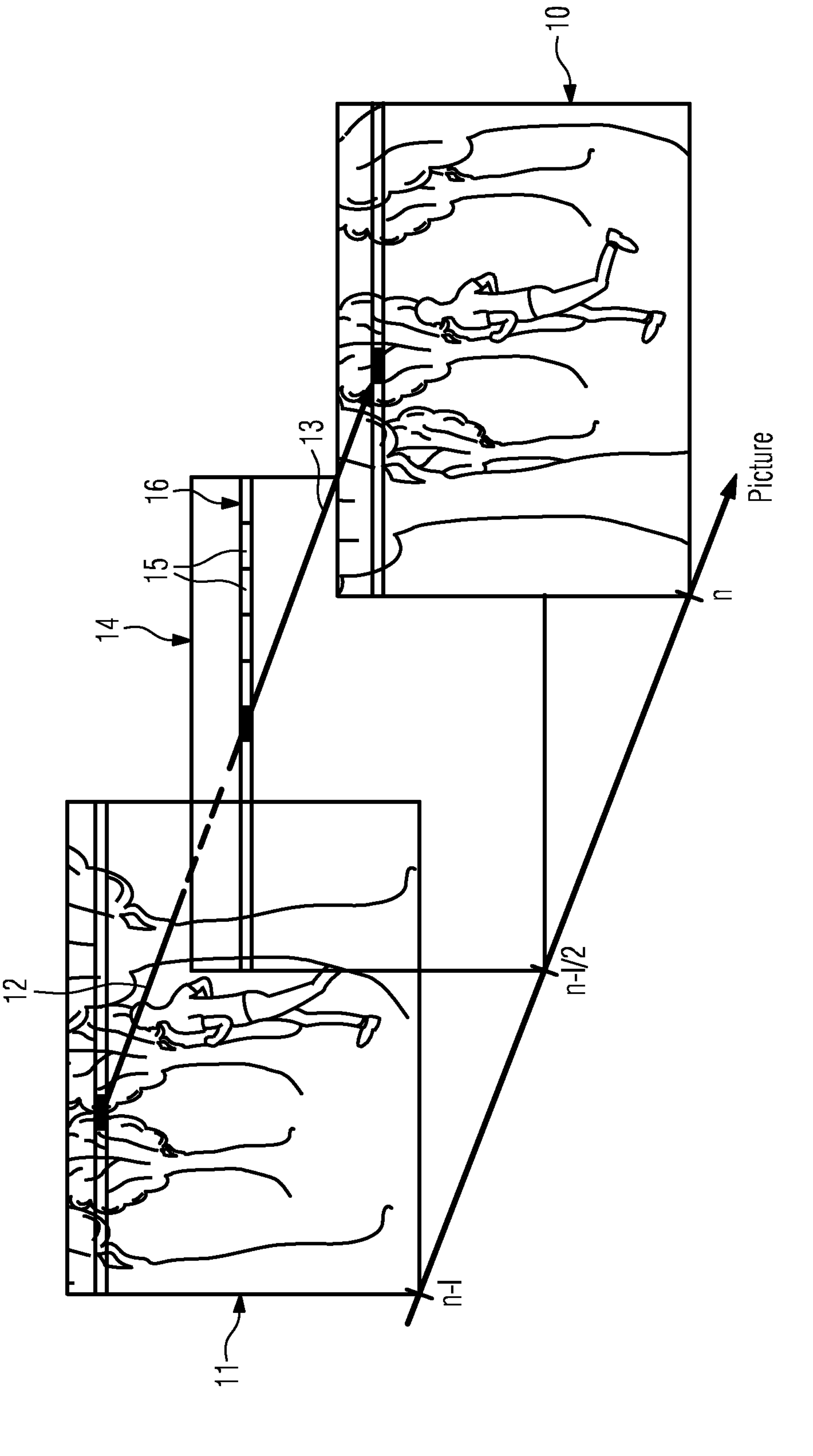

FIG. 3

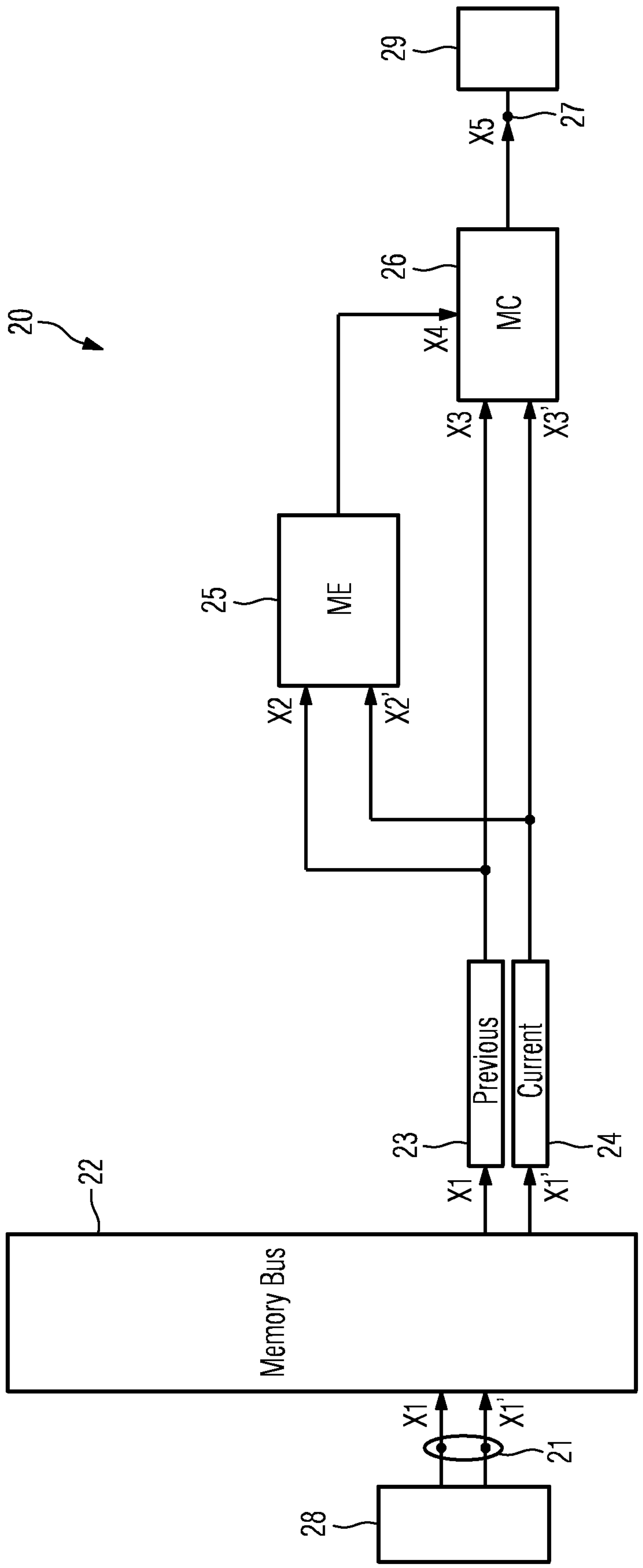
20
29
27
X5
26
MC
X4
X3
X3'
25
ME
X2
X2'
22
Memory Bus
X1
X1'
23
Previous
24
Current
X1
X1'
21
28

FIG. 4

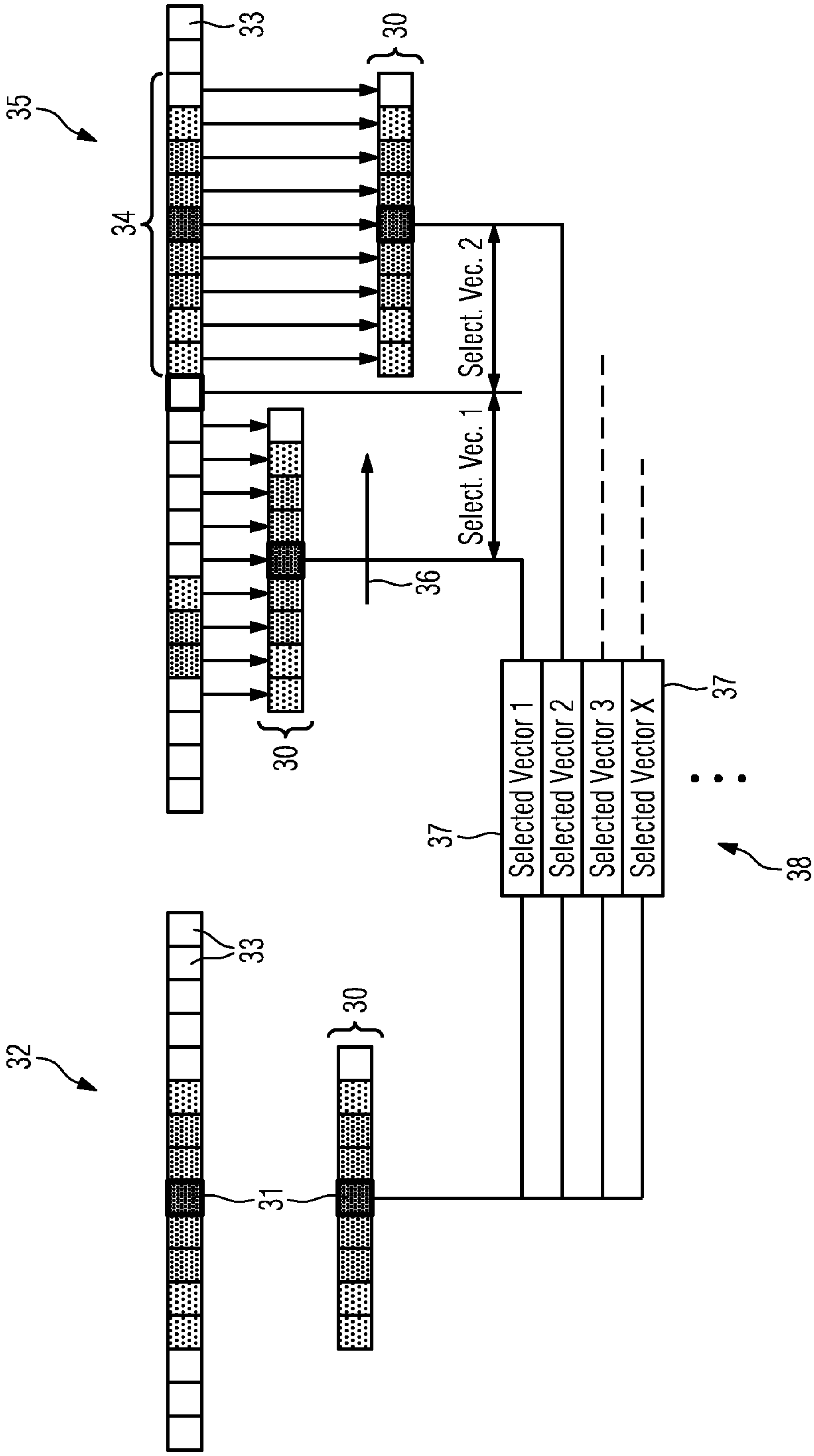
33
30
35
34
Select. Vec. 2
Select. Vec. 1
36
37
Selected Vector 1
Selected Vector 2
Selected Vector 3
Selected Vector X
37
38
33
30
32
31
31

FIG. 5

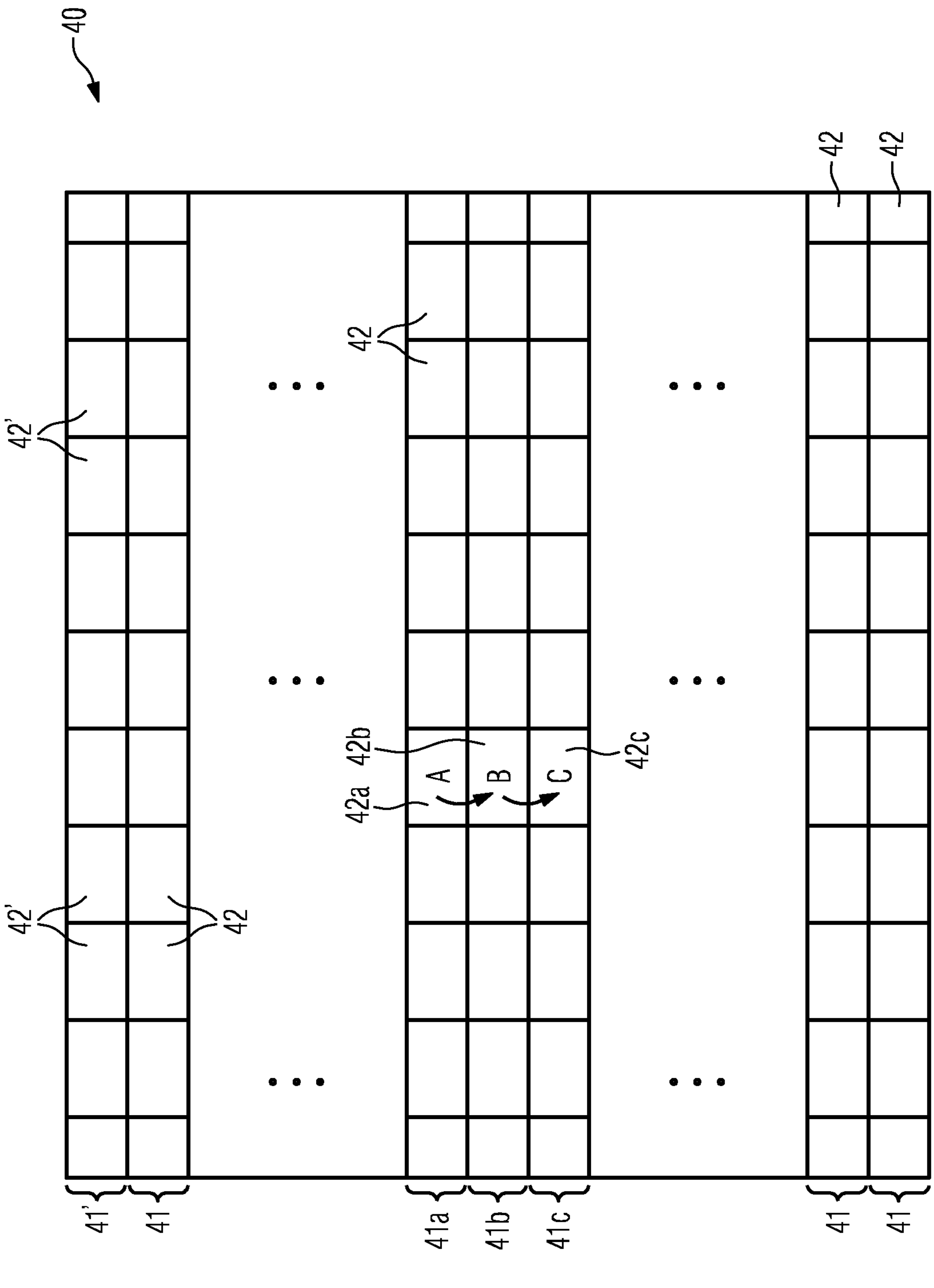

FIG. 6

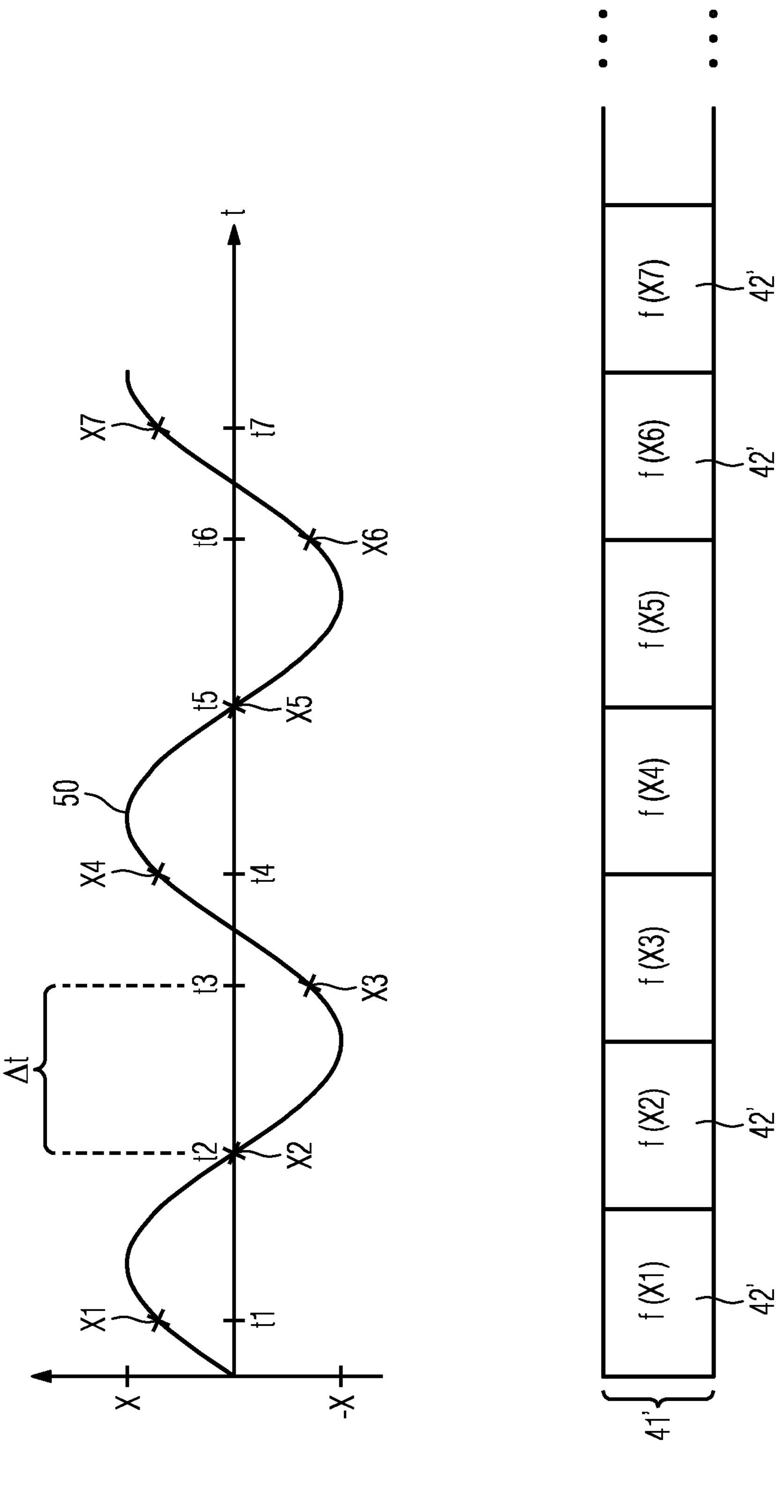
X
-X
t
t1
t2
t3
t4
t5
t6
t7
X1
X2
X3
X4
X5
X6
X7
50
Δt
f (X1)
f (X2)
f (X3)
f (X4)
f (X5)
f (X6)
f (X7)
42'
41'

FIG. 7

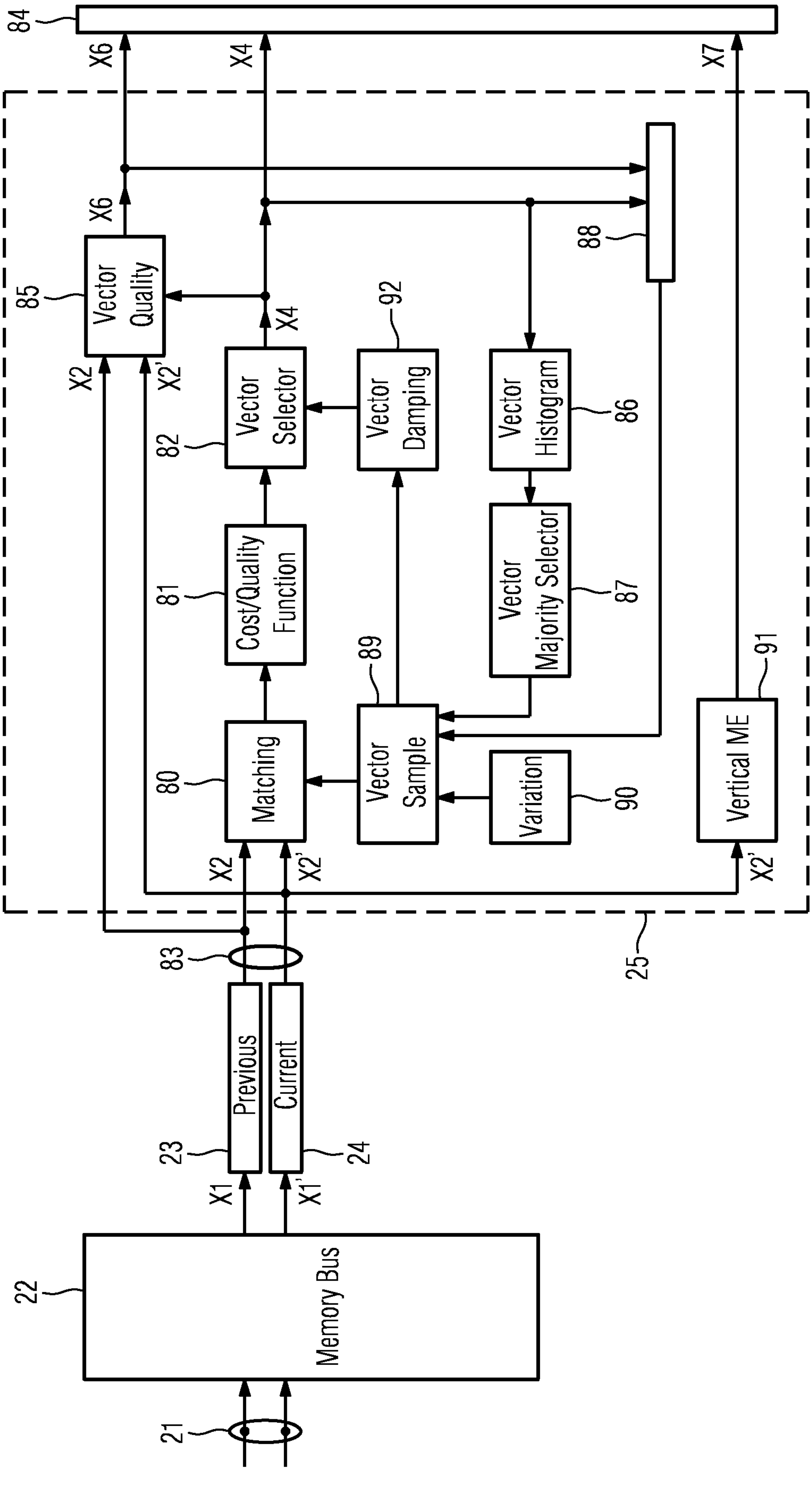
84
X6
X4
X7
85
Vector Quality
X2
X2'
88
92
Vector Damping
Vector Selector
82
Vector Histogram
86
Cost/Quality Function
81
Vector Majority Selector
87
89
Vector Sample
Matching
80
Variation
90
Vertical ME
91
83
25
Previous
Current
23
24
X1
X1'
Memory Bus
22
21

FIG. 8

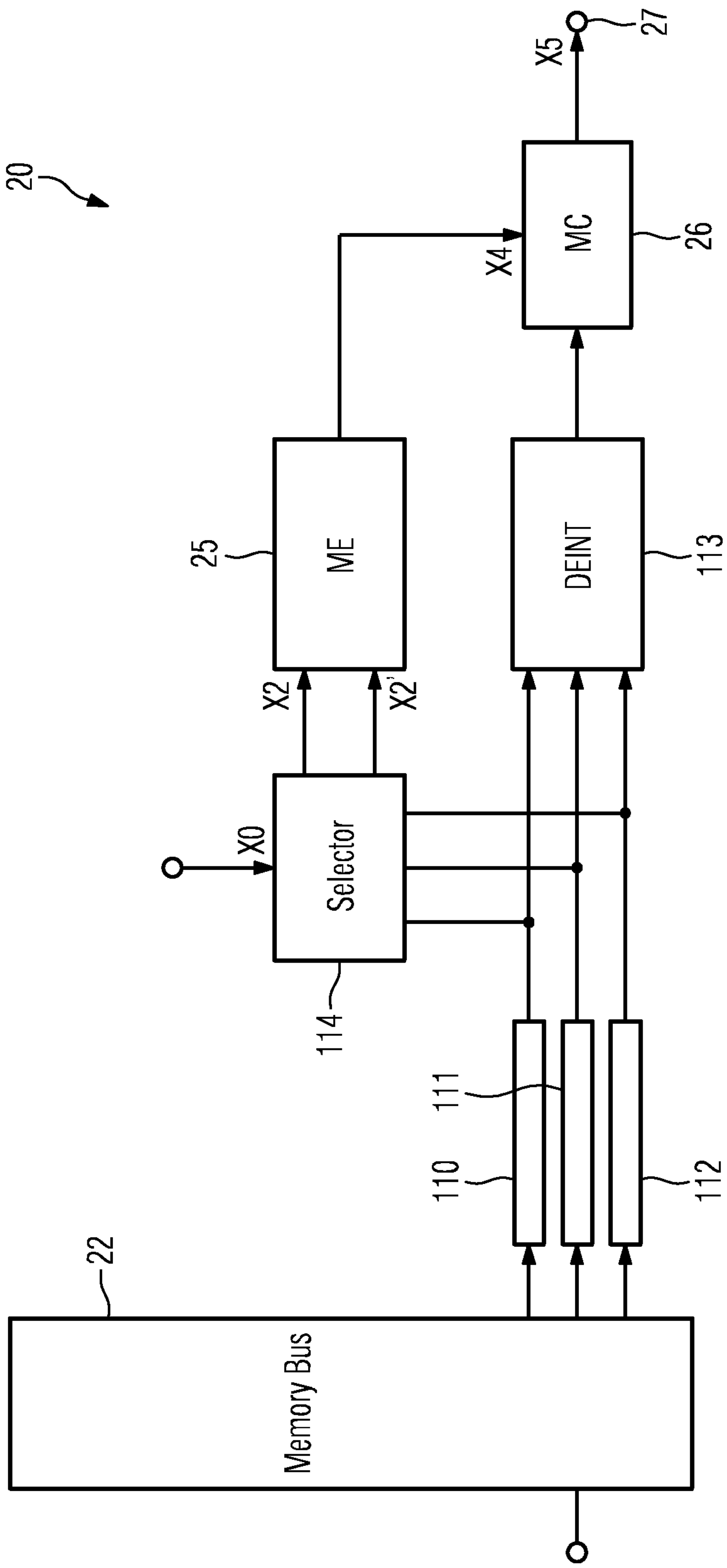
20
27
X5
MC
26
X4
25
ME
DEINT
113
X2
X2'
X0
Selector
114
111
110
112
22
Memory Bus

FIG. 9