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A Method and Device for Estimating Movement

The invention relates to a method and device for estimating movement in video signals.

Prior Art

The data-reducing coding/decoding of digital video signals is in many cases based on a movement-compensated interpolation of picture element values (interframe coding). For this purpose, movement vectors or displacement vectors are required for picture element blocks. These movement vectors are normally generated in the encoder by means of movement estimation.

A comparison is carried out in each case for a picture element block with e.g. 8*8 luminance picture elements from the current image within a search zone consisting of an enlarged picture element block of e.g. 16*16 luminance picture elements of the preceding image and referred to as search window. By means of MSE (mean squared error) or MAE (mean absolute error), within the search zone the 8*8 block with the highest correlation is determined and from the spatial position of the latter compared to the block from the current image the respective movement vector is determined.

This method is extremely compute-intensive and requires very high cycle rates. Even in hierarchical search methods complex and high-speed hardware is required.

Invention

The aim of the invention is to provide a less compute-intensive method of estimating movement. This aim is fulfilled by the method described in Claim 1.

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The invention is based on the further aim of providing a device for the method according to the invention. This aim is fulfilled by the device described in Claim 7.

In conventional methods of estimating movement, picture element values with a full word length of e.g. 8 bits are used. Detailed investigations have now shown that a movement estimation can also be effected by analysing only specific bits, e.g. the MSB or the two MSBs, of the picture element values. For this purpose these bits (of the picture element values of the current and the preceding and/or following image) are linked by logic operations and the individual results for the different block positions of the current block (e.g. 8*8 block) within the search window are in each case combined. By means of a following minimum or maximum comparison, the respective vector for the current block is then determined. The logic operations are preferably EXOR and/or EXNOR functions, the results of which within the respective search block are counted and/or added.

In principle the method according to the invention consists in that for the estimation of movement in video signals, where in each case within a search zone a reference picture element block (BS) is compared with corresponding picture element blocks (SAS) of one or several adjacent images and a movement vector is determined in accordance with the position of the principally highest correlation, in this comparison of the picture element values in each case only the MSB (most significant bit) and/or further of the MSBs (most significant bits), provided with the general reference MSBs in the following, is/are used.

Advantageous further developments of the method according to the invention are described in the associated dependent claims.

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In principle the device according to the invention for estimating movement in video signals, where in each case within a search zone a reference picture element block is compared with corresponding picture element blocks of one or several adjacent images and a movement vector is determined in accordance with the position of the principally highest correlation, is provided with:

- storage means for storing the reference picture element block and the picture element blocks of one or several adjacent images;
- EXOR or EXNOR gates which are connected to the storage means and which are in each case supplied with only the MSB (most significant bit) and/or further of the MSBs (most significant bits), referred to in general in the following as MSBs, of these picture element values;
- means for the addition, counting and/or intermediate storage of the comparison results for each of these picture element values from the EXOR or EXNOR gates which determine the movement vector from the search position with the minimum or maximum of the sum or the counting result.

Advantageous further developments of the device according to the invention are described in the associated dependent claims.

Drawings

Exemplary embodiments of the invention will be described making reference to the drawing in which:

Fig. 1 shows a block from the current image and a search zone from the preceding image;

Fig. 2 is a block diagram of a movement estimator according to the invention;

Fig. 3 is a block diagram of a further movement estimator according to the invention.

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Exemplary Embodiments

The blocks shown in Fig. 1 relate, for reasons of clarity of layout, to a block size of 2*2 picture elements. In reality block sizes of e.g. 8*8 or 16*16 picture elements are used. For the determination of a first combination result, in consecutive cycles CL in an EXOR or EXNOR function the MSBs of the picture elements of the current block are logic-linked with the MSBs of the search zone picture elements A...T (size of the search zone can be arbitrarily selected) in accordance with the following table:

EXOR	CL
$1 \oplus A$	1
$2 \oplus B$	2
$3 \oplus F$	3
$4 \oplus G$	4

For the determination of the second combination result, in consecutive cycles CL the MSBs are logic-linked in accordance with the following table:

EXOR	CL
$1 \oplus B$	1
$2 \oplus C$	2
$3 \oplus G$	3
$4 \oplus H$	4

The sequence can differ:

A)

In accordance with the above tables, firstly with the cycle CL = '1', MSB '1' (or the several MSBs corresponding to the position of MS '1') are simultaneously logic-linked in a corresponding number of EXOR functions with the MSBs (or the several MSBs corresponding to the position of MSB '1') of A, B, C, ..., N, whereupon in cycle CL = '2', MSB '2' is



simultaneously logic-linked in these EXOR or EXNOR functions with the MSBs of B, C, ..., O etc. The individual results at the outputs of these EXOR or EXNOR functions are in each case added and intermediately stored. Following the processing of the search zone for a block, in the case of EXOR functions the minimum of these sums, and in the case of EXNOR functions the maximum of these sums is determined for the search zone, and from the associated search position (i.e. where as many as possible of the 2*2 MSBs of the two blocks are identical) the corresponding movement vector is determined.

B)

Firstly, with the cycle CL = '1', in parallel EXOR- or EXNOR functions MSB'1' is logic-linked with MSB'A', MSB'2' is logic-linked with MSB'B', MSB'3' is logic-linked with MSB 'F', and MSB'4' is logic-linked with MSB'G' and directly the combination result or sum of these four individual results is determined and intermediately stored. Then, in cycle CL = '2' in parallel EXOR functions MSB '1' is logic-linked with MSB 'B', MSB '2' is logic-linked with MSB 'C', MSB '3' is logic-linked with MSB 'G', and MSB '4' is logic-linked with MSB 'H' and the corresponding combination result is determined etc. Following the processing of the search zone for a block, in the case of EXOR functions the minimum of these sums, and in the case of EXNOR functions the maximum of these sums is determined for the search zone and from the associated search position (e.g. where as many as possible of the 2*2 MSBs of the two blocks are identical) the corresponding movement vector is determined.

The movement estimator according to Fig. 2 is suitable for version A) and contains block storage means BS for the picture element values or the required bits (e.g. the MSB or the 2 or 4 MSBs) of these values of the current block. The picture elements values or the corresponding MSBs for the search zone are stored in search zone storage means SAS.



The required bit or the required bits of these picture element values are fed to EXOR or EXNOR gates $G_1, G_2, \dots, G_6$. One output of BS, via which the MSBs '1', '2', '3' and '4' are output, is connected to all the gates. From SAS a number of lines corresponding to the number of picture elements of the search zone is in each case connected to one of the gates $G_1, G_2, \dots, G_6$. The gate output values are added for each of the search positions in each case in an adder. Advantageously, on the basis of the 1-bit values this addition of the individual results can be carried out using counters $C_1, C_2, \dots, C_6$. For each search for a block, the maximum or minimum of the counting results is determined in following comparator means COM and from the associated search position the corresponding movement vector is determined.

If a plurality of (n) MSBs are analysed in parallel for the search, the circuit can be extended in different ways:

- a) n gates, n counters (in the case of MSB and MSB^{-1} or MSB^{-1} and MSB^{-2} , $n = 2$), which are arranged in parallel in an appropriate fashion;
- b) preferably n gates, a counter operating at n-fold speed or an adder;
- c) as a) or b) but to/from one or several of the MSBs from BS and from SAS prior to the analysis in the gates a defined value, e.g. 48, is added or subtracted. This defined value or defined values can be continuously adapted to the image statistic;
- d) not always the same bits are analysed, e.g. within a block in each case two of the bits MSB, MSB^{-1} and MSB^{-2} are selected.

These possibilities can also be combined in an appropriate fashion.



The movement estimator according to Fig. 3 is suitable for version B) and contains block storage means BS for the picture element values or the required bits (e.g. the MSB or the 2 or 4 MSBs) of these values of the current block. The picture element values or the corresponding MSBs for the search zone are stored in search zone storage means SAS. BS has four (depending upon the block size) outputs, each of which is connected to one of the fourth EXOR or EXNOR gates G1...G4 and via which the required bit or required bits of these picture element values are fed to the gates. Similar applies to SAS. The gate output values are added for each of the search positions in each case in an adder circuit CO and intermediately stored for all the search positions. Advantageously, on the basis of the 1-bit values this addition of the individual results can be carried out using counters. For each search for a block, the maximum or minimum of the counter results is determined in following comparator means COM and the corresponding movement vector is determined from the associated search position.

The extension possibilities referred to with reference to Fig. 2 can be applied in a corresponding fashion in the circuit according to Fig. 3.

The invention can also be used to form (e.g. local) movement vectors in a decoder.

In the case of a moving image content in interlaced images, the vector search can also be carried out within blocks which are composed only of lines of one field.

The search zone can also be non-square and/or varied in its dimensions, in particular as a function of search results preceding in respect of time and/or space.



The invention can also be implemented in the vector search for a reference block by comparison with corresponding blocks of a preceding and a following image (double-sided block matching).

Instead of MSE or MAE it is also possible to use other methods of fault level calculation. Instead of determining the movement vector in accordance with the respective highest correlation, it is also possible deliberately not to select the position of the highest correlation if a closely located position is better adapted to the surrounding vectors.

The invention can be applied for example in MPEG TV systems, in digital video recorders and in moving image transmission via telephone lines (ISDN).

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Claims

1. A method of estimating movement in video signals wherein in each case within a search zone a reference picture element block (BS) is compared with corresponding picture element blocks (SAS) of one or several adjacent images and a movement vector is determined in accordance with the position with the principally highest correlation, characterised in that in this comparison (G1...G6, C1...C6, COM) of the picture element values, in each case only the MSB (most significant bit) and/or further of the MSBs (most significant bits), referred to in general as MSBs in the following, is/are used.
2. A method as claimed in Claim 1, characterised in that in the comparison the MSBs of the picture element values from the reference block (BS) and from the search zone (SAS) are logic-linked with EXOR- or EXNOR functions.
3. A method as claimed in Claim 2, characterised in that in the logic-linking, for each of these picture element values the result of the EXOR or EXNOR function is added or counted, and the movement vector is determined from the search position with the minimum or maximum of the sum or the counting result.
4. A method as claimed in Claim 3, characterised in that at least $n=2$ MSBs for each picture element value *(from?) n EXOR or EXNOR functions are added or counted, where in each case either n parallel counters are used or a counter with n -fold speed is used.
5. A method as claimed in one or more of Claims 1 to 4, characterised in that prior to the comparison, to/from one or more of the MSBs defined values, in particular adapted to





an image statistic, are in each case added and/or subtracted.

6. A method as claimed in one or more of Claims 1 to 5, characterised in that in the comparison, within a picture element block different ones of the MSBs are analysed for different picture element values.

7. A device for a method as claimed in one or more of Claims 1 to 6 for estimating movement in video signals, wherein in each case within a search zone a reference picture element block (BS) is compared with corresponding picture element blocks (SAS) of one or more adjacent images, and a movement vector is determined in accordance with the position with the principally highest correlation, provided with:

- storage means (BS, SAS) for storing the reference picture element block and the picture element blocks of one or more adjacent images;
- EXOR or EXNOR gates (G1, G2, ..., G6...) which are connected to the storage means and which are in each case supplied with only the MSB (most significant bit) and/or further of the MSBs (most significant bits), referred to in general as MSBs in the following, of these picture element values;
- means (C1, C2, ..., C6, ..., COM, CO) for the addition, counting and/or intermediate storage of the comparison results for each of these picture element values from the EXOR or EXNOR gates which determine the movement vector from the search position with the minimum or maximum of the sum or counting result.

8. A device as claimed in Claim 7, characterised in that at least $n=2$ MSBs for each picture element value in n parallel EXOR or EXNOR gates (G1, G2, ..., G6...) are added or



counted, where in each case either n parallel counters are used or one counter with n -fold speed is used.

9. A device as claimed in Claim 7 or 8, characterised in that prior to the comparison, to/from one or more of the MSBs defined values, in particular adapted to an image statistic, are in each case added and/or subtracted.

10. A method or device as claimed in one or more of Claims 1 to 9 for use in MPEG TV systems, in digital video recorders and/or in moving image transmission via telephone lines (ISDN).

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