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Method and Apparatus for forming a video signal using motion estimation and signal paths with different interpolation processing

The present invention relates to a method and to an apparatus for forming a video signal using motion estimation and signal paths with different interpolation processing.

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Background

The invention described here is part of a motion compensated field rate upconversion system, where intermediate fields of a television picture, not present at the input, are calculated by means of motion compensated interpolation. A typical application is conversion between 50Hz and 100Hz television signals for display flicker reduction.

Invention

It is one object of the invention to disclose a method of selecting an interpolation mode in relation to a confidence measurement of the related motion vector. This object is reached by the method disclosed in claim 1.

It is a further object of the invention to disclose an apparatus which utilises the inventive method. This object is reached by the apparatus disclosed in claim 8.

In principle, every pixel in the intermediate fields can be the direct output of a motion compensated interpolator. In practice, however, there will always be areas of the picture where the motion is too fast or too complex to be estimated correctly. Patent application EP93 402505 of the applicant describes 'fallback processing' whereby a special non-compensated fallback mode or any comparable mode can be used in such areas.

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The final output is in fact the result of a soft switch or fade between the motion compensated interpolation and the fallback mode, controlled by a measure of confidence in the reliability of the estimated motion vector. The confidence measure takes values between 0 and 1, where 0 (no confidence) selects the fallback mode only, 1 (maximum confidence) selects the motion compensated interpolation only, and intermediate values mix linearly between the two.
Advantageously, the confidence measure includes the following two components: a 'basic confidence measure' which reflects the error in the motion measurement, and a measure based on the speed of movement.

In principle, the inventive method is suited for forming a video signal using motion estimation and signal paths with different interpolation processing, in particular motion compensated interpolation and fallback interpolation, whereby the output signals of said different signal paths are combined in relation to a measure of confidence which is derived from a minimum motion estimation error of the input video signal, which is in particular block based.

Advantageous additional embodiments of the inventive method are resulting from the respective dependent claims.

In principle the inventive apparatus for forming a video signal using motion estimation and signal paths with different interpolation processing, in particular motion compensated interpolation and fallback interpolation, includes:
- motion compensated interpolation means and fallback interpolation means which receive said input video signal and the output pixel values of which are mixed in combining means in relation to a measure of confidence value which is derived in combining means from a block based minimum motion estimation error of the input video signal and from a related block motion vector or its components;
- motion estimation means which calculate from said input signal, or motion information extractor means which extract from

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the transmitted input signal data stream, said block based minimum motion estimation error and said related block motion vector or its components.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claims.

Drawings

Preferred embodiments of the invention are described with reference to the accompanying drawings, which show in:

Fig. 1 example of law relating confidence to subblock matching error;

Fig. 2 example of law relating confidence to estimated speed;

Fig. 3 block diagram of confidence measurement circuit.

Preferred embodiments

One method of motion measurement is block matching followed by localization using subblock matching, as described in EP-A-93402188 of the applicant.

Such subblock matching process produces motion vectors whose components may be passed through a median filter. In calculating the motion vectors, the subblock matching process or any other comparable process generates an error (e.g. the sum of absolute, or the square of, difference values between the according pixel values in the two blocks used for matching) for each candidate motion vector and the vector giving the minimum error is chosen.

It is the value of this minimum error which is used to calculate a basic measure of confidence according to the law illustrated in Fig. 1. If this subblock matching error SBME is zero, the confidence CF takes its maximum value of 1. As the error SBME increases to a cut-off value CV, the confidence decreases to its minimum value of zero. Other, similar relations (e.g. part of a sine or cosine function or a gaussian

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function) between subblock matching error and confidence may also be used for such limiting filter.
One problem with this basic measure of confidence is that the subblock matching process usually generates high errors, leading to low or zero confidence, around the edge of an object moving over a detailed background. This means that the edge will be interpolated using the fallback mode, even though the motion vectors themselves correctly follow the edge. A solution is to pass the subblock errors through a rank order filter, for example on a 3x3 window. The filter may be a median filter or another rank order filter; for example the third highest error value in the window may be selected.

Advantageously, the measure of confidence may be modified to take account of the speed ES of movement. The aim of this modification is to ensure that, as an object accelerates out of the range of motion speeds that can be estimated and coded with a motion vector, the interpolation switches smoothly into the fallback mode. An example of a suitable law that can be applied is given in Fig. 2. Again, other relations (e.g. part of a sine or cosine function or a gaussian function, different start value SV) between motion speed ES and confidence CF may be used.
It can be applied to the true motion speed or to the two motion vector components separately, taking the minimum or some other combination of the two results. The result is combined with the main measure of confidence, for example by taking the minimum or by multiplication.

In the confidence measurement circuit of Fig. 3 an input video signal, e.g. 50Hz, 2:1 or 60Hz, 2:1, is fed to a motion compensated interpolator MCI, to a fallback filter FFI and to a motion estimator ME. A soft switch SSW operates on the output signals of interpolator MCI and filter FFI and provides the final output signal O which may have the format 100/120Hz, 2:1 or 50/60Hz, 1:1. Switch SSW is controlled by a confidence signal CF coming from a combiner CB. Motion estimator ME calculates the block matching error BME, a horizontal component MVX

and a vertical component MVY of the related motion vector. These values can also be transmitted if the motion estimator is located within a transmitter and the circuit of Fig. 3 is part of a receiver, e.g. a TV receiver. Then, circuit ME may extract the matching error and/or the motion vector and/or its components from the transmitted input signal data stream. The motion information can also be used in interpolator MCI.

Error BME passes through a rank order filter ROFI, for instance a median filter, and a first weighting filter L1 operating according to the law of Fig. 1 and is then fed into a combiner CB.

The horizontal vector component MVX passes through a first median filter MFI1 and a second weighting filter L2 operating according to the law of Fig. 2 and is then fed into combiner CB.

The vertical vector component MVY passes through a second median filter MFI2 and a third weighting filter L3 operating according to the law of Fig. 2 and is then fed into combiner CB.

The combiner CB operates as described above and can work as a look-up table which is stored in memory means. The laws of filters L2 and L3 can be different (different function or start value SV). The laws represented by filters L1, L2 and L3 can be stored in look-up tables.

In case of specific picture data characteristics (e.g. camera/film mode) different laws can be selected or downloaded into the law memories.

If the chrominance components are not controlled together with the luminance components by signal CF, they can be handled by separate means according to Fig. 3, having laws designed especially for the chrominance components.

The invention can also be used for standards conversion, bit rate reduction, digital HDTV, digital VCR and MPEG1 or MPEG2 devices (IEC/ISO standard). In case of bit rate reduction the fallback processing may be intra field coding.

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Claims

1. Method for forming a video signal (O) using motion estimation (ME) and signal paths with different interpolation processing, in particular motion compensated interpolation (MCI) and fall-back interpolation (FFI), **characterised in** that the output signals of said different signal paths are combined (SSW) in relation to a measure of confidence (CF) which is derived from a minimum motion estimation (ME) error (BME) of the input video signal (I), which is in particular block based.

2. Method according to claim 1, **characterised in** that said measure of confidence (CF) is also derived from the value of a block motion vector (MVX, MVY).

3. Method according to claim 2, **characterised in** that said measure of confidence (CF) is derived from the values of the horizontal (MVX) and vertical (MVY) components of said block motion vector.

4. Method according to any of claims 1 to 3, **characterised in** that the values of said motion estimation error (BME) pass through two-dimensional rank order filter means (ROFI) before being used to form (CB) said measure of confidence (CF).

5. Method according to any of claims 2 to 4, **characterised in** that the values of said block motion vector or its components (MVX, MVY) pass through median filter means (MFI1, MFI2) before being used to form said measure of confidence (CF).

6. Method according to any of claims 1 to 5, **characterised in** that the values or pre-processed values of said motion estimation error (BME) and/or said block motion vector or its components (MVX, MVY) pass through limiting filter means (L1, L2, L3) before being used to form said measure of confidence (CF).

7. Method according to any of claims 1 to 6, **characterised in** that from the values or pre-processed values of said motion

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estimation error (BME) and/or said block motion vector or its components (MVX, MVY) the minimum is taken, or these values are multiplied, to form said measure of confidence (CF).

8. Apparatus for forming a video signal (O) using motion estimation (ME) and signal paths with different interpolation processing, in particular motion compensated interpolation (MCI) and fallback interpolation (FFI), related to a method according to any of claims 1 to 8 and including:
- motion compensated interpolation means (MCI) and fallback interpolation means (FFI) which receive said input video signal (I) and the output pixel values of which are mixed in combining means (SSW) in relation to a measure of confidence value (CF) which is derived in combining means (CB) from a block based minimum motion estimation error (BME) of the input video signal (I) and from a related block motion vector or its components (MVX, MVY);
- motion estimation means (ME) which calculate from said input signal (I), or motion information extractor means (ME) which extract from the transmitted input signal data stream, said block based minimum motion estimation error (BME) and said related block motion vector or its components (MVX, MVY).

9. Apparatus according to claim 8, **characterised in** that said block based minimum motion estimation error (BME) and said related block motion vector or its components (MVX, MVY) pass through rank order or median filter means (ROFI, MFI1, MFI2) and/or through limiting filter means (L1, L2, L3) before being used in said combining means (CB) to form said measure of confidence value (CF).

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