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Method for encoding

The invention relates to a method for movement-compensated vertical filtering.

Prior Art

EP 0 414 113 describes a method describing how a zoom and pan vector (enlargement and pivot vector) can be generated for an entire frame from a field of movement vectors, for example derived from pixel blocks.

Invention

The invention is based on the object of specifying a method for movement-compensated vertical filtering. This object is achieved by the invention specified in Claim 1.

In principle, the method according to the invention consists in that, during encoding in which video signals which are composed of pixels are movement-compensated and are encoded with movement parameters being generated, movement parameters for movement compensation are used frame-by-frame in the case of frame format conversion being carried out before the encoding, the video signals being subsampled at least in the vertical direction during the frame format conversion and incorrectly movement-compensated pixels being determined with the aid of change detection on the basis of the movement compensation frame-by-frame, the pixels in the case of correct movement compensation being filtered vertically in the frame and, in the case of incorrect movement compensation, being filtered vertically in the field.

Advantageous developments of the method according to the invention result from subclaims 2 to 9.

In the case of data-reducing video encoding with movement compensation, movement vectors are produced for individual frames or frame parts. In order further to reduce the data rate, the video signals can be subsampled

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before the encoding.

If the video signals are present in the interlaced format before the subsampling and are intended to have a progressive format after the encoding, an interlaced/progressive frame format conversion can be carried out in a frame format converter, before the encoding. Progressive video signals can be obtained, for example, by omitting every other field, aliassing being introduced into the subsampled signal, however, without appropriate initial filtering, and the possible vertical resolution for the static frame content before the subsampling being reduced by the factor two.

Movement-adaptive vertical filtering can also be carried out before the subsampling. However, in this case, relatively large frame areas are in general regarded as moving. The vertical resolution is then reduced by more than a factor of two in these areas.

If frame format conversion with subsampling and movement-compensated encoding are carried out in series, n movement parameters for the size of the zoom and pan are present between frame n-2 and frame n-1 after the encoding of the frame. Since these parameters do not change suddenly from frame to frame in conventional television video signals, these existing zoom and pan parameters can be used as a prediction for the corresponding parameters which are not yet known between frame n-1 and frame n.

During the frame format conversion, the second field of frame n is now in each case shifted with the aid of the zoom and pan parameters to the time and spatial position of the first field of frame n. In order to reduce noise, the second field of frame n-1 and of frame n can in each case advantageously be shifted with the aid of the zoom and pan parameters to the time and spatial position of the first field of frame n.

A change detector is used to determine whether movement which has not yet been compensated for, for example within individual frame areas having different movement parameters with respect to the frame-by-frame

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movement parameters, is present for each pixel in the first field of frame n. If this is the case, the pixels from such frame areas are subjected to preliminary filtering for the subsampling, with the aid of corresponding pixels in the respective first field. If not, filtering is used which uses the pixels from the movement-compensated second field of frame n and/or from the movement-compensated second fields of frame n and n-1 and the current pixel itself (filtering in the movement-compensated frame).

The use of three fields in each case produces the noise-reducing time filtering.

Depending on the video material, the spatial resolution of the video signals which are generated during the format conversion is virtually at the limit which is feasible in terms of system theory and filter technology, and is not subject to any aliassing, which originates from subsampling without preliminary filtering. No separate movement estimation is required for the format conversion in order to allow the movement-compensated time preliminary filtering to be carried out.

Drawings

An exemplary embodiment of the invention is described with reference to the drawings, in which:

Fig. 1 is a circuit for video encoding having a frame format converter which is connected in series to an encoder;

Fig. 2 shows the frame format converter of Fig. 1.

Exemplary embodiments

Fig. 1 shows a frame format converter 14 which is connected in series with an encoder 15. A field memory 12 and a line memory 13, whose inputs are connected to one another, are connected upstream of the frame format converter. In the case of subsampling in the horizontal

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direction as well, this subsampling is advantageously carried out linked to appropriate preliminary filtering in a horizontal frame format converter 11 which is connected upstream of the field memory 12 and the line memory 13. As a result of this, the processing speed required in the following circuits is reduced. An interlaced video signal with the frames S_n, n = 1,2,3,... is supplied to the input 10. The filtered and subsampled video signal S_n is available after this at the output from the frame format converter 14 to the encoder.

Block-by-block movement parameters which originate from the encoder 15, for example for zoom and pan, are generated [sic] in a movement parameter generator 16 into frame-by-frame movement parameters p_{n-1}, for the frame pair s_{n-2}, s_{n-1} (z, v_x, v_y). This can be carried out, for example, as described in EP 0 414 113. 'z' is in this case the zoom factor, 'v_x' the shift in the horizontal direction and 'v_y' the shift in the vertical direction between two frames at a time interval of 1/25s. The required processing speed in the frame format converter is advantageously reduced by the frame-by-frame conditioning and processing of the movement parameters.

Compensation for the movement in the second fields S^2_{n-1} and S^2_n at the time of the respectively associated first field S^1_n with a time difference of ±1/50s requires that the movement parameters be divided by the value 2. Since, on the other hand, the spatial resolution in the field, apart from any possible horizontal frame format conversion, is twice as great in the horizontal direction as in the vertical direction, and the movement parameters to be used in the frame format converter 14 are given by:

$Z = z/2$

$V_x = v_x$

$V_y = v_y/2$

The compensated 2nd fields S^{2k}_n, S^{2k}_{n-1} can be calculated as follows:

$S^{2k}_n(x,y) = S^2_n((1-Z)*x-V_x, (1-Z)*y-V_y)$

$S^{2k}_{n-1}(x,y) = S^2_{n-1}((1+Z)*x+V_x, (1+Z)*y+V_y)$,

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(x,y) originating from a coordinate system whose origin is in the frame centre.

The absolute values of the differences between the movement-compensated second fields S^{2k}_{n-1}, S^{2k}_{n} are added up to produce a value Σ, using a change detector 17, for every position (x,y) in the first field S^{1}_{n} in a window of pixel positions arranged symmetrically with respect thereto. The size of the window is variable. It is preferably 5*4 pixels.

If the value Σ does not exceed a further threshold T_1, then filtering is carried out in the movement-compensated frame:

$S^{1f}_{n}(x,y) = fil^{v}_{n}(x,y)$.

If the value Σ exceeds a second, higher threshold T_2, then filtering is carried out in the field:

$S^{1f}_{n}(x,y) = fil^{h}_{n}(x,y)$.

If the value Σ is between the two thresholds, then the result of a linear combination of both filter signals is:

$S^{1f}_{n}(x,y) = w*fil^{v}_{n}(x,y)+(1-r)*fil^{h}_{n}(x,y)$,

where $r = (T_2-\Sigma)/T_2-T_1)$.

The thresholds can be selected to be, for example, T_1 = 6* (number of pixels in the window) and T_2 = 12* (number of pixels in the window).

A pixel movement detector such as that described in EP 0 333 069 can be used, for example, for change detection. The change detector 17 receives corresponding input data from the frame format converter 14, and sends back the value Σ.

The number of lines stored in the line memory 13 corresponds to the maximum movement compensation in the vertical direction.

The filter length for the vertical filtering advantageously corresponds to the window for the change detection in the vertical direction.

For the vertical frame filter, it is possible that:

$$fil^{v}_{n}(x,y) = [k_0*S^{1}_{n}(x,y)+ k_1*(S^{2k}_{n-1}(x,y-1)+S^{2k}_{n}(x,y-1))+$$

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$$k_1*(S^{2k}_{n-1}(x,y\ \ )+S^{2k}_{n}(x,y\ \ ))+$$
$$k_2*(S^{2k}_{n-1}(x,y+1)+S^{2k}_{n}(x,y+1))+$$
$$k_2*(S^{2k}_{n-1}(x,y+2)+S^{2k}_{n}(x,y+2))]/$$
$$(k_0+4*(k_1+k_2)),$$

where $k_0 = 128$, $k_1 = 75$, $k_2 = -11$.

In this case, it must be noted that $S^2_n(x,y-1)$ in the frame is located immediately above $S^1_n(x,y)$ and $S^2_n(x,y)$ is located immediately underneath it.

For the vertical field filter, it is possible that:

$$fil^h_n\ (x,y) = [k_0*S^1_n(x,y)+$$
$$k_1*(S^1_n(x,y-1)+S^1_n(x,y+1))]/$$
$$(k_0+2*k_1),$$

where $k_0 = 8$, $k_1 = 1$.

The video signal s_n to be encoded is now obtained from the first field S^{1f}_n after it has been subsampled for example, by the factor two horizontally and vertically.

The input signals S_n at the input 10 may have the format 625L/50Hz/2:1 with 720*576 active pixels for the luminance component and with in each case 360*576 active pixels for the chrominance components. The chrominance components can be processed in a corresponding manner to the luminance component or else, in principle, can be filtered in the field.

The output signals s_n from the frame format converter 14 and in encoded form at the output 18 can have, for example, a progressive frame format with 360*288 active pixels for the luminance component and with in each case 180*144 active pixels for the chrominance components.

Fig. 2 shows the frame format converter 14 in more detail. The first input 20 is connected to a frame memory 22 and receives video signals, delayed by one field, in each case of the first field, from the field memory 12, the second input 21 is connected to a movement compensation circuit 23 and receives line-delayed video signals in each case of the second field from the line memory 13, the third input 24 is likewise connected to the movement compensation circuit and receives movement

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parameters from the movement parameter generator 16, and the fourth input 27 receives output signals from the change detector 17.

The video signals from the line memory 13 are movement-compensated using known methods in a corresponding manner to the frame-by-frame movement parameters from the movement parameter generator and are supplied to the frame memory 22. The lines in the line memory can be addressed via the output 211. Frame signals having the maximum vertical spatial resolution are now present at the output of the frame memory, which signals are filtered in the downstream vertical filter 25 pixel-by-pixel in a corresponding manner to the signal at the fourth input 27 in the frame or in the field, and are likewise supplied via the output 26 to the change detector 17.

The vertical filter is followed by a subsampling stage 28, at whose output 29 the video signal s_n can be picked off.

The frame-by-frame movement parameters can in each case contain valid zoom and/or pan factors for an entire frame or can be shift vectors for sections within the frames. For example, one shift vector can be formed for each pixel block of 8*8 pixels.

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Patent Claims

1. Method for encoding, in the case of which video signals which are composed of pixels are movement-compensated and are encoded with movement parameters being generated, characterized in that movement parameters for movement compensation are used frame-by-frame in the case of frame format conversion (14) carried out before the encoding (15), the video signals being subsampled at least in the vertical direction during the frame format conversion and incorrectly movement-compensated pixels being determined with the aid of change detection (17) on the basis of the movement compensation frame-by-frame, the pixels in the case of correct movement compensation being filtered (25) vertically in the frame and, in the case of incorrect movement compensation, being filtered (25) vertically in the field before or during the subsampling.

2. Method according to Claim 1, characterized in that, after the frame format conversion (14), the video signals are subsampled by a factor of 2 with respect to the original video signals in the vertical direction and/or horizontal direction, the video signals being present, in particular, before the frame format conversion in the interlaced format and after the frame format conversion in a progressive format.

3. Method according to Claim 1 or 2, characterized in that, before the filtering (25) and the subsampling (28), a second field S^2_n is in each case shifted into the corresponding spatial and time position of the corresponding first field S^1_n, n = 1,2,3,... .

4. Method according to one of more of Claims 1 to 3, characterized in that, before the filtering (25) and the subsampling (28), a second field S^2_n and a second field S^2_{n-1} of the preceding frame S_{n-1} are in each case shifted into the corresponding spatial and time position of the corresponding first field S^1_n, the two second fields S^2_n and S^2_{n-1} being averaged.

5. Method according to one or more of Claims 1 to 4,

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characterized in that, during the change detection (17) for each pixel in the first field S^1_n, the absolute values of the differences between the movement-compensated second fields S^{2k}_{n-1}, S^{2k}_n are added up, to produce a value Σ, in a window of pixel positions arranged symmetrically with respect to said first field S^1_n, the size of the window being, in particular, 5*4 pixels.

6. Method according to Claim 5, characterized in that filtering is carried out in the movement-compensated frame if the value Σ is less than or equal to a first threshold T_1, and in that filtering is carried out in the field if the value Σ is greater than a second, higher threshold T_2.

7. Method according to Claim 6, characterized in that an appropriate linear combination of both filter signals is used if the value Σ is between the two thresholds T_1 and T_2.

8. Method according to Claim 6 or 7, characterized in that the first threshold has a value of approximately six times the number of pixels in the window, and the second threshold has a value of approximately twelve times the number of pixels in the window.

9. Method according to one or more of Claims 1 to 8, characterized in that the frame-by-frame movement parameters contain zoom and/or pan factors which in each case apply to an entire frame or are shift vectors for sections within the frames.

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