Method of making a hierarchical estimate of the movement in a television signal

The invention is based upon a method in accordance with the first part of claim 1. Such an estimate of the movement in a television signal (so-called motion estimation) serves, in particular, for the purposes of data reduction, for saving transmission bandwidth, transmission time or storage capacity in a recorder. Thereby, in accordance with the result of the estimate of the movement, successive pictures are not transmitted completely as in the case of a conventional television signal but rather, difference factors are transmitted which represent any alteration between successive pictures. A further usage of the estimate of the movement consists in switching-over certain signal processing circuits such as e.g. comb filters, as regards their manner of operation in dependence on the movement in the television signal. An estimate of the movement is also required in video cameras in which jerky alterations occurring in the image, which are due to unintentional shaking of the camera, are balanced out mechanically or electronically.

The estimate of the movement between video images is the more effective, the greater the search range. In order to overcome the heavy layout on hardware which is associated therewith, one adopts hierarchical arrangements. Thereby, initially and in a relatively coarse manner, a best movement factor is sought for throughout the whole search range in order to then improve the factor by resolving more finely in the neighbourhood of the location that has been found.

In the known manner of estimating movement in accordance with the "block matching algorithm", a video image that is to be processed is divided into blocks of fixed size. The movement with respect to a second video image is determined for each block in that an error magnitude (distortion) of the block is calculated for each possible displacement within a search range and thereafter the minimum one of the values is determined.

Thereby, the implementation in hardware is based on commercially available motion estimation chips such as the STI3220 from SGS-Thomson for example. This module computes the displacement having the least distortion in a search range of -8/+7 horizontally and vertically. The search range can be enlarged by cascading a plurality of chips. For the high resolution HDTV system on the one hand, and for video images in accordance with the MPEG standard, in which the movement between images lying further apart in time is computed, on the other hand, one wishes to use as large a search range as possible for estimating the movement and thereby determining displacements with a resolution of 1/2 pel (pel = pixel = picture element). With "full search

block matching", in which each possible displacement means a parallel arithmetic unit, a number of modules amounting to several hundreds is required even when using the integrated motion estimation chips.

The expenditure on hardware can be reduced by estimating the movement in a hierarchical manner. Hereby, in a first step, the whole search range is investigated using a reduced resolution. Thereafter, in a fresh step, the smallest distortion effect is determined using a higher resolution around the position having the lowest distortion. This process can be repeated as often as desired using ever finer resolutions.

The object of the invention is to reduce the amount of circuitry, the so-called hardware, which is required for such an estimation of the movement. This object is achieved by the invention defined in claim 1. Advantageous developments of the invention are specified in the appendant claims.

Thus, with the invention, mutually non-overlapping ranges are produced at the lower, more finely resolved hierarchical level and the critical points of these ranges are used as the points for an analysis at a level that is located higher in the hierarchy. Preferably, points, which lie between the lines and which do not represent real picture elements in the line raster, are investigated in the mutually non-overlapping ranges.

The invention will be explained hereinafter with the help of the drawing. Therein

Fig. 1 shows an example for a known manner of estimating movement,

Fig. 2 the principle of the manner of estimating movement in accordance with the invention,

Fig. 3 an example for a 4 pel resolution at an upper level of the hierarchy and

Fig. 4 an example of how filtered values are computed.

Fig. 1 shows two blocks 1, 2 having an overlapping range Ü. When making the estimate of the movement, initially, only the boldly marked crosses 3 are investigated during a first hierarchical step. If, for example, the point 4a appears to be optimal, one would then only consider the points 4b, 4c, 4d, 4e surrounding this point. This then leads to one having to carry out an evaluation in the neighbourhood of these points. As Fig. 1 depicts, this would be the respective eight points in one of the blocks 1, 2 represented by the lightly marked crosses 4. This means that, in the second hierarchical step, the amount of

circuitry required has to be apportioned for these eight points. Fig. 1 thus shows an example involving a first search using a one picture element (pel) resolution and a subsequent search using 1/2 pel resolution around the first found pel. It is apparent that the 1/2 pel search ranges around one pel-value overlap. Each 1/2 pel value appertains to at least two hierarchical search ranges, the 1/2 pel diagonals thereby actually appertaining to four search ranges.

In Fig. 2, the blocks 1a and 2a no longer have any overlapping ranges. Consequently, each point appertains unambiguously to one point in the uppermost category. In the first hierarchy, the points 5 represented by the circles are investigated, i.e. - in contrast to Fig. 1 - not the points 3 represented by the crosses. Thereafter, in the second hierarchical step, four points around the point 5 are investigated in each case. It is apparent, that now, only four points have to be investigated and not eight as in Fig. 1. The amount of circuitry required, or, the hardware, is consequently reduced by approximately this factor. The points 5 are no longer actual picture elements since they lie outside the line raster illustrated in Fig. 1. The amount of circuitry required for the investigation of these points 5 is, however, relatively low. It merely consists of a filter, in which the values of these points are added and the sum resulting thereby is divided by 4. In other words, a formation of the real average value of these four points is carried out. Thus, in the first hierarchical step, one no longer uses the original pel-values but rather, the filtered pel-values. In the second hierarchical step, one now makes a search in the neighbourhood of these filtered values.

The method may also be extended for use in multi-level hierarchical methods.

Fig. 3 shows an example for a 4 pel resolution at an upper level of the hierarchy and a subsequent pel resolution in accordance with the conventional method. Here, 24 positions have to be analysed in the lower levels of the hierarchy.

In contrast thereto, Fig. 4 again shows the embodiment using mutually non-overlapping blocks. At the upper level of the hierarchy, 4 pel values are computed which lie in the critical part of the ranges. Thereafter, one makes a search in the neighbourhood of that filtered 4 pel value which has been found that has the lowest distortion whereby only 16 positions now come into question.

The method in accordance with the invention is not restricted to the estimation of movement but can be put to use anywhere where hierarchical structures are useful. In each case, mutually non-overlapping ranges are produced at the lower more finely

resolved hierarchical levels and the critical points of these ranges are used as the points for analysis at the level thereabove.

Claims

1. Method of making a hierarchical estimate of the movement in a television signal, in which the video image is divided into blocks of fixed size and the movement relative to a second video image is determined for each block, characterised in that, mutually non-overlapping ranges are produced at the lower, more finely resolved hierarchical level and the critical points of these ranges are used as the points for analysis at a level that is located higher in the hierarchy.

2. Method in accordance with Claim 1, characterised in that, points, which lie between the lines and which do not represent real picture elements in the line raster, are investigated in the mutually non-overlapping ranges.

* C L M S *