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UNE METHODE D'ESTIMATION DES MOUVEMENTS BASEE SUR LES PROJECTIONS DES DIFFERENCES D'IMAGES, D'ELEMENTS ET DE LIGNES.

A MOTION ESTIMATION SCHEME USING PROJECTIONS OF FRAME, ELEMENT AND LINE DIFFERENCES.

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RESUME

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Nous decrivons une methode d'estimation des mouvements qui pourrait etre consideree comme une variante de la methode differentielle classique.

La scene est divisee en parties mobiles et immobiles et les vecteurs de mouvements sont obtenus en ne tenant compte que des zones mobiles.

Nous calculons les projections des signaux des differences d'images, des differences d'elements et des differences de lignes sur des axes verticuax et horizontaux. Les vecteurs de mouvements des zones mobiles sont obtenus a partir de ces projections.

Nous avons implemente cette methode et nous L'avons appliquee a la reconstruction d'image a partir du calcul des vecteurs de mouvement et de precedentes images.

Nous montrons egalement les resultats d'une application au filtrage median selon l'axe des temps.

SUMMARY

ABSTRACT

A motion estimation scheme which could be considered a variant of the well known differential method is described.

The scene is segmented into moving and stationary blocks and motion vectors are obtained in the considered moving areas only.

For the moving areas we compute the projections on to the vertical and horizontal axis, of the frame difference, element difference and line difference signals. Using the projections, we obtain motion vectors for the moving areas.

We have implemented this scheme and applied it to image frame reconstruction from previous frame and computed motion vectors.

Results are also shown of an application to temporal median filtering.

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INTRODUCTION

It has been realized that signal processing techniques performed on image sequences yield better results when temporal changes are taken into consideration. This is more so when the change from frame to frame is due to the motion of objects within the scene being pictured. We are thus interested in computing motion vectors for the moving objects.

Huang and Hsu, [3], expounded on the problems of temporal filtering and showed that for both linear and nonlinear filtering, motion compensation gives a better result.

The performance of image coding algorithms are greatly reduced by noise. This stems from the fact that the noise sets a lower bound on the compression ratio achievable. Dubois and Sabri, [1], were able to reduce noise in television signal using motion compensated non linear filtering. The 'cleaned up' signal was to be used as the input to a predictive coder. They reported improvements, as a result of motion-compensated prefiltering. Furukawa et al, [2] demonstrated the feasibility of motion-adaptive interpolation for use in video conference pictures. Using computed motion vectors they were able to reproduce skipped frames.

The need for an accurate means of estimating the motion vectors for a moving object, from frame to frame is evident from the foregoing. Three major methods are recognised for estimating interframe motion vectors. The Fourier method, which is based on the fact that the Fourier transform of a displaced version of an original image will only exhibit a change in the phase term.

The correlation or matching technique estimates the motion vector from the point of highest correlation coefficient. It could also be based on the point where some cost function is minimum. There is also the method of differential, which assumes a continuous image function and expands the displaced version in a Taylors series about the motion vectors.

The various problems attending these techniques are well documented in the literature. Various ways of implementing the aforementioned techniques are dictated by the application areas.

We have derived equations which give estimates of motion vectors on a block basis. The derivation is a variation of the method of differential. Limb and Murphy, [4] were able to estimate motion vectors for a moving object over two frames by appropriately normalizing the frame difference signal by the element difference signal.

An improvement upon this work was published by Netravali and Robins, [5], who used a recursive algorithm which minimizes some function of the prediction error. Following similar reasoning to that of Limb and Murphy we have derived equations for estimating motion, which use projections onto the vertical and horizontal axis of frame, element and line difference signals.

MOTION AND ESTIMATION ALGORITHM

a. Description

Given two frames from a sequence of images. Let the first frame be modelled by the luminance (grey level) value at each pixel point thus, $I(x,y,t)$.x,y are the coordinates of the pixel point and t is the time at which the frame was acquired.

The next frame which is separated from the first by a time interval τ is given as

$$I(x,y,t+\tau)$$

If during the time interval τ, the pixels in the first frame have been displaced in the x and y direction by Δx and Δy respectively, we can write

$$I(x,y,t+\tau) = I(x + \Delta x,\ y + \Delta y,\ t) \tag{1}$$

we shall define the frame difference signal as

$$FD(x,y) = I(x,y,t) - I(x,y,t+\tau) \tag{2}$$

Using (1) in (2) we can write

$$FD(x,y) = I(x,y,t) - I(x+\Delta x,y+\Delta x,t) \tag{3}$$

If we assume that this function behaves well, a Taylor's series expansion about the displacements Δx and Δy gives

$$FD(x,y) = I(x,y,t) - I(x,y,t) - \Delta x \frac{\partial}{\partial x} I(x,y,t) - \Delta y \frac{\partial}{\partial y} I(x,y,t) - \varepsilon$$

ε represents the higher order terms of the expansion which may be neglected

$$FD(x,y) = -\Delta x \frac{\partial}{\partial x} I(x,y,t) - \Delta y \frac{\partial}{\partial y} I(x,y,t) \tag{4}$$

This is the well known differential method, and it is only valid over those pixels values in the moving area.

Furthermore we shall define

$$\frac{\partial}{\partial x} I(x,y,t)$$

as the element difference signal (ED), derived by differencing the intra frame pixel values in the x-direction.

Similarly

$$\frac{\partial}{\partial y} I(x,y,t)$$

will be called the line difference (LD) and derived by differencing the intra frame pixel values in the y direction. Hence we can write

$$FD(x,y) = -\Delta x \; ED - \Delta y \; LD$$

If we take projections of the frame difference signal, over the moving areas, along the x and y directions respectively (denoting as $\sum_x$ the projections onto x and as $\sum_y$ the projections onto y, we shall have

$$\sum_x FD(x,y) = -\Delta x \sum_x ED - \Delta y \sum_x LD \qquad (5)$$

and

$$\sum_y FD(x,y) = -\Delta x \sum_y ED - \Delta y \sum_y LD \qquad (6)$$

We can solve for Δx and Δy to obtain equations for the motion vector estimates. Thus,

$$\Delta x = \frac{\sum_x FD \sum_y LD - \sum_y FD \sum_x LD}{\sum_y ED \sum_x LD - \sum_x ED \sum_y LD}$$

and

$$\Delta y = \frac{\sum_y FD \sum_x ED - \sum_y ED \sum_x FD}{\sum_y ED \sum_x LD - \sum_x ED \sum_y LD}$$

b. Implementation

In implementing the algorithm, the whole picture frame (128x128) was segmented into moving and stationary areas. The equations of motion were applied to those areas that were deemed to have moved.

A simple segmentation strategy was used. For each window under consideration the mean value of the absolute frame difference was computed. If the mean value is above a set threshold and the percentage of pixel points with absolute frame difference greater than or equal to the mean value exceeds a set threshold, then the pixels within that window are deemed to have moved.

The effect of segmentation on this algorithm cannot be over emphasised. A choice of a scheme that brings in stationary points into the moving area will result in a breakdown of the motion equations.

The element and line difference signals were computed for the whole image.

ED(x,y)=(2*Image1(x,y)-Image1(x+1,y)-Image1(x-1,y))/2

LD(x,y)=(2*Image1(x,y)-Image1(x,y+1)-Image1(x,y-1))/2

These were summed in the x and y directions to produce the projections. For any two frames, we generate two sets of motion matrices, the Δx and Δy .

EXPERIMENTAL RESULTS

Identically distributed gaussian noise signals with mean 60 and variance 15 were added to a set of images of the 'moving man'. The pixel values were rescaled to within 0 and 255. A motion compensated temporal median filtering was performed on the set using our algorithm to estimate motion. The method described by Limb and Murphy was also used to estimate motion for motion-compensated temporal median filtering.

Figs. 1a, 1b and 1c show samples from the original image. Figs. 2a, 2b and 2c show samples from the noisy set of images. Figs. 3a and 3b show the result of temporal filtering using our algorithm. Figs. 4a and 4b show the result of temporal filtering using the algorithm described by Limb and Murphy. It could be seen from the frame reproduced that our algorithm preserves the edges more than the algorithm [4].

With our algorithm we also reconstructed an (n+1)th frame using the nth frame and motion estimates between nth and (n+1)th frames.

Our algorithm performs better than that described by [4], under the same conditions. Figures 5a and 5b show the result of reconstruction using our algorithm and algorithm of [4] respectively.

CONCLUSION

We have derived a motion estimation algorithm and demonstrated its feasibility. Edges were preserved in temporal median filtering. A near faithful reconstruction of a frame based on the previous frame and motion estimate between the two frames was achieved. Further experimentation is underway in improving the accuracy of the algorithm.

Fig. 1a

Fig. 1b

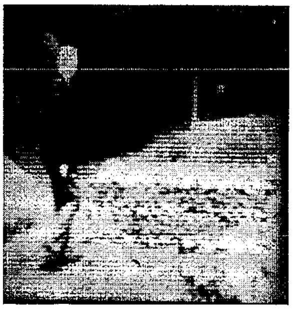

Fig. 1c

Figs. 1a, 1b, 1c
Samples from the
original image

Figs. 2a, 2b, 2c
Samples from noisy image

Fig. 2a

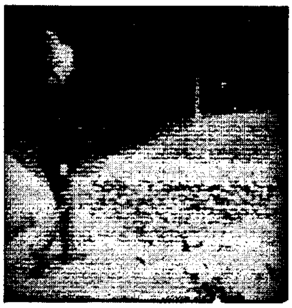

Fig. 2b

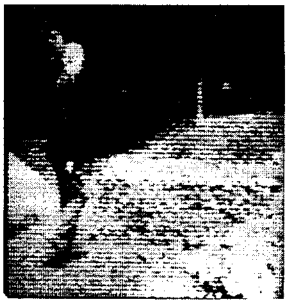

Fig. 2c

Fig. 3a

Fig. 3b

Figs. 3a and 3b
Filtered noisy image using our algorithm

Fig. 4a

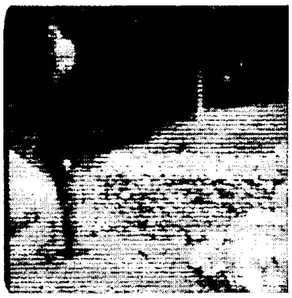

Fig. 4b

Figs. 4a and 4b : Filtered noisy image using algorithm of [4]

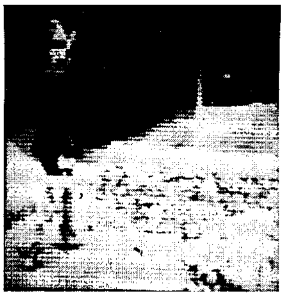

Fig. 5a

Fig. 5b

Fig. 5a : Reconstruction of Fig. 1b from Fig. 1a using our algorithm.

Fig. 5b : Reconstruction of Fig. 1b from Fig. 1a using algorithm of [4]

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