Dynamic Motion Detection Technique for Fast and Efficient Video Coding

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***Abstract*-Motion estimation and compensation is the most computationally complex module of video coder. In this paper, an innovative algorithm is proposed for a further complexity reduction of the motion estimation (ME) module of video coder by employing motion detection prior to motion compensation. A Dynamic Motion Detection (DMD) module can be added to the video coder in order to decide whether the current block contains motion or is with zero motion. This work propounds a DMD module which depends on motion activity. Generally, the variance of the difference of two consecutive frames is a good criterion to measure motion activity. We have applied the dynamic calculation of local variance of the difference frame as a threshold to detect the motion activity. The result shows that this proposed scheme can simplify the encoder complexity, maintaining high compression rate and good video quality. Moreover this method is valid for every kind of video sequences having a static and moving background.**

Keywords: Motion estimation, motion detection.

I. INTRODUCTION

The wide range of multimedia applications based on video compression (video telephony, video surveillance, digital television) leads to different kind of requirements for a video coding standard (image quality, compression efficiency). Several multimedia application areas require high power efficiency (especially in the video encoder part) in order to work on embedded systems and mobile terminals [1] [2]. This requirement implies the need to dramatically reduce the complexity of the video encoder. Algorithmic analysis shows that motion estimation is the most complex module in the video encoder. This is mainly due to the great number of calculation in motion estimation. Having this in mind, the present paper postulates dynamic motion detection for fast and efficient video coding [3]. Many algorithms are suggested in the literature to reduce the number of calculation intended for motion estimation based on spatial and temporal correlation of motion vector [4][5][6].

We suggest motion detection method to separate out an active region and an inactive region within a frame. A novel reduced complexity motion estimation technique is presented in this paper. It is based on segmenting the current frame in to blocks containing moving objects (an active region) and stationary background (an inactive region). The inactive region is assumed with zero motion vectors. And for the motion vector estimation of an active region standard motion estimation algorithm is applied. It has been experimentally proved that about 85% of the total blocks within frame corresponds to stationary background and that can be considered with zero motion vector. The early detection of blocks with zero motion vector leads to significant redundant computation being skipped and thus speed up the coding of video sequence. In this paper more precise threshold value is proposed to decide motion activity of a block. The threshold value is derived from the concept of frame variance and no assumption is adopted, ensuring that video quality is not degraded.

Section II describes the proposed approach of motion detection, section III presents motion estimation technique. Section IV brings about experimental results and concluding touch is presented in section V.

II. DYNAMIC MOTION DETECTION ALGORITHM

Motion detection is carried out prior to motion estimation to avoid the heavy computational overhead. This work recommends a simple method for motion detection based on frame variance. Calculate the variance of the frame difference as

$$v_{FD} = \frac{1}{MXN}\sum_{i=1}^{M}\sum_{j=1}^{N}(f_{FD}(i,j)-\overline{f}_{FD})^2 \qquad (1)$$

Where f_{FD} denote the intensity difference between the current and previous frame. $M \times N$ is the frame size and $\overline{f}_{FD}$ is the mean of the difference frame. v_{FD} is taken as a threshold value. An input frame is partitioned into blocks of p × q pixels, and then the local variance of $p \times q$ block is premeditated by,

$$v_{BD} = \frac{1}{pXq}\sum_{i=1}^{p}\sum_{j=1}^{q}(f_{FD}(i,j) - \overline{f}_{BD})^2 \qquad (2)$$

Where $\overline{f}_{BD}$ denotes the mean of the block difference of current and reference frame. There is comparisons made between v_{BD} and threshold v_{FD} to classify the block under consideration as a part of moving objects (active region) or as part of stationary back ground (inactive region). If $v_{BD} > v_{FD}$, the block is a part of moving objects and if $v_{BD} < v_{FD}$, the block is a part of stationary background and is considered with zero motion vector. The motion activity is not constant over the entire frame of an image sequence thus the block variance (threshold), is not taken as a constant value but it is locally calculated.

Fig. 1 (a) and (b) shows the two successive frames of News sequence and Fig (d) and (e) shows two successive frames of Claire sequence. Fig. 1 (c) and (f) depicts the motion detected region obtained by the motion detection algorithm. It is apparent that, approximately only 15% of the frame area is detected as an active region. Remaining 85% frame area is found as an inactive region. The inactive region is consider with zero motion vectors. Thus we can save intense computations involved in finding motion vectors. Only active region will be consider for motion estimation

III. Motion Estimation

The proposed motion detection module is utilized to find the active region of motion. Motion detection decides whether to subject the block for the motion vector estimation or block is consider with zero motion vector. The complexity of the video coder is strongly influenced by the number of calculations required to find motion vector. Consequently by reducing the number of blocks for motion estimation can save a measurable time in the encoder process with minor effects on the quality of the produced video sequence.

Block matching algorithms are the most popular motion estimation methods, which are adopted by various video coding standards such as MPEG-1 and MPEG-2 due to their less computational complexity [7] [8]. In block matching algorithms, the current frame is divided into N x N pixels termed as macro block. Each macro block is predicted from the previous or future frame, by estimating the amount of motion of the macro block called as motion vector during the frame time interval. The video coding syntax specifies how to represent the motion information for each macro block. It does not, however, specify how such vectors are to be computed. The motion vector is obtained by finding a Block Distortion Measure (BDM) function, measuring the mismatch between the reference and the current block [9]. To find the best matching macro-block producing the minimum mismatch error, we need to calculate distortion function at several locations in the search range.

One of the first algorithms to be used for block based motion estimation is full search algorithm (FSA) or exhaustive search algorithm (ESA), which evaluates the block distortion measure (BDM) function at every possible pixel locations in the search area [9]. Although this algorithm is the best in terms of quality of the predicted frame and simplicity, it is computationally intensive. In the past two decades, several fast search methods for motion estimation have been introduced to reduce the computational complexity of block matching, for examples, two dimensional logarithmic search (LOGS) [6], three-step search (3SS) [10], four step search (4SS)[11]. *Among these algorithms, 3SS becomes most popular one for low bit rate application owing to its simplicity and effectiveness*

The three-step search algorithm (3SS) is proposed by Koga. [12] in 1981. This algorithm is based on a coarse-to-fine approach with logarithmic decreasing in step size as shown in Fig. 2. The initial step size is half of the maximum motion displacement *d*. For each step, nine checking points are matched and the minimum BDM point of that step is chosen as the starting center of the next step. The three step search algorithm (3SS) tests eight points around the center [12]. For a center [*cx,cy*] and step size *d* ,all the eight positions [*cx-d*, *cy-d*], [*cx-d*, *cy*], [*cx-d*, *cy+d*], [*cx*, *cy-d*], [*cx*, *cy*], [*cx*, *cy+d*], [*cx+d*, *cy-d*], [*cx+d*, *cy*], [cx+*d*, *cy+d*] are examined. After each stage the step size is halved and minimum distortion of that stage is chosen as the starting center of the next stage. The procedure continues till the step size becomes one. The number of checking points required equals to $[1+\lceil \log (d+1) \rceil]$. The proposed paper suggests three step search algorithm for motion vector estimation of active region.

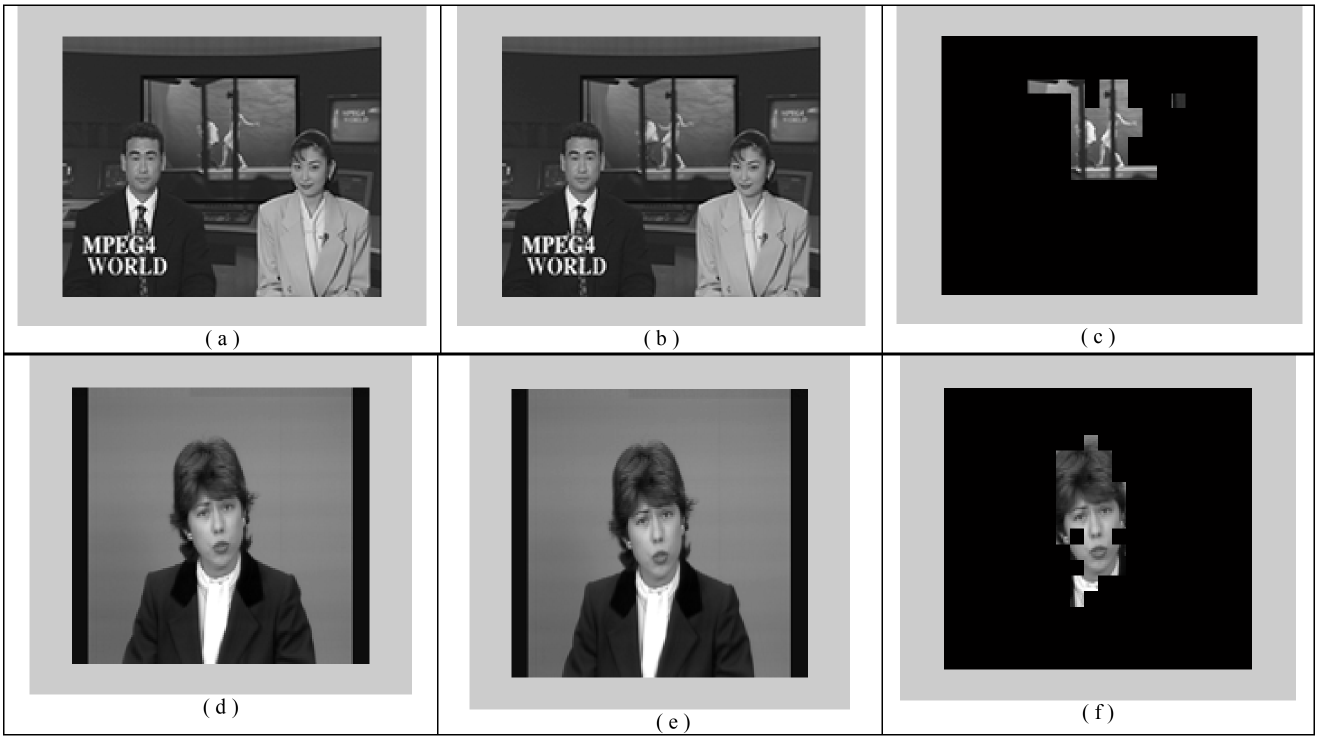

Figure 1. Performance of motion detection method: For News sequence (a) 65th Frame (b) 66th Frame (c) active region and for Claire sequence (d) 60th Frame (e) 61st Frame (f) active region

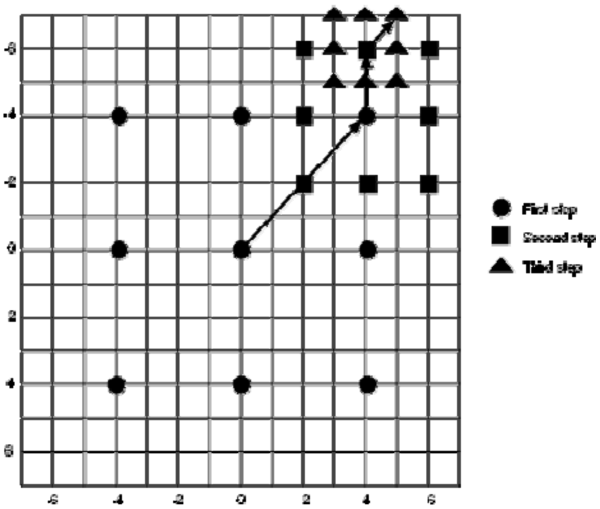

Figure 2. Search pattern used in the first step of 3SS

IV. RESULTS

The test sequences used in the experimental results are the four standard QCIF (176 X 144) videos (100 frames) of Foreman, Claire, Carphone and Silent defining different motion content We had selected block size as 8 x 8 as a tradeoff between computational complexity and the quality of the image. Out of total 396 blocks, Table I list the average number of inactive blocks detected by the dynamic motion detection module. It is not essential to execute motion estimation and compensation for all these blocks. These blocks are considered with zero motion vectors. As a result, numerous unnecessary calculations required for motion estimation of these blocks are saved. To find the motion vectors of the blocks in the active region the paper tested the result of the proposed method by adopting standard three step search algorithm with block size as 4 x 4. To evaluate the performance of standard algorithms and proposed method three metrics are used as mean square error, signal to noise ratio and number of search points per block needed for motion vector calculation.

Proposed dynamic motion detection technique along with 3SS is compared with the standard algorithms like FSA, 3SS. Table II indicates that the performance of the proposed method degrades for the sequence of high motion content like Foreman. Where as the proposed technique shows good performance for the sequence of moderate to slow motion sequences like Claire, Carphone and Silent. Average signal to noise ratio is used as a measure of quantitative analysis of the suggested method which is depicted in Table III. It is seen that quality of the presented technique is close to the standard methods as FSA and 3SS.

TABLE I

AVERAGE NUMBER OF INACTIVE BLOCKS FOR DIFFERENT VIDEO SEQUENCES DETECTED BY DMD TECHNIQUE.

Foreman	Claire	Carphone	Silent
290.350	348.930	306.9400	359.8500

TABLE II

AVERAGE MSE FOR DIFFERENT ALGORITHMS AND DIFFERENT VIDEO SEQUENCES.

BMA	Foreman	Claire	Carphone	Silent
FSA	26.36	3.60	20.6	12.54
3SS	34.13	3.67	24.52	14.87
DMD+3SS	42.45	3.21	22.74	13.20

TABLE III

AVERAGE SNR FOR DIFFERENT ALGORITHMS AND DIFFERENT VIDEO SEQUENCES

BMA	Foreman	Claire	Carphone	Silent
FSA	34.2	43.25	35.2	37.861
3SS	33.2	43.20	34.6	37.18
DMD+3SS	32.83	43.3	35.03	37.81

TABLE IV

AVERAGE SEARCH POINTS FOR DIFFERENT ALGORITHMS AND DIFFERENT SEQUENCES

BMA	Foreman	Claire	Carphone	Silent
FSA	205.8	205.8	205.8	205.8
3SS	25	25	25	25
DMD+3SS	27	12.77	24.00	9.84

The computational complexity of the different techniques is shown in Table IV. We can observe the measurable difference in number of search points required by the DMD technique as compared to the standard techniques. The result shows that our proposed scheme can simplify the encoder complexity, maintaining high compression rate and good video quality. The present algorithm is strongly influenced by the detection of threshold value, it is because the estimation of detected movements depends on threshold value (using high value all of the motions cannot be detected, otherwise low value can cause the detection of background noise as relevant motion). In the projected method, threshold value as block variance is calculated dynamically and it is not taken as a constant value.

V. CONCLUSION

Thus to conclude, this paper propounds the dynamic motion detection algorithm which is presented and tested on a set of sequences. DMD is an innovative algorithm for motion estimation complexity reduction based on active motion detection. A classifier based on the frame variance has been employed to detect active and inactive blocks. Additionally the threshold value in the algorithm is calculated automatically which avoids user interaction. It has been experimentally proved that the majorities of the blocks within a frame are inactive and can be taken with zero motion vectors. As a result we saved measurable computational time required for motion vector estimation for these blocks.

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