RESEARCH ARTICLE OPEN ACCESS

Optimization of Macro Block Size for Adaptive Rood Pattern Search Block Matching Method in Motion Estimation

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ABSTRACT
In area of video compression, Motion Estimation is one of the most important modules and play an important role to design and implementation of any the video encoder. It consumes more than 85% of video encoding time due to searching of a candidate block in the search window of the reference frame. Various block matching methods have been developed to minimize the search time. In this context, Adaptive Rood Pattern Search is one of the less expensive block matching methods, which is widely acceptable for better Motion Estimation in video data processing. In this paper we have proposed to optimize the macro block size used in adaptive rood pattern search method for improvement in motion estimation.
Keywords: Video Compression, Motion Estimation, Adaptive Rood Pattern Search, Macro Block.

I. VIDEO COMPRESSION

Video compression techniques are about reducing and removing redundant video data so that a digital video file can be effectively sent over a network and stored on computer disks. With efficient compression techniques, a significant reduction in file size can be achieved with little or no adverse effect on the visual quality. The video quality, however, can be affected if the file size is further lowered by raising the compression level for a given compression technique.

Today, various compression technologies are available for removing the temporal redundancy. Most network video vendors today use standard compression techniques. Standards are important in ensuring compatibility and interoperability. They are particularly relevant to video compression since video may be used for different purposes and, in some video surveillance applications, needs to be viewable many years from the recording date. By deploying standards, end users are able to pick and choose from different vendors, rather than be tied to one supplier when designing a video surveillance system.

II. Motion Estimation Techniques

In video editing motion estimation is a type of video compression scheme. The motion estimation process is done by the coder to find the motion vector pointing to the best prediction macroblock in a reference frame or field. For compression redundancy between adjacent frames can be exploited where a frame is selected as a reference and subsequent frames are predicted from the reference using motion estimation. The motion estimation process analyzes previous or future frames to identify blocks that have not changed, and motion vectors are stored in place of blocks. The process of video compression using motion estimation is also known as interframe coding.

Motion estimation techniques have been successfully applied in motion compensated predictive coding for reducing temporal redundancies. They belong to the class of nonlinear predictive coding techniques. An efficient representation of motion is critical in order to reach high performance in video coding. Motion estimation techniques should on one hand provide good prediction, but on the other hand should have low computational load. In block based motion estimation image is partitioned into blocks and the same displacement vector is assigned to all pixels within a block. The motion model assumes that an image is usually composed of rigid objects in translational motion.

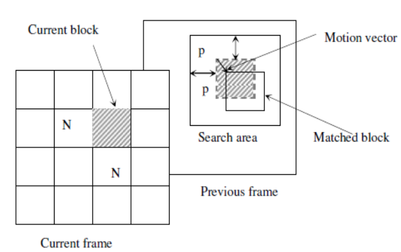

Figure 1: The concept of motion estimation

Although the assumption of translational motion is often considered to be a major drawback in the presence of zoom but the block matching technique is able to estimate closely the true zooming motion. And hence the block matching motion estimation results globally in motion fields more representative of true motion in the scene. The concept of block matching motion estimation is depicted in Figure 1.

III. BLOCK BASE MOTION ESTIMATION

The block base matching is a temporal compression technique used in the video encoding. The main purpose of this method is to determine the displacements of each block of pixels between two successive frames. This technique, performed in the step of motion estimation, occupies the majority of the total time of video coding.

The motion of a block of MxN pixels centered at point (x, y) within a frame interval is estimated as shown in Figure 2. The goal is to find the best match or the least distortion block between the MxN blocks in the frame k (current frame) and a corresponding block in the frame (k-1) (previous frame) within a search area of size $(M+2m_2)\mathrm{x}(N+2n_1)$ within the previous frame, in a given search window. The range of the motion vector is constrained by the search window. Block matching methods (BMAs) ignore rotational motion and assume that all pixels within the MxN block have the same uniform motion. Adaptive Rood Pattern Search is widely acceptable block matching method that blocks search faster inside the search window to find the motion vector for the best match block of the current frame from the candidate blocks inside the search window in the previous frame. The candidate that gives the best match is chosen as the estimated motion vector.

Matching Criteria

In order to measure the similarity between current frame block and a candidate block of the reference frame, various criteria can be used as a measure for the block matching between the two blocks, such as minimum MSE (mean square error), minimum MAD (mean absolute difference) or minimum SAD (sum of absolute differences). Among these SAD is often chosen because it achieves the same performance as the others, without requiring any multiplication in the calculation. The distortion measure between the block in the present frame and the displaced block in the previous frame can be defined as follows:

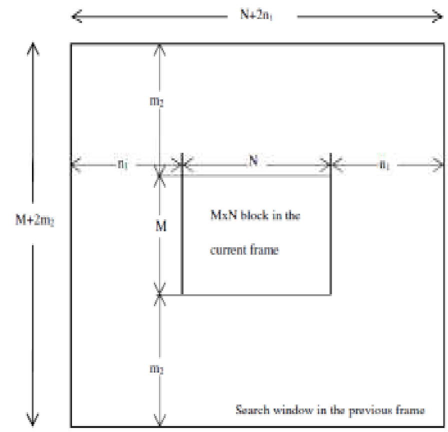

Figure 2: Block base Motion Estimation

Mean Square Error

Mean square error (MSE) can be defined as follows:

$$MSE(i,j) = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}\left(X_{m,n} - X_{m+i,n+j}^{R}\right)^2$$
$$|i| \le m_2, |j| \le n_1 \quad ..... \ (1)$$

$X_{m,n}$ is the pel intensity at row m and column n in the present frame and $X_{m+i,n+j}^{R}$ refers to row $m+i$ and column $n+j$ in the reference frame. The minimum MSE criterion is rarely used in very large scale implement (VLSI) implementation because it is difficult to realize the square operation in hardware.

Mean Absolute Difference

Mean absolute difference (MAD) is defined as follows:

$$MAD(i,j) = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}\left|X_{m,n} - X_{m+i,n+j}^{R}\right|$$
$$|i| \le m_2, |j| \le n_1 \quad ...... \ (2)$$

It is well known that the performance of the MAD criterion decreases, as the search area becomes large due to the presence of local minimum, still MAD is widely used for VLSI implementations.

Sum of Absolute Difference

Sum of absolute difference (SAD) is defined as:

$$SAD(i,j) = \sum_{m=1}^{M}\sum_{n=1}^{N}\left|X_{m,n} - X_{m+i,n+j}^{R}\right|$$
$$|i| \le m_2, |j| \le n_1 \quad .... \quad (3)$$

This is often used because of its simplicity.

Matching Performance Measuring Parameters

Mean square error (MSE) and peak signal to noise ratio (PSNR) are used to evaluate the subjective quality of a reconstructed video sequence.

PSNR is defined as follows:

PSNR=10log10 (2552/MSE) …. (4)

IV. ADAPTIVE ROOD PATTERN SEARCH (ARPS)

Adaptive rood pattern search is one of the widely used block matching method because it is less computational complexity on acceptable level of PSNR. This method makes use of the fact that the general motion in a frame is usually coherent, i.e. if the macro blocks around the current macro block moved in a particular direction then there is a high probability that the current macro block will also have a similar motion vector. This method uses the motion vector of the macro block to its immediate left to predict its own motion vector. The predicted motion vector points to (3, -2). In addition to checking the location pointed by the predicted motion vector, it also checks at a rood pattern distributed points, as shown in Fig 3, where they are at a step size of S = Max (|X|, |Y|). X and Y are the x-coordinate and y-coordinate of the predicted motion vector. This rood pattern search is always the first step. It directly puts the search in an area where there is a high probability of finding a good matching block. The point that has the least weight becomes the origin for subsequent search steps, and the search pattern is changed to small diamond search pattern. The method keeps on doing SDSP until least weighted point is found to be at the center of the small diamond search pattern. A further small improvement in the method can be to check for Zero Motion Prejudgment, using which the search is stopped half way if the least weighted point is already at the center of the rood pattern.

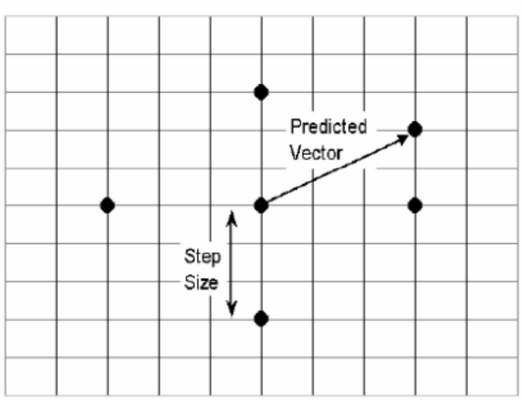

Figure 3: Adaptive Root Pattern: The predicted motion vector is (3,-2), and the step size S = Max (|3|, |-2|) = 3.

The precaution has to be taken not only to repeat the computation at point that were checked but also needs to care has to be taken to not repeat the computations at points that were earlier but also needs to be taken when the predicted motion vector turns to match one of the rood pattern location. We have to avoid double computation at that point. For macro blocks in the first column of the frame, rood pattern step size is fixed at 2 pixels.

The aim of this work is to optimize the macro block size for adaptive rood pattern search after calculation of PSNR and computations involve in this method for macro block size 4x4, 8x8 and 16x16 Block Matching. This work does not focus only on the complexity and computation time of method, but it also gives objective and subjective quality assessment of decoded video frame by means of each search method.

Fixed Size of Macro Block

In the fixed-size Block Matching method, the size of block is predefined. The motion estimation process is only to find a block with the minimum matching error from the reference frame(s). Often the sizes of block are set as 16x16, 8x8, or 4x4. As for a large size block, such as 16x16, there may be different motions in the same block, which will increases the prediction error. However, the block size reduce go to improve prediction error. The technique was easy to implement, and thus widely adopted. Each image frame is divided into a fixed number of usually square blocks. For each block in the frame, a search is made in the reference frame over an area of the image that allows for the maximum translation that the coder can use. The search is for the best matching block, to give the least prediction error, usually minimizing either mean square difference, or mean absolute difference which is easier to compute. Typical block sizes are of the order of 16xl6 pixels, and the maximum displacement might be +-64 pixels from a block's original position. Several search strategies are possible, usually using some kind of sampling mechanism.

A good match during the search means that a good prediction can be made, but the improvement in prediction must outweigh the cost of transmitting the motion vector. A good match requires that the whole block has undergone the same translation, and the block should not overlap objects in the image that have different degrees of motion, including the background. The choice of block-size to use for motion compensation is always a compromise, smaller and more numerous blocks can better represent complex motion than fewer large ones. This reduces the work and transmission costs of subsequent correction stages but with greater cost for the motion information itself. The choice of block-size can be affected not only by motion vector accuracy but also by other scene characteristics such as texture and inter-frame noise.

V. SIMULATION AND DISCUSSION

In this paper, ARPS method for motion estimation using block matching is implemented in MATLAB 2013b for Garden video sequences having SIF (352x240) format with distance of 2 between current frame and reference frame is used to generate the frames by frame and compared with well known parameters like peak signal to noise ratio (PSNR) and computations for various macro size block. ,. There are total 20 (data set) frames having macro block size 16x16 8x8 and 4x4 with fix search parameter (p=7) are taken for testing and experimentation purpose. The average value of PSNR and computations for different size of block are given in Table 1.

Table 1: Comparison of computations and PSNR for different macro block size

Macro Block	PSNR	Computations
4	30.445045	10.46164
8	29.35503	10.288825
16	27.885405	10.005435

The optimization of average value of PSNR and its average value of computations about adaptive rood pattern search (ARPS) method for macro block 4x4, 8x8 and 16x16 are graphically represented in figure 4 and 5. That clearly shows that the average computations for various sizes of macro block are nearly close to their average value while the average value of PSNR for macro block size 4x4 is better as compared to other macro block size of 8x8 and 16x16.

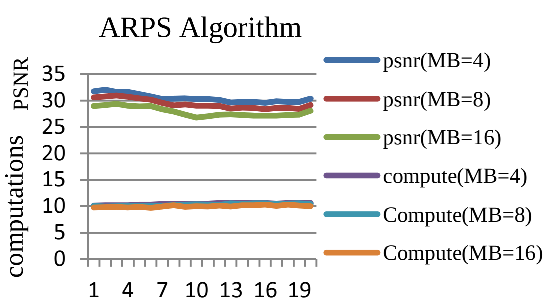

Figure 4: Frame by frame testing using various macro block size

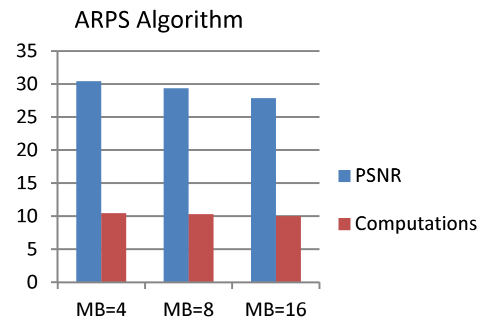

Figure 5: Avg value of PSNR and computations for different size of macro block

VI. CONCLUSION

As per analysis of above facts and result , we are in position to say that the ARPS method for macro block size 4x4 has optimum values, performing better result in terms of PSNR with slight compromisation of computations. Hence, this method can be recommended for better motion estimation for 4x4 macro block size.

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