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Categories for Fast Block Matching Algorithm

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Abstract: ***Motion Estimation plays a vital role in a motion compensated hybrid DCT video compression scheme. To reduce the computational complexity in finding the near to exact match of the block, many fast search algorithms have been proposed. This paper is survey paper in which fast block matching algorithm are categorized. Unsymmetrical multi hexagon search, Adaptive rood pattern search, Fast full search are described.***

Index term: Block matching, Hexagonal search, Adaptive rood pattern, Validity Metrics

I. INTRODUCTION

A. Block Matching Motion Estimation

Block matching algorithm (BMA)[11] is the most used technique for motion estimation in which the current luminance frame is divided into non-overlapped blocks of size N×N that are then compared with corresponding block and its adjacent blocks in the reference frame to create a vector that stipulates the movement of a block from one location to another in the reference frame , i.e finding matching block of the same size N×N in the search area in the reference frame . The position of the matching block gives the motion vector (MV) of the current block, as shown in Figure 1. This motion vector has two parts a vertical and a horizontal. These parts can be positive or negative. A positive value means motion to the downward or right and a negative value means motion to the left or motion upward. These motion vectors will be used to predict new frame from the reference which is called motion compensation, as shown in Figure 2. The matching criteria or measure [2] is usually one of Block Distortion Measure (BDM) like mean absolute difference (MAD) or sum of absolute differences (SAD) or mean square error (MSE). The block with the least distortion cost is considered the matching one to the current block.

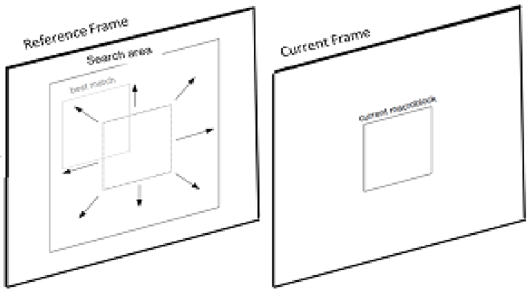

Figure 1. Block Motion Estimation in the search area

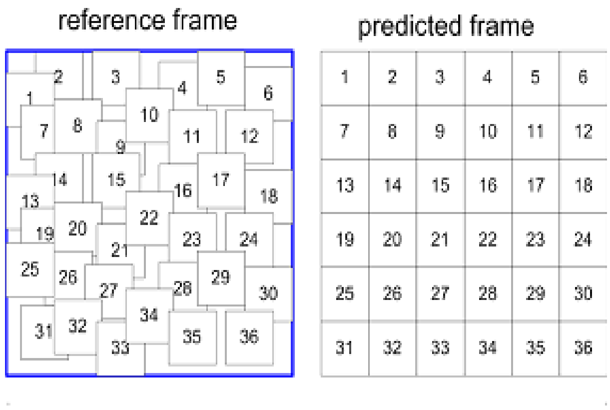

Figure 2. Motion Compensation, [16].

II. CATEGORIES OF FAST MOTION ESTIMATION ALGORITHMS

Fast Block-matching algorithm can be classified [3] as below:

Category I: Search Pattern

In this Various Geometrical Search pattern are used. In this category search techniques are used in which a subset of the possible search candidate locations are selected. 2-D Logarithmic Search (2D-LOG) , Three Step Search (TSS) , four step search 4SS , New Three Step Search (NTSS) , Diamond Search (DS) , cross-diamond search, Hexagonal search algorithm are the few.

Unsymmetrical Multi Hexagon Search

Unsymmetrical Multi Hexagon Search (UMHexagonS) [10] algorithm can save up to 90% of the computing complexity compared to Full Search. It uses multi-level, different shapes of search pattern, which can prevent from falling in local optimization. UM HexagonS algorithm also uses sum of absolute difference as its matching criterion, and early termination mechanism. In most cases, the best matching point is very close to the initial prediction point, which means that in many cases, the motion estimation search is superfluous.

There are mainly four steps for unsymmetrical multi hexagonal search, I. Starting search point prediction, II. Asymmetric cross search, III. Uneven multi-level hexagon search and IV. Extended hexagon search. Optimization of Unsymmetrical Multi Hexagon Search can be done by following ways .1. Optimization on Early termination and 2. Adoption of Movement Intensity.

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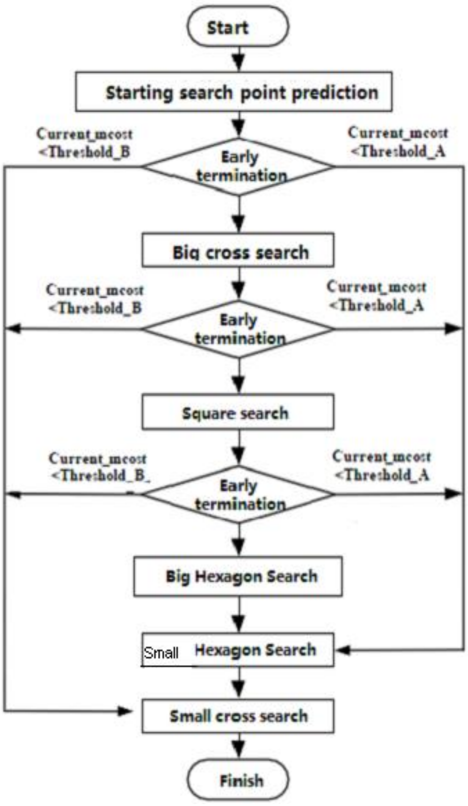

Figure 3: Flow chart of UM HexagonS

Category II: Predictive search

The predicted motion vector can be obtained by selecting one of the neighboring motion vectors according to certain criteria or by calculating the statistical mean of the neighboring motion vectors. This predictive motion estimation [4] can effectively reduce the stipulated search area as well as the computation.

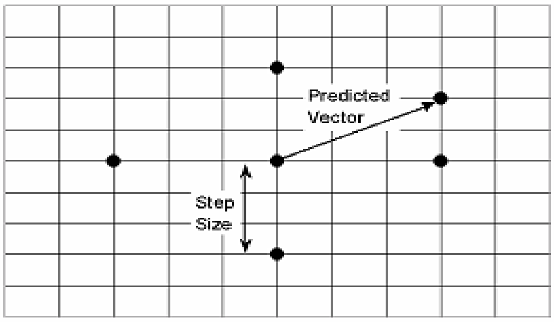

Figure 4: Adaptive Root Pattern

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

This example uses the motion vector of the block to its immediate left to predict its own motion vector. This rood pattern search is always the first step. It directly puts the search in an area where there is a high possibility of finding a good matching block. The point that has the least distortion cost becomes the origin for subsequent search steps, and the search pattern is then changed to small diamond search pattern.

Category III: Bit width Reduction

This search technique[3] reduces the bit resolution from 8 to one or two in order to reduce the hardware cost , power consumption, and then applying conventional motion estimation search strategies.

Category IV: Sub-sampled Pixels on Matching-error Computation

This technique [3] is based on reducing the number of pixels that can be been used to compute the distortion error between the current block and candidate block. For example the sub-sampled method may use only a fraction of pixels within a block by performing 2 : 1 pixel sub-sampling in both horizontal and vertical directions. So the result of the total computation can be reduced by a factor of 4.

Category V: Hierarchical Search

Hierarchical Block Matching (HBM)[6] allows to combine the advantages of small and large blocks, and the search range can be reduced as the algorithm progresses. The idea behind HBM is to create a pyramid for the pair of images whose motion to estimate. The resolution of the images in the pyramid increases as the bottom level is reached. At the bottom level, the pyramid may contain the original image. The number of levels in the hierarchy will depend on the size of the original images as well as the desired sub-pixel accuracy for the motion vectors.

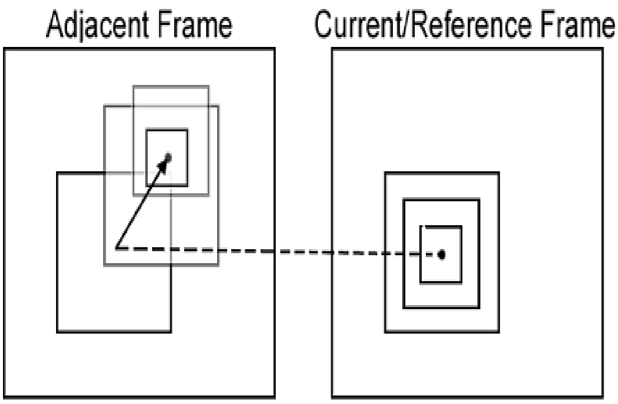

Figure 5. Hierarchical block matching progression.

Category VI: Fast Full Search

Fast full search[8] techniques first make a simple check to detect whether a candidate block is possible to be the matching one. Then, only the potential candidate blocks are further processed for detailed distortion calculation.

A fast block-matching algorithm [5] that uses three fast matching error measures, An incoming reference block in the current frame is compared to candidate blocks within the search window using multiple matching criteria. These three fast matching error measures are established on the integral projections, They have the advantages of being good block features and having simple complexity in measuring matching errors. Most of the candidate blocks can be avoided only by calculating one or more of the three fast matching error measures. The time-consuming computations of mean square error are performed on only a few candidate blocks that pass all three fast matching criteria. The three fast matching error measures are defined as follows:

$$M_p(i,j) = |m_{t,(l,k)} - m_{t-1,(l+i,k+j)}|^p, \quad -W \le i,j \le W$$

$$V_p(i,j) = \sum_{y=0}^{N-1} |v_{t,(l,k)}(y) - v_{t-1,(l+i,k+j)}(y)|^p, \quad -W \le i,j \le W$$

$$H_p(i,j) = \sum_{x=0}^{N-1} |h_{t,(l,k)}(x) - h_{t-1,(l+i,k+j)}(x)|^p, \quad -W \le i,j \le W.$$

III. FAST COMPUTATIONS OF FULL SEARCH

The technique[3] could be classified as fast full search type, but differs from the other as it keeps the resolution exactly the same of FS technique. This technique reduces the processing time by stopping the computation if the sum absolute different value between the current block and each blocks in the search area exceeds the previous sum absolute different value.

Step 1: Compute the sum of absolute differences (SADcentre) between the current block and the block at the same location in the reference . let SADmin=SADcentre.

Step 2 : Compute the sum of the absolute differences between the pixels of next candidate block and the current block, if the summation exceeds the SADmin then stop computing the SAD for the rest of the pixels and go to step 3. Otherwise continue the process of computing SAD for the rest of the pixels until the pixels of the blocks are finished and go to step 4.

Step 3: Move to the next block in the search area and go to step 2.

Step 4: Assign the new SAD from step 2 to the SADmin and move to the next candidate MP then go to step 2.

Step 5: The last SADmin will give the matching macro block .

Validiy Metrics for BME

An overview of existing validity metrics [6] for block-based motion estimation algorithms is given below.

1) Smoothness-Based Validity

Wang et al. introduced smoothness-based validity. A confidence value was assigned to each MV based on the block correlation and MV smooth-ness.

$$R(\mathbf{v}) \approx \frac{Corr(\mathbf{x}, \mathbf{x}+\mathbf{v}) + Smooth(\mathbf{v})}{\sum_{k \in V^4} [Corr(\mathbf{x}, \mathbf{x}+\mathbf{v}_k) + Smooth(\mathbf{v}_k)]},$$

where v is the current motion vector, and x is the position in a block B of pixels. Liu and Shen introduced similar smoothness-based validity metric. Thresholds were applied to classify a motion vector as valid or invalid to both the normalized SAD and smoothness .

2) Gradient/Variance-Based Validity

$$R_x(\mathbf{v}) = \frac{1}{1 + \frac{1 + Corr(\mathbf{x}, \mathbf{x}+\mathbf{v})}{2\,Text_x(\mathbf{x})}}.$$

Patti et al. introduced a variance-based validity metric. An adaptive threshold-based metric was used that assumes regions of low local variance should have a low SAD threshold value, whereas regions of high local variance should have a high SAD threshold value.

IV. CONCLUSION

This paper describes the various categories in which FAST motion estimation algorithm can be categorized. The UMHS Adaptive rood pattern, Hierarchical block matching algorithm are explained followed by FCFS and validity metrics for block-based motion estimation algorithms.

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