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Fast Block Based Motion Estimation using Various Search Patterns

P. A. Bhalge, S. Y. Amdani

Abstract— ***Accurate motion estimation is a key factor for achieving enhanced compression ratio. It is the process of determining an offset to a suitable reference area in previously coded frame and has a significant effect on performance of coders and decoders (CODEC).This paper is survey paper for block based motion estimation. This paper describes the classical Full search motion estimation algorithm, diamond search, hexagonal search and octagon with square pattern search algorithm for motion estimation.***

Index Terms— ***Block matching, Diamond Search, Hexagonal Search, Motion Estimation, Video Coding.***

I. INTRODUCTION

Image compression techniques are based on two principles: the reduction of the statistical redundancies in the data and the considerations of the human visual system imperfections. What characterizes video compression and makes this domain of study substantially different from that of still image compression is the fact that it addresses the problem of compressing a sequence of images.

The main idea behind block matching estimation is the partitioning of the target (predicted) frame into square blocks of pixels and finding the best match for these blocks in a current (anchor) frame. To find the best match, a search inside a previously coded frame is performed and the matching criterion is utilized on the candidate matching blocks. The displacement between the block in the predictor frame and the best match in the anchor frame defines a motion vector. On the one hand, motion estimation algorithms should provide suitable prediction information, and while on the other hand, they should have low overhead information[13][14]. In section II The Block Matching Algorithms(BMA) described are Full Search Motion Estimation[1], A New diamond Search [4], Cross Diamond Search Algorithm[5], Novel Cross Diamond Hexagonal Search[6],Enhanced DS using Four Corner based Inner search[7] Adaptive Square Diamond Search[8] and Three Step Diamond Search[9] ,New Unsymmetrical multi hexagon search[10],Octagonal and square search .

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II. MOTION ESTIMATION ALGORITHMS

1) Full Search Algorithm For Motion Estimation

It is not feasible to evaluate the cost function for every possible set of prediction parameters for any block of pixels. A subset of positions must be selected for this evaluation. The most common approach in VLSI implementations is the well known full search block-matching algorithm [1], where a rectangular window is defined in the reference frame, and block-matching is performed at every position within that window (Figure 1). This algorithm is used frequently because it is conceptually intuitive, and provides accurate motion estimation results. The search window is typically centered on the co-located position in the reference frame of the original block, and is defined by its dimensions. In most applications, search ranges from 8 to 64 pixels in each dimension are used [12].

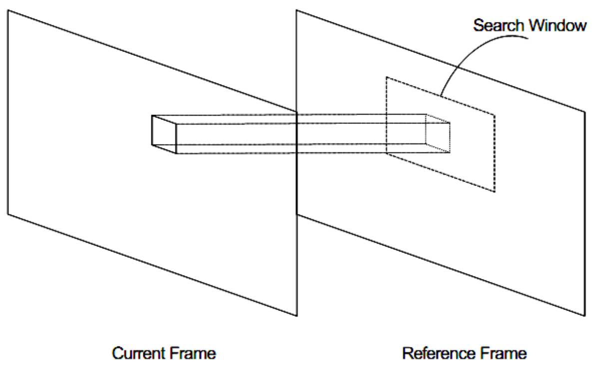

Figure 1: Full search block-matching search window

Matching functions

Given an n X n block, a matching criteria, M(p, q), measures the dissimilarity of a block in the current frame, Ic, and a block in the reference frame, Ir, shifted by (p, q).

SAD : The sum of the absolute values of the differences in the two blocks:

$$M(p,q)=\sum_{i=1}^{n}\sum_{j=1}^{n} abs((I_c(i,j)-I_r(i+p,j+q)))$$

MAD: The mean of the absolute values of the differences in the two blocks:

$$M(p,q)=\frac{1}{n*n}\sum_{i=1}^{n}\sum_{j=1}^{n} abs((I_c(i,j)-I_r(i+ p, j+q)))$$

MSD: The mean of square of differences in the two blocks.

$$M(p,q)=\frac{1}{n*n}\sum_{i=1}^{n}\sum_{j=1}^{n}(I_c(i,j)-I_r(i+p,j+q))^2$$

Some variations of Diamond search algorithms are summarized below

2a) Diamond Search (DS)

The Diamond Search algorithm uses two search patterns. The first pattern, called large diamond search pattern ,it consists of nine checking points from which eight points surround the center one to compose a diamond shape ,and small diamond shape pattern is formed by five checking points ,

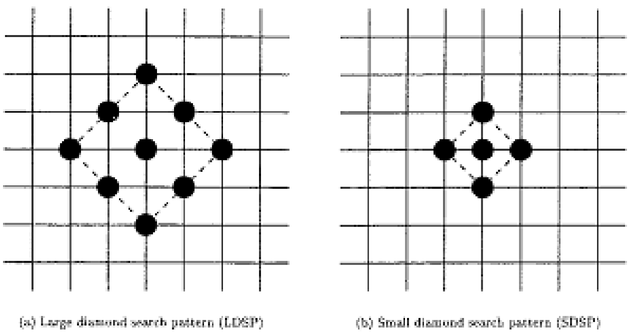

Figure 2: Search patterns used in Diamond search

The Diamond Search [4] algorithm is summarized as follows.

Step I. The initial Large diamond search pattern is centered at the origin of the search window, and the 9 checking points of search pattern are tested. If the Minimum Block Distortion point calculated is found located at the center position, perform Step III; else, go to Step II.

Step II. The Minimum Block Distortion point found in the previous search step is repositioned as the center point to form a new Large Diamond Search Pattern. If the new Minimum Block Distortion point obtained is located at the center position, perform Step III**.** otherwise, recursively repeat step II.

Step III. Switch the search pattern from Large Diamond Search Pattern to Small Diamond Search Pattern. The Minimum Block Distortion point found in this step is the final solution of the displacement vector which points to the best matching block.

b) New Cross Diamond Search

The algorithm[5] is as below.

Step I :(Starting - Small Cross Shape Pattern SCSP): A minimum Block Distortion Measure is found from the 5 search points of the Small Cross Search Pattern located at the center of search window. If the minimum Block Distortion Measure point occurs at the center of the Small Cross Search Pattern ,the search stops (First Step Stop); else perform step II

Step II :(Small Cross Search Pattern): With the minimum Block Distortion Measure point in the first Small Cross Search Pattern as the center, a new Small Cross Search Pattern is formed. If the minimum Block Distortion Measure point occurs at the center of this Small Cross Search Pattern, the step2, stops else perform Step III.

Step III : The three unchecked outermost search points of the central – Large Cross Search Pattern are checked.

Step IV: A new Large Diamond Search Pattern is formed by repositioning the minimum Block Distortion Measure found in previous step as the center of the Large Diamond Search Pattern. If the new minimum Block distortion Measure point is at the center of the newly formed Large Diamond Search Point, perform Step 5 else step 4 is repeated.

Step V: With the minimum Block Distortion Measure point in the previous step as the center, a Small Diamond-Shaped Pattern is formed. Find the new minimum Block Distortion Measure point from the search, which is the final solution for the motion vector.

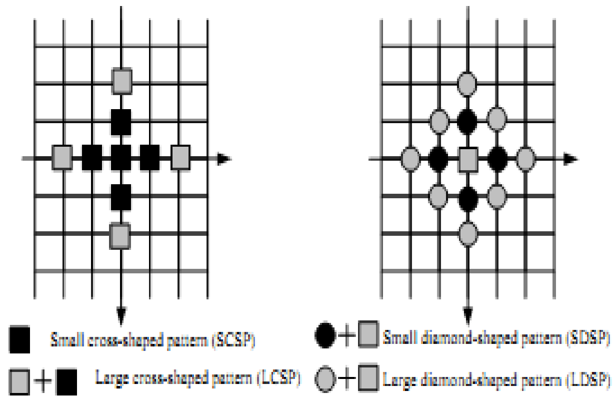

Figure 3: Cross search pattern used in Diamond search.

c) Cross-Diamond-Hexagonal Search(CDHS):

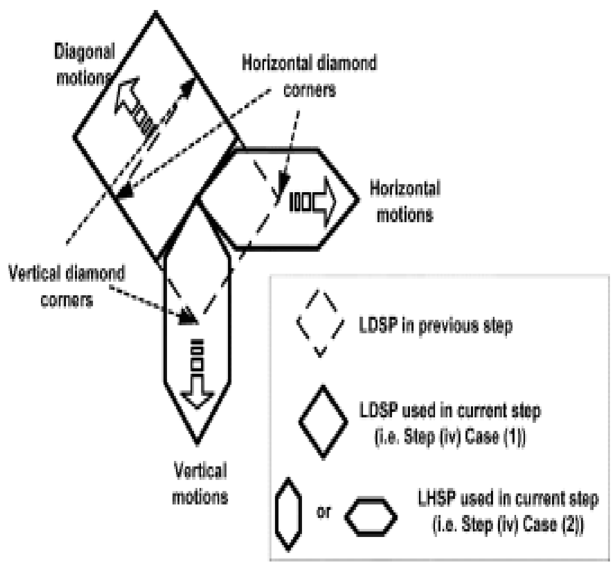

Figure 4: Search patterns switched for different directions

Cross-Diamond-Hexagonal Search [6] algorithms differ from Diamond Search and Hexagonal based search , and Cross diamond search by performing a highly cross-center-biased search with Small Cross Search Pattern in the first step. In addition, the search may involve up to two different patterns: diamond-shaped Large Diamond Search Pattern and hexagonal pair Large Hexagonal Search Pattern. The common strategy amongst them is employing a halfway-stop technique.

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Step I: Starting: A minimum Block Distortion Measure point is found from the five checking points of SCSP at the center of search area. If the minimum BDM occurs at SCSP center, the search stops.

Step II: Large Cross Searching: The four outermost points of the central **:** Large Cross Search are evaluated, This step guides another possible correct direction for the subsequent steps.

Step III: Half-diamond Searching: Two additional points of the central Large Diamond Search Pattern closest to the current minimum Block Distortion Measure of the central Large Cross Search Pattern are checked,. If the minimum Block distortion measure found in previous steps is at any endpoint of Small Cross Search pattern , and the new minimum Block Distortion Measure found in this step still coincides with this point, the search stops.

Step IV: Searching: – Case (I): If Large Diamond Search Pattern is used in previous step and the minimum Block Distortion Measure is found located at any point on diamond edge, a new Large Diamond Search Pattern is formed by repositioning the previous minimum Block distortion measure point as the center of large diamond search pattern..

– Case (II): If Large Diamond Search Pattern is used in previous step and the minimum Block Distortion Measure is found located at either of the horizontal (vertical) diamond corners, a new horizontal (vertical) large Hexagonal Search pattern is formed by repositioning the previous minimum Block Distortion Measure as the center of large Hexagonal Search pattern .

– Case (III): Otherwise, a new large Hexagonal Search pattern of the same shape is formed by repositioning the previous minimum Block Distortion Measure as the center of large Hexagonal Search pattern .

Three new checking points are evaluated. If the new minimum BDM point is still at the center of the newly formed Large diamond or hexagonal, go to the final Step (v) else , step 3 is repeated..

Step V: With the minimum Block Distortion Measure point in the previous step as the center, a new Small diamond search pattern is formed if large diamond search pattern is used in previous step; otherwise, a small hexagonal search pattern is used otherwise . The new minimum Block Distortion Measure point should be identified, that is the final motion vector.

d) Enhanced Diamond Search Algorithm

With the use of the proposed 4-corner-based fast inner search, the enhanced diamond search is summarized as follow:

Step I: Set the minimum distortion point to the center of the search area (0, 0)

Step II: A minimum distortion point is found from the 9 checking points of Large Diamond Search Pattern with the center at the previous minimum distortion point. If the new minimum distortion occurs at the center of Large diamond search pattern , go to Step III; else step II is repeated again.

Step III: Compute the 4-corner-based group distortions of the LDSP and find the minimum group distortion. Based on the minimum group distortion, compute the distortion of the additional search point within the corner and then identify the new minimum distortion point, which is the final motion vector.

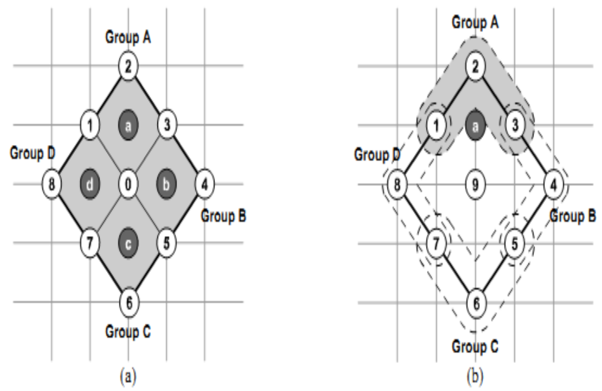

Figure 5: (a) The configuration of large diamond search pattern (0-8) and its inner search points (a-d). (b) Point a is searched finally as group A has the smallest group distortion

e) Adaptive Square Diamond Search (ASDS)

For initial search, the algorithm [8] uses a square pattern adaptively by selecting the step size based on Maximum Absolute Value of predicted motion vector. This search pattern is aimed to reduce the computational complexity of the ME block and find the least error. If the least error point is in the middle of the pattern, it shows that image is still and terminates the search. If the least error point is other than the middle point, then it becomes a new origin for subsequent refined local search with the pattern as small diamond.

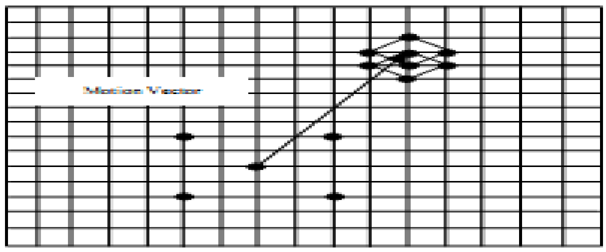

Figure 6: Adaptive Square Diamond search

f) Three Step Diamond search Algorithm:

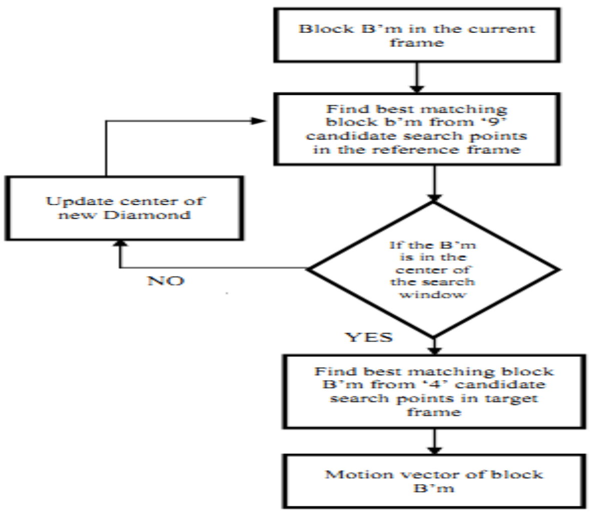

Figure 7: Flow chart for three step Diamond search

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The algorithm is as below[9].

Step I: Initial large diamond search pattern is centered at the origin of the search window. Now, test each points in the search pattern. If the minimum block distortion measure point is the center point perform step III,else perform step II.

Step II: Form a new large diamond search pattern with the minimum block distortion measure point as the center point. If the new the minimum block distortion point is at the center position, go to step III. Otherwise repeat this step for one more time.

Step III: Form the SDSP with previous the minimum block distortion point as the center point. The new the minimum block distortion point obtained in this step becomes the final solution i.e., the motion vector (x ,y). The number of search points depends on the location of the minimum block distortion point also determines the search direction.

3) New-Unsymmetrical Multi Hexagon Search

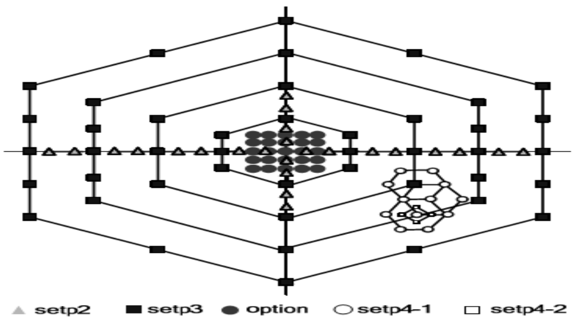

Figure 8: Search process and search pattern of new unsymmetrical multi hexagon search

New unsymmetrical multi hexagon search algorithm combines motion vector characteristics with search strategy. The patterns are divided into different regions, algorithm can adaptively select search region; reduce number of search points by motion vector distribution prediction.

NUMHexagonS algorithm gets the following three ways to optimize [10]

(I)Design a new uneven multi-hexagon grid search based on search radius decreasing.

(II)Adaptively select the number of layers using macro block motion intensity in uneven multi-hexagon grid search pattern.

(III)Perform 5 x 5 Full search based on macro block motion intensity.

4) Octagon and Square pattern search

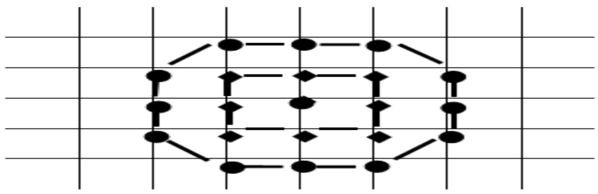

Figure 9: Octagon and Square pattern

Algorithm is given below.

Step I: Block distortion measure is calculated for center point if it comes out zero perform step IV.

Step II: Calculate block distortion measure for 21 points i.e.octagon and square .The point having minimum block distortion measure should be selected which act as center for further processing.

Step III: for this step the search pattern is changed to square. repeat step 3 until center point gets minimum block distortion measure.

Step IV: Search gets finished with final motion vector.

III. CONCLUSION

In this paper, some Block matching motion estimation algorithms has been discussed. Full search Motion Estimation algorithm is not fit for real-time applications because of its unacceptable computational cost. Various fast block based motion estimation algorithm like Diamond search,Cross diamond search,Cross Diamond Hexagonal Search,Adaptive Square Diamond search and three step Diamond search,New unsymmetrical multi Hexagon search, octagon and square pattern are discussed.

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