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COMPARATIVE ANALYSIS OF DIFFERENT DIAMOND SEARCH ALGORITHMS FOR BLOCK MATCHING IN MOTION ESTIMATION

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ABSTRACT

Motion estimation is one of the intensive operations used to compress the video signal in an effective manner. It gives the value of motion vector which comes from the displacement of current frame with respect to its reference frame. Diamond search is one of the most used techniques for Block matching in Motion Estimation and few types which are commonly used are diamond search algorithm, cross diamond search algorithm, modified cross hexagon diamond search algorithm, new cross diamond search algorithm. This paper studies the number of search points used by these algorithms and its effectiveness in terms of time, speed and complexity.

Keyword: cross diamond, modified cross hexagon diamond search, new cross diamond search.

1. INTRODUCTION

Motion estimation is a process which gives motion vector value by determining 2D images. It compares two consecutive images and finds the displacement value called as motion vector. This technique will create a model for the current frame by modifying the reference frames so that it nearly matches the current frame. This current frame which is estimated is then motion compensated and the compensated image is then encoded and transmitted. Block matching is a technique which removes the redundancy between two consecutive frames and gives the motion compensated value [1]. Here, frames are being divided into regular sized blocks, called as macro blocks (MB) and is used to seek for the best-matched block from the reference frame, usually the first frame, within a search window which is present in a fixed size. On the basis of block distortion measure (BDM) or other matching criteria, the shifting of the best-matched block will be described as the motion vector (MV) in the current frame. The best match is mostly computed by a cost function based on a block distortion measure such as Mean Square Error (MSE), or Sum of Absolute Differences (SAD) [3, 4, 5].

Over the past years, motion estimation has been developed and consecutively its speed is getting increased by modifying the block matching algorithm. The most well-known developed Block matching algorithms (BMA) [2] are fast in their speed namely diamond search (DS), cross-diamond search (CDS), modified cross hexagon diamond search and new cross diamond search. In the last decade, many BMAs have been inspired by the characteristics of motion vector distribution [6]. The diamond search is basically highly center-biased and works on two types namely diamond shaped search and highly unrestricted step search. It resolves the local minima. Further it is classified into SDSP (Small Diamond Search Pattern) and LDSP (Large Diamond Search Pattern). The following section deals with the various techniques adopted by different diamond search algorithms.

2. DIAMOND SEARCH (DS) ALGORITHM

As the name implies, diamond search algorithm takes 9 points formed in a diamond shape. It has corner as well as edges point which force to use low frequency resulting in large delay. This algorithm uses an unrestricted center biased searching process. The diamond search uses a large diamond search pattern (LDSP) and a small diamond search pattern (SDSP) [8].

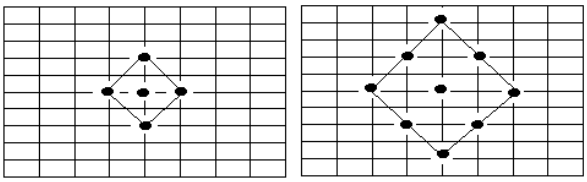

Figure-1. SDSP and LDSP.

The susceptibility of getting stuck at local minima due to its pact shape and relatively large step size in the horizontal as well as vertical direction can be reduced by diamond search algorithm.

Step 1: As diamond search algorithm uses 9 points, it calculates minimum BDM between reference frame and current frame.

Step 2: If the minimum search point is occurring at the edges then the process will continue with large diamond shape.

Step 3: If the minimum BDM point is coming at the center then the diamond search pattern uses small diamond shape which consist of 5 search points.

Step 4: Again if the minimum BDM point is coming at the center then the process will get stopped. Else it will continue from step 2.

2.1 Cross Diamond Search (CDS) algorithm

Cross Diamond Search Algorithm [09] uses less search points than three step search [7] and diamond search.

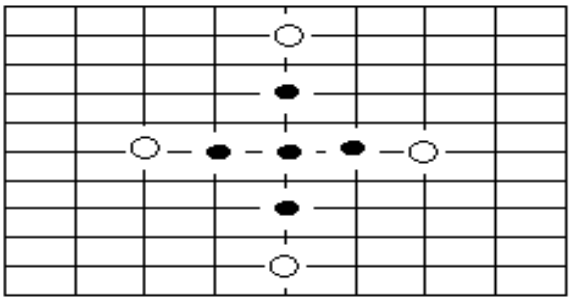

Figure-2. Cross diamond search.

The cross diamond search algorithm divides into two types based on their search point. One is small cross search pattern and another is large cross search pattern.

Step 1: It has a cross shaped pattern having 9 points as large diamond search and 5 points as small diamond search pattern. It will calculate the minimum BDM point.

Step 2: If the minimum BDM point is lying on the vertex, then it will create another large cross search pattern.

Step 3: If the minimum BDM point is at the center (0, 0) then it will create a small search pattern and calculates the minimum BDM point. If it is lying again on the center then process will get stopped else it goes to step 4.

Step 4: If it is not occurring at the center then the process will continue.

The final minimum BDM value will give the motion vector value.

2.2 Modified Cross Hexagon Diamond Search (MCHDS) algorithm

This algorithm uses hybrid architecture consisting of symmetric cross pattern with step size of 2, modified asymmetric hexagon with step size of 1 and small diamond search pattern with step size of 1[11].

Step 1: Initially, symmetric cross search pattern with step size of 2 has to be used as shown in Figure-3. In that we have to find the MAD value. If the Mean absolute difference (MAD) value is at the centre then go to step 3, else go to the step 2.

Step 2: After getting the MAD value other than the center of symmetric cross pattern, take that point as the center and form a modified asymmetric hexagon with step size of 1 shown in Figure-4 and get the MAD value.

Step 3: Draw the small diamond search pattern at the center of the symmetric cross pattern search if the MAD value of the step 1 is (0,0) or else small diamond search pattern will form by taking MAD value of the step 2 as its center and the final minimum cost value will be found.

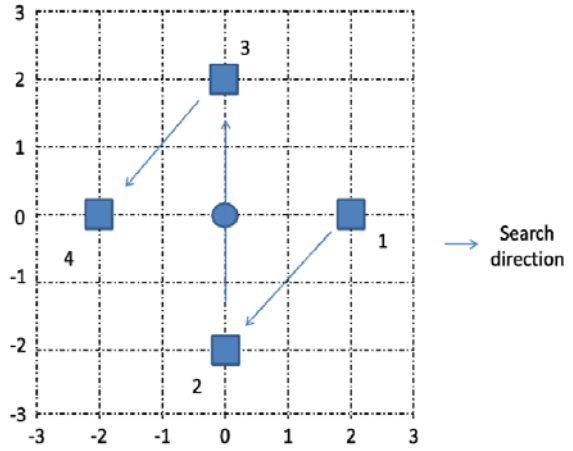

Figure-3. First Search in modified cross hexagon.

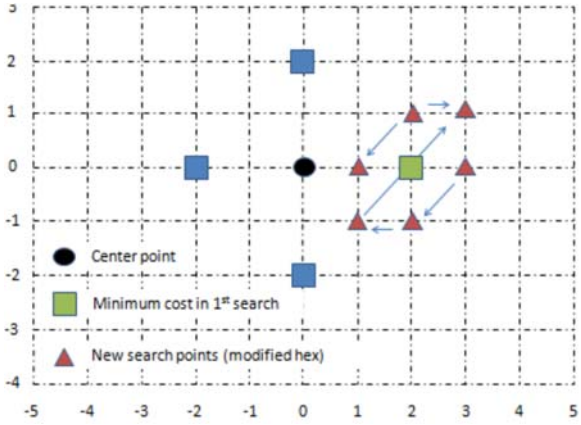

Figure-4. Second search in modified cross hexagon.

This modified cross diamond search has some advantages as it reduces the time required to process by an average of 18.05% compared to other algorithms. Also it reduces the number of search points needed to 13.

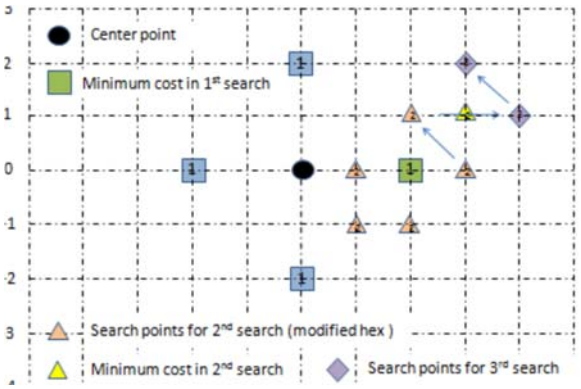

Figure-5. Third search in modified cross hexagon.

2.3 New Cross Diamond Search Algorithm (NCDS)

This new algorithm uses a small cross-shaped search pattern for first two steps to increase the speed of blocks. The search technique used in NCDS follows two types, one is diamond search and other one is cross search. Each cross search and diamond search are further divided into small cross shaped pattern (SCSP) and large cross shaped pattern (LCSP) [10].

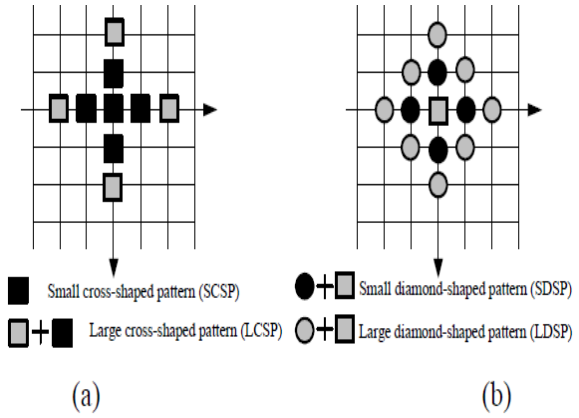

Figure-6. New-cross-diamond search.

Step 1: By using Minimum BDM it forms a small cross search pattern. Again it calculates the minimum BDM and if it finds center then stops the search process or else goes to step 2.

Step 2: With the highest point in the first small cross shaped pattern as the centre, a new small cross shaped pattern is formed. If the minimum BDM point occurs at the centre of this SCSP, the search stops, else go to the step 3.

Step 3: A new Large Diamond Search Pattern (LDSP) is formed by using the minimum BDM found in previous step as the centre of the LDSP. If the new minimum BDM point is at the centre of the newly formed LDSP, then go to Step 5 for converging the final solution. Otherwise process continued by using minimum BDM point.

Step 4: With the minimum BDM point in the previous step as the centre, a Small Diamond Shaped Pattern is formed. Again we have to identify the new minimum BDM point from the SDSP, which is the ultimate solution for the motion.

Because of first two steps in SCSP, it reduces the number of search points and increases the speed. And it has much higher computational complexity than DS and CDS.

The search window is divided into three parts which is equally distributed for four different types of Diamond Search. Individually, it has shown different rows and columns where it is indicating the number of search points being used. For example, in DS 0th row and 0th column uses 13 search points and as rows and columns are increasing number of search points are also simultaneously increasing. From the below table, it is inferred that NCDS uses less number of search points compared to others.

The Cross Diamond Search algorithm consumes less number of search points, with small difference in SAD values compared to other algorithms. In video sequences conferencing the Cross Diamond Search algorithm achieves 40% searching speed and 3% gain in quality of the video than the Diamond Search.

Table-1. Comparison of search points.

	DS			MCHDS		
	0	**1**	**2**	**0**	**1**	**2**
0	13	13	18	17	20	20
1	13	16	16	20	22	22
2	18	16	19	20	22	22

	CDS			NCDS		
	0	**1**	**2**	**0**	**1**	**2**
0	9	11	19	7	10	11
1	11	17	17	11	13	14
2	19	17	22	11	16	14

The Modified Cross Hexagon Diamond Search algorithm reduces an average time of 18.05 % compared to Hexagon Search, 35.91% motion estimation time compared to Diamond Search and 33.32% of the Motion Estimation time compared to New Hexagon Search. The quality of the video is not lost and the number of search point also reduced. New Cross Diamond Search algorithm reduces the less number of search points compared with the other algorithm and helps to improve the speed up to 14% compared to Cross diamond search.

CONCLUSIONS

In this Comparative analysis of different type's diamond search algorithm, it is observed that diamond search has vertex as well as edges which consume less frequency hence leading to consume more time in searching whereas modified hexagon diamond search uses large number of search points compare to cross diamond search. Therefore, the new cross diamond search (NCDS) gives the best result by using less number of search points consuming less time but at the cost of increasing computational complexity.

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