Variable Block Based Motion Estimation Using Hexagon Diamond Full Search Algorithm (HDFSA) via Block Subtraction Technique

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Abstract. Motion estimation is a process of estimating the pixels displacement between two successive frames. The most common motion estimation technique used in the modern world is the block based motion estimation method. There are two types of block based motion estimation method which is the fixed block size and variable block size. This paper introduces a newly developed variable block based Hexagon Diamond Full Search Algorithm which uses the variable block based motion estimation integrating the block subtraction technique. Three different variable block size of 16 × 16 pixels, 8 × 8 pixels and 4 × 4 pixels are introduced in this paper to estimate the different types of motions. In order to select a particular variable block size, the block subtraction technique is applied before the motion estimation process is conducted. The block subtraction technique is mainly used to select the variable block size based on the pixels changes that occur during the motion estimation process. In order to evaluate the performance of the variable block based Hexagon Diamond Full Search Algorithm, superior algorithms are used to compare its performance in terms of average Peak Signal to Noise Ratio (PSNR), average search points and elapsed processing time.

Keywords: Variable Block Based, Motion Estimation, Hexagon Diamond, Block Subtraction Technique.

1 Introduction

Motion estimation process is to exploits the temporal redundancy that exists between two consecutive frames [1]. The pixels displacements are either individually or in a small group is determined while exploiting the temporal redundancy [2]. The pixels displacement usually represents a motion vector at coordinate (x, y). There are few techniques used for motion estimation, such as the pel-recursive [3], frequency domain [4], and block based [5]. The most commonly used technique is the block based technique. This technique divides the frames into equal square macro blocks [1].

V.V. Das and P.M. El-Kafrawy (Eds.): SPIT 2012, LNICST 117, pp. 82–87, 2014.
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The macro blocks are sized into 16 × 16 pixels, 8 × 8 pixels and 4 × 4 pixels block based on the algorithm development requirements. All the macro blocks are compared between the current frame and previous frame for motion estimation process [6-7].

In this paper, a new variable block based Hexagon Diamond Full Search Algorithm (HDFSA) is developed to estimate the motion estimation. The HDFSA algorithm applies the 16 × 16 pixels, 8 × 8 pixels and 4 × 4 pixels types of block sizes. The selection of the block size is based on the change that occurs in the pixels value through the block subtraction technique.

2 Proposed Method

As illustrated in Figure 1, the hexagon search pattern consists of seven search points with one search point is located the center point whereas the diamond search pattern consists of five search points with one search point is located the center point. The hexagon search pattern evaluates all the search points to determine the best Mean Absolute Difference (MAD). If the best MAD point is found at one of the six search points surrounding the center point, that point will be located as the new center point. The new hexagon search pattern will consists of three new search points and four old search point from the previous hexagon search pattern. If the best MAD point is found at the center search point of the hexagon search pattern in the first search step, the search pattern will change to the small diamond search pattern.

Figure 2 shows the full search pattern search points evaluation in a search window to find the best MAD to determine the best matched motion vector coordinate point. The methodology of the full search pattern is illustrated in Figure 2.

The hexagon diamond search pattern implements the 16 × 16 pixels and 8 × 8 pixels of block size whereas the full search step apply the 4 × 4 pixels block size. Before the selection of block size for motion estimation process, threshold value is obtained from the first frame and second frame from the 144 × 176 pixels input video sequence. The first frame and second frame is divided into 16 × 16 pixels block size using Equation 1.

$$\text{Block} = (1+BS*(i-1): BS*i,\ 1+BS*(j-1): BS*j) \tag{1}$$

Where
r = 144 (horizontal pixels),
c = 176 (vertical pixels),
BS = 16 (block size),
i = 1: (r / BS),
j = 1: (c / BS).

Then the block subtraction technique is applied to subtract the extracted blocks from the first frame and second frame as shown in Figure 3. The subtraction process is initialized according to the location of the blocks for an example if the block in the second frame is located at coordinate (1, 1), then the block in the first frame also must be located at coordinate (1, 1).

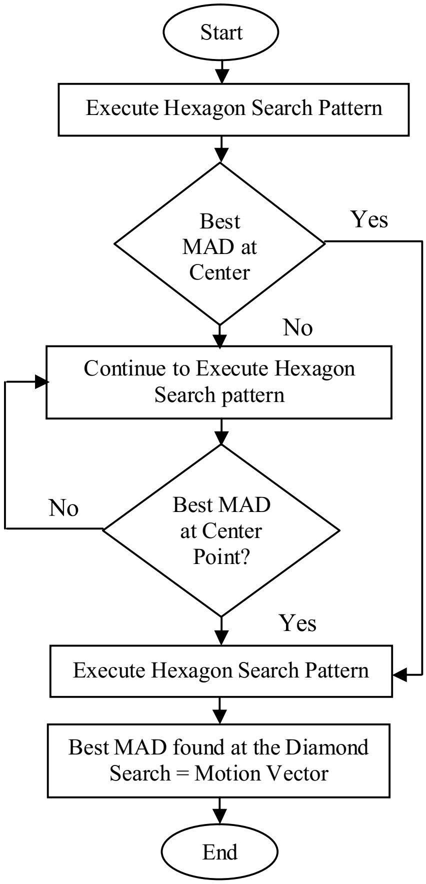

Fig. 1. Hexagon Diamond Search Pattern Methodology

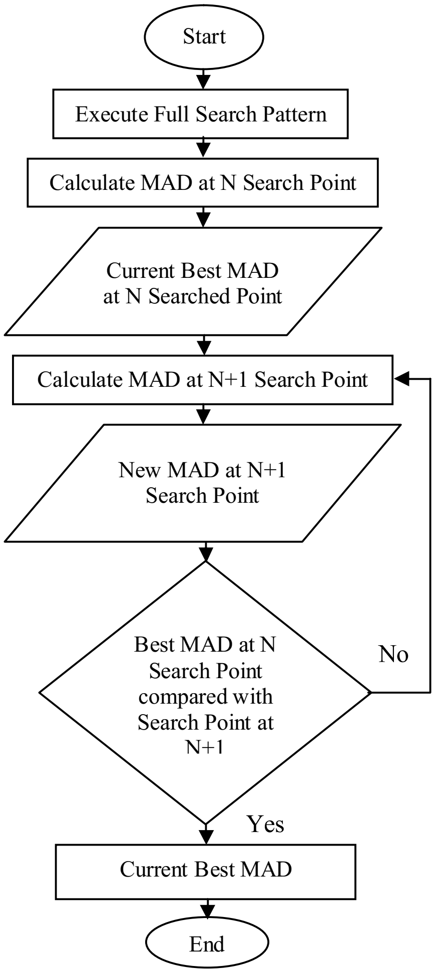

Fig. 2. Full Search Pattern Methodology

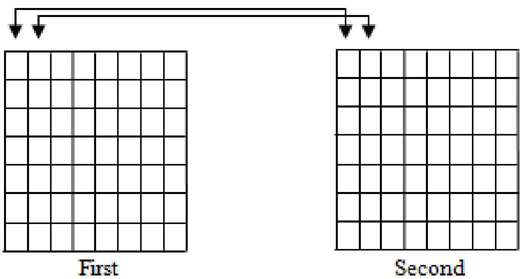

Fig. 3. Block Subtraction Technique

After completing the subtraction process, non-zero elements that exist in each block is calculated and arranged into a matrix form. The non-zero elements are scanned to determine the maximum and minimum value that exists in the matrix form. Those maximum and minimum values are used to calculate the threshold value to select a particular block size. The threshold value is usually divided into two sections as shown in Figure 4.

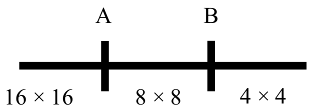

Fig. 4. Threshold Point for Block Size Selection

Table 1. Threshold Value

	Point A	Point B
Akiyo	61 ≤	≥ 123
Coastguard	203 ≤	≥ 225
Foreman	192 ≤	≥ 223
News	166 ≤	≥ 204

The total amount of non-zero elements for each block is used to select the block size based on evaluated threshold value. If the evaluated non-zero values fall at the left region of point A as shown in Figure 4, the block size will remains at 16 × 16 pixels. Thus, if the evaluated non-zero values fall at the right region of point B as shown in Figure 4, then the 16 × 16 pixels block size is divided into smaller block size of 4 × 4 pixels. Hence, if the evaluated non-zero values fall in between the point A and point B region as shown in Fig. 4, then the 16 × 16 pixels block size is divided into 8 × 8 pixels block size. The threshold value for point A and point B for the each respective video sequences is shown in Table 1.

3 Experimental Results and Analysis

The performance of the proposed variable block based HDFSA is evaluated based on the average Peak Signal to Noise Ratio (PSNR) value, average search point and elapsed processing time. Four different types of video sequence with frame size of 144 × 176 pixels are used in this experiment. The results recorded are for ten frames for each video sequence. The results for average PSNR value, average search points and elapsed processing time is presented in Table 2, Table 3 and Table 4 respectively. The results of the proposed variable block based HDFSA are compared with superior algorithms which are the Full Search, Three Step Search (TSS), Four Step Search (FSS), and Diamond Search (DS).

Table 2. Average PSNR value (dB)

	FS	TSS	FSS	DS	HDFSA
Akiyo	47.06	47.06	47.06	47.06	46.55
Coastguard	33.11	33.11	33.11	33.12	31.01
Foreman	26.40	26.28	26.29	24.54	24.83
News	37.65	37.67	37.66	37.22	36.91

Table 2 show that the newly developed variable block based HDFSA achieved a similar average PSNR value compared with the superior algorithms. The degradation of PSNR performance is mainly caused by the reduce of the search points. Table 3 shows the variable block based HDFSA manage to reduce the used of search points compared with the superior algorithms. This shows that the variable block based HDFSA is able to have similar image quality while reducing the number of search points as recorded in Table 2. However, variable block based HDFSA algorithm's elapsed processing time increased due to the application of variable block based search. This has caused the elapsed processing time increases compared with the TSS, FSS and DS algorithms but still lower compared with FS algorithm as shown in Table 4.

Table 3. Average Search Point

	FS	TSS	FSS	DS	HDFSA
Akiyo	225	25	18	14	9
Coastguard	225	25	18	14	9
Foreman	225	25	21	17	10
News	225	25	18	14	11

Table 4. Elapsed Processing Time (Seconds)

	FS	TSS	FSS	DS	HDFSA
Akiyo	1.89	1.07	1.07	1.04	1.37
Coastguard	2.17	1.06	1.05	1.03	1.58
Foreman	1.83	1.08	1.05	1.02	1.58
News	1.85	1.08	1.04	1.02	1.15

4 Discussion

Pixels are the main component used to represent information in an image in the form of color representation. A change in the pixels value indicates of motion or interference at a particular region of interest. If the pixels value remains unchanged this indicates that there is no motion or interference has occurred. Thus, block subtraction technique is integrated to further analyze the motion estimation for motion vector finding in a reference block based on the first frame and second frame.

The 16 × 16 pixels, 8 × 8 pixels and 4 × 4 pixels block sizes are used to evaluate the changes that occur in an image pixels value. The evaluation process only take place based on the type of motion complexity occurred during the threshold value measurement. The block size is adapted into the variable block based HDFSA based on the threshold value complexity shown in Table 1.

The result presented in Table 2, Table 3 and Table 4 shows each video sequence have its own motion complexity when the block subtraction technique is applied to measure the maximum and minimum of non-zero elements. Based on the threshold value presented in Table 1, initially the variable block based HDFSA search will conduct the search using the 16 × 16 pixels block size before switching to 8 × 8 pixels block size and finally to 4 × 4 pixels block size search for the motion vector estimation process.

The variable block based HDFSA algorithm is developed to determine or estimate the motion estimation based on the change in image pixels value. Experiment results and analysis is tabulated in section 3 after conducting the experiment. Based on the result, variable block based HDFSA algorithm proven able to measure the similar PSNR value while reducing the number of search points compared with DS algorithm as shown in Table 2 and Table 3. The elapsed processing time in Table 4 for variable block based HDFSA increase compared with DS, FSS and TS is due to the variable block methodology. Whereas the all the superior algorithms are developed and experimented using fixed block based methodology.

Also, this paper also emphasizes that the variable block based methodology can be used as motion estimation search methodology to estimation the motion translation for an area of interest.

5 Conclusion

The variable block based HDFSA is a newly developed algorithm which estimate or determine the motion estimation using the pixels value threshold measured using the block subtraction technique. This algorithm is able to produce similar average PSNR value compared with FS, TSS, FSS and DS while reducing the search point.

Acknowledgements. Funding for this project is provided by the Fundamental Research Grant Scheme (FRGS), Malaysia. This research has been conducted at Universiti Teknikal Malaysia Melaka. We would like to express our gratitude to Universiti Teknikal Malaysia Melaka whom funded this research.

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