Enhanced Cross Search algorithm using Predicted Motion Vector for Fast Block Motion Estimation

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Abstract

Various Motion Estimation (ME) algorithms have been proposed since ME requires large computational complexity. The proposed algorithm employs Enhanced Cross Search Pattern (ECSP) using motion vector of neighbor-blocks to search the motion vector. The experimental results show that proposed algorithm reduces the search point up to 35% compared to conventional methods.

1. Introduction

Various Fast Motion Estimation (FME) algorithms have been proposed since ME requires large computational complexity in a video encoder. Block Matching Motion Estimation (BMME) is an essential part of video-coding techniques basically in order to improve the encoding performance by reducing temporal redundancy. Full Search (FS) method of ME gives the global optimum solution while a respectable amount of computational load is needed. Such as H.261, H.263, H.264, MPEG-1, MPEG-2 and MPEG-4 [1], video coding standard is necessary to amount of computation about 35-40% for Motion Estimation. To overcome this disadvantage, many Fast Block Matching Algorithms (FBMAs) have been developed, such as the two-dimensional logarithmic search algorithm [2], three-step search (TSS), new three-step search (NTSS) [3], four-step search (4SS) [4] and a new diamond search (DS) [5]. Fast Block Matching algorithms are highly thirsted to significantly speed up the ME. We propose the Enhanced Cross Search algorithm using a predicted motion vector for Fast Block Matching Motion Estimation (FBMME).

This paper is organized as follows. In sec. 2 the Enhanced Cross Search Pattern is described and in Sec. 3, the FBMME using spatial correlation of neighbor-blocks is proposed. Experimental results and conclusions are given in Sec. 4 and 5, respectively.

2. The Enhanced Cross Search algorithm

The proposed method assumes that a motion vector can be existed a strong probability in 4x4 block size about center of macroblock size [6], such as Fig. 1.

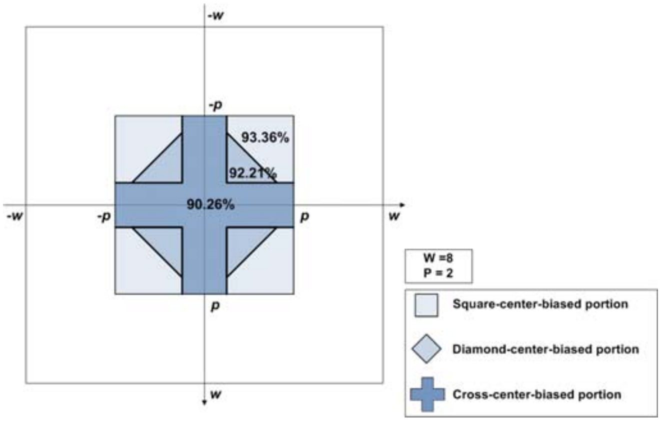


Fig. 1. The existence of motion vector in Macroblock

Fig. 2 shows the process of ECS algorithm. The proposed algorithm computes a motion vector using a search pattern of enhanced cross shape.

ECS algorithm uses the Sum of Absolute Difference (SAD) for locating a motion vector and uses the Enhanced Cross Search Pattern (ECSP) for searching motion vector. The ECSP for locating a motion vector is calculated by

$$SAD = \sum_{i=1}^{N} \sum_{j=1}^{N} \left| C(x,y) - R(x+i, y+j) \right| \quad (1)$$

where $C(x, y)$ denotes the position of the candidate motion vector of the current frame, $R(x+i, y+j)$ is reference frame. (x, y) denotes the pixel position of block. When the center of block denotes (0, 0), the position of Enhanced Cross Search Pattern (ECSP) indicates {(-1, -1), (-1, 1), (0, 0), (1, -1), (1, 1)} about (i, j).

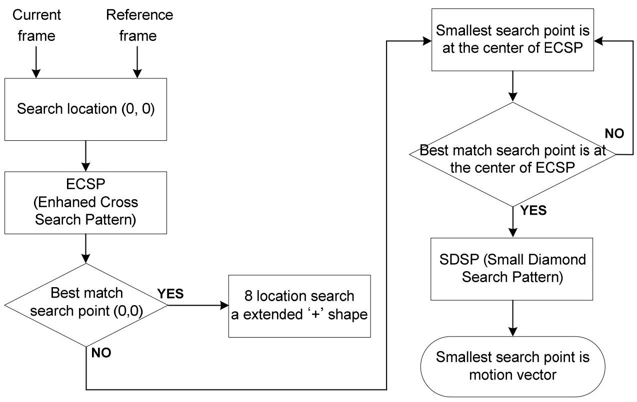
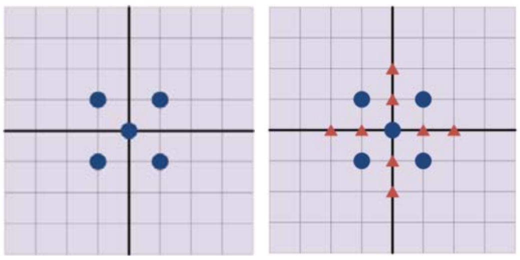
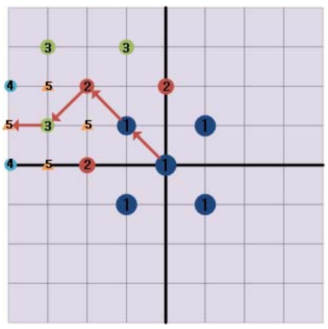


Fig. 2. The flow chart of the ECS algorithm



(a) **(b)**



(c)

Fig. 3. (a) Enhanced Cross Search Pattern (ECSP), (b) Extended '+' shape search pattern, (c) The process about ECS algorithm

In the searching procedure of the ECS algorithm, ECSP is repeatedly used until that the center position computed the SAD value at the step. ECSP shows in Fig. 3(a). If center position of block is SAD value of ECSP, the point searches an extended '+' shape followed such as Fig. 3(b). It is possible to search Large Diamond Search Pattern (LDSP) and Small Diamond Search Pattern (SDSP) [5].

As initial ECSP, if point of SAD value is not center position, the point computed SAD value at the ECSP is placed center position and the step is repositioned as the center point to form a new ECSP. If the SAD point is located at the center position, the pattern switches from ECSP to SDSP. The point had the SAD value found in this step is the final motion vector which points to the best matching block. Fig. 3(c) shows a process of motion vector location using ECS algorithm. The proposed ECS algorithm employs three search patterns as shown in Fig. 3(c). The first pattern, called Enhanced Cross Search Pattern (ECSP), the second pattern is SDSP and the other is extended '+' shape search pattern.

3. The FBMME using spatial correlation of neighbor-blocks

We propose a Fast Motion Estimation algorithm that changes the initial search point by using pre-computed MVs of neighbor-blocks. Fig. 4 is the process to use motion vector of neighbor-blocks. The motion vector of current block can be predicted by motion vectors of computed neighbor-blocks using spatial correlation.

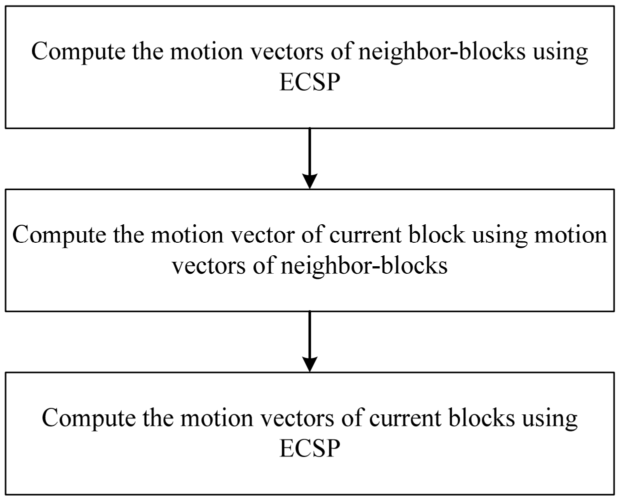


Fig. 4. The process of the proposed algorithm

Fig. 5 shows a spatial correlation of neighbor-blocks and current block. Predicted motion vector is decided by average of motion vector of neighbor-blocks by the equation (2).

TABLE 1. Experimental results (ECS algorithm)

Search method \ Image		Fight 800x336	Susie 704x480	Flower 640x480	Ice 720x480	Football 512x480	Tennis 640x480	Salesman 512x480	Word 480x272	Average
FS	Total Search point	1105492	1397647	1269083	1429788	1011955	1269083	1011955	530256	1128157
	PSNR	25.83	27.64	22.42	32.96	34.51	29.04	46.11	40.53	32.38
DS	Total Search point	32644	48394	26913	44607	19829	17426	14742	9014	26696
	PSNR	22.82	25.62	21.52	25.43	33.31	28.33	45.97	31.02	29.25
ECS	Total Search point	23978	37148	18903	21879	13734	15174	13252	7543	18951
	PSNR	22.36	25.71	20.99	23.97	32.88	28.46	45.95	30.69	28.88

TABLE 2. Experimental results (ECS algorithm to use Motion Vectors of neighbor blocks)

Search method \ Image		Fight 800x336	Susie 704x480	Flower 640x480	Ice 720x480	Football 512x480	Tennis 640x480	Salesman 512x480	Word 480x272	Average
DS To use neighbor blocks MV	Total Search point	26444	46709	21204	38257	17950	16508	13986	8901	23745
	PSNR	23.60	27.33	21.51	25.87	33.49	28.60	45.99	31.23	29.70
ECS To use neighbor blocks MV	Total Search point	18954	36172	16812	19727	12617	14057	12918	7126	17297
	PSNR	22.97	27.07	21.25	25.28	33.43	28.72	46.03	31.10	29.48

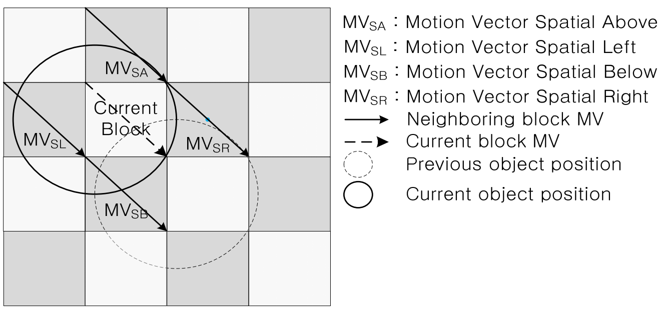


Fig. 5. Spatial correlation of blocks

$$V(x,y) = \frac{1}{K}\sum_{i=1}^{K} MV_i \quad (2)$$

where $V(x, y)$ is a predicted motion vector, (x, y) represents the position of current block. The number of neighbor-block is K and MVi denotes motion vector of neighbor-blocks.

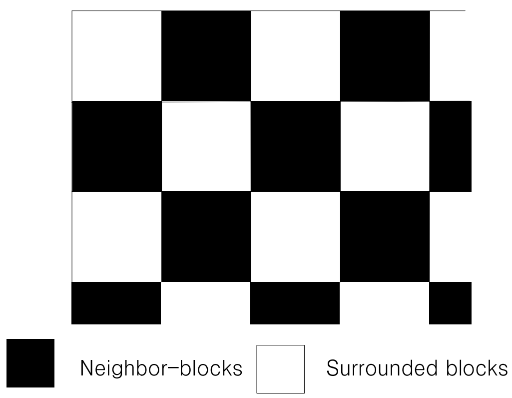


Fig. 6. Example of current frame

The first step is to compute motion vectors of neighbor-blocks by Enhanced Cross Search (ECS) algorithm. As shown in Fig. 6, neighbor-blocks are located on left, right, above and below. The second step is to compute the search point of surrounded block with four neighbor-blocks. Search point of surrounded blocks is computed by averaging four motion vectors of neighbor-blocks. The final step computes by using ECSP from a predicted motion vector of surrounded blocks.

4. Experimental results

We present the experimental results of the proposed algorithm compared with the conventional methods about total search points and PSNR. Total search points are computed by averaging about search points of 30 frames. PSNR evaluates the quality of image. TABLE 1 shows that the proposed algorithm reduces the total search points up to 29% compared to Diamond Search and there is no difference upon 0.5% about PSNR. TABLE 2 verifies that to use correlation of neighbor-blocks is better than conventional algorithm about search point and PSNR. To use a predicted motion vector algorithm falls off 35% about the total search points and when PSNR is compared to DS algorithm, that is very similar.

The Proposed algorithm compared with DS algorithm that applied using the motion vectors of neighbor-blocks, so that the total search points decrease up to 27% and also PSNR is difference upon 0.3%.

5. Conclusion

In this paper, we proposed enhanced FBM algorithms. ECS algorithm using spatial correlation of neighbor-blocks for motion estimation gains speedup than other fast search methods and also maintains similar distortion performance. The proposed algorithm can find motion vector by reducing search point and also preserve image quality.

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