Improved Fast Motion Block Matching Based Adaptive Rood Pattern Search

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Abstract: − Block-matching motion estimation plays an important role in video coding. Various simple and efficient Block-Matching Algorithms (BMAs) are developed, like some popular methods, Exhaustive Search (ES), Three Step Search (TSS), New Three Step Search (NTSS), Diamond Search (DS) etc… In this paper, we propose an improved for the fast motion Adaptive Rood Pattern Search (ARPS), which consists of two sequential search stages: Initial Search and Refined Local Search. The key idea of this method is above different motion characteristics of different sequence images, we adopt different Thresholds in the Mean Absolute Difference (MAD) between the current and reference block. The proposed algorithm are compared which some BMAs by tested at several video sequences, the excellent performance is verified and it is suitable for videoconferencing sequences.

Key-Words: - Motion estimation, Block-matching algorithms, Adaptive Rood Pattern Search.

1 Introduction

Block-Matching Algorithm (BMA) for the motion estimation has been widely used in block based video coding standards such as H.261, H.263, MPEG-2, MPEG-4 and H.264 because of its simplicity for implementation. The most straightforward BMA is the full search (FS), which exhaustively searches for the best matching block within the search window. However, FS yields very high computational complexity and makes Motion Estimation (ME) the main bottleneck in real-time video coding applications. Due to this extensive computation, many kinds of fast block-matching have been developed [1]. A Diamond Search (DS) has been proposed with a large diamond and small diamond patterns and the improved version is proposed in [2] [3].

Adaptive Rood Pattern Search (ARPS) which is based on two sequential search stages has been developed in [4]. By using neighbouring MB's motion vectors, ARPS size is dynamically determined at initial search stage. Then, a unit-size rood pattern is exploited repeatedly, an unrestrictedly to find the best motion vector (MV) in the refined local search stage. The improved version of ARPS denoted ARPS-2 was proposed to speed up the searching procedure too [5].

We propose a new, efficient and speed version of ARPS based on the thresholds of the distortion criteria MAD. The proposed algorithm provides a faster search while maintaining the image quality at a level similar to or better than ARPS, ARPS-2 and others. Section II explains the proposed adaptive pattern search algorithm and the above algorithm in detail. Section III the simulation results and their interpretation. Section IV some concluding and remarks are given.

2 The Proposed Adaptive Rood Pattern Search Algorithm

2.1 Adaptive Rood Pattern Search Algorithm

A novel and simple fast block matching algorithm, called adaptive rood pattern search (APRS) consists of two sequential search steps [6]. The initial search is utilized to locate a good starting point. In this way, the chance for being trapped by local minima is highly reduced and unnecessary intermediate search points can be skipped. For initial search, as shown by Fig.1, rood pattern has been utilized while size of the rood is dependent on the motion vectors of neighbour blocks which

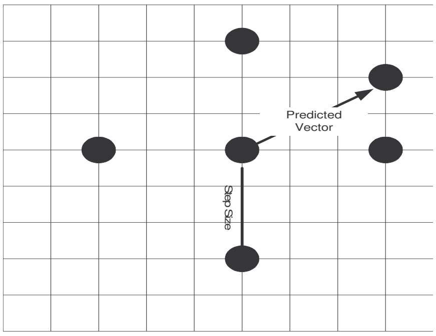

Fig.1 Adaptive Rood Pattern Search (ARPS), with Motion Vector MV (3,2).

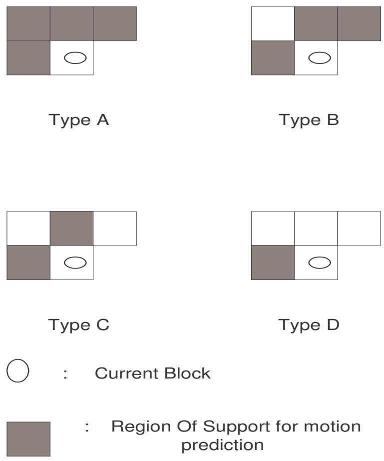

Fig.2 Four types of ROS

are called region of support (ROS). The speed and accuracy of the rood pattern based search algorithm is highly related to the size of pattern. First step of the proposed method permits the algorithm to adapt itself to content of motion. In most cases, adjacent blocks belong to same moving object have similar motions. Therefore, it is reasonable to predict the motion of current blocks from motion vectors of adjacent blocks. In order to obtain accurate prediction for MV of current block, the choice of ROS is of importance. In spatial domain, since blocks of each video frame are processed in a raster-scan order, the candidate blocks for prediction of motion in current block are immediate left, above, above left and above right to current bock as shown in Fig. 2. Calculating the statistical average of MVs in the ROS is a common approach for prediction of motion vector in current block. Experimental results show that four possible choice of ROS shown in Fig. 2 and two types of prediction criteria, the mean and median, fairy yield similar results in terms of PSNR given by equation (1). Another cost function is Mean Squared Error (MSE) given by equation (2).

$$Psnr = 10Log_{10}\left[\frac{255^2}{MSE}\right] \quad (1)$$

$$MSE = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left(C_{ij} - R_{ij}\right)^2 \quad (2)$$

$$MAD = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left|C_{ij} - R_{ij}\right| \quad (3)$$

where N is the side of the macro block, C_{ij} and R_{ij} are the pixels being compared in current macro block and reference macro block respectively.
Therefore, the simplest ROS i.e. immediate left block (Type A) has been and adapted in ARPS [2] and since only one block is used for prediction criteria which also reduces hardware complexity. The ARPS leads to the new search centre directly to the most promising area which is around the global minimum. Hence, instead of performing full search, a compact and small search pattern can be utilized to locate the global minimum. When a minimum point is located, this point can be the center for next iteration until the minimum occurs at the center of search pattern. The number of static motion blocks per frame could be as high as 70% for most video sequences. Therefore, zero-motion prejudgement [2] can be also employed to reduce computations. Zero-motion pre-judgement reduces the number of searches by predicting that if the block motion in next frame is zero and therefore it can skip the search for that block.

2.2 The Idea of the Proposed Algorithm

The idea of the proposed algorithm is to improve the speed of the block-matching by utilisation ARPS algorithm. If we set thresholds T and compare it at the MAD given by equation (3):

- When MAD ≥ T: In this way, the search process for the next block and repeat this step, if the condition isn't guaranteed.
- When MAD < T: The MAD point in this step is the final solution of the motion vector which points to the best matching block.

The block diagram of the proposed algorithm is presented in the Fig.3.

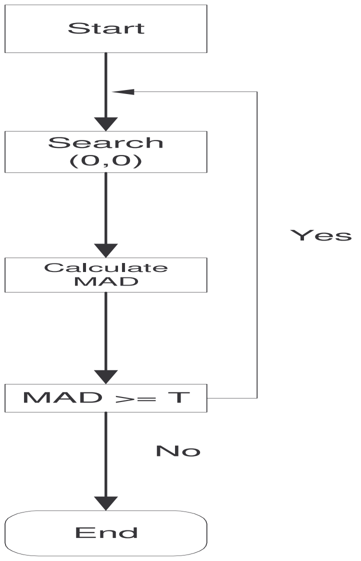

Fig.3 Flow Chart

3 Simulations Results

In our simulation, the block size is fixed at 16x16. To make a consistent comparison, block matching is conducted within a 15x15 search window (i.e.$\pm$7 pels displacement in horizontal and vertical direction). In this section, we will examine the proposed algorithm for comparison with the some popular BMAs. For the fast BMAs, computational complexity can be measured by the average time per frame and the average number of search points per motion vector estimation.

Table 1 and Table 2 illustrate the average time in seconds per frame, the average number of_search points per motion vector estimation respectively for some BMAs and the proposed algorithm in PC configuration (CPU 1.86 Ghz, 512 Memory, and Microsoft Windows XP Professional). Table 1 show when compared ARPS which other BMAs it is better speed (up to 15,06% than DS, up to 36.38% than ES in Claire sequence, it is similar ratio in the other sequences…). Experimental results show ES are very high computation in relation to other BMAs. The improved ARPS and proposed achieves better speed (up to 5,16% in Claire sequence, up to 21,06% in tennis sequence, up to 10,10% in foreman sequence) and computational by ARPS. Table 1 illustrate the speed in time by frame on the other hand Table 2 show the speed of the proposed BMAs in Average number of Search Points (ASP) per motion vector estimation. It can be clear seen the proposed algorithm achieves the smallest ASP with the marginal PSNR (Fig. 4 and Fig. 5) compared with other fast BMAs like ARPS. For the Claire sequence the proposed algorithm achieves 30,69% ASP speedup over ARPS while the PSNR only increases 0,9 db. For the sequence tennis with relatively higher degree of motion, the proposed algorithm gives above 35,99% ASP speedup over ARPS while the PSNR only increases 1,3db. Therefore the Fig.4 and Fig.5 show the degradation in PSNR per frame of the some proposed BMAs; ES, DS, ARPS and the proposed algorithm at the Claire and tennis sequence respectively. The high degradation illustrates approximately the 28th frame in Claire sequence than the 23th frame in tennis sequence for all BMAs and the proposed algorithm. The proposed algorithm presents the better speed than ARPS with increases maximally the PSNR to 0,9db for Claire, to 1,3db for tennis. The degradation will become significant when the sequence is of large motion like tennis and insignificant when the sequence is of small motion like Claire.

Table 1.Average time (in seconds) for BMAs per frame

	Claire	Diskus	Alex	Tennis	Foreman
	Resolution				
	288x352	**288x352**	**288x352x3**	**240x352x3**	**144x176x3**
ES	3.8096	3.7561	11.820	9.7005	2.7929
4SS	0.3444	0.3809	1.0773	0.8638	0.3259
TSS	0.4663	0.4726	1.3866	1.1293	0.3499
SESTSS	0.3861	0.3640	1.0863	0.9101	0.2725
NTSS	0.3919	0.3906	1.0911	0.8815	0.3633
DS	0.3222	0.3614	0.9967	0.7763	0.3273
ARPS	0.1716	0.2114	0.6230	0.4129	0.2011
Proposed	**0.1200**	**0.1223**	**0.4112**	**0.2023**	**0.1001**

Table 2 Average Number of Search Points per Motion Vector Estimation

	Claire	Diskus	Alex	Tennis	Foreman
	Resolution				
	288x352	**288x352**	**288x352x3**	**240x352x3**	**144x176x3**
ES	204.2828	204.2828	210.3165	208.0162	195.9630
TSS	23.4718	23.3628	23.8543	23.6369	22.8413
NTSS	17.9062	18.8229	17.0561	19.9024	22.6735
SESTSS	16.8754	16.5787	16.9354	16.5906	15.6780
4SS	16.5741	17.3435	17.1018	17.9929	19.1705
DS	13.3532	14.4870	14.1372	15.6592	17.3941
ARPS	6.4298	7.7251	7.4432	8.8701	10.1337
Proposed	**4.4567**	**5.6703**	**5.2440**	**5.6775**	**6.6554**

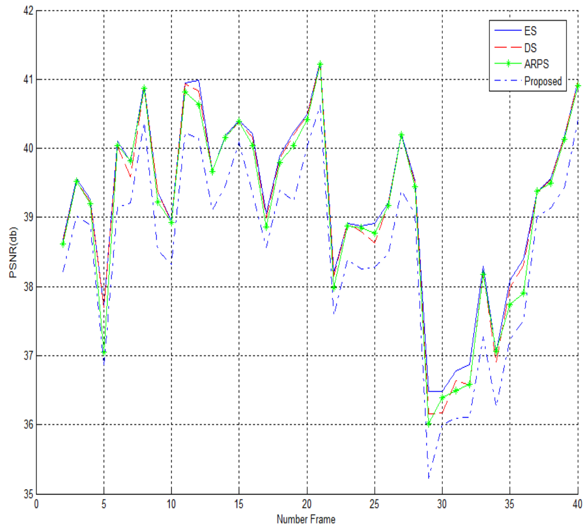

Fig.4 Frame-based PSNR (db) performance of ES, DS, ARPS and the proposed algorithm in claire sequence.

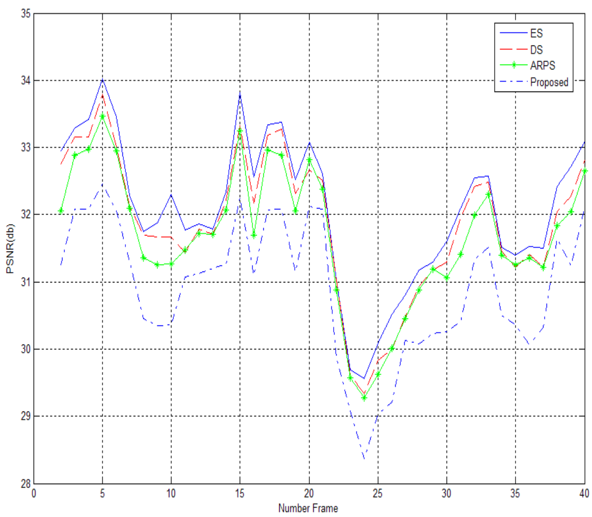

Fig.5 Frame-based PSNR (db) performance of ES, DS, ARPS and the proposed algorithm in tennis sequence

4 Conclusion

In this paper, search pattern and search strategies of certain existing fast BMAs are analysed. We have proposed a novel and simple fast block-matching algorithm of ARPS based threshold of minimum distortion (MAD). Simulation experiments conducted clearly demonstrate that the proposed algorithm greatly outperforms the well-know ARPS algorithm while reducing its computation by to 30% for the small motion and 35% for the large motion approximately. Experimental results showed that the proposed algorithm improves the search speed significantly which similar distortion of some motion, especially for video sequences, it can improve the codec H.264 too [7].

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