A New Fast Motion Estimation Algorithm

- Literature Survey

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1. Abstract

Video compression is vital for efficient storage and transmission of digital signal. The hybrid video coding techniques based on predictive and transform coding are adopted by many video coding standards such as ISO MPEG-1/2 and ITU-T H.261/263, owing to its high compression efficiency. Motion +compensation is an predictive technique for exploiting the temporal redundancy between successive frames of video sequence. Block matching techniques are widely used motion estimation method to obtain the motion compensated prediction. By splitting each frame into macroblocks, motion vector of each macroblock is obtained by using block matching algorithm (or motion estimation algorithm). In order to get motion vector of each macroblock, the most obvious and simplistic method is full search algorithm. All possible displacements in the search window are evaluated using block-matching criteria (cost function). The advantage of full search is that we can find the absolute optimal solution. However, its high computational complexity makes it impossible for real-time implementation. Because the computational complexity of video compression, the compression efficiency and the compression quality is determined by the motion estimation algorithm, development of Fast Motion Estimation Algorithm for real-time application becomes compelling.

The computational complexity of a motion estimation technique can then be determined by three factors: 1. search algorithm. 2. cost function/evaluate function. 3. search range parameter p. Actually, we can reduce the complexity of the motion estimation algorithms by reducing the complexity of the applied search algorithm and/or the complexity of the selected cost function. An

full search algorithm evaluates all the weights in the search window, and a more efficient, less complex search algorithm will decrease the search space.

We will identify and evaluate the recent and widely used fast estimation algorithms, especially in hybrid estimation algorithms: how they get the trade-off between video quality and compression efficiency? Based on this, we will propose our new motion estimation algorithm produced our new video encoder. To test its validation and its efficiency, we used the standard tested video sequences, which include three kinds of sequences: one is little motion sequences, second is moderate motion sequences, and third is the fast motion sequences. The encoder software will download from Internet. We change some parts and formed our new encoder (Abided by H.263 standard).

2. Fast Block Motion Estimation Algorithms

Block-matching methods are the most widely used motion estimation methods for the low computation complexity compared with other methods such as optical flow based methods and pel-recursive methods. It is also adopted by many video coding standards (MPEG-1/2 and H.261.262/263).

Many fast block-matching methods are developed based on some basic assumptions. Among them, there are two assumed by many block-matching methods.

1. *The block of pixels has the same translation motion from frame to frame.*
2. *Block distortion measure (BDM) increases monotonically as the checking point moves*

away from the global minimum BDM point.

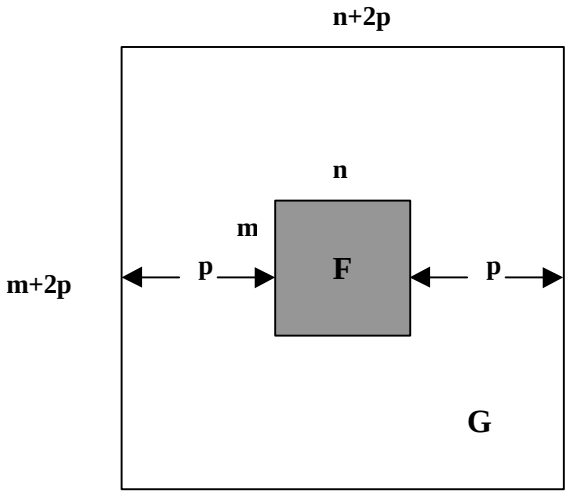

Figure 1. The search area in block matching methods

Figure1 depicts the search area of the block-matching methods. The current frame is divided into many rectangle blocks. For each blocks the motion displacement is achieved by finding the displaced coordinate of a match block within the search window of a reference frame. The 'F' block is the block of the current frame and 'G' block is the block of the reference frame. The maximum number of the checking point in vertical direction of the search window is 2m+p and 2n+p in horizon direction. A best-matched motion vector is obtained by finding within a search window of size (2m+p)(2n+p) in the reference frame.

2.1 Cost function

In order to measure the similarity between the block of the current frame and a candidate block of the reference frame, three matching cost functions are defined: Mean square error (MSE),

Mean absolute error (MAE) and Pixel Difference Classification (PDC). Mean absolute error (MAE) is the most commonly used cost function, since it doesn't need multiplication operation.

2.2 Block-matching algorithms (BMA)

The most straightforward block-matching method is the full search algorithm. The best-matched motion vector is obtained by searching the all the checking points within the search window. Full search algorithm can achieve the most accurate motion vector but it is impractical to use due to its computation complexity, which is O(n) for a n-point block-matching search. Many BMAs have been proposed to reduce the computation complexity by reducing the number of the checking point or the size of the search window. The most commonly used methods are three-step algorithm [1], two-dimension logarithmic search algorithm [2] and hierarchical block-matching algorithm [3]. Their computation complexity may be as low as O(log n), which is practical to be implemented using the available hardware. These algorithms also serve as the benchmark for the development of the new algorithms.

Based on these mature algorithms, some novel hybrid search algorithms have been proposed [4]. The main idea of these algorithms is to firstly predict the types of the motion as stationary, small or large using a pre-defined threshold and then use proper algorithms to search for the best-matched motion vector. These algorithms can adapt to the different type of motions, thus is more suitable for the real world video sequence.

Another way to reduce the number of the checking point is to use halfway-stop technique in the BDM calculation. Some algorithms were proposed based on such technique [5]. In such algorithms, the partial distortion is compared with the current minimum total distortion. If the partial distortion of the candidate motion vector is greater than the current minimum total distortion, this vector is

rejected. These algorithms can reduce the computation complexity greatly by using the MAE cost function, in which the comparison operation is relatively lower compared with the multiplication.

In the real world video sequence, the true frame-to-frame displacements are not always related to the integer pixel sampling grids. To increase the accuracy of the motion prediction, half-pixel technique was proposed. Many coding standards such as MPEG-1/2 and H.262/263 permit motion vectors to be a half-pixel accuracy. With minor alteration, almost all the algorithms mentioned above can get the half-pixel accuracy by incorporating half-pixel technique.

3. Implementation

A lot of motion estimation algorithms have been invented to reduce the complexity of motion estimation associated with full search. Some reduce the calculation of cost function [11]. Others reduce the search points [7,9,10]. Specially, hybrid search algorithms [4] can get excellent result. Hybrid algorithms can use different motion estimation algorithms by judging object's motion scope. Few algorithms combine the reducing of the calculation of cost function with the reducing the search points.

We will propose a new algorithm combined the two fields together to aim to get more high compression efficiency, at the same time, we keep the image quality. On other hand, we will use the previous motion vectors in our new algorithm.

We will do as follow: First, we choose the mean absolute error (MAE) as our search criterion. Second, we predict the motion vector based the hybrid search algorithm [4], in each step of searching the optimal motion vector, we use partial distortion instead of using full distortion [4]. We choose 16X16 macroblock, which is divided into 16 sub-blocks. By comparing the sub-block's MAE with the previous minimum MAE, we can get halfway stop. So, we can improve search speed

and performance. Third, we can use the previous motion vector to predict the initiate predicting point and use for adaptively choosing the searching step.

By the above-described method, we implemented our software encoder, which is abided by H.263 standard. At last, use the standard sampling sequences to test our encoder, and get the simulation result.

References

[1]. T. Koga, K. Iinuma, A. Hirano, Y Iijima, and T. Ishiguro, "Motion compensated interframe image coding for video conference," *Proc. NTC81,* pp. G5.3.1, Nov. 1981.

[2]. J. R. Jain and A. K. Jain, "Displacement measurement and its application in interframe image coding*," IEEE Trans. Commun.*, vol. 29, pp. 1799-1806, Dec. 1981.

[3]. M. Bierling, "Displacement estimation by hierarchical block-matching," *in Proc. SPIE Conf. On Vis. Commun. And Image Proc.*, vol. 1001, pp. 942-951, Jan. 1988.

[4]. C. K. Cheung and L. M. Po, "A hybrid adaptive search algorithm for fast block motion estimation," *IEEE International Symp. Signal Proc.* and its Appl., vol. 1, pp.365-368, Aug. 1996.

[5]. C. K. Cheung and L. M. Po, "A hierarchical block motion estimation algorithm using partial distortion measure," *IEEE International Conference on Image Processing*, vol. III, pp. 606-609, Oct. 1997.

[6]. Kai Sun, "Adaptive Motion Estimation Based on Statistical Sum of Absolute Difference," *IEEE International Conference on Image Processing*, vol.III, pp.601-604,Oct. 1998.

[7]. Alan C. K. Ng and Bing Zeng, "A New Fast Motion Estimation Algorithm Based on Search Window Sub-sampling and Object Boundary Pixel Block Matching*," IEEE International*

Conference on Image Processing, vol. III, pp.605-608,Oct. 1998.

[8]. Yuen-Wen Lee, Faouzi Kossentini and Rabab Ward, "Efficient RD Optimized macroblock coding mode selection for MPEG-2 video encoding,*" IEEE International Conference on Image Processing*, vol. II, pp.803-806, Oct. 1997.

[9]. Bing Zeng, Renxiang Li and Ming L. Liou, "Optimization of Fast Block Motion Estimation Algorithms,*" IEEE Transactions on circuit and systems for video technology*, vol.7, No.6, pp.833-844,December, 1997.

[10]. Lai-Man Po and Wing-Chung Ma, "A Novel Four-Step Search Algorithm for Fast Block Motion Estimation," *IEEE Transactions on circuit and systems for video technology*, vol.6, No.3, pp.313-317,June, 1996.

[11]. Xiaobing Lee and Ya-Qin Zhang, "A Fast Hierarchical Motion Compensation Scheme for Video Coding Using Block Feature Matching," *IEEE Transactions on circuit and systems for video technology*, vol.6, No.6, pp.627-635, December, 1996.