Improved Strategy for TZSearch Algorithm

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Abstract - TZSearch algorithm is a fast search algorithm which is adopted in multiview video coding. In this paper, improved methods for TZSearch algorithm are proposed. The octagon-based search pattern is used to replace the 8-point diamond search pattern (or 8-point square search pattern) in the initial search step of TZSearch algorithm. In addition, a threshold is set up to terminate the initial search in advance. These improvements reduce the number of search points substantially and speed up the encoding process of multiview video. The experimental results show that, in various testing sequences, the runtime of TZSearch algorithm and the total encoding time reduce about 80% and 40% separately, which are dramatic in comparison with the approximately unchanged PSNR and bitrate.

Keywords: multiview video coding (MVC), motion estimation, TZSearch algorithm, octagon-based search pattern

1. Introduction

Traditional video presents a two-dimensional image which is taken by one camera, while multiview video contains a number of two-dimensional images which are taken by several cameras from different places in the same scene from which people can feel the depths of the objects in the scene [1]. Multiview video can be extensively used in numerous fields, such as entertainment, industrial control and teleeducation [2]. Since the entire data of multiview video is more than twice the data of traditional video, it is important to encode multiview video to compress the tremendous data [2]. The encoding solution of multiview video is proposed in the extended standard of H.264/AVC [3]. JMVC [4,5], the corresponding test model, exploits the temporal and spatial information of images to implement motion estimation in encoding multiview video. To reduce the bitrate while maintaining the PSNR of multiview video, motion estimation occupies a large amount of time consuming while encoding multiview video. According to the researches in several references, motion estimation consumes 80% of the total encoding time when encoding video including 5 points of view [6,7].

TZSearch algorithm is one of the fast search algorithms in motion estimation of JMVC which reduces the encoding time while maintaining PSNR and bitrate approximately unchanged. In spite of this, the encoding time is far from the demand of real time multiview video coding. There is a requirement to further speed up the encoding while keeping PSNR and bitrate in an appropriate range. The existing improvements of TZSearch algorithm are choosing different search pattern and setting threshold to terminate search ahead of time [8,9]. To decrease encoding time and get a well performance of both PSNR and bitrate, improved methods for TZSearch algorithm are proposed in this paper, which incorporate a modified octagon-based search pattern and a threshold. The remainder of the paper is organized as follows. In section 2, original TZSearch algorithm will be introduced. Section 3 describes the improved methods for TZSearch algorithm. Experimental results are presented of the original and the improved TZSearch algorithm in section 4 followed by conclusion in section 5.

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2. Analysis of TZSearch algorithm

TZSearch Algorithm is a mixture search algorithm with good encoding performance but time consuming. The procedure of TZSearch algorithm can be described as follows:

Step 1: At the beginning, a start point should be determined as the search center of next step. It calculates the SAD (Sum of Absolute Difference) of five points with different predicted motion vector (zero, median, left, up and upper right) in the reference frame. The start point is the one with the minimum SAD.

Step 2: In the initial search, the 8-point diamond search pattern or the 8-point square search pattern is used to search the window in the reference frame with different stride lengths. If the search range is 64, the stride length ranges from 1 to 64, in multiples of 2. The point with the smallest SAD is the center of further refined search and the stride length of the center point is stored as the shortest distance.

Step 3: If the shortest distance is 1, the 2-point search pattern is used to calculate SAD of two points near the center and the shortest distance is set 0. If the shortest distance is greater than the parameter ‘iRaster’, the raster search pattern is employed to find the point with the smallest SAD as the center of next step. The stride length of raster search, iRaster, is stored in the shortest distance.

Step 4: If the shortest distance is greater than 0, the raster refinement or the star refinement is implemented until it is 0. Both of these refinements include 8-point diamond search pattern, 8-point square search pattern and 2-point search pattern. When the shortest distance is 0, the center point is the optimal point and the search algorithm is finished.

3. Improved strategy

3.1 Directional center-biased characteristic

The statistical results of experiments show that motion estimation is center-biased [10,11], which means that the probability distribution of the optimal point declines around the center in the search window. The statistic of 18 standard video sequences [11] shows the average probability distribution of motion vector which is presented in Table 1. In this table, the horizontal and vertical numbers are the absolute distance from the center point to the searching points. It can be concluded that 58.05% of motion vectors are just in the center of the search window (i.e. A in Fig. 1) and 76.57% of motion vectors are in the cross center (i.e. A+B in Fig. 1). According to the statistic of motion vectors, it is in favor of adopting appropriate search pattern to search points around the center of the search window to improve the speed and precision of the search. In addition, it is obviously that the motion vector distributes in horizontal and vertical directions more than other directions which is also proved in paper [12]. Therefore, the directional distribution of motion vectors should be taken advantage of to reduce the redundancy of the search. The above-mentioned characteristic is the foundation of the proposed improvements for TZSearch algorithm in this paper.

Table 1 Average probability distribution of motion vector [11]

<table>
<thead>
<tr>
<th>Radius</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
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<td>0.0591</td>
<td>0.0170</td>
<td>0.0072</td>
<td>0.0054</td>
</tr>
<tr>
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<td>0.0242</td>
<td>0.0092</td>
<td>0.0051</td>
<td>0.0041</td>
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<td>0.0062</td>
<td>0.0034</td>
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<td>0.0017</td>
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</tr>
<tr>
<td>3</td>
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<td>0.0029</td>
<td>0.0019</td>
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<td>0.0012</td>
<td>0.0009</td>
</tr>
<tr>
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<td>0.0012</td>
<td>0.0010</td>
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</tr>
<tr>
<td>5</td>
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<td>0.0016</td>
<td>0.0009</td>
<td>0.0011</td>
<td>0.0007</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

Fig. 1 Total probability of motion vector at the same distance to the center

3.2 Improvements for TZSearch algorithm with octagon-based search pattern

In the motion estimation, the performance of search algorithm is impacted by the shape of the search pattern. Ideally, a circle-shaped pattern is the most appropriate search pattern, for the symmetrical distribution characteristic which includes the minimum number of search points and the lowest matching error. On the basis
of the theory, the octagon-based search pattern [13] is used to replace the 8-point diamond pattern or 8-point square pattern in the initial search step of TZSearch algorithm. The octagon-based search pattern, which is illustrated in Fig. 2, consists of a rood pattern and an octagon pattern around the center approximating a circle.

In the improved method, the rood pattern is used to determine the direction of the search. If the center is not the optimal point when searching the five points in the rood pattern, the direction from the center to the optimal point will be used in the following search. The process will be repeated until the optimal point is in the center, and the stride length of the loop should not be greater than the parameter ‘iRaster’, exactly as paper [9], setting a threshold to terminate the initial search in advance.

The improved process of the initial search step is as follows:

1. Search the five points in the rood pattern while the stride length is 1. If the optimal point is the center (i.e. Point 1 in Fig. 2), the initial search is finished.

2. If the optimal point is on the top, bottom, left or right of the center, search four points in the octagon pattern which are chosen according to the direction from the center to the optimal point. For example, if the optimal point is Point 2 in Fig. 2, search Point 6, 7, 8 and 9 in the octagon pattern.

3. Multiply the stride length by 2 and repeat the above-mentioned two processes. The initial search step is finished until the stride length is greater than the parameter ‘iRaster’.

Because 58.05% of motion vectors are in the center, the number of the search points of the improved method in this paper can be calculated as follow:

\[ N = 1 + (4 + 4 \times (1 - 0.5805)) \times n \]

The speed improvement rate (SIR) is:

\[ SIR(\%) = \frac{M - N}{M} \times 100\% = (2.322 \times n - 4) \times 100\% \]

When the parameter ‘iRaster’ is 5, the search round is 3 (ceiling of \( \sqrt{5} + 1 \)), and the SIR is 14.12%, which means that in a 5*5 search window, 14.12 percent of the search points can be reduced which drastically speeds up the encoding.

4. Experiment results

The experiments validate the proposed improved TZSearch algorithm on the reference software JMVC8.5, running on Win 7 64-bit operating system, Intel Core i7 920@2.67 GHz, 6 GB RAM, using the standard testing sequences, ballroom, exit and vassar which are provided by MERL [14]. The parameter ‘QP’ adopts 24, 28, 32 and 36 separately, ‘searchrange’ is 64, ‘GOP’ is 12 and the threshold ‘iRaster’ is 5. All of the sequences are 25 fps and 640 * 480 frame size. Each sequence is encoded of 8 views while each view contains 100 frames. The PSNR in the experiments is calculated by the formula: PSNR = (Y-PSNR * 4 + U-PSNR + V-PSNR) / 4. The values of PSNR, bitrate, runtime and total encoding are the average of 8 views which are presented in Table 2, and the RD curves of the three sequences are illustrated in Fig. 3.

The three standard testing sequences, ballroom, exit and vassar are belong to different kinds of movement sequences. In ballroom, the movement of the background is slow while the movement of the foreground is moderate. The backgrounds of exit and vassar are both static while the foregrounds are moderate movement and rapid movement separately. In the results, it can be obviously seen that the runtime of the improved TZSearch algorithm is drastically reduced 80% and the total encoding time decreases almost 40% while the PSNR and the bitrate are approximately unchanged compared with the original TZSearch algorithm in different kinds of movement sequences.


5. Conclusion

In this paper, improved methods for TZSearch algorithm are proposed to reduce the encoding time of multiview video while maintaining PSNR and bitrate. The octagon-based search pattern is adopted in the initial search step which increases the accuracy of predicting motion vector according to the directional center-biased characteristic. In addition, a threshold is set to terminate the initial search in advance. These improvements dramatically reduce the number of the search points and speed up the multiview video coding. The experimental results demonstrate that the encoding time is drastically reduced while the PSNR and the bitrate are approximately unchanged, which benefits the realization of the real time multiview video coding. Further research will be reducing the encoding time of the refinement search step of TZSearch algorithm while both PSNR and bitrate are negligible impaired.

6. Acknowledgment

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7. References