DOI: 10.53469/jissr.2022.09(03).35

An Improved Fast Motion Estimation Algorithm in H.266/VVC

Jiabo Wang[1], Jing Yang[2]

[1,2]Shanghai Maritime University, College of Information Engineering, Shanghai, China
[1]*wangjiabo9606@163.com*, [2]*jingyang@shmtu.edu.cn*

Abstract: ***Motion estimation is a key technique of video compression coding, H.266/VVC (Versatile Video Coding) inter TZsearch fast motion estimation algorithm using the diamond search model, although the search model matching precision is high, but because of the number of search points need to match, so the computational complexity is higher also, for this defect, the article on the basis of the standard algorithm, The fast algorithm of TZSearch is optimized and improved. Firstly, the hexagonal search model with excellent performance and speed is used to replace the diamond search model in the standard algorithm. Secondly, on the basis of the rotation hexagon model, the number of initial matching search points of the rotation hexagon search model is further increased by using the feature of natural video prediction MV center bias. At the same time, a reasonable early termination threshold is set for the whole motion estimation process. Simulation results show that compared with VTM14.0 standard algorithm, the proposed algorithm reduces BDBR by 0.17% and BDPSNR by 0.04dB on average, and the overall coding time is saved by 48.85% on average. The proposed algorithm can effectively reduce the computational complexity of motion estimation process on the premise of guaranteeing the coding quality.***

Keywords: Motion estimation, Tzsearch, Early termination, Hexagonal search, Diamond search.

1. Introduction

The main function of motion estimation technology is to use the strong similarity between consecutive image frames to reduce the temporal information redundancy between image frames during encoding[1]. Since inter-frame prediction is an important part of the H.26/VVC video coding framework, it accounts for about 50% to 70% of the entire coding time, and the motion estimation process is the main component of inter-frame prediction, so in recent years Many scholars have studied and improved motion estimation techniques[2].

Reference[6] optimizes the UMHexagons algorithm in the H.264 standard. First, only the spatial prediction method is used to predict the search starting point. For the situation where the best matching point in the spatial prediction has a relatively large probability of appearing in the median prediction, a threshold judgment process is added to the termination prediction. At the same time, the asymmetric cross search template in the algorithm is optimized, and the motion mode of the object is judged in advance according to the size of the horizontal and vertical components of the motion vector predicted in the previous step, so as to decide different search modes. Reference[7] uses a small rhombus as a starting matching template, then transitions to a hexagonal matching template, and finally uses a square matching template to refine the search for motion vectors. This algorithm is highly applicable to video sequences with various image textures. Compared with the traditional motion estimation algorithm, the speed is also improved. Reference[8] proposed a motion estimation algorithm based on motion decomposition estimation. This method uses the principle of matrix decomposition to decompose the global motion into inter-frame motion and previous frame motion, which ensures the accuracy of the motion estimation algorithm under the condition of rapid scene changes. Timeliness. Reference[9] proposed an asymmetric three-step search algorithm. The image first divides the current coded frame into fixed-size macroblocks as the basic compression unit, and then takes the center point of the macroblock as the center, and uses asymmetric three-step search. The algorithm searches for the center point of the best matching block and obtains the motion vector of the current coding block.

Aiming at the problem that the computational complexity of the inter-frame prediction motion estimation process in H.266/VVC is significantly improved compared to H.265/HEVC, this paper proposes an improved fast motion estimation algorithm. The proposed method first replaces the diamond matching model in VTM14.0 with a rotating hexagonal matching model with excellent speed and performance, which reduces the number of matching search points; secondly, based on the rotating hexagonal matching model On the one hand, the center offset of the predicted motion vector of the natural video sequence is used to further increase the number of search points for the initial matching of the rotating hexagon search template, and at the same time, a reasonable early termination threshold is set for the entire motion estimation process. The overall required encoding time is reduced.

2. Motion Estimation Technology

The common motion estimation methods at this stage are all based on the idea of block matching. The process of this method in the motion estimation process is generally as follows: first, each frame of image in the image sequence is divided into non-overlapping blocks, and a coding block is divided into blocks. When performing motion estimation, it is considered that all pixels in the coding block have the same motion vector, and then a search area is set for each coding block, and the block that is most similar to the current coding block is found according to the block matching criterion. The displacement between the optimal matching block and the current coding block is its motion vector, as shown in Figure 1 below. Common motion estimation algorithms including block matching ideas include diamond search algorithm, hexagon search algorithm and TZSearch search algorithm.

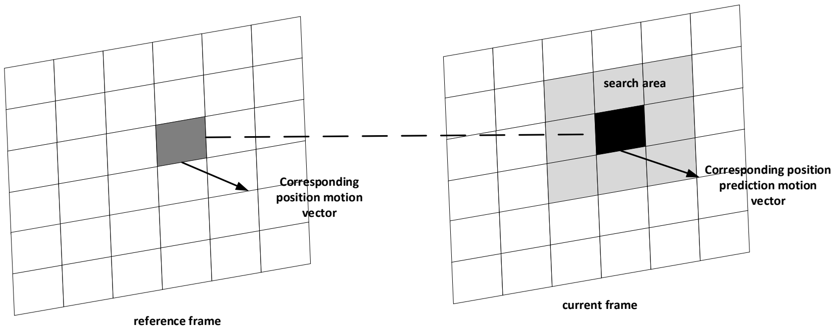


Figure 1: Schematic diagram of motion estimation

2.1 Diamond Search Algorithm

The diamond search algorithm utilizes the center offset characteristic of the motion vector. As shown in Figure 2 below, starting from the center of the search area, a large diamond search is performed first and rough matching is performed according to certain matching criteria. The large diamond template consists of 9 steps of 2 points. If the optimal matching point searched in the rough matching stage is in the center of the search template, the small diamond-shaped template is used for the refined search. The small diamond-shaped search template consists of 4 pixel points with a step size of 1. The obtained optimal matching point is the center of the search template, then the motion estimation process of the current coding block ends, otherwise, the current optimal matching point is used as the center to continue to use the large diamond and the small diamond to search until the optimal matching point is the small diamond template. Up to the midpoint. The search shape of the diamond search algorithm can cover most of the search area, which ensures the accuracy of the diamond search algorithm. At the same time, the diamond search algorithm can flexibly convert search templates when dealing with video sequences of different texture complexity. First, the large diamond template is used for rough positioning, in order to avoid the searched optimal point entering the local optimum when using the small diamond template; After the rough positioning is completed, a small diamond template is used for precise positioning[10].

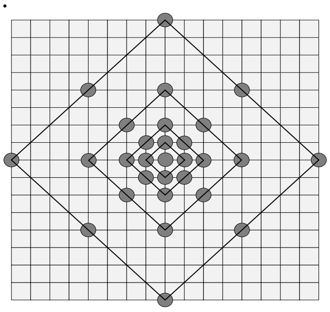
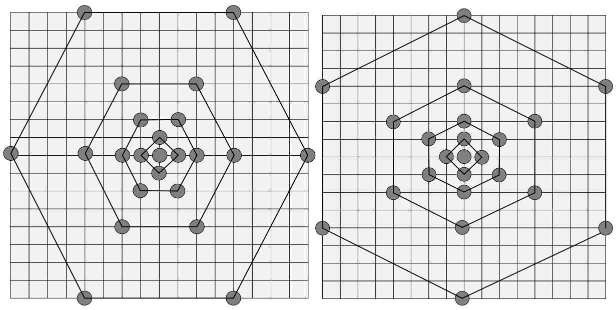


Figure 2: Diamond search model

2.2 Hexagonal Search Algorithm

The hexagonal search algorithm is similar to the diamond algorithm, because the number of pixels that need to be matched in the search process is less than that of the diamond search algorithm, so the matching speed of the hexagonal search algorithm is slightly better than that of the diamond algorithm. It is widely used in motion estimation algorithms[13]. The basic process of the algorithm is: first, use the hexagonal template (horizontal or vertical direction) to perform block matching calculation on the search points. The hexagonal search template includes a total of 7 search points including the starting point. In the rough search stage, if the optimal matching point is the center of the template, the small quadrilateral template is used to perform a refined search on the basis of the center point. If the optimal point searched by the hexagonal template is not the center point of the template, continue to use this center point as the center to perform the hexagonal template search until the optimal point is the center of the search model. The difference between the hexagonal model and the diamond model is that the number of search points in each round is different. The diamond model has 8 search points in one round, and the hexagonal model has 6 search points in one round. Therefore, the hexagonal model has 6 search points. The search time is theoretically 23% less than that of the diamond model, but its accuracy is not as good as that of the diamond model.



(a) (b)

Figure 3: Horizontal Hexagon Model and Vertical Hexagon Model

2.3 TZSearch Search Algorithm

The fast motion estimation search algorithm used in VTM14.0 is Tzsearch. The specific steps of the algorithm are as follows:

Step 1: Use Advanced Motion Vector Predicton (AMVP) to determine the search starting point of the motion estimation process;

Step 2: First, use a small diamond search template with a step size of 1 to perform search point matching in the set search area, and then perform search point matching in a step size increase method of a power of 2, and calculate the rate distortion of each search point. Select the search point with the smallest rate distortion as the optimal matching point in this step;

Step 3: Check the search step size of the optimal matching point in the second step. A refined two-point search is performed around the matching point, as shown in Figure 4. The purpose of the two-point refined search is to perform a supplementary search for the points that have not been searched;

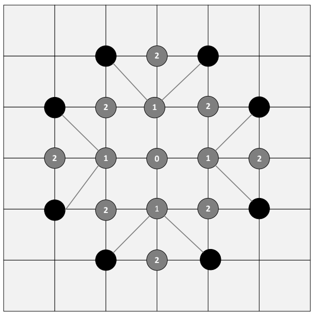


Figure 4: Two-point refinement search

Step 4: Check the step size of the matching search template in step 2. If the search step size is greater than the threshold set by the algorithm, take the current optimal point as the search center, conduct a full search and select the minimum rate-distortion search in the full search area. The prime point is used as the optimal point;

Step 5: The optimal point obtained by the matching in step 4 is used as the new search starting point, and steps 2 to 4 are repeated for the purpose of further refining the search. When the optimal matching points obtained by the quantization search are the same, the current motion vector is used as the real motion vector of the coding block.

3. Algorithm Research of Rotating Hexagon Model

3.1 Defects of Basic Hexagon Model

In the current mainstream video coding standards, the more common motion estimation search models include the diamond model and the hexagonal model. Compared with the diamond search model, the hexagonal search model has significant advantages in coding efficiency. Assuming that the size of the search window is 64×64 pixels, when using the diamond template to search, 6 large diamond boxes are needed for searching, each large diamond box contains 8 search points, and a small diamond search box in the middle is also included. , the box contains 4 search points, and a total of 52 search points need to be matched and calculated, as shown in Figure 2; when using the hexagonal search model to search the search box, six hexagonal searches are also required to search, each hexagonal box contains 6 search points, and also contains a small diamond box containing 4 search points, a total of 40 points that need to be matched and searched, as shown in Figure 3. Obviously, the hexagonal model search template is more efficient than the diamond search model, and the time required is shorter, which saves about 23% of the search time. However, compared with the diamond search model, the cost of saving time in the hexagonal search model is that the quality of the reconstructed video image after encoding is slightly degraded. The fundamental reason is that the diamond search template contains motion estimation searches in 8 directions. The hexagonal search template only includes motion estimation searches in 6 directions, and the accuracy of the motion vector obtained by motion estimation is lower than that of the diamond template.

3.2 Rotated Hexagon Model

After the above analysis, it is found that a single horizontal or vertical hexagon search algorithm has certain shortcomings in the motion estimation process. The vertical hexagonal search template and the horizontal hexagonal search template are combined to form a rotated hexagonal search template, which is used to replace the diamond search template in the Tzsearch motion estimation algorithm. The basic idea is that in the search area, the small diamond search template in the conventional hexagonal search is used in the first round. If the vertical hexagonal search template is used in the second round of search, the horizontal six is used in the next round of search. Hexagonal search template, vertical and horizontal hexagonal search templates are used alternately. It can be found that the rotating hexagon search algorithm proposed in this paper has the following advantages. The search model can take into account the motion estimation in the horizontal and vertical directions. At the same time, in the specific motion estimation process, the number of search points to be matched is not limited. So the rotating hexagon search model has a better matching speed than the diamond search template while having good matching accuracy.

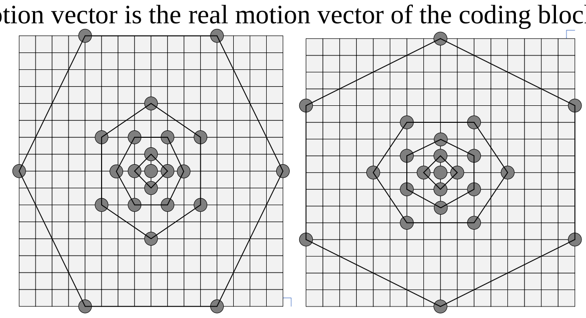
The specific search steps of the rotating hexagon search algorithm are as follows:

Step 1: Use advanced motion vector prediction technology to determine the starting point of the rotating hexagon matching search;

Step 2: Use the rotating hexagon to search for the initial small diamond in the model The model performs a preliminary search for the motion vector of the encoded block, and then performs further search point matching with an integer power of 2 incrementing step size;

Step 3: If the best matching point obtained in the second step is the small value used in the initial search. For the search point in the rhombus template, two points are searched near the search point to further refine the accuracy of the motion vector. If the step size of the optimal matching point obtained in step 2 is greater than a certain threshold, perform a full search in the remaining search range to find the optimal matching point;

Step 4: Take the optimal point obtained in step 3 as the new Start the search point, repeat steps 2 and 3, if the position of the optimal point found by the two matching searches is the same, stop the matching search process, that is, the current motion vector is the real motion vector of the coding block.



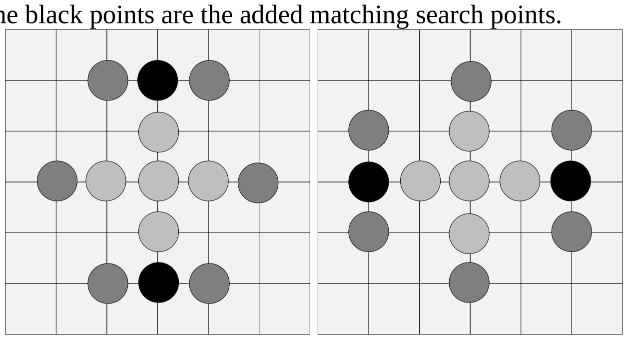
(a) (b)

Figure 5: Two rotating hexagon models

3.3 Enhanced Rotated Hexagon Model

The study found that the final real motion vector of the coding block has the characteristics of center offset, which means that when the video image sequence is compressed and encoded, the moving objects in the image have the same magnitude and speed of motion between consecutive frames. Within a range, for coding blocks containing moving objects, most of the optimal matching points appear around the initial search point. For video sequences containing natural motion, studies have shown that more than 76% of the motion vectors of coding blocks between the two frames are distributed in the initial search point (±2,0) and (0,±2) pixel units surrounded by Therefore, in the process of motion estimation, the probability that the search matching point in the initial small diamond search template becomes the optimal point is much larger than that of the surrounding matching points with larger step size .

The analysis found that in the first round of small diamond search and the second round of hexagonal search, all possible matching points of the hexagonal search template include the five light gray search points in the first round of search in Fig. The six dark gray search points in the second round of hexagonal template search, in the search process of the first two rounds of matching points, ignore the two points in the vertical or horizontal direction that are more likely to be the optimal matching points, such as shown by the black dots in Figure 7. In all motion estimation search algorithms, the accuracy of the early search points has a great influence on the search of the final optimal matching point. Therefore, this paper considers further improvement on the basis of the rotating hexagonal search, that is, when searching for the initial small diamond template in the rotating hexagon search template, two matching search points are added in the horizontal and vertical directions. The final preliminary search template of the rotating hexagon search algorithm is shown in Figure 7, with a total of eight search points, of which the black points are the added matching search points.



(a) (b)

Figure 6: Defective small diamond model

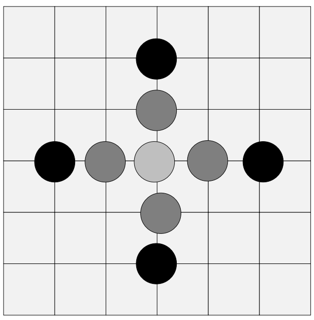


Figure 7: Enhanced small diamond model

At the same time, in order to reduce the amount of calculation when using the enhanced rotating hexagon search template for motion estimation, the algorithm in this paper sets a judgment threshold for whether the second round of hexagon search is carried out. The threshold value is set by calculating the rate-distortion cost value of the starting search point and the rate-distortion cost value of the surrounding 8 search points at the end of the first round of search using the small diamond template, and calculating the rate-distortion cost value of the surrounding 8 positions at the same time. The difference between the distortion cost value and the rate-distortion cost value of the starting point search point. If the ratio of the obtained difference to the rate-distortion cost value of the starting search is less than the set threshold, the optimal point matching search process continues to use rotation Hexagonal search template, and if the number of search rounds is greater than 7, it will enter the full search mode to find the best matching point, otherwise it will skip the matching calculation of the subsequent search points, and directly use the initial 9 matching search points. The search point with the smallest distortion value is taken as the optimal point. After the initial incremental search for the rotated hexagon is enhanced and optimized, the complete flow of the algorithm proposed in this paper is shown in Figure 8.

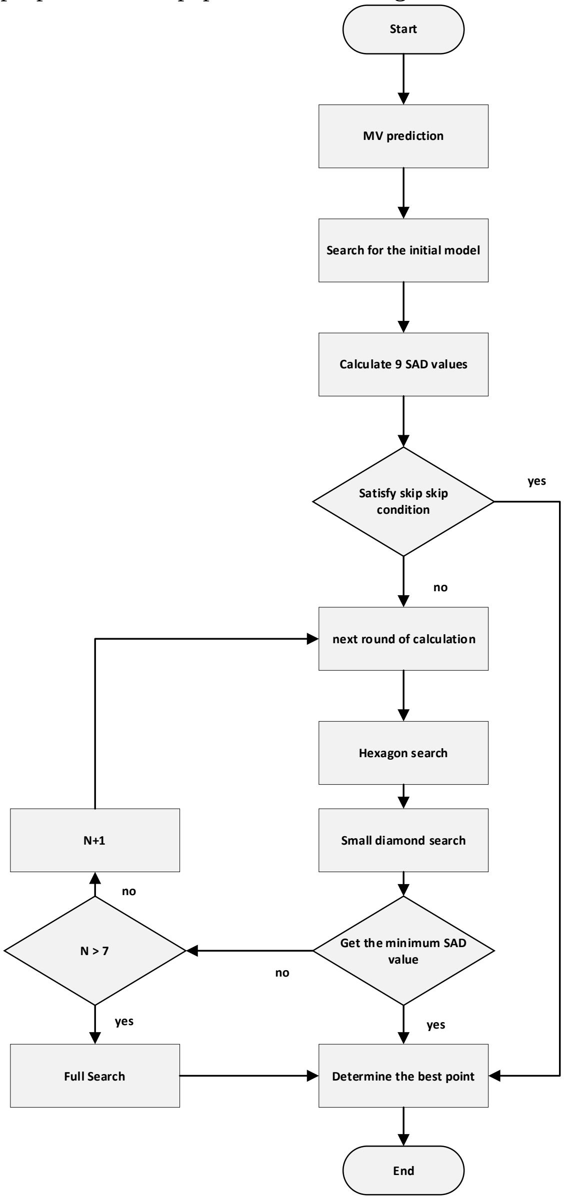


Figure 8: The algorithm flow chart of this paper

In order to set the threshold more reasonably, this paper dynamically adjusts the threshold, and then determines the final threshold used in the algorithm according to the quality and coding efficiency of the reconstructed video image after encoding with different thresholds.

4. Experimental Simulation

4.1 Simulation Environment Settings

The algorithm simulation in this paper takes the H.266/VVC standard reference software VTM14.0 as the platform, the configuration file is encoder_lowdelay_vtm.cfg, the quantization parameters are 22, 27, 32 and 37, the encoding test sequence is the officially recommended video sequence, and the test range is for all video sequences from class A to class F. The hardware simulation environment of the experiment is 11th Gen Intel(R) Core(TM) i5-1135G7 CPU, the main frequency is 2.42GHZ, the memory is 16GB, and the integrated development environment is VS 2019. The experimental encoding performance is measured by the bit change rate BD-BR and the percentage reduction in encoding time ΔT. Among them, BD-BR represents the average change of the code rate under the condition that the image quality is not degraded, that is, the PSNR is consistent. If BD-BR is a negative number, it means that the code rate is saved; on the contrary, it means that the code rate has increased. ΔT is a negative number, which means that compared with the VVC standard algorithm, the proposed algorithm can reduce the time required for encoding the same test sequence; on the contrary, it increases the time required for encoding the same test sequence. Among them, the calculation method of ΔT is shown in the following formula (1):

$$\Delta T=\frac{1}{4}\sum_{i=1}^{4}\frac{T_{test}^{i}-T_{std}^{i}}{T_{std}^{i}}\times 100\% \qquad (1)$$

where i represents four different quantization parameters, T_{test}^{i} represents the time required for encoding the algorithm proposed in this paper under a certain quantization parameter, and T_{std}^{i} represents the time required for the standard algorithm to encode the same video sequence.

4.2 Simulation Results of the Rotating Hexagon Model Algorithm

Table 1 shows the performance comparison of motion estimation using rotated hexagons and conventional hexagon search algorithms. The experimental simulation results show that compared with the VTM14.0 standard algorithm, the rotating hexagon search algorithm reduces the overall coding time by 17.28% on average, the BDBR only increases by 0.16%, and the BDPSNR value decreases by 0.03dB; while the conventional hexagon search model Compared with the VTM14.0 standard algorithm, the overall encoding time is reduced by 18.37% on average, but its BDBR has increased by 0.34%, and the BDPSNR value has decreased by 0.05dB, indicating that the code rate after encoding compression is compared with that of rotating hexagon search. The algorithm is 2.1 times higher, and according to the BDPSNR value, it can be found that compared with the conventional hexagon search algorithm, the rotated hexagon search algorithm can obtain better reconstructed image quality after encoding. Therefore, the rotating hexagon search algorithm can achieve a good balance between the time required for coding and the image compression rate. It not only maintains the excellent coding efficiency of the hexagon search algorithm, but also further improves the image compression rate and reduces the bandwidth required for video image transmission after compression and encoding improves the quality of the reconstructed video image.

Table 1: Rotated Hexagon Model Simulation Results

Class	Sequence name	Regular hexagon			Rotating hexagon		
		***BDBR*(%)**	***BDPSNR*(*dB*)**	**Δ*T*(%)**	***BDBR*(%)**	***BDPSNR*(*dB*)**	**Δ*T*(%)**
A	PeopleOnStreet	0.31	-0.04	16.22	0.05	-0.03	15.43
	Traffic	0.27	-0.03	17.27	0.03	-0.02	16.29
B	Cactus	0.29	-0.06	18.32	0.08	-0.02	17.29
	BasketballDrive	0.25	-0.05	16.54	0.07	-0.03	15.22
	BQTerrace	0.26	-0.04	14.12	0.06	-0.03	12.03
	MarketPlace	0.25	-0.04	15.35	0.07	-0.02	14.27
C	RaceHorsesC	0.43	-0.06	21.76	0.16	-0.04	20.26
	BQMall	0.57	-0.06	22.76	0.23	-0.06	22.38
	PartyScene	0.54	-0.08	24.23	0.25	-0.06	23.53
	BasketballDrill	0.49	-0.07	22.79	0.22	-0.05	22.07
D	RaceHorses	0.23	-0.05	13.53	0.06	-0.04	12.25
	BlowingBubbles	0.24	-0.07	18.23	0.08	-0.05	17.43
	BasketballPass	0.26	-0.05	13.23	0.07	-0.02	12.54
	BQSquare	0.24	-0.05	15.66	0.06	-0.03	14.33
E	FourPeople	0.62	-0.07	28.16	0.35	-0.04	27.25
	Johnny	0.48	-0.03	24.66	0.21	-0.01	23.52
	KristenAndSara	0.26	-0.03	19.96	0.09	-0.01	19.24
F	BasketballDrillText	0.27	-0.05	14.56	0.05	-0.03	12.55
	SlideEditing	0.24	-0.04	15.21	0.07	-0.02	14.36
	ArenaOfValor	0.32	-0.05	14.77	0.05	-0.03	13.33
	Average	**0.34**	**-0.05**	**18.37**	**0.16**	**-0.03**	**17.28**

4.3 Enhanced Rotation Hexagon Model Algorithm Simulation

4.3.1 Determination of Threshold

In order to improve the accuracy of the threshold, this paper dynamically sets the threshold according to the PSNR and the average number of skip search points, and encodes four video sequences with different motion types and resolutions to determine the threshold.

The left picture of Figure 9 below shows the change trend of PSNR in the four video image sequences with different resolutions under different threshold values, compared with the VTM14.0 standard algorithm and the proposed enhanced rotated hexagon search algorithm; The figure on the right shows that in the case of different threshold values, compared with the VTM14.0 standard algorithm, the number of search points reduced by the proposed enhanced rotating hexagon search algorithm in the motion estimation process accounts for the number of search points that the standard algorithm needs to match. The percentage value can reflect the computational complexity of the proposed algorithm under different thresholds. Through the simulation results, it can be found that the proposed algorithm can achieve a good balance between the reconstructed video image quality and coding efficiency by setting the threshold of early termination at about 0.5.

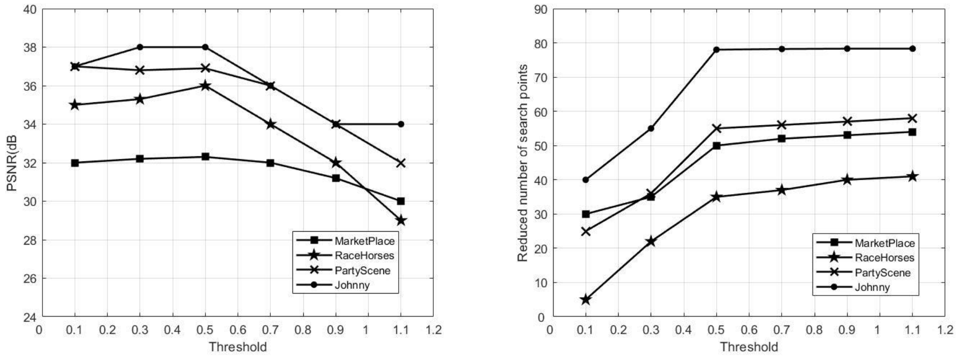


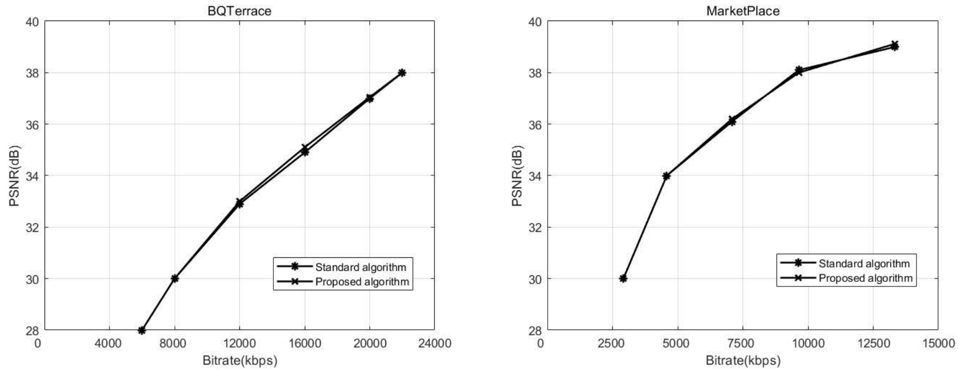
Figure 9: Thresholding Line Chart

4.3.2 Simulation results

Table 2 shows the motion estimation performance comparison between the fast-stop rotation hexagon search algorithm without adding the initial search point and the enhanced fast-stop rotation hexagon search algorithm with the addition of the initial search point. The experimental simulation results show that, compared with the VTM14.0 standard algorithm, the enhanced fast rotating hexagon search algorithm proposed in this paper, for the same video image sequence, pays an average cost of 0.17% BDBR and 0.04 dBBDPSNR, and the overall coding is the time was reduced by 48.82% on average. Compared with the VTM14.0 standard algorithm, the fast termination algorithm without adding the initial search point only calculates 5 search points in the first round of search, and the calculation amount is less than that of the enhanced fast termination hexagon search algorithm, so Compared with the standard algorithm, its overall encoding time is reduced by 51.30%, which saves more overall encoding time than the algorithm proposed in this paper, but its BDBR has increased by 0.34%, which is twice that of the algorithm in this paper, and the average BDPSNR is reduced by 0.09dB. , the loss of image quality is also slightly higher than the algorithm proposed in this paper. Therefore, it can be seen that the enhanced fast termination rotating hexagon search algorithm proposed in this paper can save the overall coding time of the video image sequence, and can better ensure the quality of the reconstructed image, so the algorithm performance is better.

Table 2: Enhanced Rotated Hexagon Experimental Simulation Results

Class	Sequence name	Quickly terminate a rotated hexagon model			Enhanced quick termination of rotating hexagon models		
		BDBR(%)	***BDPSNR***(***dB***)	Δ***T***(%)	***BDBR***(%)	***BDPSNR***(***dB***)	Δ***T***(%)
A	PeopleOnStreet	0.38	-0.07	54.66	0.11	-0.03	53.21
	Traffic	0.29	-0.11	53.74	0.09	-0.04	51.29
B	Cactus	0.15	-0.08	55.98	0.12	-0.02	52.25
	BasketballDrive	0.25	-0.05	56.14	0.10	-0.03	47.55
	BQTerrace	0.13	-0.06	39.98	0.09	-0.02	40.52
	MarketPlace	0.17	-0.05	41.27	0.10	-0.03	40.75
C	RaceHorsesC	0.44	-0.07	51.76	0.18	-0.05	47.55
	BQMall	0.30	-0.13	58.67	0.27	-0.04	57.64
	PartyScene	0.22	-0.06	59.29	0.31	-0.02	56.56
	BasketballDrill	0.32	-0.09	54.33	0.25	-0.03	52.97
D	RaceHorses	0.23	-0.11	43.53	0.08	-0.05	34.26
	BlowingBubbles	0.39	-0.07	41.88	0.11	-0.05	43.65
	BasketballPass	0.26	-0.05	43.23	0.09	-0.04	35.45
	Bqsquare	0.25	-0.07	43.65	0.13	-0.05	39.51
E	FourPeople	0.56	-0.19	76.09	0.38	-0.04	77.56
	Johnny	1.17	-0.07	65.71	0.26	-0.03	65.12
	KristenAndSara	0.26	-0.06	59.96	0.13	-0.03	60.54
F	BasketballDrillText	0.25	-0.13	44.27	0.17	-0.05	42.55
	SlideEditing	0.34	-0.09	39.79	0.21	-0.03	37.22
	ArenaOfValor	0.37	-0.11	41.99	0.27	-0.05	40.29
	Average	**0.34**	**-0.09**	**51.30**	**0.17**	**-0.04**	**48.82**



(a) (b)

Figure 10: RD curves before and after optimization

Figure 10 shows the rate-distortion graph of the video image sequences BQTerrrace and MarketPlace of the same resolution. The rate-distortion graph can reflect the performance of the encoder. Generally, the higher the point of the curve, the better the performance of the encoder. It can be seen from Figure 10 that the video image sequence of the same resolution, the coding performance of the algorithm proposed in this paper is very close to the rate-distortion curve of the coding performance of the VTM14.0 standard algorithm, which shows that the compression quality of the algorithm proposed in this paper is comparable to Standard algorithms are not much different. Because the motion of the content objects of the BQTerrace video image sequence is more intense, the texture complexity is higher than that of the MarketPlace video image sequence. It can be seen from the reduction of the specific encoding time of the two that the algorithm proposed in this paper changes in content. Better coding performance can be obtained in slow video image sequences.

Comparing the algorithm proposed in this paper with the TZSearch early termination motion estimation algorithm proposed in literature[21], the algorithm proposed in literature[21] reduces the time required for motion estimation by a large margin. Compared with the standard algorithm, Reference[21] saves 51.59% of the overall encoding time under the condition of paying 0.28% BDBR on average. The algorithm proposed in this paper, at the cost of only 0.17% BDBR, obtains a coding efficiency similar to that of the literature[21]. It can be seen that the algorithm proposed in this paper can effectively guarantee the coding efficiency under the premise of ensuring the coding efficiency. Reduce the bandwidth required for compressed transmission of video image sequences. Comparing the algorithm proposed in this paper with the optimal fast motion estimation algorithm based on the rate complexity distortion analysis model proposed in the literature[22], the algorithm proposed in the literature[22], the reconstructed video image quality and encoding efficiency after encoding A good balance is achieved between them, but when encoding the same video image sequence, the encoding speed is far less than the algorithm proposed in the literature[21] and this paper.

Table 3: Comparison of motion estimation performance of three different algorithms

references	BDBR(%)	ΔT (%)
[11]	0.28	51.59
[12]	0.01	21.4
Proposed algorithm	0.17	48.82

5. Conclusion

Based on the analysis and research of the traditional fast motion estimation algorithm of inter-frame TZsearch in H.266/VVC, an improved fast motion estimation algorithm is proposed. The algorithm first replaces the diamond search model in the VTM14.0 standard algorithm with a rotating hexagon search model with excellent speed and performance, in order to reduce the overall coding of video image sequences on the premise of ensuring the quality of the reconstructed image. Then, on the premise of replacing the rotation hexagon search model, this paper continues to propose an enhanced fast termination rotation hexagon search algorithm. The number of search points for the initial matching of the shape search template, and a reasonable early termination threshold is set for the entire motion estimation process. The experimental simulation results show that compared with the motion estimation algorithm in the VTM14.0 standard, the guaranteed compression Under the premise of the quality of the reconstructed video image after encoding, the algorithm in this paper can reduce the overall encoding time by 48.82% on average, which proves that the algorithm in this paper can effectively improve the computational complexity of H.266/VVC inter-frame prediction and reduce the need for encoding. In the future research work, based on the algorithm in this paper, the threshold for determining whether to quickly terminate the motion estimation process can be adaptively set, so as to further improve the image quality or reduce the coding complexity.

References

[1] S. Park and E. S. Jang. Comments on “Fast Motion Estimation Based on Content Property for Low-Complexity H.265/HEVC Encoder”. IEEE Transactions on Broadcasting, 2017, 63(4): 740-742.

[2] X. Li， R. Wang， X. Cui, et al. Context-Adaptive Fast Motion Estimation OF HEVC. 2015 IEEE International Symposium on Circuits and Systems (ISCAS), 2015: 2784-2787.

[3] P. A. Bhalge and S. Y. Amdani, Reduced Hexagonal Search Algorithm for Fast Motion Estimation.2018 3rd International Conference on Communication and Electronics Systems (ICCES), 2018: 291-293.

[4] D. T. Nghia, T. S. Kim, H. Lee, et al. A modified TZ search algorithm for parallel integer motion estimation in high efficiency video coding. 2015 International SoC Design Conference (ISOCC), 2015: 97-98.

[5] R. Garg and K. B. Ravi Teja. A High-Speed Pipelined Architecture for Block Motion Estimation Using Hexagon-Based Search Algorithm. 2018 15th IEEE India Council International Conference (INDICON), 2018: 1-4.
[6] P. Arnaudov and T. Ogunfunmi. Adaptive search pattern for fast motion estimation in HD video. 2017 51st Asilomar Conference on Signals, Systems, and Computers, 2017: 173-177.
[7] N. A. Hamid, A. M. Darsono, N. A. Manap, et al. Adaptive Diamond Orthogonal Search Algorithm for Motion Estimation. 2015 International Conference on Computer, Communications, and Control Technology (I4CT), 2015: 498-501.
[8] G. Choi, P. Heo and H. Park. Triple-Frame-Based Bi-Directional Motion Estimation for Motion-Compensated Frame Interpolation. IEEE Transactions on Circuits and Systems for Video Technology, 2019, 29(5): 1251-1258.
[9] Y. Lai and L. Lien. Fast Motion Estimation Based on Diamond Refinement Search for High Efficiency Video Coding. 2019 IEEE International Conference on Consumer Electronics (ICCE), 2019: 1-2.
[10] S. Gogoi and R. Peesapati. A Hybrid Motion Estimation Search Algorithm for HEVC/H.265. 2019 IEEE International Symposium on Smart Electronic Systems (iSES) (Formerly iNiS), 2019: 129-132.
[11] Jia L, Tsui C Y, Au O C, et al. A new rate-complexity-distortion model for fast motion estimation algorithm in HEVC. IEEE Transactions on Multimedia, 2018, 21(4): 835-850.

Author Profile

Jiabo Wang studied at Shanghai Maritime University for the master degree from 2019 to 2022, and the research direction is image communication and video coding and decoding.