# 비디오 영상에서 통계적 영상특징에 의한 블록 모션 측정

## Statistical Image Feature Based Block Motion Estimation for Video Sequences

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요 약

이 논문에서는 비디오 영상에서의 블록 모션 측정을 위한 통계학적인 특징에 기반 한 알고리즘을 제안한다.

우선 참조 블록의 통계학적인 특징을 구하고, 이를 참조 블록의 통계적 특징과 정규 시작점 패턴 (SPP) 에 퍼져 있는 블록에서의 특징을 비교하여, SPP에서의 시작점 (SP) 후보를 선택 하는 데에 적용한다. 최종적인 SP 들은 SP 후보 들에서의 *평균절대차이 (MAD)* 값으로 구한다.

마지막으로 기존의 고속탐색 알고리즘인 BBG나 DS 그리고 TSS 중 하나를 이용하여 참조블록의 모션 벡터를 최종 SP를 시작점으로 하여 계산하였다.

실험결과는 기대 했던 바와 같이 최종 SP로부터 의 시작점들이 전역최소값 (*global minimum*)에 근접 함을 보여 주었다.

**Abstract**

We propose a block motion estimation algorithm based on a statistical image feature for video sequences.

The statistical feature of the reference block is obtained, then applied to select the candidate starting points (SPs) in the regular starting points pattern (SPP) by comparing the statistical feature of reference block *with that of blocks which are spread over regular SPP.* The final SPs are obtained by their Mean Absolute Difference(MAD) value among the candidate SPs.

Finally, one of conventional fast search algorithms, such as BBGDS, DS, and three-step search (TSS), has been applied *to generate the motion vector of reference* block using the final SPs as its starting points.

The experimental results showed that the starting points from final SPs were as close as to the global minimum as we expected.

## I. Introduction

Motion estimation plays an important role in video coding and processing, because it reduces the temporal *redundancy between the successive frames of video. Among the various types of motion estimation algorithms,* block matching technique has been adopted in many applications owing to its simplicity. The full search (FS) block matching algorithm is the simplest, but requires huge computations. So, many fast algorithms have been suggested, such as the three-step search(TSS)[1], the conjugate directional algorithm[2], the new three-step algorithm[3], and the block-based gradient descent algorithm(BBGDS)[4]. The main aim of them was to reduce the computation time and complexity by searching the eligible checking points in a search window. However, these fast algorithms had the local minimum problem due to their assumption: the error space that is composed of the block matching distortion over all blocks in a search window be unimodal. It means that distortion function increases monotonically as the search point moves away form the global minimum[5]. Unfortunately, the distortion function is usually not true in real-world video sequences. Consequently, the minimum value on error space extracted by these fast algorithm is often higher than that extracted by full search algorithm(FSA). In order to overcome this failure, Y. L. Chan[6] has suggested the edge-assisted search algorithm(EAS) that uses the edge in a block by modifying search points pattern(SPP) which are perhaps nearby global minimum on error space.

We have developed the search algorithm in order to modify SPP in a search window using statistical feature of each block. The statistical feature of each block makes the final starting points(SP) as close as possible to global minimum on error space. In this paper, the histogram is used as statistical feature. Section II describes the detail of proposed search algorithm, and the experimental results were shown in section III. Finally, the conclusion is drawn in section IV.

## II. Histogram-Based Search(HBS) Algorithm

The histogram is used as statistical image feature in this paper due to its simplicity and well-represented distribution of pixel value. First of all, the histogram of reference block is obtained, and then it is compared to that of blocks located at regular SPP that are distributed evenly across the search window. When the histogram of block associated with one point of the regular SPP is similar to that of reference block, it will be one of the candidate SPs. The cost function, which is called histogram similarity score(HSS), justified the similarity of two histograms. That is

$$HSS(u,v)=\sum_{i=0}^{255}N(h_r(i),h_c(i)) \qquad (1)$$

where $$N(x,y)=\begin{cases}1, & |x-y|\le\beta\\ 0, & else\end{cases}$$

where, (u,v) means the candidate starting point, and hr(i) is the histogram of reference block, hc(i) is the histogram of candidate block in a search window, is pre-defined threshold value, and N() means the threshold function defined by difference of two histogram. The HSS represents the similarity of intensity distribution of two blocks to be compared. In next step, the final SPs are selected by their mean absolute difference(MAD) among the candidate SPs.

$$SP_n=\begin{cases}1, & MAD_n - MAD_{\min}\le\mu\\ 0, & else\end{cases} \qquad (2)$$

where, if SPn is 1, this point is selected to final SP, MADn is MAD value of candidate SPn, is the pre-defined threshold value, and MADmin is the minimum value in the candidate SPs. According to these steps, the final SPs are determined for starting point of conventional fast algorithm, such as BBGDS, three-step, and diamond searching. Fig. 1. shows the pseudo code for proposed algorithm

## III. Experimental Results

Four video sequences were used for test sequences in the experiment. They consisted of two real-world video sequences, which include tilt down camera motion and zoom out camera motion respectively, Susie, and Table tennis. In our experiments, the block size is fixed at 16x16, and the range of search window is 15 pixels, in both horizontal and vertical directions respectively. Also we have set the threshold value, and , to 3 and 5, respectively. We have used the mean absolute difference(MAD) as the objective function for block motion estimation and selecting the final SPs in the candidate SPs. The MAD value is as follow.

$$MAD(u,v)=\sum_{i=0}^{16}\sum_{j=0}^{16}\left|I_t(i,j)-I_{t+1}(i+u,j+v)\right| \qquad (3)$$

where, (u,v) means the candidate motion vector, It(,) and It+1(,) refer to the blocks in the current frame and in the reference frame which are to be compared. In the experiments, we used the mean square error(MSE) per pixel as the measure of performance. Each video sequence is processed by three search algorithms: full search algorithm(FSA), block-based gradient descent search(BBGDS), and BBGDS based on the proposed search scheme. FSA is, as mentioned before, the most accurate strategy that exhaustively evaluated all candidate points within a search area, however, requires the huge amount of computational burden. BBGDS evaluates the point in a specific search pattern. The minimum point within the search pattern is to determine the grddient descent direction, and of thier search procedure moves the searching path in a gradient descent direction to obtain the global minimum which has the best matcning block. The degree of computational complexity of each algorithm with respect to full search algorithm and MSE is calculated. The experimental results are shown in Table 1 and Fig. 2. Table 1 showed the result of each block matching algorithm in terms of its complexity and average MSE value. Additionally, Fig. 2 depicted the MSE value of each algorithm for each test video sequence frame by frame. The experimental results show that the complexities of HBS are slightly higher than that of BBGDS, but the performances of HBS is higher than that of BBGDS.

## IV. Conclusion

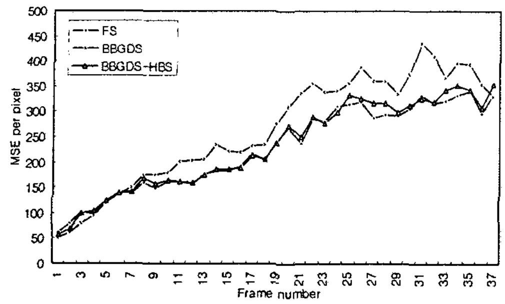
In this paper, we have proposed the new search algorithm for block motion estimation. The proposed search algorithm based on statistical feature, which is histogram in this paper, in order to modify SPP for reducing computational complexity and increasing performance. The results showed the performance of the proposed search scheme is better than that of BBGDS and is closer to that of FSA. However, the proposed search algorithm had some weaknesses to video sequence that had only object moving, in case of Table tennis. This weakness would be reduced in further researches.

```
Hr = Get_Historam(Reference_Block);
for i=0:number of SPP
  Hc = Get_Histogram(SPP_Block(i));
  if(HSS(Hr,Hc)>Threshold for HSS)
    Set SPP(i) to Candidate_SP;
End
MADr = Calculate_MAD(Reference_Blcok);
For i=0:number of Candidate_SP
  MADc = Caculate_MAD(Candidate_SP_Block(i));
  if((MADr-MADc)<=threshold)
    Set Candidate_SP(i) to Final_SP
End
For i=0:number of Final_SP
  Set Final_SP(i) to the starting point of fast algorithm
  Do_Block_Matching(Final_SP(i));
  MAD(i)=Calculate_MAD(Final_SP(i));
End
Find the minimum MAD(i)
Set Final_SP(i) to moving vector
```

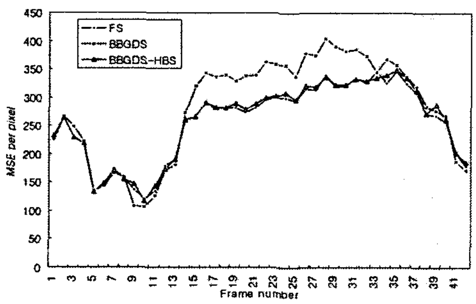
Fig. 1. The psuedo code of the proposed HBS algorithm

Table 1. Comparison of Computational Complexity for various Algorithms

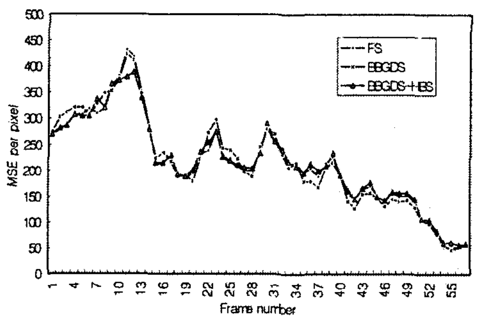
| | DOWN | | OUT | | SUSIE | | TABLE TENNIS | |
|---|---|---|---|---|---|---|---|---|
| | Complexity | Avg.MSE | Complexity | Avg.MSE | Complexity | Avg.MSE | Complexity | Avg.MSE |
| FSA | 100% | 226.8 | 100% | 257.6 | 100% | 216.2 | 100% | 285.6 |
| BBGDS | 1.15% | 264.7 | 1.3% | 283.3 | 1.11% | 216.8 | 0.38% | 292.7 |
| BBGDS + HBS | 1.84% | 231.6 | 2.52% | 260.4 | 1.38% | 217.5 | 0.96% | 318.3 |



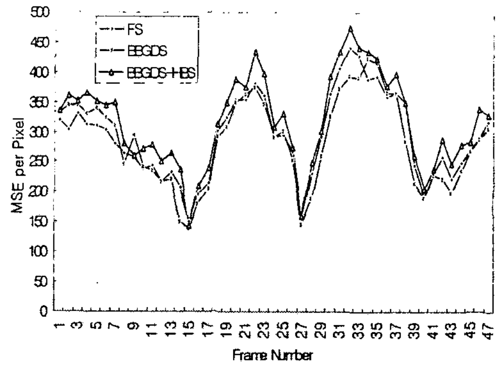

(a) DOWN




(b) OUT




(c) SUSIE




(d) TABLE TENNIS

Fig. 2. MSE produced by the proposed search algorithm to 4 different video sequences

## References

[1] T. Koga, K. Iinuma, A. Hirano, Y.Iijima, and T. Ishiguro , "Motion compensated interframe coding for video conferencing," in Proc. NTC 81, C9.6.1-9.6.5, 1981.

[2] R. Srinivasan and K.R. Rao, "Predictive coding based on efficient motion estimation," IEEE Trans. Commun., Vol.COM-33, pp. 1011-1015, 1985

[3] R.L. Li, B. Zeng, and M. L. Liou, "A new three-step search algorithm for block motion estimation," IEEE Trans. On Circuits Syst. Video Technol., Vol. 4, pp. 438-442, 1994.

[4] L. K. Liu and E. Feig, "A block-based gradient descent search algorithm for block motion estimation in video coding," IEEE Trans. Circuits Syst. Video Technol., pp. 419-422, 1996.

[5] M. Bierling, "Displacement estimation by hierarchical block matching," Proc. SPIE, Vol. 1001, pp. 942-951, 1998.

[6] Y. L. Chan and W. C. Siu, "An efficient search strategy for block motion estimation using image feature," IEEE Trans. Image Proc., Vol. 10, No. 8, pp. 1223-1238, 2001.

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