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Adaptive adjustment of the search window for block-matching algorithm with variable block size

Hwang-Seok Oh and Heung-Kyu Lee

Department of Computer Science,
Korea Advanced Institute of Science and Technology(KAIST),
373-1, Kusong-Dong, Yusong-Gu, Taejon,
Republic of Korea, 305-701
E-mail: {hsoh,hklee}@casaturn.kaist.ac.kr

Abstract—**An adaptive adjustment of the search window for block-matching algorithm(BMA) with variable size of the block is presented to reduce the computational complexity of full search BMA(FSBMA). The size of the search window is adjusted by using the block similarity and the displaced block difference(DBD). Experiments with test video sequences show that the presented scheme has good MSE performance and less complexity compared with FSBMA and other previous works.**

I. Introduction

Motion estimation & compensation techniques have been widely used in video compression due to their capability of reducing the temporal redundancies between frames. Most of the algorithms developed so far are block-based techniques, called block-matching algorithm(BMA), that estimate a motion vector(MV) for a given block. The general approach for BMA is to use full search block-matching algorithm(FSBMA). In FSBMA, all possible $(2w+1)^2$ candidate blocks are compared to obtain the best matched block, where w is allowable displacement.

Because of the intensive computation to get MV or displacement of the block that has the smallest distortion function of the matching criterion in FSBMA, many fast search algorithms such as three step search(TSS), new three step search(NTSS), 2-D logarithm search, one at a time search algorithm(OTS), and parallel hierarchical 1-D search(PHODS), etc., have been investigated. But there is a critical problem on these techniques: falling into a local-minimum, owing to the assumption that the distortion increases monotonically as the searched point moves away from the position of minimum distortion. Another approach to reduce the computational complexity is an adjustment of the size of search window , which has been suggested in [1,2,3]. In [1], a method to reduce the size of search window in TSS according to the magnitude of the DBD was presented. The approach proposed in [2] set the size of search window to in proportion to the DBD of blocks. The method, called an adaptive adjustment of search window(AASW) for BMA, exploits the motion correlation of spatially neighboring blocks to determine the search origin and adjusts the search range according to the different motion content of the block. The scheme is performed with three stages, (1)Set a search origin, (2)Determine the size of search window, and (3)Update the thresholds for classification of motion contents of block frame by frame. In the AASW, the size of search window is determined only considering the DBD of current block. That is, it assumes that the magnitude of MV is proportional to the magnitude of the DBD, i.e. if the best matched candidate block in the reference block is far away from the search origin, then, the DBD becomes very large. But, with the real test images, there is not a significant correlation between them. In [3], a dynamic adjustment of search window with fixed size of block(DASWF) is presented to improve the accuracy of motion estimation using block similarity as the similar manner in [2].

In this summary, a new BMA with dynamic adjustment of search window with variable size of the block(DASWV) is presented to improve the accuracy of MV and to reduce the computational complexity. The DASWV uses the segmentation information of current frame to divide the frame into variable size of blocks. The size of search window for each block is determined by using the correlation of block similarity to adjacent blocks and their MVs.

II. Dynamic Adjustment of the Search Window with Variable Size of Block(DASWV)

In video sequences, especially for the low bit-rate applications such as video-phone or video-conferencing, the motion field is smooth and changes slowly frame by frame. The correlation between MVs for adjacent blocks is very high if each block belongs to the same object because an object spans several blocks. Based on the fact, we present a new BMA with DASWV, which exploits motion structures of objects to reduce the number of matching blocks(candidate blocks). The DASWV algorithm is described briefly in Fig. 1. Because each motion displacement of the block is greatly related to the moving objects in successive video frames, if some blocks belong to the same object region, they have similar motion displacements and DBDs. In the DASWV, we take advantage of motion structures of objects to determine the size of search window by considering the block similarity which is computed using the segmentation information of a given frame.

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Algorithm : DASWV

Step 1: Segment the current frame using a simple region split algorithm.

Step 2: Divide the current frame into variable size of blocks, that contain only homogeneous regions. The largest size of block is 32x32 and the smallest one is 8x8. For each block, block homogeneity, the ratio of how many pixels are in the same region to the number of a given block, is calculated.

Step 3: Sort the blocks descending order of the homogeneity.

Step 4: Perform BMA with initial value of search window for first block.

Step 5: For the other blocks, perform BMA within the determined search window as follows:

If the block has no adjacent block which has already done the motion estimation, the size of search window is set as w. Otherwise, the size of search window are set as from the magnitude of adjacent block's MV to w, considering the block similarity with adjacent blocks which has done motion estimation and their MV, where w is initial value of search window

Step 6: Update the threshold for frame segmentation.

Fig. 1. The DASWV algorithm for determination the size of search window based on the block similarity and DBDs

III. EXPERIMENTAL RESULTS

Two video sequences *Miss America* and *Carphone* are used to evaluate the proposed motion estimation scheme with the block size of 16 by 16, maximum displacement 16. Each scheme for adjustment of search window is applied to FS, TSS, NTSS. The scheme called conv. for conventional window adjustment sets the search window as initial value, AASW is a scheme suggested by[1], DASWF is a scheme suggested by[2], and DASWV is a newly proposed one. The average performance of the algorithms are summarized in Table 1 in terms of mean square error(MSE) per pixel, number of matching points(NSP), and number of blocks(NB) per frame. When each scheme applied to FS, the proposed DASWV has better MSE performance compared with AASW, DASWF with similar complexity and similar MSE performance with about a half complexity compared with FS-conv. In TSS, the performance gain is more significant than FS and NTSS. With the DASWV, complexity is significantly reduced and MSE is also decreased about 20% above. In NTSS, we can get a similar performance gains. The DASWV scheme needs an additional bits for representation of variable size of blocks. But the number of blocks in a frame is lower than the schemes using fixed block size, so the additional bits are compensated. Simulation results show that the proposed motion estimation is premised that it can be used for low complexity video applications such as video-phone or video-conferencing because of low computational complexity.

TABLE I

AVERAGE MSE, NSP, AND NB OF EACH SEARCH WINDOW ADJUSTMENT SCHEME APPLIED FOR FS, TSS, NTSS

(a) Results of each method applied for FS

BMA method	Miss America			Carphone		
	MSE	NSP	NB	MSE	NSP	NB
FS-conv.	7.18	984	396	27.97	984	396
FS-AASW	7.78	432	396	31.59	243	396
FS-DASWF	7.49	353	396	28.84	275	396
FS-DASWV	7.01	372	357	25.41	286	378

(b) Results of each method applied for TSS

BMA method	Miss America			Carphone		
	MSE	NSP	NB	MSE	NSP	NB
TSS-conv.	8.39	31	396	37.18	31	396
TSS-AASW	8.61	25	396	38.19	23	396
TSS-DASWF	7.65	19	396	35.63	21	396
TSS-DASWV	7.31	20	364	33.73	22	381

(c) Results of each method applied for NTSS

BMA method	Miss America			Carphone		
	MSE	NSP	NB	MSE	NSP	NB
NTSS-conv.	7.54	22	396	33.69	22	396
NTSS-AASW	7.50	25	396	35.11	23	396
NTSS-DASWF	7.67	22	396	33.15	22	396
NTSS-DASWV	7.19	21	365	31.24	24	384

IV. CONCLUSION

An adjustment of the search window for BMA with variable size of blocks is presented to reduce the complexity. The DASWV can be used for low complexity video applications because of its good MSE performance and lower computational complexity. Simulation results show that the DASWV has better performance in terms of MSE and NSP.

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