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Performance Analysis of Block Based Motion Estimation Algorithms Using MATLAB

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ABSTRACT: Video compression uses Motion Estimation (ME) technique to achieve very high compression ratio. However ME is the most computational part of video encoding. Therefore development of many fast ME algorithms have been done to reduce the computations. Block-based techniques are the most popular one due to its simplicity. This research paper implements five Block Matching Algorithms (BMAs) namely Exhaustive Search (ES), Three Step Search (TSS), New Three Step Search (NTSS), Four Step Search (4SS) and Diamond Search (DS).Their performances are compared and analyzed based on the number of computations and PSNR.

KEYWORDS: Video Compression, Motion Estimation, Block Matching Algorithms, PSNR.

I.INTRODUCTION

Video compression uses ME technique to reduce temporal redundancy. These redundancies are present between the successive frames of video in the time domain. Several motion estimation algorithms for video coding have been presented in literature. In this paper, we focus on block-based motion estimation algorithms. The idea behind block matching algorithm is to divide the current frame into equal size non overlapping blocks and the best match for each block present in the current frame can be found in the reference frame by making use of some matching criterion. This search generates motion vectors representing the displacement of each block between two frames .The search window used for the matching is constrained up to p (search parameter) pixels around the position of the block in the target frame. Faster motions require a larger p but the larger the search parameter the more computationally expensive the process of motion estimation becomes [1]. Matching one block with another in the target frame is based on the minimization of a cost function , which is called distance measure. The popular cost functions are the Mean Absolute Difference (MAD), the Mean Squared Difference (MSD), and the Pixel Difference Classification (PDC) [2].

The performance analysis of BMAs can be done by using various parameters such as computation cost, number of operations needed for estimating displacement field and the prediction error.

In this research paper, we study some of the block based motion estimation algorithms available in the literature and analyse their performance using MATLAB.

II. BLOCK MATCHING TECHNIQUES

A. Exhaustive Search (ES)

The exhaustive search (ES) [2] algorithm is considered as the simplest BMA. It is also known as full search. This technique of motion estimation is the most computationally expensive. In this method the best matched candidate block is found by calculating the cost function at each possible location in the search window. Because of this it gives the highest PSNR amongst any block matching algorithms. But this algorithm is expensive and time consuming. Therefore various fast block matching algorithms developed to achieve the same PSNR doing little computation as possible. The disadvantage of ES is that the larger the search window requires greater number of computations.

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B. Three Step Search (TSS)

The TSS [3] algorithm was introduced by Koga et al in 1981. This algorithm became very popular because of its robustness and simplicity. Its performance is near optimal result of ES. It tries to search for the best motion vectors in a course to fine search pattern. This algorithm can be explained as following:
Step 1: An initial step size is taken. The eight checking points are picked up for comparison at a distance of step size from the centre (around the centre block).
Step 2: The centre is moved to the point with the minimum distortion and then the step size is reduced to halve. The point which gives the smallest criterion value among all tested points is selected as the final motion vector 'm'.
TSS reduces radically the number of candidate vectors to test, but the amount of computation required for evaluating the matching criterion value for each vector stays the same. This algorithm is unable to find global maximum and global minimum but it may find only a local minimum and this results in the reduction of the motion compensated image quality. Moreover, it provides an ease of using other matching criteria in searching the accurate motion vector for the given block.

C. New Three Step Search (NTSS)

The complexity of NTSS [2] is comparable to that of TSS. But it has two improvements over TSS. First, it has a center biased searching scheme and second, it involves the provisions to stop half way. Hence in this way it can reduce the computational cost efficiently. This technique was widely accepted fast algorithms in MPEG 1 and H.261. In this technique 17 points are checked for each block. In its worst case 33 positions are checked for a single block but in spite of this worst case scenario it is still much faster than TSS.

D. Four Step Search (FSS)

The four-step search algorithm (4SS) [4] is proposed by L.M. Po and W. C. Main 1996. In this technique the center-biased characteristics of the real world video sequences are exploited by using a smaller initial step size as compared with TSS. In this method the initial step size is fourth of the selected maximum motion displacement 'p' (i.e. p/4). Hence, the smaller initial step size of the 4SS algorithm takes four searching steps to reach the boundary of a search window when p = 7. Same as the N3SS algorithm, the 4SS algorithm also uses technique of halfway-stop in its second and third step's search to detect the small motions in the scene.

E. Diamond Search (DS)

The DS algorithm [5] employs two search patterns. The first search pattern is called large diamond search pattern (LDSP). Comprises nine checking points from which eight points surround the center one to compose a shape of diamond, whereas the second searching pattern consist of five checking points and forms a small diamond shape, called small diamond search pattern (SDSP). In the searching procedure of the DS algorithm, LDSP is recursively used till the minimum block distortion (MBD) occurs at the center point and then the search pattern is switched from LDSP to SDSP when it reaches to the final search stage. The position yielding the minimum block distortion (MBD), among the five checking points of SDSP, provides the motion vector of the best matching block. The DS algorithm can not only provides similar or in many cases better results than NTSS, but also reduces complexity by as much as 75%.

III. PERFORMANCE ANALYSIS OF TECHNIQUES

In this research work, we used two consecutive frames of "foreman" video for performance comparison of discussed algorithms. The 'foreman' video frames are chosen since this video has medium motion movement. The first frame is called reference frame and is shown in Fig. 1 and Fig. 2 shows the second video frame called target frame. The size of each frame is (288,352). Simulations are done on Intel(R) Core(TM) i3-3217U CPU@1.80GHz configured system using MATLAB version R2010a.

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Fig. 1 Reference frame

Fig. 2 Target frame

The experiments were performed by keeping block size of (16, 16) pixels and the search range of (+7,-7). Computational cost and PSNR is calculated for each case. The simulation results in terms of computations performed and PSNR obtained are illustrated in Fig. 3 and Fig. 4 respectively. We used MAD as an error criterion for finding optimum motion vector.

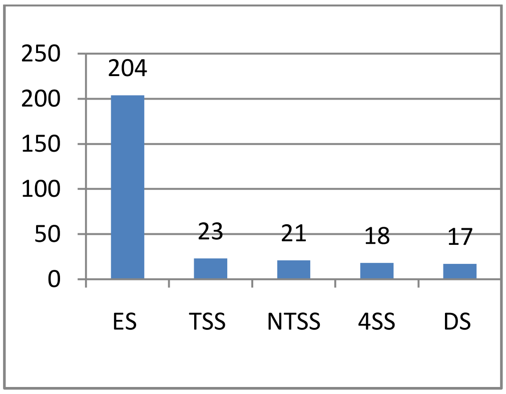

Fig. 3 Comparison of computations performed

The result obtained from the simulation shows that the Exhaustive Search (ES) technique slightly gives higher PSNR value rather than other four BMA techniques (Fig. 4). Also, the other BMA techniques give a faster encoding time because ES will compute every available pixel in the search area while the other BMA will not.

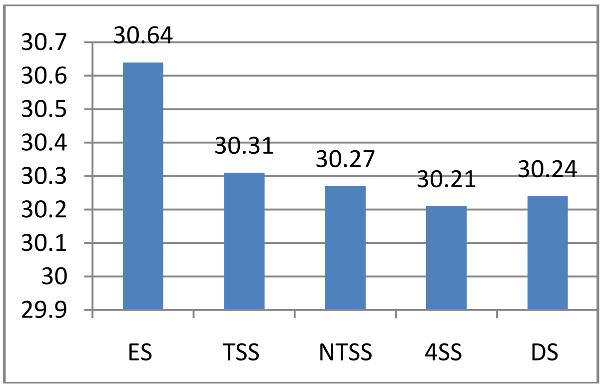

Fig. 4 Comparison of PSNR obtained

Hence from the results of this paper DS outperforms all the mentioned algorithms because it shows great reduction in computations but only small compromise in terms of quality.

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IV. CONCLUSION AND FUTURE WORK

Performance of different block matching motion estimation algorithms are analysed and compared with respect to their result of PSNR and computational complexity. From this analysis, we have found that the full search (FS) technique produces better quality image as it gives better performance in PSNR calculation, but takes larger number of search points whereas diamond search (DS) algorithm takes a few number of search points and also give average performance in PSNR calculation. Other algorithms (i.e. TSS, NTSS, and FSS) take lesser number of search points, but produce distorted image because of poor PSNR performance. As DS algorithm take fewer number of search points, it is faster. The image quality of DS can be improved by increasing the PSNR value. Therefore, it is still a research area for developing a fast block based motion estimation algorithm for better quality image with less number of searching points. .

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BIOGRAPHY

Ms. Chandana Pandey is presently pursuing M.Tech in Electronics and Communication Engineering from Amity University, Uttar Pradesh, Lucknow. She has completed her B.Tech in Electronics & Communication Engineering from Integral University, Lucknow in 2013. Presently, she has focused her working area within the various aspects of the video processing using MATLAB as simulation software in the vicinity of implementation of some highly efficient and accurate algorithms for motion estimation. Her research interests also include video compression.

Dr. Deependra Pandey obtained his Ph.D. in Electronics from RML Avadh University, Faizabad. He has over twelve years of teaching experience at B.Tech. and M.Tech. level. He is presently working as an Assistant Professor in the Dept. of Electronics and Communication Engineering, ASET, Amity University Uttar Pradesh Lucknow Campus. His area of interest includes Analog Signal Processing, VHDL, FPGA Implementation of Image Compression and Speech Recognition on FPGA. He has published several research papers in International/National Journals/Seminar/Conference. He is also involved in organizing number of National Conferences and Seminars.

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