New Technique of Three Step Search Algorithm used for Motion Estimation in Video Compression

Mr. Rahul Bhandari[1], Mr. Ashutosh Vyas[2]

[1] *Assistant Professor, Department of Computer Science and Engineering, Jodhpur Institute of Engineering and Technology, Jodhpur, Rajasthan, India*

[2] *Associate Professor, Department of Computer Science and Engineering, Jodhpur Institute of Engineering and Technology, Jodhpur, Rajasthan, India*

---***---

Abstract - *Motion estimation is key role in video compression world. There are various motion estimation algorithm such as Three Step Search algorithm, Logarithmic Search algorithm, Cross Search algorithm, Diamond Search algorithm etc. This paper describes new searching technique of Three Step Search algorithm which is based on both three step search and cross search algorithm for block matching motion estimation. This new algorithm called Three Step-Cross Search algorithm can compared with both Three Step and Cross Search algorithm with the help of instrumentation profiling tool.*

Key Words: Motion Estimation, SAD, TSS, CS, TSCS.

1. INTRODUCTION

With increasing popularity of internet streaming and video conferencing, video compression is a key component for broadcasting and entertainment media. Motion estimation techniques, which can eliminate temporal redundancy between adjacent frames which can, used in various video compression standards such as H.261, H.263, MPEG-2, etc. There are various other approaches to motion estimation, some of them using frequency or wavelet domain. Block Matching Algorithm (BMA) is most common used method for Motion Estimation. Typically each macro block i.e. 16 x 16 pixels in the new frame is compared with shifted regions of same size from previously frame. Motion vector is used for estimate best match with minimum error [3].

2. BLOCK MATCHING METHODS

Block Matching Motion Estimation Algorithms (BMMEA) is most commonly algorithms used for compressing a video. Firstly, current frame is divided into M x N pixels blocks. Then an algorithm assumes that all pixels within the block undergo same translational movement. Thus a motion vector is assigned to all pixels within a block. This motion vector is estimated by searching best match block in large searching area in the window. There are various matching criteria used in Block Matching Motion Estimation (BMME). Sum of Absolute Difference (SAD) is simplest and easiest way to find best match [4, 5].

$$\mathrm{SAD}(k,l;m,n) = \sum_{i=0}^{N}\sum_{j=0}^{N} |I_n(k+i,l+j) - I_{n-1}(k+i+m,l+j+n)|$$

Where I_n and I_{n-1} in the above formula represent the macro block in current and reference frame respectively. m and n are the search location motion vector and N is the block size. k and l represent the index of macro blocks.

To represent the motion of each block, a motion vector is defined as the relative displacement between the current candidate block and the best matching block within the search window in the reference frame. It is a directional pair representing the displacement in horizontal (x-axis) direction and vertical (y-axis) direction. The maximum value of motion vector is determined by the search range. The larger the search range, the more bits needed to code the motion vector [4].

3. BLOCK MATCHING METHODS

Block based matching algorithms are used for finding minimum vector in the motion estimation process. Various algorithms for finding motion vector give different results. In modern coding standards, various block matching algorithms are used such as Three Step Search (TSS) algorithm, Full Search algorithm, Logarithmic Search (LS) algorithm, Diamond Search (DS) algorithm etc.

3.1. THREE STEP SEARCH (TSS) ALGORITHM

Koga has proposed Three Step Search (TSS) algorithm [6] and can be implemented by Lee et al [7]. The three step search reduces the number of candidate blocks and covers a large area, making it a fast search technique.

In first step in TSS algorithm, compare nine search points surrounding the center point with p step size equal to or large maximum searching area. In the second step, search eight search points around best match among first step. In the third step, again search eight points around best match among second step. The best match from this third step is chosen as the result of the search algorithm [8]. A description of the three step search follows:

1. Search center location (0, 0).
2. Set step size S = 2N−1.
3. Search eight locations ±S pixels around the center (0, 0).
4. Pick the location with smallest SAD from nine searching location and make this new search origin.
5. Set step size S = S/2.
6. Repeat step 3 to 5 until S=1.

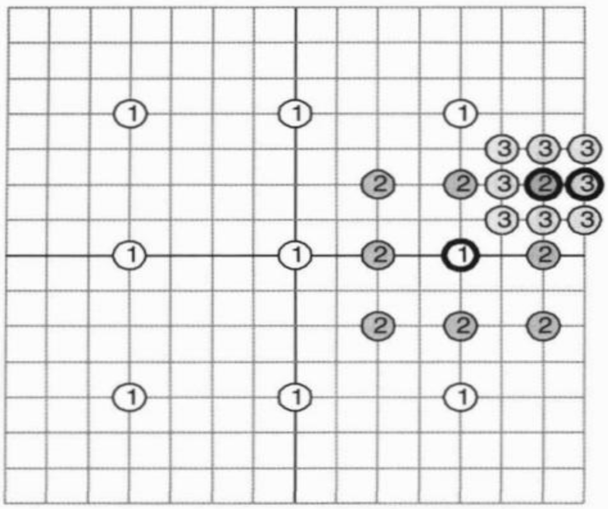

Fig -1: Three Step Search (TSS) Algorithm

There are 25 search comparisons are required for finding best match in TSS algorithm for motion estimation. In general, (8N+ 1) comparisons are required for a search area of +/- (2N - 1) pixels.

3.1. CROSS SEARCH (CS) ALGORITHM

The Cross Search Algorithm is just similar to Three Step Search Algorithm for Motion Estimation. Except four neighbors candidate blocks, forming cross pattern, in each iteration rather than eight in case of Three Step Search. It is faster than Three Step Search due to reduction of candidate blocks [10]. A description of the three step search follows:

1. Search origin i.e. (0,0).
2. Search four location around origin at +/- S, forming 'X' shape.(where S=2N-1 as same as TSS)
3. Set new origin by best match among them.
4. If S!=1 then S=S/2 and go to step 2; otherwise go to step 5.
5. If the best match is at the top left or bottom right of the X, evaluate four more points in an X at a distance of +/-1; otherwise evaluate four more points in a + at a distance of +/-1.

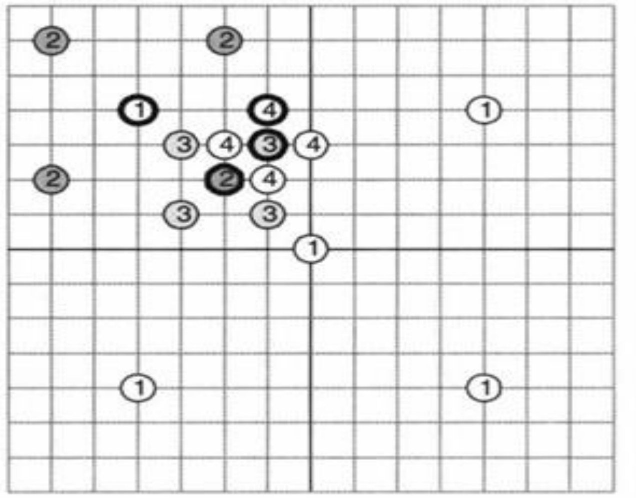

Fig -2: Cross Search (CS) Algorithm

There are 17 comparisons are required for finding best match in Cross Search algorithm for motion estimation. In general, (4N + 5) comparisons are required for a search area of +/- (2N - 1) pixels.

4. THREE STEP-CROSS SEARCH (TSCS) ALGORITHM

This new algorithm is primary based on two existing algorithms i.e. Three Step Search Algorithm and Cross Search Algorithm. A description of the three step-cross search follows:

1. Search origin i.e. (0, 0).
2. Search four location around origin at +/- S, forming '+' shape (where S=2N-1).
3. Set new origin by best match among them.
4. Pick the location with minimum SAD from four searching location and make this new search origin.
5. Set S=S/2 and pick another three location around its new origin.
6. Pick the Location with minimum SAD value and make this new origin.
7. If S! =1, then go to Step5, otherwise go to step 7.
8. Finally search eight new locations around new origin and then find minimum SAD value.

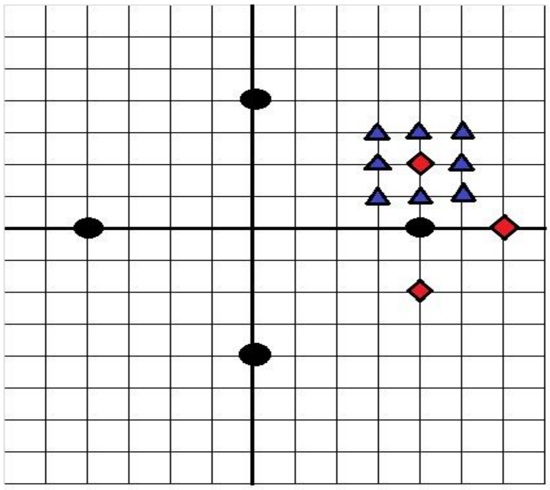

Fig -3: Three Step-Cross Search Algorithm for Motion Estimation

There are 15 comparisons are required for finding best match in Cross Search algorithm for motion estimation. In general, (2N+1) comparisons are required for a search area of +/- (2N - 1) pixels.

5. EXPERIMENTAL RESULT

The Experimental Result can be calculated by Profiler Instrumentation tool which is depending upon internal or external resources i.e. resources could be anything from I/O. There are two parameter i.e. exclusive and inclusive time for comparing performance [11].

Table -1: Illustrate instrumentation profiling method for CIF_LAB.yuv

	Three Step Search	Cross Search	Three Step-Cross Search
Inclusive Time	1718.90	1458.17	1618.16
Exclusive Time	320.5	320.72	312.03
Inclusive Time %	2.13	1.82	1.93
Exclusive Time %	0.4	0.4	0.37

Taking CIF_LAB.yuv as input which contains 213 frames. In above Table1, three algorithms have analyzed i.e. Three Step Search, Cross Search and Three Step-Cross Search Algorithms on the basis on inclusive and exclusive time. In Three Step Search algorithm, motion estimation function works on 320.5 ms for estimate the motion in video compression. In Three Step-Cross Search algorithm, motion estimation function works on 312.03 ms for estimate the motion in video compression. In cross search algorithm, motion estimation function works on 320.72 ms for estimate the motion in video compression.

6. CONCLUSIONS

According to Experimental result, Three Step-Cross Search Algorithm is comparatively high performance from both Three Step and Cross Search Algorithm for Motion Estimation.

REFERENCES

[1]. A. Murat Tekalp. Digital Video Processing. Prentice Hall, 1995. ISBN: 0131900757.

[2]. Alan C. Bovik. Handbook of Image and Video Processing. Academic Press, 2000. ISBN: 0121197905.

[3]. E. M. Fakhouri. Variable block-size motion estimation. cite- seer.ist.psu.edu /fakhouri97variable.html.

[4]. I. E. G. Richardson, "H.264 and MPEG-4 Video Compression", John Wiley Publisher, 2003.

[5]. D. Salomon. Data Compression: The Complete Reference. Springer, 2004.

[6]. T. Koga, K. Iinuna, A. Hirano, Y. Iijima and T. Ishiguro, "Motion Compensated Inter frame Coding for Video Conferencing", In Proc. of National Telecomm. Conf., pages G5.3.1– G5.3.5, New Orleans, Nov. 1981.

[7]. W. Lee, Y. Kim, R. J. Gove, and C. J. Read, "Media Station 5000: Integrating Video and Audio", IEEE Trans. Multimedia, 1(2):50–61, 1994.

[8]. Borko Furht, Joshua Greenberg, Raymond Westwater, "Motion Estimation Algorithms for Video Compression", Massachusetts: Kluwer Academic Publishers, 1997. Chapter 2 & 3.

[9]. R. Li, B. Zeng, and M. L. Liou, "A new three-step search algorithm for block motion estimation", IEEE TRANSACTIONS Circuits System Video Technology, vol. 4, pp. 438-442, Aug 1994.

[10]. M. GHANBARI, "The Cross-Search Algorithm for Motion Estimation", IEEE Transactions on Communications, Vol. 38, No. I, July 1990.

[11]. Microsoft Corporation, "Instrumentation Profiling methods", 2004, www.microsoft.com/en-in/library/ms182369.aspx

BIOGRAPHIES

Mr. Rahul Bhandari
Assistant Professor, Department of Computer Science & Technology, Jodhpur Institute of Engineering and Technology, Jodhpur , Rajasthan, INDIA

Mr. Ashutosh Vyas
Associate Professor & HOD(PG), Department of Computer Science & Engineering, Jodhpur Institute of Engineering and Technology, Jodhpur, Rajasthan, INDIA.