Hybrid Adaptable Search Window with Diamond Pattern

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Abstract-In Video Coding Standards such as MPEG, H.26X contains Block Matching Motion Estimation process in Video processing. Finding Motion Vectors are important in Video Compression point of view. Since any video coding techniques can be included after movement estimation. Many quick quest calculations are accessible for Motion Estimation. The proposed algorithm contains a combination of the Adaptive Search Area Selection and the Diamond Search algorithm, which is called the Hybrid ASW-DS algorithm to reduce the processing time of ME. The proposed algorithm is compared to other algorithms by considering parameters such as PSNR, Computations per block and Search Point number.

Keywords-Motion Estimation, Sum of Absolute Difference, Exhaustive Search, Diamond Search, PSNR, Search points, Mean Square Error, Search Window selection

I. INTRODUCTION

Several rapid motion estimation methods have been proposed, such as a Three-step search [1], a New three-step search [1], a four-step search [2], a Simple and Efficient Search [3], a diamond search [4] and an Adaptive Rood Pattern [5].An adaptive I-B-P frames determination is suggested in [6] that allows future and past frames to be stored that take further computation time. North-South –East-West affine translation is suggested to replace B-frames I-or P frames. Cross Diamond Search Pattern were talked about in [7-9]. There are three different ways to lessen Motion estimation multifaceted nature: 1.Diminish the number of search points for each macro block.2. Minimize the calculations processedat each search point. At each search point, variable block size mode decision can be used.3.Early ter mination can be used by detecting zero motion in frame.

Adaptive search algorithms have been implemented later in Motion Estimation algorithms that can adjust the search region scale, block size and search point number. The number of search points can differ depending on the search criteria chosen in the algorithm. Adaptive search set dependent on depth details is addressed in [10]. The color textures here capture pixel luminance and chrominance details throughout the scenes. Depth maps show the distances of artifacts identified with each pixel in color textures. The object is nearer to the viewer when the gray value of pixels at the particular location of depth map is lighter. Depth maps can provide additional information about pixels of objects within equal distance. With the help of the Depth or Motion Relationship Map (DMRMap), the more or less motion activities of objects among the successive frames could be projected by depth maps. Since the Mean intensity depth is a matching criterion for differentiating the various objects at various distances in the successive frames, Depth maps point the location or pixel value of the object in the video scene from the image plane. Adaptive search range centered on the adjacent depth intensity weighted total is addressed in [11]. With the aid of the adjacent motion vector predictor (MVP) in the search path, the optimum motion vector (MV) is chosen by reducing the distortion cost within the predefined search pane. Computation is minimized in multi-frame motion estimation [12]. Here, the first frame motion vector will be used to change the correct scale of the scope window for the rest of the reference frames. If several small blocks have a same value of motion vector, the combined large block could use such motion vectors as an initial point for further adjustment of smaller search window size. There are two forms of predictions: 1. Object dependent prediction 2. Background dependent prediction. Movement backgrounds seldom appear in images from stationary image capturing devices. Adaptive search window for surveillance videos of less difficulty is addressed in [13]. Depth level mapping, which is a graph of motion vector amplitude and depth strength, is used in the collection of an adaptive search range [14].Depth maps provide references to objects at the equal distance from the projected screen in a three dimensional scene. Irregular search window reusable scheme is discussed in [15]. Adaptive search range algorithm that exploits the correlation among the neighboring blocks motion parameters and the current block search range [16].Movement vector estimation with a wider coding device defines a broader search set for fast motion. Movement Vector 's estimation of a wider coding function defines a narrower scope set for slow motion [17].Here, Suggestedwork aims to boost the efficiency of video compression rate in terms of processing time. The suggested approach is a hybrid of the adaptive window and the diamond search pattern. The quick ME increases compression rate and decreases computational complexity.

In Exhaustive search (ES), all the pixels in each blocks in current frame are compared with respective reference frame pixels in terms of cost function to find the best fitting block. Exhaustive search provides better performance in terms of PSNR and SSIM but it takes more computation of ME. Several fast ME techniques are evolved such as TSS, 4SS, SESS and ARPS etc. In rapid ME Techniques, it is not required to compare all the pixels in each block of current frame with corresponding pixels in reference frame. Based on the search path or pattern, the less number of pixels are compared with respective pixels in reference frame. Therefore, several fast ME techniques are accepted for ME with minimum computation time and optimum picture quality i.e. PSNR and SSIM when compared to Exhaustive search.

Fixed search range or window is the boundary to compute the minimum distortion among the pixels in reference and current frames. In fixed window or pane of search, all the blocks in current frame are needed to compare with reference frame blocks even there is no movement of objects between current and reference frames which has motion vector (0,0). At that time, variable size windows are better than fixed size window for searching best fitting blocks. Search pane could be varied based on the motion activities involved in a video. Adaptable window size could be used where the number of blocks involved for computation of ME is reduced in a frame when there are non-moving objects presented between frames.

By combining the fast ME technique with Adaptable window size, Hybrid algorithm is achieved less computations of ME with optimum picture quality.

Section II discusses the Adaptive Search window related work Section III discusses previous work on Block based motion estimation algorithms. Section IV discusses the proposed hybrid work of the BBME algorithm. The results are discussed in Section V. The conclusion and the future of the work are discussed in Section VI.

II.RELATED WORKS

A faster ME algorithm with Adaptive Search Range (ASR) was proposed in this paper [18]. The CPU efficiently determines and passes the searching ranges to the GPU. The Graphics Processing Unit executes the ME algorithm. This GPU-based ME algorithm process a rapid Motion Estimation with negligible coding losses.In the ASR evaluation, the frame was divided into two types with an interpretation of the motion feature of the previous frame and a specification of the searching ranges corresponding to the classification type. Following an ASR statement, the GPU conducts the ME cycle with the ASRs. The Lee algorithm [19] is used for the GPU-based ME implementation. The Concurrent Parallel Reduction (CPR) method is combined with exhaustive search to diminish the problems related to conventional parallel reduction with the aid of the availability of thread and synchronization. The frame-wise GPU-based ME produces HEVC dependence problems in the Motion Vector Prediction method. In this paper, therefore, Predictor of Motion Vector is derived from temporal Motion Vectors (MVs) to remove the dependency problem.

Motion vector distribution is modelled by Cauchy distribution in the novel adaptive SR algorithm [20] which reduces the complexity of the ME process. A new diamond shaped search window (SW) is suggested in [21]. A frame level adaptive search range (SR) algorithm is presented to vary the size of the diamond shaped search window dynamically. The optimal motion vector difference (MVD) distribution is modelled using Laplace distribution within the frame and the model parameters are estimated by the maximum likelihood estimation (MLE).The motion vector computed in the first reference frame is extremely useful for the adaptive control of the search window size of the rest of the reference frames [22]. In addition, the motion vector is calculated for small sized blocks initially and the same motion vector smaller blocks are utilized to construct the motion vectors for larger blocks. The processing speed of motion estimation for broad blocks is increased by optimizing the narrow search window around the motion vector.

The suggested method [23] incorporated the faster ME methods with background and foreground coding for the reduction of search points and the calculations involved at each search point. Background images are extracted with the help of the background subtraction and frame differentiation. The discrepancy picture is then split into16×16 blocks according to the maximum H.264 macro block dimension. The total Absolute Difference (TAD) is used to measure the overall expense of calculations for each block. The comparative threshold is used to choose foreground block or backdrop block. The blocks which have higher TAD compared with threshold are known to be foreground blocks which has more gestures. The blocks which have lesser TAD compared with threshold are known to be background blocks. Background region is partitioned into 16×16 irrelevant to other partitions. Since the surveillance videos are made up of background region, computational complexity is reduced greatly with 16×16 partitions. Because of this method, the overall bit rate is diminished by the background coding while the foreground quality is retained. The search range for the background region could be modified to reduce computational complexity further. Based on the analysis of the MVD distribution, the proposed algorithm [24] further optimizes the ME algorithm. Since more than 85 percentage of the best fitting blocks are inside the 16x16 search window (SR=8), the optimal search limit to be implemented is 8.The Motion vector distributions are highly correlated with the depth level can be assumed while calculating motion vectors. It is not required to apply ME on a search range of 8 for some block sizes; Greater search range (SR) sizes are applied for greater CUs, whereas smaller search range dimensions lead to smaller CUs.

III. PREVIOUS WORK OF BBME

A. ADAPTIVE SEARCH WINDOW

Based on the initial motion vector in a frame or previous frame motion vector magnitude, window size could be increased or decreased to reduce the computation time. The larger magnitude of MV tells that there are more moving objects presented between frames to increase the window size. The lesser magnitude of MV tells that there are less moving objects presented between frames to decrease the window size.

Exhaustive Search is applied to find motion vector with the matching criteria of Total Absolute Difference (TAD) as shown in eq(1).

The following steps explain the Adaptive Search Window (ASW) based Motion Estimation (ME).

Step1: Take the video and convert into frames

Step2: Set P=7 with fixed size search window initially as shown in fig 2.

Step 3: Find Motion Vectors (MVs) of best matched block in current frame and reference frame using Exhaustive search.

Step 4: Check whether MV=0(i.e MVx=0 and MVy=0), If yes Search Window size is 4 and go to step 3.

Step 5: Else if 0<MVx<4 and 0<MVy<4 then P1=4, P2=7,P3=4 and P4=7 and go to Step 3.

Else if 0<MVx<4 and -4<MVy<0 then P1=4, P2=7,P3=7 and P4=4 and go to Step 3.

Else if -4<MVx<0 and 4<MVy<0 then P1=7, P2=4,P3=4 and P4=7 and go to Step 3.

Else if MVx>4 and MVy<-4 then P1=16, P2=4, P3=4 and P4=16 and go to Step 3.

Else if MVx<-4 and MVy>4 then P1=4, P2=16,P3=16,P4=4 and go to Step 3.

Else if -4>MVx and -4>MVy then P1=16,P2=4,P3=16,P4=4 and go to Step 3.

Step 6: Repeat the steps 1to 5 for next frame.

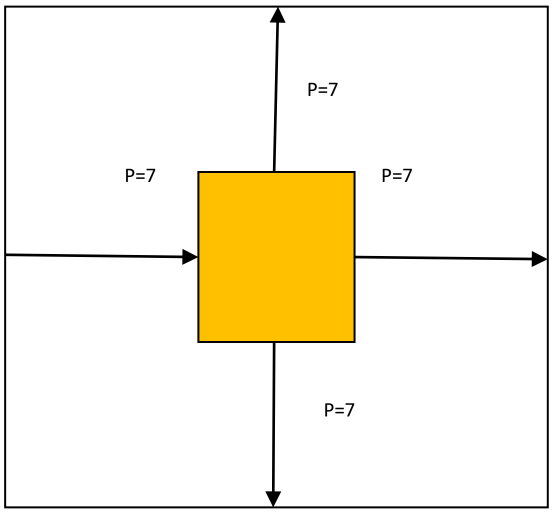

Fig.1.Flowchart of ASWwith ES

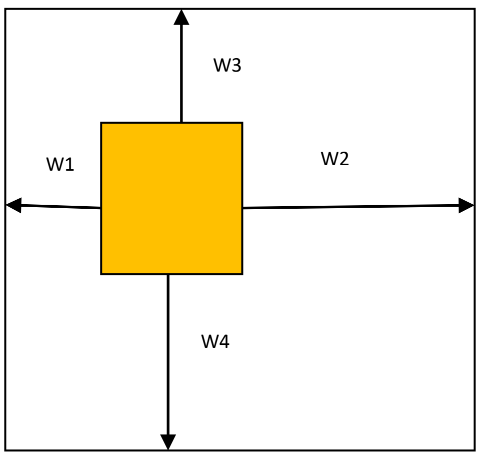

Fig.2.Fixed Search Window(ASW)

B. DIAMOND SEARCH

Diamond Search is one of the fastest methods to evaluate motion vector. Total Absolute difference is considered as a matching criterion.

The following steps explain the Diamond Search (DS) based Motion Estimation (ME).

Step1: Take the video and convert into frames.

Step 2: Set P=7 with fixed size search window initially.

Step 3: Search 9 locations in large Diamond Search Pattern (LDSP). Search 4 locations at s=±2 around the centre in horizontal and vertical directions. Search 4 more locations around the centre at s=±1 locations in diagonal locations.

Step 4: Find the cost functions for all above 9 locations.

Step 5: Apply the small diamond search pattern (SDSP) in four locations at s=±1 around the centre location while minimum cost is at centre. Go to step 7.

Step 6: Mark that location as new centre when the least cost belong to any edge point of diamond shape. Go to step 2.

Step 7: Save the motion vector of least cost function in small diamond search pattern (SDSP).

Step 8: Repeat the steps 1 to 7 for next frame.

IV. PROPOSED WORK

Motion or movement Vector is the linear displacement between the candidate block(C) and reference block (R) with minimum cost function. Here Total Absolute Difference (TAD) is cost function.

$$TAD = \Sigma\Sigma|C(i,j) - R(i\,,j)|^2 \qquad (1)$$

Where R (i,j) and C(i,j) are pixel values from reference and candidate block respectively.

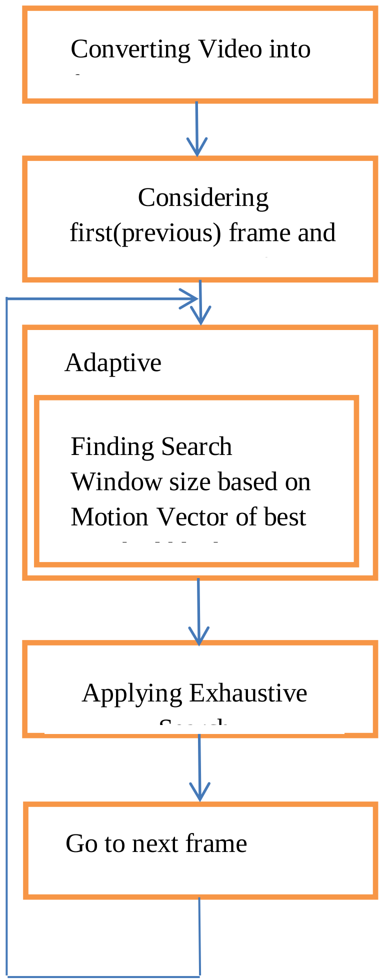

Fig.4.Flowchart of ASW-DS based ME

The following steps explain the ASW-DS based Motion Estimation (ME).
Step1: Take the video and convert into frames
Step2: Set P=7 with fixed size search window initially to find Motion Vectors(MVs) of best matching block in current frame with reference to previous frame.
Step 3: Search 9 locations in large sized Diamond Search Pattern (LDSP). Search 4 locations at s=±2 around the centre in horizontal and vertical directions. Search 4 more locations around the centre at s=±1 locations in diagonal locations.
Step 4: Find the cost functions for all above 9 locations.
Step 5: Apply the small diamond search pattern (SDSP) in four locations at s=±1 around the centre location while minimum cost is at centre. Go to step 7.
Step 6: Mark that location as new centre when the least cost belong to any edge point of diamond shape. Go to step 3.
Step 7: Save the motion vector of least cost function in small diamond search pattern (SDSP).
Step 8: Check whether MV of previous frame is 0(i.e MVx=0 and MVy=0), If yes Search Window size is 4 and go to step 3.
Step 9:
Else if 0<MVx<4 and 0<MVy<4 then P1=4, P2=7,P3=4 and P4=7 and go to Step 3.
Else if 0<MVx<4 and -4<MVy<0 then P1=4, P2=7,P3=7 and P4=4 and go to Step 3.
Else if -4<MVx<0 and 4<MVy<0 then P1=7, P2=4,P3=4 and P4=7 and go to Step 3.
Else if -4<MVx<0 and -4<MVy<0 then P1=7, P2=4, P3=7 and P4=4 and go to Step 3.
Else if MVx>4 and MVy>4 then P1=4, P2=16, P3=4 and P4=16 and go to Step 3.
Else if MVx>4 and MVy<-4 then P1=16, P2=4, P3=4 and P4=16 and go to Step 3.
Else if MVx<-4 and MVy>4 then P1=4, P2=16,P3=16,P4=4 and go to Step 3.
Else if -4>MVxand -4>MVy then P1=16, P2=4,P3=16,P4=4 and go to Step 3.
Step 10: Repeat the steps 3 to 9(same procedure) for next frame.

V. RESULTS AND DISCUSSION

Six standard video sequences were used which are illustrated in figure 5(a),(b) and (c). They are "Carphone" (150 frames), "Forman" (300 frames), "Container" (300 frames), with the size of 256 × 256.

Fig.5(a) Carphone

Fig.5 (b) Container

Fig 5 (c) Foreman

The count of search points (C) directly related to size of the block and size of search pane or window. The number of evaluations for a non-adaptive search pane (fixed) and adaptive search pane are described in (2) and (3) respectively. C defines the number of computations in a frame.

$C_{adaptive} = (P_1+P_2+1)(P_3+P_4+1)* B^2 * n$ (2)

$C_{Fixed} = (2P+1)^{2} * B^2 * n$ (3)

Where n = number of blocks in a frame.

PSNR is the performance parameter which defines the ratio between square of Peak value in a frame and Mean Square Error. Mean Square Error is calculated between original frame and compensated frame after motion compensation.

From the PSNR performance illustrated in Figure 6, Picture quality of Carphone and Foreman video sequences are enhanced with high PSNR value with full search in ASW. Picture of quality of Container degraded to 0.03dB which is less relative to the number of calculations involved in the searching process. Better PSNR is achieved for the videos *Container, Foreman* and *Carphone* with DASW and diamond search.

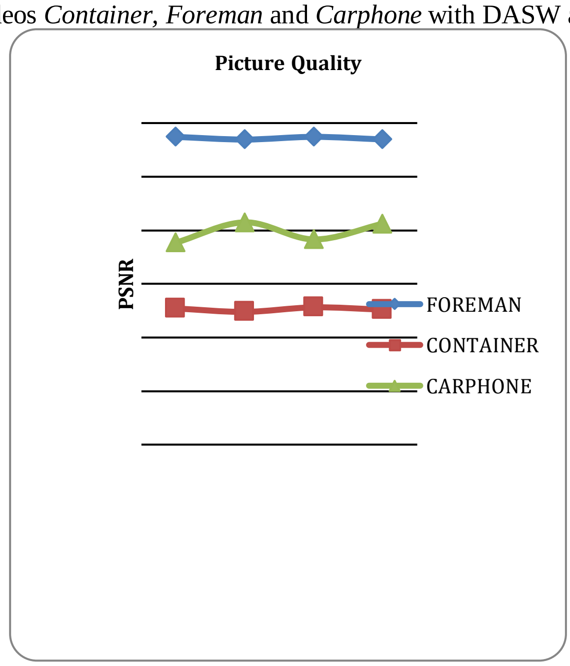

Fig. 6.PSNR Performance

HYBRID results the PSNR near to ES which is a conventional method.DS involves the less count of search points in its search pane among all the fastest ME algorithms. Even though the Performance parameter of PSNR value of all rapid searches is comparatively same, the suggested HYBRID involves less calculations per block when DS reduces the complexity of calculations combined with adaptable search pane.

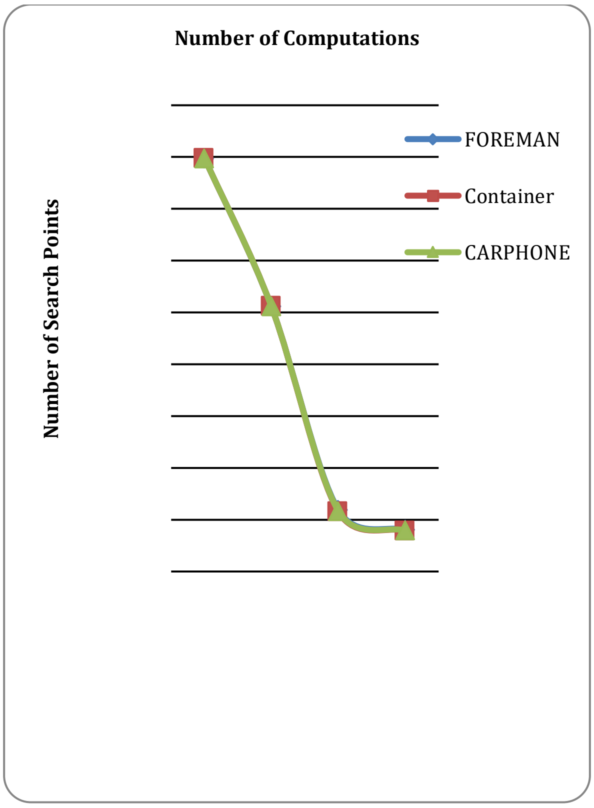

Fig. 7. Number of Search Points Compared with Exhaustive search+Fixed size window

CONCLUSION

Over the past two decades, there has been a growing revolution in multimedia. Motion Estimation is vital process in video compression while archiving the entertainment video (CD / DVD) and real time video applications. While ISO MPEG and ITU sets the standard for the above applications with less compression rate, it is decisive to reduce the computation time of motion estimation in video coding and compression point of view. Over past decades, Work has concentrated on reduction of all these effects of motion estimation. ASW+DS reduced computation to 87.5 percent relative to non-adaptive exhaustive search algorithm and the proposed hybrid quick-search algorithm takes a factor of 8.5 less computations. Further development can be accomplished with the proposed algorithm by adding several parameters for block evaluation by utilizing soft computational techniques that enhance the block evaluation.

REFERENCES

1. Renxiang Li, Bing Zeng, and Ming L. Liou, “A New Three-Step Search Algorithm for Block Motion Estimation”, IEEE Trans. Circuits And Systems For Video Technology, vol 4., no. 4, pp. 438-442, August1994.
2. Lai-Man Po, and Wing-Chung Ma, “A Novel Four-Step Search Algorithm for Fast Block Motion Estimation”, IEEE Trans. Circuits And Systems For Video Technology, vol 6, no. 3, pp. 313-317, June1996.
3. Jianhua Lu, and Ming L. Liou, “A Simple and Efficient Search Algorithm for Block-Matching Motion Estimation”, IEEE Trans.Circuits And Systems For Video Technology, vol 7, no. 2, pp. 429-433,April 1997
4. Shan Zhu, and Kai-Kuang Ma, “ A New Diamond Search Algorithm for Fast Block-Matching Motion Estimation”, IEEE Trans. Image Processing, vol 9, no. 2, pp. 287-290, February 2000.
5. Yao Nie, and Kai-Kuang Ma, “Adaptive Rood Pattern Search for Fast Block-Matching Motion Estimation”, IEEE Trans. Image Processing, vol 11, no. 12, pp. 1442-1448, December 2002.
6. D. Dolly, Raveena Judie, G. JoseminBala, and J. Dinesh Peter. "A Hybrid Tactic Model Intended for Video Compression Using Global Affine Motion and Local Free-Form Transformation Parameters." Arabian Journal for Science and Engineering, 1-15, 2017.
7. Chun-Ho Cheung, and Lai-Man Po, “A Novel Small Cross-Diamond Search Algorithm for Fast Video Coding and Video Conferencing Applications”, Proc. IEEE ICIP, September 2002.

8. Chun-Ho Cheung, and Lai-Man Po, “A Novel Cross-Diamond Search Algorithm for Fast Block Motion Estimation”, IEEE Trans. Circuits And Systems For Video Technology, vol 12., no. 12, pp. 1168-1177,December 2002.
9. C. W. Lam, L. M. Po and C. H. Cheung, "A New Cross-Diamond Search Algorithm for Fast Block Matching Motion Estimation", Proceeding of IEEE International Conference on Neural Networks and Signal Processing, pp. 1262-1265, Dec. 2003, Nanjing, China.
10. Tsz-Kwan Lee, Yui-Lam Chan, and Wan-Chi Siu, ’Adaptive Search Range for HEVC Motion Estimation based on Depth Information’ IEEE Transactions on Circuits and Systems for Video Technology,2016.
11. T.-K. Lee,Y.-L.Chan✉ and W.-C. Siu,’ Adaptive search range by neighbouring depth intensity weighted sum for HEVC texture coding’, Electronics Letters,9th June 2016,Vol. 52,No. 12,pp. 1018–1020
12. Liang-Ming JiAnd Wan-Chi. Siu,’ Reduced Computation Using Adaptive Search Window Size For H.264 Multi-Frame Motion Estimation’14th European Signal Processing Conference (Eusipco 2006), Florence, Italy, September 4-8, 2006
13. MohdAzraf MohdRazif, Musa Mokji and Muhammad Mun’im Ahmad Zabidi,’ Adaptive Search Window for Low Complexity Surveillance Video Coding’ International Symposium on Technology Management and Emerging Technologies(ISTMET), August 25 - 27, 2015
14. Tsz-Kwan Lee, Yui-Lam Chan, and Wan-Chi Siu,’ Depth-based Adaptive Search Range Algorithm for Motion Estimation in HEVC’Proceedings of the 19th International Conference on Digital Signal Processing,20-23 August 2014
15. Xianghui Wei†, Shen Li, Yang Song, Satoshi Goto,’ An Irregular Search Window Reuse Scheme for Motion Estimation in MPEG-2 to H.264 Transcoding’ Proceedings of IEEE conference 2007.
16. Longshan Du, Zhenyu Liu, Takeshi Ikenaga And Dongsheng Wang,’ Linear Adaptive Search Range Model For Uni-Prediction And Motion Analysis For Bi-Prediction In HEVC’ proceedings Of IEEE Conference-ICIP,2014
17. Zih-Ting Liao And Chung-An Shen,’ A Novel Search Window Selection Scheme For The Motion Estimation Of HEVC Systems’ Proceedings Of IEEE Conference-ISOCC, 2015.
18. Sangmin Kim, Dong-Kyu Lee, Chae-Bong Sohn, and Seoung-Jun Oh,‘Fast Motion Estimation For HEVC With Adaptive Search Range Decision On CPU And GPU’,IEEE,2014.
19. K. Lee and S. J. Oh, “Variable block size motion estimation implementation on compute unified device architecture (CUDA),” IEEE International Conference on Consumer Electronics, Las Vegas, pp. 635-636, Jan. 2013.
20. Wei Dai, Oscar C. Au, Sijin Li, Lin Sun and Ruobing Zou,’ Adaptive Search Range Algorithm Based On Cauchy Distribution, Circuits and Systems for Video Technology, IEEE Trans-actions on, vol.15, no.5, pp. 645- 658, May 2005
21. Luheng Jia, Oscar C. Au, Chi-ying Tsui, Yongfang Shi, Rui Ma, Hong Zhang,’A Diamond Search Window Based Adaptive Search Range Algorithm’
22. Liang-Ming Ji and Wan-Chi. Siu, ’Reduced Computation Using Adaptive Search Window Size For H.264 Multi-Frame Motion Estimation’ 14th European Signal Processing Conference (EUSIPCO 2006), Florence, Italy, September 4-8, 2006.
23. Mohd Azraf Mohd Razif, Musa Mokji and Muhammad Mun’im Ahmad Zabidi, ’Adaptive Search Window for Low Complexity Surveillance Video Coding’ International Symposium on Technology Management and Emerging Technologies (ISTMET), August 25 - 27, 2015
24. Kibeya, Fatma Belghith, Mohamed Ali Ben Ayed and Nouri Masmoudi ,’Adaptive Motion Estimation Search Window Size for HEVC Standard Hassan’ 7th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT), 2016