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BLOCK MATCHING ALGORITHM BY FUZZY MEMBERSHIP FUNCTION TO DETERMINE MOTION VECTOR

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ABSTRACT

Video compression ratio , quality and efficiency are determined by the motion estimation algorithm. In this research paper a motion estimation technique based on fuzzy membership function has been proposed .Fuzzy logic starts with the concept of a fuzzy set. A fuzzy set can be described as a set and a membership function it contain elements with only a partial degree of membership the associated function specifies the degree to which a given input belongs to a set. The degree of membership defines the output of a membership function and the output value is always lies between 0 and 1 , which is considered the membership value or membership grade. The individual frames are divided into blocks and the fuzzy membership function value is calculated for every macro block in the previous frame and current frame with the fuzzy inference system a minimum block distortion is selected and motion vectors are computed for the predicted frame . The motion estimation block uses fuzzy membership function to estimate the connectedness of different blocks of the current frame to that of the reference frame The fuzzy decision matching is done based on the matching criterion and the best matching block is selected. The motion vectors are thus calculated with respect to the reference frame.

Keywords: Block matching, Fuzzy logic, Motion vector, Reference frame , Current frame , Compression.

INTRODUCTION

Successive video frames may contain the same objects; motion estimation examines the movement of objects in an image sequence to try to obtain vectors representing the estimated motion. There are two mainstream techniques of motion estimation, pixel-recursive algorithm and block-matching algorithm Pixel – recursive algorithms are iterative refining of motion estimation for individual pixels by gradient methods. It is one type of region-matching technique. It recursively estimates displacement vectors for each pixel in an image frame. The displacement vector of a pixel is estimated by recursively minimizing a nonlinear function of the dissimilarity between two certain regions located in two consecutive frames.

Block Matching Algorithms assume that all the pixels within a block have the same motion activity. BMAs estimate motion on the basis of rectangular blocks and produce one motion vector for each block. PRAs involve more computational complexity and less regularity, so they are difficult to realize in hardware. In general, BMAs are more suitable for a simple hardware realization because of their regularity and simplicity.

Full search is the simplest algorithm which finds the block in the reference frame with minimum sum of absolute difference here comparison is done with all of the blocks in the search area which increases the computational complexity [1]. Several algorithms for fast search and real time deployment were proposed to resolve the limitations of the complete search algorithm. Some of these algorithms look for matching block only

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in a set of blocks in the search area. The logarithmic search, three step searches, four step search, diamond search and octagon search algorithms are some of these algorithms. In all of these algorithms unimodal error surface assumption is made. The pixel redundancy within frames of a video sequence may differ depending on the movement in the video. Thus regular boundary conditions to determine the blocks may not as effective. The uncertainty in pixel redundancy can be alleviated by using fuzzy techniques. Several fuzzy based motion estimation have also been presented by the researchers. Spatio-temporal fuzzy search algorithm using a look-up table structure (LUT) is employed[2].

RELATED WORK

Suvojit Acharjee et al. [3] suggested an algorithm named, "Fuzzy Logic Based Three Step Search Algorithm for Motion Vector Estimation". In this a fuzzy logic based three Step Search algorithm has been implemented . This provides the better results than the Three Step Search(TSS), New Three Step Search(NTSS), and Four Step Search(FSS) algorithm[3].

Suvojit Acharjee et al. Sheli Sinha Chaudhuri [4] suggested a Fuzzy Logic Based Four Step Search Algorithm for Motion Vector Estimation. In the fuzzy logic based Four Step Search algorithm a fuzzy membership value introduced according to intensity for every block. From the intensity values of the pixels within a macro block a value is calculated which defines whether the macro block is in darker or lighter region. Search can only work if the fuzzy membership value of the macro block of the reference frame is in the permitted range of macro block of the coordinate system is within the allowable range of macro block of the present frame. The search pattern and other step is similar like four step search[4].

Hung-Ming Chen et al. [5] suggested Fuzzy Thresholding Early Termination Scheme of Fast Motion Estimation The proposed algorithm is an early termination scheme which depends on threshold values obtained through fuzzy inference. The search patterns of MDGDS algorithm are used. The alternative search patterns of fuzzy inference on applied three times using an scale factor. In each round of the search the search can be terminated early prior to the each round to prevent unnecessary computation . It reduced the number of search point when it is compared to MDGDS. The algorithm makes significant improvements in motion estimation[5].

Mohammed Alreshoodi,et al.[6] suggested Fuzzy logic inference system-based hybrid quality prediction model for wireless 4k UHD , H.265 coded video streaming. In real time video streaming to maintain the quality of service is not practical .The available tools are not sufficient to provide the original video streaming at the receiver end. A survey on the impact of quality of service (QoS) parameters for the 4kUHD in H.265-coded video transmission in under experimental environment. The model based on fuzzy logic inference system is developed to predict the visual quality by mapping QoS parameters to the measured quality of experience[6].

Davoud Fani,et al. [7] suggested GOP-level fuzzy rate control algorithm for high-delay applications of HEVC. Video broadcasting and video streaming applications where the high-delay video is noticed if a variable bit-rate videos is applied a higher video quality can be rather than constant bit rate videos. The suggested this algorithm , a rate control algorithm (RCA) can be implemented for HEVC standard with a buffering constraint. In the RCA algorithm a fuzzy controller and a virtual buffer are used. The role of fuzzy controller minimizes the fluctuations of quantization parameter when the buffering constraint is applied . For each group of pictures it computes a base quantization parameter . By this way unnecessary fluctuation of quantization parameter is removed thus a higher visual quality can be achieved.

Linh Van Ma,et al. [8] suggested Fuzzy-Based Adaptive Streaming Algorithm for Reducing Entropy Rate of DASH Bitrate Fluctuation to Improve Mobile Quality of Service. DASH is technology which deals with uncertainty of network . The quality of a video streaming fluctuates along with the network changes, and it might reduce the quality of service. Streaming over HTTP (DASH). Moving average of the bandwidth and buffer values for a given period, are first calculated. On the basis of differences between real and average values, a fuzzy logic system is used to deduce the value of the video quality representation for the next request.

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Hyun Jun Kim,et al. [9] suggested Modification of the Fuzzy Logic Based DASH Adaptation Scheme . The suggested proposed scheme (mFDASH) modifies the Fuzzy Logic controller by using a appropriate bit rate controller thus estimates more accurate bandwidth which is better than FDASH.

Bachu Srinivas and K Manjunathachari [10] suggested Adaptive Order Cross–Square–Hexagonal search and fuzzy tangential-weighted trade-off for H.264 in motion estimation. The algorithm, which employs a smaller cross-shaped pattern before the first step of a square pattern and replaces the square-shaped pattern with the hexagon search patterns in subsequent steps. To find the best matching block is considered not increasing the search point rather than A fuzzy tangent –weighted function is applied to calculate the rate of distortion to select the matching points.

Bachu Srinivas and N. Ramya Teja [11] also suggested Fuzzy Holoentropy-Based Adaptive Inter-Prediction Mode Selection for H.264 Video Coding. As put forth by the authors, the major drawback in the H.264 is that it performs the exhaustive search over the interlayer prediction to gain the best rate-distortion performance. To reduce the computation overhead due to exhaustive search on mode prediction process, a new technique for inter prediction mode selection based on the fuzzy holoentropy has been presented

PROPOSED MODEL

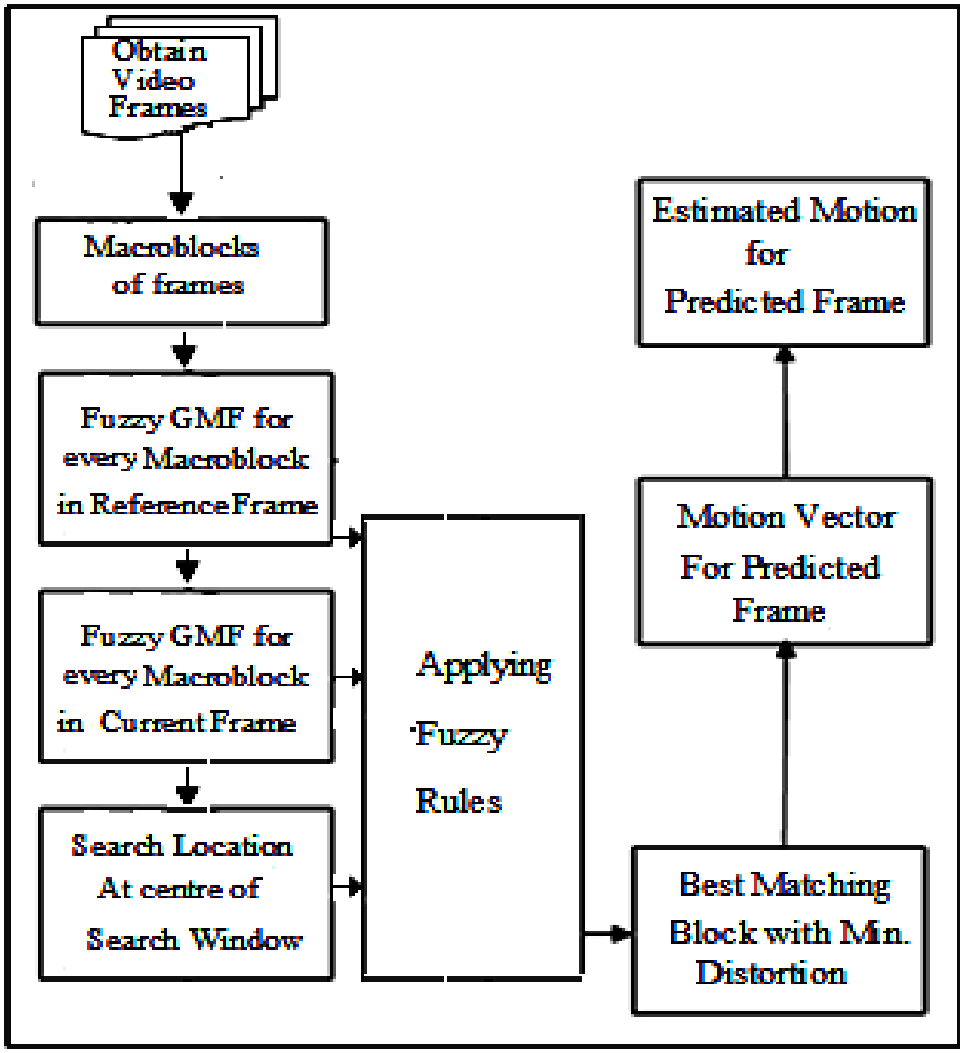

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Figure 1: Block diagram of proposed block matching algorithm using fuzzy membership function

The individual frames are divided into blocks and the fuzzy membership function value is calculated for every macro block in the previous frame and current frame with the fuzzy inference system a minimum block distortion is selected and motion vectors are computed for the predicted frame.

The basic block diagram of the proposed model the motion vector estimation depicted in figure 1 .

The video frames are divided into blocks ,then Fuzzy membership function of every macro block is evaluated in the previous frame and fuzzy membership function of every macro block is evaluated in the current frame .Search window parameter is selected and by applying fuzzy logic search direction is decided..The minimum block distortion is considered as a best block .Finally the motion vectors of the predicted frame are calculated

PROPOSED ALGORITHM

The key factor of the proposed algorithm depends on the fuzzy membership (Gaussian Membership Function) of each pixel and the value of sum of difference. These steps are followed by the algorithm figure 2 shows the initial point of the search and figure 3 the updated search point and the new search area.

This algorithm tends to reduce the search steps for this an adaptive step search strategy is taken and the key factor is sum of absolute differences (SAD) which is a measurement of the similarities between the blocks which are taken for comparison as block size 8x8 or 16x16 the absolute difference between each pixel in the reference frame block and the corresponding pixel in the block of target frame. Unlike the other algorithm here the SAD is calculated by the Gaussian membership function (GMF) which is assigned for macroblock for previous frame and the macroblocks of target frame for each pixel and a membership data matrix is created.

Start searching for the pixel with minimum SAD as compared to target frame the centre point of membership function is decided on the basis of minimum SAD and a search area is constructed and with an updated centre of the membership function a new search area is constructed

The Sum of Absolute Differences (SAD) parameter is utilized to obtain the motion vectors of the moving blocks. The blocks for which minimum SAD is obtained constitute the candidates for motion vectors
The Gaussian membership function has only two parameters that can be determined by macro block pixels; thus, image pixels distribution can be treated as a regular distribution according to the membership function. A macro block with size “M x N” can be treated as the data matrix, and for this the corresponding membership matrix can be obtained using Gaussian membership functions

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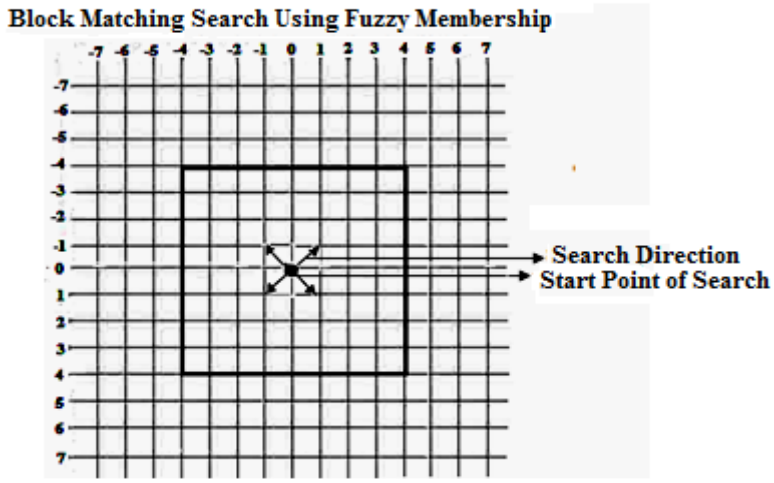

Figure 2:Sketch Diagram of Proposed Algorithm Initial Search

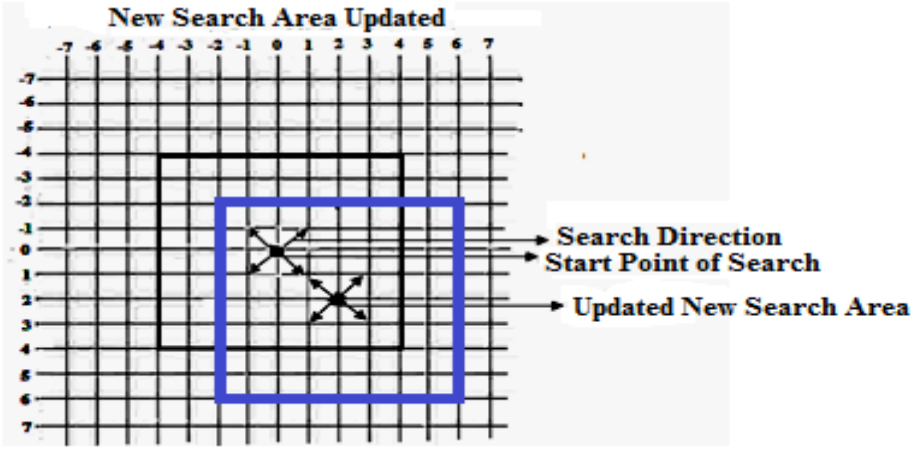

Figure 3:Sketch Diagram of Proposed Algorithm Updated Search

This membership matrix contains an array of fuzzy sets, namely the fuzzy set of corresponding pixels values. $u(im_{ij})$ represents the degree of membership each pixels as in eq 1. After formulating the membership function, each crisp pixel value im(i,j) is assigned as a membership value $u(im_{ij})$ value which is the corresponding membership degree of the fuzzy set.

$$u(im_{ij}) = e^{\frac{-(imij\ -c)^2}{2\varphi\sigma^2}} \quad \text{---------- (1)}$$

Where imij represents the macroblocks' intensity, φ is the amplification factor, σ the macroblocks standard deviation and their width is the GMF, c the centre of the GMF and the macroblock's average value is described.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(im\,(i,j)-c)^2}{MxN}} \quad \text{-----(2)}$$

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$$c = \frac{1}{MxN}\sum_{i=1}^{M}\sum_{j=1}^{N}(im(i,j) - c)$$-----(3)

Where im(i,j) is the pixel value at position (i, j),M and N is the size of the block.

The membership functions as defined in above equations are calculated for both current frame and the previous or reference frame. The fuzzy decision for the predicted frame motion vectors is calculated by finding difference of the two membership values.

em=(abs(ur(imij)-uc(imij))); ----------(4)

where ur(imij) is membership of reference block and uc(imij) is membership of current frame blocks. The sum of absolute difference of membership value of all blocks is the de-fuzzification expression.

SAD= $\sum_{k=1}^{B} em$ ----------(5)

where "B" represents all the macroblocks. The Sum of Absolute Differences (SAD) parameter is utilized to obtain the motion vectors of the moving blocks. The blocks for which minimum SAD is obtained constitute the candidates for motion vectors.

EXPERIMENTAL RESULTS

For the implementation of proposed algorithm a video clip named "foreman.avi" has been taken the bit rate of this video is 4 bits/s ,the frames are the size 352x288. The proposed algorithm uses search area p =8 pixels and the block size =8 pixels , p=8 , b =16 and p=16 and b =16. Figure 2 ,3 and 4 shows the comparative results with other algorithms as Full search , 3 step search and proposed method . The PSNR comparison reflects in table 1 . All the results have taken from MATLAB software for the implemented algorithm.

(A)Taking the search area p=8, b=8

(a)

(b)

(c)

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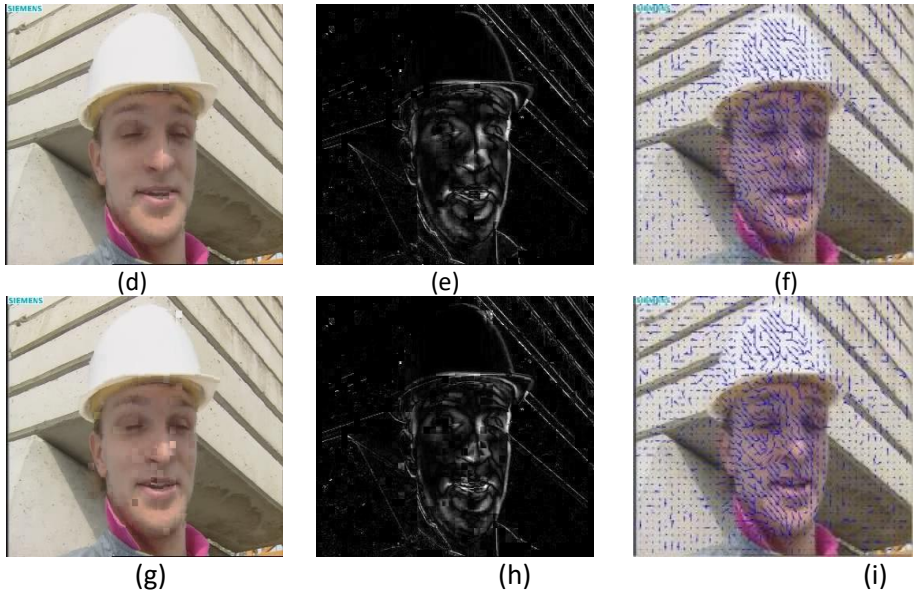
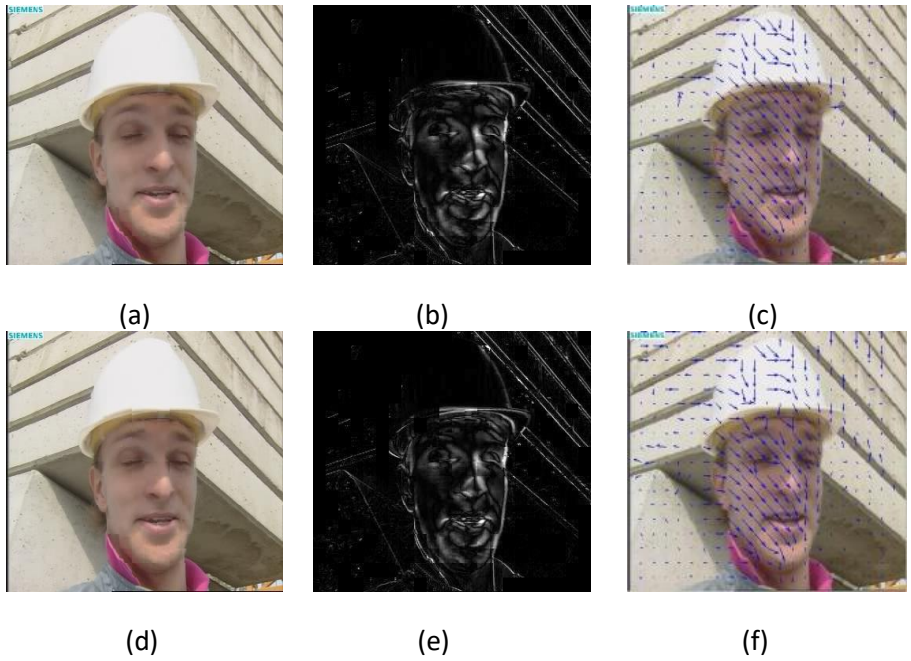


Figure 4: (a)Predicted Frame(FS) (b)Residual(FS) (c) Motion Vector(FS) (d)Predicted Frame(3SS) (e)Residual(3SS) (f) Motion Vector(3SS) (g) Predicted Frame(Proposed) (h)Residual(Proposed) (i) Motion Vector(Proposed

(B)Taking Search Area,p=8, b=16



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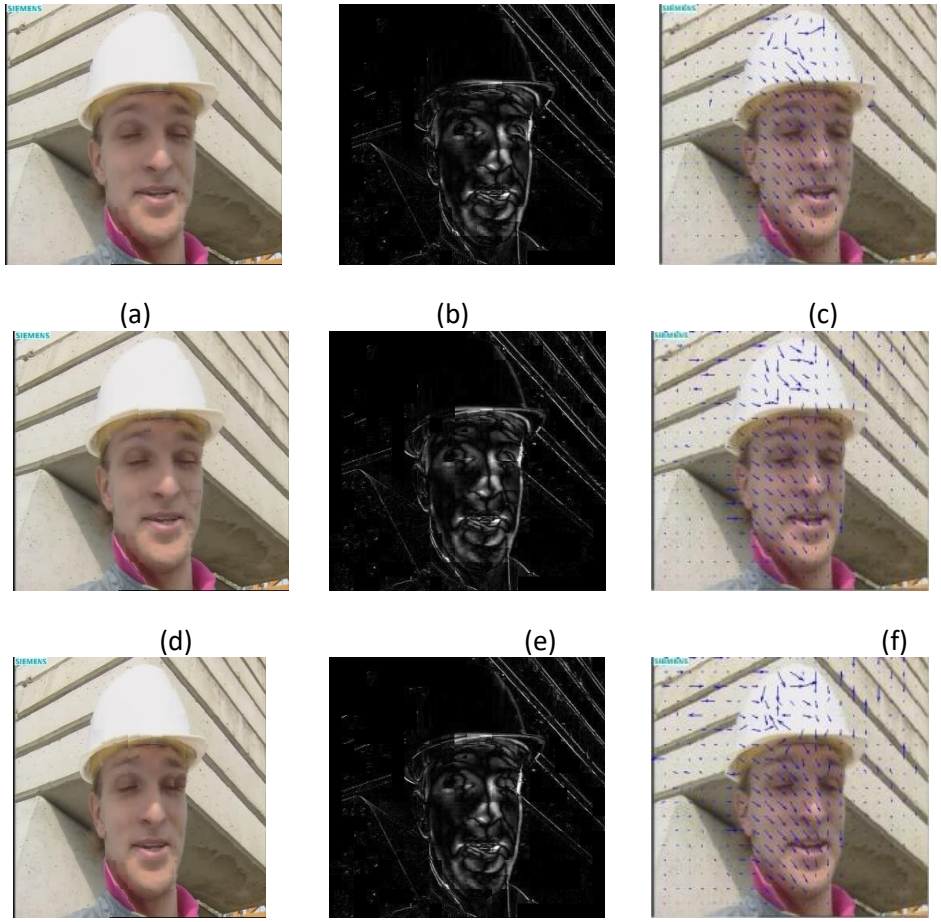
(g) (h) (i)

Figure 5: (a)Predicted Frame(FS) (b)Residual(FS) (c) Motion Vector(FS) (d)Predicted Frame(3SS) (e)Residual(3SS) (f) Motion Vector(3SS) (g) Predicted Frame(Proposed) (h)Residual(Proposed) (i) Motion Vector(Proposed)

(C)Taking the search area p=16, b=16



(a) (b) (c)

(d) (e) (f)

(g) (h) (i)

Figure 6: (a)Predicted Frame(FS) (b)Residual(FS) (c) Motion Vector(FS) (d)Predicted Frame(3SS) (e)Residual(3SS) (f) Motion Vector(3SS) (g) Predicted Frame(Proposed) (h)Residual(Proposed) (i) Motion Vector(Proposed)

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COPMARATIVE ANALYSIS

The proposed algorithm implemented in MATLAB software and the comparison is depicted in the table 1

Method	p=8,b=8	p=8,b=16	p=16,b=16
FS	76.0552913297614	76.1250368238704	76.0258449962979
3SS	76.2852060926333	76.2710990470443	76.0138862669877
Proposed	76.9186024523255	76.6895144943009	76.4724994344757

Table 1: PSNR Comparison table for various methods

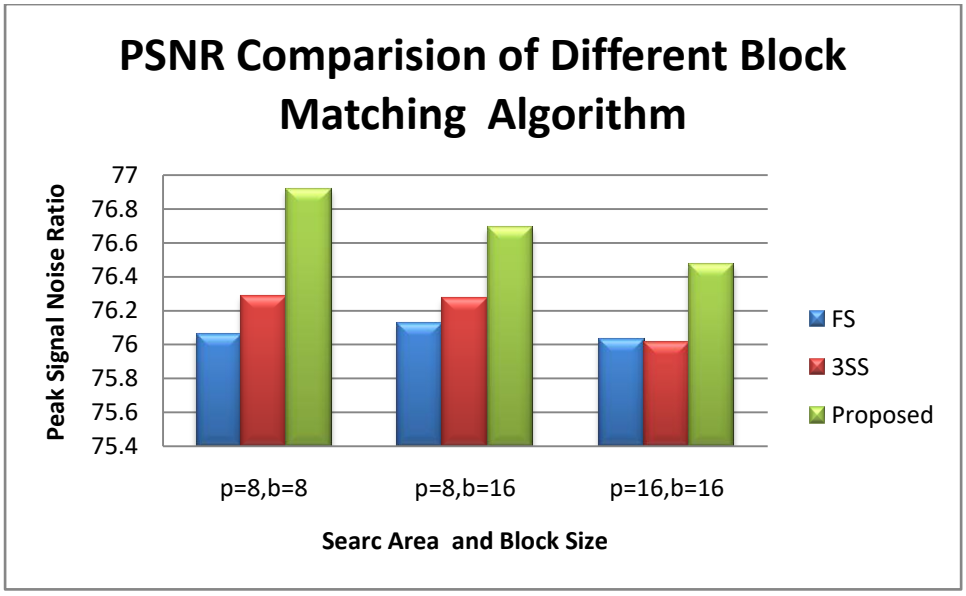

Figure 7:PSNR Comparision chart

CONCLUSION

In table (1) the PSNR value for the different block matching algorithms compared with the for the various values pf serach area “p” and block size “b” parameters . For search area p=8 pixels and block size .b=8 pixels and in the same way other parameters as p= 8 and b=16 , the proposed fuzzy membership based search method achieves a high PSNR value in comparison to full search and three step search algorithms for each parameter set . Thus it can be concluded that the proposed fuzzy based membership function search algorithm provides a high PSNR value as compared to other algorithms. In the figure 7 the graphical representation of these values have been shown.

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FUTURE SCOPE

In this paper, we have presented the strength of fuzzy logic for searching the best block in the block matching algorithm the use use of fuzzy membership function updated the search procedure automatically. We are currently approaching to replace the computationally expensive block matching algorithm further the motion vectors can be determined by this approach which is helpful in real time video streaming of data which can be used in mobile devices..In future we will refine this approach and compared with other algorithms.

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