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BIT RATE REDUCTION FOR H.264/AVC VIDEO BASED ON NOVEL HEXAGON SEARCH ALGORITHM

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Abstract

Video compression without losing the quality of information is more complex and time consuming process in video communication. H.264/AVC is designed and developed to meet corresponding video compression. Motion estimation and motor vector are the two important key techniques considered during video compression. The encoder complexity and process time is increased as demand increases for better quality of video service. The proposed model mainly concentrated on bit rate reduction of H.264/AVC with reduced rate distortion optimization (RDO) computation. Based on the texture information each input frame slices into 16 × 16 and 4 × 4 Macro block (MB) divisions. For each MB a gradient bit cost and RDO value is calculated for the best mode selection. If the bit cost of the MB is less than predefined level then DC mode are directly chosen for frame prediction, similarly the process is repeated for all chroma samples. This process of mode selection minimizes the RDO calculation up to 36 modes, further the complexity of encoder is reduced by using a motion search algorithms. The proposed system is implemented using MATLAB tool with Hexagonal motion search and Binary Search methods to reduce the bit rate video frames. The system performance is analysed by using a PSNR value and bit rate of the Predicted frame.

Keywords:

H.264/AVC, Video Compression, Bit rate, PSNR, Novel Hexagon Search Algorithm

1. INTRODUCTION

In telecommunication the demand of digital video service is increasing day by day in home, corporate sector and especially in entertainment industry. This increasing in the demand for better quality of video with less operational bandwidth is very difficult. The previous video standard method used 150Mbits/sec data rate for video transmission which consumes large bandwidth. As there is increase in quality of video needs a larger operational bandwidth. In modern communication systems, diversity of applications exists, where coded video has become an important part. So Video Compression standards are developed, enabling video data transmission in an efficient way. This problem is studied and new H.264 video compression standard model is jointly developed by ITU-T (International Telecommunication Union) Video Coding Expert Group and ISO/IEC Moving Picture Experts Groups. Video codec demands certain significant features such as coding efficiency, robustness to channel changes and flexibility with regard to application. Video compression is one of the considerable parameter during video codec, during video compression the homogenous video information is compressed during transmission. There are various video compression techniques available in digital video communication services. The respective compression model is selected depending on the computation time, required latency and corresponding communication bit rate. However H.264/AVC codec can fulfil these requirements and meet the solution for different problems of multimedia systems.

Lossy and Lossless compressions are the two types of compression techniques [1] used in video compression. Lossless data compression can be used when the data has to be compressed without loss of data and therefore, the reconstructed data is accurate as it was before compression. Lossy compression can be used when the data doesn’t have to be restored accurately. Some loss of information is acceptable with Lossy compression. For the development of video compression standards, the International Telecommunication Union (ITU) and Moving Picture Experts Group (MPEG) are working in parallel. Various applications such as video conferencing, internet video streaming, mobile TV, DVD-Video and digital television makes use of video compression technology. Decoding is an inverse process, which converts encoded data to original data, prior to display.

By the application of H.264 video compression, video communication reached to a new level of information transmission. In H.264, encoder considers three frames i.e. I-frames, P-frames and B-frames. Depending on the video profile any one frame module is considered by encoder during video encoding. Before encoding an input video, compressions of the visual information is done by using intra and inter frame encoding techniques. The similarity within the frame and between frames is founded by using special processing unit called as Macro block. The macro block format perform discrete linear block transformation, each block consist 16×16 samples. These samples again subdivided into different prediction block such as 4×4, 8×8 for intra mode and for inter mode 16×16, 16×8, 8×16, 8×8, 8×4, 4×8 and 4×4 block size is used. Normally 8×16, 16×8 and 16×16 are termed as large block modes which are generally used to find larger homogenous area of the frame in H.264. 8×8, 8×4, 4×8 and 4×4 are defined as sub block modes generally used to distinguish small variation in video frames. For each macro block the respective rate distortion optimisation (RDO) is computed and finally a single block mode which gives minimum cost is selected for video encoding [2].

In H.264/AVC Encoder perform the compression operation in two methods, they are termed as intra mode and inter mode operation. Intra prediction in H.264/AVC is always conducted in spatial domain, by referring to neighbouring samples of previously coded blocks, which are to the left and/or above the block to be predicted. Here frames are independently decoded without referring any previous video frames. The use of intra frame video compression method reduces the possibility of error at the decoding side.

Inter frame prediction and coding is take advantage of the temporal redundancies that exist between successive frames, hence it provides very efficient coding of video sequences. It divided into two modules, i.e. Predictive inter frames (P-frames) and bi-predictive inter frames (B-frames). The selected reference frame(s) for motion estimation is a previously encoded frame(s), the frame to be encoded is referred to as a P-picture. Both a previously encoded frame and a future frame are chosen as reference frames, and then the frame to be encoded is referred to as a B-picture. H.264 supports a new inter-stream transitional picture called an SP-picture. The inclusion of SP-pictures in a bit stream enables efficient switching between bit streams with similar content encoded at different bit rates, as well as random access and fast playback modes.

For the luminance (luma) samples, intra prediction formed by using either 4×4 block or 16×16 macro block. There are a total of 9 optional prediction modes for each 4×4 luma block and there are 4 optional modes for a 16×16 luma block. The latest H.264 standard also defines 8x8 blocks and also has 9 prediction modes which are the same as those modes used in 4×4 block. It means that for a macro block encoder perform a 736 RDO calculation before considering the best block mode for video compression. The coding efficiency of H.264/AVC improved as compared to other video compression standards [3].

2. LITERATURE REVIEW

Wang et al. [4] has worked on binary search and implemented a new video motion estimation model with low power consumption and minimum operational bandwidth. In the referred paper author used an all binary motion estimation (ABME) method for motion estimation and encode the video sequences in minimum bit streams. The used ABME algorithm includes four advanced features, at first level the preprocessing technique is applied for every macro block. Further a binary pyramid search structure is formed efficiently, after that 16×16 and 8×8 macro block parallel processing is computed. At the end author concluded that the performance of the designed model good i.e. in terms power consumption, operational speed and bus access better.

Nisar et al. [5] proposed a novel fast directional search algorithm for fractional pixel motion estimation. For achieving higher compression efficiency and more precise motion vectors, fractional pixel motion estimation is required. The proposed algorithm includes directional quadrant, early termination, motion prediction and point-based search pattern to speed up the process. It is based on the strict application of UESA. Firstly, the search area is divided into four quadrants and later the minimum error point is found by searching only few points, which lie in that quadrant. Compared to HFPS algorithm, the proposed algorithm saves the FME time around 8% to 18% with negligible performance degradation. Therefore, they can be used in mobile video applications which require low computational complexity. In addition to this, the proposed algorithms can be able to work mutually with any integer pixel motion estimation algorithm.

Sudhakar et al. [6] designed video encoding model using DCT and Modified Unsymmetrical – Cross Multi Hexagonal-Grid Search (MUM Hexagonal) block matching motion estimation algorithms. In referred paper used algorithm basically reduces the search points and a new structure as compared to the previous conventional UM Hexagons. This saves operational time of motion estimation, increase system efficiency during video encoding. The working efficiency of the model is enhanced by using Three- Dimensional Discrete Cosine Transformation video compression technique with MUM Hexagonal algorithm. In the referred paper performance of the proposed model is compared with UM hexagonal, based on the comparison result author concluded that designed model gives better performance and applicable for the real time video coding applications.

Anthon et al. [7] has proposed new algorithm used in reduction of the bit planes in Distributed Video Coding (DVC). DVC is one if the video compression module, in referred paper the author worked on Wyner-Ziv (WZ) frames. In the referred base module where decoder requests a parity or syndrome bits every time from the encoder side. This problem is analysed by the author and new approach is designed fast Wyner-Ziv (WZ) frame reconstruction using less parity bit needed from encoder. At lastly based on comparison method author concluded that the proposed module reduces error presents between during frame reconstruction.

Gu et al. [8] has worked on bidirectional motion search of B frames coding in H.264/AVC. In H.264/AVC a bi-directional motion search is most important features of B-picture during coding process. However there is huge mathematical complexity and large amount of memory is required for the storage. To overcome this problem author design and VLSI based new storage structure; here only two searching windows are used full motion search. In referred paper designed model support real-time video system which provides the video signal processing capacity up to 149M MB/sec by using 300MHz clock frequency.

Oliveria et al. [9] has conducted research on PW-SSIM used with HEVC (High Efficiency Video Coding) and H.264. Recently the need of bandwidth due to increase demand of digital video transmission, a new video encoding model is designed by ISO/IEC MPEG and ITU-T VCEG group. The designed model increases the encoder performance and reduces the bit rate up to 50% without compromising the quality of video. In the referred paper author mainly analyse the spatial information complexity present in HEVC and H.264 by using PW-SSIM. The performance of both HEVC and H.264 is analysed by considering PSNR level both video encoding method with PW-SSIW characteristics.

Bachu et al. [10] designed block matching motion estimation model using square and hexagonal search algorithm. The proposed model is defined as Adaptive Order Square Hexagonal Search (AOSH) algorithm. In the referred paper the used motion search algorithm is done by using minimum number of search points. Here trade of criterion function used to for searching function, so the proposed include tangent weighted function to compute matching point during block searching. The video quality and compression performance of H.264 increased by using tangent – weighted trade – off method. The experiment is conducted by using three video namely, tennis football and garden. The Structural Similarity Index (SSIM) and Peak – Signal – to – Noise – Ratio (PSNR) parameter are used to determine the working efficiency of proposed system and existing system.

Baruffa et al. [11] has worked on JPEG 2000 intra – coded video compression, in the referred paper author provide theoretical frame structures for dynamic joint channel and bit rate allocation for respective video coding. For respective video frame Lagrangian optimization is used to calculate the desire code rate. Used lagrangian optimization is simple and adaptive for both channel condition and bit rate during transmission. Reed –

Solomon (R - S) coding method is used for stimulation results and the proposed system performance is represented by MSSIM and PSNR parameters. At lastly author concluded that application of Largrangian optimization reduces the computational complexity presents during video encoding.

Elyousfi et al. [12] has designed algorithm for fast mode selection during intra coding of the video frame. In the referred paper block's gravity centre vector is used to prediction mode selection during intracoding, in the referred algorithm direction of gravity centre vector is used for best prediction mode selection. For RDO calculation minimum numbers of intra-prediction modes are selected. The proposed system performance is evaluated by using different video sequences. At lastly the conclusion is made that, used intra-prediction mode techniques reduces the computational time with increase in the Peak-Signal-to-Noise-Ratio, without reducing the quality of digital video sequences.

Oh et al. [13] has worked on motion estimation method during video analysis. In the referred paper author considered single and multiple reference frames to remove irrelevant worthless information during motion estimation. The referred multiple blocks classifies into two parts i.e. valid and invalid depending on the motion estimation. Depending on motion estimation irrelevant computational information is removed by using single reference to the invalid blocks. JM 9.5 software tool is used for performance analysis of the proposed system such as bit rate, video quality and motion estimation time. The referred mainly concentrated on motion estimation time, at the end based on stimulation result it is concluded total 39% of the system is saved as compared to the existing model.

Mathew et al. [14] designed intra mode decision algorithm for video coding in H.264/AVC. The block type skipping method is used to reduce the encoding time involved in mode selection process. Based on minimum SATD value the best chroma prediction mode selected for chroma samples. For luma prediction the minimum SATD cost with 16×16 selected which provide detail information about the MB, 4×4 prediction blocks are skipped when adaptive threshold will be less than 16×16 luma samples. The proposed system performance is measured by using JM 18.6 software tool, the performance is analysed by using PSNR, and increasing the bit rate by 0.74% on average with reduce the encoding time of the proposed model as compared to existing system.

Vijay et al. [15] worked on motion estimation operation for the input video sequences, in the referred paper author used four different motion estimation algorithms. Number of computation is done for evaluating a best motion estimation algorithm for video encoding. For each motion estimation algorithm corresponding PSNR value is computed, based on the resultant PSNR value, author concluded that modified diamond search (MDS) algorithm is good. In referred paper simulation is done on both subjective and objective, based on simulation result author explains that modified block matching algorithm is best as compared to full search and three step search algorithms.

Kulkarni et al. [16] has worked on medical video sequences, latest electronic devices used in medical sector such as CT Machines and MRI scanner gives a large amount medical data in the form of frames or Images. Hence there is need of large amount of memory storage to keep secure and have track on all medical sequences is important. In the referred paper author mainly considered medical video sequence as an input parameter and motion estimation is applied to sequence of video frames to reduce the storage area while transmitting the medical information from one place to another place. For video compression author used a three step search algorithm for estimation. At last based on simulation result author concluded that as compared full search block searching algorithm the three step search block matching algorithm gives better performance within minimum computational time.

Verma et al. [17] designed a VLSI new fast three step search algorithm for motion estimation. As compared to standard three step search algorithm, the designed FTSS algorithm uses a minimum check points during motion estimation. Application of FTSS method help the encoder to encode the video stream is various data rate with minimum bandwidth requirements. In the referred model the used algorithm reduce the computational complexity involved during motion estimation; along with that motion compensation error will be less. The model is designed with VLSI, here on – chip buffer eliminate the bandwidth requirements. The simulation result of the designed model is compared with FS and TSS performance, based on the result author concluded that, designed VLSI based fast motion search algorithm reduces the mathematical complexity and bit rate to HDTV systems.

Leela et al. [18] worked on motion estimation using Adaptive rood pattern search algorithm. The block matching search algorithm is done in stages, initial search is performed in first stage and refined local search is done at second stage. Refined local search method will good only when initial search present good starting point. The adaptive rood search algorithm reduces the error related with block matching. For each MB adaptive search pattern (ARP) is determined at initial stage and size of ARP is calculated. After ARP determination rood pattern is repeated at refined local search stage. The model is implemented using Matlab software and last simulation result is compared with DS and FS algorithms. At last author concluded that the proposed model performance is very fast as compared to the DS and FS.

Form the literature review it is cleared that lot of research has been done to transmit high quality video signals within less bandwidth. In the proposed paper designed methodology mainly focused on bit rate and the operational modes involved in RDO calculations. In H.264/AVC the number of modes used in RDO computation during intra frame prediction i.e. for each macro block (MB) is given as $N8 \times (16 \times N4 + N16) = 592$. Where number of modes of 8×8 chroma block is represented byN8, similarly N4, N16 denotes the operational modes of 4×4 and 16×16 luma blocks, this huge RDO computation for single MB in an intra-frame increase the complexity of the encoder during frame encoding. In the proposed model the research is done on H.264/AVC to reduce the computation modes. Here we meet the result where quality of matching MB is done using only 36 modes (i.e.$1 \times (2 \times 16 + 4) = 36$). Further the efficiency of the encoder will be increased by using block matching motion search algorithms to encode the video frame in less bit streams. The below section explain the working of the individual processing block of the proposed system.

3. METHODOLOGY

The proposed work implemented using Novel Hexagon Search algorithm and Binary search algorithm. The designed architecture of the proposed system work is shown in below Fig.1.

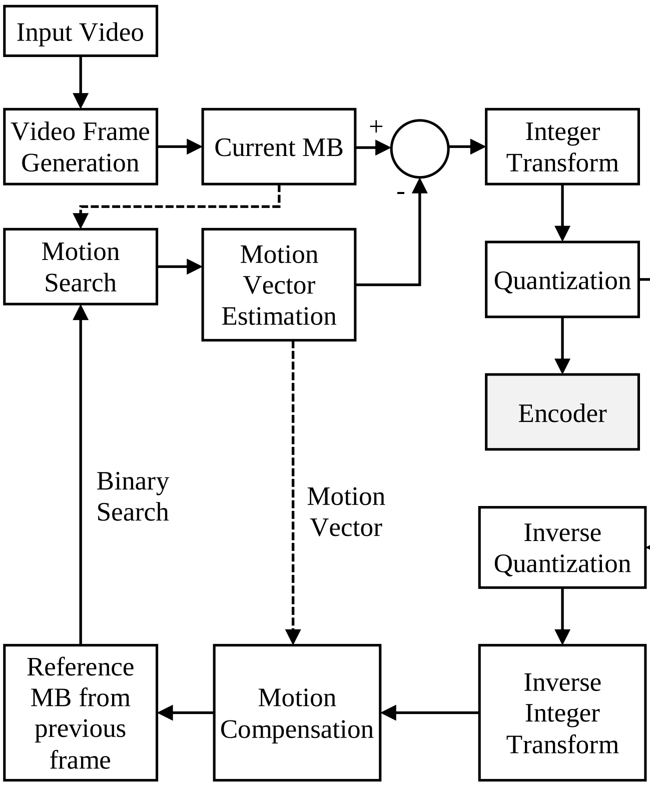


Fig.1. Architecture of the proposed model

The input video consist a number of frames, a video frame generation block is used to separate the video frames. Pre-processing steps are applied for individual frames as suitable for the next frame operation. Based on the texture information, I frame is divided into 16×16 and 4×4 macro blocks. Homogeneity within the intra frame is determined by using 16×16 and 4×4 Macroblock (MB). Here Group of Picture (GOP) techniques is used to specify the arrangement of I frame, P frame followed by B frame.

In frame prediction, the predefined threshold value is set for mode selection of the particular MB. The model switch to gradient based calculation, when the computed cost energy value is more than the predefined threshold. In gradient based calculation bit cost computation is done for the all 16×16 and 4×4 MB modes using sum of difference, and finally the mode with less cost is selected for the input MB. Correspondingly rate distortion optimization computation is done for each and individual MB of the input frame. The mode which gives minimum RDO is considered as the best mode for frame prediction. In the proposed system RDO calculation is done for every time and each MB. If the computed cost is less compared to the threshold level than, designed model is directly switch to DC mode for frame prediction of the input MB. Usually in intra frame prediction, for mode selection of each MB is done by computing 592 RDO computations but in designed model RDO computation is reduced to 36.

Further the predicted MB is passed to the interpolation block, the quality of video MB is enhanced by applying interpolation technique, and this method increases the PSNR level of predicted MB. A Novel Hexagonal and Binary Search pattern is used in intra frame prediction of input video sequences. In this search pattern the difference between the current frame MB and previous frame MB is estimated, based on the difference between the MB a motion vector is formed and finally encoded. The application of Hexagonal block matching, binary search and interpolation techniques encodes video frames in less bit streams in H.264/AVC with better PSNR value. The working of intermediated function algorithm is explained in below sections.

3.1 GOP

GOP is defined as an arrangement of I frame and P frame during video compression, in H.264/AVC video compression GOP plays a significance role. The coding efficiency of H.264/AVC standard is increased by selecting proper size of the GOP. Based on the size, GOP is divided into two type's i.e. static and variable type. Normally most of the video standard uses a static size of GOP to reduce bit rate and encode the video sequence in less bit streams. Once GOP size is fixed then the same size will be maintained during entire video encoding. GOP structure is directly affected the quality of video and bit rate of the encoder [19]. In the proposed system static size of GOP is formed it include 3 frames, this GOP size is maintained for all the input data set i.e. video 1, video 2 and video 3.

3.1.1 Gradient based Intra Prediction:

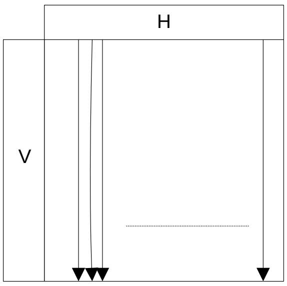
In gradient based intra frame prediction, gradient calculation is applied for each MB. The mode which gives the minimum bit cost and less RDO value is considered as Best mode for frame prediction. RD optimization is one of the important key parameter considered in mode selection. The compression efficiency of the H.264 is completely depend on the encoding mode used by respective macro block in intra frame prediction. In H.264 the mode which has minimum rate distortion cost is selected as best MB mode. Mainly Lagrangian minimization is used for computing RD cost, the mathematical equation of RD cost computation is given as:

$$J = D + R.\lambda \tag{4}$$

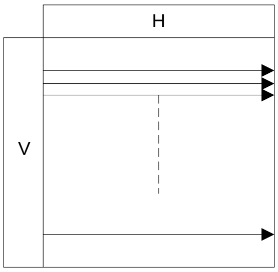
The minimum cost is represented by J, R denotes bit rate cost and Lagrangian multiplier is represented by λ. In rate distortion optimization Lagrangian multiplier is an important paramter, because increse in the λ reduces the bit rate and increase the distortion. Simillary smaller λ value increase the bit rate and reduce the distortion. So proper selection of λ value is very important. The Lagrangian multiplier value is calculated as:

$$\Lambda = 0.85\times2^{(QP\text{-}12/3)} \tag{5}$$

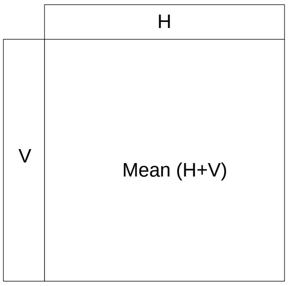
where, λ is function of QP for the best result (i.e. within the range between 0 to 51).



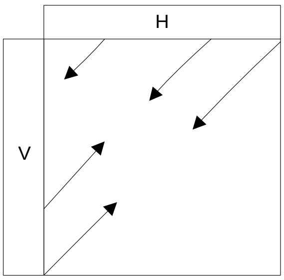
0 (Vertical)



1 (Horizontal)



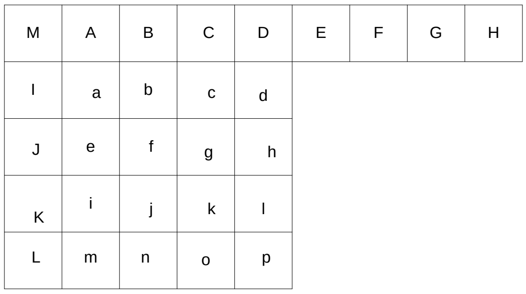
2 (DC)



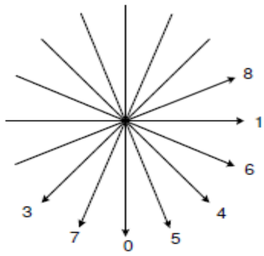
3 (Plane)

Fig.2. 4 Modes of 16×16 luma Blocks

Each modes sample prediction of 16×16 MB is as shown in above Fig.2. Hence only one direction is considered during gradient calculation, based on direction orientation any one of the mode is selected for frame prediction. The Fig.3(b) shown the use of the particular mode in different direction. In some condition first and second quadrant are not defined by any modes, at such situation DC mode is randomly chosen.



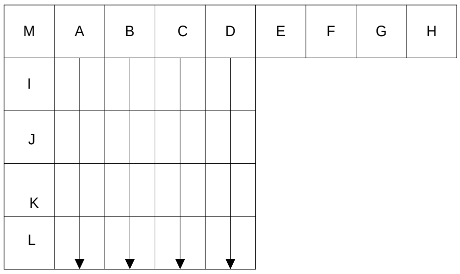
(a)



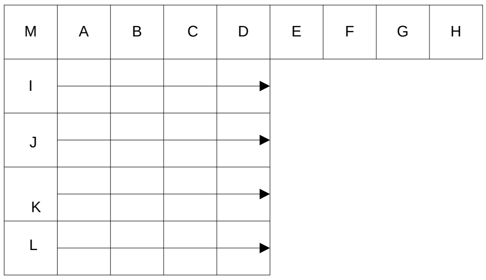
(b)

Fig.3. Prediction Modes for Various Directions

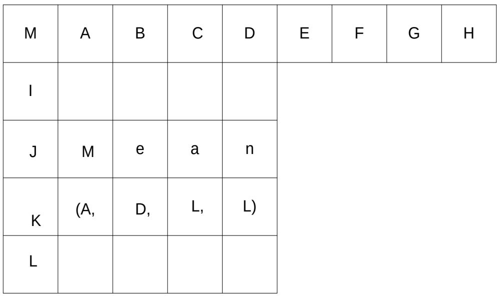
The Fig.4 gives pictorial information about 9 different modes of 4×4 luma samples, from the Fig.3 and Fig.4 it is cleared that direction towards the intensity change in the video frame is directly dependent on mode selection.



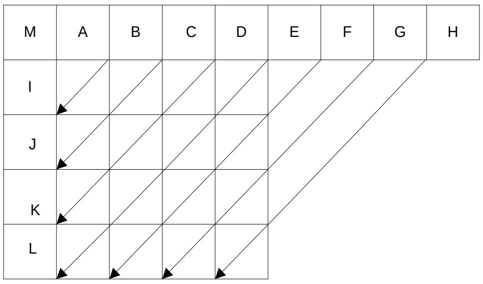
0 (Vertical)



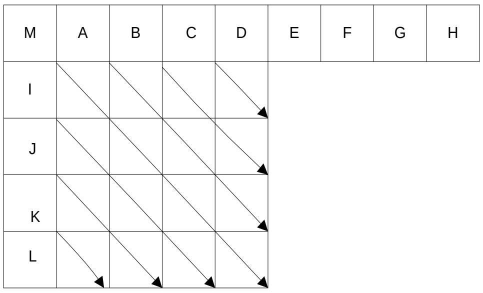
1 (Horizontal)



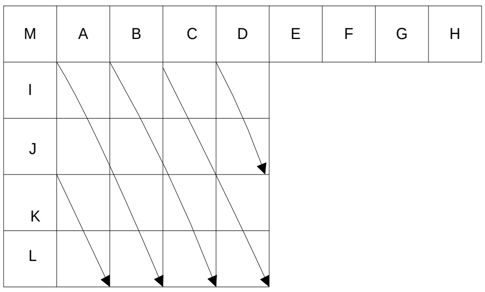
2 (DC)



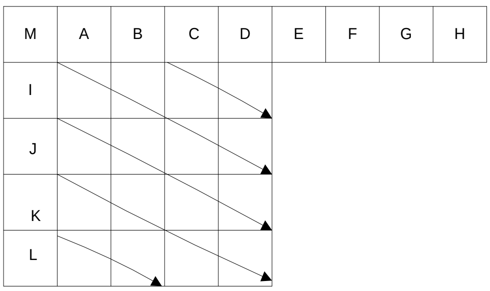
3 (Diagonal down - left)



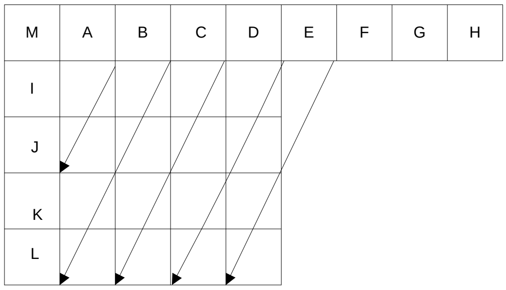
4 (Diagonal down - right)



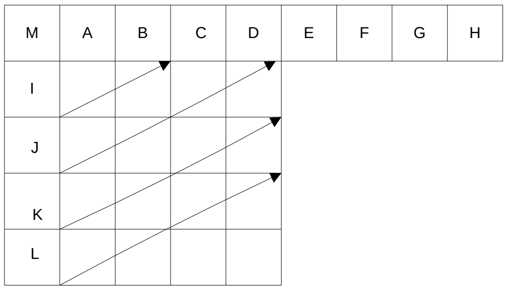
5 (Vertical - right)



6 (Horizontal - down)



7 (Vertical - left)



8 (Horizontal - up)

Fig.4. 9 Modes of 4×4 luma Blocks

In designed model the respective mode for each MB is selected based on threshold level, initially computed energy level is compared with the predefined energy value. The model switched to gradient based intra frame encoding when computed energy is more than the threshold level. Whereas DC mode intra frame encoding will be chosen, if the computed energy is less than threshold level.

3.1.2 Intra Prediction using DC Mode:

DC mode is operated independent to the direction, It is considered as one the best frame prediction mode in video coding. Initially if the calculated is energy is below than threshold range then DC mode is selected for frame prediction. In the proposed system for luma samples a 4×4 MB used, in N4 the selected DC mode replace all the pixels by mean value of adjcent pixels. The working flow of 4×4 MB is explained in below steps using Fig.3(a). For 4×4 MB the *A*, *B*, *C*, *D*, *I*, *J*, *K*, and *L* are considered as referrence pixels, The below steps are followed during DC prediction.

Step 1: If all the reference samples available than current samples values are predicted by using below Eq.(1).

$$(A + B + C + D + I + J + K + L + 4) \gg 3 \quad (1)$$

Step 2: If only *I*, *J*, *K*, *L* referrence sample available than all the current sample value is predicted as

$$(I + J + K + L + 2) \gg 2 \quad (2)$$

Step 3: If *A*, *B*, *C*, *D* referrence samples available than current sample value is predicted by

$$(A + B + C + D + 2) \gg 2 \quad (3)$$

Step 4: If referrence samples are not at all available, than all the luma samples presented in 4×4 is assigned with 128 values [20].

3.2 MOTION ESTIMATION METHOD

There number of algorithm has been designed for motion estimation, in the proposed model Hexagonal search and binary search algorithms are used for block matching motion search.

3.2.1 Hexagonal Search Method:

There are two types in hexagonal search techniques, first one contain seven check points, which is normally used for lager area shown in Fig.5 (i.e. the points are represented by 1). Here one check point is surrounded by six end points. Second one contains only five check points, where center point is surrounded by four end points. The Fig.5 represent the example of both hexagonal search patterns.

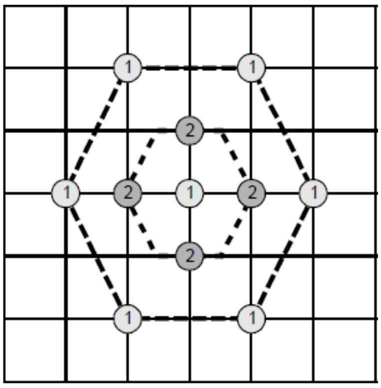


Fig.5. Large (1) and Small (2) Hexagonal Pattern

For larger homogenous region usually larger hexagonal pattern is used and for lesser texture information shrunk hexagonal pattern is preferred. During motion search when center point moves towards any one of the endpoints resultant new hexagonal patter formed with three new endpoints, on other side three endpoints are overlapped.

3.2.2 Hexagonal Search Algorithm:

Normally Motion search with seven endpoints is preferred. If the best outcome estimated at center point than directly shrunk hexagonal pattern is used for inner search. Otherwise search algorithm is continued with adjacent check points, for next block matching same large hexagonal pattern is used. The MB which has the minimum block distortion (MBD) is act as center for operation. The search pattern is continued with point direction which has less MBD as compared with other endpoints. In newly formed pattern there only three endpoints values are evaluated, where other three endpoints are overlapped. The Fig.6 represents an example of search path of Hexagonal algorithm [22].

Step 1: Seven check points with centered at (0, 0) is predefined,

Step 2: Motion estimation using search window in the motion filed.

Step 3: If the centered check points of large hexagon has the minimum block distortion (MBD), than go to Step 7, otherwise proceed with Step 4.

Step 4: Compute MBD point with less distortion ratio, form new hexagonal pattern

Step 5: Calculate MBD value of three new check points.

Step 6: Repeat Step 3 to Step 5 until MBD with less block distortion found in given frame.

Step 7: Switch the large hexagonal pattern into small pattern with five check points.

Step 8: With same centered point repeat Step 4 and Step 5

Step 9: Apply binary search operation

Step 10: Form the motion vector for matched MB of current frame to reference frame.

Step 11: For per block, total number of search points is calculated as

$$N_{HEXBS}(m_x, m_y) = 7 + 3 \times n + 4 \tag{5}$$

where, (m_x, m_y) is last formed motion vector, n is number execution Step 2.

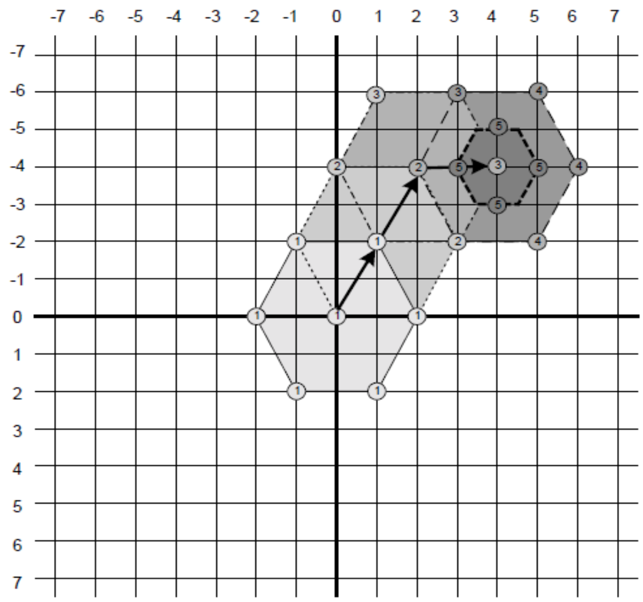


Fig.6. Hexagonal search method

The operational flow of Novel hexagonal algorithm is shown in Fig.7. The MBD term is also defined as Sum of Absolute Difference (SAD), the respective mathematical equation of both SAD and Mean Absolute Difference (MAD) is given following Eq.(6) and Eq.(7) [23].

$$SAD(x,y) = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left|C_{ij} - R_{ij}\right| \tag{6}$$

$$MAD = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left|C_{ij} - R_{ij}\right|^2 \tag{7}$$

where, N = Macro block size, C_{ij} = Current MB pixel value, R_{ij} = Reference MB pixel value.

This calculated error mean values for respective checkpoints of the hexagonal algorithm is stored and sorted based on the mean value in ascending order. Binary search algorithm is applied to sorted element of the frame to increase the efficiency motion estimation. The working of binary search is explained in next section.

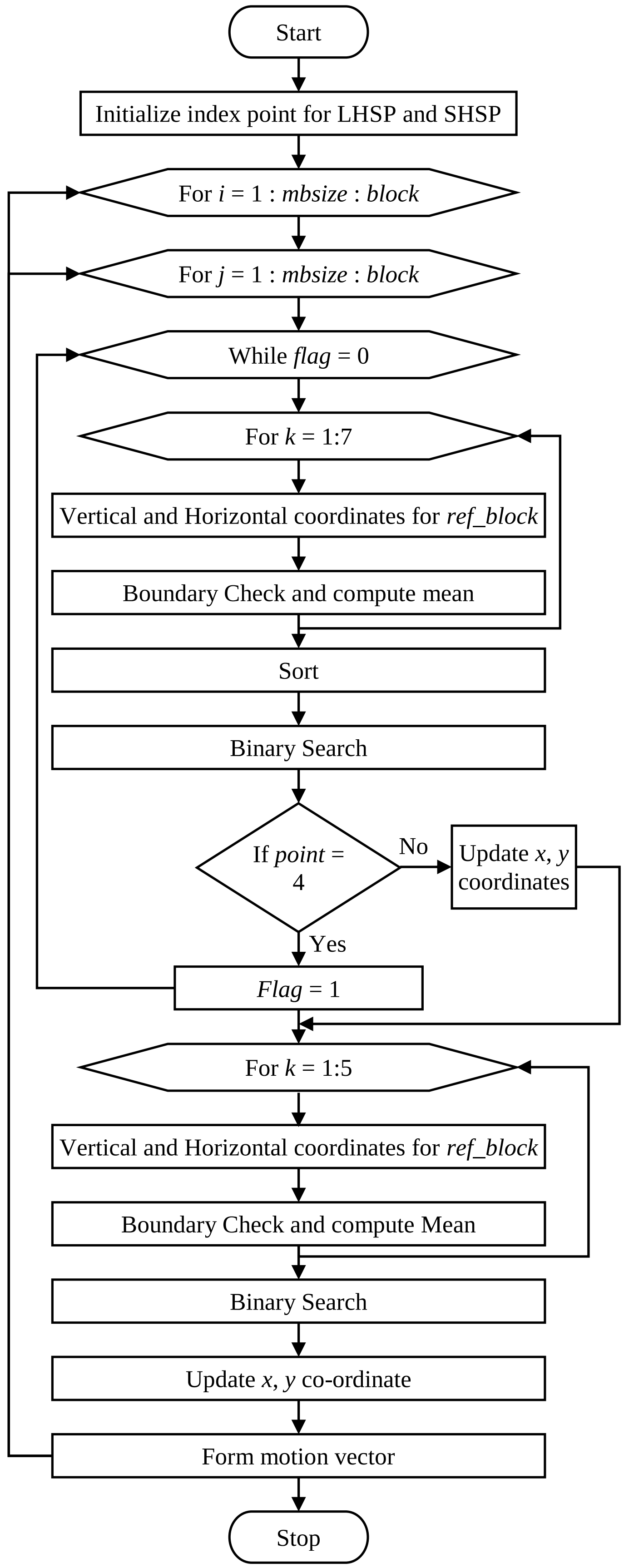


Fig.7. Operational Flow Chart of Novel Hexagonal Search algorithm

3.2.3 Binary Search:

Binary searching is one of the trees searching technique efficiently used to find the target element from the sorted array. Binary search method is termed as half interval search. In the following search technique the sorted array is divided into two parts called as two Childs of the binary search tree (BTS). These two Childs are defined as left child and right child, each check points of hexagonal search are rooted either left or right child based on their mean values. The midpoint of the sorted array is estimated by using threshold level. The check point which has less mean absolute value is comes under left child and the check point which contain higher mean absolute defined under right child. This process is repeated until to get a minimum cost mean from the respective check points of hexagonal elements.

Once the point with minimum cost value is determined, then that point acts as reference for current frame MB. This searching technique repeated for entire video frame until to determine the homogenous region within the frame. The resultant outputs from the motion estimation form the vector, for the next input video sequence only estimated displacement vector values are encoded. The Algorithm 2 explains the intermediate steps of binary search designed in proposed system.

Algorithm 2: Binary Search Algorithm

Input: Reference frame Hexagonal Search points

Output: current frame Matched MB

Step 1: Seven Hexagonal check points with their mean value

Step 2: Sort Hexagonal check points in ascending order

Step 3: If the mean value of lowest MB = highest MB

Then, compute the mean difference and update the index with least MB

Step 4: While mean of lowest MB < highest MB

Then, compute MAD of two macro block

Step 5: Compute midpoint of an array i.e.

$$mid = (from + to)/2 \tag{8}$$

Step 6: If MAD value of least MB < highest MB MAD value

Then consider highest MB as a mid-point

Else

Least MB act as mid-point

End

Step 7: Update the index

Step 8: Repeat above steps for all check points

Step 9: Finding matched block

Step 10: Form the motion vector

The Fig.8 represent the working flow of binary search algorithm during block matching. The combination of both novel hexagonal search algorithm and binary search algorithm increase the efficiency of coding this procedure repeated for number frames of the input video.

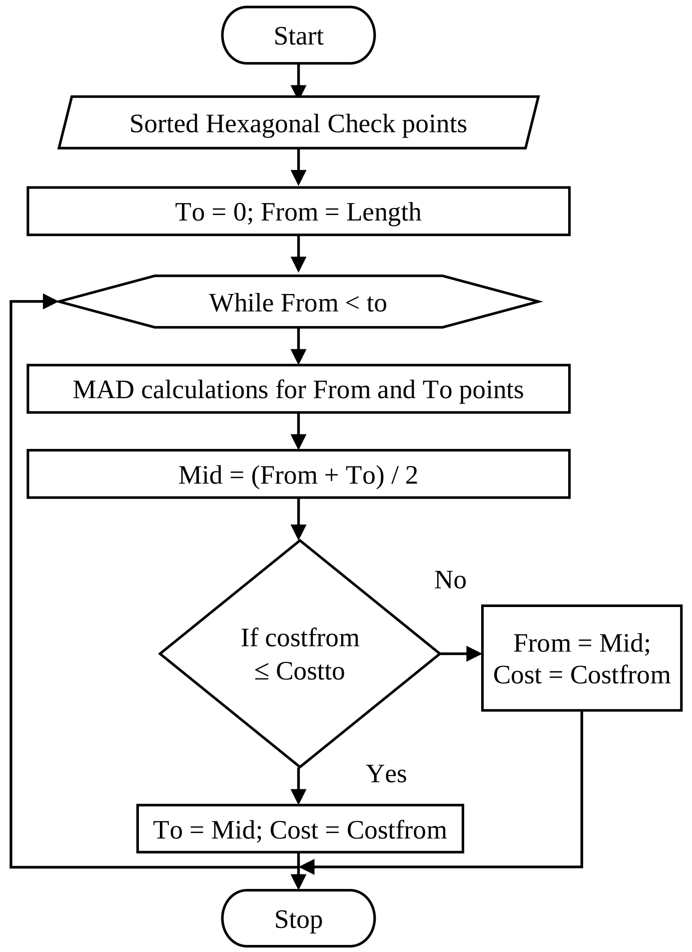


Fig.8. Operational Flow Chart of Binary Search algorithm

3.3 INTERPOLATION

Predicted MB is passed to the interpolation block, it include eight different set of polynomial equations. The reference frame is subdivided into 8 blocks, than respective co-efficient for individual 8 blocks is computed by down sampling, here for each MB is converted into 4×4. These computed value is passed to error calculation block, where original MB is used for calculating error between the frames. The error calculation block gives information about which predicted MB giving better values.

3.4 PERFORMANCE MEASUREMENT

The quality of the digital video is measured by using two approaches; first one is subjective quality measure and objective quality measures. Peak-Signal-to-Noise-Ratio (PSNR) is one of the parameter considered in objective quality measurement of the video. The optimum signal to noise ratio is computed by PSNR, in video compression the difference between original video and reconstructed video is measured by the PSNR in objective quality measurement. The PSNR parameter is valid as long as input video and codec is fixed.

The mathematical equation of PSNR is given in Eq.(9).

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \tag{9}$$

The cumulative square between original video frame and compressed video frame is computed by Mean Square Error (MSE) [24]. The compression ratio of the encoded video frame is calculated by using Eq.(11).

$$Compression\ Ratio = \frac{\begin{pmatrix} Original \\ Image \\ Value \end{pmatrix} - \begin{pmatrix} Compressed \\ Image \\ Value \end{pmatrix}}{Compressed\ Image\ values} \tag{11}$$

The bit rate of the encoded video is computed using Eq.(12).

$$\text{Bit rate} = 20 * F_R * luma_{Samples} * lines_{Frame} \tag{12}$$

where, F_R = Frames per second (rate in Hz), $luma_{Samples}$ = Per line Luma sample values, $lines_{Frame}$ = Number of lines per frame

4. EXPERIMENTAL RESULT

This section explains the intermediated results of the proposed system. The system performance measured by using three different data sets i.e. video 1, video 2 and video 3. The output is obtained for three video frames i.e. video 1, video 2 and video 3, each frame performance is measured with different quantization parameter (i.e. QP = 20, 26, 30, 36, 40). After pre-processing an input frames (i.e. I- frame), based on the texture information the respective video frame is divided into 16×16 and 4×4 macro blocks. Block mode selection will be done based on threshold energy. The calculated energy value is compared with the threshold. For 4×4 block, the mode which has a minimum RDO is considered as a best mode for frame prediction. The predicted frames of respective input data i.e. video 1, video 2 and video 3 is shown in Fig.9(b), Fig.10(b) and Fig.11(b). The resultant predicted MB is passed to interpolation block for quality improvement of the predicted frame which is shown in Fig 9(c), Fig.10(c) and Fig.11(c).

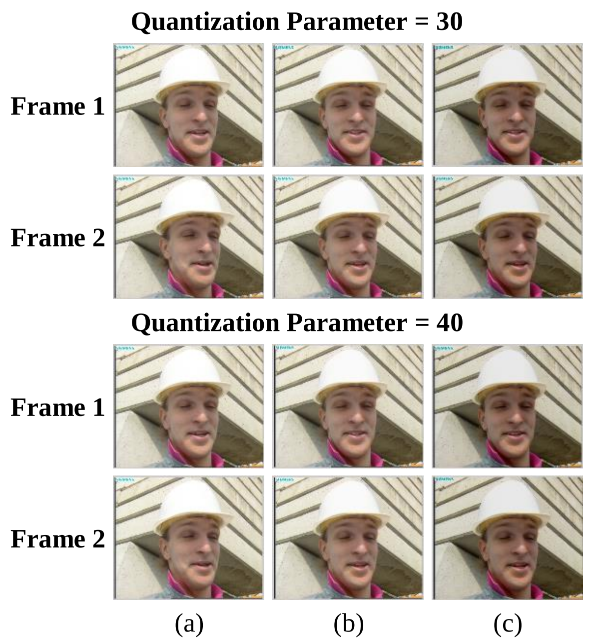


Fig.9. (a) Input Frame; (b) predicted Frame; (c) Interpolated Frame

In the proposed model we reduced the RDO calculation significantly from 1×(4×16+4) = 68, 2×(4×16 + 2) = 132, 4×(9×16 + 4) = 592 and 1×(3×16 + 2) = 50 to 1×(2×16+4) = 36 in H.264/AVC video coding. It increases the efficiency of video encoder. The experimental intermediate result is obtained with QP = 30, 40 of video 1 is shown Fig.9. The Fig.10 denotes the intermediate results of video 2 and video 3 input dataset result is explained in Fig.11.

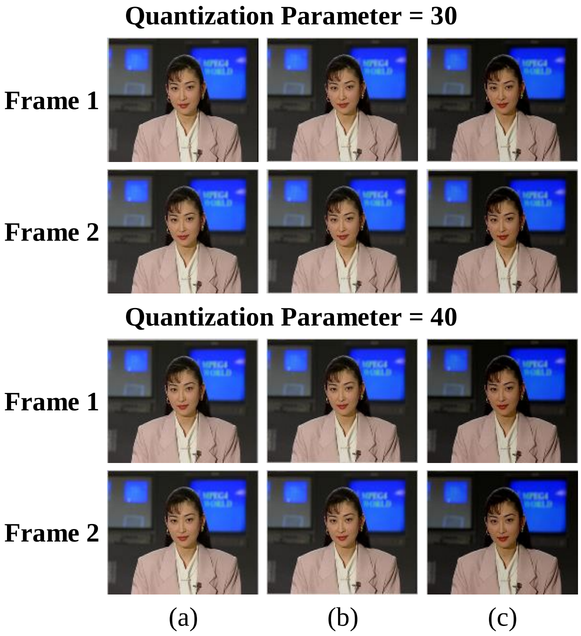
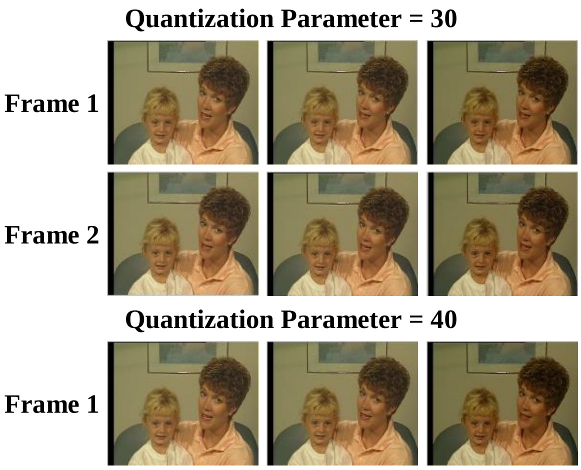


Fig.10. (a) Input Frame; (b) predicted Frame; (c) Interpolated Frame

The performance of the proposed system is compared with existing system. The Table.2 justifies that the Hexagonal motion search algorithm reduces the bit rate of the proposed model as compared to existing system. The performance of interpolation block is analysed by calculating the PSNR value for the each video input frames, and comparison graph is plotted for individual input video 1, video 2 and video 3 as shown in Fig.12(a), Fig.12(b) and Fig.12(c). The Fig.12(d) represents the average PSNR value for all the input videos with respect to the QP value.



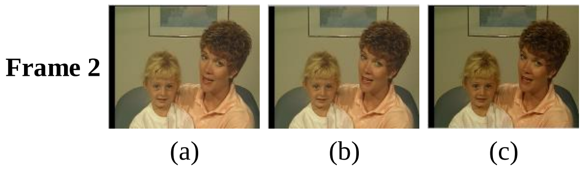


Fig.11. (a) Input Frame; (b) predicted Frame; (c) Interpolated Frame

The main motto of the designed model is to reduce the transmission bit rate of H.264 codec; this is achieved by using Hexagonal and Binary search algorithm. In Table.2 and Table.3 we are comparing the performance parameter of the proposed system with existing model. In Table.2 the bit rate of the proposed system is compared with existing model, where PSNR value of is kept constant. In Table.3 we listed we compare the proposed system PSNR values by keeping bit rate of both proposed and existing system constant.

Table.1. Performance Analysis of the Proposed System for Different QP Value

	QP	Frames	PSNR (Before Interp-olation)	PSNR (After Interp-olation)	Bit rate	Comp-ression Ratio (CR)
Foreman	20	Frame 1	47.430	50.630	1880.281	5.7394
		Frame 2	47.424	50.600	1777.328	6.1298
	26	Frame 1	43.869	47.898	1228.640	9.3138
		Frame 2	43.867	47.880	1171.484	9.8170
	30	Frame 1	40.869	43.252	878.515	13.4243
		Frame 2	40.867	43.244	843.125	14.0298
	36	Frame 1	35.266	37.869	582.718	20.7463
		Frame 2	35.250	37.867	559.312	21.6563
	40	Frame 1	31.618	33.266	451.093	27.0917
		Frame 2	31.599	33.250	431.890	28.3407
Akiyo	20	Frame 1	49.729	61.482	457.046	26.7258
		Frame 2	49.742	61.695	446.812	27.3608
	26	Frame 1	44.892	54.992	343.984	35.8388
		Frame 2	44.897	55.075	336.906	36.6128
	30	Frame 1	41.892	46.573	287.046	43.1461
		Frame 2	41.897	46.596	279.421	44.3507
	36	Frame 1	35.031	38.892	232.906	53.4081
		Frame 2	35.028	38.897	226.484	54.9508
	40	Frame 1	31.150	33.031	205.156	60.7675
		Frame 2	31.148	33.028	199.468	62.5287
Mother and	20	Frame 1	49.020	56.248	672.359	17.8470
		Frame 2	49.336	57.315	608.140	19.8372
	26	Frame 1	44.573	52.142	435.578	28.0923
		Frame 2	44.764	52.908	391.281	31.3859
	30	Frame 1	41.573	45.500	320.437	38.5459
		Frame 2	41.764	45.917	290.265	42.6565

	36	Frame 1	35.063	38.573	223.671	55.6544
		Frame 2	35.139	38.764	206.390	60.3981
	40	Frame 1	31.293	33.063	183.359	68.1101
		Frame 2	31.278	33.139	168.093	74.3865

Table.2. Comparison Table for Average PSNR and Bit Rate of the Proposed System (Maintaining PSNR Constant) with Existing System

Video	QP	Existing System [25]		Proposed System	
		PSNR (dB)	Bit rate (Kbits)	PSNR	Bit rate
Video 1 Foreman	20	41.52	422.31	41.25	394.7477
	26	36.83	180.03	36.33	156.0909
	30	33.99	103.02	33.19	86.1587
	36	29.96	45.86	29.36	38.2962

Table.3. Comparison Table for Average PSNR and Bit Rate of the Proposed System (Maintaining Bit rate Constant) with Existing System

Video	QP	Existing System [25]		Proposed System	
		PSNR (dB)	Bit rate (Kbits)	PSNR (dB)	Bit rate (Kbits)
Video 1 Foreman	20	41.52	422.31	42.12	420.21
	26	36.83	180.03	37.23	180.63
	30	33.99	103.02	35.39	101.52
	36	29.96	45.86	31.26	46.26

From the Table.2 and Table.3, it is cleared that the proposed system reduces the bit rate and increases the PSNR level as compared to existing system, based on the respective QP values.

5. CONCLUSION

The proposed methodology uses a H.264/AVC video standard for bit rate reduction of the encoded input video frame. The mode combination is reduced by using gradient based approach with minimum number of RDO calculation i.e. 36. The used Novel Hexagonal search algorithm and Binary searching methods efficiently reduce the bit rate of video sequences, the difference between current MB and reference MB encoded with help of motion vector. The computational complexity associated with block matching is eliminated by using binary search algorithm. As compared to existing model, the proposed system efficient video transmission with less bit streams.

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