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Performance and Analysis of Video Compression Using Block Based Singular Value Decomposition Algorithm

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Abstract: *This paper presents analysis of video compression based on block SVD Algorithm. Video compression is a process of efficiently coding digital video to reduce the number of bits required in representing video frames. Its purpose is to reduce the storage space and transmission cost while maintaining good quality. Current video compression standards like MPEG, H.26x series are highly computationally expensive and hence they are not suitable for real time applications. Current applications like video calling, video conferencing require low complexity video compression algorithms. The block SVD algorithms are used to provide higher PSNR at the same bit rate. Further we can analysis to reduce the time complexity of the video compression process based on block SVD Algorithm.*

Index Terms: *Block SVD, Low-Complexity video Compression.*

I. Introduction

Video compression is one of the most important blocks of an image acquisition system. With the growth of multimedia and internet, compressions Techniques have become the thrust area in the fields of computers. Many different video compression techniques currently exist for the compression of different types of video frames. Video compression is fundamental to the efficient and cost-effective use of digital imaging technology and applications. In video compression the images are called as frames. Due to the rapid developments in internet technology and computers, popularity of video streaming applications is rapidly growing. Therefore today, storing and transmitting uncompressed raw video requires large storage space and network bandwidth. Special algorithms which take these characteristics of the video into account can compress the video with high compression ratios. In a video, the images called as frames are streamed at the rate of 25-30 frames per second (fps). Video is characterized by huge amount of data. An uncompressed CIF video at a resolution of 288 X 352 at 25 fps has a data rate of30.41Mbits/s. As a result, transmission of raw video requires huge bandwidth. Also, the memory required to store this uncompressed video is enormous. These two drawbacks make it impractical to use raw video. To reduce the transmission bandwidth and the storage requirements, video compression is done. During compression, the redundant information is removed.

Video is a sequence of images which are displayed in order. Each of these images is called a frame. This technology (video compression) reduces redundancies in spatial and temporal directions. Spatial reduction physically reduces the size of the video data by selectively discarding up to a fourth or more of unneeded parts of the original data in a frame. Temporal reduction, Inter-frame delta compression or motion compression, significantly reduces the amount of data needed to store a video frame by encoding only the pixels that change between consecutive frames in a sequence. Compression algorithms typically exploit spatial, temporal and psycho-visual redundancies. Present in a video. Some of the widely used video compression algorithms are MJPEG, MPEG series and H.26x series. In MJPEG (Motion JPEG), each frame is individually coded using the JPEG algorithm. MJPEG does not exploit the temporal redundancies in the video and therefore it results in lower compression. A compression ratio of around 10:1 to 15:1 can be achieved using MJPEG without introducing any visual artifacts. MPEG (Moving Pictures Experts Group) is an experts group set by ISO and IEC. They have come up with standards like MPEG-1, MPEG-2, MPEG-4 etc. which have been widely used for video compression.

The heart of MPEG or H.26x algorithm is the motion estimation and motion compensation block. Motion estimation and compensation is responsible for exploiting the temporal redundancies in the video. Here, rather than coding each block independently, a block in the current frame is used to find the same block in the previous frame. Rather than sending the entire block, only the error and the motion vectors are encoded and sent to the decoder. Therefore the block can be represented with lower number of bits. Motion estimation and compensation is an efficient algorithm and a compression anywhere between 30:1 to 100:1 can be achieved. However, it is highly computationally complex. Due to the high computationally complexity, the power consumption is increased thereby reducing the battery life. Also, hardware implementation becomes difficult. We proposed Block SVD algorithm low computational complexity so greatly reduced time complexity.

The Comparison of the proposed block SVD coding scheme existing relevant non-ME-based low complexity code shows its advantage, which provides higher PSNR at the same bit rate [1]. In SVD algorithm when singular value increases size of compressed image also increases, the quality of compressed image also improve. In BTC with increase in size of block visual quality of image degrades and there is no much reduce in compression size with increase of block size. In DCT when coefficient value is increase Image quality improve of compressed image remains same [2].The latest video compression standard MPEG-4, AVC/H.264 gives 50% improvement in compression efficiency compared to previous standard. Increased computational complexity at the encoder [3].A video surveillance compression system the main problem is to increase in computational complexity, high energy consumptions, short batter life [4].The main problem for this hybrid coding system also causes interframe dependence in decompression ,the error occur frequently in the error- prone channel, so losses occurred in the channel [5] . Error resilient pre/post-filtering for DCT-based block coding systems coding efficiency heavily suffers from ignoring correlation between blocks. So blocking artifacts present at low bit rate [6]. DCT-SVD video compression technique cannot provide good compression and also energy loss is high [7]. The 2D SVD is the deals with only smaller matrices [8]. H.264/AVC is the higher compression efficiency .It is high computational complexity at the encoder due to the ME process. It is estimated that for the h.264 code, the computational complexity of inter frame coding 5-10 times higher than that of inter frame [9]. The adaptive algorithm which reduces the average memory bandwidth and power consumption is high [10]. Fast three step algorithms cannot be used in low power real time application resource scarce system [11].The high complexity process for encoder side because of two stage adaptive vector quantization is used to implement coding technique [12]. Optimum bit rate pyramid coding method the quality of the reconstructed image is ranged from lossless image compression. It's used for low bit requirement application like visual telephone and telebrowsing only [13].The PIT algorithm is encoding this sequence by transmitting from smallest to the largest size .so it's take longer time for the encoding process [14]. The main drawback of JPEG is blackness appears in the images when the compression ratio is pushed too high [15].

II. Singular Value Decomposition

In Linear Algebra, Singular Value decomposition is nothing but factorization of a matrix in the form

$$A = U \Sigma V \qquad (1)$$

Where U and V are orthogonal matrices and Σ is a diagonal matrix.
A= (Orthogonal) (Diagonal) (Orthogonal)

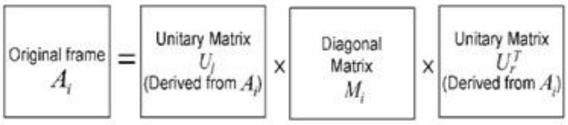

Fig .1.SVD decomposition

Fig .1.shows the SVD decomposition process. The columns of U are composed of the eigenvectors of A^T , the columns of V are composed of the eigenvectors of A^TA. The diagonal values of Σ are nothing but the square roots of the non-zero eigenvalues of both AA^T and A^TA.2D-SVD is an extension of the above mentioned 1DSVD.2D-SVD has been extensively studied for computer vision. The main drawback of 1D-SVD for image compression applications is that, even though it provides the most energy compaction (the coefficients are present only along the diagonal), it requires the transmission of the two eigenvector matrices for each block. This incurs very high overhead thereby reducing the compression efficiency. In 2D-SVD, the eigenvector matrices are extracted from a group of blocks. Therefore, the two matrices have to be transmitted only for a group of blocks. This results in higher compression. The block SVD algorithms are used to achieve higher PSNR at the same bit rate.

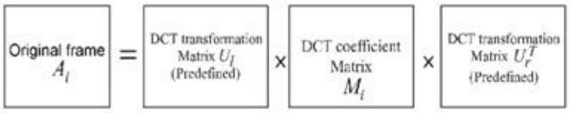

Fig. 2.DCT decomposition

For the DCT one fixed matrix is used, thus U_l=Ur. The DCT decomposition is shown in Fig.2. Since the transformation matrix is fixed, we can simply represent Ai with Mi.

The main problem for block-based 1-D SVD coding is that, although its coefficient matrix contains the fewest nonzero coefficients compared with other transforms, its and transformation matrices are not fixed and, hence, need to be sent to the decoder for each frame. As a result, the overall coding efficiency for the block-based 1-D SVD coding is not very promising.

III. 2d SVD Process

An image or a video frame can be divided into m x m non overlapping blocks. The 2D SVD decomposition is shown in Fig. 3.

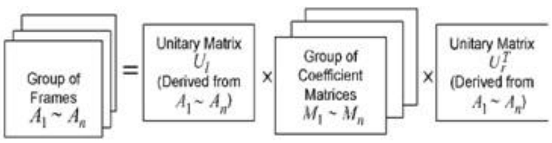

Fig. 3.Two-dimensional SVD decomposition

The basic algorithm to find the coefficient matrix is given below:

1) Given a group of frames $A_1 \ldots\ldots A_n$, find the mean frame Amean. Obtain the mean subtracted frames .i.e. $A_i^1 = A_i - A_{mean}$

2) For any GOB (Group of Blocks), B in the mean-subtracted frames, we denote as each block in B as $b_1 \ldots\ldots b_n$. For each GOB, find the row-row and column-column covariance matrices F and G

$$F=\sum_{i=0}^{n} bib\, T \quad (2)$$

$$G=\sum_{i=0}^{n} bT\, bi \quad (3)$$

U_l and Ur are made up of the k principal eigenvectors of F and s principal eigenvectors of respectively. It has been reported in that the lowest mean squared error is obtained when k=s=1.

3) The coefficient matrix M is obtained using the formula

$$M= U_l^T b_i U_r \quad (4)$$

it is to be noted that Miis not a diagonal
Matrix. However, most of the non-zero coefficients willbe located close to the principal diagonal.

4) To get back the original frame, the mean subtracted block is first obtained using the
Formula

$$bi=U_l MiUr^T \quad (5)$$

The near optimal approximation of each block is obtained using

$$b_i^{''}=b_i^{'}+b_{mean} \quad (6)$$

Where bmean is the corresponding block in the mean frame

IV. Proposed Technique

The application of the algorithm proposed in yielded the following observation. The Fig. 4 shows the video compression based on block SVD algorithm. The various steps are involved in the process of Block SVD video compression techniques. The sequence of process is input video sequence, pre-processing frames, block SVD, decoding and finally will get the reconstructed video sequence.

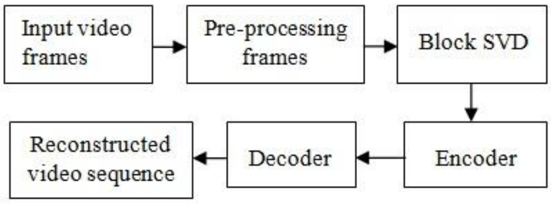

Fig.4. Video compression based on Block SVD method

In video compression the images are called as the frames. Input video frames are given the input to the pre-processing frames. Pre-processing algorithms improve on the performance of a video compression system. Its increases compression efficiency and attenuates coding artifacts. The size of the video frames is high means it's not display for some applications. So the frames are reconstructed to the standard size. Block SVD algorithm used for data reduction technique. The purpose of an encoder is to reduce the number of bits in the original image. Each frame is divided into several blocks. The block sizes are m x m non –over lapping group of blocks (GOB). The group of co-efficient matrices is optimized for block SVD. According to the experiment minimum mean square error is achieved. The decoder is the reverse steps of encoder process. The group of information is decoded in the function of decoder. Here the group of information size is small, successfully received. The Each frame are decode independently, just like an intra frame video codec. The sampling and quantization techniques are used to remove the error in decoder process. Finally get the quality of the reconstructed video frames and also sizes of frames are reduced. It's the purpose of reducing storage space in the memory.

Proposed Algorithm:

1) For videos with low motion, increase in GOP increased the compression ratio while maintaining the PSNR almost constant. This is because the percentage of GI to the coefficients is reduced, while maintaining the energy compaction property of SVD.
2) For videos with high motion, increase in GOP decreased the compression ratio and the PSNR also reduced. This is because the energy is distributed over a large number of coefficients thereby reducing the coding efficiency.

From the above observation it is clear that, for videos with low motion, a large GOP can be used and for videos with high motion a very low value of GOP must be used to maintain the compression ratio and the PSNR. The proposed algorithm is based on this inference:

1) First, the incoming images are divided into 8X8 non-overlapping blocks, Bj where j=0… $\frac{heightxwidth}{64}$
2) For each block Bj, the difference between the current block and the corresponding block in the 10th next frame is computed. The sum of these differences is computed.
3) If this sum is less than the threshold *th*, then the GOP value is set to GOPhigh. If it is greater than the threshold, then it is set to GOPlow. For each block, a group related information is first sent to the decoder. In this GI, the first bit set to 1 if GOP = GOPhigh and it is set to 0 if GOP = GOPlow.
4) The mean block b mean, is calculated using the formula

$$b_{mean} = \frac{1}{GOP} \sum_{i=1}^{GOP} bi \quad (7)$$

The mean block is then encoded using the JPEG algorithm. It is to be noted that, GOPhigh is chosen to be an integral multiple of GOPlow. If the GOP is GOPlow then GOPhigh GOPlow number of mean blocks are sent.

5) Block SVD mentioned above is used to obtain the corresponding eigenvector matrices U_l^j and U_r^j the group of 8 X 8 coefficient matrices M_1^j…..M_n^j
6) The eigenvectors $U_l^j = (U_1^j \ldots U_8^j)$ and $U_r^j = (U_r^j \ldots U_r^j)$ are encoded using the Vector Quantization strategy. Code books of length 256, 256, 128, 128, 128, 64, 64, and 32 are used to quantize the eigenvectors respectively. Eigenvectors derived by applying the Block SVD algorithm to some standard sequences are used to learn the codebooks. The LBG algorithm is used to learn these codebooks. These codebooks are stored in both encoder and decoder, therefore the coding of the eigenvectors is achieved using the least amount of bits possible.
7) There is no need to transmit all the obtained eigenvectors. Let $=M_i^j(x,y)$denote the coefficient value at frame i of block j at position (x,y). If Xmax denotes the maximum x position of the non-zero coefficients for block j and frames i...N and Ymax denotes the maximum y position of the non-zero coefficients, then we need to transmit only the eigenvectors $(U_1^j \ldots U_{X\,max}^j)$ and $(V_1^j \ldots U_{Ymax}^j)$. Six bits are included in GI, to denote the number of eigenvectors sent per GOB.
8) The coefficient matrices $M_1^j \ldots M_n^j$ are then quantized, zigzag read and entropy encoded using the JPEG algorithm.

V. Results

The proposed Block SVD algorithm the GOP was set as 16, as it was found that this provided the highest PSNR for a given bit rate for the specified sequences (Akiyo, Claire).Figure 5 shows the plot of PSNR vs. Bit rate for varying GOP, when the proposed algorithm is applied to the first 192 frames of Claire. From this plot it is clear that the highest PSNR is obtained when GOPhigh = 48 and GOPlow = 4.

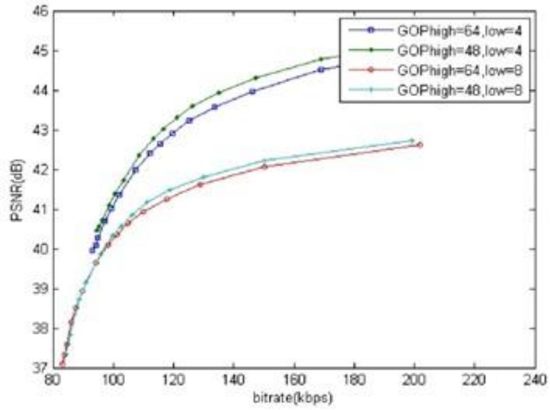

Fig.5. PSNR vs. Bit rate for varying GOP (first 192 frames of Claire).

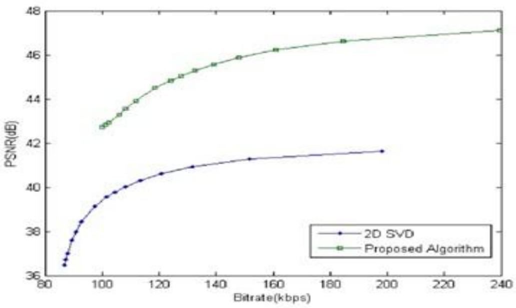

Fig. 6. PSNR vs. Bit rate for Akiyo

Fig.6. gives the plot of PSNR vs. Bit rate for the first 192frames of the Akiyo test sequence.To obtain these results, the GOP of Block SVD algorithm was set as 16 and for the proposed algorithm, GOP_{high} was chosen as 48 and GOP_{low} was chosen as 4. It can be seen clearly from these figures that, our proposed algorithm gives almost 2dB higher PSNR at the same bit rate.

VI. Conclusion

The video compression based on block SVD algorithm was implemented in MATLAB. Video compression is gaining popularity since storage and network bandwidth requirements are able to be reduced with compression. Many algorithms for video compression which are designed with a different target in mind have been proposed. Video compression such as H.261, 263 and 263+, MPEG-1, 2, 4, 7 and H.264. Most recent efforts on video compression for video have focused on scalable video coding. The primary objectives of on-going research on scalable video coding are to achieve high compression efficiency high flexibility (bandwidth scalability) and/or low complexity. Due to the conflicting nature of efficiency, flexibility and complexity, each scalable video coding scheme seeks tradeoffs on the three factors. Designers of video services need to choose an appropriate scalable video coding scheme, which meets the target efficiency and flexibility at an affordable cost and complexity. The biggest advantage of hybrid video coding technique is that it is designed for real time transmission. The low complexity video coding based on Block SVD algorithm used to get reconstructed video frames. The higher PSNR are present at the same bit rate Further we can analysis to reduce the time complexity of the video compression process based on block SVD Algorithm.

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