ABSTRACT

Digital video technique plays vital role in many applications like video on demand, tele-conferencing, storage medium (DVD) and surveillance in remote areas. The digital video in an uncompressed format requires high amount of storage space. Many compression algorithms are developed in the past to compress the video sequence. Among them, lossy compression algorithms are preferred in most of the applications. Motion Picture Experts Group (MPEG) and Video Coding Experts Group (H.26x) are the two international bodies which play a significant role in developing set of lossy compression standards. Nowadays, the digital video is handled by the coders developed by these international bodies. Recently, a new methodology to video coding based on 3D-DCT (Three Dimensional Discrete Cosine Transform) has been introduced to meet the growing demand of efficient transmission of video. In standard video coder temporal redundancy between frames is removed by using complex motion compensation and prediction algorithms. However it is not required for 3D-DCT based coder. Here the redundancy is removed by computing 3D-DCT along the spatial and temporal domain. The advantages of this algorithm are reduction in hardware design cycle time and complexity due to the symmetry that exist between encoder and decoder. This thesis presents new way to enhance the 3D-DCT based algorithm by embedding adaptive cube selection model. Also efforts are made to propose an optimal hardware structure for computing 3D-DCT.

In standard compression algorithms usually, the motion level between frames in the video sequence is determined by Mean Absolute Difference (MAD). In this work, a new modified MAD based algorithm is proposed which adaptively determines the optimal cube dimension for
encoding, based on the motion level of the video sequence. Here, the motion level of the cube is determined by computing the MAD between the 1st and 8th frame. Based on that, the motion level of the cube is categorized as ‘Low’, ‘Medium’ and ‘High’. The effectiveness of adaptive nature of the algorithm is verified by performing a Rate Vs Distortion comparison with the existing fixed cube and variable temporal length cube based encoding technique. Peak Signal to Noise Ratio (PSNR) has been taken as a measure of distortion. Few test sequences having different motion levels are taken for analysis. Experimental results reveal that, when compared to fixed cube method, 3-13% improvement in PSNR was observed in proposed MAD based method. However it does not adapts well for fast motion video sequences.

There is a chance that cubes are misclassified if, MAD values of 1st and 8th frame are alone considered for predicting the motion level of the cube. The performance of adaptive 3D-DCT based coder can be improved further by accurately predicting the motion level of the cube. Using the energy compaction property of DCT, a new and more accurate method based on 3D-DCT is proposed for determining the motion level of the cube. It adapts well for both slow motion and fast motion sequence. Here the categorization of cubes as ‘Low’, Medium’ and ‘High’ is made based on the threshold value set by clustering the number of 3D-DCT coefficients required to reconstruct 99% of cube energy. Experimental result reveals that proposed 3D-DCT based motion level prediction method outperforms the MAD based method and also, it adapts well for both slow and fast motion video sequences. Further the result of the proposed algorithm is compared against the standard motion level prediction and compensation algorithm like MPEG-2. PSNR and Structural Similarity index (SSIM) were chosen as a metric to differentiate the encoding nature of video coders. The proposed 3D-DCT based method outperforms the MPEG-2 at higher data rate with better SSIM value.
Suitable hardware for computing 3D-DCT is necessary in order to encode the video and image sequences in real time. Many research efforts are made to efficiently implement the real value 1D and 2D-DCT algorithms in hardware by reducing the computational complexity. Recently DCT with integer coefficients are of great interest, because the design is simpler and implemented more efficiently than real value DCT. So an attempt is made to propose a new low complex hardware structure for computing the 3D-Integer DCT suitable for video coders. Here optimal integer set is determined by analyzing different integer approximation methods in terms Mean Squared Error (MSE), computational complexity and coding efficiency. Further, the structure is simulated in Xilinx ISE simulator and implemented the same in Artix-7 FPGA board. The experimental results reveal that least resources are utilized for the integer set that has shorter bit values. Also it was observed that, there is no much deviation in PSNR if real value DCT was replaced by integer DCT. In addition to that the power utilization of 3D-Integer DCT structure was determined using Xilinx Power Estimation (XPE) tool so that, it can be integrated in to portable handheld devices. The direct method of computing the 3D-integer DCT using the optimal integer set [10, 9, 6, 2, 3, 1, 1] was implemented with 100 MHz clock frequency and this design consumes 0.201watts of power.

The results show the effectiveness of the different strategies adopted and confirm its potential. Hence it is concluded from the study that the performance of 3D-DCT based coder can be well enhanced with these strategies. The proposed novel algorithms are likely be useful in implementing low complex 3D-DCT based video coder in real time.