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COMPARATIVE ANALYSIS OF VIDEO COMPRESSION STANDARDS AND ITS APPLICATIONS

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Abstract: In the modern digital world, the information such as news, sports, multimedia images and videos are available anytime, anywhere to the end user, the need of video compression plays vital role in storing and transmitting the digital data efficiently and accurately without degrading the video signal. The data quantity is very large for the digital video and the memory of the storage devices and the bandwidth of the transmission channel are not infinite, so it is not practical for us to store the full digital video without processing. For instance, we have a 720 x 480 pixels per frame, 30 frames per second, total 90 minutes full color video, then the full data quantity of this video is about 167.96 GB. Thus, several video compression standards, techniques and algorithms had been developed to reduce the data quantity and provide the acceptable quality as possible as can. The main focus of this paper is to analyze video compression techniques, so as to provide low complexity, faster transmission and high visual quality and low memory. We evaluate the video compression techniques for finding compression ratio in terms of performance, speed and accuracy.

Keywords: Scalable video coding, DWT, DCT, Motion estimation.

1. INTRODUCTION

The video signal is an integral part of multimedia which has a tremendous importance in most of the applications involving the concept of the multimedia i.e. video conferencing; video-on-demand, broadcast digital video, and high-definition television (HDTV), etc. Fortunately, digital video has significant redundancies and eliminating or reducing those redundancies results in compression. Video compression can be lossy or loss less. Loss less video compression reproduces identical video after de-compression. We primarily consider lossy compression that yields perceptually equivalent, but not identical video compared to the uncompressed source. Video compression is typically achieved by exploiting four types of redundancies: 1. perceptual, 2. temporal, 3. spatial, and 4. statistical redundancies. Some popular video coding techniques in spatial domain like vector quantization, Block Transform, Discrete Cosine Transform and temporal domain like Frame Differencing, Motion Compensation, Block Matching. This paper provides the summary of all these techniques in terms of the problem they solve or their methodology in video compression techniques or the tools which are implemented over them and so on. The video compression techniques include, PCA/ICA based method, Accordion Function, EZW and SPIHT Algorithms, Wavelet Based Rate Scalable Method. Performance metrics used are Peak Signal to Noise Ratio (PSNR) and Compression Ratio (CR).

2. REVIEW OF LITERATURE

Wavelet Transform and DBMA with MC: Zhengxin Hou, *et al.* [1] proposed I frame encoding adopts wavelet transform and set partitioning in hierarchical trees (SPIHT) algorithm; for P frames, each frame

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sets the reconstructed frame of its previous frame as a reference frame, and then P frames proceed to code with ME and MC.

Mobile Internet using Transform Domain: Dhaval *et al*. [2] proposed a simpler algorithm to implement on relatively slower processors of mobile gadgets. Here authors are modifying the MPEG-2 algorithm, which is based on subjective compression, from the transform domain perspective, which is used in the intra frame compression of the video. Here paper introduces a new approach for converting the frames in frequency domain in such a way that using MPEG-2 we can achieve the compression ratio approximately equal to MPEG- 4, with lesser complexity of the encoder and decoder. In the encoder of regular MPEG first of all, the video is converted into the sequence of frames which are nothing but like still images sequence. Then the 10 sequential frames are selected (GOP) and format of the sequence is changed from RGB to YCbCr. Third stage re-samples the chrominance components of the frames from 4:4:4 to 4:2:0, as human eyes are less sensitive towards the chrominance components we

can reduce no. of samples in that for compression. Then in group of pictures (GOP) the sequence is converted into sequence of IBBPBBPBBI with use of motion estimation and compensation technique.

Active Mesh Based MC Algorithm in Wavelet Sub-Bands: Mohammad Hossein Bisjerdi *et al*. [3] proposed a remedy for the problem of motion estimation methods in video compression, a new algorithm is used based on an active mesh model. The method uses a combination of 2-D formable meshes and feature matching algorithm to calculate motion vectors more precisely. In this algorithm, image features (interest points) are extracted using the Kanade-Lucas-Tomasi (KLT) feature extractor technique. Interest points are used as mesh vertices in order to generate an unstructured mesh over the video frame by Delaunay triangulation algorithm. To compute motion vectors, the matching points of the features are found using the improved Lucas-Kanade feature matching algorithm, which utilizes image pyramids for the calculation of match points. The method calculates match point of each feature individually with sub-pixel accuracy. However, because motion vectors are calculated independently, motion vectors are somewhat chaotic. Thus, the match points of the previous step are not considered as true match points. In order to find true match points, mesh energies are defined based on the location of feature points, their matches and other attributes of the generated mesh and video frames. The tracking of mesh is performed by minimizing the mesh energy which considers the motion information of nearby features to remove erroneous matches and enhance the ac-curacy.

Low complexity DCT:Tarek Ouni *et al*. [4] proposed a new video compression method which exploits objectively the temporal redundancy. With the apparent gains in compression efficiency, it strongly exploits temporal redundancy with the minimum of processing complexity which facilitates its implementation in video embedded systems. The basic idea is to represent video data with high correlated form .Thus, we have to exploit both temporal and spatial redundancies in video signal. The input of our encoder is so called video cube, which is made up of a number of frames. This cube will be decomposed into temporal frames which will be gathered into one frame (2 dimensions). The final step consists of coding the obtained frame. In high bit rate, it gives the best compromise between quality and complexity. It provides better performance than MJPEG and MJPEG2000 almost in different bit rate values. Over 2000kb/s bit rate values this compression method performance becomes comparable to the MPEG 4 especially for low motion sequences. The proposed ACC-JPEG method provides following advantages symmetry, simplicity, objectivity, flexibility and random access

Three Dimensional Discrete Pseudo Cosine Transform: EugeniyBelyaev *et al*. [9] Proposed a new spatial scalable and low complexity video compression algorithm based on multiplication free three dimensional discrete pseudo cosine transform. This paper shows an efficient results compared with H.264/ SVC as well as it can be used for robust video transmission over wireless channels.

An Adaptive Fast Search Algorithm for Block Motion Estimation in H.264: Cong Dao Han *et al*.[10] implemented a novel search algorithm which utilizes an adaptive hexagon and small diamond search to enhance search speed. Simulation results showed that the proposed approach can speed up the search process with little effect on distortion performance compared with other adaptive approaches.

Fast Full-Search Block-Matching Algorithm: Yih-Chuan Lin and Shen-Chuan Tai *et al* [11] have proposed a technique "Fast Full-Search Block-Matching Algorithm for Motion-Compensated Video Compression" in 1997. Nikita Bansal and Sanjay Kumar Dubey (2013) illustrated a hybrid image compression transform technique. The main aim is to have high compression ratio by maintaining good quality and also to reconstruct the image with less computation resources. The steps involved are: Input image 256 × 256 is divided into 32 × 32 using DCT technique; 1st level of 2D-DWT is performed on the 32 × 32 image to obtain 16x16 blocks; by implementing the 2nd level of 2D-DWT the image is divided into 4 × 4; scaling is done and at the receiver's end rescaling and inverse of DWT and DCT technique is applied. DCT technique performs effectively at medium rates; using DWT technique produces blurring image at boundaries. By combining the advantages of both techniques, higher compression ratio is achieved.

3. MOTION JPEG AND MPEG STANDARDS

(a) Motion JPEG and Motion JPEG 200: A digital video sequence can be represented as a series of JPEG pictures. The main disadvantage of both the compression techniques is that since it uses only a series of still pictures it makes no use of video compression techniques [12]. The result is a slightly lower compression ratio for video sequences compared to "real" video compression techniques.

(b) MPEG-1: MPEG-1 video compression is based upon the same technique that is used in JPEG [13]. In addition to that it also includes techniques for efficient coding of a video sequence.

(c) MPEG-2: The MPEG-2 standard is targeted at TV transmission and other applications capable of 4 Mbps and higher data rates. MPEG-2 features very high picture quality. MPEG-2 supports interlaced video formats, increased image quality, and other features aimed at HDTV. MPEG-2 is a compatible extension of MPEG-1, The MPEG-2 systems standard specifies how to combine multiple audio, video, and private-data streams into a single multiplexed stream and supports a wide range of broadcast, telecommunications, computing, and storage applications. MPEG-2, ISO/IEC 13818, also provides more advanced techniques to enhance the video quality at the same bit-rate. The expense is the need for far more complex equipment. Therefore these features are not suitable for use in real-time surveillance applications. As a note, DVD movies are compressed using the techniques of MPEG-2.

(d) MPEG-4:The most important new features of MPEG-4, ISO/IEC 14496, concerning video compression are the support of even lower bandwidth consuming applications, e.g. mobile units, and on the other hand applications with extremely high quality and almost unlimited bandwidth. The making of studio movies is one such an example [14]. Most of the differences between MPEG-2 and MPEG-4 are features not related to video coding and therefore not related to surveillance applications MPEG involves fully encoding only key frames through the JPEG algorithm (described above) and estimating the motion changes between these key frames. Since minimal information is sent between every four or five frames, a significant reduction in bits required to describe the image results. Consequently, compression ratios above 100:1 [15] are common. The scheme is asymmetric; the MPEG encoder is very complex and places a very heavy computational load for motion estimation.

(e) H.261: H.261 (last modified in 1993) is the video compression standard included under the H.320 umbrella (and others) for videoconferencing standards. H.261 is a motion compression algorithm developed specifically for videoconferencing, encoding is based on the discrete cosine transform (DCT) .The main elements of the H.261 source coder are prediction, block transformation (spatial to frequency domain translation), quantization, and entropy coding. While the decoder requires prediction, motion compensation is an option. Another option inside the recommendation is loop filtering. The loop filer is applied to the prediction data to reduce large errors when using interframe coding. Loop filtering provides a noticeable improvement in video quality but demands extra processing power. The operation of the decoder allows for many H.261-compliant CODECs to provide very different levels of quality at different cost points. The H.261 standard does not specify a particular adaptive quantization method.

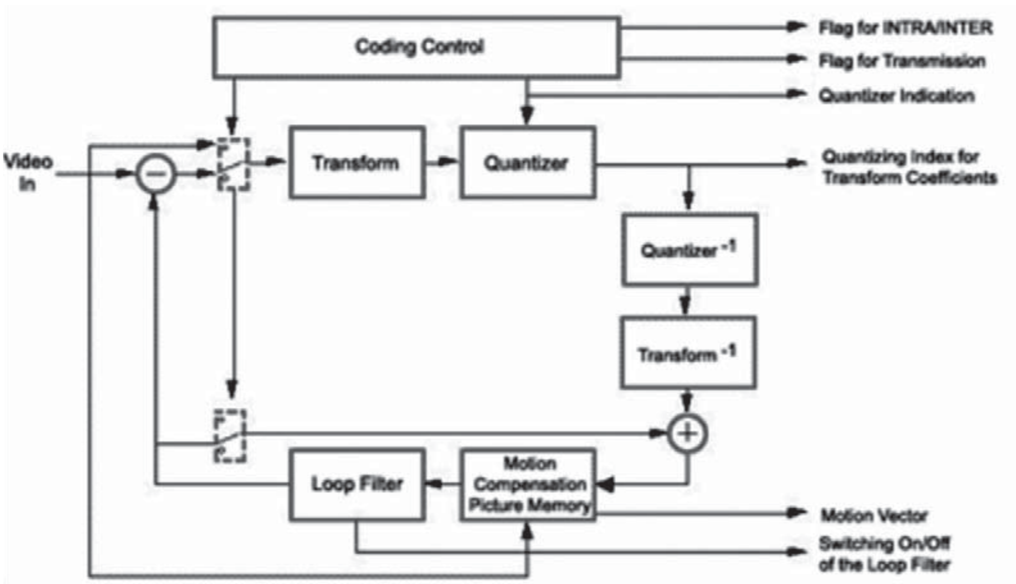

Figure 1 H.261 source coder block diagram.

(f) H.263: H.263 is the video codec introduced with H.324, the ITU recommendation "Multimedia Terminal for Low Bitrate Visual Telephone Services Over the GSTN". H.324 is for videoconferencing over the analog phone network (POTS). While video is an option under H.324, any terminal supporting video must support both H.263 and H.261.

At bandwidths under 1000 kbps [16], H.263 picture quality is superior to that of H.261. Images are greatly improved by using a required 1/2 pixel new motion estimation rather than the optional integer estimation used in H.261. Half pixel techniques give better matches, and are noticeably superior with low resolution images (SQCIF). The 4:3 pixel aspect ratio is the same for each of these picture formats.

Table 1.
H 263 picture formats

Picture Format	*pixels luminance*	*lines luminance*	*pixels chrominance*	*lines chrominance*	*H.261*	*H.263*
sub-QCIF	128	96	64	48	Optional	Required
QCIF	176	144	88	72	Required	Required
CIF	352	288	176	144	Optional	Optional
4CIF	704	576	352	288	NA	Optional
16CIF	1408	1152	704	576	NA	Optional

(g) H.264: H.264 is the result of a joint project between the ITUT's Video coding Experts group and the ISO/IEC Moving Picture Experts Group (MPEG). [17]. H.264 is the name used by ITU-T, while ISO/IEC has named it MPEG-4 Part 1/AVC since it is presented as a new part in its MPEG-4 suite. The MPEG-4 suite includes, for example, MPEG-4 Part 2, which is a standard that has been used by IP-based video encoders and network cameras. Designed to address several weaknesses in previous video compression standards, H.264 delivers on its goals of supporting:

1. Implementations that deliver an average bit rate reduction of 50%, given a fixed video quality compared with any other video standard.
2. Error robustness so that transmission errors over various networks are tolerated.
3. Low latency capabilities and better quality for higher latency.
4. Straightforward syntax specification that simplifies implementations.
5. Exact match decoding, which defines exactly how numerical calculations are to be made by an encoder and a decoder to avoid errors from accumulating.

3.1 MPEG COMPARISON

All MPEG standards are back compatible. This means that an MPEG-1 video sequence also can be packetized as MPEG-2 or MPEG-4 video. Similarly, MPEG-2 can be packetized as an MPEG-4 video sequence. The difference between a true MPEG-4 video and an MPEG-4-packetized MPEG-1 video sequence is that the lower standard does not make use of the enhanced or new features of the higher standard [18].

The comparison of the MPEGs in Table II, contains the MPEG-1 with its most often used limitation (Constrained Parameters Bitstream, CPB), MPEG-2 with its Main Profile at Main Level (MP@ML), and MPEG-4 Main Profile at L3 Level.

Table 2.
MPEG Comparision

Standards	*MPEG1*	*MPEG2*	*MPEG4*
Max bit rate(Mbps)	1.86	15	15
Picture Width (Pixels)	352	720	720
Picture height(Pixels)	288	576	576
Picture rate(fps)	30	30	30

When comparing the performance of MPEG standards such as MPEG-4 and H.264, it is important to note that results may vary between encoders that use the same standard. An MPEG standard, therefore, cannot guarantee a given bit rate or quality, and comparisons cannot be properly made without first defining how the standards are implemented in an encoder. A decoder, unlike an encoder, must implement all the required parts of a standard in order to decode a compliant bit stream. A standard specifies exactly how a decompression algorithm should restore every bit of a compressed video.

Table 3.
MPEG Comparison with Pros & Cons

Standards/ Formats	Compression Factor	Pros	Cons
M-JPEG	1:20	1. Low CPU utilisation 2. Clearer images at lower frame rates, compared to MPEG-4 3. Not sensitive to motion complexity, i.e. highly random motion	1. Nowhere near as efficient as MPEG-4 and H. 264 2. Quality deteriorates for frames with complex textures, lines, and curves
MPEG-4 Part2	1:50	1. Good for video streaming and television broadcasting. 2. Compatibility with a variety of digital and mobile devices	1. Sensitive to motion complexity (compression not as efficient) 2. High CPU utilisation
H.264	1:100	1. Most efficient 2. Extremely efficient for low-motion video content	1. Highest CPU utilisation 2. Sensitive to motion complexity (compression not as efficient)

International standards nor offers any compression enhancements compared to MPEG, they are not of any real interest. There are two approaches to achieving video compression, viz. intra-frame and inter-frame. Intra-frame compression uses the current video frame for compression: essentially image compression. Inter-frame compression uses one or more preceding and/or succeeding frames in a

sequence, to compress the contents of the current frame. An example of intra-frame compression is the Motion JPEG (M-JPEG) standard [19]. The MPEG-1 (CD, VCD), MPEG- 2 (DVD), MPEG-4, and H.264 standards are examples of inter-frame compression. The popular video compression standards in the IP video surveillance market are M-JPEG, MPEG-4, and H.264are in Table 3.

3. SUMMARY

In this paper we survey various video compression techniques that have been employed. We have seen that all the schemes discussed above Frame Difference Approaches, Fuzzy concepts, PCA based method, CABAC Method, Accordion Function, EZW and FSBM,SPIHT Algorithms, Active Mesh Based, Wavelet Based Rate Scalable Method and Morphological operators. From the review of various video compression papers it infers that there are still lots of possibilities for the improvement of video compression technique. This survey paper very helpful for find the video compression in current trends and next level of problem identification. There is a constant improvement in video compression factors, thanks to new techniques and technology, and some new formats in the horizon are H.265 and VP8:1) H.265 is still in the process of being formulated, and aims to achieve a 25% improvement in the compression factor while lowering computational overhead by 50%: for the same perceived video quality.2) VP8 is a codec from On2 Technologies (which recently agreed to be acquired by Google), who claims that the codec brings bandwidth savings and uses less data than H.264: to the extent of 40%. There is currently a fight over the standard to be chosen for Web video (fuelled by the upcoming HTML5 standard), and VP8 is slugging it out with H.264.

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