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Comparative Study of Video Compression Techniques- H.264/AVC

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Abstract— This paper reviews several recently information hiding technique in H.264/avc video compression standards. H.264/AVC is a recently concluded video compression standard jointly developed by ITU-T and ISO MPEG standards committees. The standard is becoming more favoured as it promises much higher compression than that possible with earlier standards. The objective of the H.264/AVC project was to create a standard, capable of providing good video quality at substantially lower bit rates than foregoing standards (i.e., half or less the bit rate of MPEG-2, H.263, or MPEG-4 Part 2), without increasing the difficulty of design. This paper provides an overview of the H.264 features and summarizes the emerging studies associated to new coding features of the standard. H.264 entails significant improvements in coding efficiency, latency, difficulty and robustness. It provides new possibilities for creating better video encoders and decoders that provide higher quality video streams at prolonged bit-rates (compared to previous standards), or, conversely, the same quality video at a lower bit-rate. Hence, suitable video compression techniques that meet video applications requirements have to be selected.

Keywords— H.264,AVC, video compression, Video Comparison, Intraprediction, Rate distortion, Pixels.

I. Introduction

As recent multimedia applications are spreading rapidly, video compression requires higher performance as well as new features. The newest video coding standard is evolved by the joint of video teams of ISO/IEC MPEG and ITU_T VCEG as the international of standard 14496-10 (MPEG-4 part 10) advanced video coding (AVC). H.264/AVC has gained more and more attention; mostly due to its high coding efficiency (the average bit rate saving up to 50% as compared to H.263+ and MPEG-4 Simple Profile), minor increase in decoder difficulty compared to existing standards[1]. To achieve outstanding coding performance, H.264/AVC employs various powerful coding techniques such as 4x4 integer transform, inter-prediction with variable block-size motion remuneration motion vector of quarter-pel accuracy, in-loop de-blocking filter, improved entropy coding such as context-adaptive unsteady-length coding (CAVLC) and content-adaptive binary arithmetic coding (CABAC), enhanced intra-divination, multiple reference picture, and the forth. Due to this new features, encoder computational complexity is especially increased compared to previous standards [2]. This makes H.264/AVC difficult for applications with low computational abilities (such as mobile devices). Thus until now, the reduction of its complexity is a challenging task in H.264/AVC [3]. Among many new features, the intra-divination technique is recognized to be one of the main factors that contribute to the success of H.264/AVC.

II. OVERVIEW OF THE H.264 STANDARD

H.264/MPEG-4 AVC is a block-oriented motion compensation based codec standard developed by the ITU-T Video Coding Experts Group (VCEG) together with the ISO/IEC JTC1 Moving Picture Experts Group (MPEG) [4]. The project partnership effort is known as the Video Team (JVT). The ITU-T H.264 standard and the ISO/IEC MPEG-4 AVC standard are jointly maintained so that they have identical technical content. The standard provides flexibilities in coding and organization of data which enable efficient error resilience[5].The increased coding efficiency offers new application areas and business opportunities. As might be expected, the increases in compression efficiency and flexibility come at the expense of increase in complexity, which is a fact that must be overcome. Figure shows the Structure of H.264/AVC video encoder. To deal with the need for flexibility and customizability, the H.264 standard covers a Video Coding Layer (VCL), which is designed for well-organized representation of the video content and is a block based hybrid video coding approach , and a Network Abstraction Layer (NAL), which formats the VCL representation of the video and provides header information in a way that is appropriate for transportation by different transport layers or storage media[5]. A picture may be split into one or several slices. In H.264, slices consist of macro blocks processed in raster scan order. A picture then can be split into many macro block scanning patterns such as interleaved slices, dispersed macro block allocation. H.264 standard is more flexible in the selection of motion compensation (MC) block sizes and shapes than any previous standard, with a minimum luma Macro block size as small as 4x4.

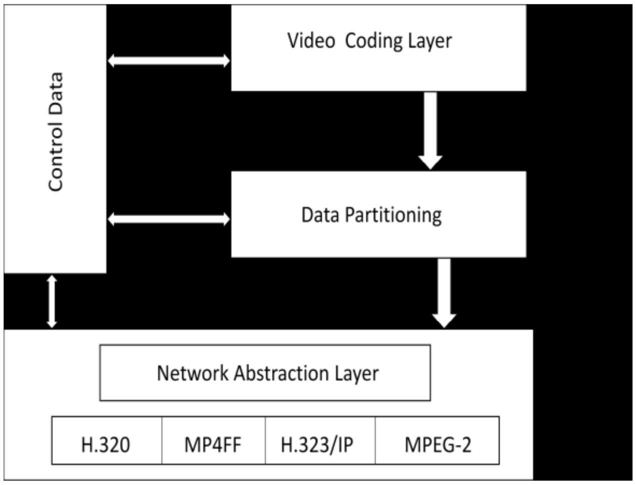

Fig:1 Structure of H.264/AVC Video Encoder

III. INFORMATION HIDING TECHNIQNE

There are several information hiding technique in H.264/AVC Video compression standard. Here, a brief survey on the information hiding in H.264/AVC video encoder is presented.

A. Prediction Mode and Block Type

In H.264/AVC video encoder, rate Controller decides all prediction types to be used in each macroblock. These prediction reduce the spatial redundancy to achieve higher compression ratio. If a macroblock is encoded in intra-mode, a prediction block is formed by selecting one of the 14 prediction modes by referring to previously encoded and reconstructed blocks.to exploit mode selections for information hiding, mapping rules are usually considered to improve the carrier capacity without causing significant bitrate increment.

Yang et al.restricted information hiding to qualified 4*4 blocks in I-frame. Information is embedded by modulating the prediction mode using a pre-defined rule. These blocks are chosen because they have more non-zero coefficients and hardly lead to visible artifacts after data embedding as compared to 16*16 blocks. The qualified candidate blocks are divided into two groups and two bits of information are mapped to every three blocks by matrix coding.

B. Inter-Pixel Vector Range

The technique of tree-based motion estimation is adopted in H.264/AVC standard to support a range of block sizes and to find sub-sample motion vectors. For each macro-blocked, the motion search first proceeds in the location of the integer-pixel, then in the sub-pixel level around the best integer pixel position and finally in quarter-pixel level around the sub-pixel position to find the best matching point for creating motion vector. Payload can be hidden by modulating the search points of the motion estimation of inter-pixel according to the mapping rule. This technique uses two different search point range (M,N)with respect to the embedding bits (β) as shown in formula below:

$$Searchpoint = \begin{array}{ll} M = 0,1,3,6,8 & if\ \beta = 0 \\ N = 2,4,5,7 & Otherwise \end{array}$$

Experiment result indicate that no obvious change is observed in terms of bitrate as well as quality of the video.

C. Motion Vector Displacement

Information hiding using motion vectors can be achieved by changing the candidate motion vector attributes.In Guo’s algorithm,secret informatiion is embedded in the motion vector betwwen two SP frames.it changes the horizontal and vertical offsewts in motion vector displacement for real-time operation in stream switching application.

D. Chroma and Luma Coefficients

Utilizing the same data carrier, Aly proposed a different data hiding approach towards achieving a minimum prediction error and data size overhead [2]. This technique replaces the host video signal x = (d, E) with a regular pair of vector component $d^h(x, y)$ and prediction error $E^h(x, y)$ during the encoding process. An adaptive threshold is introduced to over- come the difficulty of dealing with the non-linear quantization process. This technique causes lower distortion to the quality of the video and suppresses bitstream size increment.

E. Quantization Scale

Shanableh utilized matrix encoding technique to hide information in quantization scales and motion vectors of H.264/SVC compressed video [6]. A video transcoding process is introduced to allows information embedding in motion vectors using a non-iterative procedure regardless of the availability of the original raw video. Matrix encoding is utilized to minimize the modifications on quantization scales of single layer video. To increase carrier capacity, the coding structure of H.264/SVC is exploited. In particular, quantization scales in both the base layer and enhancement layer(s) are utilized to host information.

IV. DISCUSSIONS AND ANALYSIS

Among all the information hiding techniques, inter block type selection and intra prediction type modulation offer a simple way to encode external payload by pairing the selection index with groups of bits. These techniques maintain coding efficiency with slight fluctuation in bit-rate, but they cause video file size increment in general. On the other hand, hiding information in inter-pixel vector search range provides minimal impact on video quality and bitrate. The current approaches merely divide the search range into two groups and offer minimal embedding capacity. Hence, a possible extension is to extend the search range (4 or 8 group) to encode more information.

Motion vectors in all the P and B frames lead to high embedding capacity for information hiding purposes. However, techniques involving motion vector increase the complexity of video encoding process. This class of techniques requires precise computation to avoid inaccurate prediction error during the frame reconstruction process, which may propagate until the next GOP is encountered. Carrier capacity can be further increased when the payload is embedded using the transformed coefficients. However, this approach may lead to noticeable degradation in video quality and significant bit stream size increment Modulating quantization parameter inefficiently will cause significant degradation in visual quality[6,7]. Therefore, matrix encoding technique is applied to reach high payloads while maintaining video quality, but at the expense of higher complexity in video coding. Realizing information hiding in entropy coding allows payload to be embedded with low embed/extract time overhead. It needs to be applied according to different syntax/attributes to avoid visible visual artifacts. The proposed technique in CAVLC can be further extended to the latest CABAC to obtain higher payload and minimize change in video bitrate[8,9].

Table summarizes the comparison among different venues to realize information hiding in H.264/AVC video compression standard. We can see that there is no perfect solution for obtaining high embedding capacity, low complexity, low video quality degradation and low video size increment simulta- neously. In future, these techniques are recommended to be implemented simultaneously to fill the gaps among each other. Also, Rate Distortion Optimization (RDO) can be utilized to determine a suitable technique to apply on different frame and macroblock. Certainly, the computation complexity will be higher than just applying a particular technique[10]. Nonetheless, the increment in computational complexity can be justified by the common trend of including extended processor instruction sets to support and handle video encoding/decoding in modern CPU's.

Hiding Method	Venue	Payload Amount	Video Size	Video Quality	Coding Complexity
Inter block type selection	P Frame, Intra/Inter prediction	Moderate	Increase	High distortion	Low
Intra prediction mode selection	P Frame, Intra prediction	Low	Low	Low distortion	Moderate
Inter-pixel search vector range	P Frame, Inter prediction	Low	Moderate	Low distortion	Moderate
LSB in MV prediction error	P Frame, Inter prediction	High	Increase	Low distortion	High
LSB in MV displacement	P Frame, Inter prediction	High	Increase	Moderate	High
LSB in Chroma & Luma DCT Coefficient	I/P Frame, Intra prediction	High	Moderate	High distortion	Moderate
Quantization parameter	I/P Frame, Intra/Inter prediction	High	Increase	Low distortion	High
CAVLC Coefficient parity bit selection	I/P Frame, Intra/Inter prediction	Low	Moderate	High distortion	Low

Table:1 COMPARISON VIEW ON INFORMATION HIDING TECHNIQUES [2]

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