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Analysis of Video Compression Technique

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Abstract
Video compression has been the object of intensive research in the last thirty years. Video compression technique is now mature as is proven by the large number of applications that make use of this technology. This paper gives the idea about different techniques available for video compression. H.264/AVC exhibits superior coding performance improvement over its predecessors. The next generation standards are being generated by both VCEG and MPEG. In this paper, we also summarized the progress of those next generation video coding standard projects and existing new video coding techniques. In this paper is organized as describes the various basic techniques available for the video compression; the implementation strategies of video compression techniques; various generations ; latest trend in video compression; different issues related to emerging technologies.

Keywords
H.264/AVC, JVT, Video Codec, Issues, KTA, MPEG, VCEG.

Introduction

Video coding techniques provide efficient solutions to represent video data in a more compact and robust way so that the storage and transmission of video can be realized in less cost in terms of size, bandwidth and power consumption. ITU-T and ISO/IEC these are the main two international organizations which decides the standards for video compressions. ISO/IEC MPEG standard includes MPEG-1, MPEG-2, MPEG-4, MPEG-4 Part 10 (AVC), MPEG-7, MPEG- 21 and M-JPEG. ITU-I VCEG standard includes H.26x series, H.261, H.263, and H.264. Currently, both VCEG and MPEG are launching their next-generation video coding project. This new generation aims to meet the new requirements future applications may impose on the video coding standard. The entire compression and decompression process requires a codec consisting of a decoder and an encoder. The encoder compresses the data at a target bit rate for transmission or storage while the decoder decompresses the video signals to be viewed by the user. This whole process is shown in fig.1. In general decoding is considerably less complex than encoding. Due to this reason research and implementation efforts are more focused on encoding.

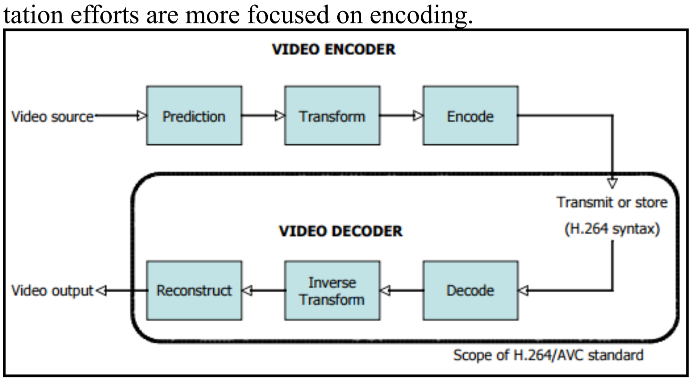

Fig. 1 : Video Encoder and Video Decoder

Basic Techniques

All the video coding standards based on motion prediction and discrete cosine transform produce block artifacts at low data rate. To reduce blocking artifacts a lot of work using post processing techniques has been done . A great deal of work has been done to investigate the use of wavelets in video coding. To reduce blocking artifacts mainly two directions are there: 1 The first one is to code the prediction error of the hybrid scheme using the DWT . 2 The second one is to use a full 3-D wavelet decomposition. These approaches have reported coding efficiency improvements with respect to the hybrid schemes. These schemes are intended to provide further functionalities such as scalability and progressive transmission. Long-term memory prediction extends motion compensation from the previous frame to several past frames with the result of increased coding efficiency.

One of the approaches that reports major improvements using the hybrid approach. The approach is combined with affine motion compensation. Data rate savings between 20 and 50% are achieved using the test model of H.263+. The corresponding gains in PSNR are between 3 and 0.8 dB. MPEG-4 and H.263+ represent the state of the art in video coding. H.263+ provides a framework for doing frame-based low to moderate data rate compression. It (MPEG-4) combines frame-based and segmentation-based approaches along with the mixing of natural and synthetic content allowing efficient coding as well as content access and manipulation.

No doubt, there is that other schemes may improve the coding efficiency established in MPEG-4 and H.263+ but no significant breakthrough has been presented to date. During the last ten years, the hybrid scheme combining motion compensated prediction and DCT has represented the state of the art in video coding. This hybrid scheme approach is used by the ITU H.263 and H.261 standards as well as for the MPEG-2 and MPEG-1 standards. In 1993, the need to add new content-based functionalities and to provide the user the possibility to manipulate the audiovisual content was recognized and a new standard effort known as MPEG-4 was launched. Functionalities in addition to these, MPEG-4 provides also the possibility of combining natural and synthetic content. MPEG-4 phase 1 became an international standard in 1999 MPEG-4 is having difficulties finding wide-spread use, main reason is due to the protection of intellectual property and the need to develop automatic and efficient segmentation schemes.

Video Compression Standards

Video Compression is the term used to define a method for reducing the data used to encode digital video content. This reduction in data translates to benefits such as smaller storage requirements and lower transmission bandwidth requirements, for a clip of video content.

Video compression typically involves an elision of information not considered critical to the viewing of the video content, and an effective video compression codec (format) is one that delivers the benefits mentioned above: without a significant degradation in the visual experience of the video content, post-compression, and without requiring significant hardware overhead to achieve the compression. Even within a particular video compression codec, there are various levels of compression that can be applied (so called profiles); and the more aggressive the compression, the greater the savings in storage space and transmission bandwidth, but the lower the quality of the compressed video [as manifested in visual artifacts – blockiness, pixelated edges, blurring, rings – that appear in the video] and the greater the computing power required.

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. 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.264.

Time Line of Video Compression Standards

Year	Standard	Publisher	Popular implementations
1984	H.120	ITU-T	
1988	H.261	ITU-T	Videoconferencing, video telephony
1993	MPEG-1 Part 2	ISO, IEC	Video-CD
1995	H.262/ MPEG-2 Part 2	ISO, IEC, ITU-T	DVD Video, Blu-ray, Digital Video Broadcasting, SVCD
1996	H.263	ITU-T	Videoconferencing, video telephony, video on mobile phones (3GP)
1999	MPEG-4 Part 2	ISO, IEC	Video on Internet (DivX, Xvid ...)
2003	H.264/ MPEG-4 AVC	Sony, Panasonic, Samsung, ISO, IEC, ITU-T	Blu-ray, HD DVD, Digital Video Broadcasting, iPod Video, Apple TV, videoconferencing
2009	VC-2 (Dirac)	SMPTE	Video on Internet, HDTV broadcast, UHDTV
2013	H.265	ISO, IEC, ITU-T	

Video Codec

A **video codec** is an electronic circuit or software that compresses or decompresses digital video. It converts raw (uncompressed) digital video to a compressed format or vice versa. In the

Context of video compression, "codec" is a concatenation of "encoder" and "decoder"—a device that only compresses is typically called an *encoder*, and one that only decompresses is a *decoder*.

The compressed data format usually conforms to a standard video compression specification. The compression is typically lossy, meaning that the compressed video lacks some information present in the original video. A consequence of this is that decompressed video has lower quality than the original, uncompressed video because there is insufficient information to accurately reconstruct the original video. There are complex relationships between the video quality, the amount of data used to represent the video (determined by the bit rate), the complexity of the encoding and decoding algorithms, sensitivity to data losses and errors, ease of editing, random access, and end-to-end delay (latency).

MPEG (Motion Picture Experts Group) is one of the biggest families in video codec, and it is the most common video format. The MPG, MPE, MPA, M15, M1V, MP2 etc. are all from this family. MPEG format, including MPEG video, MPEG audio and MPEG (video, audio synchronization) of three parts, MP3 (MPEG-3) audio files is a typical application of the MPEG audio, video include MPEG-1, MPEG-2 and MPEG4.

• **MPEG-1**, its compression algorithm is widely used in the production of VCD and the download of some video clip. Almost all VCD is compressed using the Mpeg-1 format (*. Dat file format). Using MPEG-1 compression algorithm, a 120-minute film (the original video files) can be compressed to about the size of 1.2 GB, and the file format is generally mpg and dat files.

• **MPEG-2**, its compression algorithm used in the production of the DVD (* vob - file formats), and also in some of the HDTV (high definition television) and high demand video editing, processing of the application. Using MPEG-2 compression algorithm could produce a 120-minute film (the original video files) in the size of about 4GB to 8GB, of course, image quality indicators are MPEG-1 can not be compared. Use this compressed file format made by the algorithm is generally the vob file.

• **MPEG-4** is a new compression algorithm, the use of this compression algorithm can be a 120 minute film (the original video files) is compressed to about 300MB. Now, this compression algorithm of the MPEG are used by many encoding formats, such as ASF, DivX, Xvid, mp4 (Apple, mpeg-4 encoding format) are using the MPEG-4 compression algorithm.

•**DivX** video encoding technology can be said produced for DVD, which works with a certain type of MPEG-4 file, and was often used to rip DVDs in the pre-HD era. Most of the DivX videos use avi file extension, of course, DivX and Div extension.

•**XviD**, an open source version of DivX, popular among movie pirates. In general, as long as you install the Xvid decoder, your machine will be able to play all DivX media files. Most use Xvid encoded files to avi extension.

•**X264**, which compresses H.264 videos (Also known as MPEG-4 AVC), and is very popular for high definition videos.

Video Codec Design

Video codecs seek to represent a fundamentally analog data set in a digital format. Because of the design of analog video signals, which represent luminance and color information chrominance, separately, a common first step in image compression in codec design is to represent and store the image in a YCbCr color space. The conversion to YCbCr provides two benefits: first, it improves compressibility by providing decorrelation of the color signals; and second, it separates the luma signal, which is perceptually much more important, from the chroma signal, which is less perceptually important and which can be represented at lower resolution to achieve more efficient data compression. It is common to represent the ratios of information stored in these different channels in the following way Y:Cb:Cr. Refer to the following article for more information:Chroma subsampling.

Different codecs use different chroma subsampling ratios as appropriate to their compression needs. Video compression schemes for Web and DVD make use of a 4:2:1 color sampling pattern, and the DV standard uses 4:1:1 sampling ratios. Professional video codecs designed to function at much higher bitrates and to record a greater amount of color information for post-production manipulation sample in 3:1:1 , 4:2:2 and 4:4:4 ratios.

Examples of these codecs include Panasonic's DVCPRO50 and DVCPROHD codecs (4:2:2), and then Sony's HDCAM-SR (4:4:4) or Panasonic's HDD5 (4:2:2). Apple's Prores HQ 422 codec also samples in 4:2:2 color space. More codecs that sample in 4:4:4 patterns exist as well, but are less common, and tend to be used internally in post-production houses. It is also worth noting that video codecs can operate in RGB space as well. These codecs tend not to sample the red, green, and blue channels in different ratios, since there is less perceptual motivation for doing so—just the blue channel could be under sampled.

Some amount of spatial and temporal down sampling may also be used to reduce the raw data rate before the basic encoding process. The most popular such transform is the 8x8discrete cosine transform (DCT). Codecs which make use of a wavelet transform are also entering the market, especially in camera workflows which involve dealing with RAW image formatting in motion sequences. The output of the transform is first quantized, then entropy encoding is applied to the quantized values.

When a DCT has been used, the coefficients are typically scanned using a zig-zag scan order, and the entropy coding typically combines a number of consecutive zero-valued quantized coefficients with the value of the next non-zero quantized coefficient into a single symbol, and also has special ways of indicating when all of the remaining quantized coefficient values are equal to zero. The entropy coding method typically uses variable-length coding tables. Some encoders can compress the video in a multiple step process called *n-pass* encoding (e.g. 2-pass), which performs a slower but potentially better quality compression.

The decoding process consists of performing, to the extent possible, an inversion of each stage of the encoding process. The one stage that cannot be exactly inverted is the quantization stage. There, a best-effort approximation of inversion is performed. This part of the process is often called "inverse quantization" or "dequantization", although quantization is an inherently non-invertible process.

This process involves representing the video image as a set of macro blocks. For more information about this critical facet of video codec design, see B-frames. Video codec designs are usually standardized or eventually become standardized—i.e., specified precisely in a published document. However, only the decoding process need be standardized to enable interoperability. The encoding process is typically not specified at all in a standard, and implementers are free to design their encoder however they want, as long as the video can be decoded in the specified manner. For this reason, the quality of the video produced by decoding the results of different encoders that use the same video codec standard can vary dramatically from one encoder implementation to another.

Video File Format

A **video file format** is a type of file format for storing digital video data on a computer system. Video is almost always stored in compressed form to reduce the file size.

A video file normally consists of a container format (e.g. Matroska) containing video data in a video coding format (e.g. VP9) alongside audio data in an audio coding format (e.g.Opus). The container format can also contain synchronization information, subtitles, and metadata such as title. A standardized (or in some cases de facto standard) video file type such as .webm is a profile specified by a restriction on which container format and which video and audio compression formats are allowed.

The coded video and audio inside a video file container (i.e. not headers, footers and metadata) is called the essence. A program (or hardware) which can decode video or audio is called a codec; playing or encoding a video file will sometimes require the user to install a codec library corresponding to the type of video and audio coding used in the file.

Good design normally dictates that a file extension enables the user to derive which program will open the file from the file extension. That is the case with some video file formats, such as WebM (.webm), Windows Media Video (.wmv), and Ogg Video (.ogv), each of which can only contain a few well-defined subtypes of video and audio coding formats, making it relatively easy to know which codec will play the file. In contrast to that, some very general-purpose container types like AVI (.avi) and QuickTime (.mov) can contain video and audio in almost any format, and have file extensions named after the container type, making it very hard for the end user to use the file extension to derive which codec or program to use to play the files.

Name	File extension(s)	Video coding format(s)
Windows Media Video	.wmv	Windows Media Video, Windows Media Video Screen, Windows Media Video Image
Raw video format	.yuv	Doesn't apply
QuickTime File Format	.mov, .qt	Many
MPEG-4 Part 14 (MP4)	.mp4, .m4p (with DRM), .m4v	H.264,MPEG-4 Part 2, MPEG-2, MPEG-1
MPEG-2 – Video	.mpg, .mpeg, .m2v	H.262
GIF	.gif	N/A
Flash Video(FLV)	.flv	VP6,Sorenson Spark, Screen video, Screen video 2, H.264
AVI	.avi	any
3GPP	.3gp	MPEG-4 Part 2, H.263,H.264

Conclusion

In this paper we have concluded the basic different techniques available for video compression and the latest technique (H.264/AVC) available for video compression is also included. We have seen here that H.264/AVC has been developed by both the ISO/IEC (MPEG) and ITU-T (VCEG) organizations. It has various improvements in terms of coding efficiency, like flexibility, robustness and application domains. No doubt as per the requirements and applications, there will be always new development in video compression technique. From the review of various video compression papers it infers that there are still lots of possibilities for the improvement of video compression technique.

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