Research Paper Engineering

A Study of Digital Video Compression Techniques

Dr. Saroj Choudhary Department of Applied Science JECRC, Jodhpur, Rajasthan, India

Purneshwari Varshney Department of ECE JIET, Jodhpur, Rajasthan, India

ABSTRACT

Earlier, digital video compression technologies have become an integral part of the creation, communication and consumption of visual information. In this, techniques for video compression techniques are reviewed. The paper explains the basic concepts of video codec design and various features which have been integrated into international standards and including the recent standard, H.264/AVC. The ITU-T H.264 video coding standard has been developed to achieve significant improvements over MPEG-2 standard in terms of compression. Although the basic coding framework of the standard is similar to that of the existing standards, H.264 introduces many new features.

KEYWORDS H.264, MPEG-2, PSNR.

INTRODUCTION

The basic communication problem may be posed as conveying source data with the highest fidelity possible within an available bit rate, or it may be posed as conveying the source data using the lowest bit rate possible while maintaining specified reproduction fidelity [7]. In either case, a fundamental tradeoff is made between bit rate and fidelity. The ability of a source coding system to make this tradeoff well is called its coding efficiency or rate-distortion performance, and the coding system itself is referred to as a codec (i.e., a system comprising a coder and a decoder). The various application scenarios of video communication show very different optimum working points, and these working points have shifted over time as the constraints on complexity have been eased by Moore's law and as higher bit-rate channels have become available. In this paper, we examine the video codec design problem and the evolution of its solutions up to the latest international standard known as H.264 or MPEG-4 Advanced Video Coding (H.264/AVC).

VIDEO COMPRESSION TECHNIQUES

A. JPEG

For single-frame image compression, the industry standard with the greatest acceptance is JPEG (Joint Photographic Experts Group). JPEG consists of a minimum implementation (called a baseline system) which all implementations are required to support, and various extensions for specific applications. JPEG has received wide acceptance, largely driven by the proliferation of image manipulation software which often includes the JPEG compression algorithm in software form as part of a graphics illustration or video editing package. The image frame consists of three 2-D patterns of pixels, one for luminance and two for chrominance. Because the human eye is less sensitive to high-frequency color information, JPEG calls for the coding of chrominance (color) information at a reduced resolution compared to the luminance (brightness) information. In the pixel format, there is usually a large amount of low-spatial-frequency information and relatively small amounts of high-frequency information.

B. MPEG

MPEG is the "Moving Picture Experts Group", working under the joint direction of the International Standards Organization (ISO) and the International Electro-Technical Commission (IEC). This group works on standards for the coding of moving pictures and associated audio. 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 are common. The scheme is asymmetric; the MPEG encoder is very complex and places a very heavy computational load for motion estimation. Decoding is much simpler and can be done by today's desktop CPUs or with low cost decoder chips. The MPEG encoder may chose to make a prediction about an image and transform and encode the difference between the prediction and the image. The prediction accounts for movement within an image by using motion estimation.

C. 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, though it may be employed for any motion video compression task. H.261 allows for use with communication channels that are multiples of 64 kbps (P=1,2,3...30.), the same data structure as ISDN. H.261 is sometimes called Px64.

H.261 encoding is based on the discrete cosine transform (DCT) and allows for fully-encoding only certain frames (INTRA-frame) while encoding the differences between other frames (INTER-frame). 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 which provides a noticeable improvement in video quality but demands extra processing power.

D. H.263

H.263 is a structurally similar refinement (a five year update) to H.261 and is backward compatible with H.261. At bandwidths under 1000 kbps, 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). Both H.261 and H.263 algorithms are available in host-software formats, and both are already supported by several coprocessor chips out in the market. The basic configuration of the H.263 algorithm is based on ITU-T Recommendation H.261.

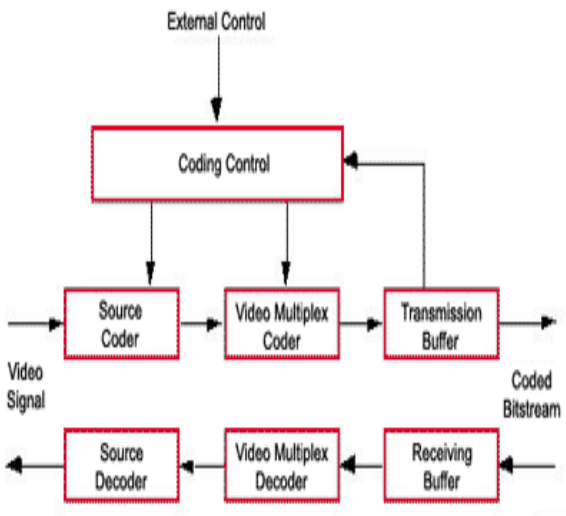

Fig. 1 H.263 overall block diagram

H.263 uses a hybrid of inter-picture prediction to utilize temporal redundancy and transform coding of the remaining signal to reduce spatial redundancy is adopted.

With the Unrestricted Motion Vector mode, motion vectors are allowed to point outside the picture. The edge pixels are used as prediction for the "not existing" pixels. With this mode, a significant gain is achieved if there is movement across the edges of the picture, especially for the smaller picture formats.

The Syntax-based Arithmetic Coding mode means that arithmetic coding is used instead of variable length coding. The SNR and reconstructed frames will be the same, but significantly fewer bits will be produced.

Also new in H.263 are PB frames. A PB-frame consists of two pictures being coded as one unit. The name PB comes from the name of picture types in MPEG where there are P-pictures and B-pictures. Thus a PB-frame consists of one P-picture which is predicted from the last decoded P-picture and one B-picture which is predicted from both the last decoded P-picture and the P-picture currently being decoded. This last picture is called a B-picture, because parts of it may be bidirectionally predicted from the past and future P-pictures. With this coding option, the picture rate can be increased considerably without increasing the bitrate significantly.

E. H.264

H.264 is the latest generation standard for video encoding. This initiative has many goals. It should provide good video quality at substantially lower bit rates than previous standards and with better error robustness – or better video quality at an unchanged but rate. An additional goal was to provide enough flexibility to allow the standard to be applied to a wide variety of applications: for both low and high bit rates, for low and high resolution video, and with high and low demands on latency. Indeed, a number of applications with different requirements have been identified for H.264:

> Entertainment video including broadcast, satellite, cable, DVD, etc (1-10 Mbps, high latency)
> Telecom services (<1Mbps, low latency)
> Streaming services (low bit-rate, high latency)
> And others

As a note, DVD players for high-definition DVD formats such as HD-DVD and Blu-ray support movies encoded with H.264. The latest video compression standard, H.264 (also known as MPEG-4 Part 10/AVC for Advanced Video Coding), is expected to become the video standard of choice in the coming years.

H.264 is an open, licensed standard that supports the most efficient video compression techniques available today. Without compromising image quality, an H.264 encoder can reduce the size of a digital video file by more than 80% compared with the Motion JPEG format. This means that much less network bandwidth and storage space are required for a video file.

Jointly defined by standardization organizations in the telecommunications and IT industries, H.264 is expected to be more widely adopted than previous standards. H.264 has already been introduced in new electronic gadgets such as mobile phones and digital video players, and has gained fast acceptance by end users. Service providers such as online video storage and telecommunications companies are also beginning to adopt H.264.

In the video surveillance industry, H.264 will most likely find the quickest traction in applications where there are demands for high frame rates and high resolution, such as in the surveillance of highways, airports and casinos, where the use of 30/25 (NTSC/PAL) frames per second is the norm. This is where the economies of reduced bandwidth and storage needs will deliver the biggest savings.

F. MPE G-21

MPEG-21 is a standard that defines means of sharing digital rights, permissions, and restrictions for digital content. MPEG-21 is an XML-based standard, and is developed to counter illegitimate distribution of digital content. MPEG-21 is not particularly relevant for video surveillance situations

- APPLICATIONS OF H.264 / MPEG-4
- The H.264 / MPEG-4 part 10 AVC has a broad range of applications for video content. Some of them are listed below:
- Video streaming over the internet
- Cable TV on optical networks
- Direct broadcast satellite video services
- Digital subscriber line (DSL) video services
- Digital terrestrial television broadcasting, cable modem (DSL)
- Interactive Media Storage
- Multimedia mailing
- Multimedia services over packet networks
- Real-time conversational services (videoconferencing, videophone, etc.)
- Remote Video Surveillance
- Serial storage media (digital VTR, etc.)
- Scalable video coding (SVC) and multi-view video coding (MVC) have been adopted as extensions to the H.264

CONCLUSION

This paper describes an evaluation of the emerging H.264 video coding standard in terms of frame rate compared to existing most common video coding standards. H.264 is a new standard for video compression which has more advanced compression methods than the basic MPEG-2 compression. One of the advantages of H.264 is the high compression rate. It is about 1.5 times more efficient than MPEG-2 encoding. This high compression rate makes it possible to record more information on the same hard disk. H.264/AVC represents a major step in the development of video coding standards, in terms of both coding and efficiency enhancement and flexibility for effective use over a broad variety of network types and application domains. Being the latest, when compared with the other currently available video coding standards, H264 provides good quality with better compression rates.

References

1. "ITU-T H.263 Encoder, version 2", Signal Processing and Multimedia Group, University of British Columbia, Canada.
2. MPEG-2 video codec, Computer Science Division- EECS, Univ. of Calif. at Berkeley.
3. Telenor H.263 codec, "ITU-T/SG-15, video codec test model, TMN5", Telenor Research, 1995.

4. ISO/IEC 11172: "Information technology—coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s," Geneva, 1993.
5. ISO/IEC 13818–2: "Generic coding of moving pictures and associated audio information—Part 2: Video," 1994, also ITU-T Recommendation H.262.
6. ITU-T Recommendation H.263, "Video Coding for Low bit rate Communication".
7. Iain E G Richardson, "H.264/MPEG-4 Part 10 White Paper."
8. ITU-T Recommendation H.264 and ISO/IEC 14496-10 MPEG-4 Part 10, Advanced Video Coding (AVC), 2003.
9. T. Wiegand et al., "Overview of H.264/AVC Video Coding Standard", IEEE Trans. on Circ. and Sys. For Video Technology, Vol. 13, No. 7, pp. 560–576, July 2003.
10. T. Wiegand et al., "Rate-Constrained Coder Control and Comparision of Video Coding Standards", IEEE Trans. on Circ. and Sys. for Video Technology, Vol. 13, No. 7, pp. 688–703, July 2003.
11. "MPEG-4 AVC/H.264 Video Codecs Comparison" by Dr. Dmitriy Vatolin, Dr. Dmitriy Kulikov at Moscow, CS MSU Graphics&Media Lab, Video Group, May 2011.