MPEG: A Video Compression Standard for Multimedia Applications

Summary

Published in *Communication of the ACM – Special Issue on Digital Multimedia Systems* back in April 1991, "MPEG: A Video Compression Standard for Multimedia Applications" presents an overview of MPEG-Video which has become an international standard for video compression techniques. The development of video technology in the 1980s enabled the use of digital video for telecommunication, digital broadcast codec, and video telephony. Such development, as claims by the author, raised a high priority on the standardization of video compression techniques because it is the only way to reduce the cost of video compression codecs and to expand the compatibility of equipments from different manufacturers.

MPEG-Video standard is started by the expert group named MPEG: Moving Picture Experts Group and addresses the compression of video signals at about 1.5 Mbits. The MPEG-Video standard leads to two very important consequences:

1. Video becomes a form of computer data, and can be integrated with text and graphics.
2. Motion video and its associated audio can be transmitted over computer and telecommunication networks.

The challenge of MPEG is to identify the constraints and requirements put forth by the proposed applications while design a standard that is flexible enough to accommodate them while be independent of any particular application. The paper listed the requirements as follow:

1. Random Access – An essential feature that requires a video bit stream to be accessible in the middle and be decoded in a limited amount of time.
2. Fast Forward/Reverse Search – Essentially a more demanding form of random accessibility where scan compressed bit stream is possible depending on the storage medium.
3. Reverse Playback – possibly use by interactive applications and should be available without an extreme cost in memory.
4. Audio-video synchronization – A mechanism that would permanently resynchronized the video and audio should those two signals be derived from different clocks.
5. Robustness to Error – The source coding scheme should be robust to errors to avoid catastrophic effects when errors are presented in storage media and/or communication channels.
6. Coding/Decoding Delay – The video compression algorithm should perform well over the range of acceptable delays and the delay is to be considered a parameter.
7. Editability – The compressed video should have an acceptable level of editability and be able to construct editing units of a short time duration.

8. Format Flexibility – the compressed video should have large flexibility in terms of raster size and frame rate.
9. Cost Tradeoffs – The decoder needs to be implementable in a small number of chips and the encoding process should be able to perform in real time.

The paper presented an overview of the MPEG compression algorithm in two sections: the reduction of temporal redundancy and spatial redundancy. To maximize temporal redundancy, MPEG compression algorithm uses three types of pictures to reduce video bit-rate while provides random access feature. The three types of picture in MPEG consist of:

- Intrapictures: provide access point for random access.
- Predicted pictures: used as a reference for future predicted pictures.
- Interpolated pictures: provide high amount of compression but require both a past and future reference.

Such design allows the technique of motion-compensated prediction where current picture can be modeled as a translation of the picture at some previous time. Another technique is the motion-compensated interpolation. It is where signal is reconstructed by obtaining additional correction term from a past and a future reference.

While MPEG compression algorithm supports a wide range of spatial and temporal resolution and bit-rates, a constrained parameter set was defined to prevent manufacturers from building overdesigned system. So while MPEG algorithm could be applied to higher resolutions and bit rates, it might not be optimal as claimed by the author.

Review

The objective of this article is rather straightforward. Despite the lack of a proper abstract and an extensive coverage on background information and standardization effort, the objective was clear when the requirements for MPEG-Video was introduced.

As an overview on MPEG-Video, the paper is particularly useful because it provides the necessary background including the motivation for such international standard and the challenges in designing a flexible standard that would fulfill application requirements. The requirement for MPEG compression algorithm is particularly interesting. Not only did it largely outline the features of future multimedia which is evidenced in current multimedia technology, it even predicted the transfer of compressed video over computer networks.

In the Background: Relevant Standards section, the paper did emphasize on the closeness and similarity of MPEG and H.261. However, there is no further mentioning of the similarity and difference between the two. It might be a good addition to the paper because I believe the two standards are closely related.

One weakness of MPEG-Video is that despite the fact it could theoretically be applied to higher resolution video, the constrained parameter set limits the capability of the algorithm because encoding will be difficult and hardware requirements are unknown with manufacturers follow only the constrained set. The flexibility of MPEG-Video is therefore wasted without further parameter sets designed more specifically for higher resolution videos.

A weakness of the paper is due to the overview nature of this article, no specific data or comparison is presented. However, overall the paper is a great contribution to the field and has tremendous impact that has greatly influenced how multimedia technology has changed. It is a well written article presented with detailed explanation. It serves as a great overview on MPEG-Video.