Digital Video Coding Principles from H.261 to H.265/HEVC

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INTRODUCTION

Multimedia applications and services have already possessed a major portion of today traffic over communication networks. The revolution and evolution of World Wide Web has enabled the wide provision of multimedia content over the Internet and any other autonomous network.

Among the various types of multimedia, video services (transmission of moving images and sound) are proven dominant for present and future communication networks. Although the available network bandwidth and the corresponding supporting bit rates continue to increase, the raw video data necessitate high bandwidth requirements for its transmission. For example, current commercial communication networks throughput rates are insufficient to handle raw video in real time, even if low spatial and temporal resolution (i.e. frame size and frame rate) has been selected. Towards alleviating the network bandwidth requirements for efficient transmission of audiovisual content, coding techniques have been applied on raw video data, which perform compression by exploiting both temporal and spatial redundancy in video sequences.

Video coding is defined as the process of compressing and decompressing a raw digital video sequence, which results in lower data volumes, besides enabling the transmission of video signals over bandwidth limited means, where uncompressed video signals would not be possible to be transmitted. The use of coding and compression techniques leads to better exploitation and more efficient management of the available bandwidth.

Video compression algorithms exploit the fact that a video signal consists of sequence series with high similarity in the spatial, temporal and frequency domain. Thus, by removing this redundancy in these three different domain types, it is possible to achieve high compression of the deduced data, sacrificing a certain amount of visual information, which however it is not highly noticeable by the mechanisms of the Human Visual System, which in not sensitive at this type of visual degradation (Richardson, 2003).

Thus, the research area of video compression has been a very active field during the last years by proposing various algorithms and techniques for video coding (MPEG,1998, 2005a, 2005b, 2013; ITU, 1993, 2005a, 2005b, 2013). In general video compression techniques can be classified into two classes: The lossy ones and information preserving (lossless). The first methods although maintain the video quality of the original/uncompressed signal they do not succeed high compression ratios, while the lossless ones which compress more efficiently the data volume of initial raw video signal with the cost of degrading the perceived quality of the video service.

The lossy video coding techniques are widely used, in contrast to lossless ones, due to their better performance. More specifically, by enhancing the encoding algorithms and techniques, the latest proposed coding methods try to perform in a more efficient way both the data compression and the maintenance of the deduced

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perceived quality of the encoded signal at high levels. In this framework, many of these coding techniques and algorithms have been standardized, encouraging by this way the interoperability between various products designed and developed by different manufactures.

This article deals with the fundamentals of video coding process of the lossy encoding techniques that are common on the great majority of today video coding standards and techniques.

BACKGROUND

The majority of the compression standards have been proposed by the International Telecommunication Union (ITU) and the International Organization for Standardization (ISO) bodies, by introducing the following standards H.261, H.263, H.263+, H.263++, H.264, H.265, MPEG-1, MPEG-2, MPEG-4, MPEG-4 Advanced Video Coding (AVC) and MPEG-H Part 2 (ISO/IEC 23008-2).

Some of the aforementioned standards were developed in partnership of ITU with Moving Pictures Expert Group (MPEG), exploiting similar coding techniques developed by each body separately.

Each standard was designed and proposed targeting a specific service and application, featuring therefore specific parameters and characteristics. For example H.261 was proposed in 1990 for transmission of video signals over Integrated Services Digital Network (ISDN) lines on which data rates are multiples of 64 kbit/sec. The H.263 standard was designed as a low bit rate encoding solution for videoconferencing applications.

Similarly MPEG-1 was proposed by MPEG in order to be used by the Video Compact Disc (VCD) medium, which stores digital video on a Compact Disc (CD) with a quality almost similar to that of an analog VHS video. In 1994 MPEG-2 was proposed for encoding audio and video for broadcast signals, exploiting interlace format. MPEG-2 is also the coding format used by the widely successful commercial Digital Versatile Disc (DVD) medium.

Regarding the H.264, or MPEG-4 Part 10 AVC, it was proposed in common by the ITU-T Video Coding Experts Group (VCEG) and the ISO MPEG as the outcome of a joint venture effort known as the Joint Video Team (JVT). The scope of H.264/AVC project is to create a standard that would be capable of providing broadcast video quality at very low bit rates on a wide variety of applications, networks and systems.

The most recent joint video project that was developed with the collaboration of the ITU-T VCEG and the ISO/IEC MPEG was the High Efficiency Video Coding (HEVC) which was finalized in January 2013. The scope of the HEVC standard is to significantly improve the compression performance compared to the existing standards in a range of 50% bit rate reduction for equal perceptual video quality (Sullivan, Ohm, Han, & Wiegand, 2012).

Finally, in order to create a framework, which will reassure the interoperability of the codec implementation among the various developers, the standards include the concept of profiles and levels, defining a specific set of capabilities to be defined and implemented for a specific subset of applications and services.

HIGH EFFICIENCY VIDEO CODING (HEVC)

The highly-anticipated video coding standard, ITU-T H.265 'High Efficiency Video Coding' (HEVC) while is around the corner, the truth is that at least the consumer market is not really ready for it, at least not yet. Many people try to believe that we have officially entered the 4K (UltraHD) market already but that is actually a myth because of the many challenges that the UltraHD technology has. The adoption will for this kind of new technology will be slow as many people in the business know and understand.

If someone nowadays owns a smartphone he is able to watch videos from YouTube in even FHD (1080p resolution), that's because most of the chips that exist inside your smartphone support the H.264 standard and are able to decode them.

In order for smartphones to start supporting the newly found H.265 video coding standard, chipmaker companies like Intel, Broadcom, Qualcomm and others must create new chips that will implement and support the new found H.265. Broadcom is one of these companies that have already announced chips with support for HEVC and resolutions to up to 4K (4096x2160 UltraHD at 60fps).