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MPEG VIDEO CODING: A basic tutorial introduction

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*MPEG VIDEO CODING: A basic tutorial introduction

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Summary

*MPEG has been outstandingly successful in defining standards for video compression coding, serving a wide range of applications, bit-rates, qualities and services on a worldwide basis. The standards are based upon a flexible toolkit of techniques for bit-rate reduction. MPEG video coding uses a combination of motion-compensated interframe prediction (for reducing **temporal** redundancy) with Discrete Cosine Transform (DCT) and variable length coding tools (for reducing **spatial** redundancy). The specification only defines the bitstream syntax and decoding process: the coding process is not specified and the performance of a coder will vary depending upon, for example, the quality of the motion-vector measurement, and the processes used for prediction-mode selection.*

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1. INTRODUCTION

MPEG (Moving Pictures Expert Group) started in 1988 as a Working Group of the International Standards Organisation (ISO)[1] with the aim of defining standards for digital compression of video and audio signals. It took as its basis the ITU-T standard for video-conferencing and video-telephony* with that of JPEG (Joint Photographic Experts Group) which was initially developed for compressing still images such as electronic photography.

The first goal of MPEG was to define a video coding algorithm for digital storage media; in particular, for the CD-ROM. The resulting standard was published in 1993.** It comprises three parts, covering:

- systems aspects (including multiplexing and synchronisation)[2,]
- video coding
- audio coding.3

It has been applied in the Interactive CD (CDi) system to provide full motion video playback from CD, and is widely used in PC applications, for which a range of hardware and software coders and decoders are available. This standard is known as **MPEG-1** and is restricted to non-interlaced video formats; it is primarily intended to support video coding at bit-rates up to about 1.5 Mbit/s.

In 1990, MPEG began work on a second standard, to be capable of coding interlaced pictures directly; originally to support high-quality applications at bit-rates in the range of about 5 to 10 Mbit/s. **MPEG-2**,[4] as it is now known, also supports high definition formats at bit-rates in the range of about 15 to 30 Mbit/s. As for MPEG-1, the MPEG-2 standard (published in 1994***) is comprised of three parts: systems, video and audio·

It is important to note that the MPEG standards specify only the syntax and semantics of the bit-streams and the **de**coding process; they do *not* specify the **en**coding process. Much of the latter is left to the discretion of the coder designers and this gives scope for improvement as coding techniques are refined and new techniques developed.

* This is now known as Working Group H261.

** As ISO/IEC 11172.

*** As ISO/IEC 13818.

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2. VIDEO CODING PRINCIPLES

A studio-quality 625-line component picture, when digitised according to ITU Recommendation 601/656 (i.e. 4:2:2 sampling), requires 216 Mbit/s to convey the luminance and two chrominance sample components (see Fig. 1). For bandwidth-restricted media (such as terrestrial or satellite channels), some way of reducing the very high bit-rate needed to represent the digitised picture must be obtained.

A video bit-rate reduction system[5] (for producing compression) operates by removing redundant and less important information from the signal prior to transmission, and then reconstructing an approximation of the image from the remaining (compressed) information at the decoder. In video signals, three distinct kinds of redundancy can be identified:

- **Spatial and temporal redundancy:** pixel values are not independent but are correlated with their neighbours, both within the same frame and across frames. So, to some extent, the value of a pixel is predictable, given the values of neighbouring pixels.
- **Entropy redundancy:** for any non-random digitised signal, some code values occur more frequently than others. This can be exploited by coding the more frequently-occurring values with shorter codes than would be used for the rarer values. This same principle has long been exploited in the Morse Code, where the commonest letters in English (‘E’ and ‘T’) are represented by one dot and one dash respectively whereas the rarest (‘X’, ‘Y’ and ‘Z’) are represented by four dots and dashes.

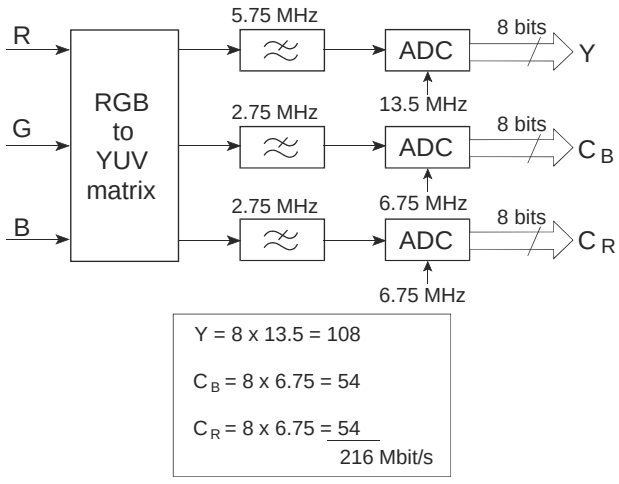

Fig. 1 - 4:2:2 sampling.

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