AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ELECTRONICS AND COMMUNICATIONS ENGINEERING
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Lossy Compression Techniques in Video Codecs

A Thesis

Submitted for Partial Fulfillment of the Requirements of the Degree of Master of Science
in Electronics and Communications Engineering

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STATEMENT

This thesis is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Electronics and communication Engineering).

The work included in this thesis was carried out by the author in the Department of Electronics and Communication Engineering, Ain Shams University.

No Part of this thesis has been submitted for a degree or a qualification at any other university or institute.

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Abbreviations

RTC: Real Time Communication

AVC: Advanced Video Codecs

DCT: Discrete Cosine Transform

VCEG: Video Coding Experts Group

ITU: International Telecommunications Union

MPEG: Moving Picture Experts Group

ISO/IEC: International Standardization Organization and International Electrotechnical Commission

FPGA: Field Programmable Gate Array

VHDL: Very High Density Logic

HVS: Human Visual System

Qstep: Quantization step size

QP: Quantization Parameter

Key Words

H.264, AVC, Transform Coding, Quantization, Lossy video compression, HVS, QP, Qstep, Discrete Cosine Transform, DCT, ITU, Hadamard, Butterfly

1 Introduction

Communication is the heart of any technological advance all over the world, so, a good communication media leads to a good atmosphere for research and development. The Real Time Communication (RTC) became the most desirable type of communications nowadays in addition to media broadcast communications. However, the available media bandwidth desired for transmission is limited and the amount of transmitted data grows up over time, it is practically impossible to transmit this huge amount of data in its natural form, especially when the data required to be transmitted is of a big size nature as image and video data. This big size data does not only affect the bandwidth resources, but also consumes storage and processing resources prior to transmission or storage operations. So, compression operation became a must in order to save transmission media, storage and processing resources. In this book we are dealing with the most bandwidth and resources consuming data, which is the image and video data.

1.1 Video coding techniques

The image and video data compression operation is called "Coding" operation. Image and video data coding operations have been updated very widely over the last years due to the dramatically updates in the image and video quality and so the data size. All data types are represented in binary coded bits, so, coding operation is practically the reduction in the amount of bits needed to represent the image or video file. The reduction operation in the coded bit stream is actually indispensable in order to save transmission bandwidth resources beside the storage and processing resources needed to code the image data or the video stream. Since then, many coding techniques rose up over time to keep pace with the enormous evolution in the quality of the image and video stream quality and so their bit representation.

A set of rules were built in order to organize the coding operation, those rules are combined in the form of a Standard Book, the Standard Book is a document that defines the coding structure of the image or video bit representation. There are 2 organizations responsible for mapping the standards for the video coding techniques [1] [2]:

1- ITU-T Video Coding Experts Group (VCEG): International Telecommunications Union –Telecommunications Standardization Sector (ITU-T, a United Nations Organization, formerly CCITT).
2- ISO/IEC Moving Picture Experts Group (MPEG): International Standardization Organization and International Electrotechnical Commission.

Those organizations came up with many standard updates since 1984 till now due to the great updates in image and video quality. The following graph illustrates the standard update history till reaching H.264 technique which is the scope of this thesis [13].

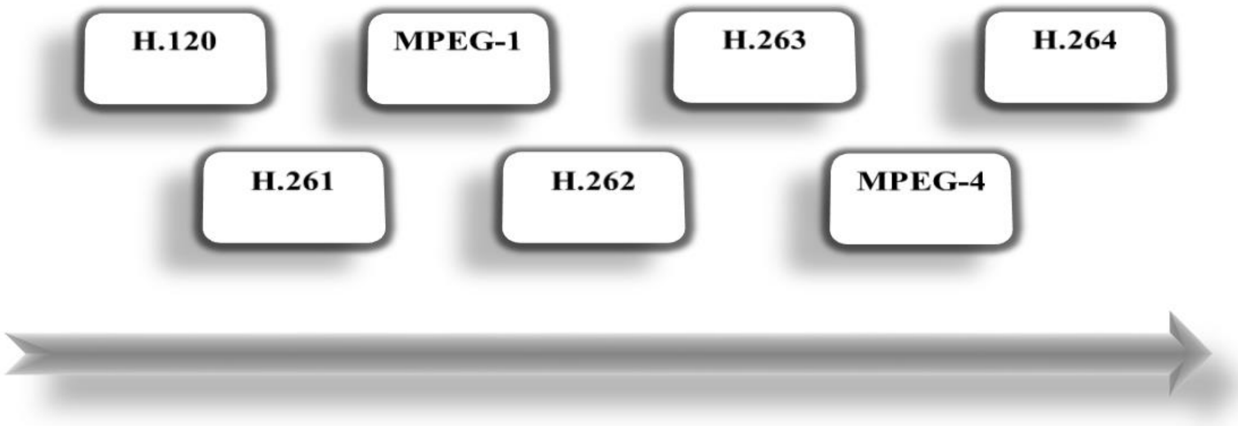

Fig. 1-1 Videos codecs standard updates

The main advantages of H.264 over all the previous coding generations is:

1. Small file size for longer recording time and better network transmission, this is due to the small coding block size (will be declared in the next chapter) and higher compression efficiency.
2. Fluent and better video quality for real time playback.
3. More efficient mobile surveillance application. [19]

1.2 Video applications

H.264/AVC rose up to be the widely used coding technique for most of the video streaming and image broadcasting applications used nowadays including [7]:

- Broadcasting over
  - Ethernet, modem or RF cable.
  - Storage over optical and magnetic drivers such as HDDs, DVDs … etc.
- Live video streaming services over
  - Wired communication media such as ISDN, LAN network … etc.
  - Wireless communication media such as WLAN, Mobile Networks … etc.
- TV video transmission
- Conversational communication applications such as video conferencing.
- Multimedia messaging services
- Video on demand applications

In order to sum up the previously discussed application types, those applications are either one way communication applications which consists of simply a transmitting device, transmission media (wired or wireless) and the receiving device which is shown in the following figure

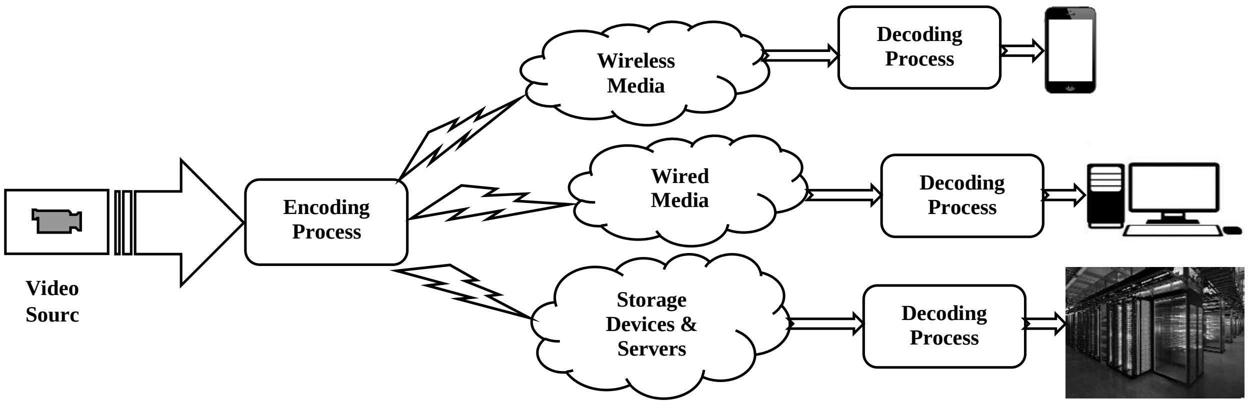

Fig. 1-2 One way transmission applications

Or two way transmission applications in which each side consists of a transceiver device. This type of application is more complicated than the one way communication type as it nearly consumes double the bandwidth, processing and storage resources. The operation is shown as follows

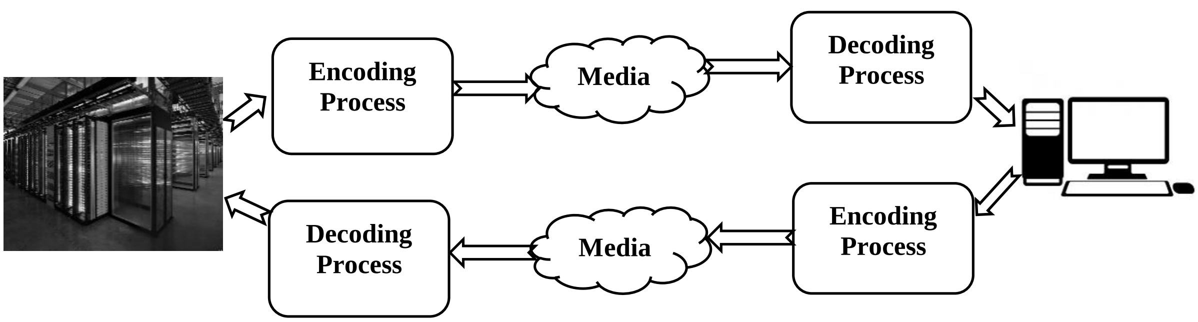

Fig. 1-3 One way transmission applications

According to the previously discussed applications and modes of data transmission, the urgency for video coding (video compression) criteria became clearer.

1.3 Types of video compression techniques

The overall video compression operation is described in the following graph [14]

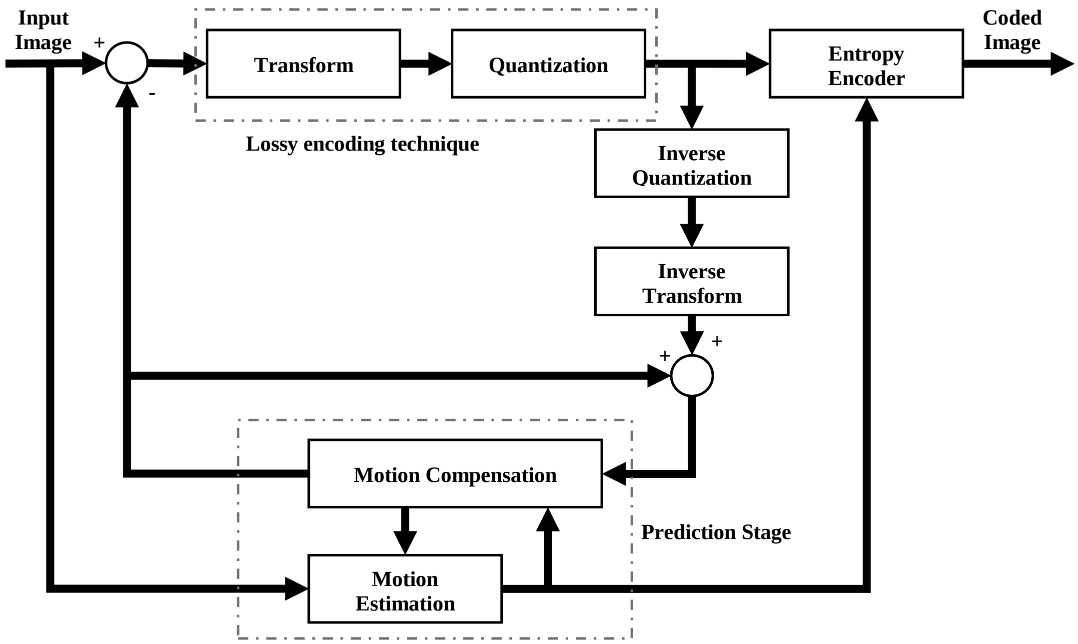

Fig. 1-4 H.264 Encoder operation [14]

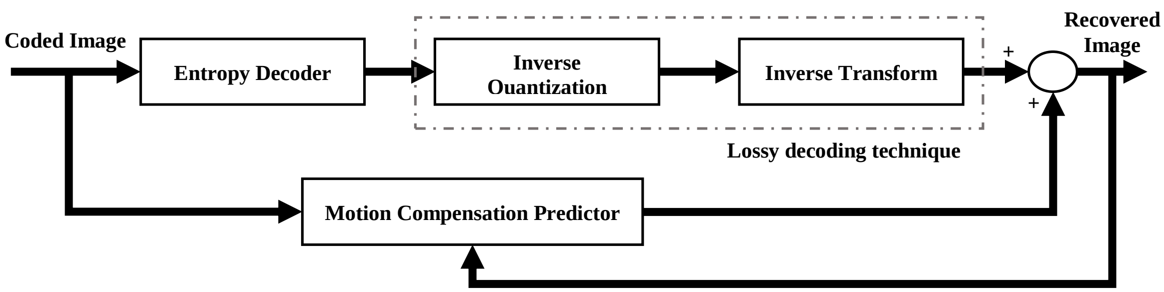

Fig. 1-5 H.264 Decoder operation [14]

As shown in figure 1-4, the encoder operation is clarified, the image or video frame (which is formed by a group of pixels that represent the image or video frame contents) is predicted and the residual data generated from the prediction stage is transferred to the compression stages. First the residual data is compressed using the lossy encoding technique procedure steps (Transformation and Quantization), and then the resulted data is transferred to the Entropy lossless encoding technique stage prior to transmission over the specified media.

In the decoding operation at the receiving side, the received data is de-compressed using lossless Entropy decoder, then it is inverse quantized and inverse transformed in order to