

Multimedia Systems

Introduction

Dr. Mojtaba Aajami

What is media?

- Information represented in different formats/media

- Text
- Graphics
- Images

Discrete media: Time independent

- Animation
- Audio
- Video

Continuous media: Time dependent

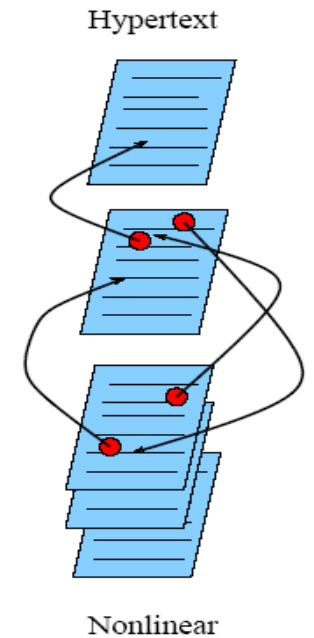
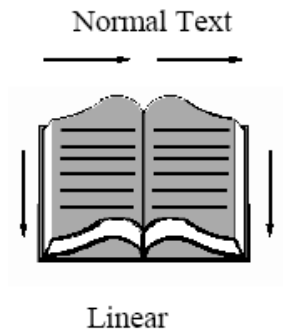
Analog vs Digital

- **Analog format**

- The time-varying feature (variable) of the signal is a continuous representation of the input, i.e., analogous to the input audio, image, or video signal.
- **The physical world is analog!**

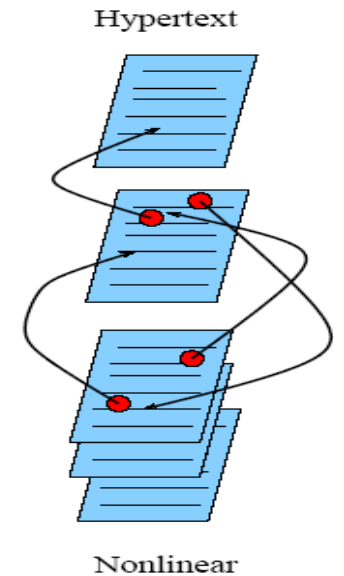
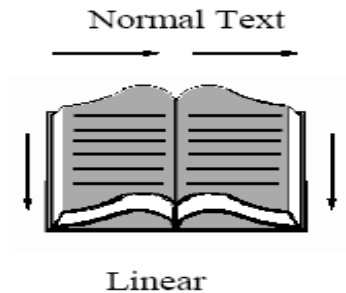
Hyper Text, Hypermedia

- A **hypertext** system: meant to be read nonlinearly, by following links that point to other parts of the document, or to other documents

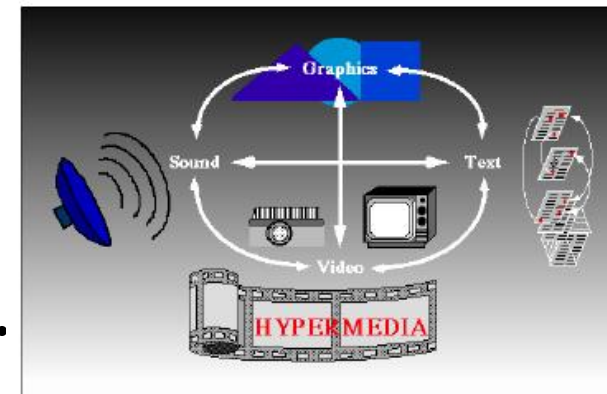


Hyper Text, Hypermedia

- A **hypertext** system: meant to be read nonlinearly, by following links that point to other parts of the document, or to other documents



- **HyperMedia**: not constrained to be text-based, can include other media, e.g., graphics, images, and especially the continuous media i.e. sound and video.



Multimedia System

- **Multimedia**

- Information represented through audio, graphics, images, video, and animation in an integrated and interactive manner (in contrast to traditional single-modality media, i.e., text and graphics drawing).

- **Multimedia System**

- The generation, manipulation, storage, presentation, and communication of multimedia information

Digital Media

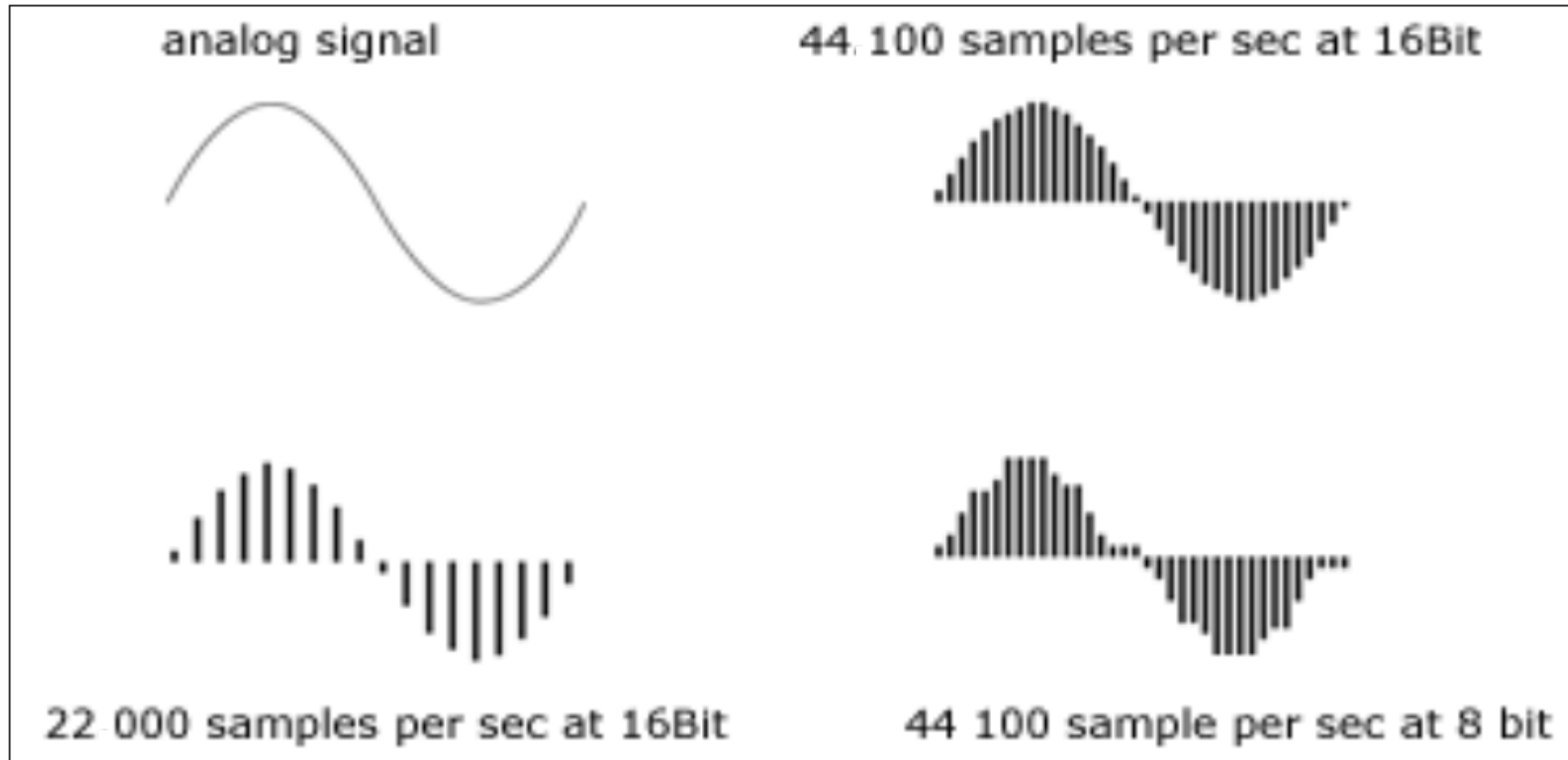
- Multimedia **digitized**
 - Captured, stored, transmitted, processing in the digital (discrete) domain.
 - By general-purpose computers or dedicated embedded computers
 - Today's digital cameras have a number of CPUs inside, many of which are more powerful than a PC of the 1990s or even 2000s.
- Audio/visual signals from the natural world are **Analog**
 - Continuous in time and space
 - Conventional storage/playback
 - Can't be handled by computer



Why digitized

- We have some challenges with analog data
 - Bulky storage (space, cost, lifetime)
 - Poor quality
 - Poor/no compression
 - Poor portability/mobility/editability
- A/D conversion
 - to 1/0 discrete signals

Audio Digitization (PCM)



Sampling Rate

- Sampling theory – Nyquist theorem

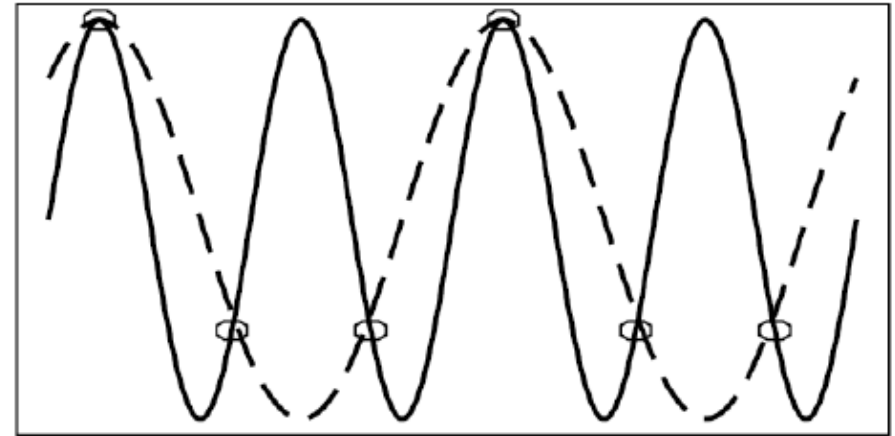
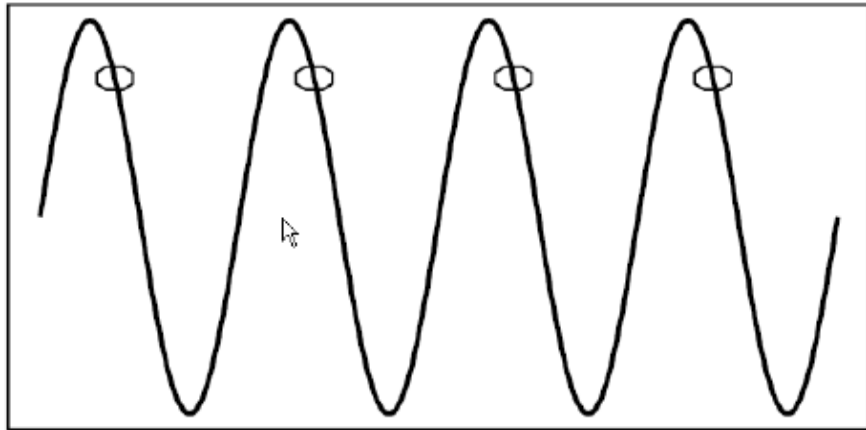


Image Digitization

- A digital image is a 2-D array of pixels
- Each pixel is represented by bits

- R:G:B

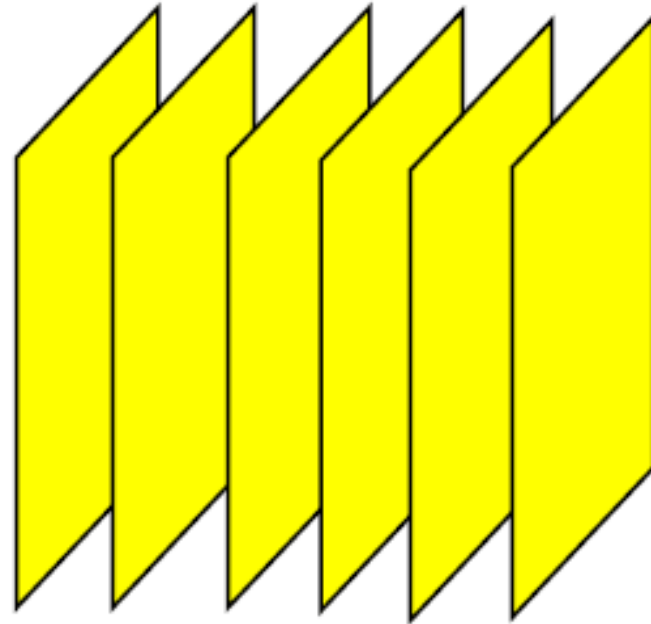


- Y:U:V

- $Y = 0.299R + 0.587G + 0.114B$ (Luminance or Brightness)
- $U = B - Y$ (Chrominance 1, color difference)
- $V = R - Y$ (Chrominance 2, color difference)

Video Digitization

- Video is a sequence of images (frames) displayed at constant frame rate.
 - e.g. 24 images/sec



Why Compression?

- Multimedia data are too big
 - “A picture is worth a thousand words! “

File Sizes for a **One-minute** Audio CD Clip

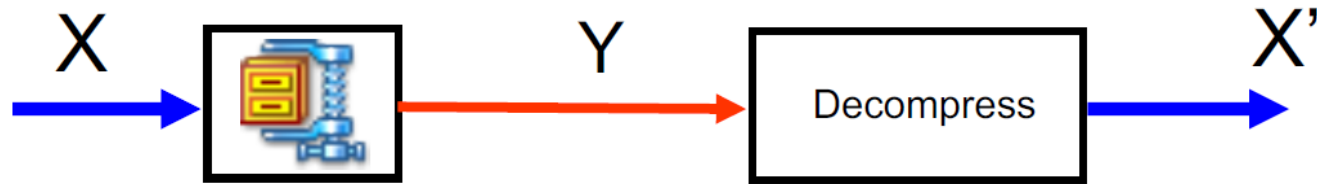
Sampling Rate	Resolution	Channels	Bit-rate (bps)	File Size (Bytes)
44,100Hz	16 bits	2	1,411,200	10,584,000

File Sizes for a **One-minute** QCIF Video Clip

Frame Rate	Frame Size	Bits / pixel	Bit-rate (bps)	File Size (Bytes)
30 frames/sec	176 x 144 pixels	12	9,123,840	68,428,800



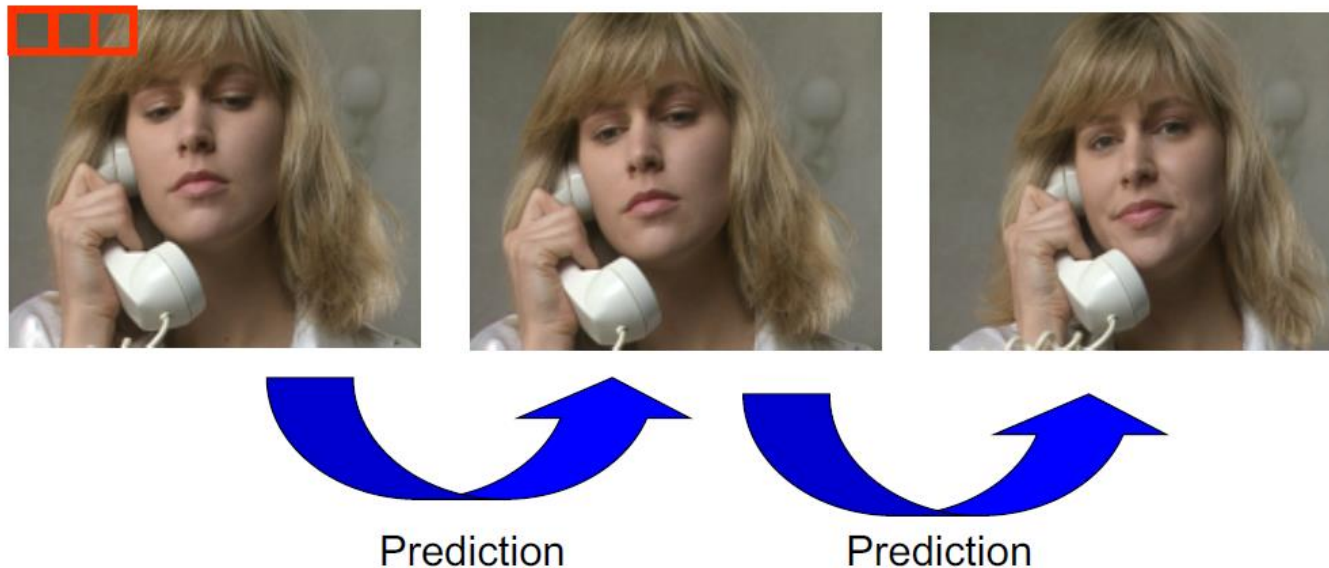
Data Compression



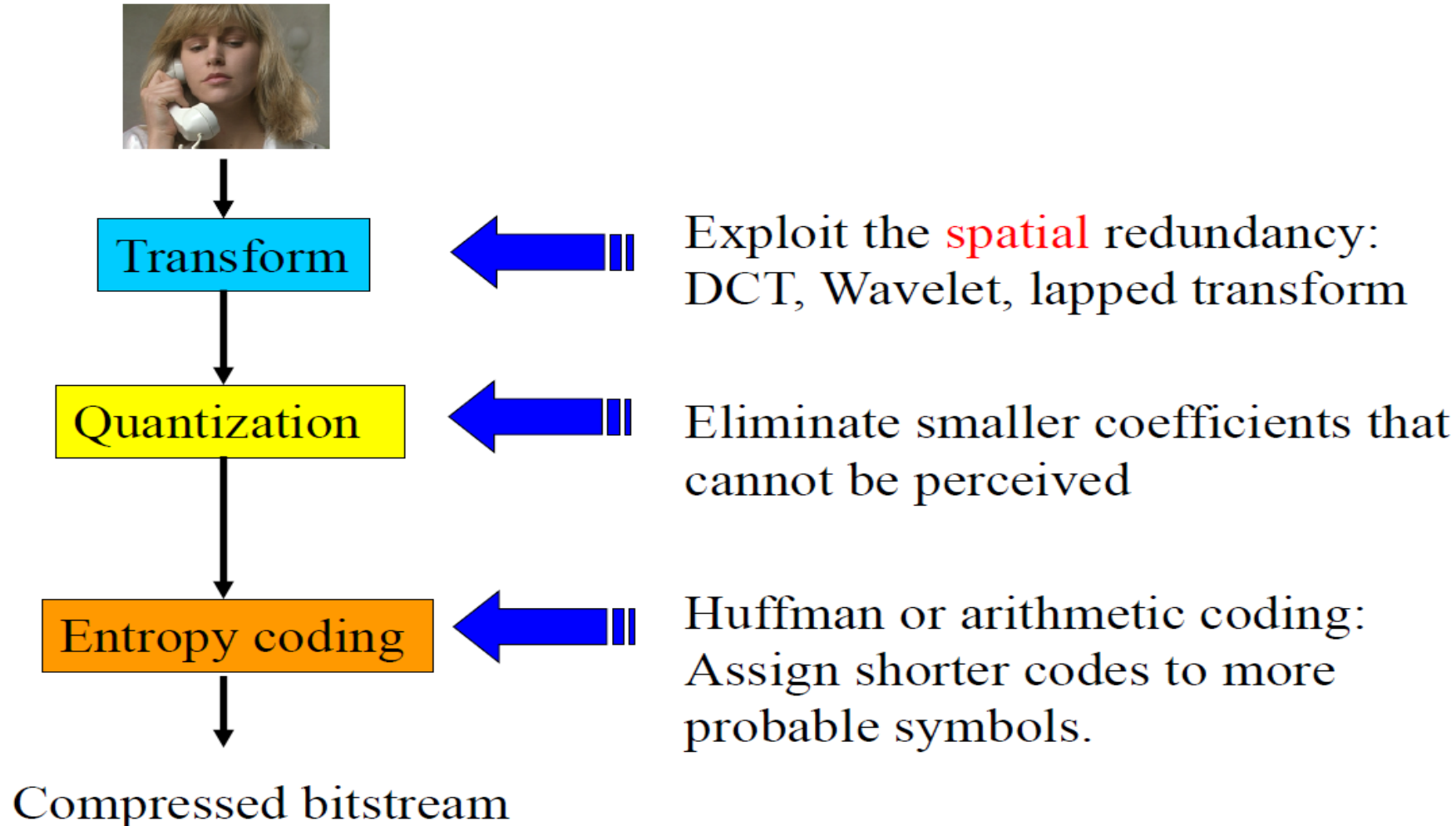
- **Lossless** Compression: $X' = X$
 - Example: Computer file compression
 - Low compression ratio
- **Lossy** Compression: $X' \neq X$
 - Many applications do not require lossless compression
 - Our eyes and ears cannot identify some details
 - High compression ratio

Essential of Compression

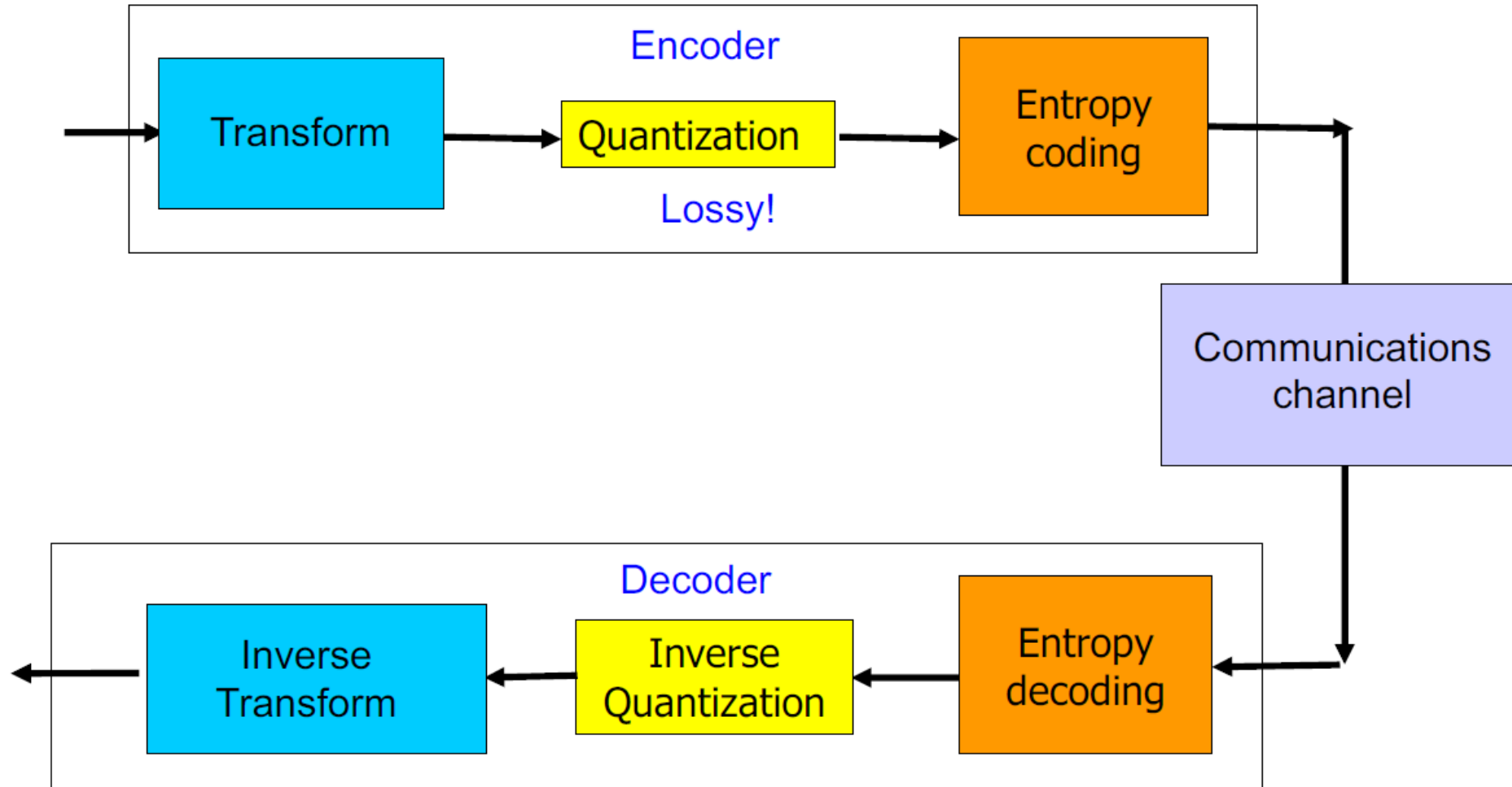
- Remove redundant information:
 - **Spatial** redundancy:
 - Neighboring samples have similar values
 - **Temporal** redundancy:
 - Neighboring frames in a video sequence are similar



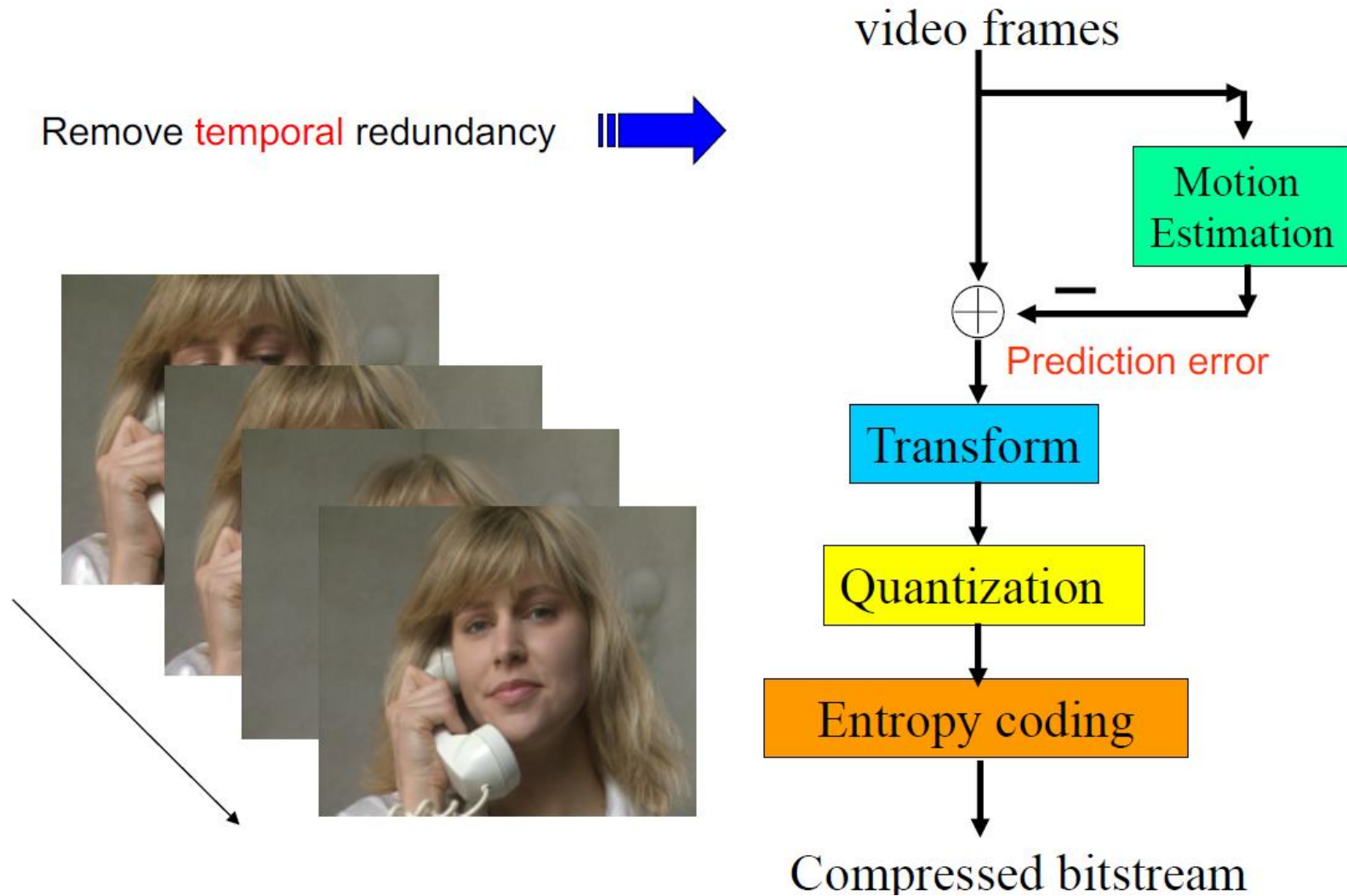
A Typical Image Compression System



A typical image communication system



A Typical Video Compression System



Compression Standards

- A **standard** allows products from multiple vendors to communicate.
 - Yet, users have flexibility in selecting equipment or software.
- Assures a large market for a particular piece of equipment or software.
- Standard does not prevent innovation
 - Only the decoder is specified by the standard
 - The encoder can still be improved

Standardization Bodies

ITU: International Telecommunications Union

- ITU-T: ITU Telecommunication Standardization Sector (CCITT)

ISO: International Standards Organization

IEC: International Electro-technical Commission

SMPTE: Society of Motion Picture and Television Engineers

JPEG (ISO/IEC Joint Photographic Experts Group)

JBIG (ISO Joint Bi-level Image Experts Group)

MPEG (ISO Motion Picture Experts Group)

VCEG (ITU-T Video Coding Experts Group)

Image Coding Standards

JPEG:1993 (JPG file format)

- DCT-based block transform

JPEG2000: Dec. 2000

- Wavelet-based
- Much more complicated than JPEG

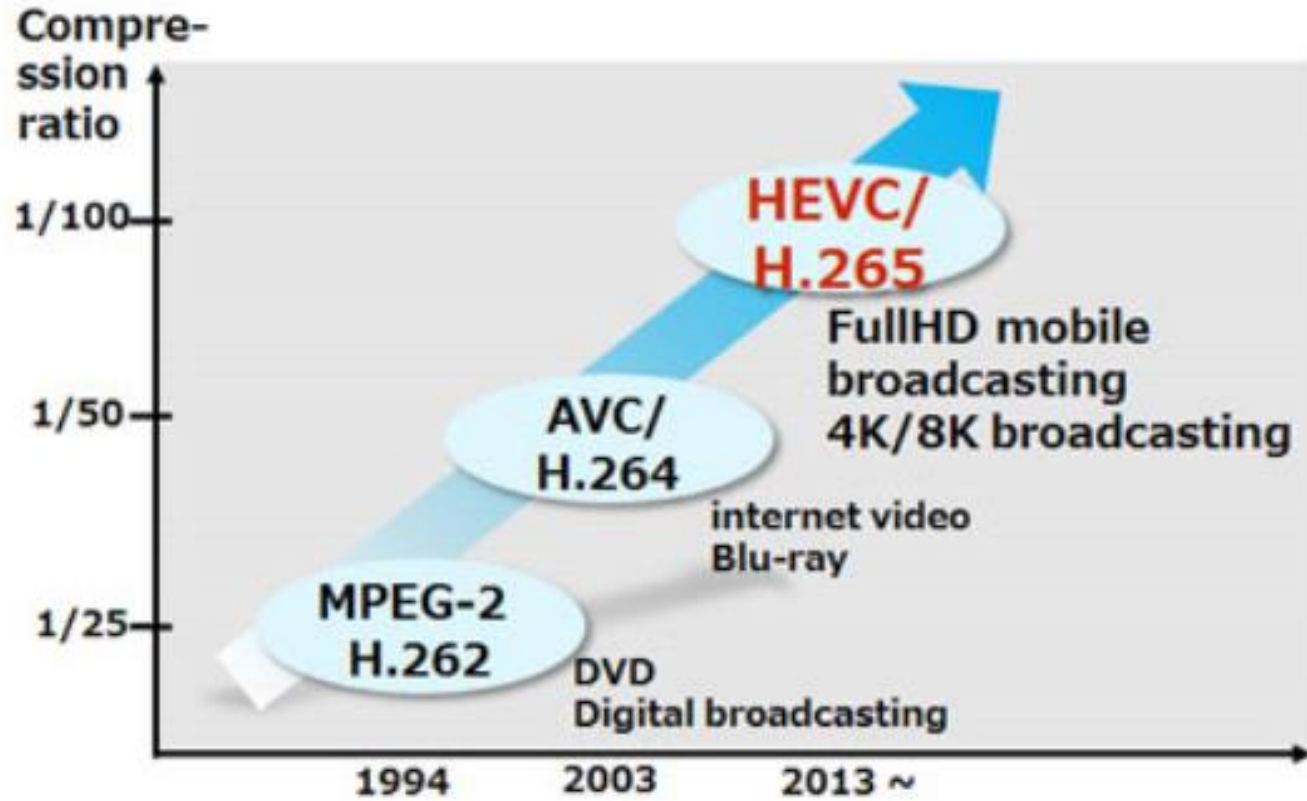
JBIG: Joint Bi-level Image Experts Group (1993)

- for lossless bi-level image compression (fax)
- can also be used for grayscale images

JBIG2: 1999

- Supports both lossless and lossy compression

Video Coding Standards



Multimedia communications

- Examples of Multimedia Communication Systems:
 - World Wide Web
 - Video conferencing
 - Video-on-demand
 - Interactive TV
 - Online games

Fundamental Characteristics

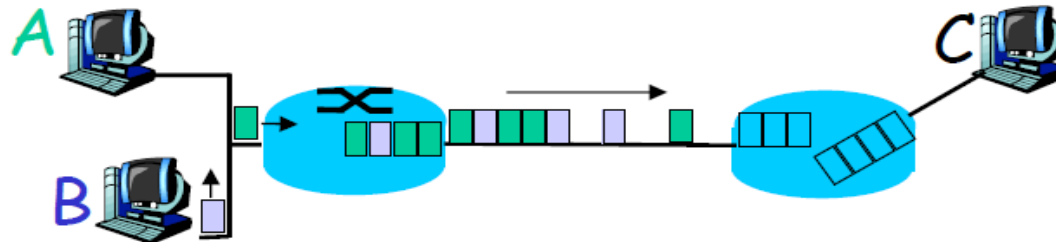
- Typically **delay sensitive**
- But can **tolerate occasional loss**:
 - infrequent losses cause minor glitches
- Cf. data transmission: (e.g. FTP)
 - loss intolerant but delay tolerant

Challenges in Multimedia Communications

- Transmission of Compressed Multimedia:
 - Real-time communications
 - Delay < 0.4 sec in a video conference
 - Sequencing within the media
 - Synchronization (e.g., between video & audio)
 - Robustness to transmission error
- We will learn how to
 - Transmit multimedia over Internet and wireless network

Internet

- Packet-switched network
- Network resources are shared
- Each packet is handled by a series of routers before being received
- Packets can be discarded if the buffer of a router is full
- All packets are treated the same way in congestion



Error Resilience

- Improve the decoded quality in the presence of lost data
 - Often occurs in wireless networks (and also Internet)
- Add redundancy at encoder
 - Error correction code
 - Layered coding
 - Multiple description coding
- Post-processing at decoder to hide the error
 - Error concealment



Multimedia and Artificial Intelligence(AI)

- Multimedia Generation
 - Text: BERT, GPT-3
 - Image: StyleGAN, BigGAN

