

Introduction to image compression

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Motivation

- ➔ image 1024×768 in „true-color“ format
 - raw: **2.25MB** (**280/CD**), JPEG(50%): **158KB** (**4200/CD**)
- ➔ fax transfer - one A4 page in 200dpi
 - raw: **3.87Mb** (**5.8min** by 14.4kBd), compr.: **193Kb** (**17sec**)
- ➔ video on CD - 30fps, 720×480 („full-motion“)
 - raw: **20.736MBps** (**31sec/CD**), compr.: **74min/CD** in VHS quality



Applications

- ➔ **image archives** (hard-disk, tape, CD)
 - art, astronomical and satellite images, X-ray and CT files, ...
- ➔ **remote data transfer** (Internet, fax, modem)
 - on-line archives, BBS, Intranet, videotelephony, videoconferencing, digital and cable TV, CCTV..
- ➔ **digital (multi)media** (hard-disk, CD)
 - fast and smooth video replay (including sound), digital cinema, 3D TV, 3D cinema, IMAX



Video-compression

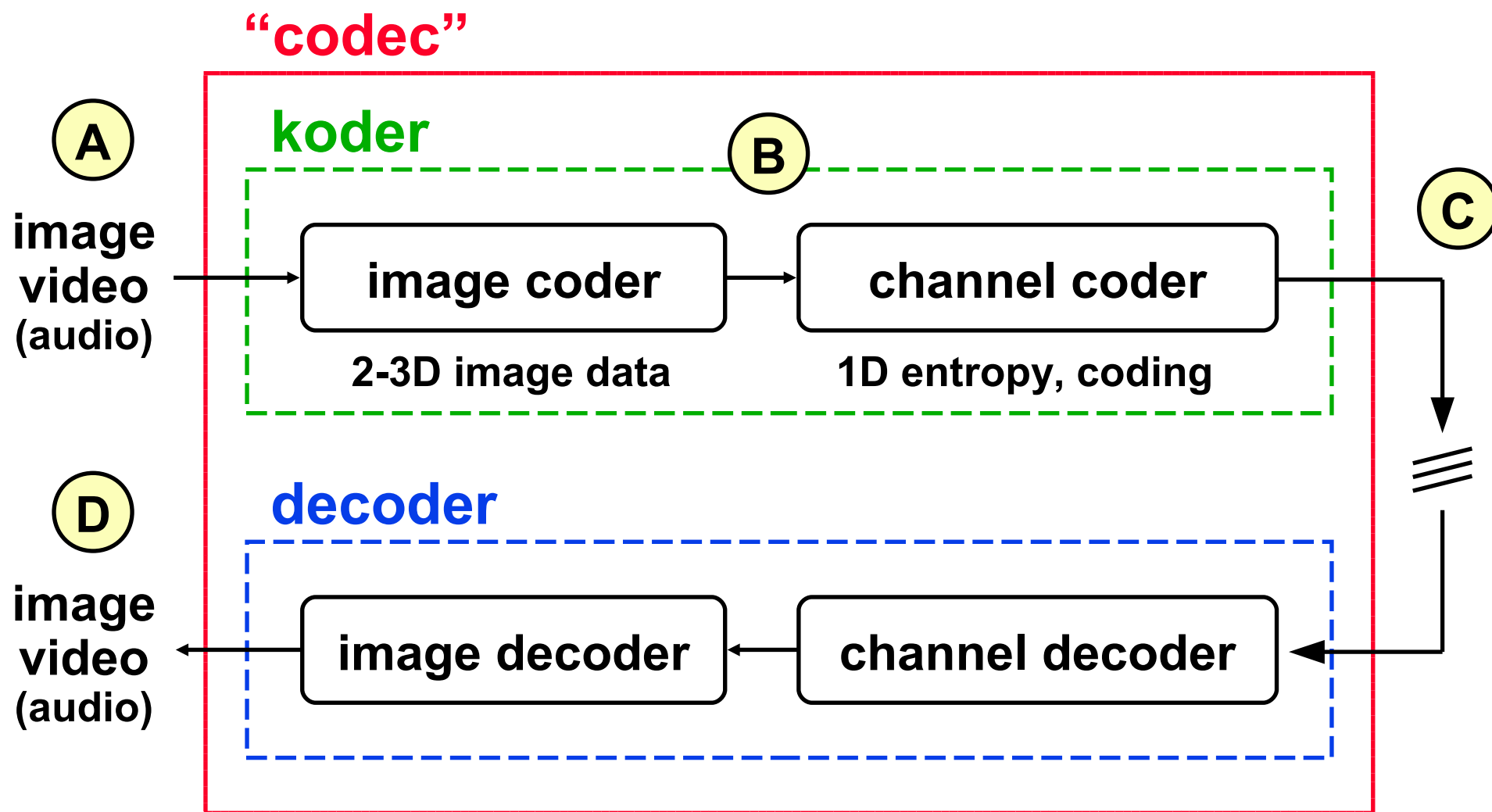
- ➔ video-conferencing, -telephony: 15fps, 352×240, 8bit
 - raw: **30.4Mbps**, H.261: **64-768Kbps** (40-475 : 1)
- ➔ video on CD: 30fps, 352×240, 8bit
 - raw: **60.8Mbps**, CD-I: **1.5-4Mbps** (15-40 : 1)
- ➔ digital TV broadcasting: 30fps, 720×480, 8bit
 - raw: **243.8Mbps**, MPEG-2: **3-8Mbps** (30-80 : 1)
- ➔ HDTV [early years]: 60fps, 1280×720, 8bit
 - raw: **1.33Gbps**, MPEG-2: **20Mbps** (66 : 1)

Sources of efficient compression

- 1 **big redundancy** of image data
 - spatial correlation: neighbor pixels are not independent
 - spectral correlation: parallel image bands (channels) carry similar information (RGB, satellite images)
 - temporal correlation: similarity of successive video frames
- 2 only part of the information is actually **important for human visual perception** (still image or video)
- 3 some visual data have more complex **properties redundant in space and time** (fractal structure, hierarchy, ..)



General compression scheme





Basic attributes

- ➔ **compression ratio**
 - data size ratio (bit-stream) in **A** and **C**
- ➔ **reconstruction quality (D with respect to A)**
 - losless/lossy compression, signal-to-noise ratio, ...
- ➔ **implementation complexity, transfer speed**
 - pps, fps, MIPS (sw), MOPS (hw), power consumpt. (mW)
 - asymmetric applications (CD-I): decompression speed
- ➔ **transfer latency (D with respect to A)**
 - on-line applications: e.g. max. 150ms in video-telephony



Genealogy

- ① methods focusing on the **2nd phase of compression**
B-C (entropy coding, channel coding)
 - PCM, transform, predictive and interpolating methods, RLE, LZW, ..
 - max. 10 : 1 for a single image

- ② methods focusing on the **1st phase of compression**
A-B (2-3D data coding, physiology of human eye)
 - local operators, image regions and contours, textural and frequency analysis, block-transform transform methods
 - up to 100 : 1 for a single image



Typology

- ① algorithms based on **data modeling**
 - [linear] prediction, AR, ARMA, polynomial compression, fractal compression, segmentation-based approaches
- ② **loseless** methods based on image **waveform**
 - statistical methods: Gilbert, Fano, Huffman, ..
 - universal methods: arithmetic coding, LZ-methods, pattern-searching (VPIC), ..
- ③ **lossy** methods based on image **waveform**
 - space, time: delta modulation, (D)PCM, vector quantiz., ..
 - spectrum: band methods, wavelets, block transforms

More properties of compression



- ◆ **compression-ratio variability / adaptivity**
 - static (user-defined) or dynamic adaptation to output channel bandwidth
- ◆ **pre-defined reconstruction quality**
 - subjective quality!, e.g. JPEG1 standard
- ◆ **low sensitivity to channel errors**
 - network applications: videotelephony, videoconferencing, TV broadcast
- ◆ **quality for iterated recoding**
 - lossy compression: errors should not grow

More properties of compression



- ◆ **progressive encoding/decoding (interlacing), „multi-resolution”**
 - remote image databases, slow landline, Internet
- ◆ **random access to video file, backward replay, video-cut-friendly compression**
 - can be a bit slower but has to be possible
- ◆ **video-audio synchronization**
 - MPEG-x, QuickTime
- ◆ **feasible/affordable HW implementation**
 - J/MPEG chips, special chips for DCT & motion compens.



The End

More information:

**A. Jain: *Image Data Compression: A Review*,
Proceedings of the IEEE, vol.73, #3, 1981**

**V. Bhaskaran, K. Konstantinides: *Image and Video
Compression Standards, Algorithms and
Architectures*, Kluwer Academic Publishers,
Boston 1995**