Image and Video Compression
EE368b

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Fall 2000/01

Introduction

- A brief history of (electronic) image communication
  - Invention of photography and cinema
  - Invention of television
  - Introduction of television broadcasting
- Current technological challenges
- Technological key problems
- What will be covered in this course?
- Organisation
Perspective Projection

Perspective Projection II
Photography and Cinema

1840  Louis J. M. Daguerre, France
William Henry Fox Talbot, USA
photographic film

1895  First public motion picture presentation
Lumière brothers, France

End 1920s  Sound motion pictures: „talkies“

1930s  Color movies

Nipkow Disk I

Transmitter  Nipkow disk  Receiver

photodetector  transmission line  amplifier
lens  amplifier  area light source
motor  viewing window  motor
observer
Nipkow Disk II

British TV pioneer J.L. Baird with Nipkow disk (around 1926)

Image Transmission by Line Scanning

\[ B_s(x,y) \rightarrow i(t) \rightarrow B_e(x,y) \]

\[ OE \rightarrow \text{time } t \rightarrow E0 \]
Cathode Ray Tube (Braun)

History of Electronic Image Communication I

1920s 
First television experiments

1930-32 
First experimental television broadcasting 
(New York City)

1935 
First German television broadcasting in Berlin

TV transmission during the Berlin summer olympics 1936 using an iconoscope camera
History of Electronic Image Communication II

1939  Regular monochrome TV service in the US
19__  First regular TV service in ________
1952  First regular TV service in Germany
1954  Introduction of NTSC color television in US
19__  Introduction of _____ color television in ___
1967  PAL color television in Germany
1970s Consumer video cassette recorder (VCR)
late 70s Fax machines
1980s Digital TV studios (ITU-R Rec. 601)

Recent Developments: 1990s

- JPEG and MPEG standards
- Digital still cameras
- Digital TV broadcasting
- Digital video/versatile disk (DVD)
- Integration of computers and video
- World Wide Web
- Internet video streaming

*Each “recent development” depends on efficient compression of images or video!*
Motivating Image Compression

- Binary image (fax)
  - 8.5 x 11 in document scanned at 7.7 lines/mm with 1 bit/pixel
  - 4.1 Mbits for 1 page = 7 minutes over 9600 baud connection
- Photos on 35 mm film
  - Scanned at 12µ resolution (3656x2664 pixels) with 8 bits per color and 3 colors
  - 233 Mbits for 1 photo, 2/3 of 48 Mbyte compact flash card

Motivating Video Compression

- Digital video studio standard ITU-R Rec. 601

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<tr>
<th></th>
<th>Y</th>
<th>Cr</th>
<th>Cb</th>
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<tr>
<td>Sampling</td>
<td>13.5 MHz</td>
<td>6.75 MHz</td>
<td>6.75 MHz</td>
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<tr>
<td>Quantization</td>
<td>8 bit</td>
<td>8 bit</td>
<td>8 bit</td>
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<tr>
<td>Raw bit rate</td>
<td><strong>216 Mbps</strong></td>
<td></td>
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<tr>
<td>W/o blanking intervals</td>
<td><strong>166 Mbps</strong></td>
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- Some interesting bit-rates
  - Terrestrial TV broadcasting channel ~20 Mbps
  - Computer hard disk 20...40 Mbps
  - DVD (max. 17 GB/length of movie) 10...20 Mbps
  - Ethernet/Fast Ethernet <10/100 Mbps
  - DSL downlink 384...2048 kbps
  - V.34 modem 28.8 kbps
  - Wireless cellular data 9.6...112 kbps
Outline EE368b

- Some fundamental results of information theory
- Scalar quantization and vector quantization
- Human visual perception
- Predictive coding
- Transform coding
- Resolution pyramids and subband coding
- Interframe coding
- Motion estimation
- Motion compensated coding
- Coding standards JPEG, H.261, H.263 and MPEG

Prerequisites EE368b

- Required
  - Signals and systems, e.g., EE261
  - Statistical signal processing, e.g., EE278
- NOT required
  - Information theory, will be reviewed in class
  - EE368a (Digital Image Processing)
EE368b Organisation

- Regularly check class home page:
  
  \[ \text{http://www.stanford.edu/class/ee368b} \]

- Mailing list:
  
  \[ \text{Send mail to majordomo@lists.stanford.edu} \]
  
  \[ \text{subscribe ee368b} \]

- Assistants
  
  - General TA: Markus Flierl
  - ISE lab TA: Sung-Won Yoon
  - Course assistant: Kelly Yilmaz

EE368b Organisation (cont.)

- Homeworks
  
  - 3-4 problem sets, require computer + Matlab
  - Term project
  - Individually or in groups, 40-50 hours per person
  - Project approval required, deadline: October 31
  - Class-room presentations of projects: Dec. 1-8
  - Web submission of project report: deadline Dec. 1, \textbf{no extensions}!

- Grading
  
  - Homeworks: 25%
  - Mid-term: 25%
  - Term project: 50%
  - No final.
ISEP laboratory

- Created by an equipment grant from Hewlett-Packard Corporation and Xerox Corporation.
- Exclusively a teaching laboratory
- Location: Packard room 066
- 11 HP Workstations, 2 PCs, scanners, printers etc.
- Access:
  - door combination for lab entry will be provided to subscribers to ee368b mailing list
  - Stanford ID chip card for after-hour entry of Packard building
  - Account on ise machine will be provided to subscribers to ee368 mailing list

Further reading

- Slides available as hand-outs and as pdf files on the web
- Reference books on image and video compression
  - W. Pennebaker, J. Mitchell, "JPEG Still Image Data Compression Standard", Van Nostrand Reinhold, New York, 1990. THE source to read about JPEG, but also a nice presentation of basic material you need to understand the rationale behind it.
  - B. Haskell, A. Puri, A. Netravali, "Digital Video: An Introduction to MPEG-2," Chapman & Hall, New York, 1994. Comprehensive coverage of MPEG-2 and also includes a chapter about MPEG-4. Some sections from Netravali & Haskell's "Digital Pictures" are included to provide background.

Fundamental books that are not image/video specific:

- N. S. Jayant, P. Noll, "Digital Coding of Waveforms," Prentice-Hall, 1984. In-depth coverage of algorithms for digital source coding, with emphasis on principles. Specific applications mostly to speech, but also to image. Scalar quantization, predictive coding, subband coding, transform coding. 15 years old, but nonetheless a valuable addition to the source coder’s library.