Image and Video Compression
EE368b

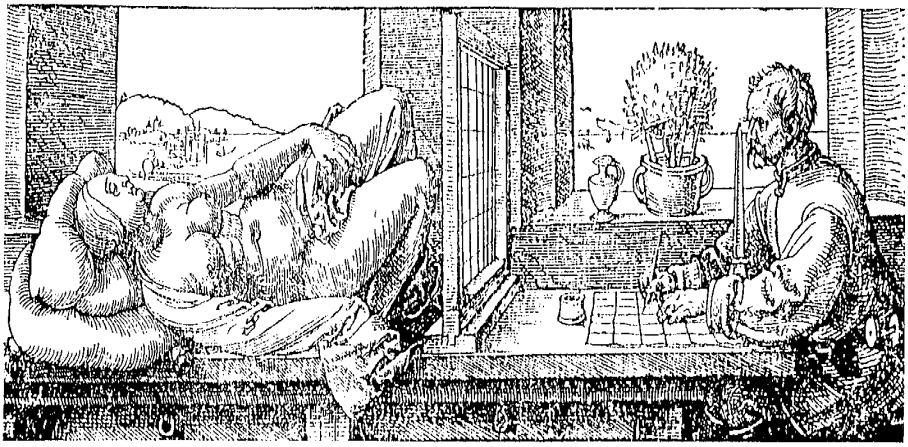
Bernd Girod
Information Systems Laboratory
Department of Electrical Engineering
Stanford University

Fall 2000/01

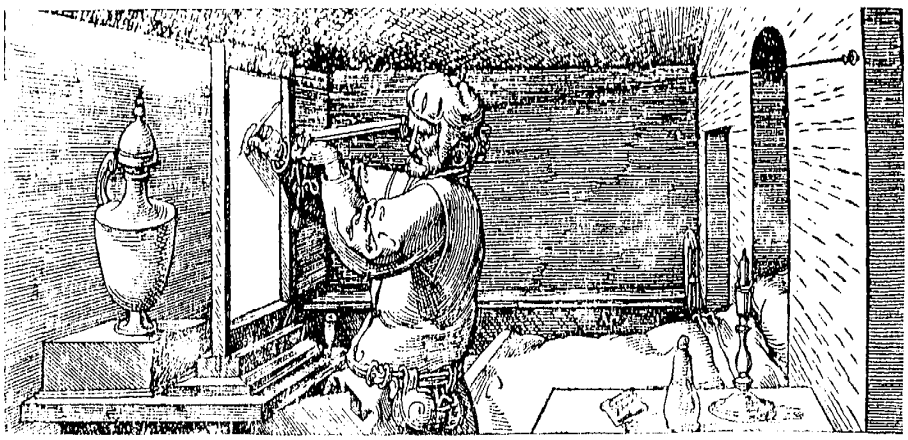
Introduction

- 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



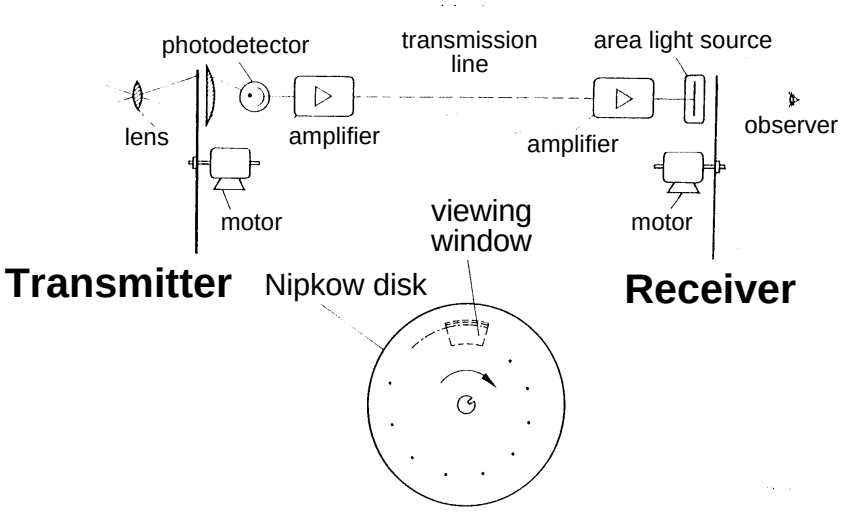
Perspective Projection II



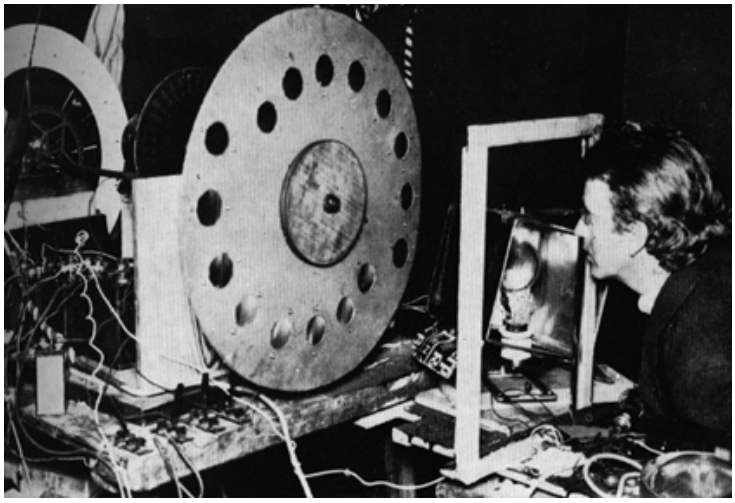
Photography and Cinema

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

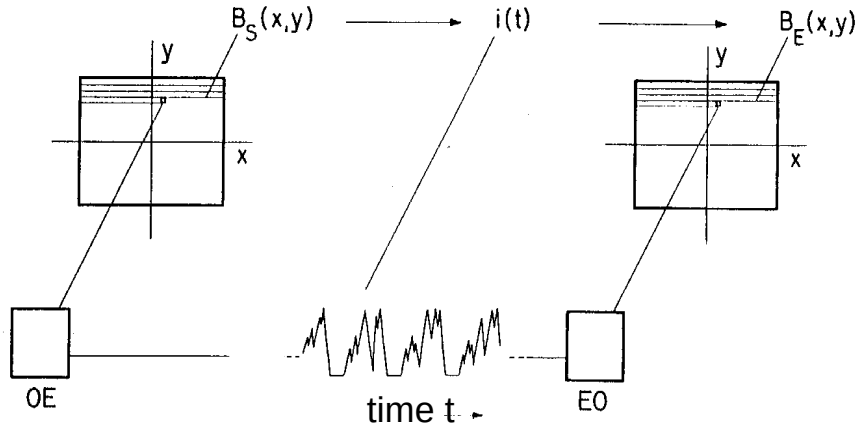


Nipkow Disk II



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

Image Transmission by Line Scanning



Cathode Ray Tube (Braun)

12. *Ueber ein Verfahren zur Demonstration und zum Studium des zeitlichen Verlaufes variabler Ströme; von Ferdinand Braun.*

1. Die im Folgenden beschriebene Methode benutzt die Ablenkbarkeit der Kathodenstrahlen durch magnetische Kräfte. Diese Strahlen wurden in Röhren erzeugt, von deren einer ich die Maasse angebe, da mir diese die im allgemeinen günstigsten zu sein scheinen (Fig. 1). *K* ist die Kathode aus Aluminiumblech, *A* Anode, *C* ein Aluminiumdiaphragma; Oeffnung des Loches = 2 mm. *D* ein mit phosphorescirender Farbe überzogener Glimmerschirm. Die Glaswand *E* muss möglichst gleichmässig und ohne Knoten, der phosphorescirende Schirm

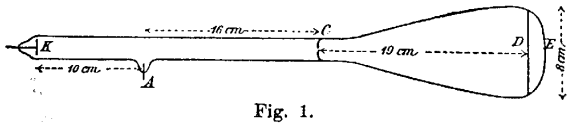
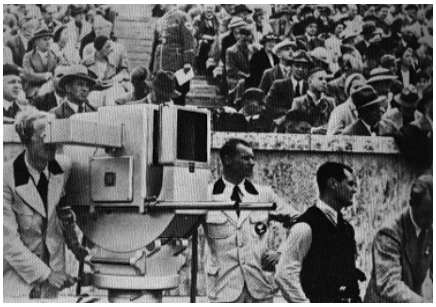


Fig. 1.

History of Electronic Image Communication I

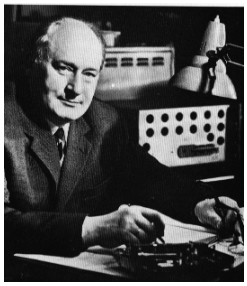
1920s	First television experiments
1930-32	First experimental television broadcasting (New York City)
1935	First German television broadcasting in Berlin



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)



Dr.-Ing. h.c. Walter Bruch, inventor of the PAL system

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

	Y	Cr	Cb
Sampling rate	13.5 MHz	6.75 MHz	6.75 MHz
Quantization	8 bit	8 bit	8 bit
Raw bit rate		**216 Mbps**	
W/o blanking intervals		**166 Mbps**	

- Some interesting bit-rates
  - Terrestial 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:

  http://www.stanford.edu/class/ee368b

- Mailing list:

  Send mail to majordomo@lists.stanford.edu

  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, **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
  - A. N. Netravali, B.G. Haskell, "Digital Pictures - Representation and Compression", 2nd edit., New York, London: Plenum Press, 1995. *Comprehensive standard book covering television standards and digital image compression. Has been augmented compared to the 1st edition from 1988, particularly to discuss the more recent standards, the greater part of the book, however, reflects the state-of-the-art of the mid-80s. Nevertheless, a must-have for image system engineers.*
  - W. Pennebaker, J. Mitchell, "JPEG Still Image Data Compression Standard", Van Nostrand Reinhold, New York, 1993. *THE source to read about JPEG, but also a nice presentation of basic material you need to understand the rationale behind it.*
  - J. Mitchell, W. Pennebaker, C. Fogg, D. LeGall, "MPEG Video Compression Standard," Chapman & Hall, New York, 1996. *Discusses MPEG-2 in detail, and some of the source coding principles, but those rather briefly. A book for practicioners.*
  - B. Haskell, A. Puri, A. Netravali, "Digital Video: An Introduction to MPEG-2," Chapman & Hall, New York, 1996.*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.*
  - V. Bhaskaran, K. Konstantinides, "Image and Video Compression Standards," Kluwer Academic Publishers, 1995. *Introduction to standards JPEG, MPEG-1 and MPEG-2, H.261. Emphasizes the foundations of the standards, rather than details. Predictive coding, transform coding, motion estimation and compensation, entropy coding.*
  - A. K. Jain, "Fundamentals of Digital Image Processing", Prentice-Hall, 1989. *Very readable and sound book that is popular as a text book for image processing classes. A lot of image processing material beyond compression.*
- Fundamental books that are not image/video specific:
  - A. Gersho and R.M. Gray, "Vector Quantization and Signal Compression," Kluwer Academic Press, 1992. *Principles and algorithms for digital source coding, with applications to images, speech, and audio. The most comprehensive and substantial source coding reference, but very readable nevertheless. State-of-the-art.*
  - 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 nevertheless a valuable addition to the source coder's library.*