

Digital Image Communication

Thomas Wiegand

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Picture: "Hotel", 720x576, 414,720 Byte



from: Blättermann



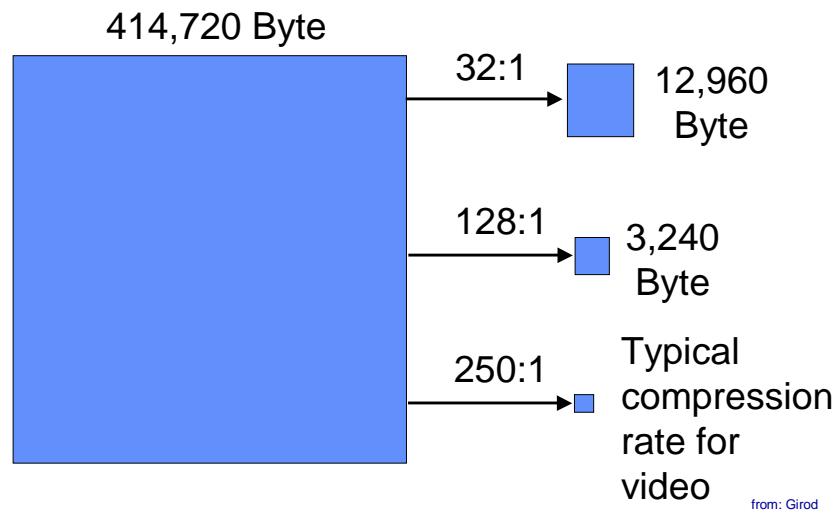
JPEG-2000 Compressed to 12,960 Byte



JPEG-2000 Compressed to 3,240 Byte



Geometric Interpretation



Nipkow Disk

Paul Nipkow: "Elektrisches Teleskop",
German Patent 1884.

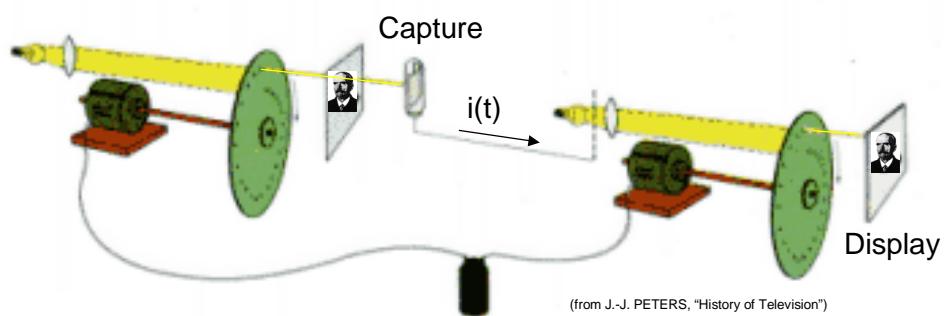
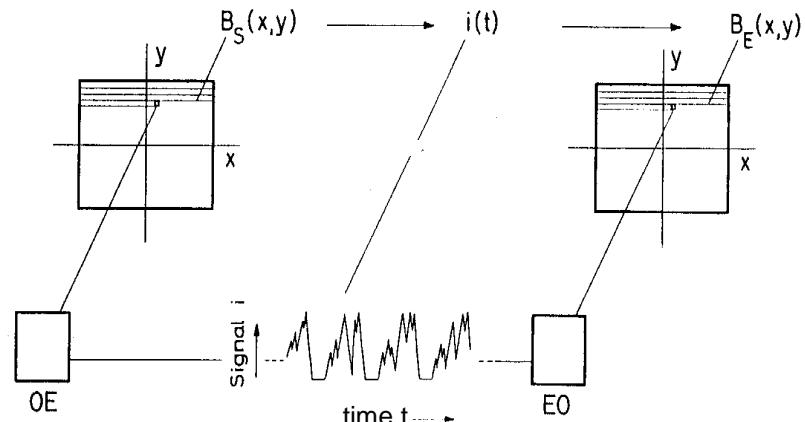


Image Transmission by Line Scanning



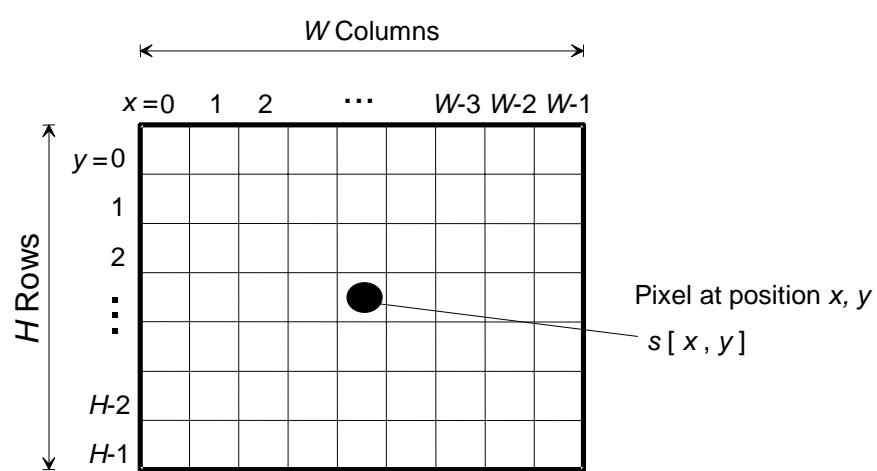
from: Theile



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The Image Matrix



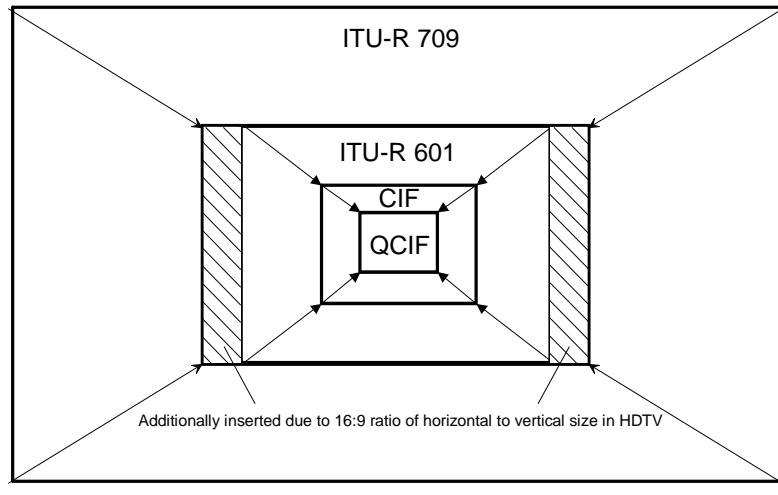
from: Ohm



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Digital Image Formats I



from: Ohm



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Digital Image Formats II

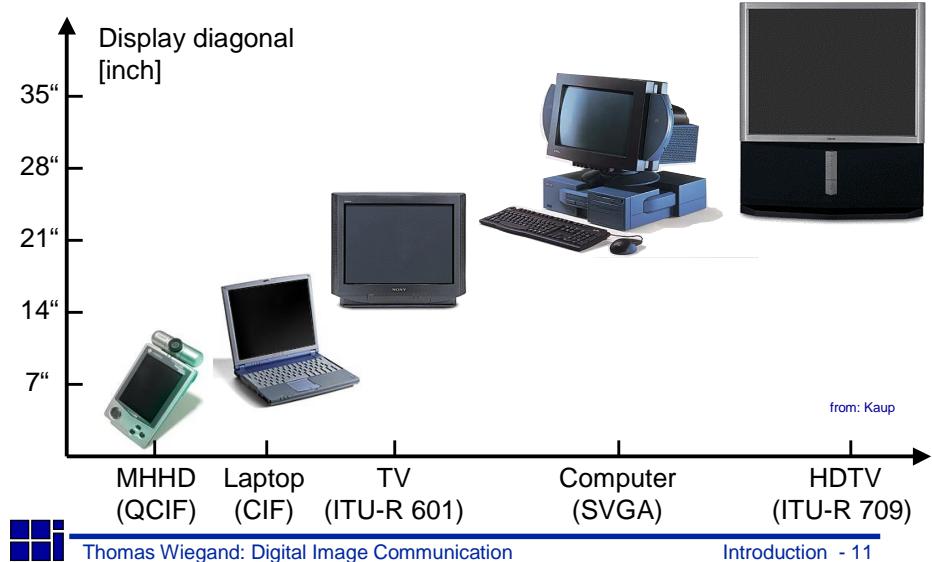
| | QCIF | CIF | ITU-R 601 | ITU-R 709 |
|--|---------------|----------------|---------------|---------------|
| Pixel / row (Y) | 176 | 352 | 720 | 1920 |
| Number of rows (Y) | 144 | 288 | 576 (480) | 1080 |
| Pixel / row (U,V) | 88 | 176 | 360 | 960 |
| Number of rows (U,V) | 72 | 144 | 576 (480) | 1080 |
| Aspect ratio | 4:3 | 4:3 | 4:3 | 16:9 |
| Pictures per second [Hz] | 5-15 | 10-30 | 25 (30) | 25 (30) |
| Bits per picture [kbyte] bei 8Bit-PCM | 38,02 | 152,1 | 829,4 (691,2) | 4.424 (3.686) |
| Bit-rate for image sequence [Mb/s] | 0,84 - 3,8 | 10,1 - 30,4 | 165,9 | 884,7 |



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Digital Image Formats and Applications



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Examples for Storage Media

| Media | Capacity | Number of pictures that can be stored in uncompressed format | | | |
|-------------|-------------|--|-------|----------|----------|
| | | QCIF | CIF | CCIR-601 | CCIR-709 |
| Floppy Disk | 1.44 Mbyte | 37.8 | 9.5 | 1.7 | 0.3 |
| Zip Disk | 100 Mbyte | 2623 | 659 | 118 | 21 |
| Jaz Disk | 1 Gbyte | 26230 | 6590 | 1180 | 210 |
| CD-ROM | 650 Mbyte | 17050 | 4283 | 767 | 136 |
| DVD | 4.7 Gbyte | 123281 | 30973 | 5546 | 987 |
| Flash | 1-100 Mbyte | 26-2623 | 7-659 | 1-118 | 0.2-21 |

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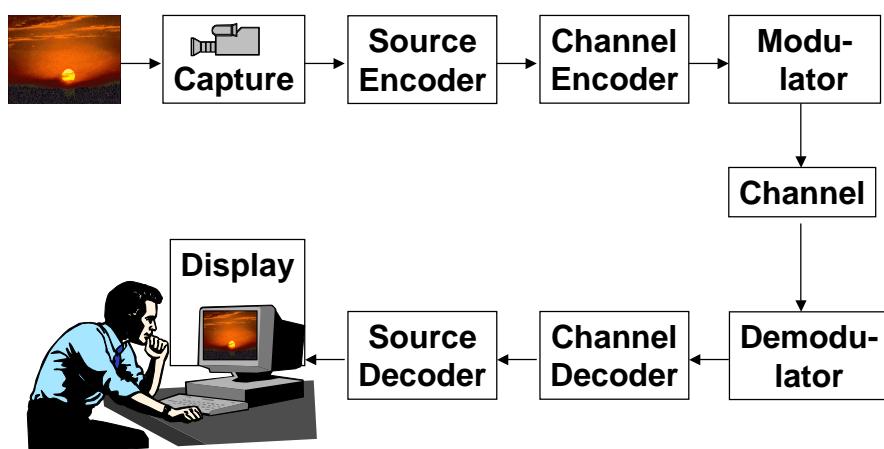
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Examples for Transmission Media

| Media | Bit-Rate | Number of pictures that can be transmitted per second in uncompressed format | | | |
|--------------|------------|--|------|----------|----------|
| | | QCIF | CIF | CCIR-601 | CCIR-709 |
| Voice Modem | 33.4 kb/s | 0.11 | 0.03 | 0.005 | 0.001 |
| ISDN | 64 kb/s | 0.21 | 0.05 | 0.010 | 0.002 |
| T1 (24xISDN) | 1.544 Mb/s | 5.1 | 1.3 | 0.2 | 0.04 |
| Ethernet | 10 Mb/s | 32.9 | 8.2 | 1.5 | 0.28 |
| FDDI | 100 Mb/s | 328.7 | 82.2 | 15.1 | 2.83 |
| GSM | 15 kb/s | 0.05 | 0.01 | 0.002 | 0.0004 |
| UMTS | 384 kb/s | 1.3 | 0.32 | 0.06 | 0.01 |



Transmission System



Optimum Scenario

Minimize costs of the complete transmission system, so that the visual information is perceived by the human observer with the desired quality.

Problems:

- Desired accuracy differs for the various applications
- Different applications permit different costs
- Transmission system is interferred by others
- Horizontal integration: design system components seperately (How about storage applications ?)
- How can we measure perceived quality ?



Why Digital Image Communication ?

- Separation of source coding and channel coding allows independent adaptation to the
 - Properties of information source and sink
 - Properties of the transmission channel
- Digital circuitry allows very large scale integration and low manufacturing costs
- Today, signals are stored and transmitted over digital media



The Human Visual System (HVS)

▪ Resolution limits:

- Textures with frequencies higher than the limit of the HVS are not recognizable
- Resolution limits for color are much lower than for luminance
- Resolution limits are higher for horizontal and vertical structures than for diagonal structures
- Still objects are recognized much sharper than moving objects
- Temporal resolution limit of the eye: flicker

▪ Contrast recognition at edges:

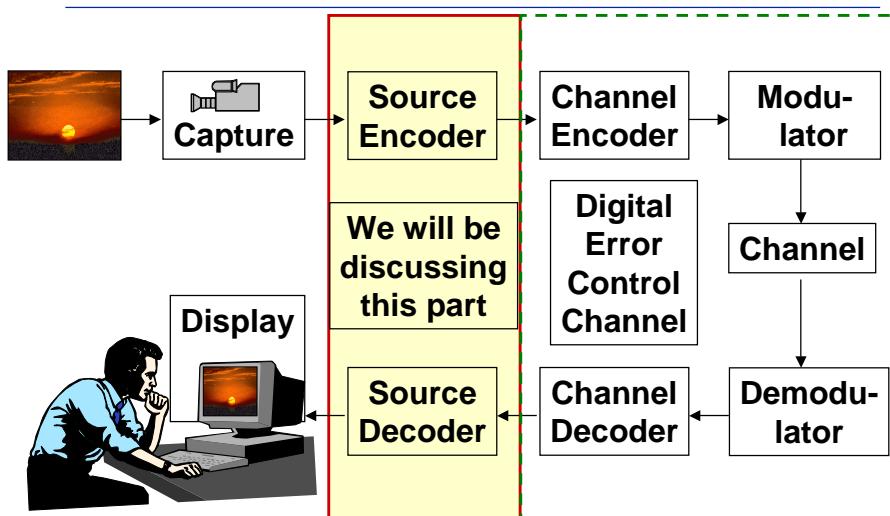
- Contrast changes at edges are enhanced
- The HVS is especially sensitive to edges

▪ Seeing:

- Combining color, motion, and depth into a collection of interferences about the world
- Regions of interest in images and videos (various dependencies)



Scope of this Lecture



Digital Image Communication

- Information and Entropy
- Rate Distortion Theory and Quantization
- Predictive Coding
- Transform Coding
- Resolution Pyramids and Subband Coding
- Image Coding Standards JPEG, JPEG-2000
- Hybrid Video Coding
- Video Transmission
- Video Coding Standards H.261, MPEG-2, H.263, and H.26L
- Video Processing Standards MPEG-4 and MPEG-7
- Laboratory Excursion (HHI)



Organisation

Lecture: Monday 14:15-15:45,
Einsteinufer 25, room FT340

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Copies of transparencies can be downloaded at URL:
<http://bs.hhi.de/~wiegand/DIC.html>



Literature I

Image Processing Basics

- A.K. Jain: "Fundamentals of Digital Image Processing", Prentice-Hall, 1989.
- W. K. Pratt: "Digital Image Processing," New York: Wiley 1978.

Human Visual System

- B. A. Wandell: "Foundations of Vision", Sinauer Associates, Sunderland, 1995.
- G. Hauske: "Systemtheorie der visuellen Wahrnehmung", B. G. Teubner Stuttgart, 1994 (in German).

Information Theory

- C. E. Shannon: "A Mathematical Theory of Communication", Bell System Technical Journal, Vol. 27, pp. 379-423 (Part I), pp. 623-656 (Part II), 1948.
- T. M. Cover and J. A. Thomas: "Elements of Information Theory", John Wiley & Sons, New York, 1991.



Literature II

Rate-Distortion Theory & Quantization

- T. Berger: "Rate Distortion Theory," Prentice-Hall, 1970
- N. S. Jayant and P. Noll: "Digital Coding of Waveforms," Prentice-Hall, 1984
- A. Gersho and R. M. Gray: "Vector Quantization and Signal Compression," Kluwer, 1992

Image Coding

- M. Vetterli and J. Kovacevic: "Wavelets and Subband Coding," Prentice-Hall, 1995
- W. Pennebaker and J. Mitchell: "JPEG Still Image Data Compression Standard", Van Nostrand Reinhold, New York, 1993.
- J.-R. Ohm: "Digitale Bildcodierung", Springer, 1995 (in German).

Journals

- IEEE Transactions on Image Processing
- IEEE Transactions on Circuits and Systems for Video Technology
- IEEE Signal Processing Magazine
- IEEE Communications Magazine

