
Digital Image Communication

Thomas Wiegand

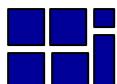
Course at Technical University of Berlin
WS 2000/2001



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



from: Blättermann



JPEG-2000 Compressed to 12,960 Byte

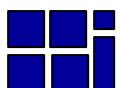
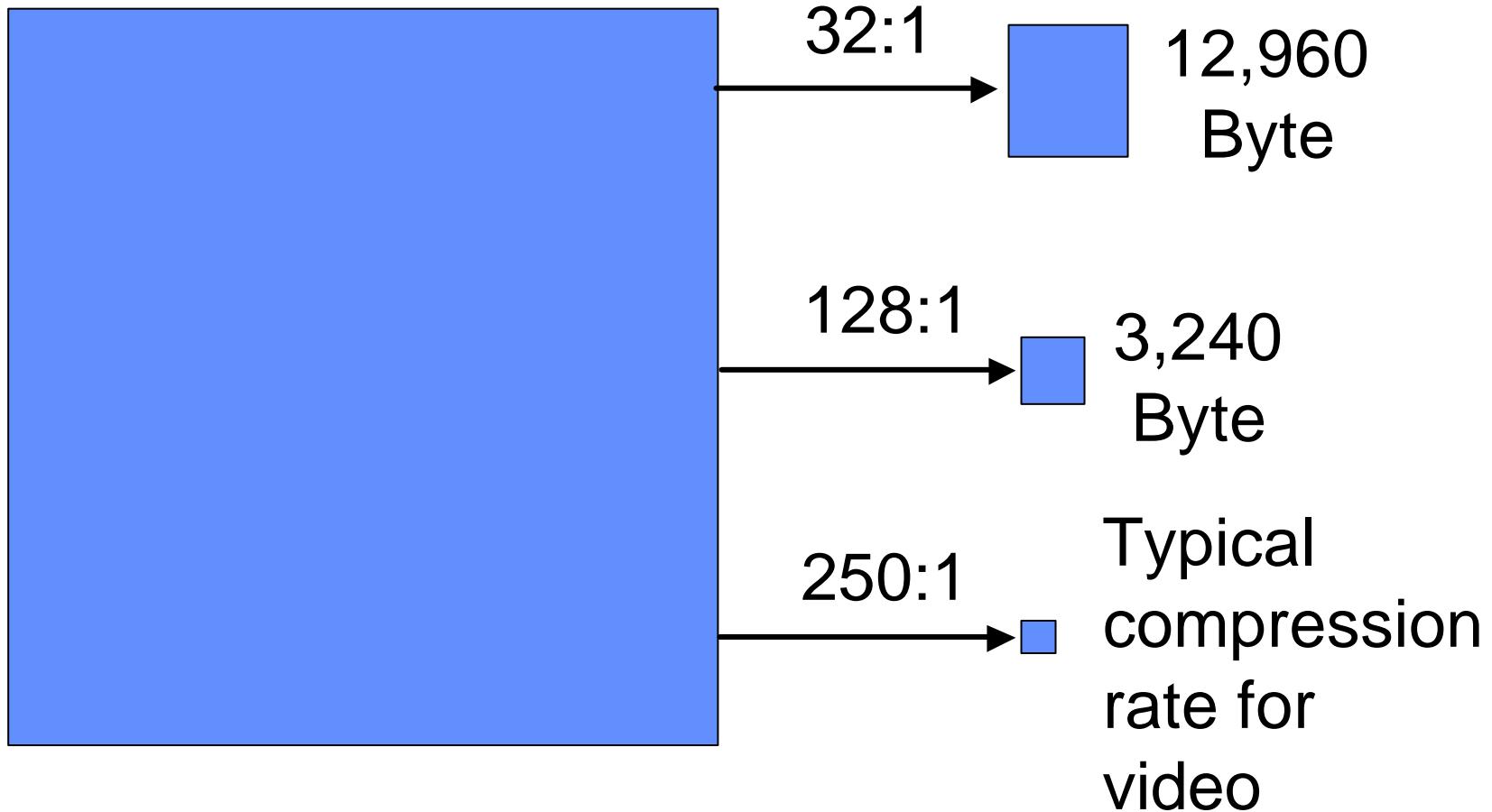


JPEG-2000 Compressed to 3,240 Byte



Geometric Interpretation

414,720 Byte



Nipkow Disk

Paul Nipkow: “Elektrisches Teleskop”,
German Patent 1884.

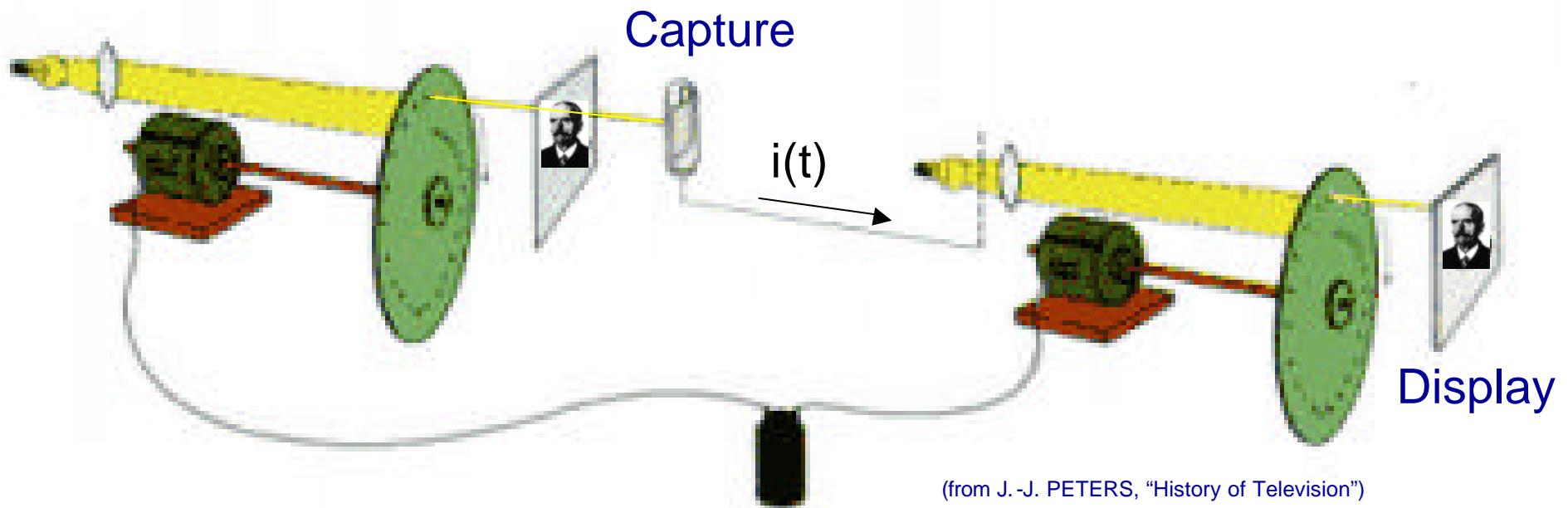
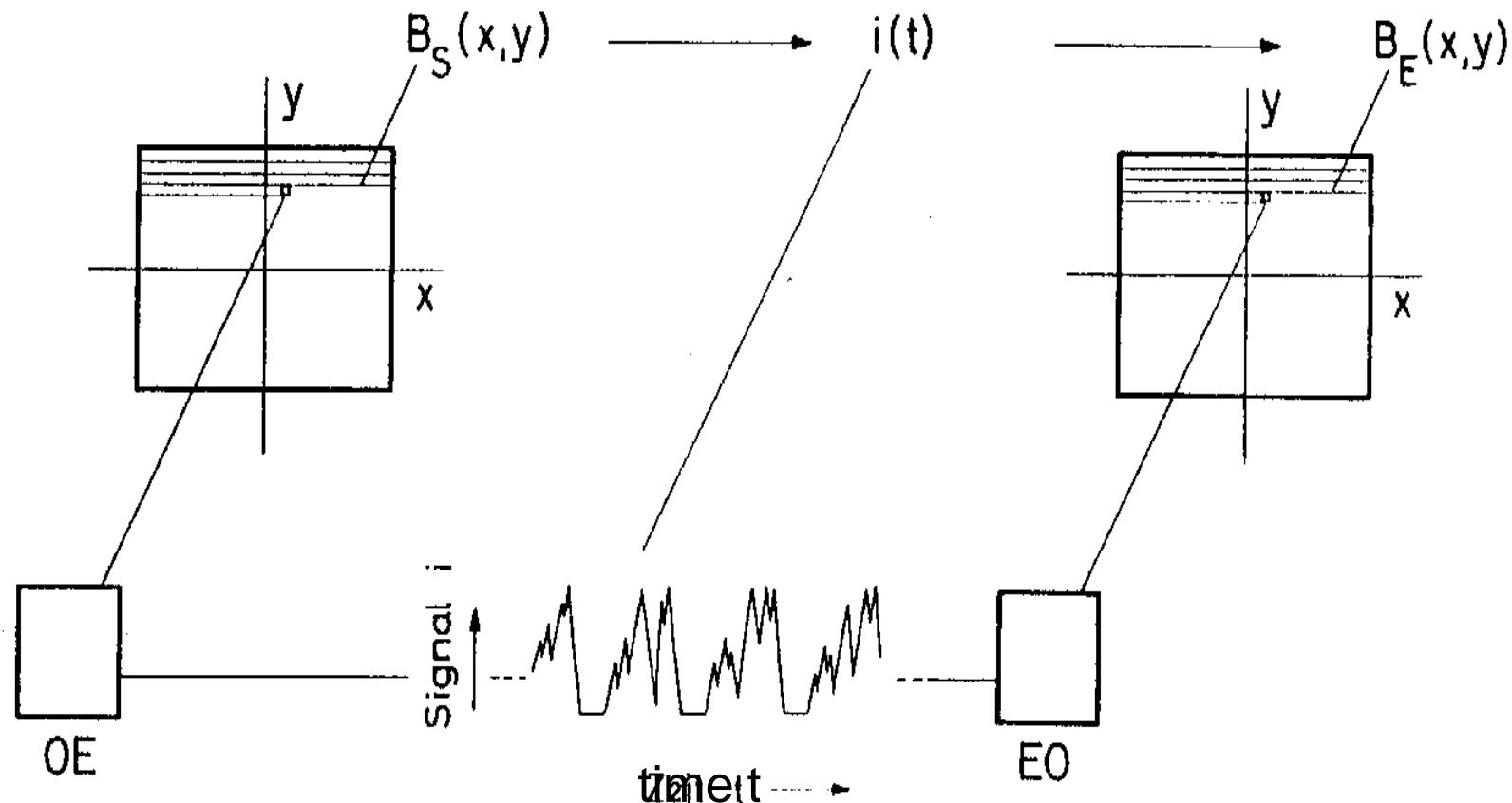
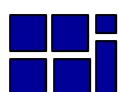


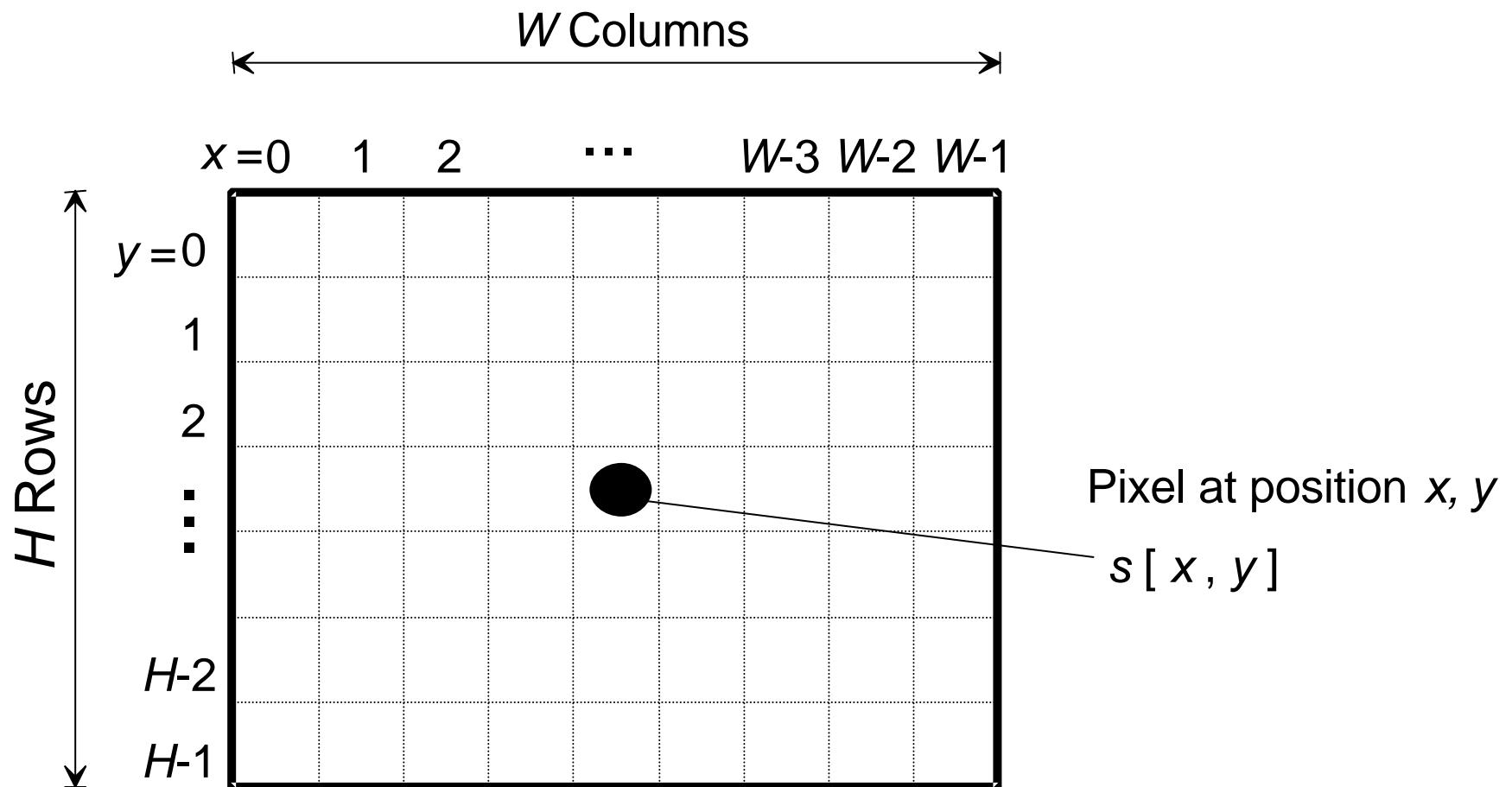
Image Transmission by Line Scanning



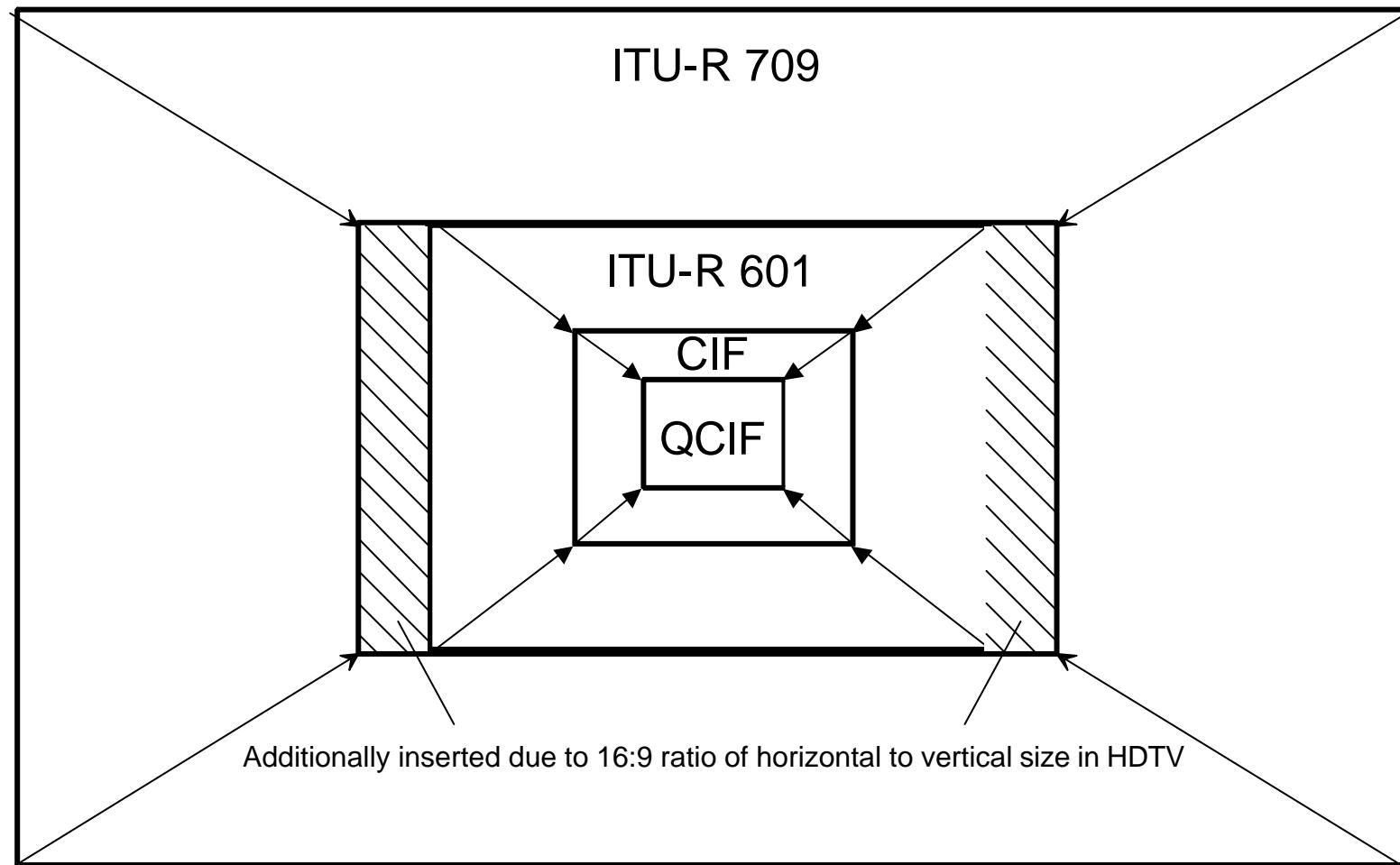
from: Theile



The Image Matrix



Digital Image Formats I



from: Ohm

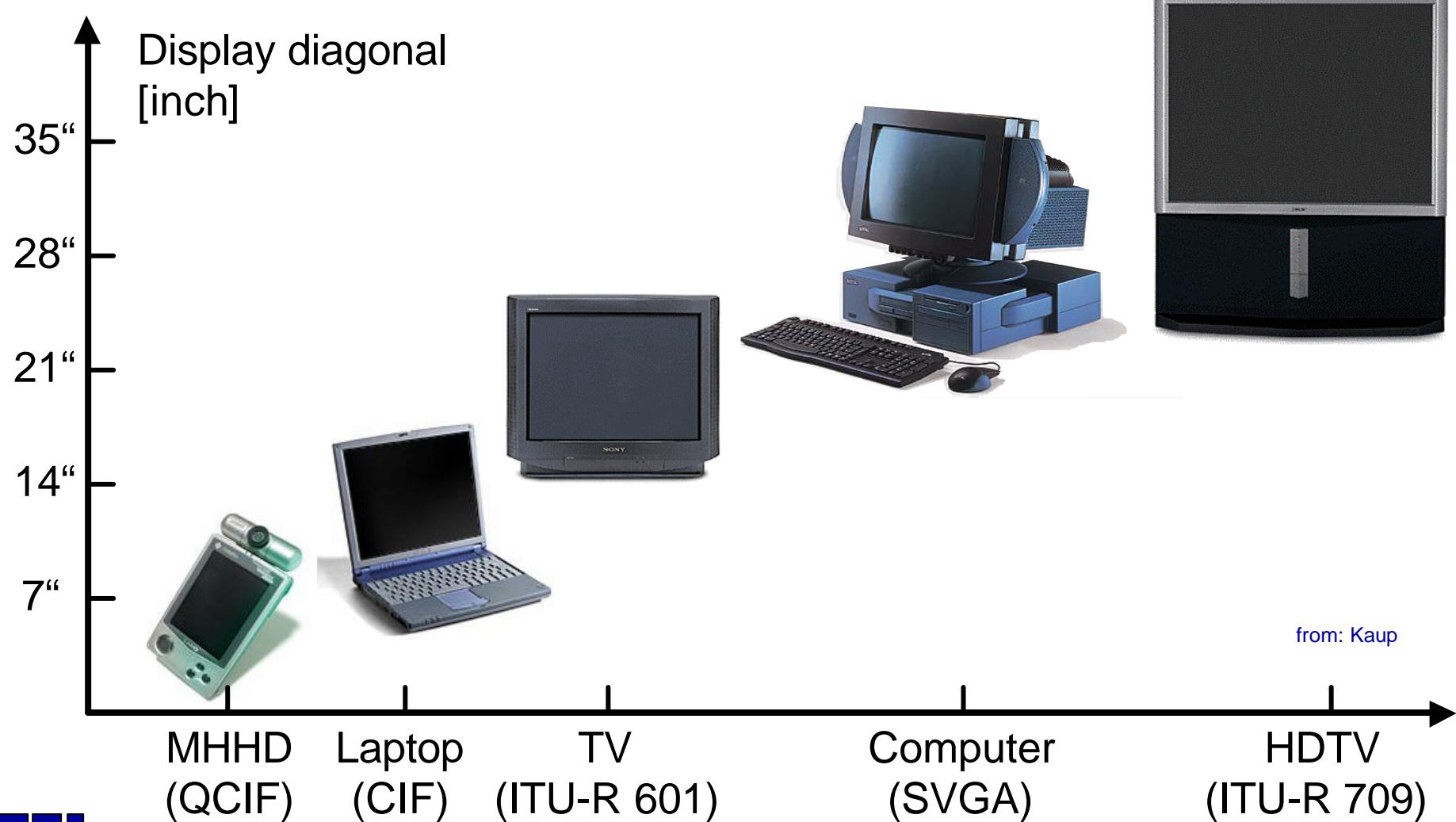


Digital Image Formats II

	<i>QCIF</i>	<i>CIF</i>	<i>ITU-R 601</i>	<i>ITU-R 709</i>
Pixel / row (<i>Y</i>)	176	352	720	1920
Number of rows (<i>Y</i>)	144	288	576 (480)	1080
Pixel / row (<i>U, V</i>)	88	176	360	960
Number of rows (<i>U, V</i>)	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

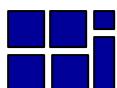


Digital Image Formats and Applications



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

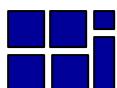
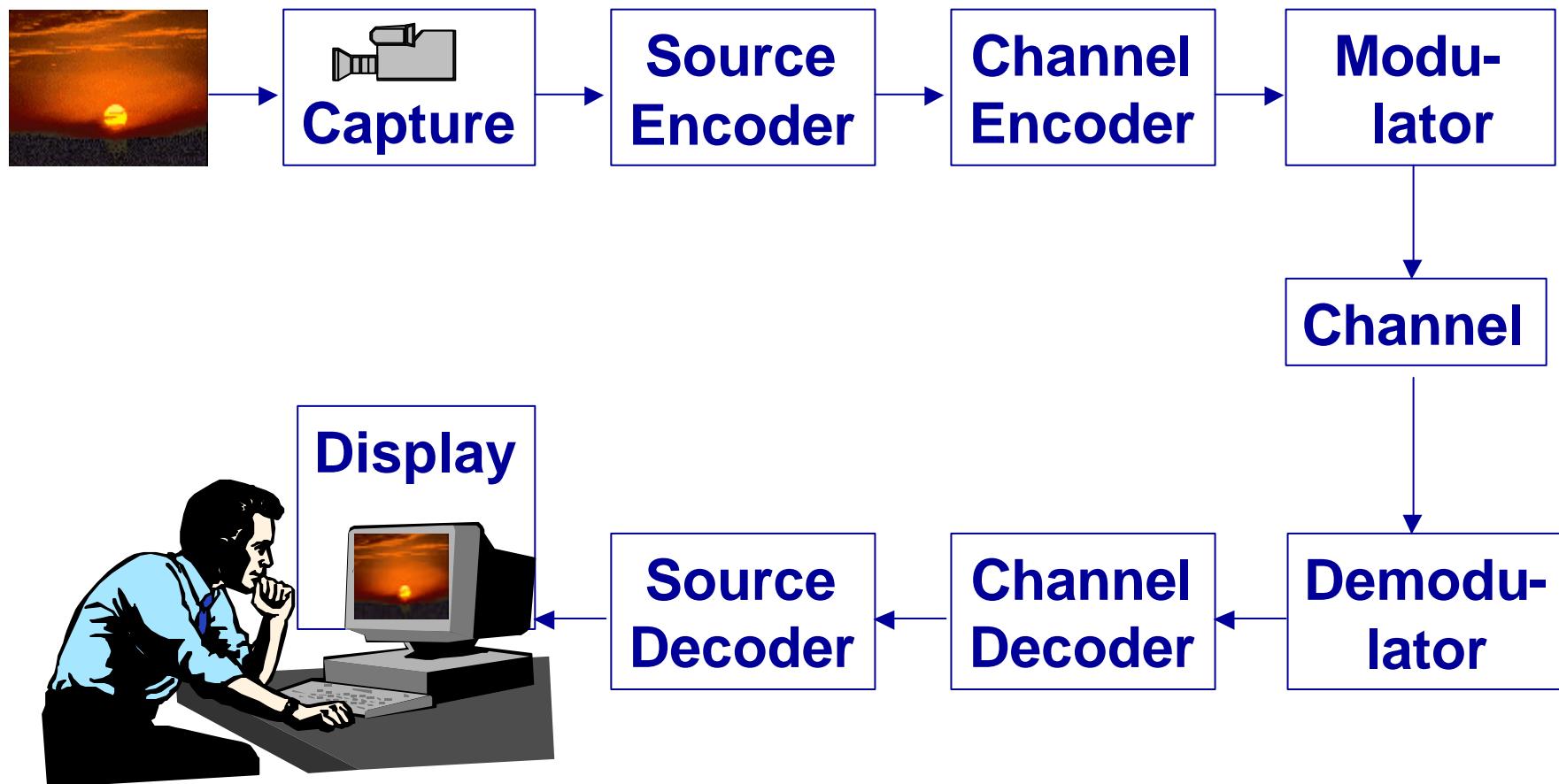


Examples for Transmission Media

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.

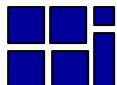
Problems:

- 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 ?



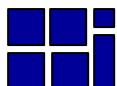
Why Digital Image Communication ?

- 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

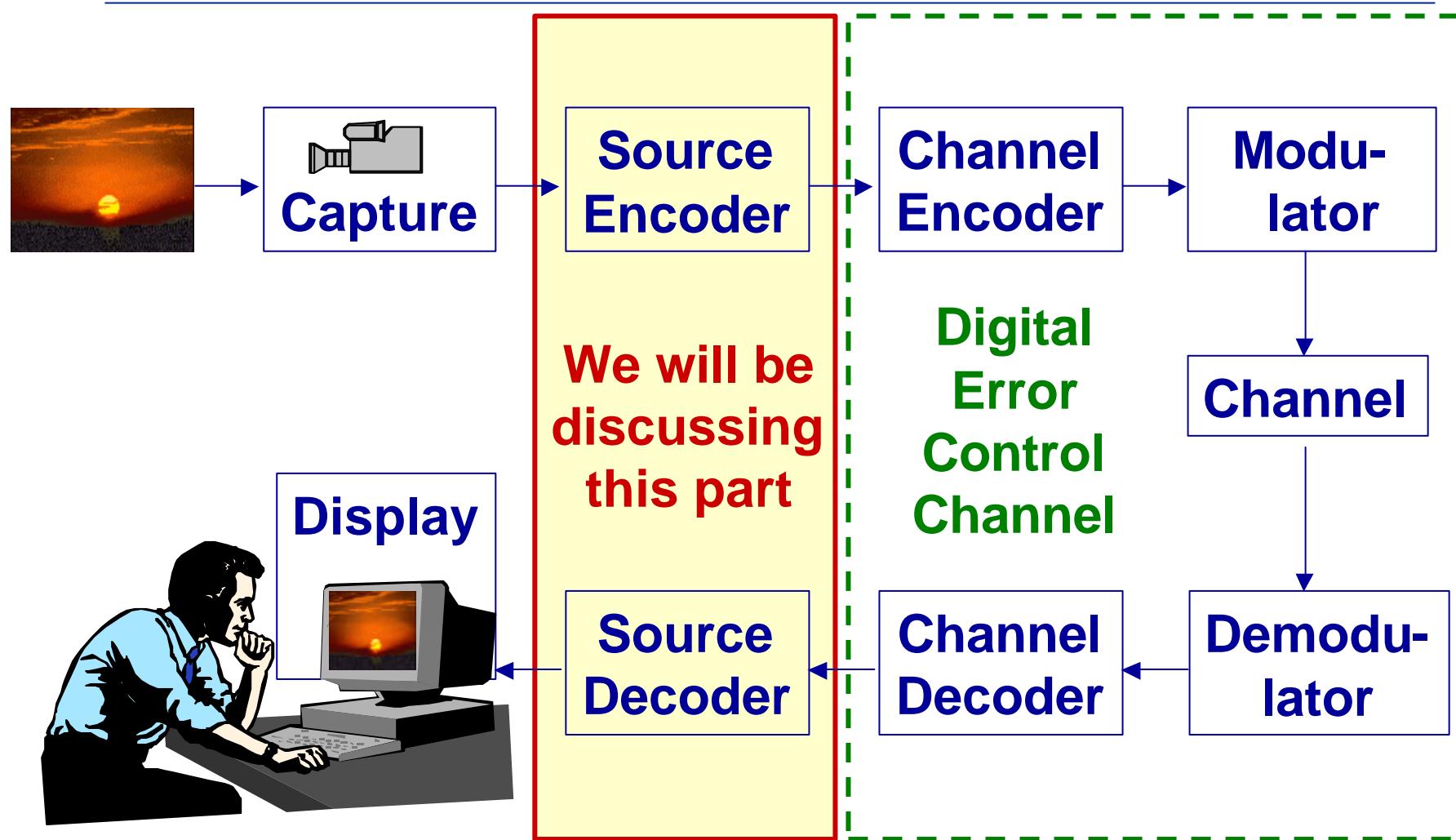


The Human Visual System (HVS)

- 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)

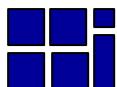


Scope of this Lecture



Digital Image Communication

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

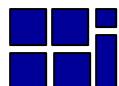


Organisation

Lecture: Monday 14:00-16:00, room EMH25

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



Literature I

Image Processing Basics

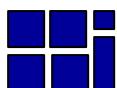
- A.K. Jain, "Fundamentals of Digital Image Processing", Prentice-Hall, 1989.
- W. K. Pratt, "Digital Image Processing," New York: Wiley 1978.

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, 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, P. Noll : "Digital Coding of Waveforms," Prentice-Hall, 1984
- A. Gersho, R. M. Gray : "Vector Quantization and Signal Compression," Kluwer, 1992

Image Coding

- Vetterli, J. Kovacevic : "Wavelets and Subband Coding," Prentice-Hall, 1995
- W. Pennebaker, 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

