Image Processing

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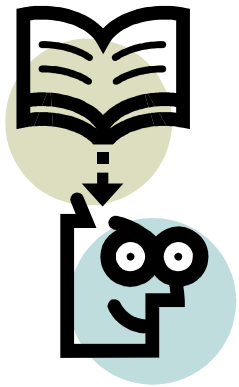
"One picture is worth more than ten thousand words"

Anonymous

Literature:

1. Lecture notes (*.pdf files)
   www.eletel.p.lodz.pl
2. R.C. **Gonzales**, R. E. **Woods**, Digital image processing, Addison-Wesley Publishing Company, 1992.
3. J. C. **Russ**, The image processing handbook, IEEE Press,1995.
4. W. K. **Pratt**, Digital image processing, John Wiley &Sons, 1991.
5. A. **Materka,** Elements of image processing (in Polish), PWN, 1991.

Assesment method:



Theory:

- written examination (50%).

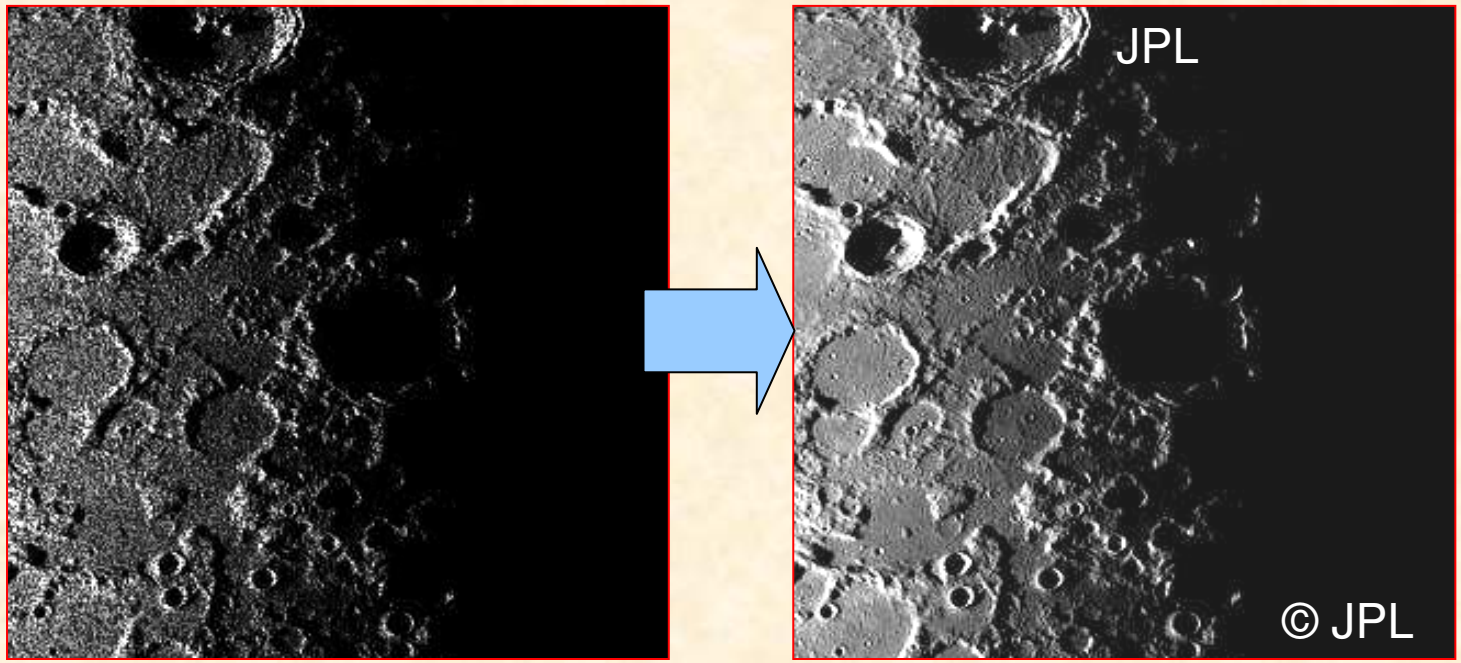
Practice:

- project report and presentation (50%)

Image processing objectives

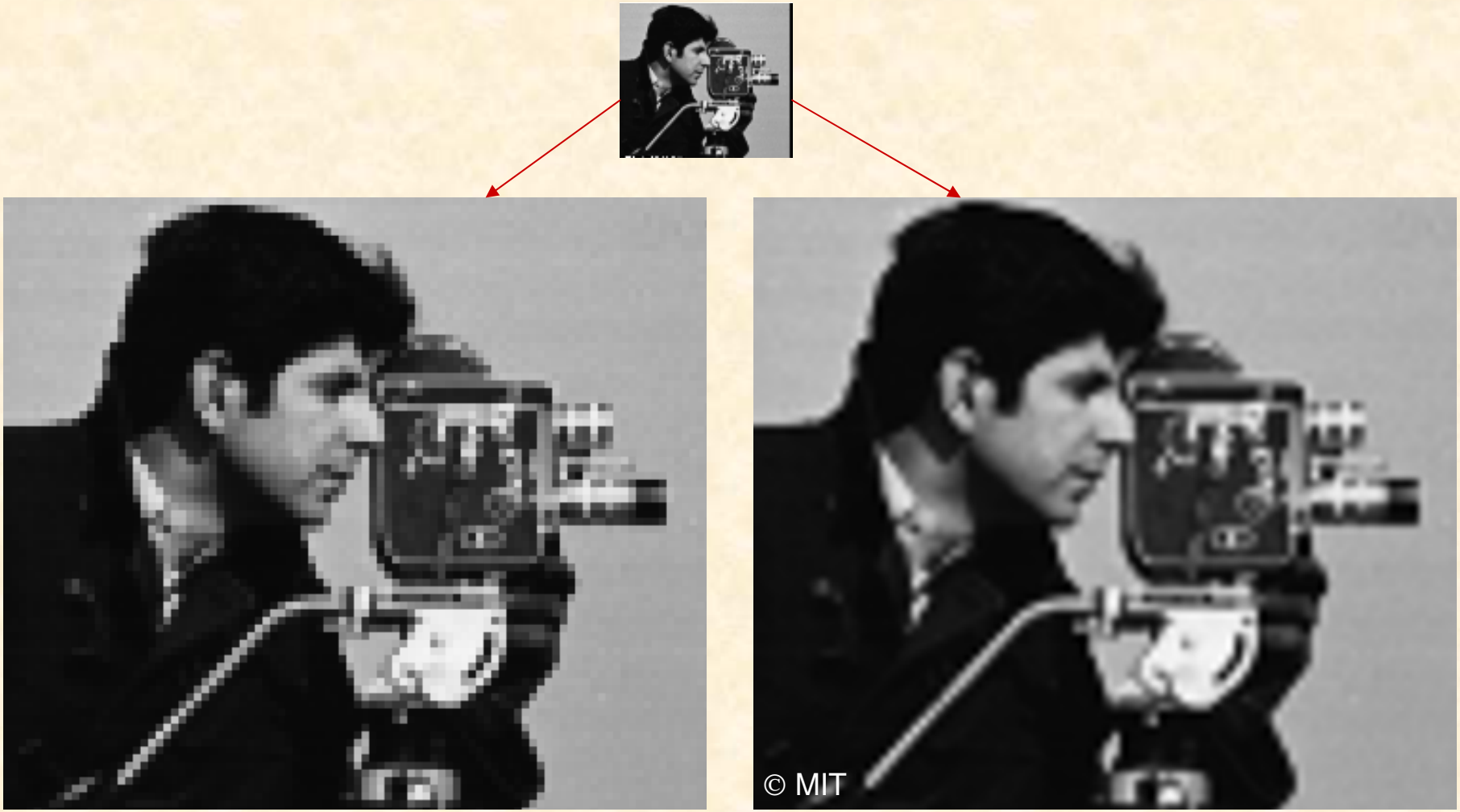
1. Improvement of subjective image quality

(e.g. in 1964, computerised image processing techniques were applied for correcting distortions of images transmitted from moon space probe Ranger 7 Jet Propulsion Laboratory, USA)



Objectives of image processing

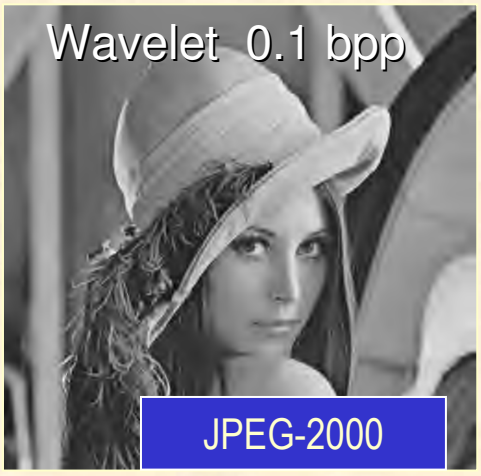
Improvement of image quality



Objectives of image processing

Processing of image data for machine perception, storage or transmission

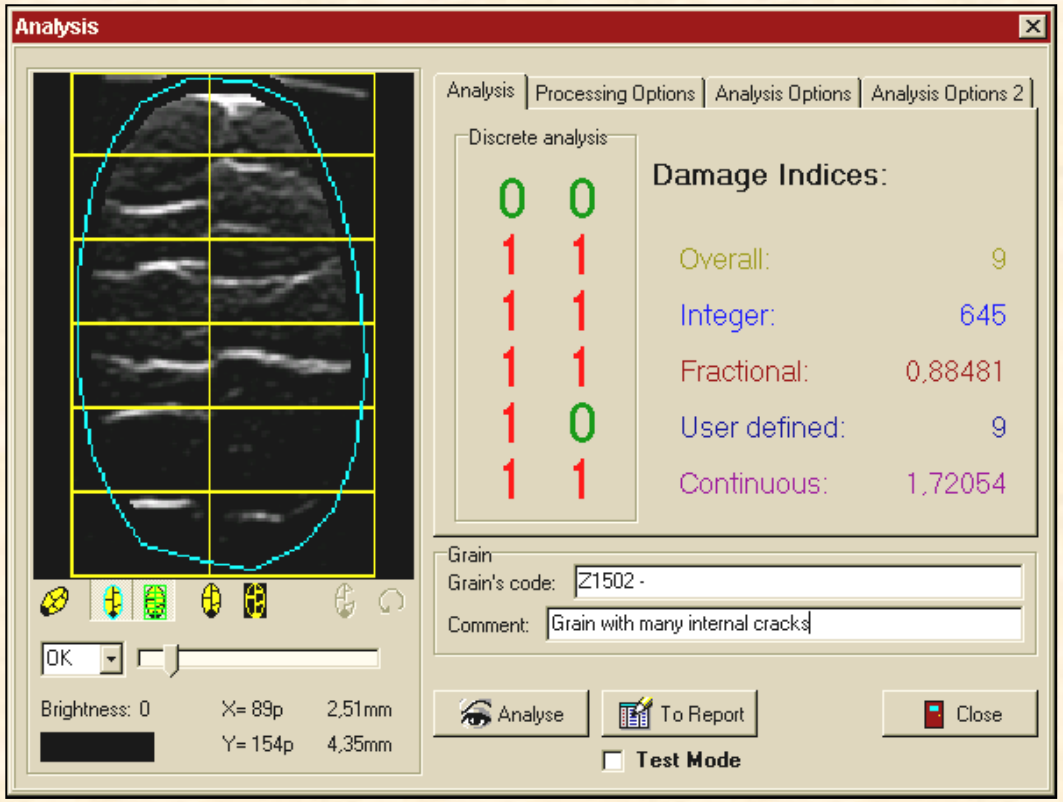
(e.g. first application of image processing techniques has enabled reduction of transmision time of an image across the Atlantic from one week to less than 3 hours)



Objectives of image processing

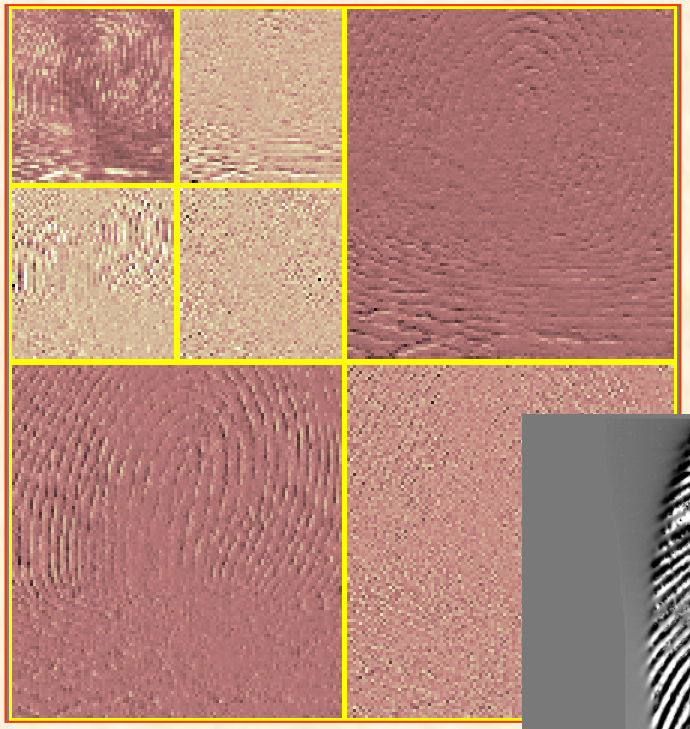
Improvement of subjective image quality for human interpretation

X-ray image of wheat grain



Objectives of image processing

Processing of image data for machine perception, storage or transmission

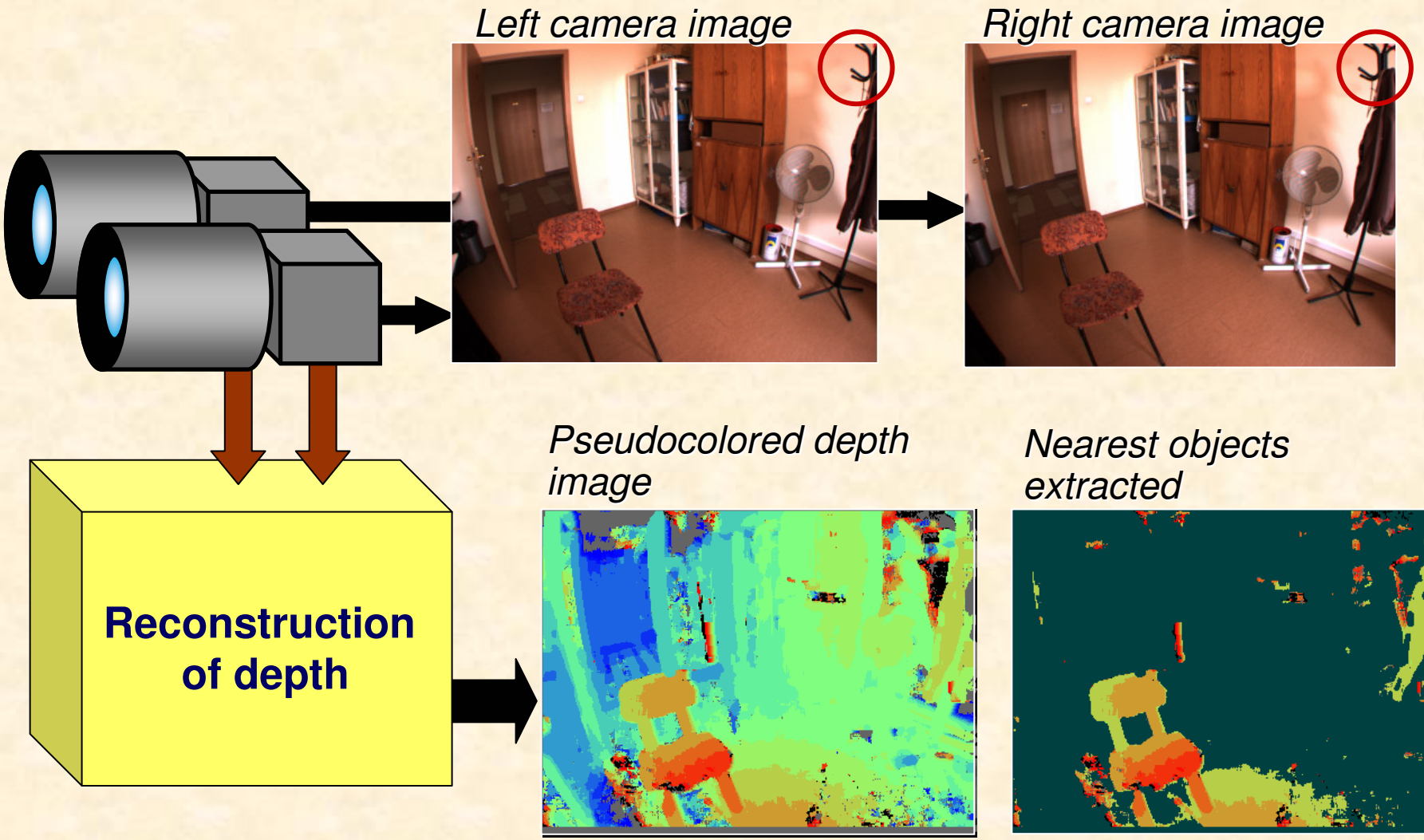


FBI fingerprint database
1992

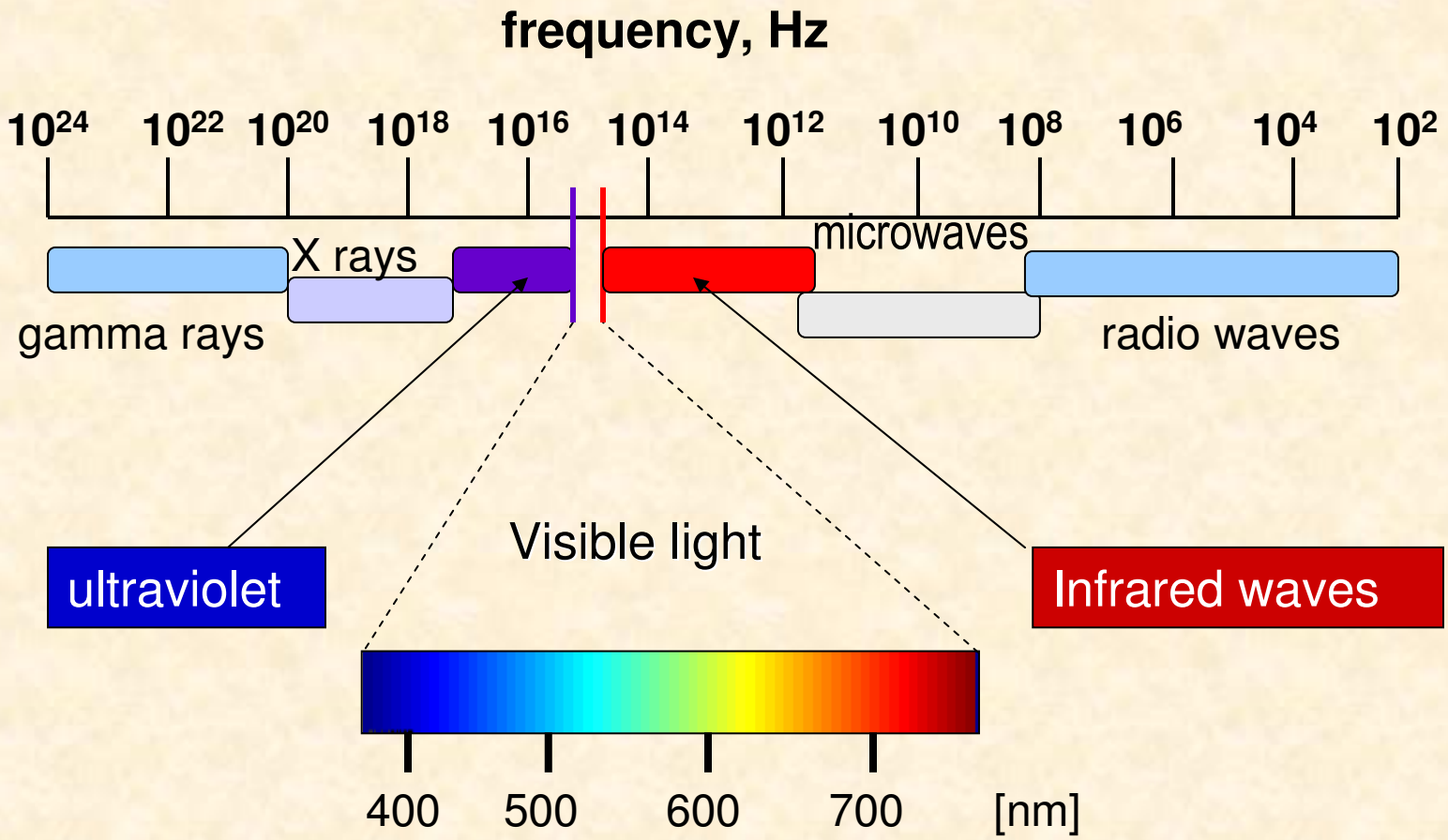
Biometry

Objectives of image processing

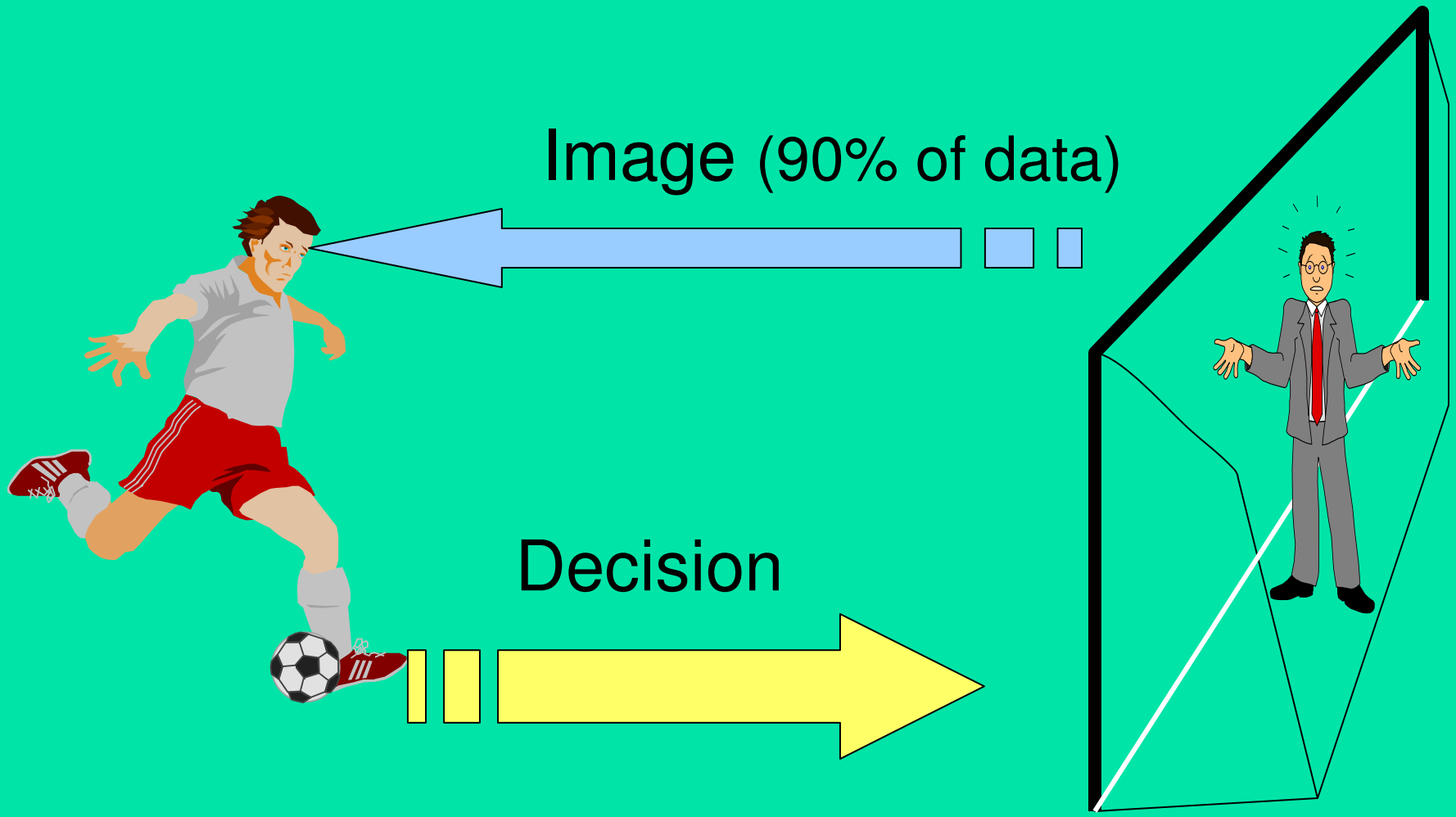
***Stereovision* – scene analysis**



Electromagnetic spectrum



Natural image processing scheme



Computer vision system

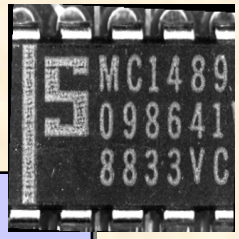


Image preprocessing

Segmentation

Feature extraction

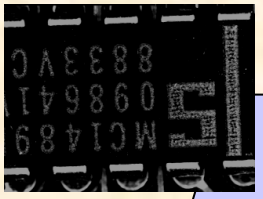


Image aquisition

Computer + program + knowledge

Image analysis and perception

Course material:

1. Image acquisition and representation
2. Image enhancement
3. Image restoration
4. Image analysis
5. Image coding

Image enhancement

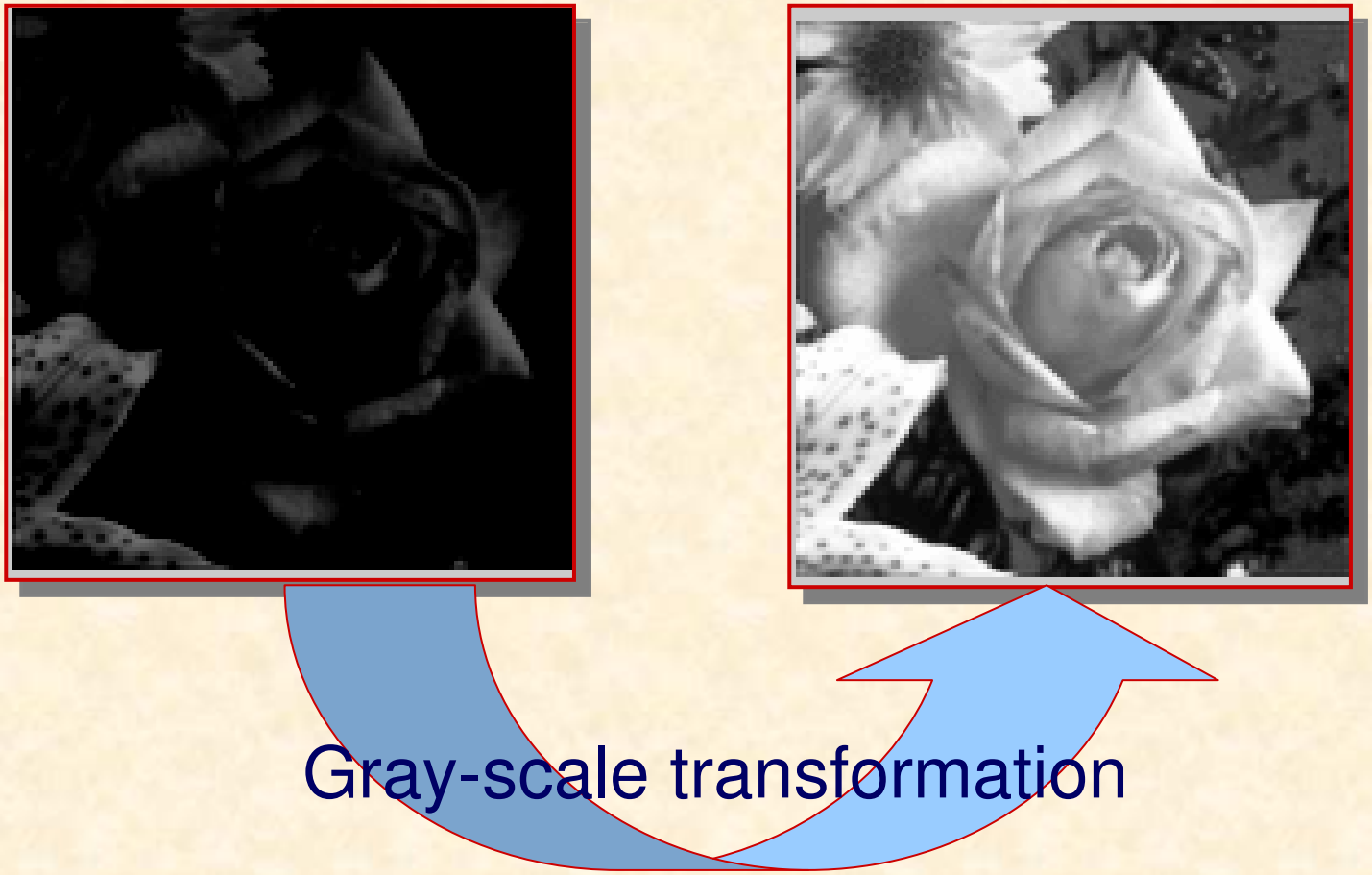


Image restoration

motion blur

restored image

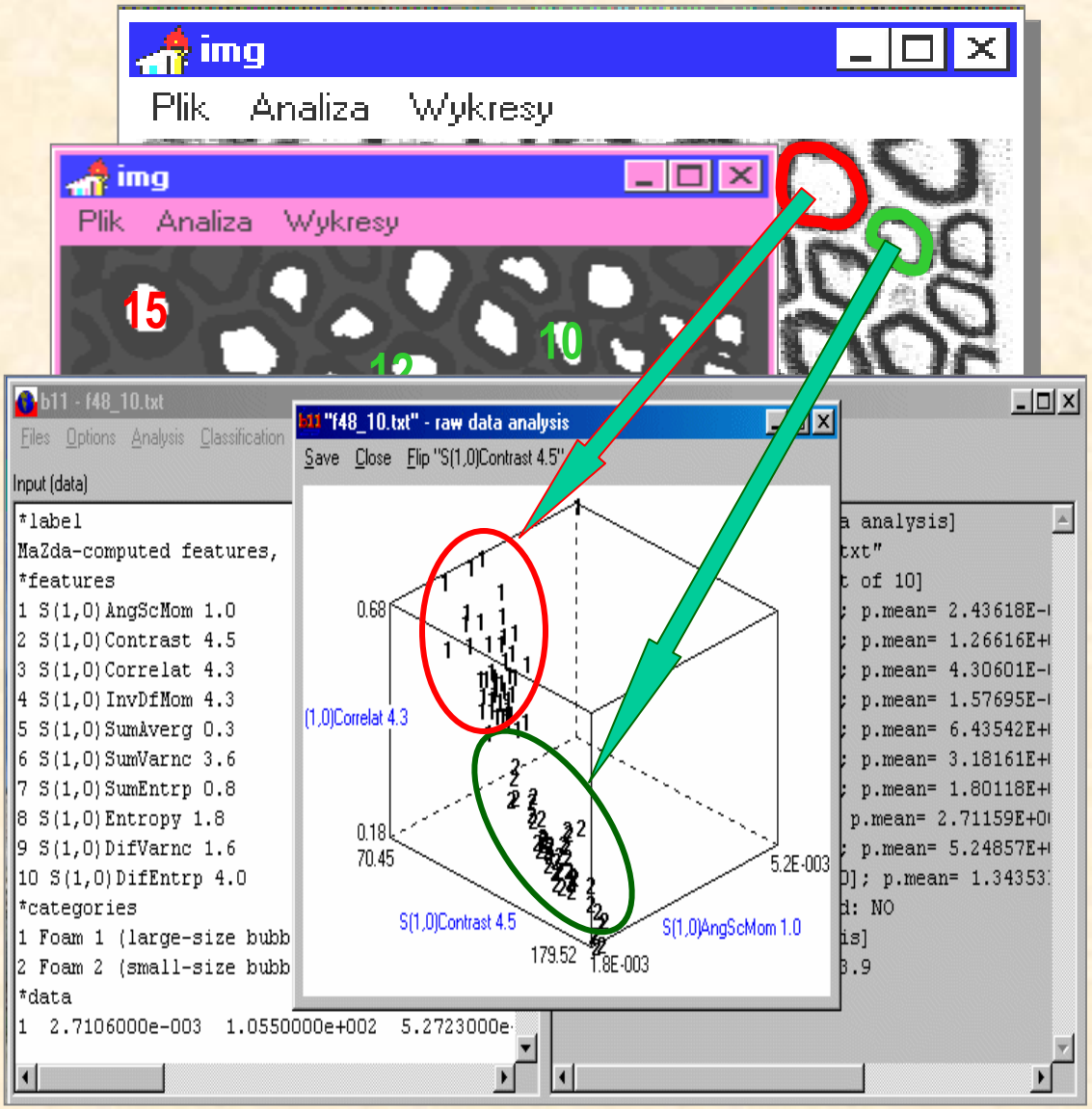
Image analysis

Image aquisition

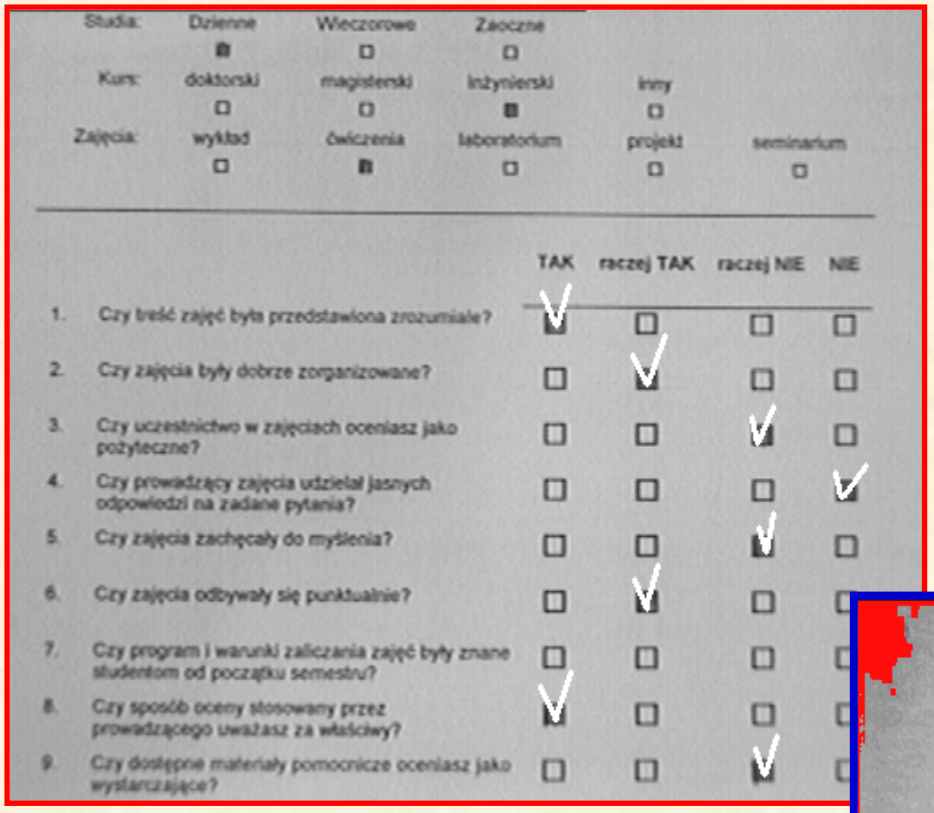
Feature extraction

Feature description

Recognition



Analysis of documents



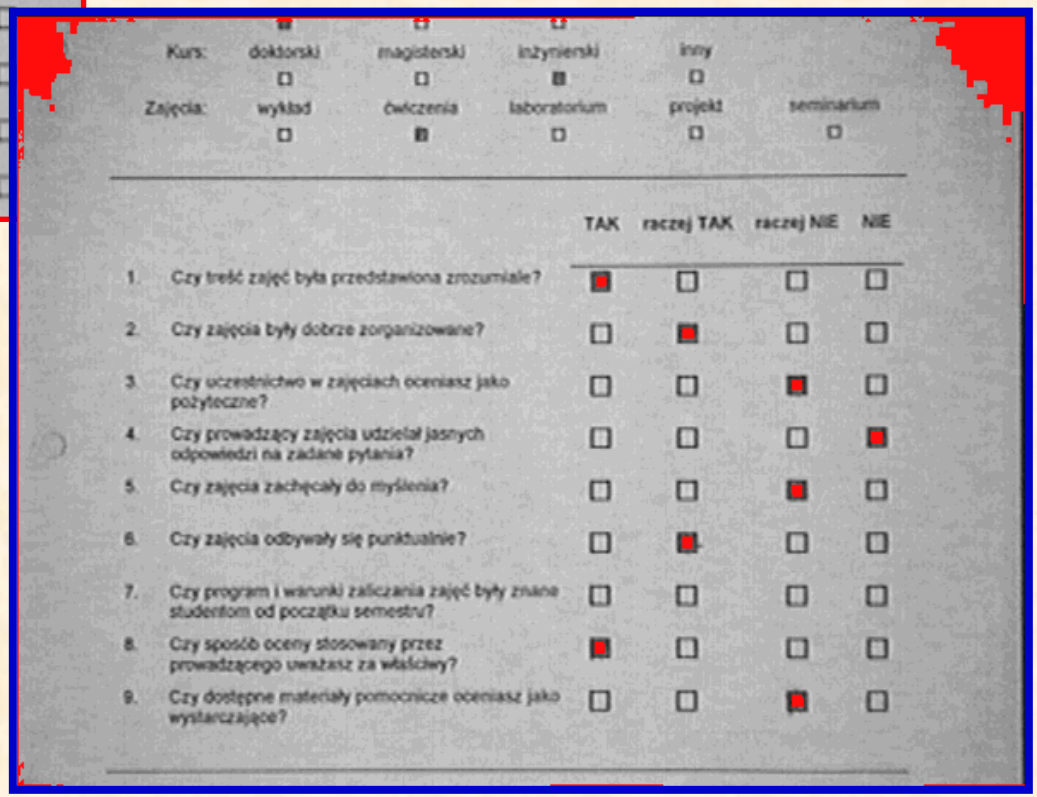
Studia: Dzienne ■ Wieczorowe □ Zaoczne □

Kurs: doktorski □ magisterski □ inżynierski ■ inny □

Zajęcia: wykład □ ćwiczenia ■ laboratorium □ projekt □ seminarium □

		TAK	raczej TAK	raczej NIE	NIE
1.	Czy treść zajęć była przedstawiona zrozumiale?	✓			
2.	Czy zajęcia były dobrze zorganizowane?		✓		
3.	Czy uczestnictwo w zajęciach oceniasz jako pożyteczne?			✓	
4.	Czy prowadzący zajęcia udzielał jasnych odpowiedzi na zadane pytania?				✓
5.	Czy zajęcia zachęcały do myślenia?			✓	
6.	Czy zajęcia odbywały się punktualnie?		✓		
7.	Czy program i warunki zaliczania zajęć były znane studentom od początku semestru?				
8.	Czy sposób oceny stosowany przez prowadzącego uważasz za właściwy?	✓			
9.	Czy dostępne materiały pomocnicze oceniasz jako wystarczające?			✓	

Student questionnaire



Kurs: doktorski □ magisterski □ inżynierski ■ inny □

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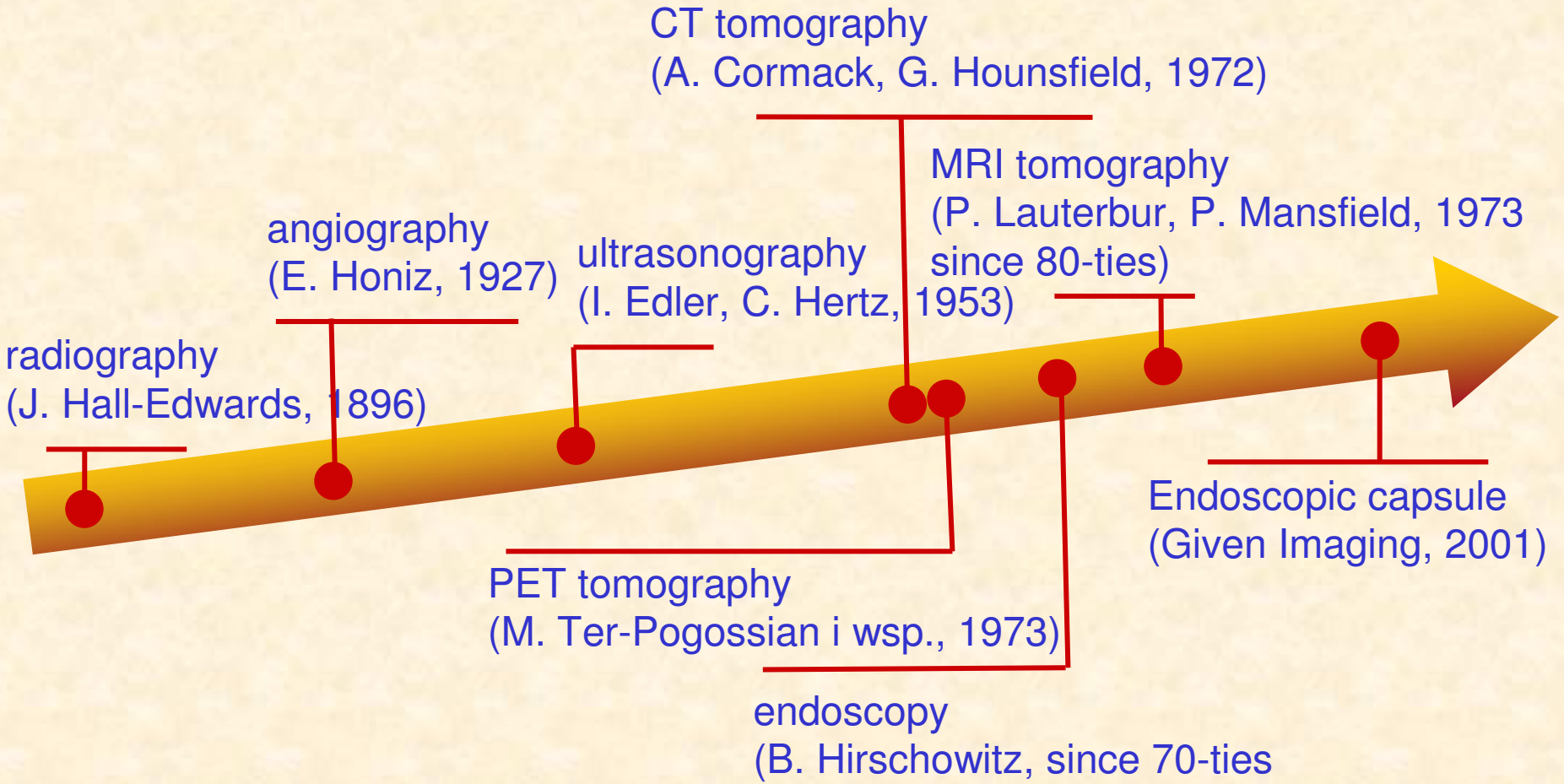
9.	Czy dostępne materiały pomocnicze oceniasz jako wystarczające?			■	

Image processing systems - applications

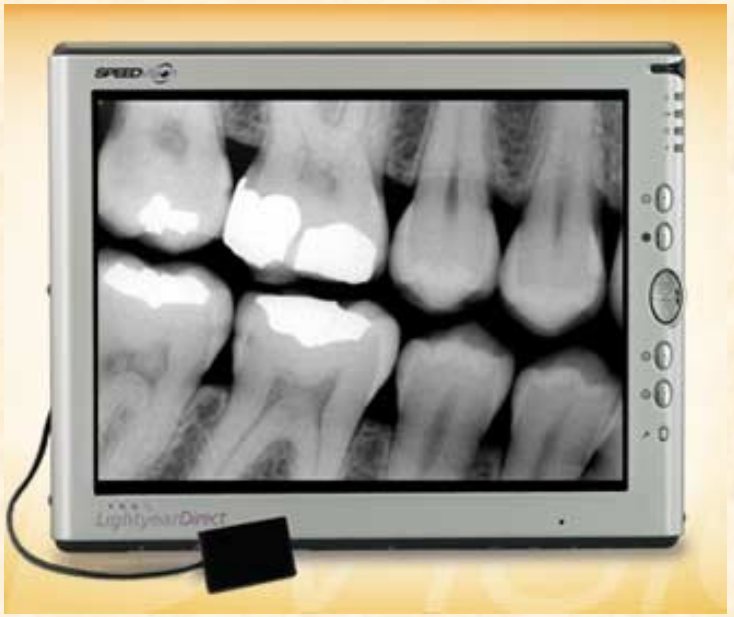
- **science and industry** (quality control, sorting, ...)
- **medicine** (X-ray images, computed tomography, MRI, USG, microscopy, ...)
- **army** (target tracking, quided missiles, unmanned flying vehicles)
- **robotics** (welding, painting, robots, ...)
- **Earth and space exploration** (interpretation of satellite images, space probes, ...)
- **Biometrics, human computer interaction systems**
- **....**

Image analysis in medicine



Radiology

- film images,
- digital images,
- invasive examination,
- limited quality,
- low equipment price, mobility

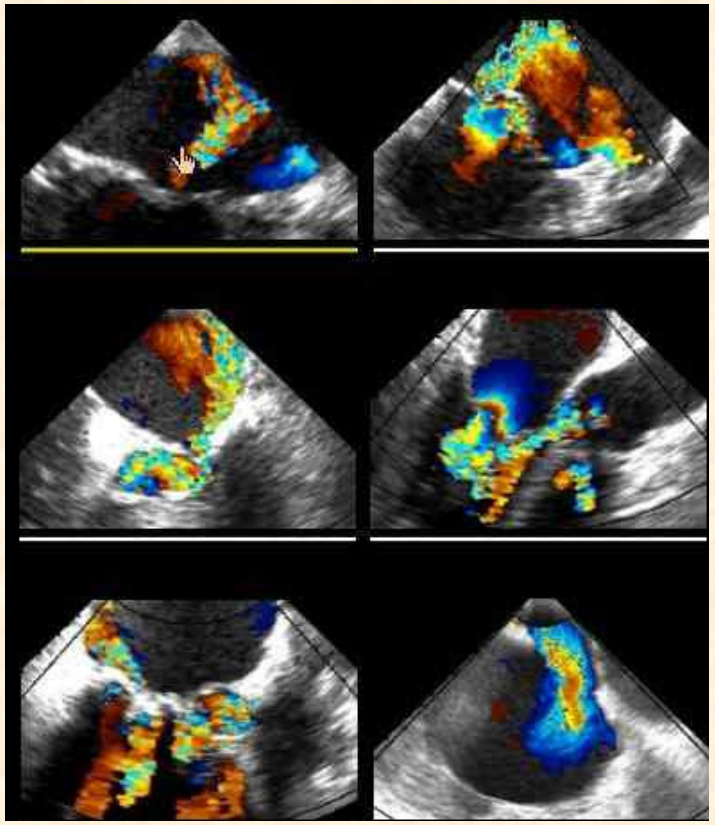


Ultrasonography

- low image quality,
- difficult for interpretation,
- blood flow examination

(Doppler effect USG),

- non-invasive examination,
- low equipment price, mobility

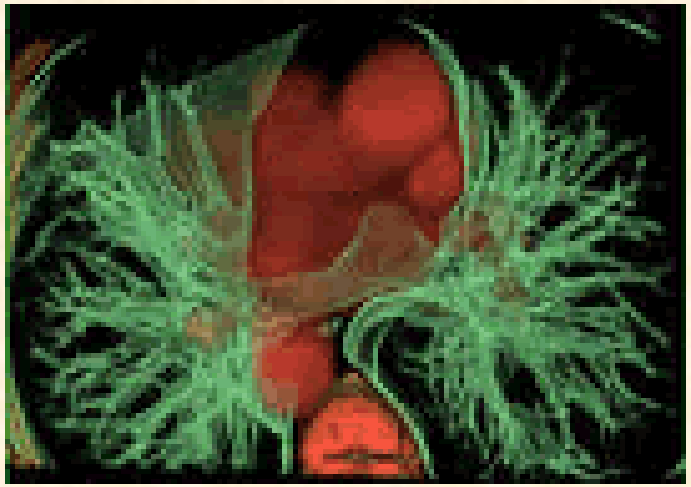


Computed Tomography

- cross-section images

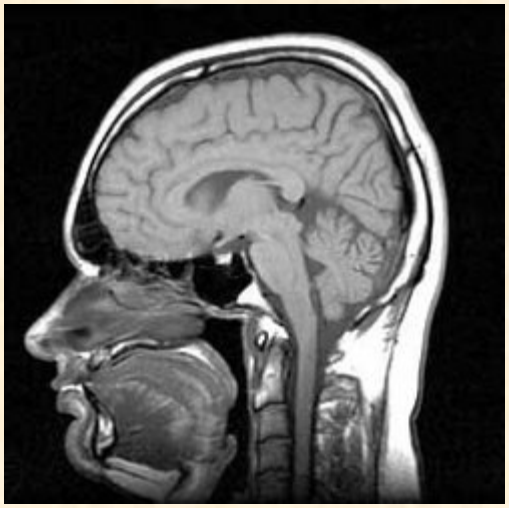
(not a projections)

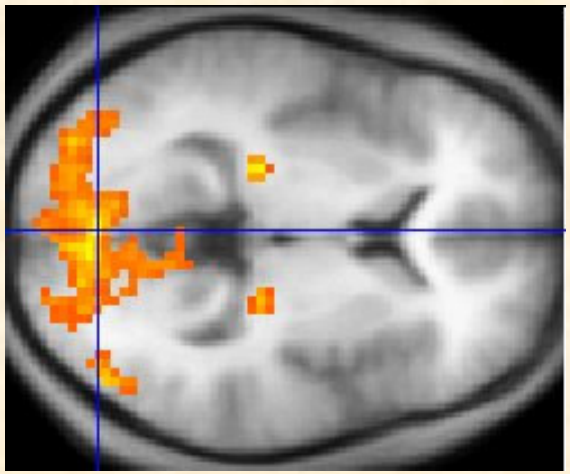
- not applicable for soft tissues,
- very good image quality,
- invasive examination,
- high equipment price



Magnetic Resonance Imaging (MRI Tomography)

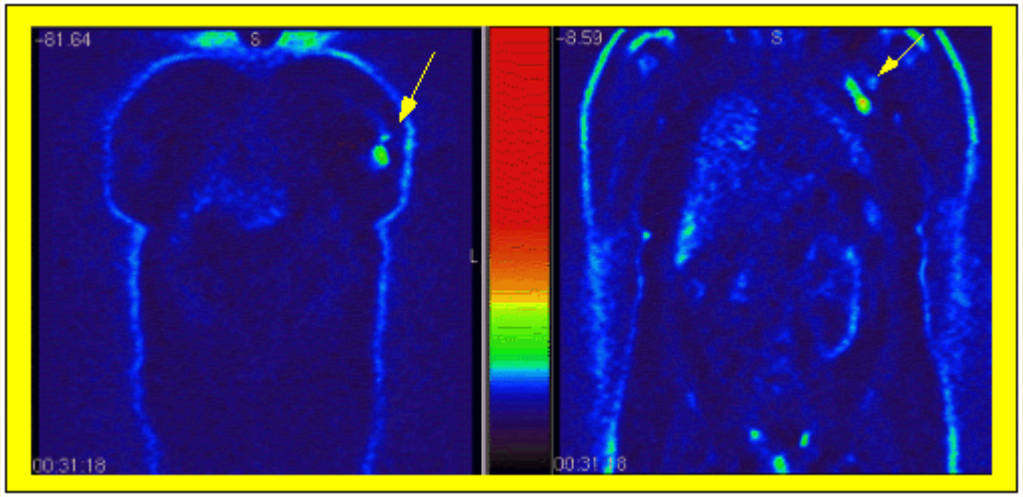
- effective for soft tissues,
- functional tomography (BOLD),
- MR angiography,
- very good image quality,
- non-invasive examination,
- high equipment price

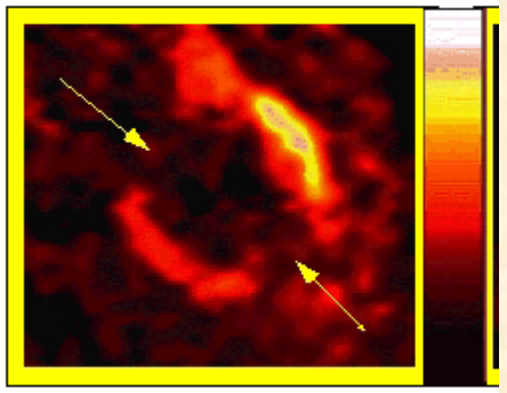




Positron Emissive Tomography

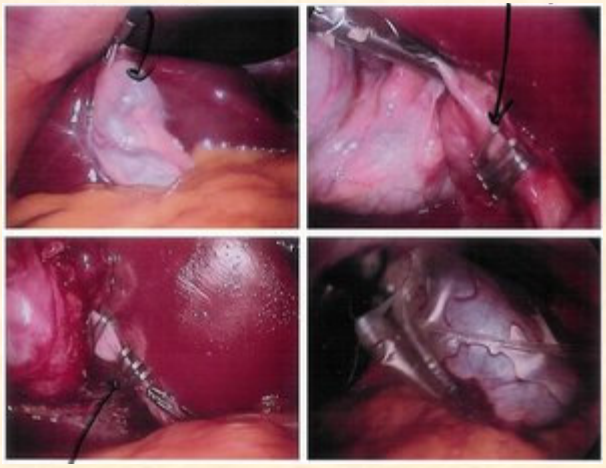
- analysis of molecular changes,
- together with CT,
- short examination time (limited by half-life disintegration of radioisotope),
- invasive examination,
- high equipment price





Endoscopy

- optical images of internal organs,
- additional surgical intervention (laparoscopy),
- endoscopic capsules,
- image processing is necessary,
- invasive examination,
- high equipment price



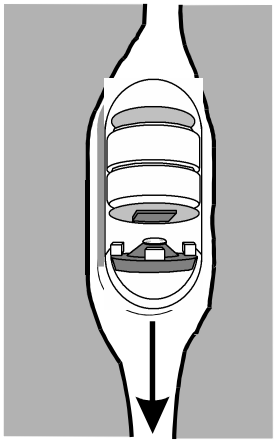
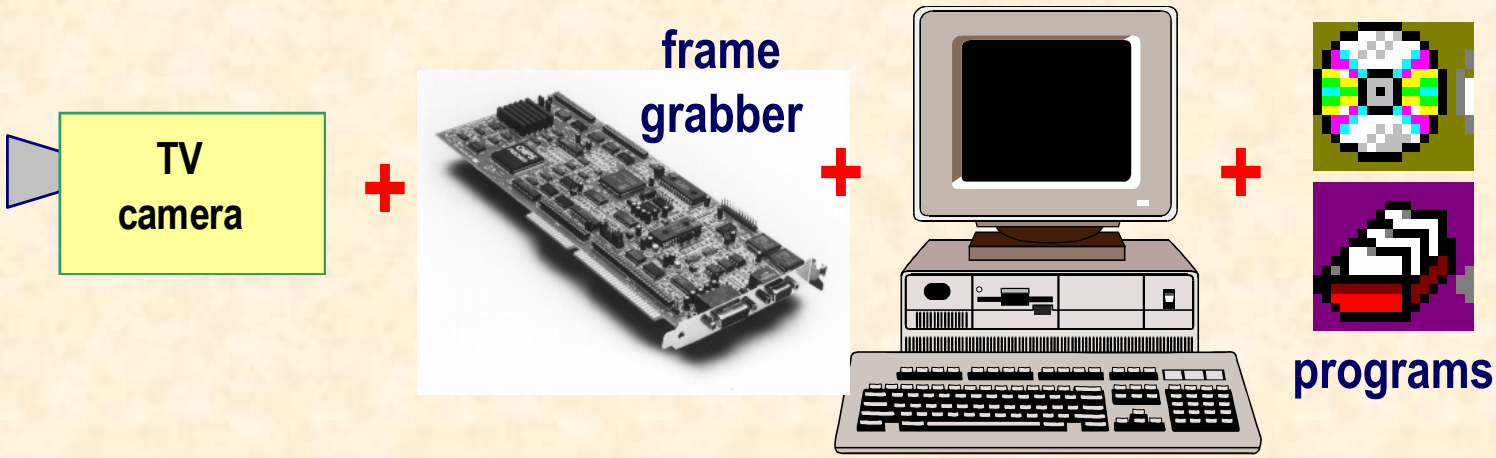
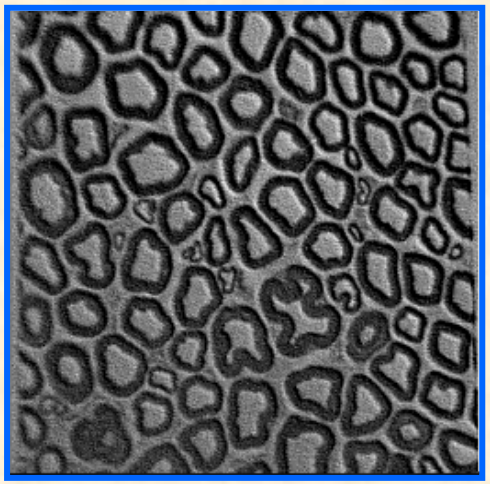
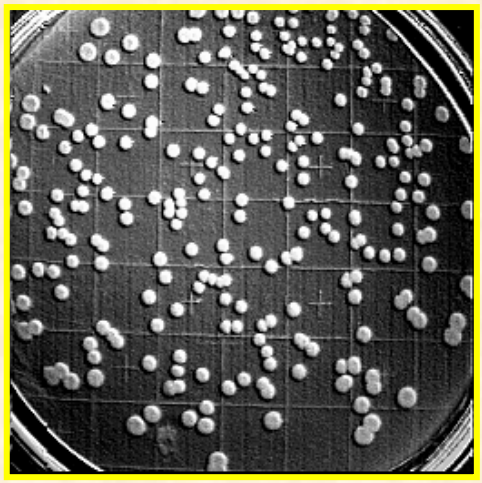


Image processing system developed at the Medical Electronics Division, Institute of Electronics in (1989)

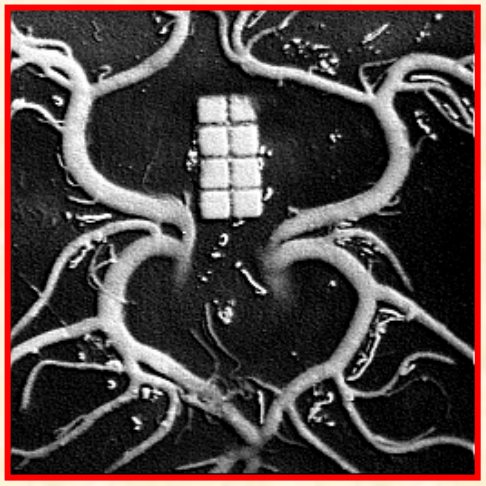




Microscope image
of a nerve tissue



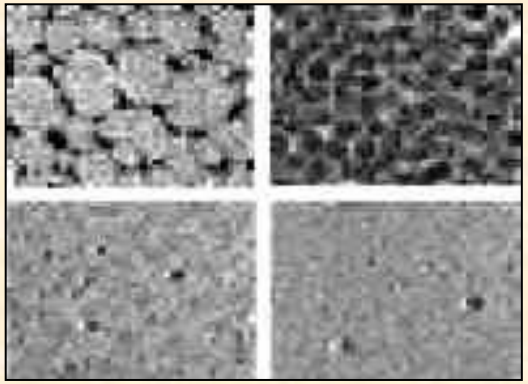
Bacteria colony image



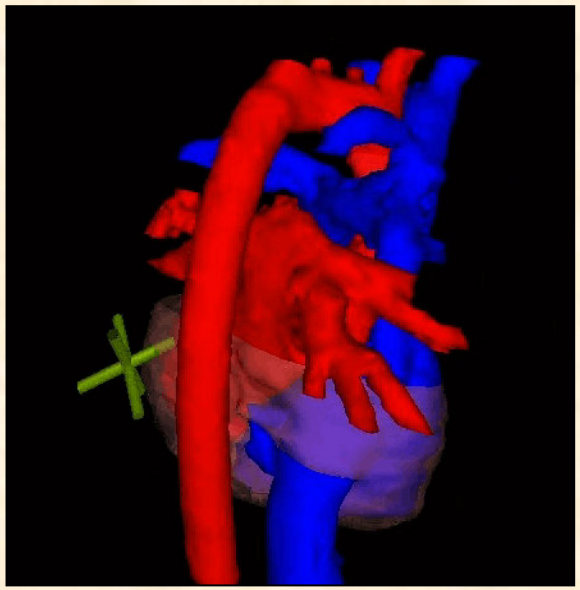
Latex model of brain veins

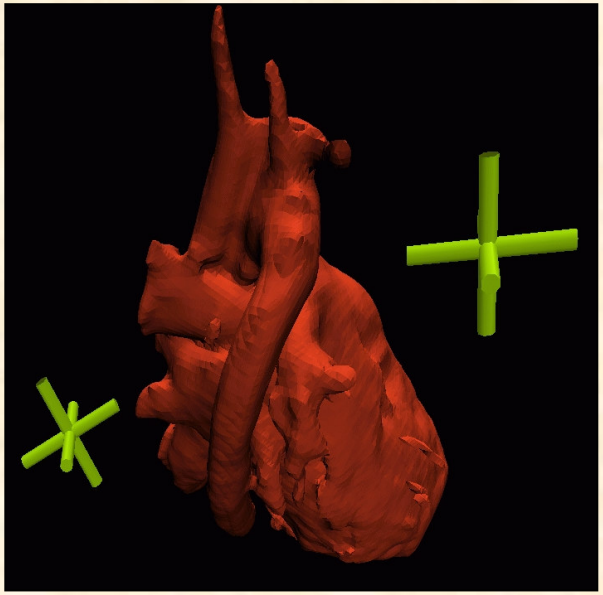
Magnetic resonance imaging (MRI)

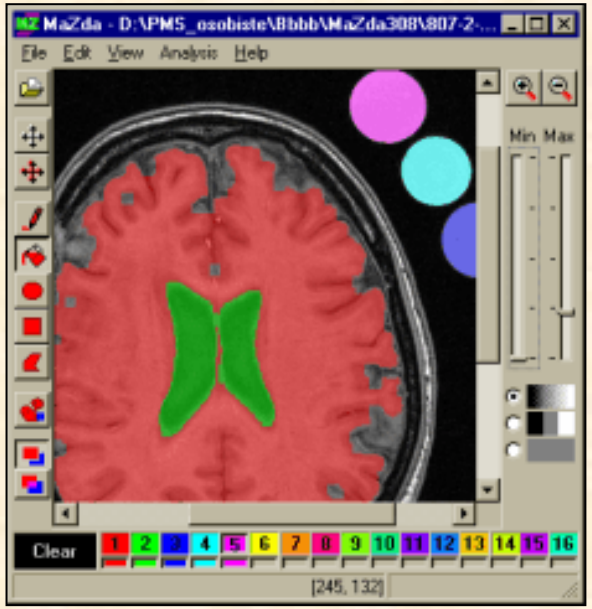
COST B11 action "Quantitation of Magnetic Resonance Image Texture„ (1998-2002)



COST B21
"Physiological modelling of MR Image formation" www.eletel.p.lodz.pl

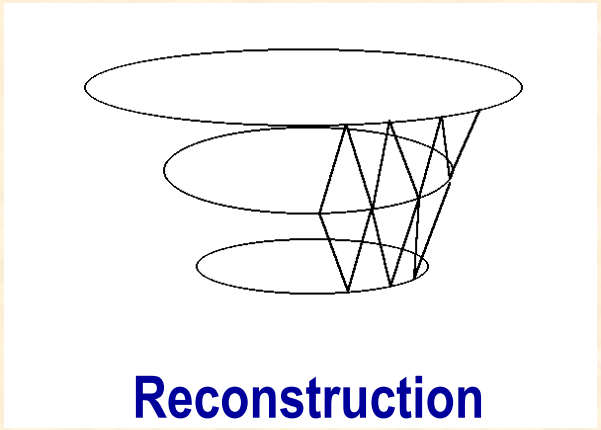




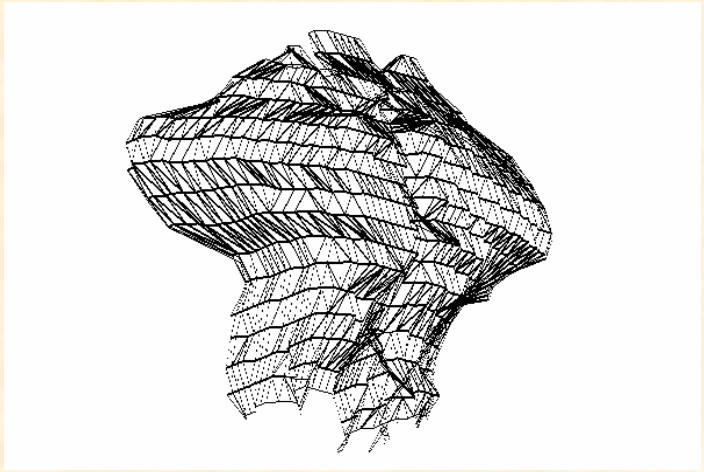


Computer graphics

3D objects modelling

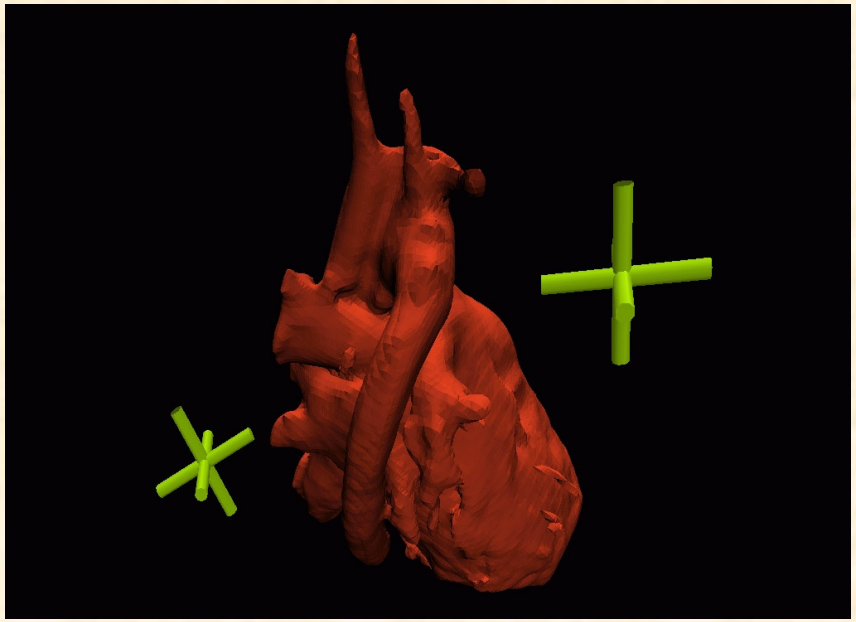


Reconstruction



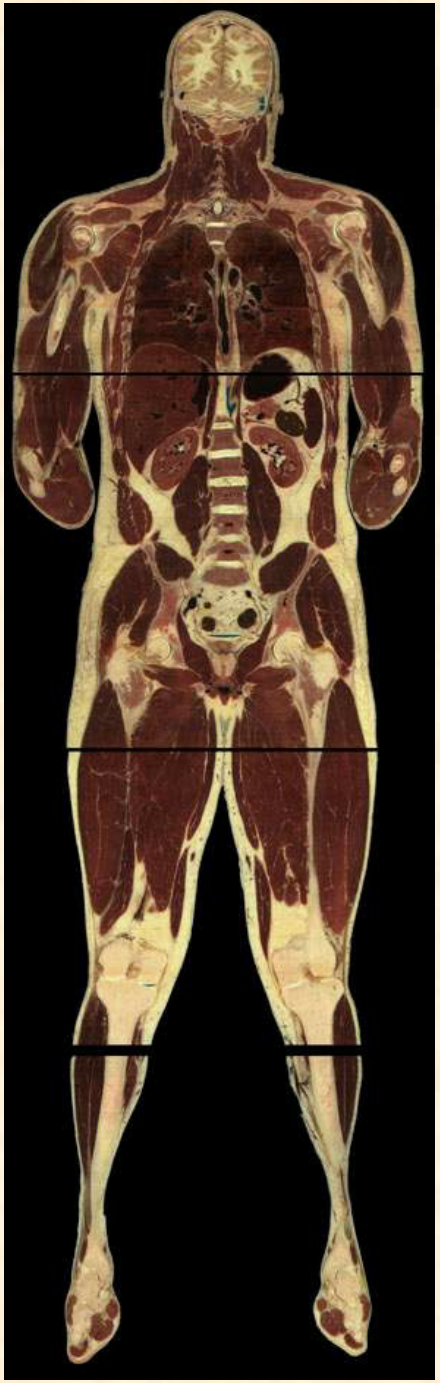
Surface rendering

3D visualisation



Virtual reality

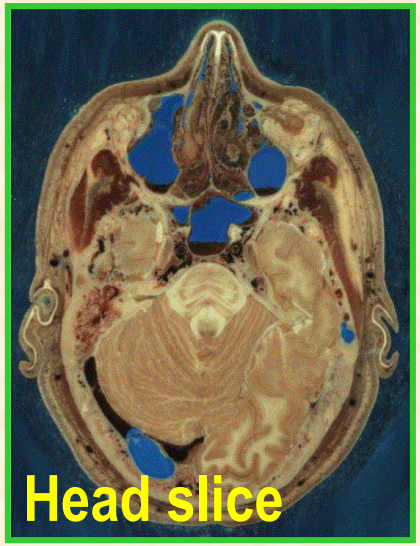
The Visible Human Project

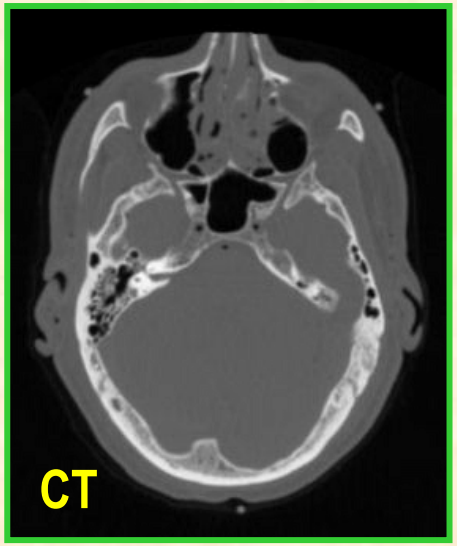


The National Library of Medicine's

Visible Human Project (TM)

Human-Computer Interaction Lab
Univ. of Maryland at College Park

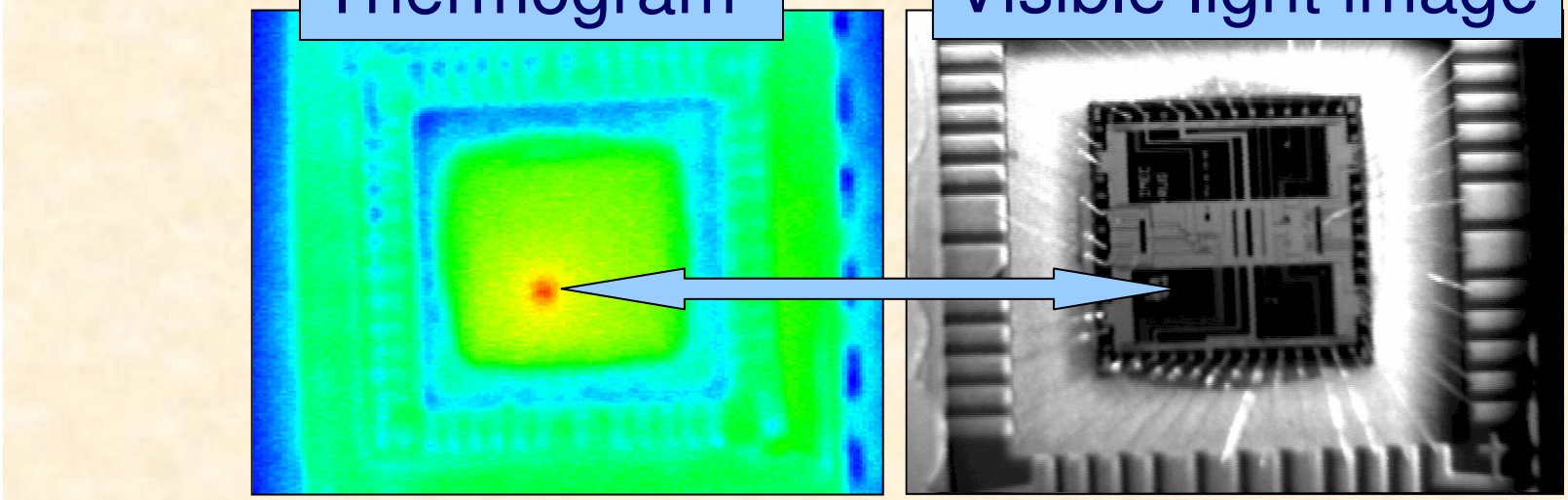




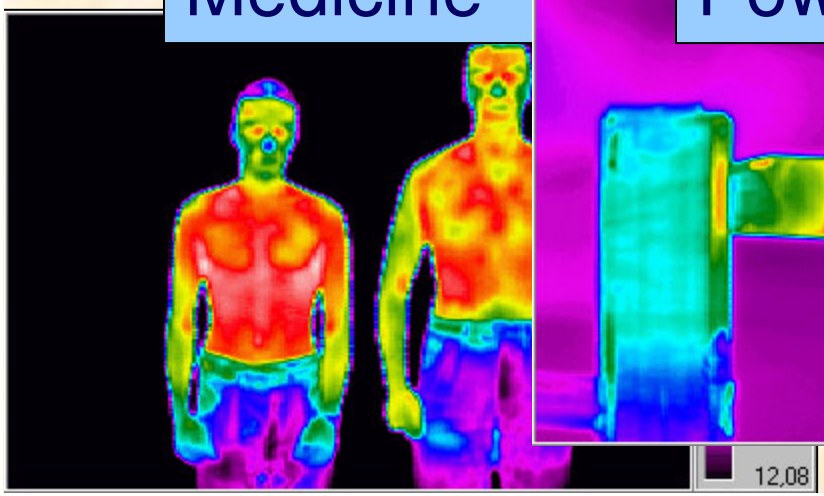
Computed thermography

Thermogram

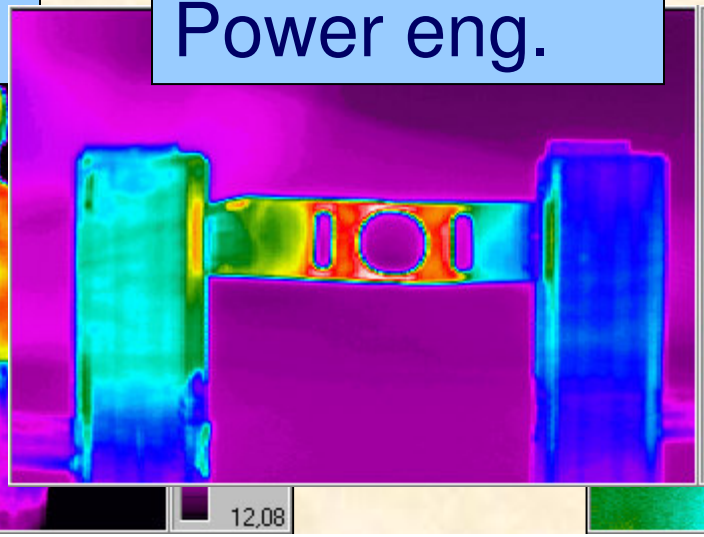
Visible light image



Medicine



Power eng.



Civil eng.

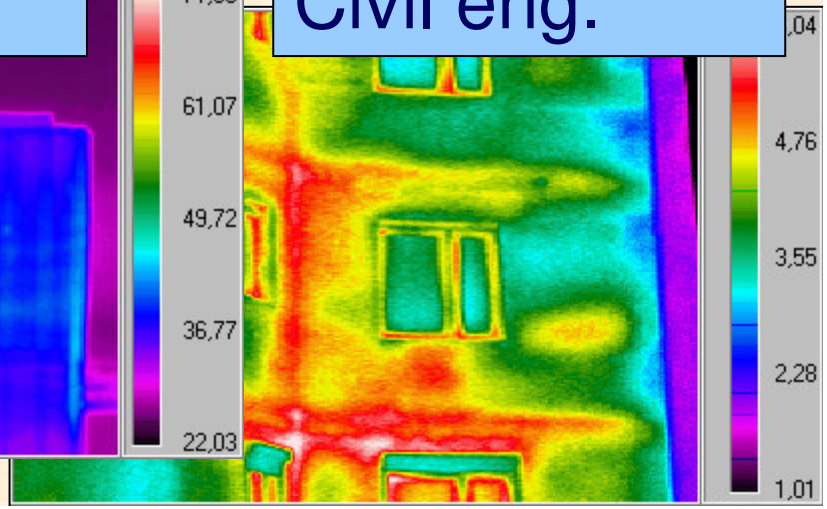
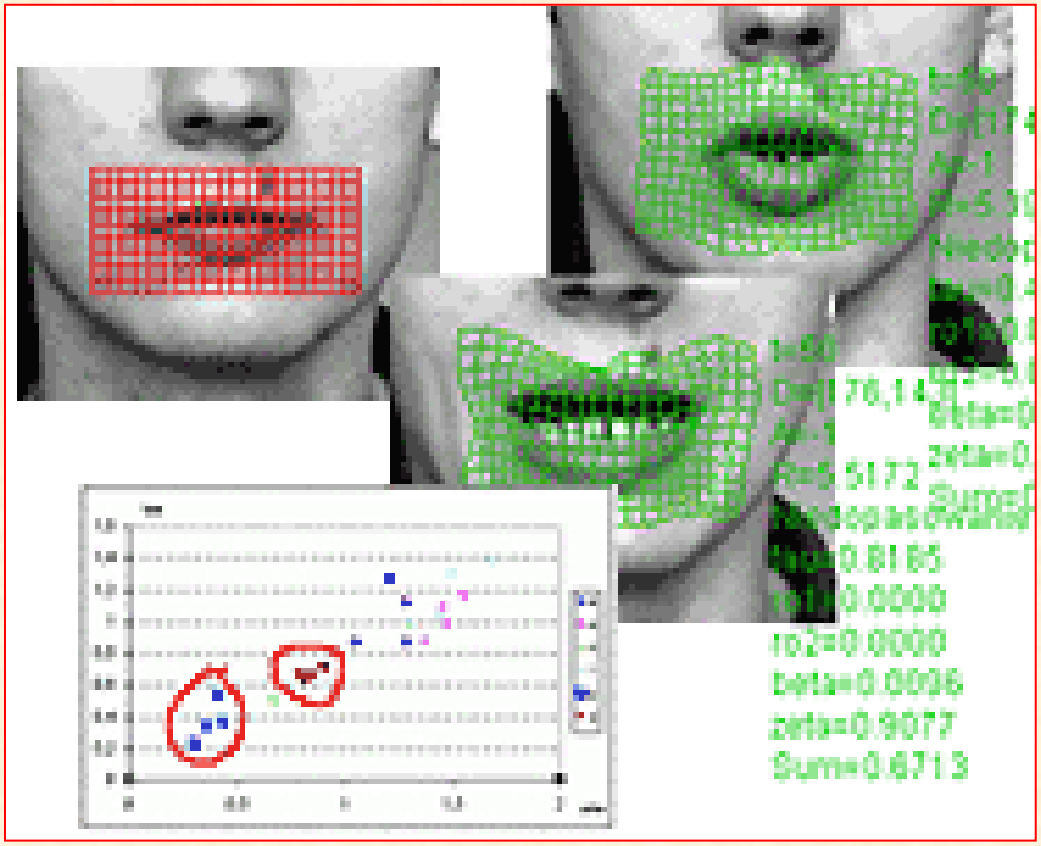
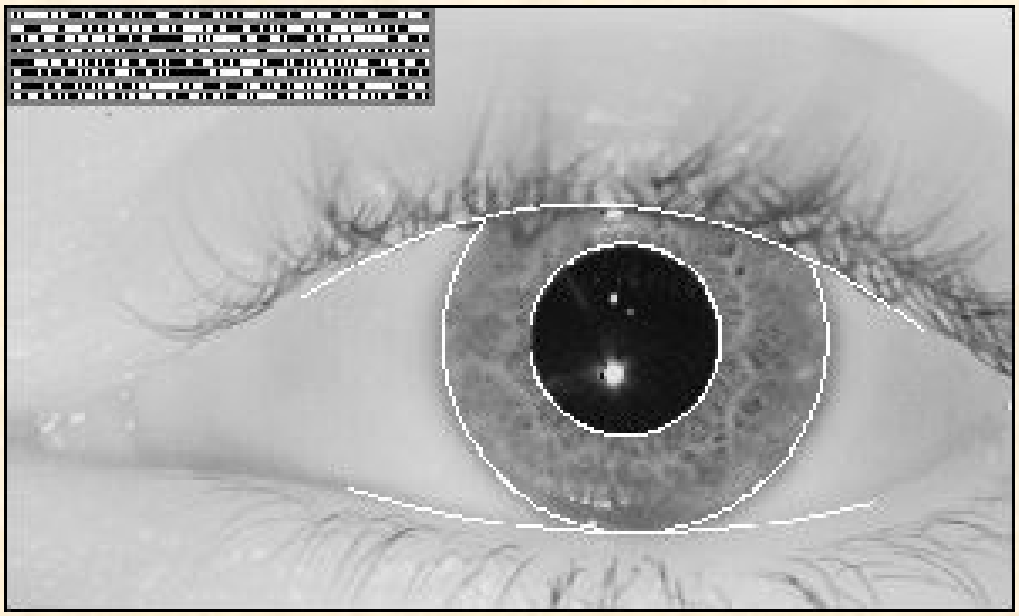


Image processing applications



H. Nowak „***Computer „lip-reading***”, PhD project conducted at the Medical Electronics Division

Image processing applications: biometrics



© J. Daugman

Image processing applications: image databases

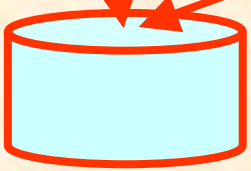
a „concept” of an image

or

a copy of an image

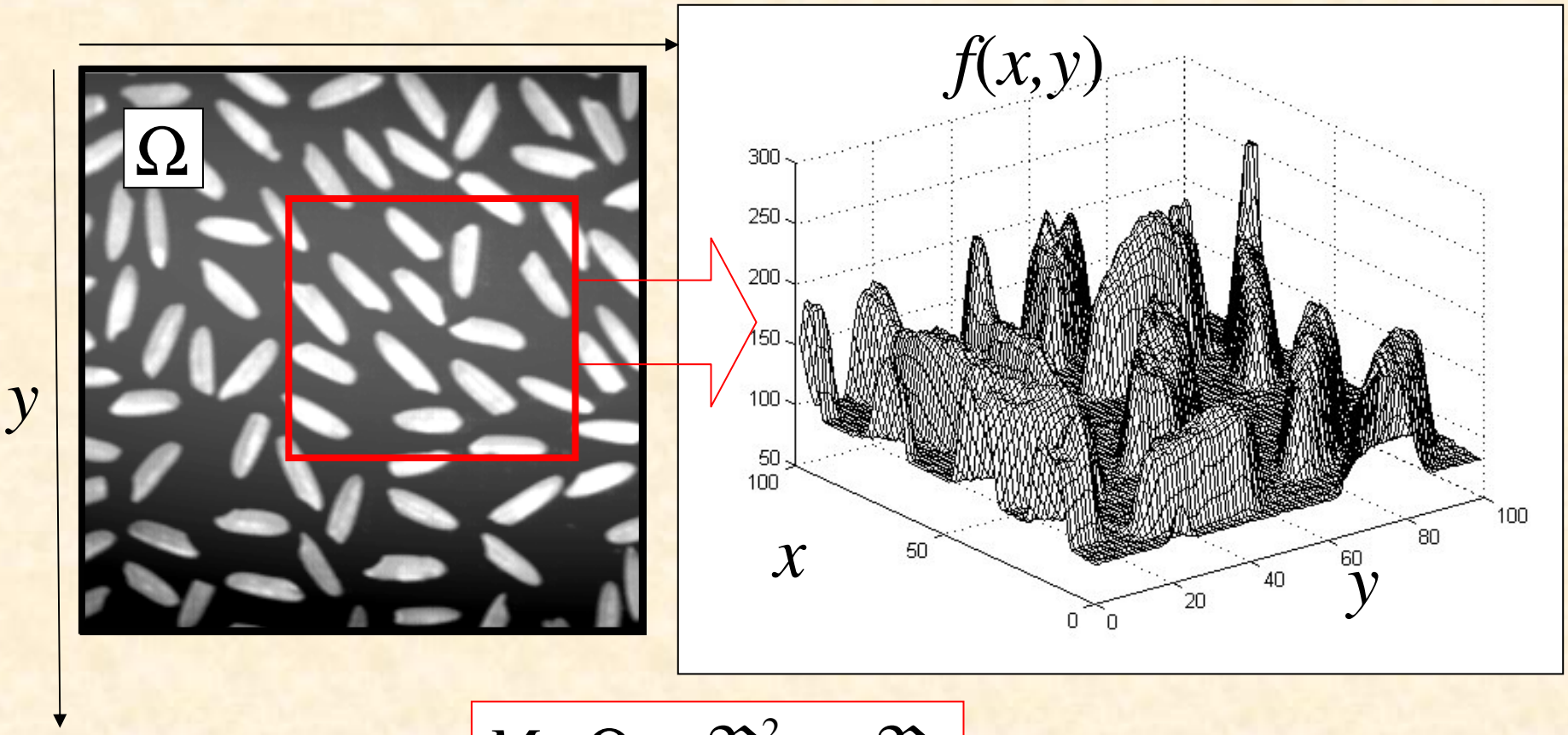
database hit

DWT



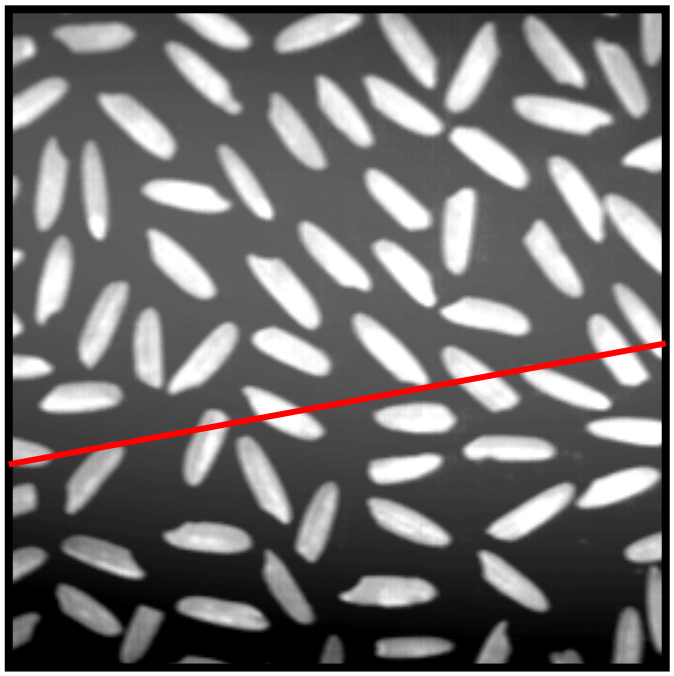
C.E. Jacobs, A. Finkelstein, D.H. Salesis,
*„**Fast multiresolution image quering**”, 1999*

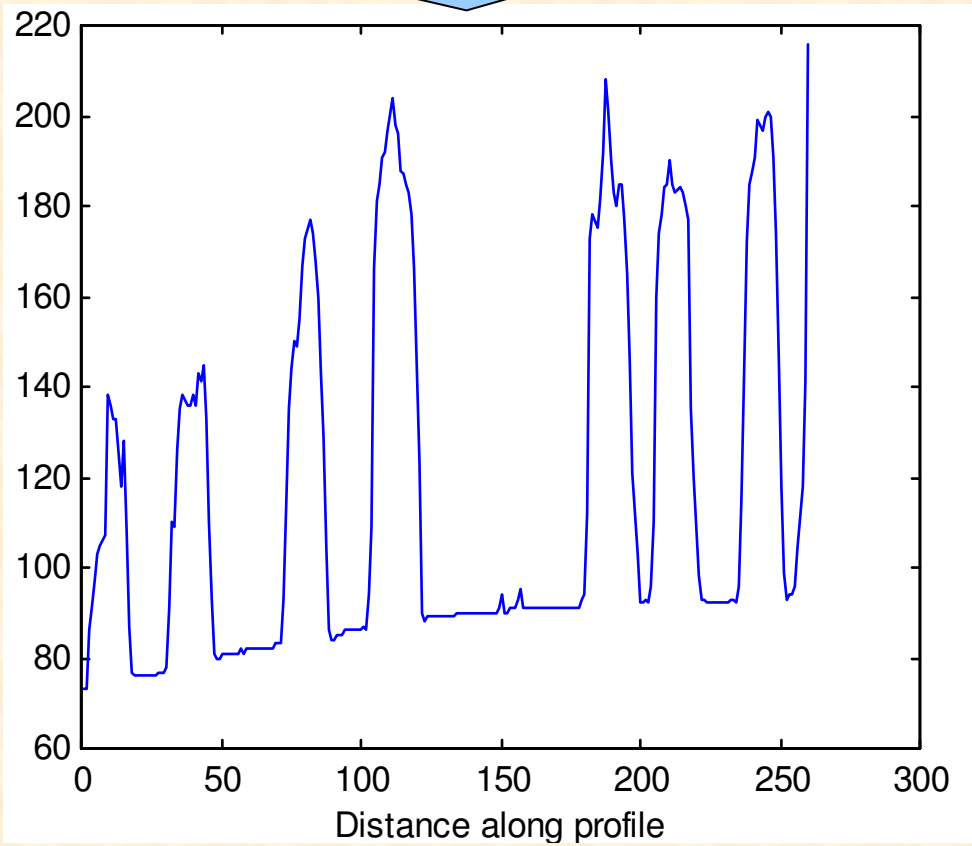
Monochrome image as a 2D function



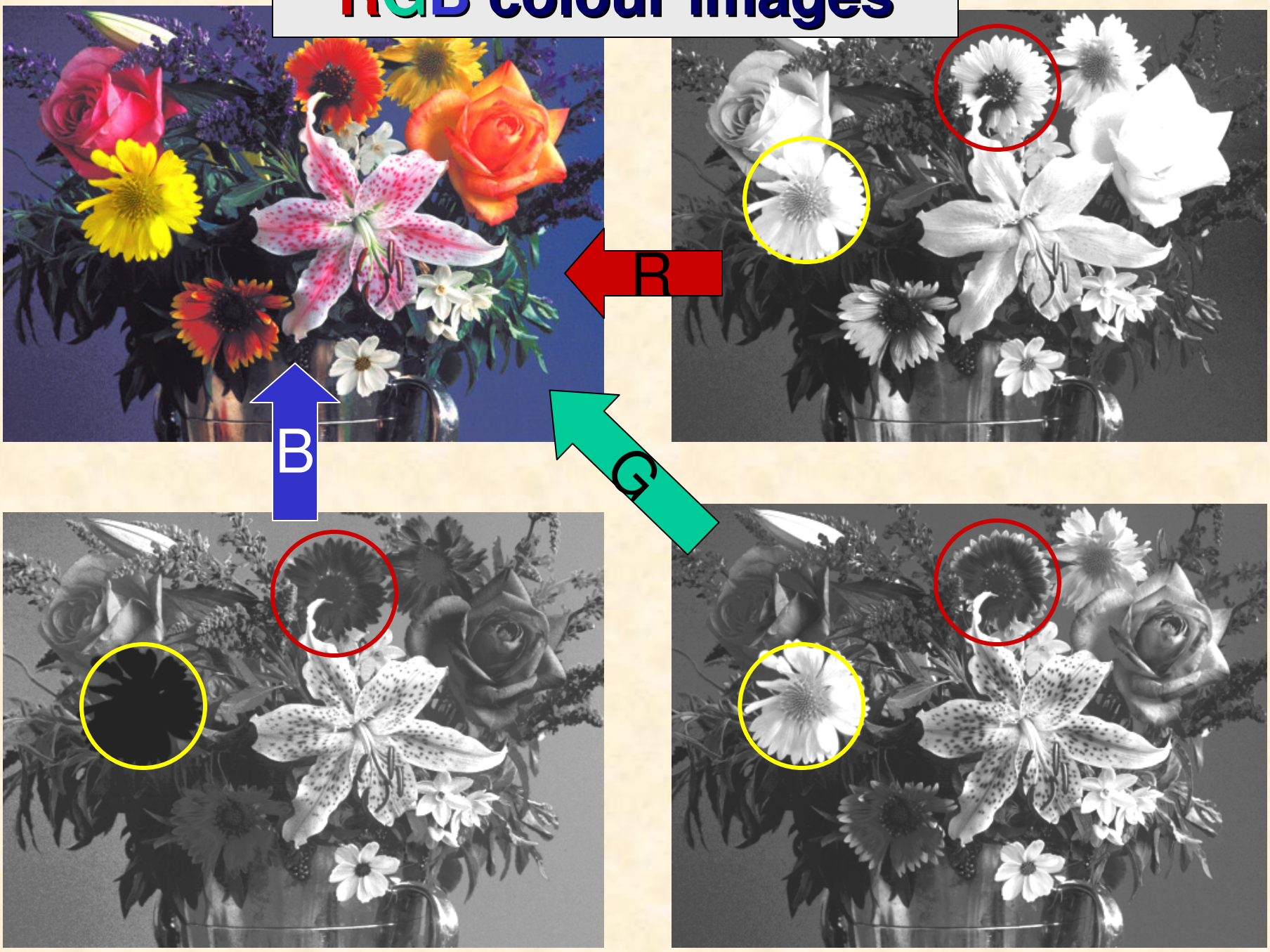
$$M : \Omega \subset \Re^2 \rightarrow \Re_+$$
$$(x, y) \rightarrow f(x, y)$$

Image brightness profile

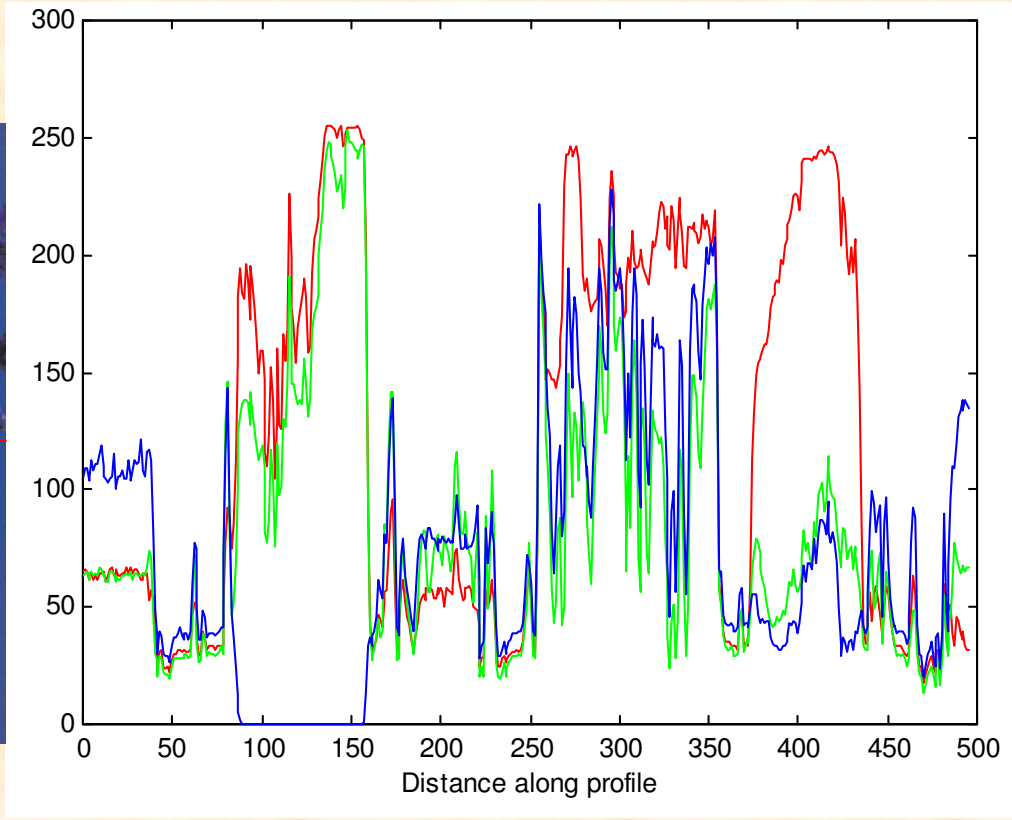




RGB colour images

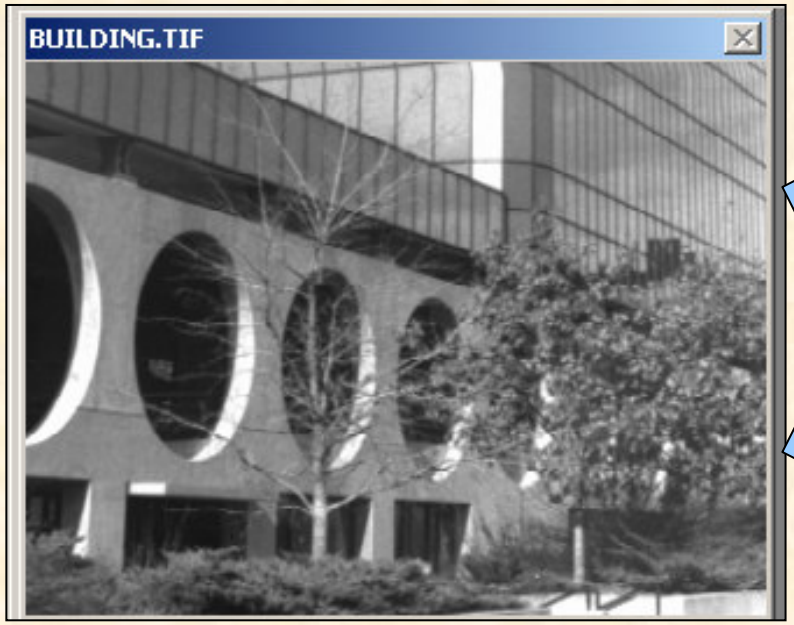


RGB colour images



RGB image and colour components profiles

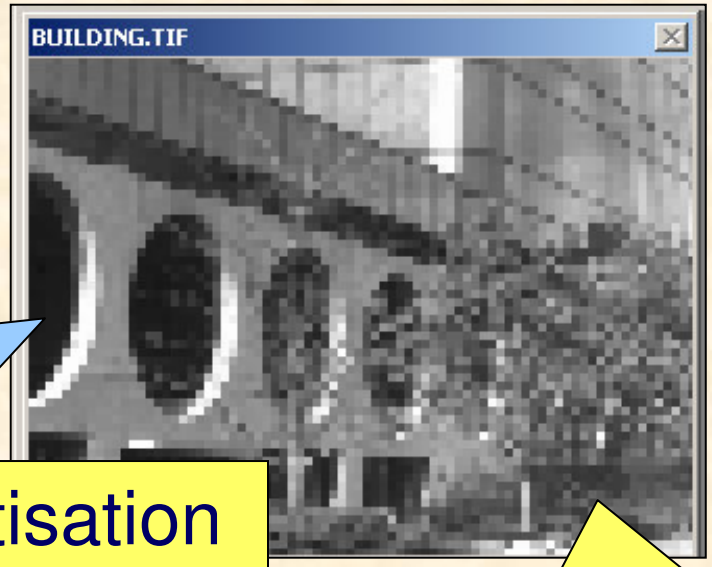
Digital image



discretisation

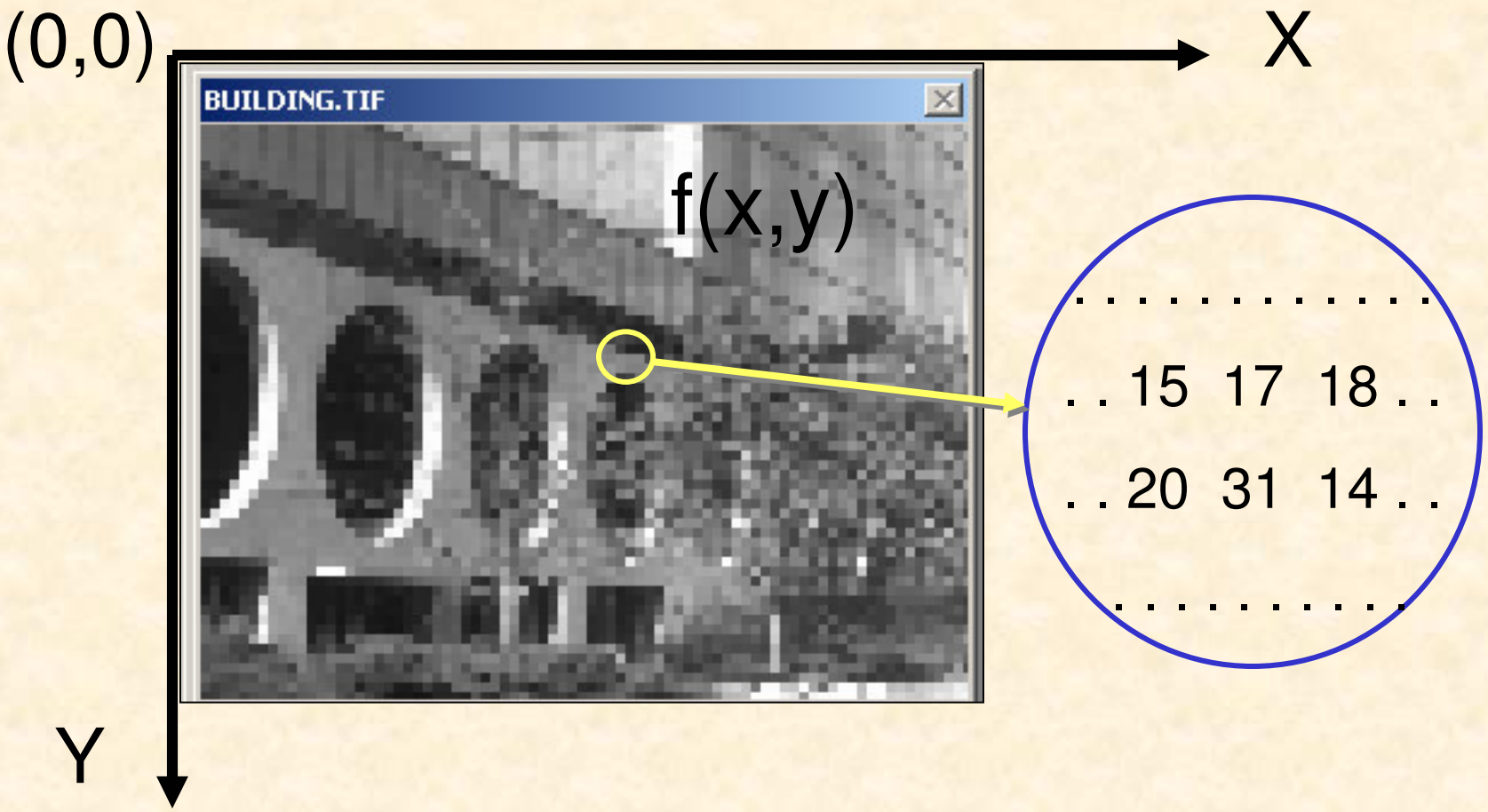
+

quantization



pixel (*picture element)*

Digital image as pixel array



Digital image as pixel array

Digital image $f(x,y)$:

2D array (M,N),
ie. of M rows and N columns,
of nonnegative elements assuming
a limited number of levels

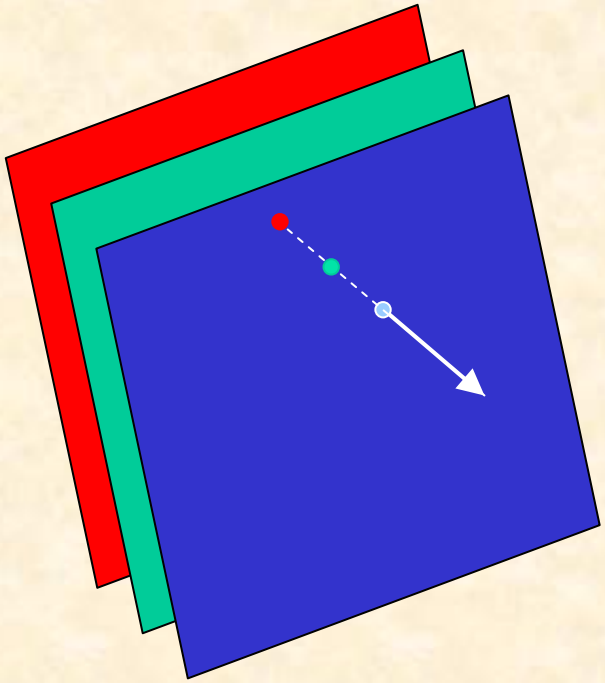
$$f(x, y) = 0,1,\ldots, L-1$$

(np. L=256)

$$x = 0,1,\ldots, N-1$$
$$y = 0,1,\ldots, M-1$$

Colour digital image?

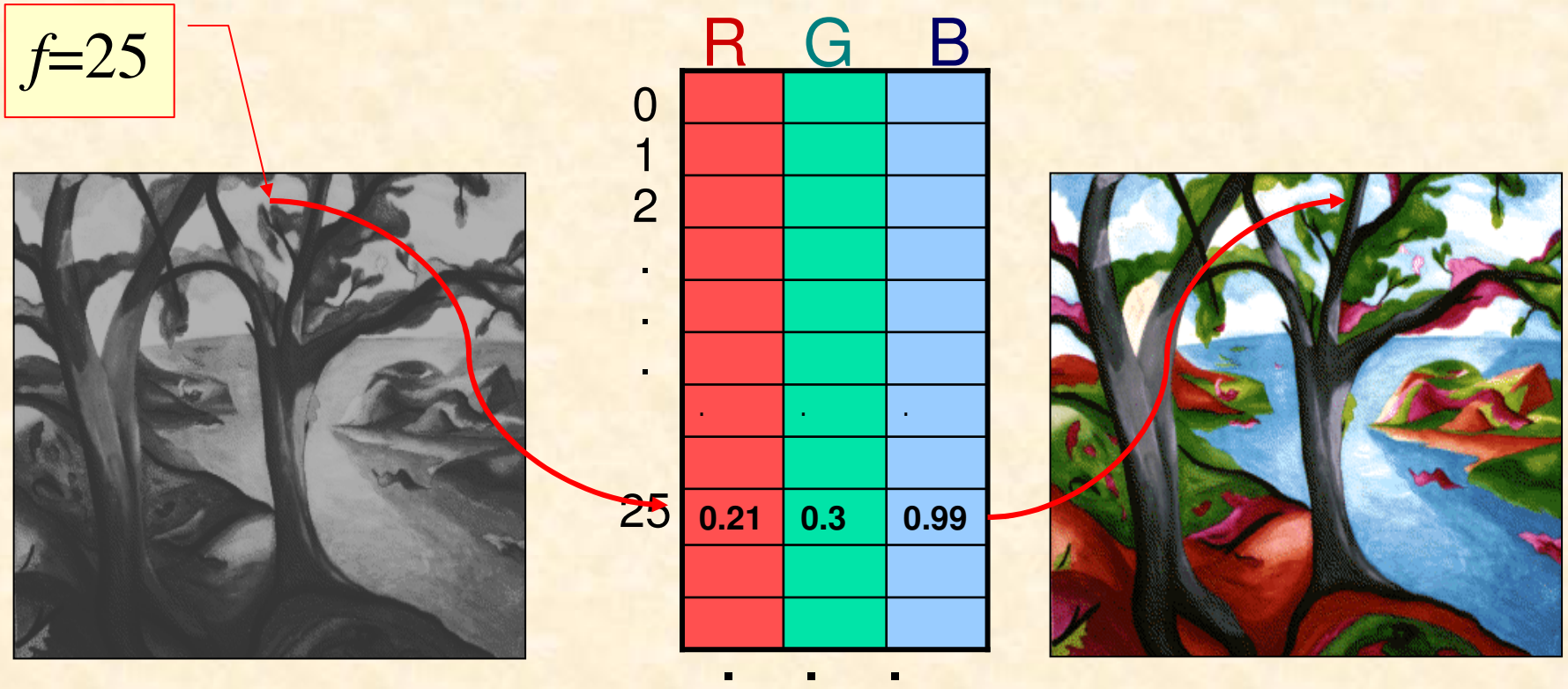
Colour digital RGB image



If each of the colour component is 8 bit coded then 2^{24} different colours can be obtained!

$$\boldsymbol{f}(x,y)=(f_R,f_G,f_B)$$

Colour indexed image



Monochrome image

Colour palette (look-up table)

Colour image

Image file formats

Image file formats were devised for the two main reasons:

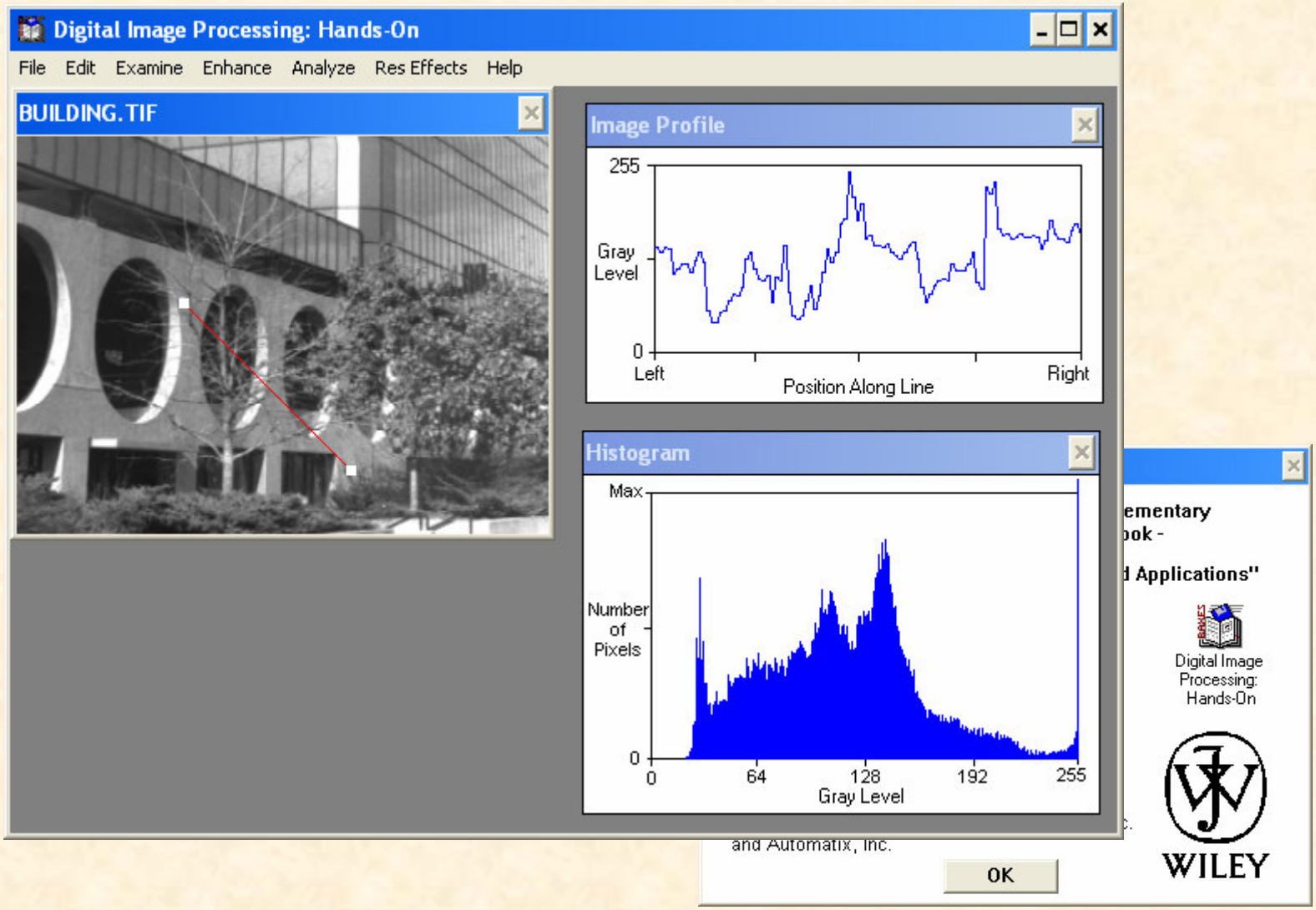
- file compatibility (exchange of data)
- data compression

The most popular image file formats:

- **JPEG** (*Joint Photographic Experts Group*) → NEW: JPEG2000
- **GIF** (*Graphics Interchange Format*)
- **PNG** (*Portable Network Graphic*)
- **TIFF** (*Tagged Image File Format*)
- **BMP, PCX**, …

Raster (bitmap) vs. Vector graphics

Comparison of main image file formats

Format	File ext.	Main features	Application
JPEG	.jpg	Transform based, CR defined lossy compression (DCT)	Very good for compressing photographs
JPEG 2000	.jp2	New transform based, CR defined lossy compression (Discrete Wavelet Transform)	Excellent for compressing photographs, to replace JPEG
GIF	.gif	Indexed image format, max. 256 colours, lossless coding	Internet, animated GIFs
PNG	.png	Promoted by the www consortium to replace GIF	Internet, no animation (foreseen MNG), alpha channel, better for text images than JPEG
TIFF	.tif	Highly structured, complicated format,	Mainly for scanning text documents
BMP	.bmp	Simple uncompressed format	For use in Windows OS

Hands on – demo