

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.

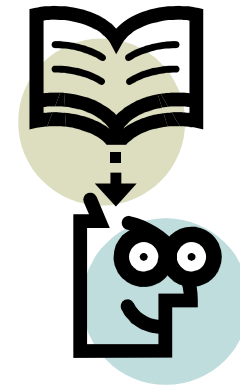
4. W. K. **Pratt**, Digital image processing, John Wiley & Sons, 1991.

5. A. **Materka**, Elements of image processing (in Polish), PWN, 1991.

Assesment method:

Theory:

- written examination (50%).



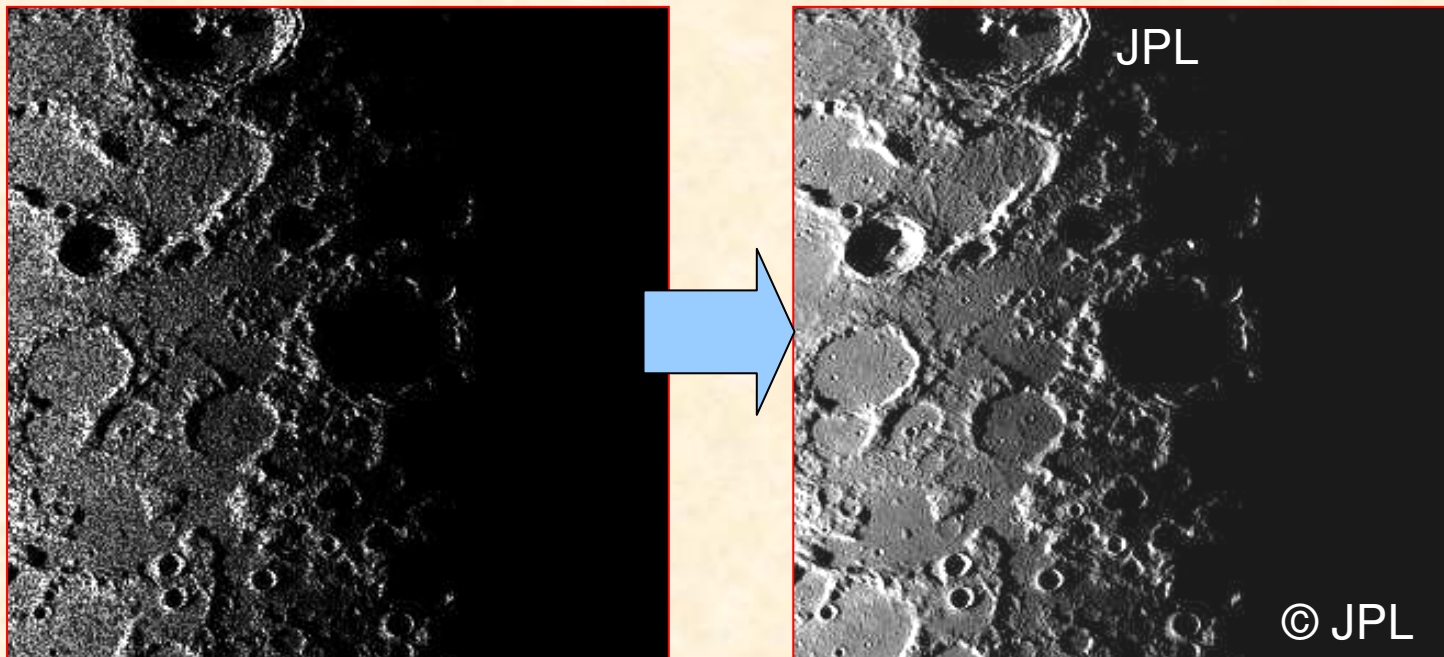
Practice:

- 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



© MIT

Objectives of image processing

Processing of image data for machine perception, storage or transmission

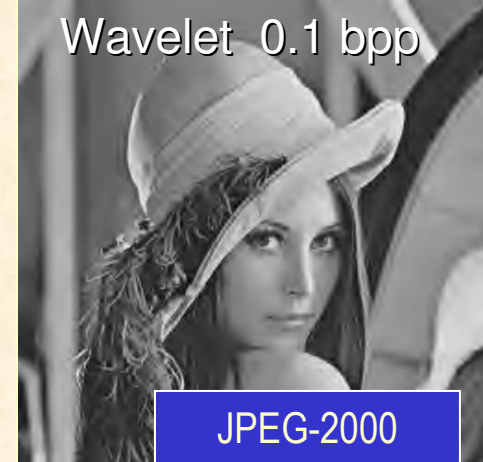
(e.g. first application of image processing techniques has enabled reduction of transmission time of an image across the Atlantic from one week to less than 3 hours)



8 bpp



JPEG 0.1 bpp



Wavelet 0.1 bpp

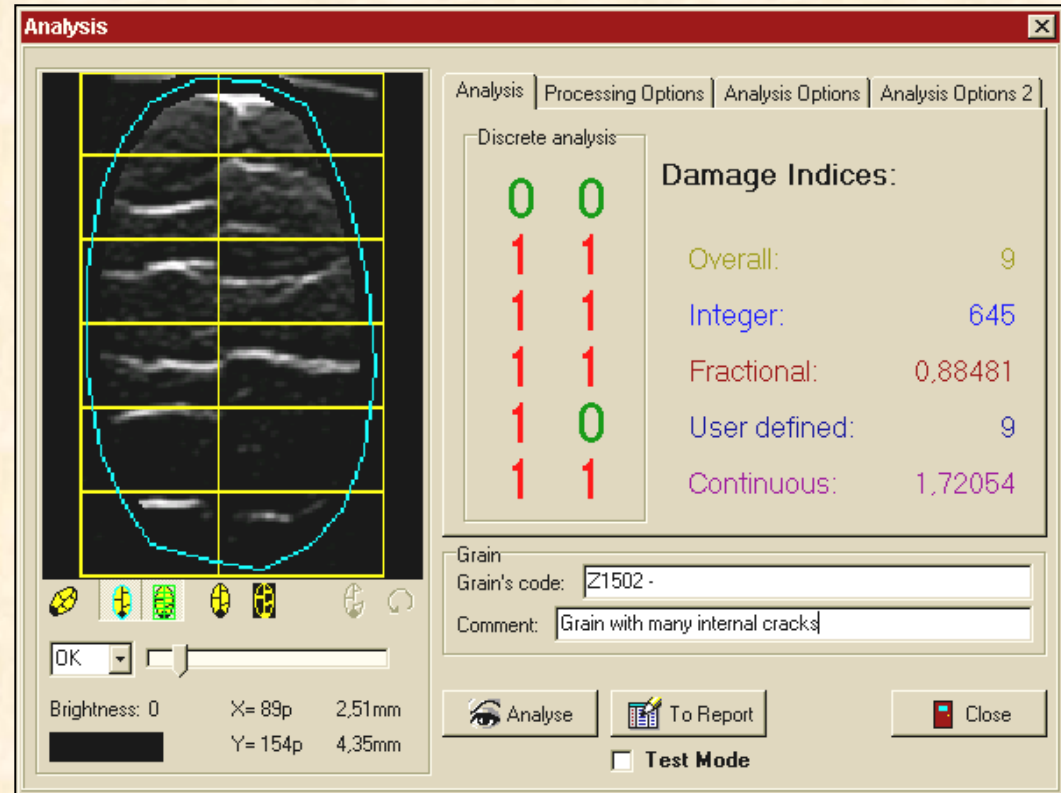
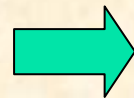
JPEG-2000

Objectives of image processing

Improvement of subjective image quality for human interpretation



X-ray image of wheat grain



The software interface displays a processed X-ray image of a wheat grain with a grid overlay. The analysis results are as follows:

Discrete analysis	
0	0
1	1
1	1
1	1
1	0
1	1

Damage Indices:

Overall:	9
Integer:	645
Fractional:	0,88481
User defined:	9
Continuous:	1,72054

Grain
Grain's code: Z1502
Comment: Grain with many internal cracks

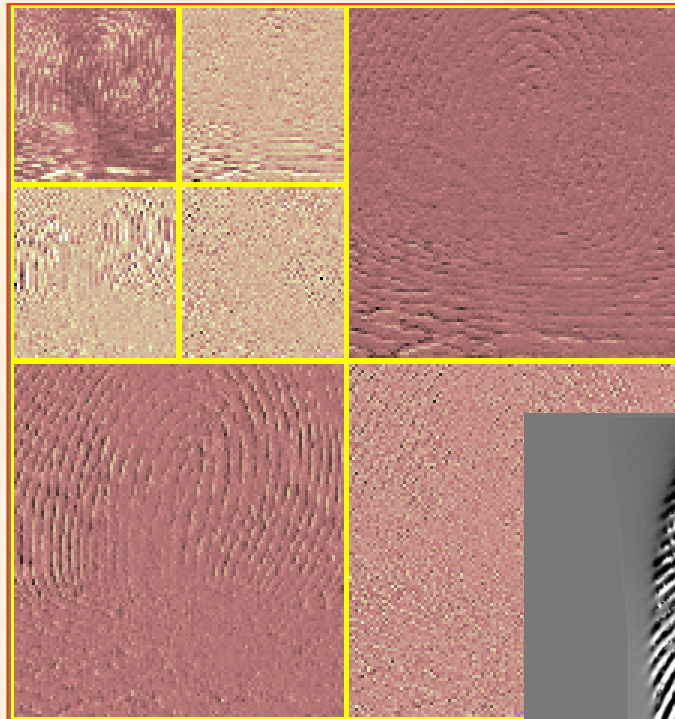
Buttons: Analyse, To Report, Close

Test Mode

Brightness: 0
X= 89p 2,51mm
Y= 154p 4,35mm

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

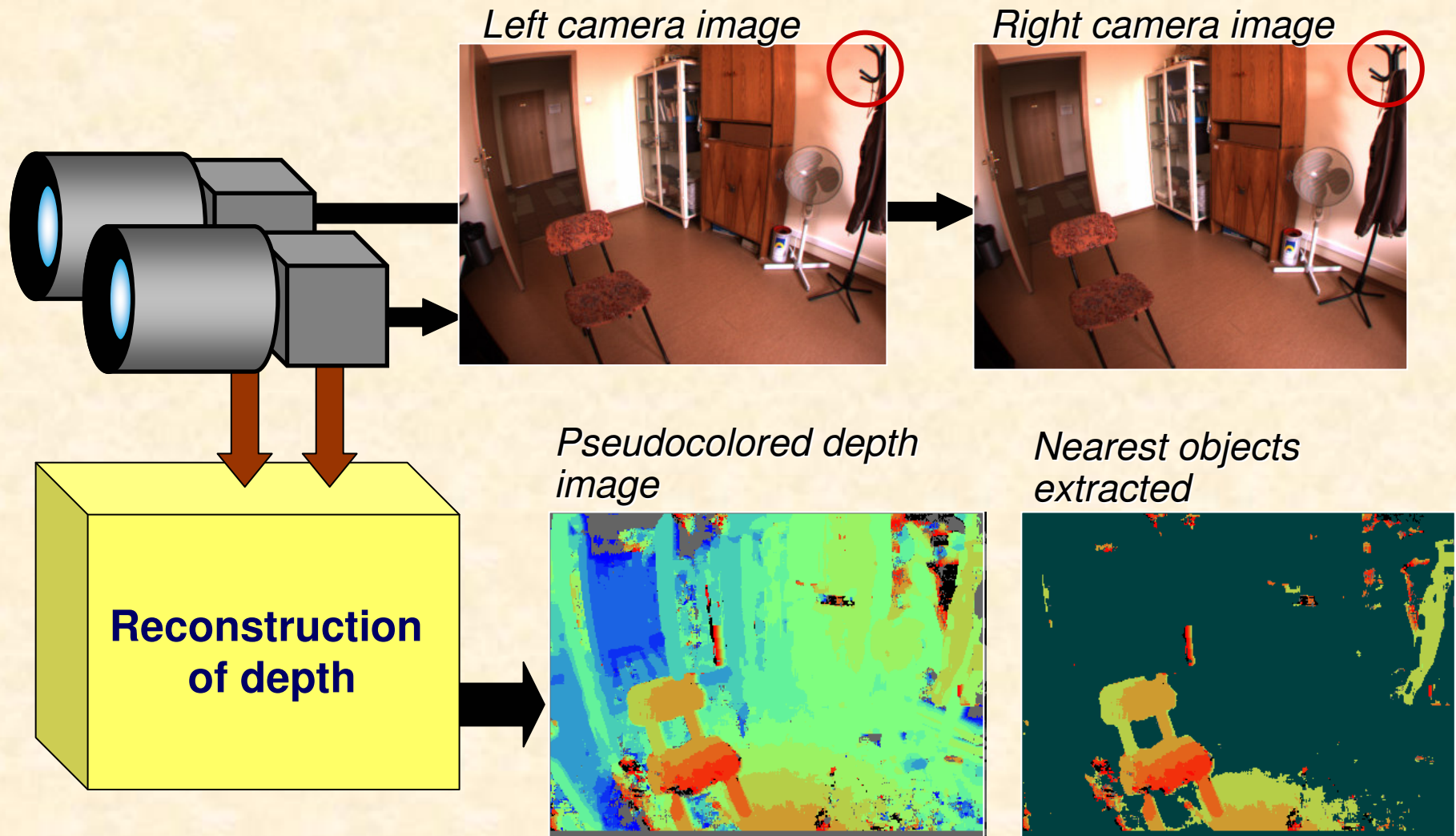
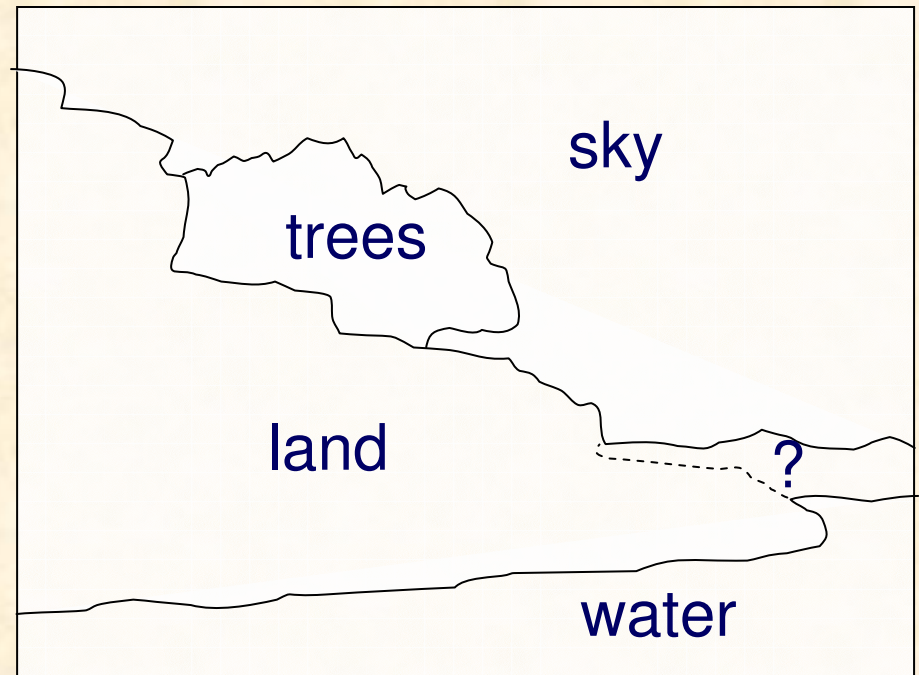
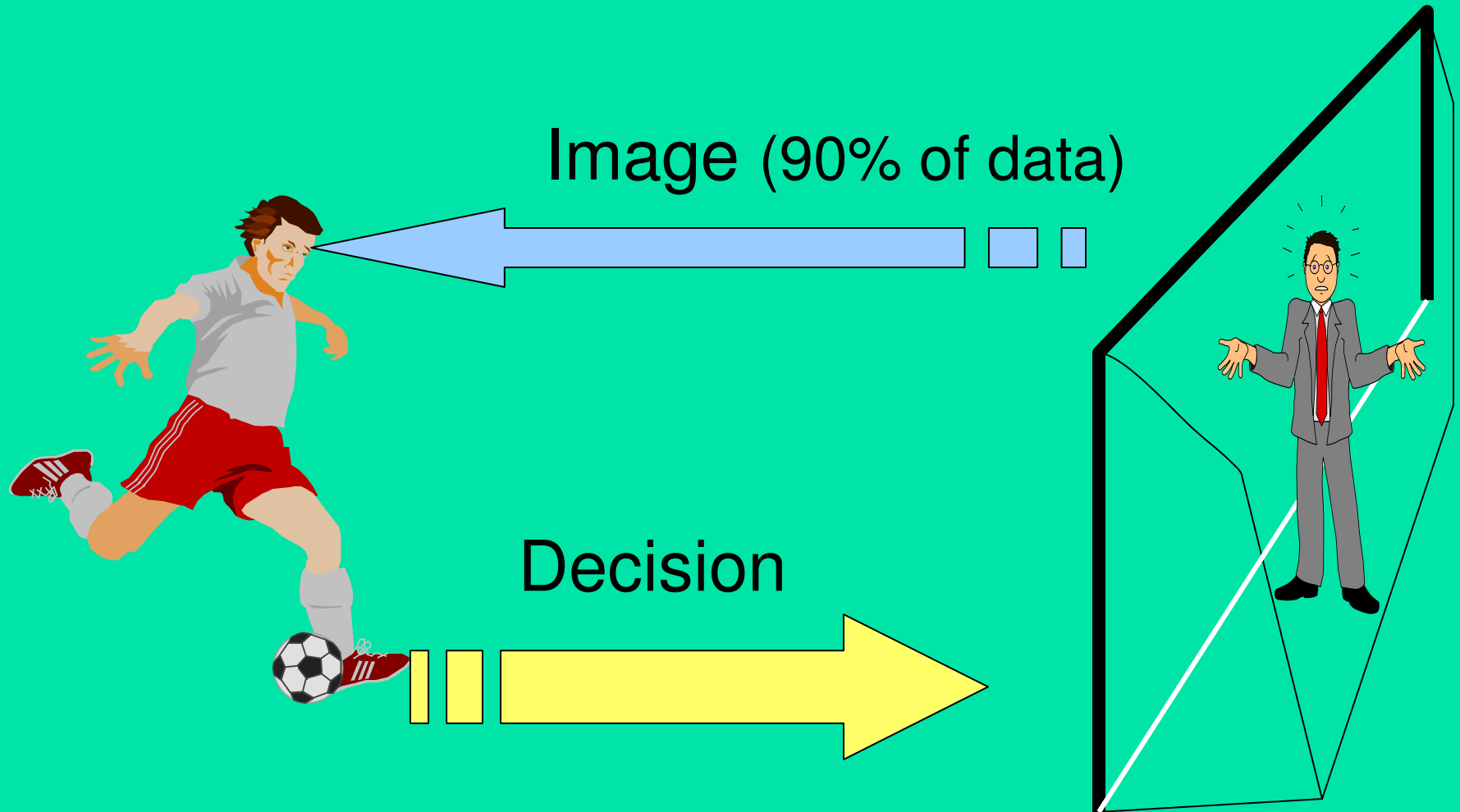


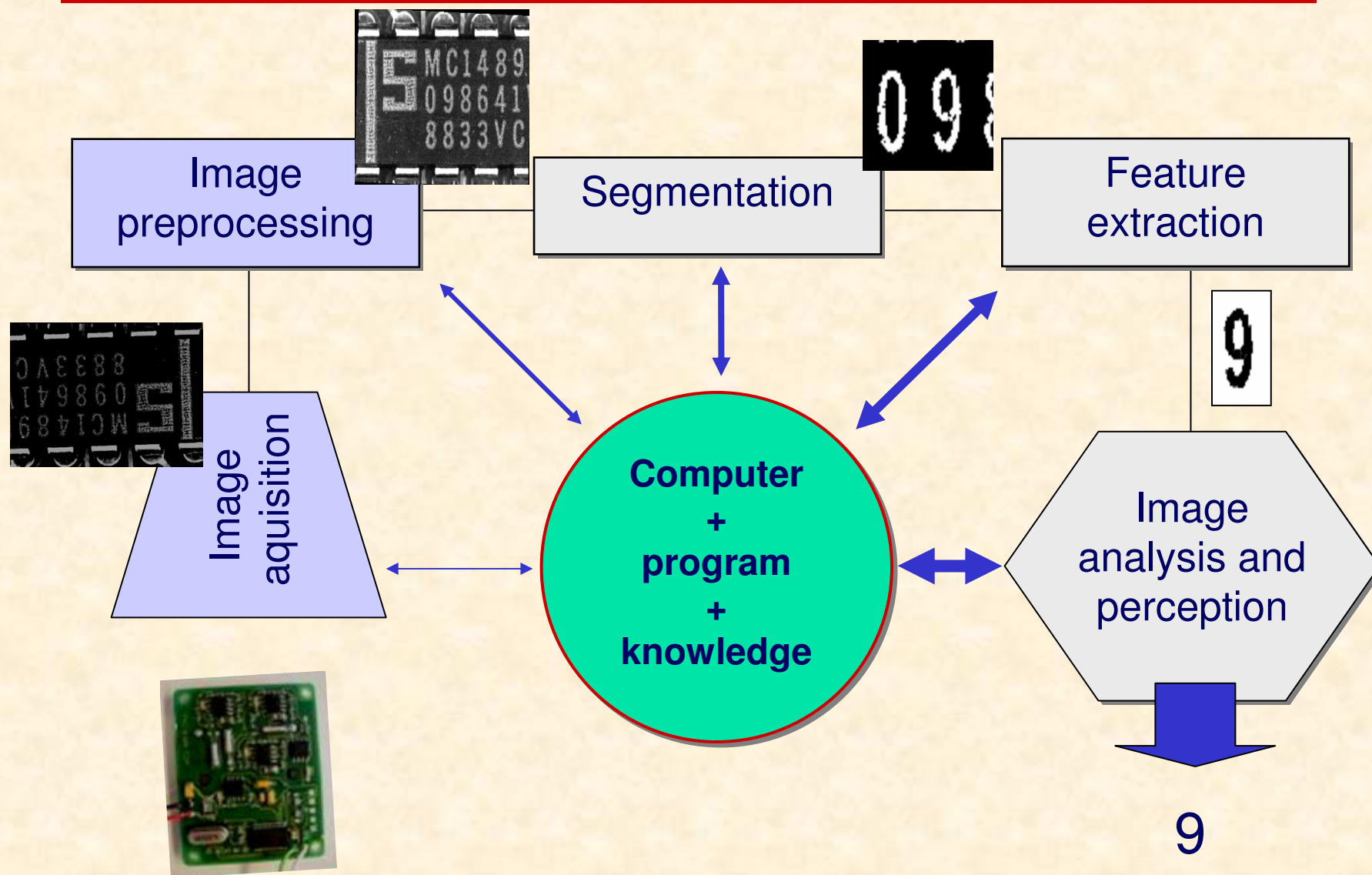
Image understanding



Natural image processing scheme



Computer vision system



Course material:

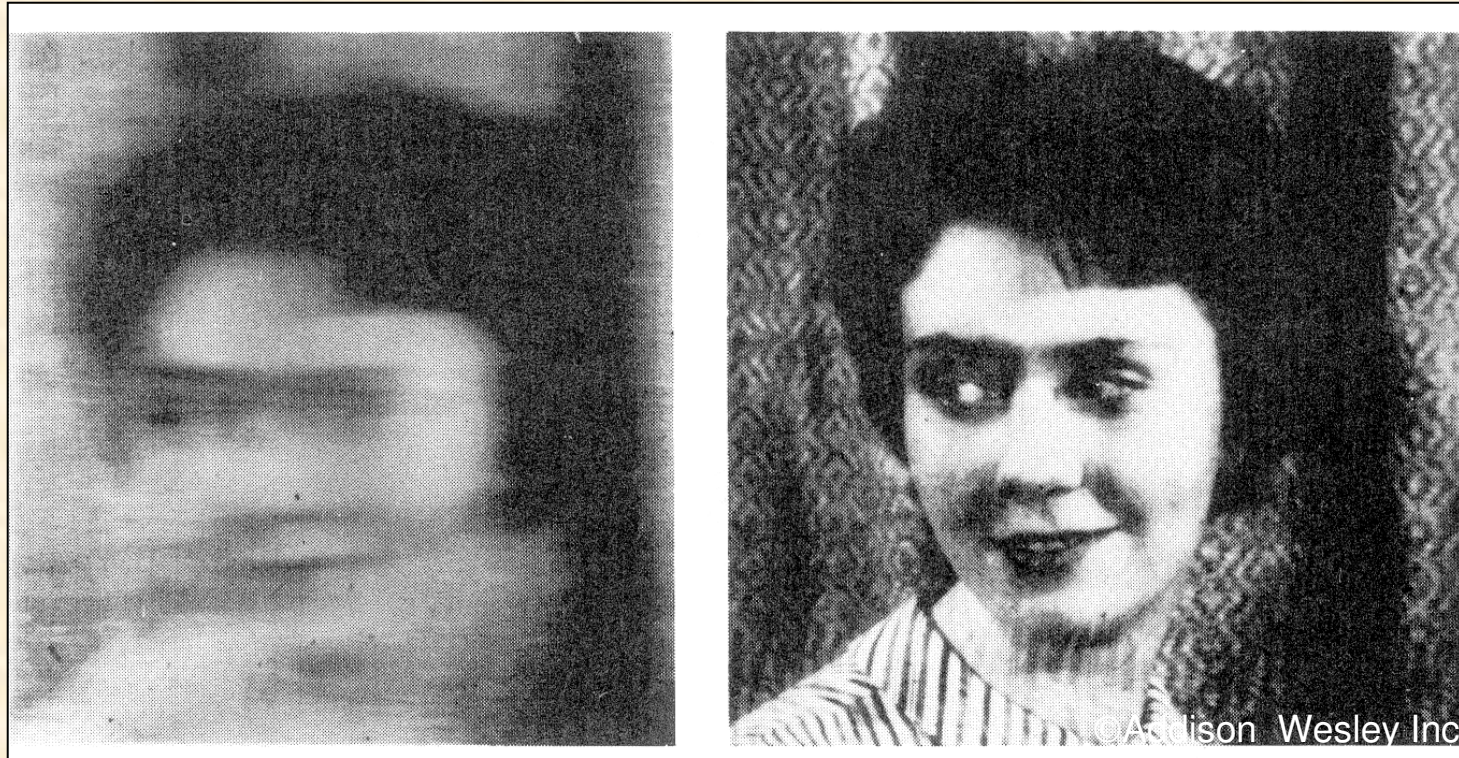
1. Image acquisition and representation
2. Image enhancement
3. Image restoration
4. Image analysis
5. Image coding
6. Stereovision

Image enhancement



Gray-scale transformation

Image restoration



motion blur

restored image

Image analysis

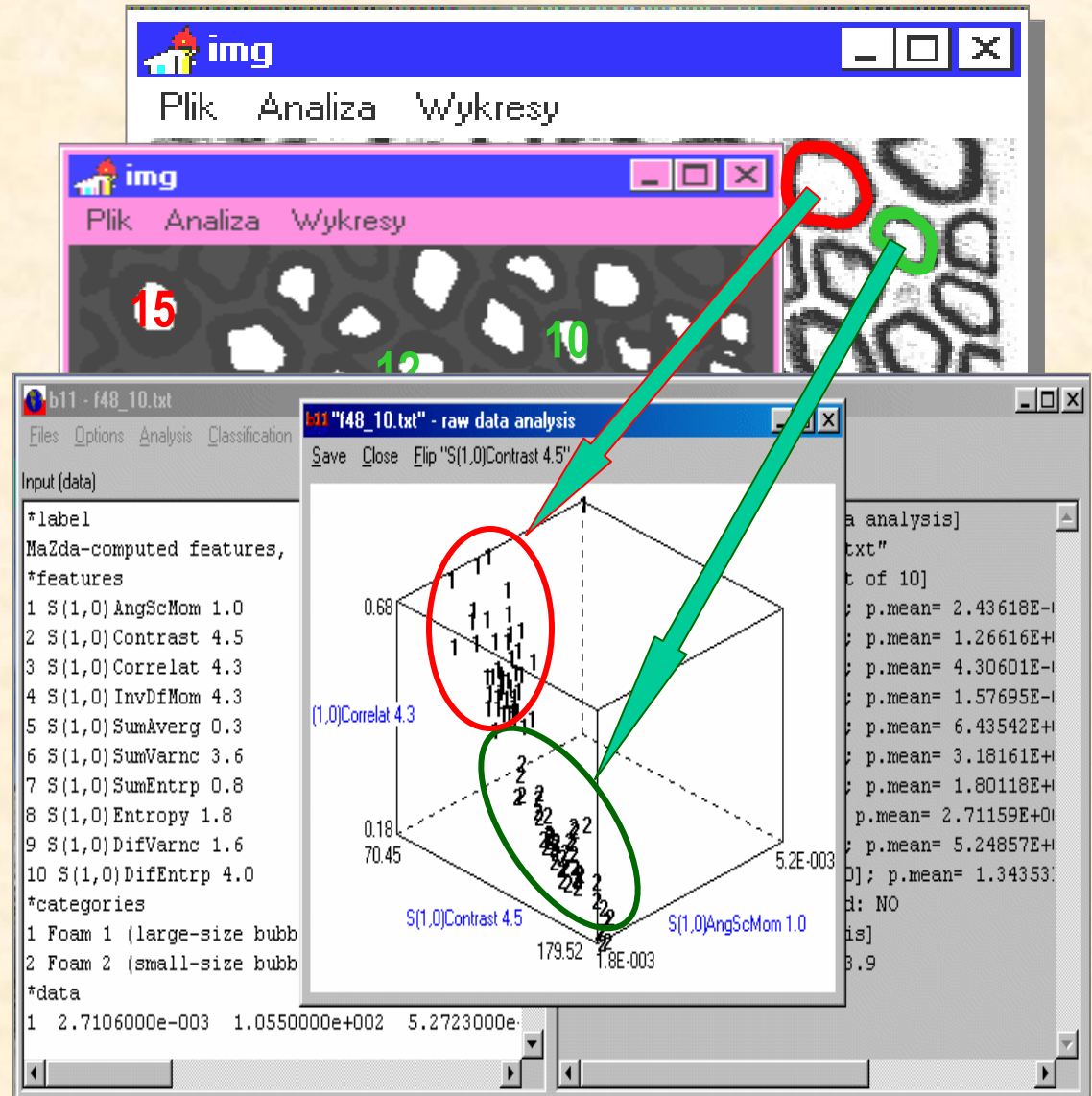
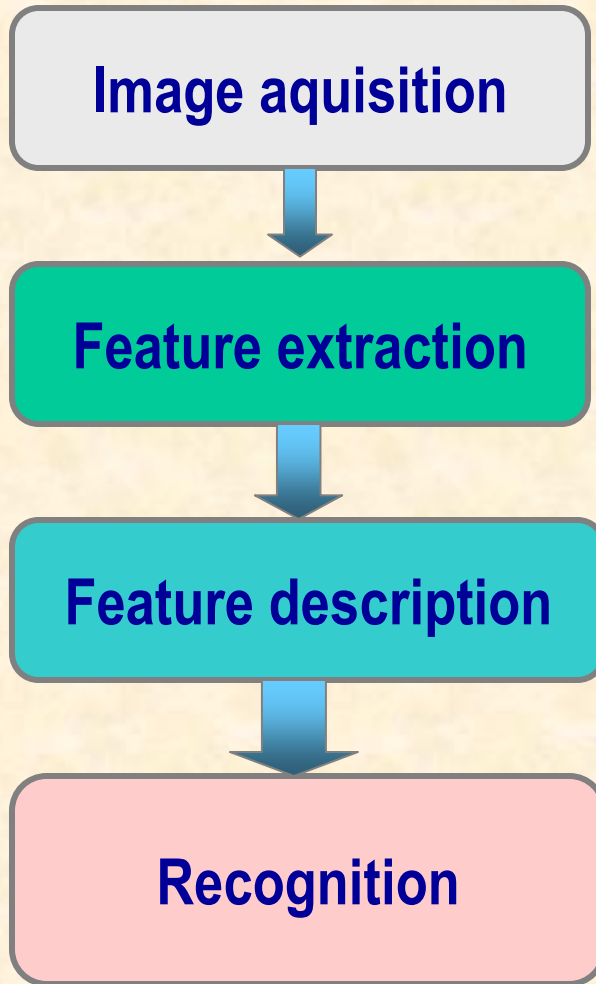
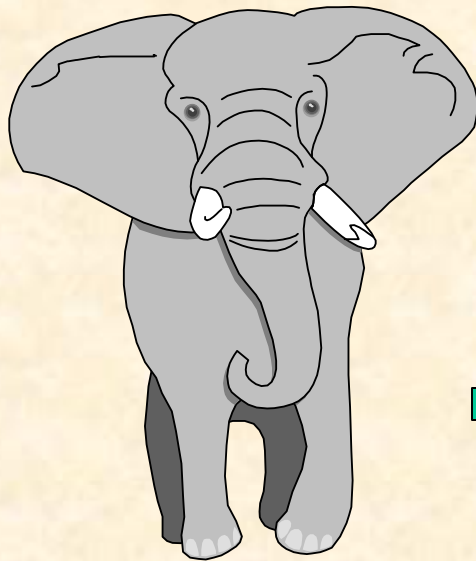


Image compression (JPEG, MPEG, JPEG2000)

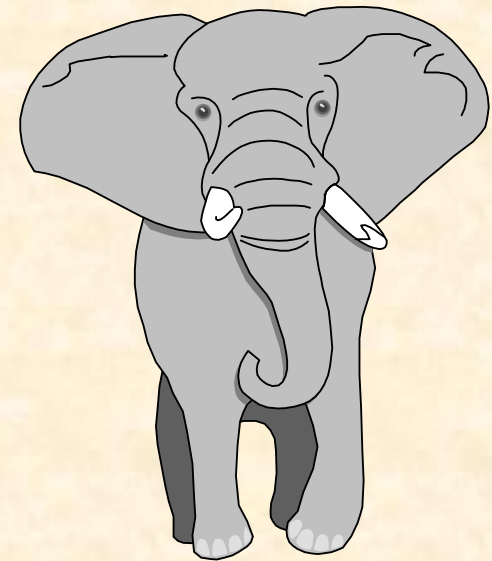
i.e. how to push an elephant through a pin-hole



Source image



**Transmission
channel**

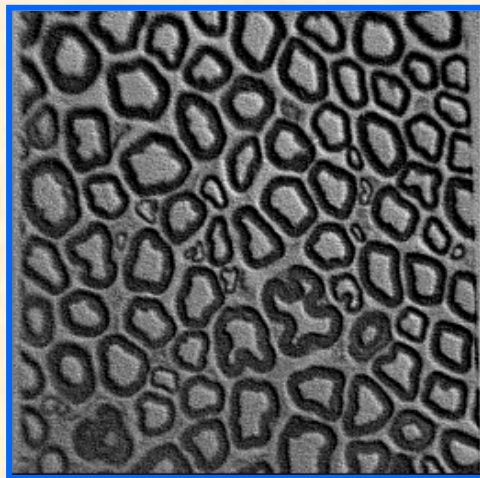
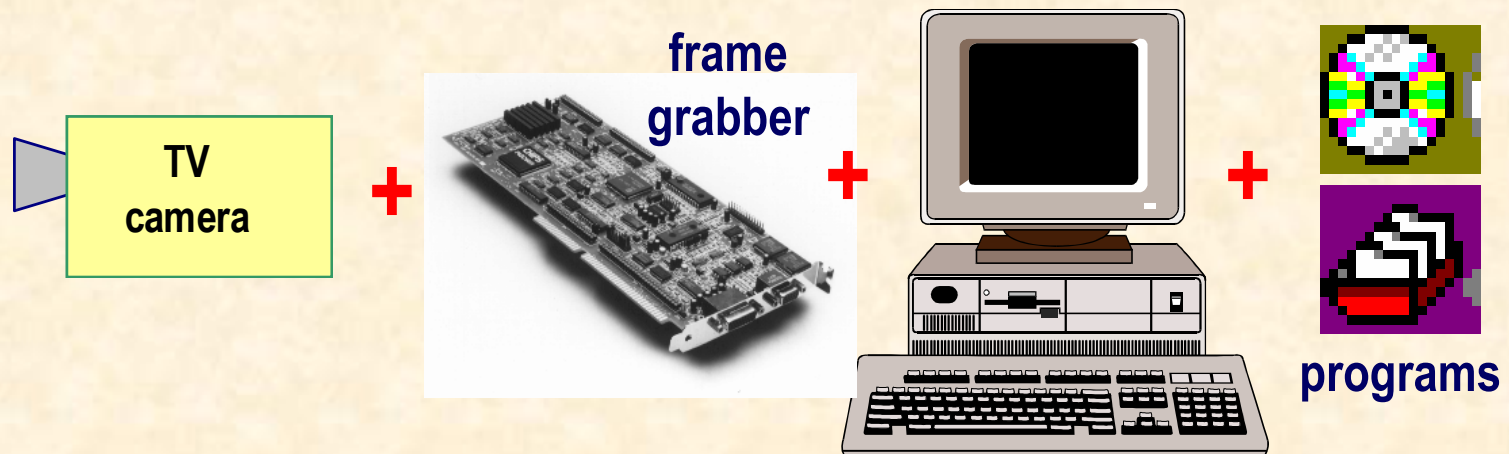


**Reconstructed
image**

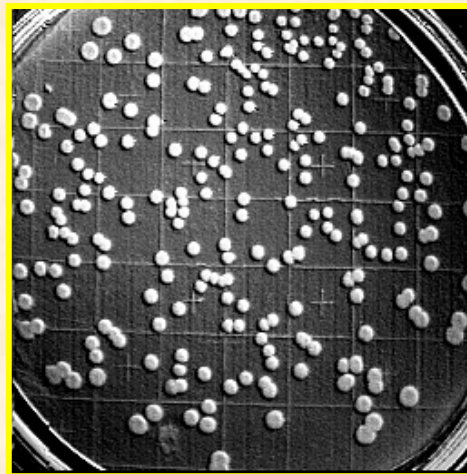
Image processing systems - applications

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

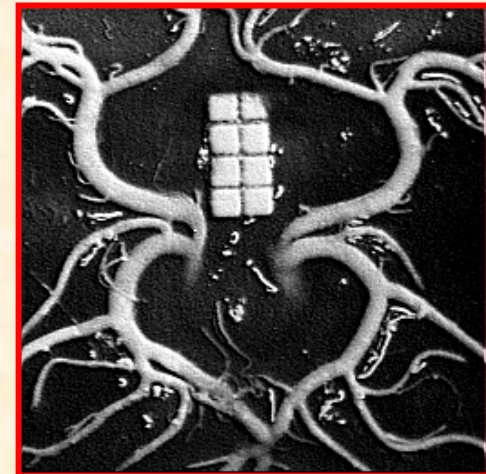
Image processing system developed at the Medical Electronics Division, Institute of Electronics in (1989)



Microscope image
of a nerve tissue



Bacteria colony image



Latex model of brain veins

Analysis of documents

Studia:	Dzienne <input checked="" type="checkbox"/>	Wieczorowe <input type="checkbox"/>	Zaoczne <input type="checkbox"/>		
Kurs:	doktorski <input type="checkbox"/>	magisterski <input type="checkbox"/>	Inżynierski <input checked="" type="checkbox"/>	inny <input type="checkbox"/>	
Zajęcia:	wykład <input type="checkbox"/>	ćwiczenia <input checked="" type="checkbox"/>	laboratorium <input type="checkbox"/>	projekt <input type="checkbox"/>	seminarium <input type="checkbox"/>

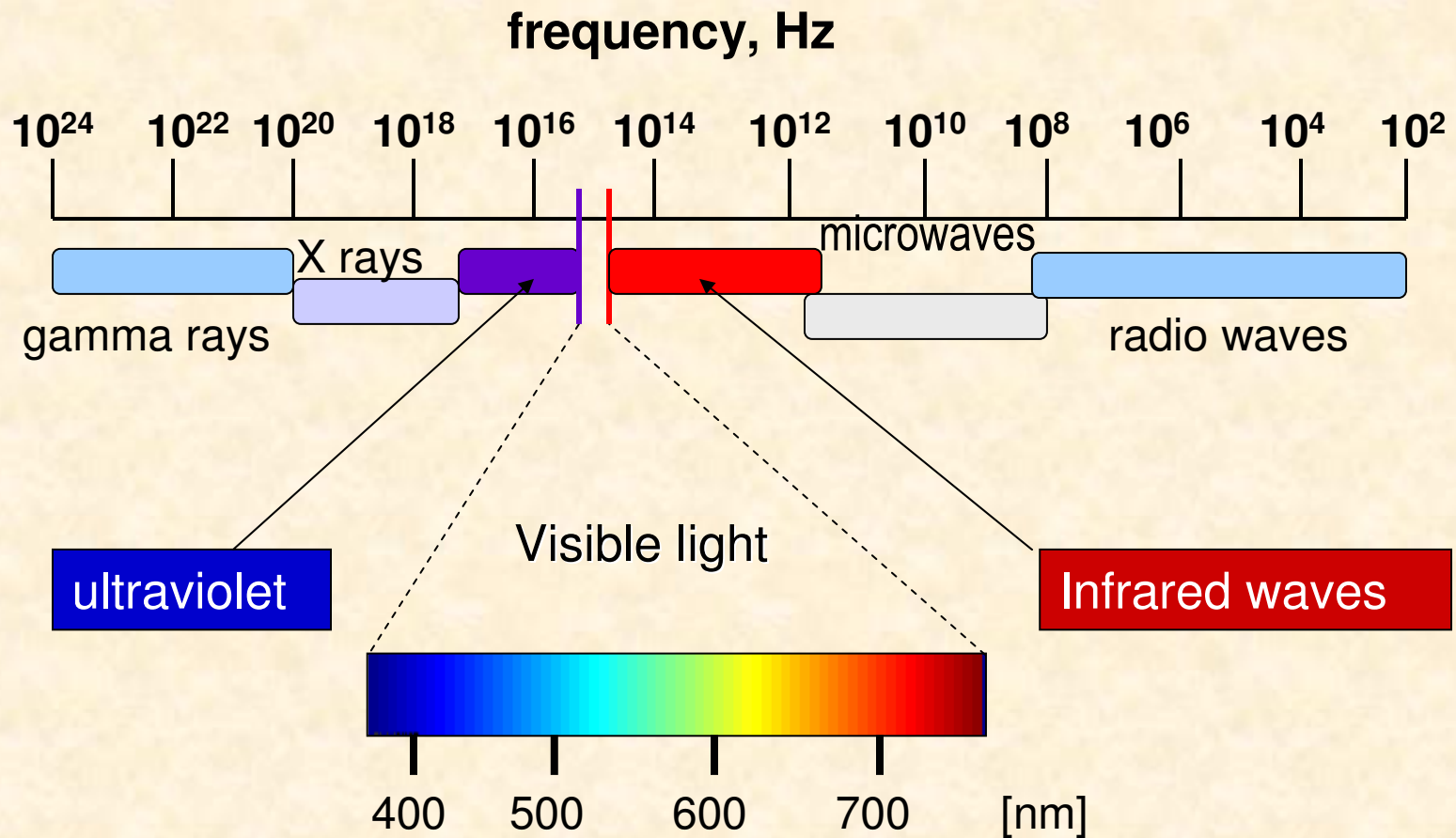
	TAK	raczej TAK	raczej NIE	NIE
1. Czy treść zajęć była przedstawiona zrozumiale?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Czy zajęcia były dobrze zorganizowane?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input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

Student questionnaire

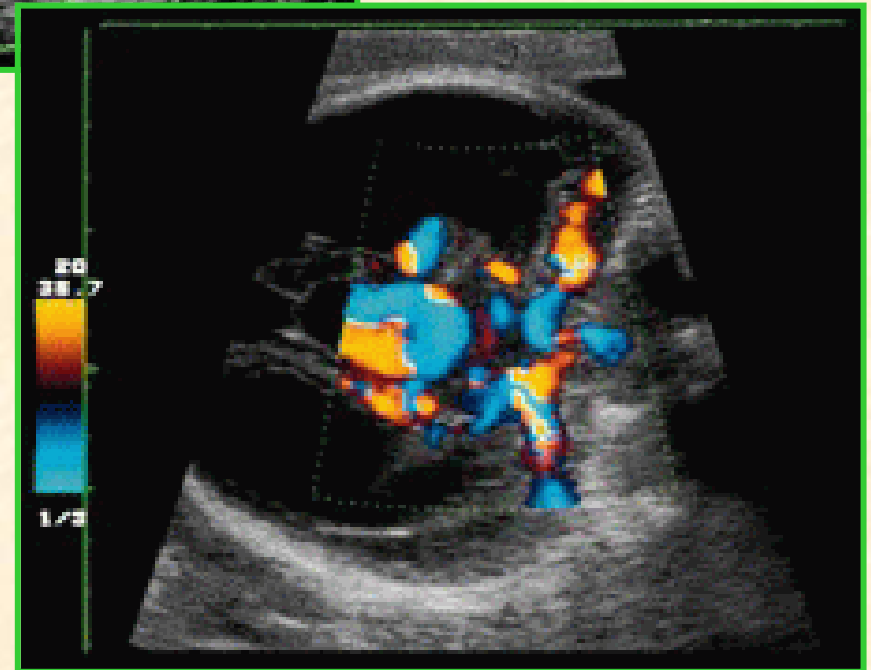
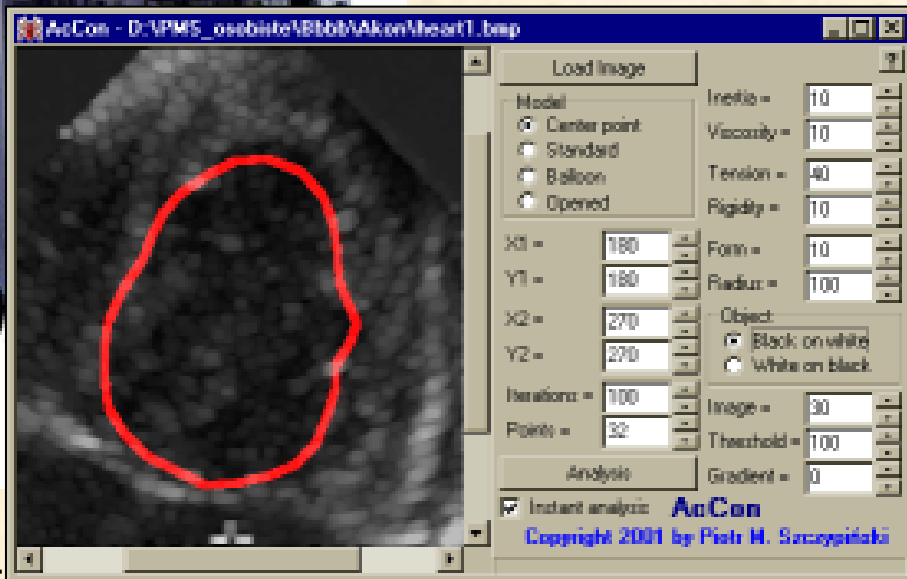
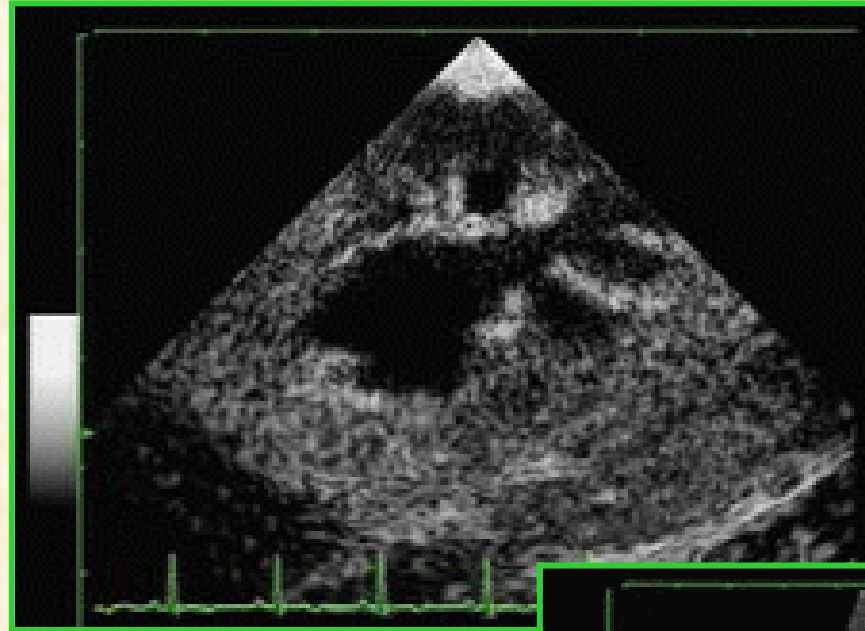
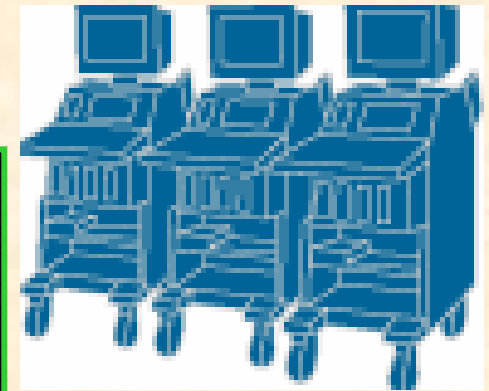
Kurs:	doktorski <input type="checkbox"/>	magisterski <input type="checkbox"/>	Inżynierski <input checked="" type="checkbox"/>	inny <input type="checkbox"/>	
Zajęcia:	wykład <input type="checkbox"/>	ćwiczenia <input checked="" type="checkbox"/>	laboratorium <input type="checkbox"/>	projekt <input type="checkbox"/>	seminarium <input type="checkbox"/>

	TAK	raczej TAK	raczej NIE	NIE
1. Czy treść zajęć była przedstawiona zrozumiale?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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9. Czy dostępne materiały pomocnicze oceniasz jako wystarczające?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

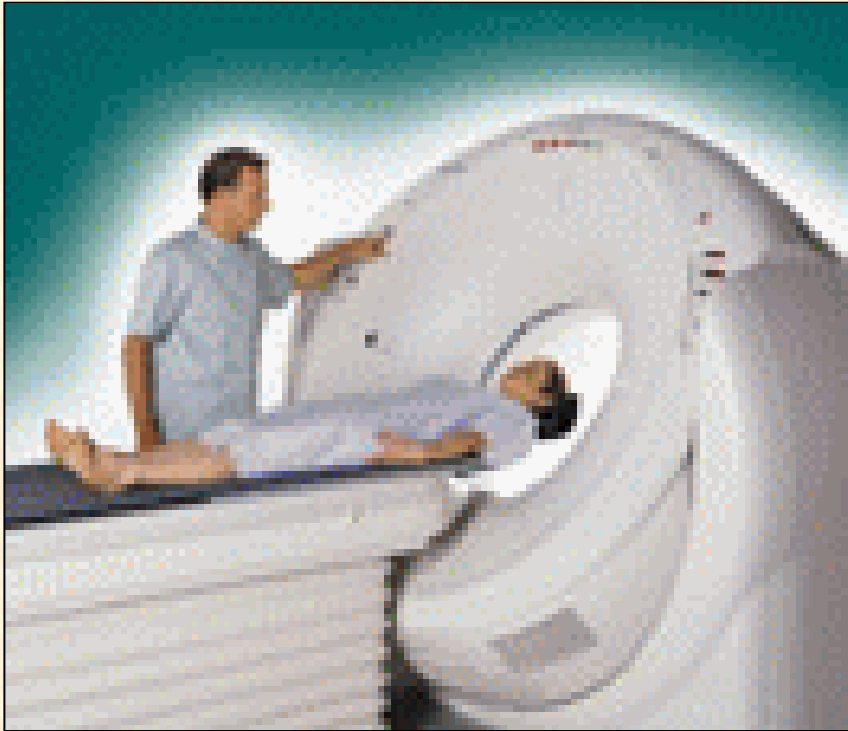
Electromagnetic spectrum



Ultrasonography



Computed tomography



PICKER

FL

Magnetic resonance imaging (MRI)

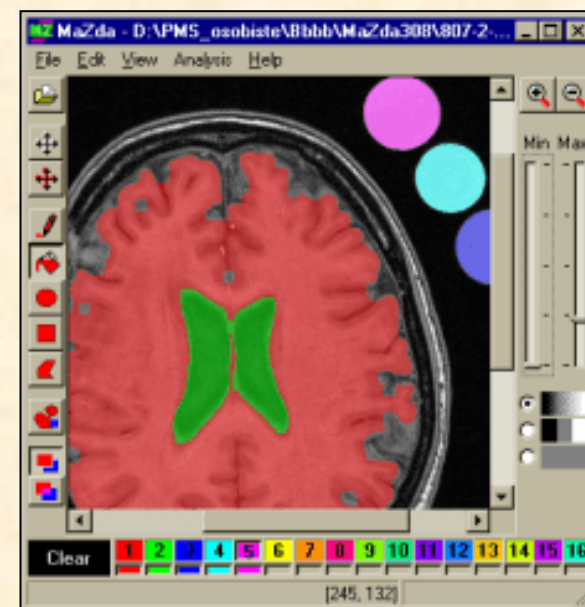
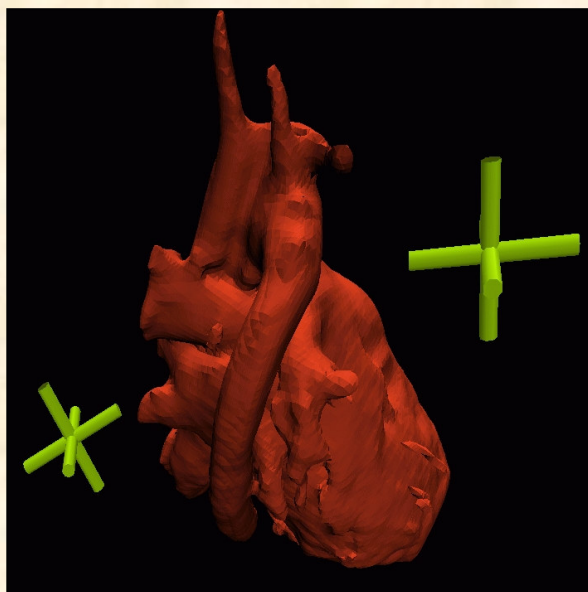
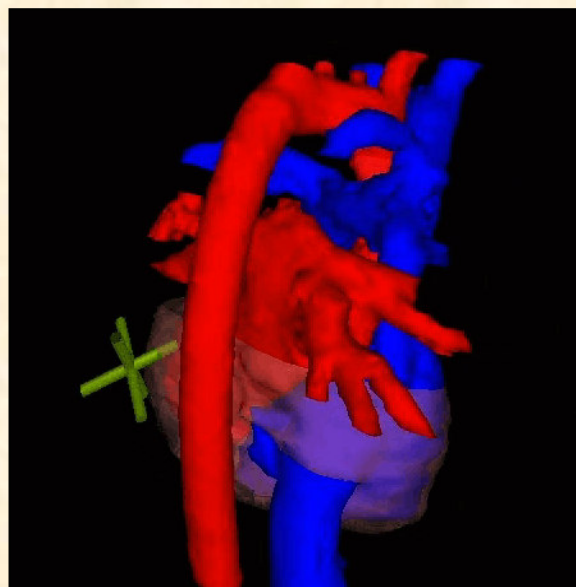
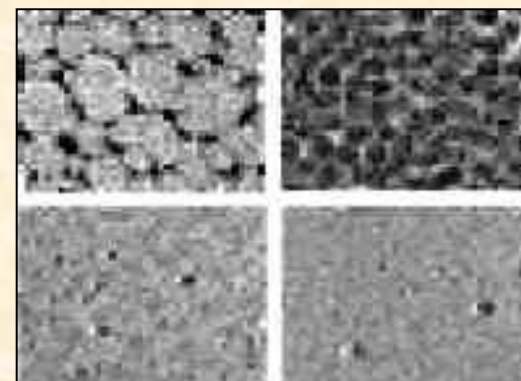


Magnetic resonance imaging (MRI)

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

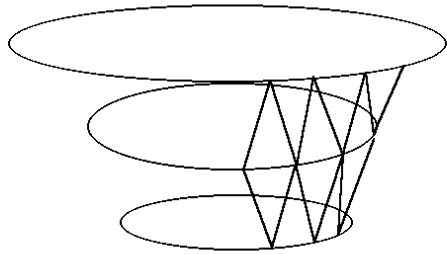
COST B21

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

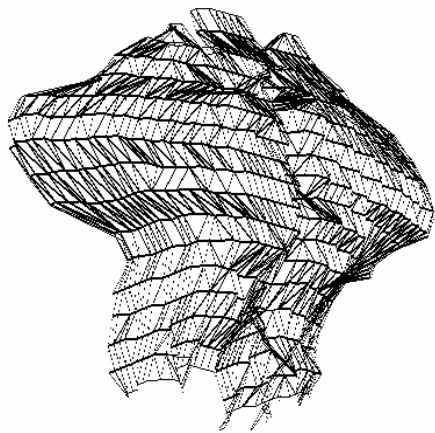


Computer graphics

3D objects modelling



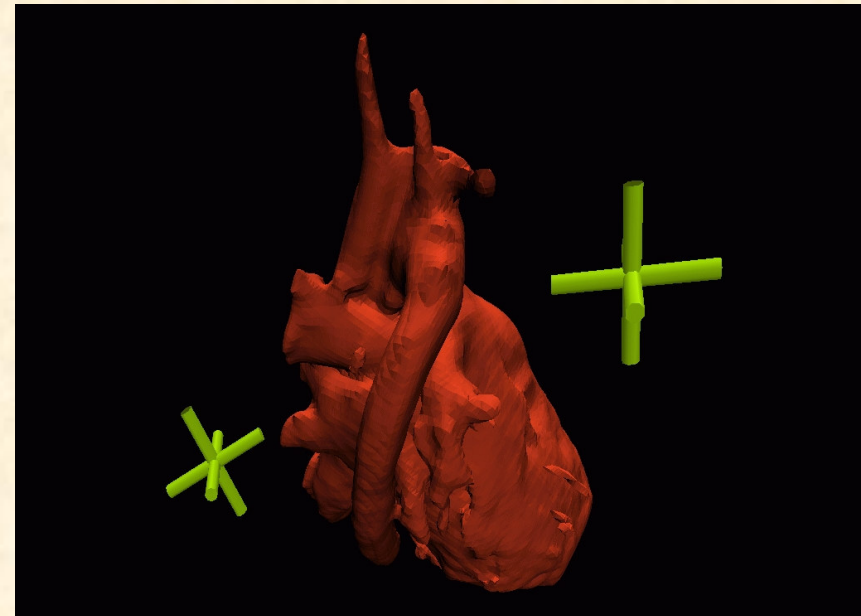
Reconstruction



Surface rendering



3D visualisation

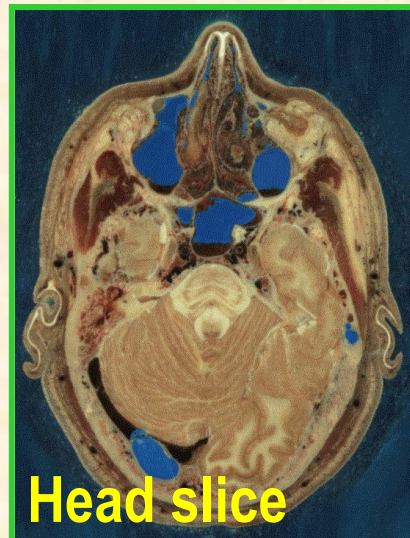
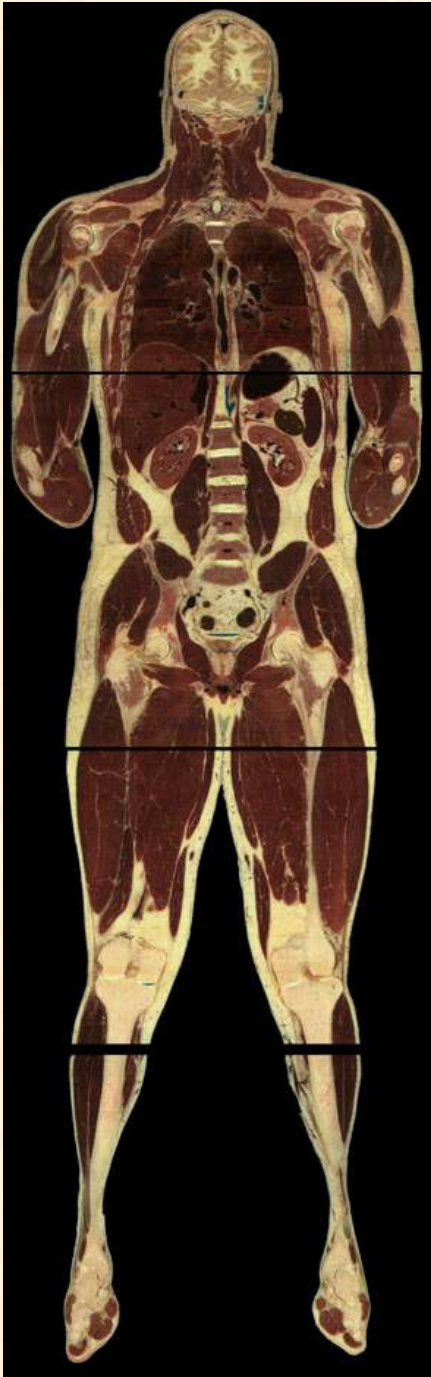


Virtual reality

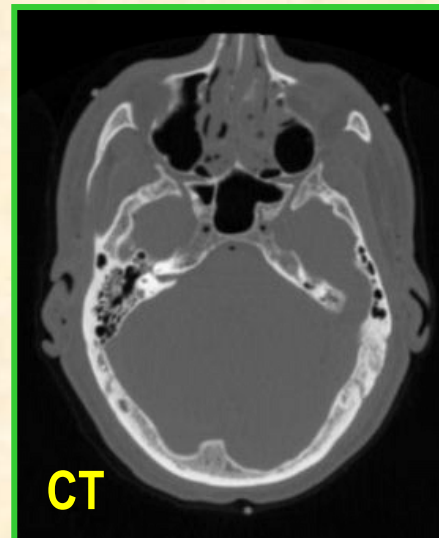
The Visible Human Project

The National Library of Medicine's
Visible Human Project (TM)

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



Head slice



CT



MRI

Computed thermography

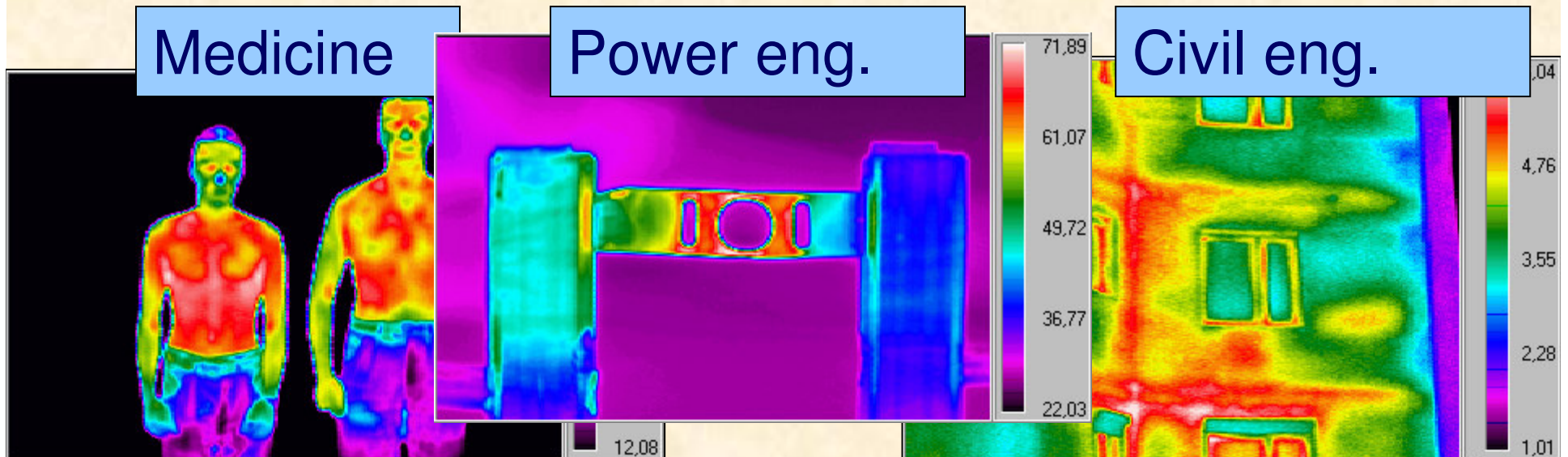
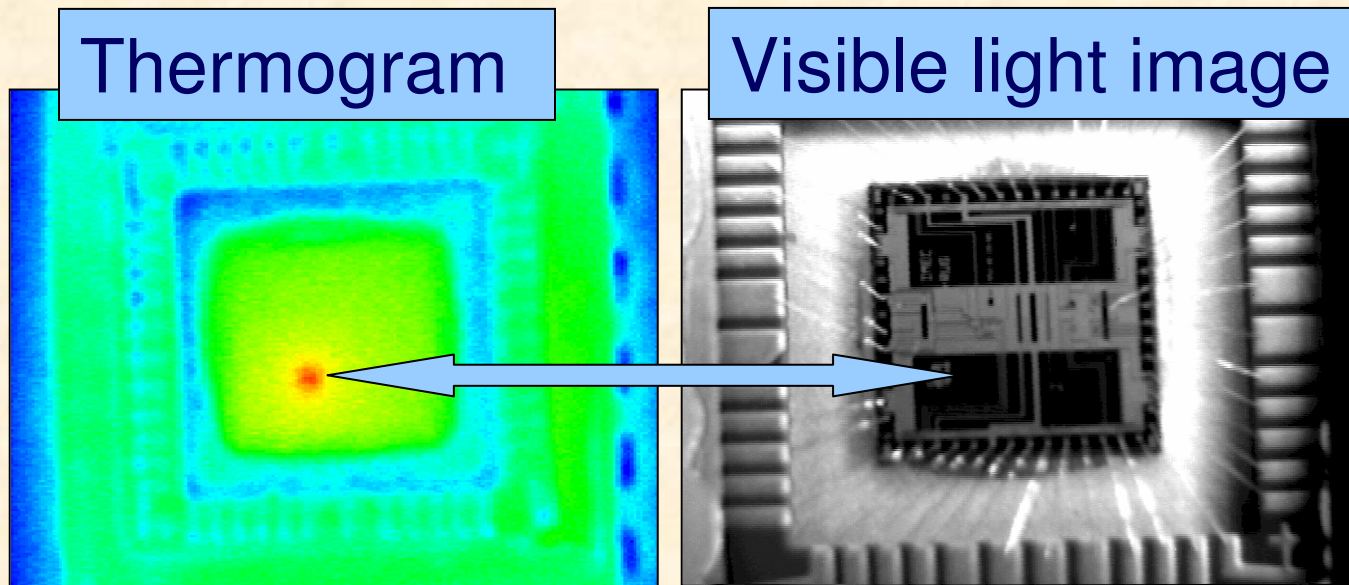


Image processing applications: mammography

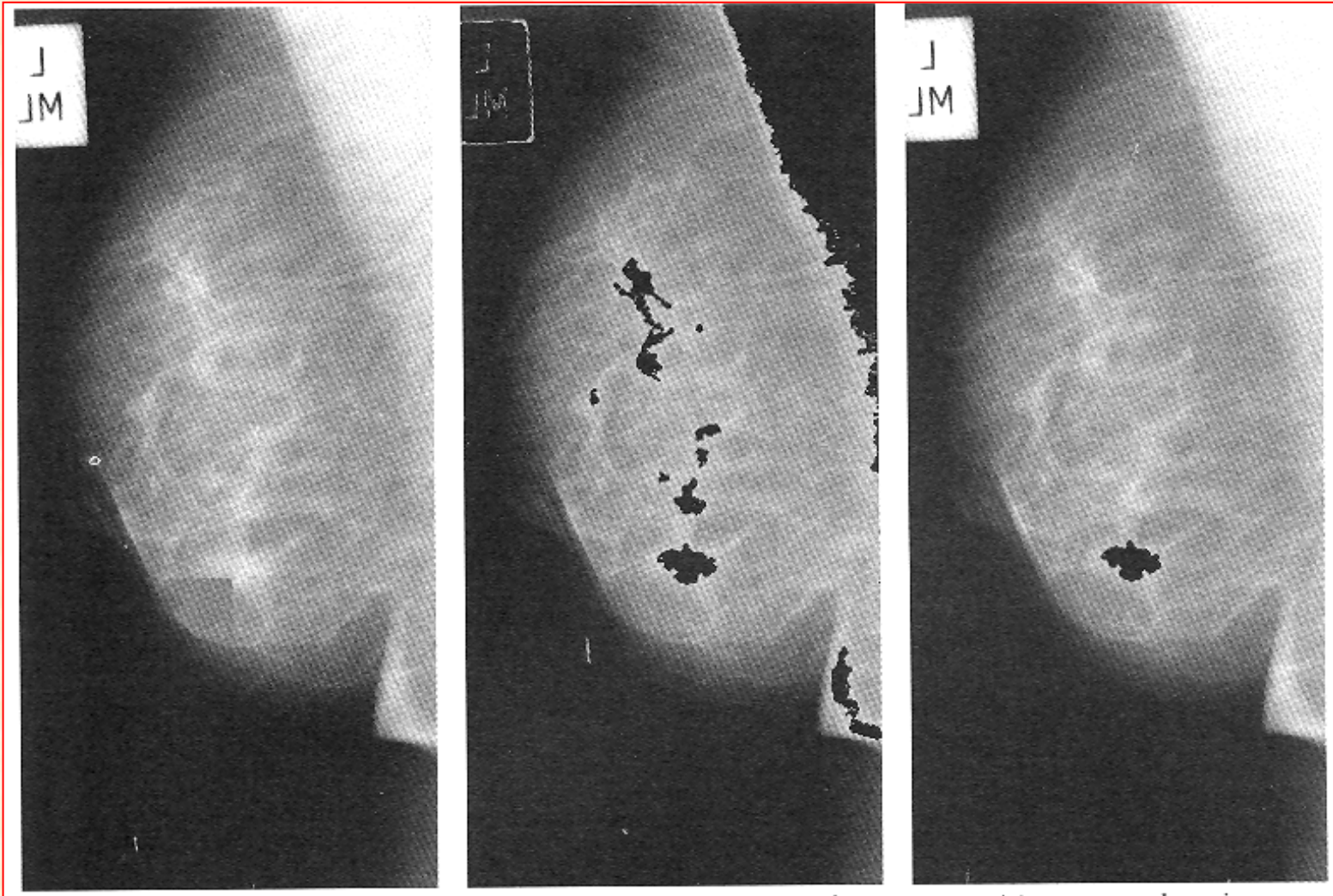
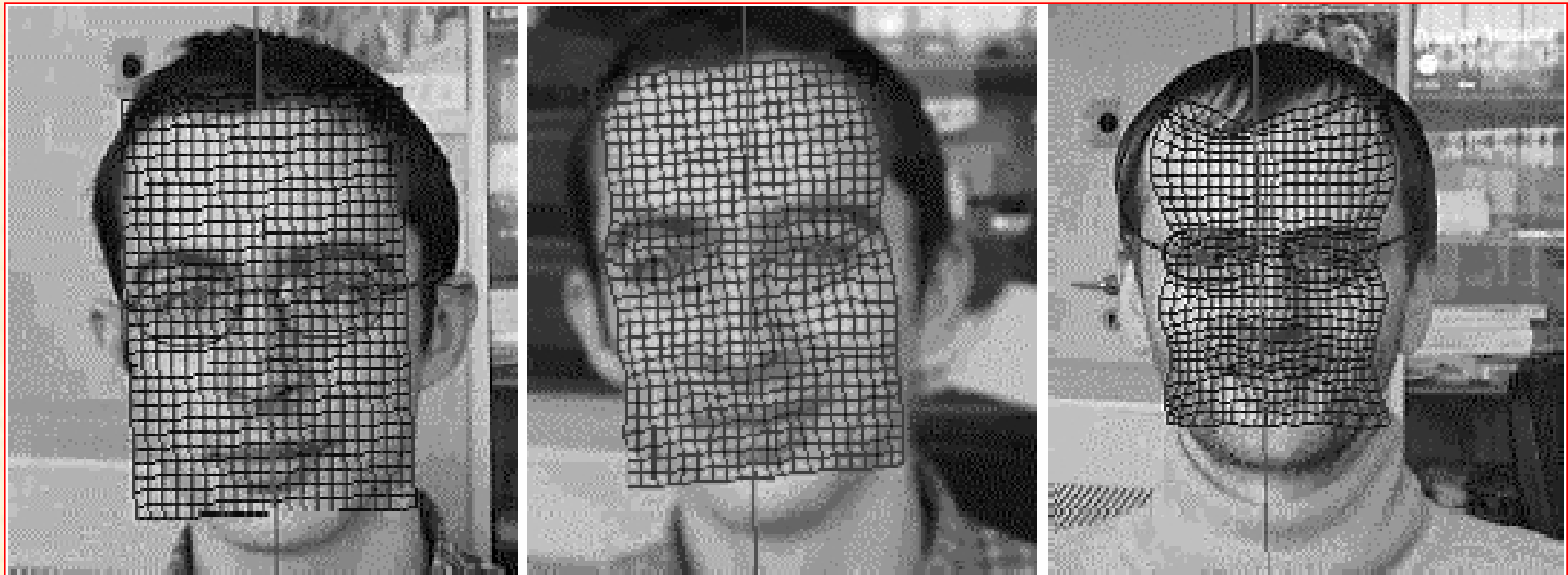
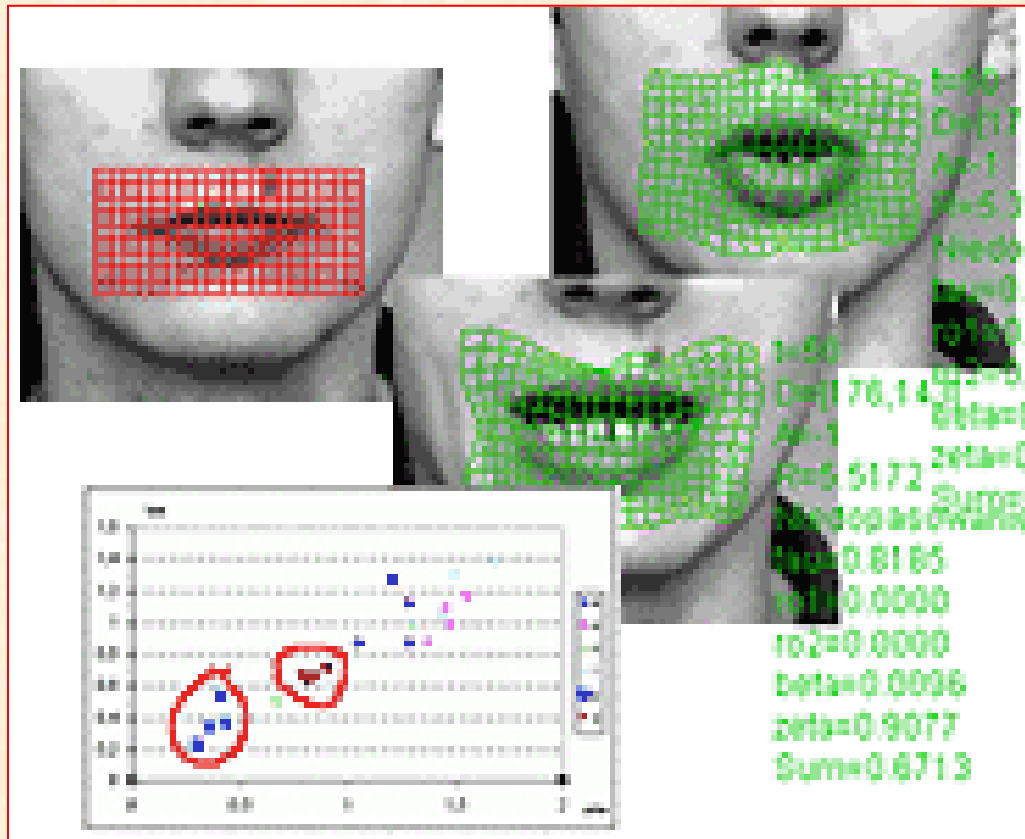


Image processing applications: biometrics



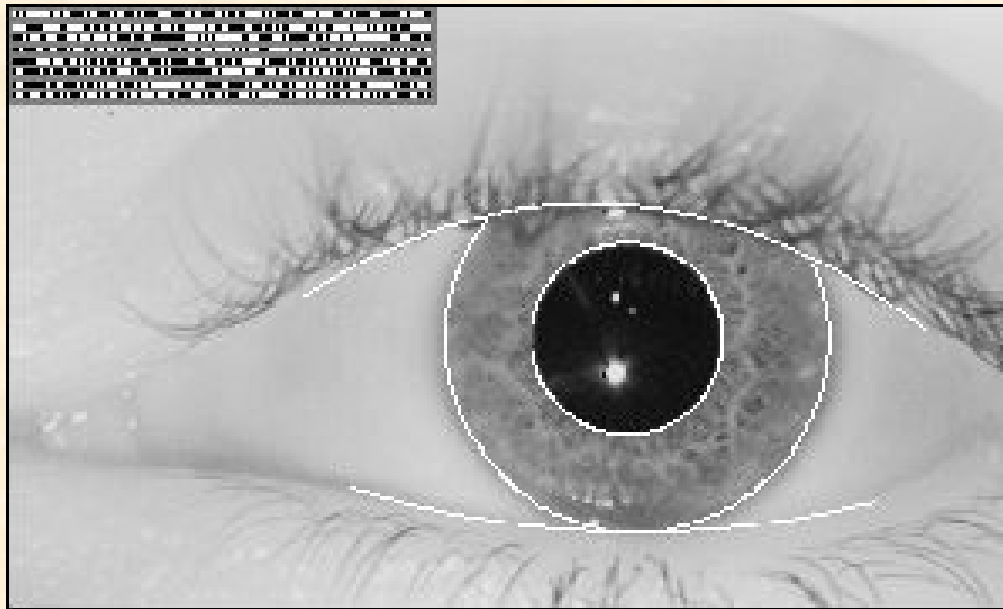
Juliusz Jaksa, Krzysztof Ślot, Piotr Szczypiński „**Face recognition using deformable models**”, ICSES'2001

Image processing applications



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

Image processing applications: biometrics



© J. Daugman

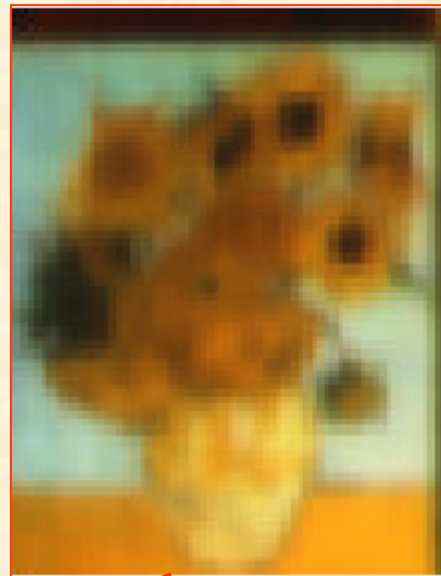
Image processing applications: image databases

a „concept” of
an image



or

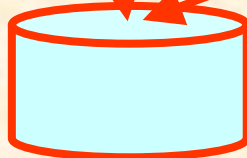
a copy of an image



database hit

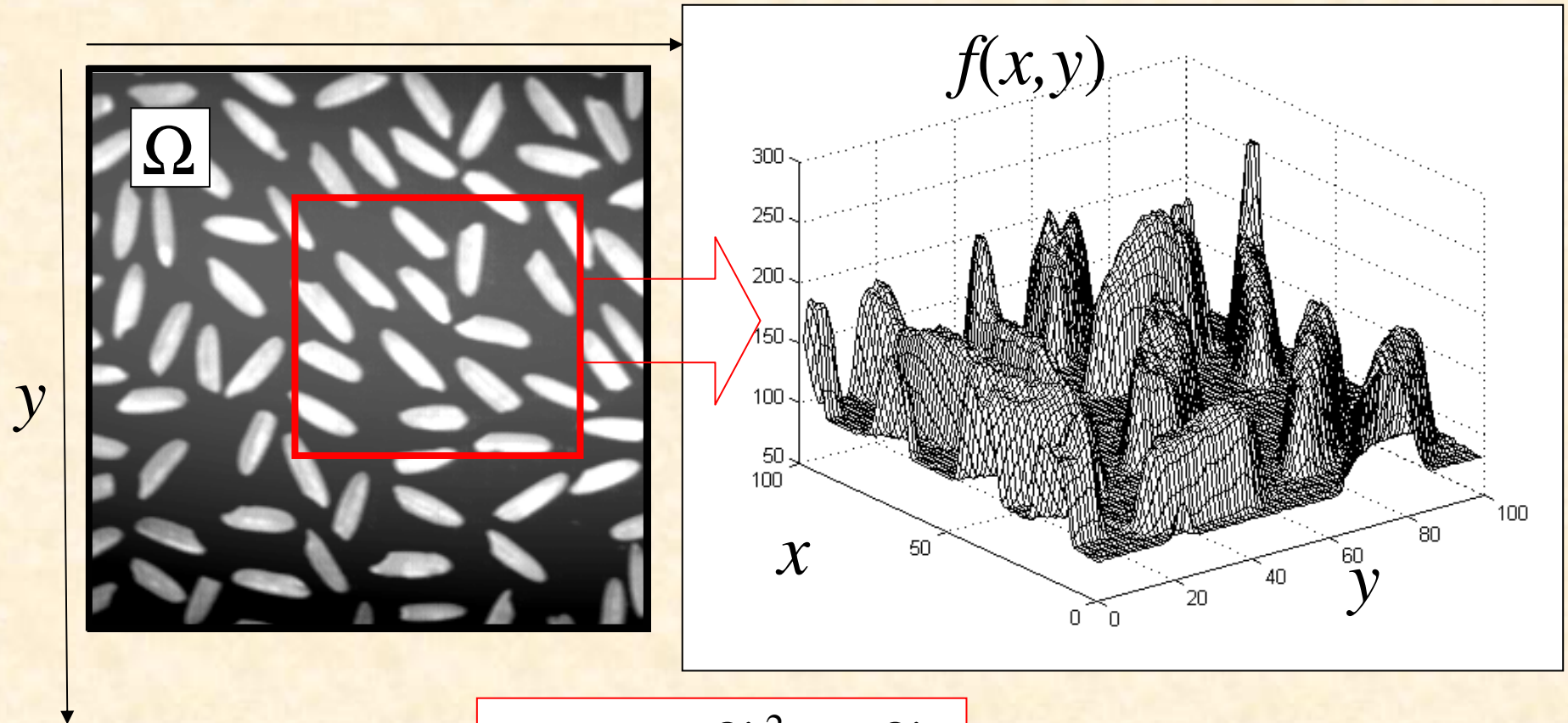


DWT



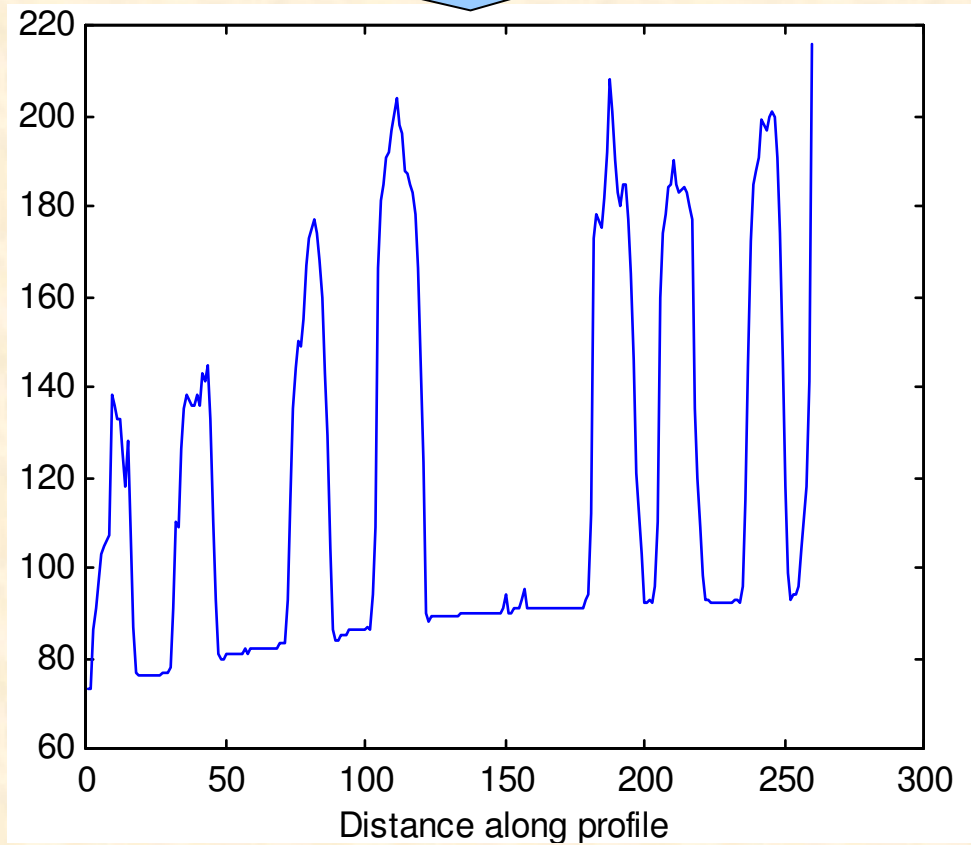
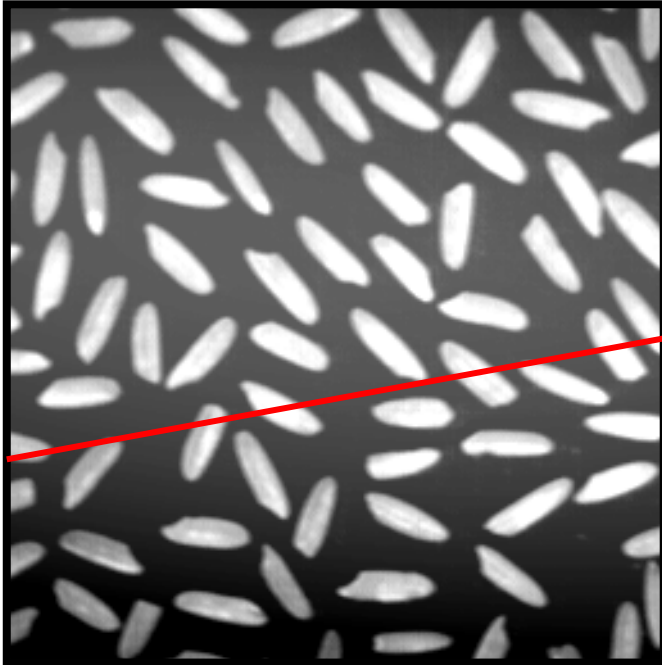
*C.E. Jacobs, A. Finkelstein, D.H. Salesis,
„Fast multiresolution image quering”, 1999*

Monochrome image as a 2D function

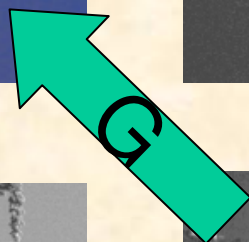


$$M : \Omega \subset \mathbb{R}^2 \rightarrow \mathbb{R}_+$$
$$(x, y) \rightarrow f(x, y)$$

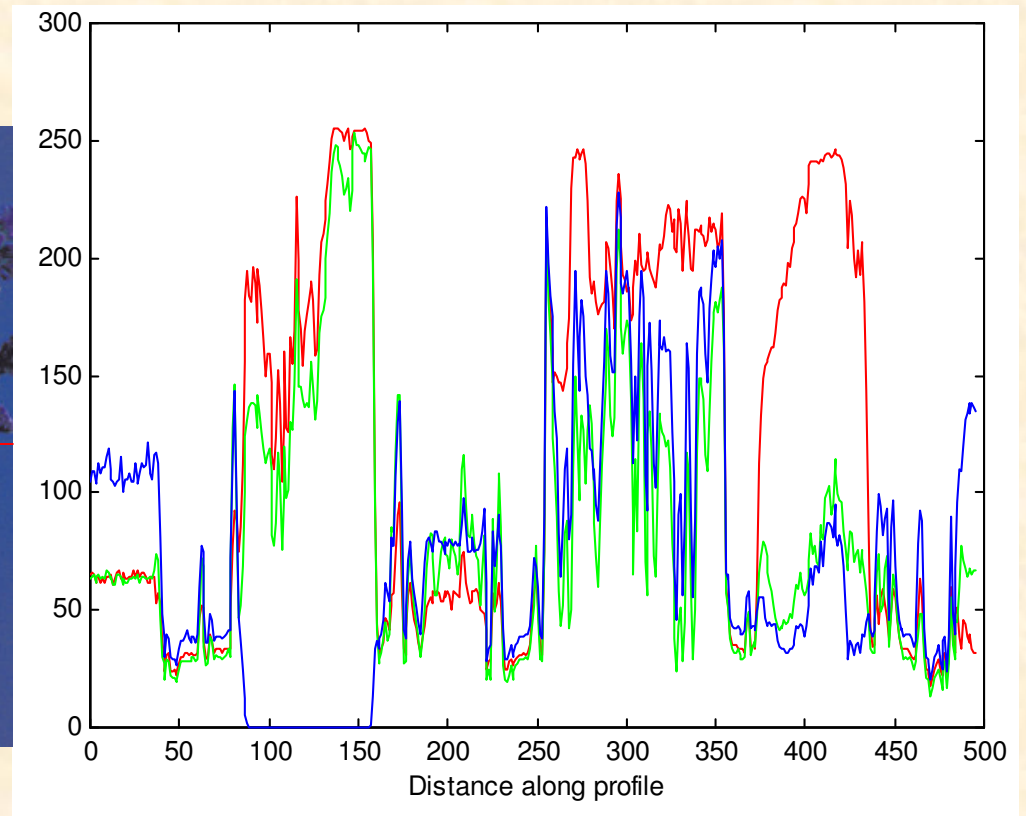
Image brightness profile



RGB colour images



RGB colour images



RGB image and colour components profiles

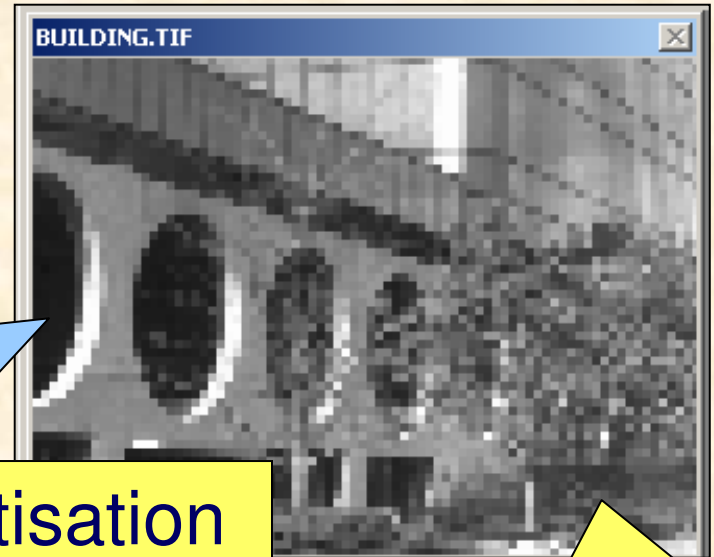
Digital image



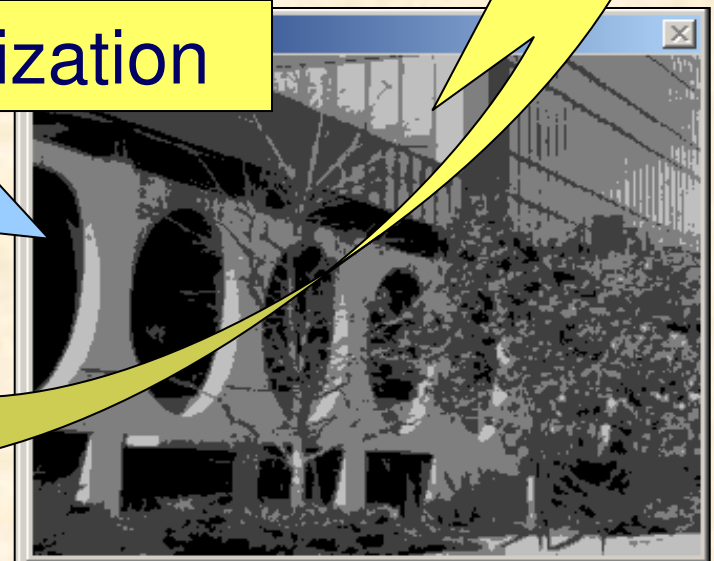
discretisation

+

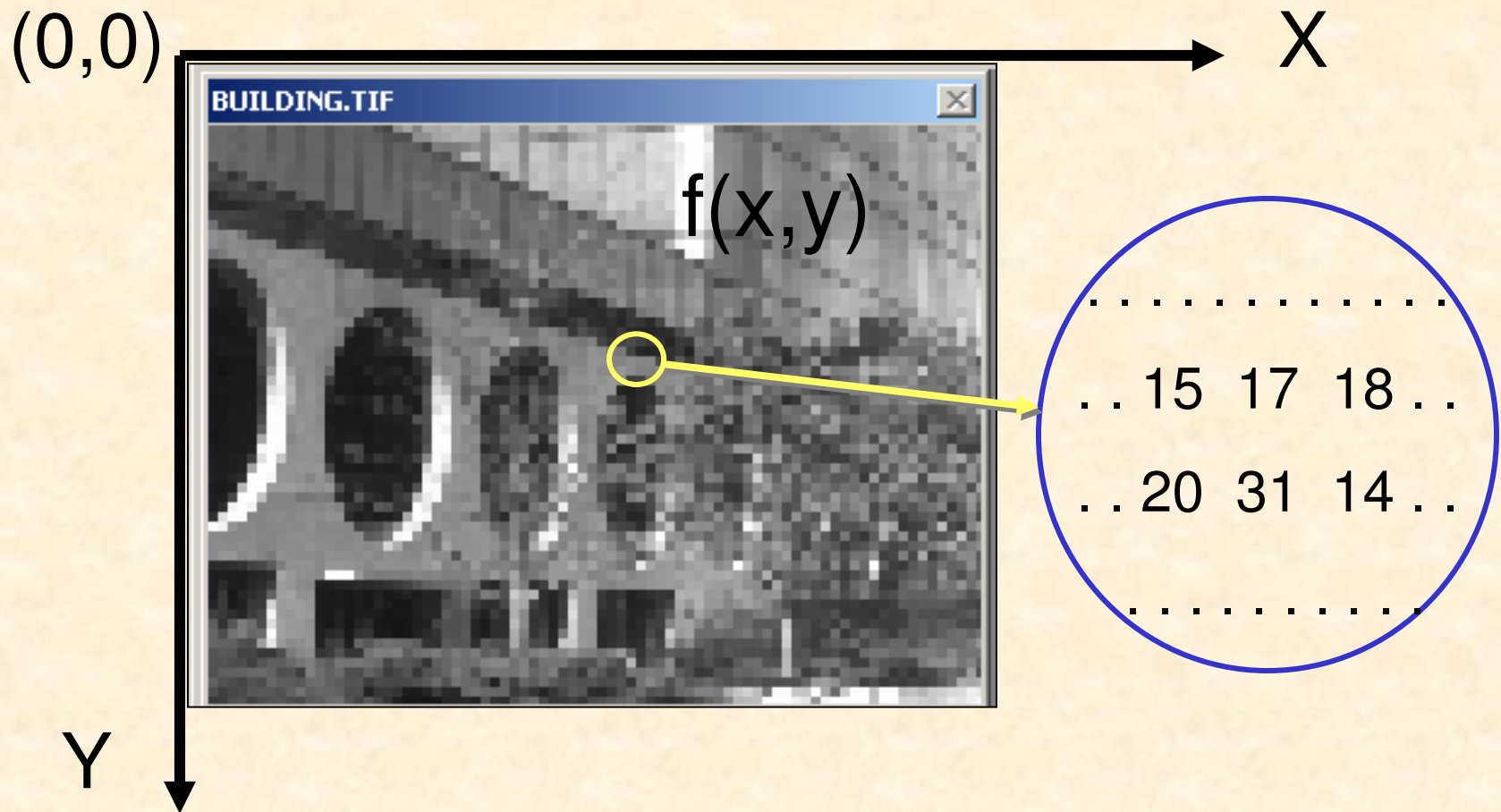
quantization



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

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

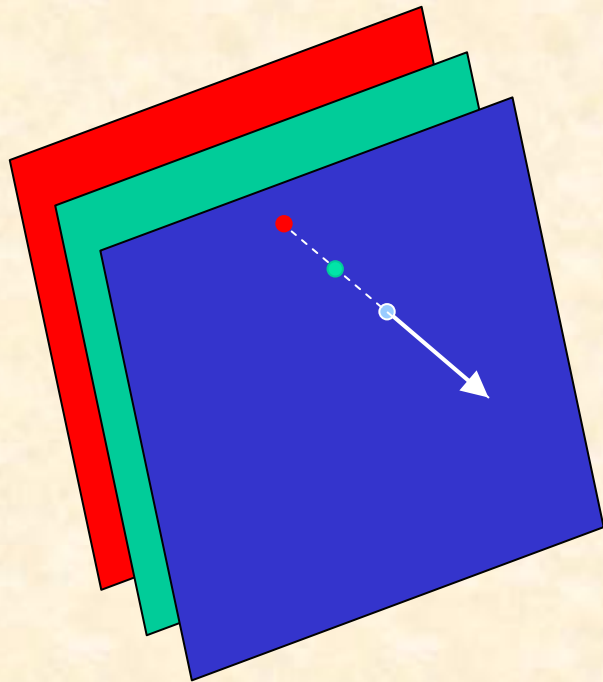
(np. $L=256$)

$$x = 0, 1, \dots, N - 1$$

$$y = 0, 1, \dots, M - 1$$

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!

$$f(x, y) = (f_R, f_G, f_B)$$



Colour indexed image

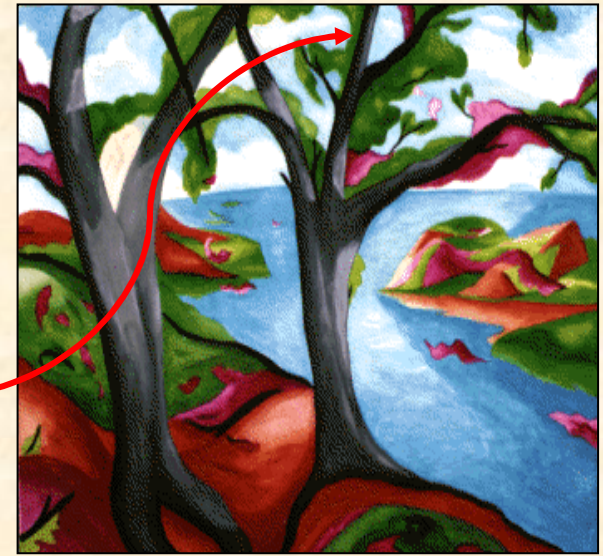
$f=25$



Monochrome image

	R	G	B
0			
1			
2			
.			
.			
.			
.			
25	0.21	0.3	0.99

*Colour palette
(look-up table)*



Colour
image

Image file formats

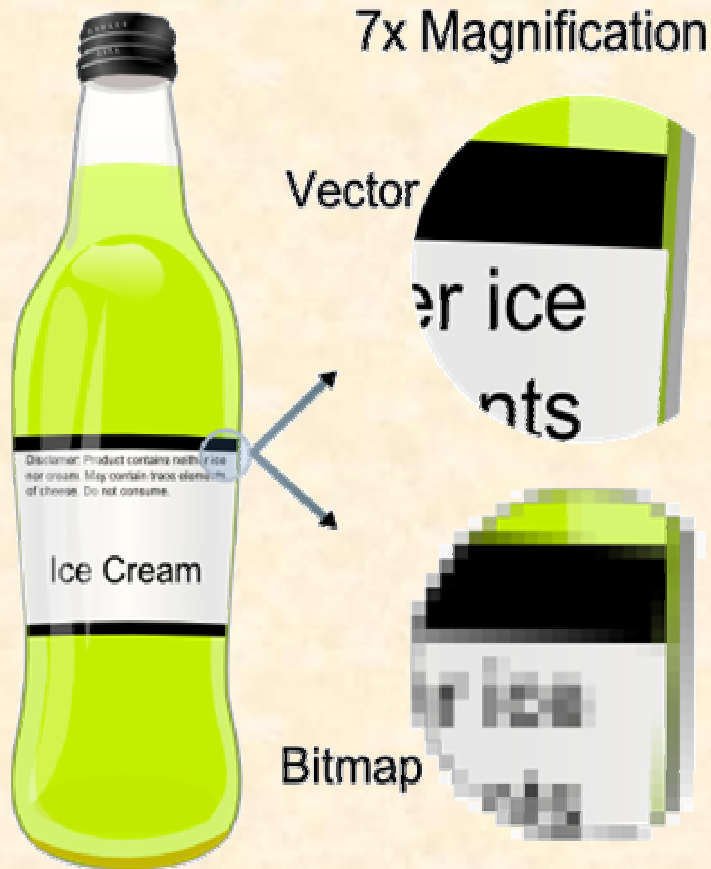
Image file formats were devised for the two main reasons:

- 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



Vector graphics:

Images are built from simple geometrical shapes: points, lines, curves, polygons

Raster graphics:

Images are built from an array of elementary points (pixels),

© Wikipedia

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

The screenshot displays a software window titled "Digital Image Processing: Hands-On" with a menu bar containing "File", "Edit", "Examine", "Enhance", "Analyze", "Res Effects", and "Help". The main workspace shows a grayscale image of a building with a red line drawn across it. Two panels are open: "Image Profile" and "Histogram".

The "Image Profile" panel shows a line graph with "Gray Level" on the y-axis (0 to 255) and "Position Along Line" on the x-axis (Left to Right). The graph shows a fluctuating blue line representing the intensity profile across the red line in the image.

The "Histogram" panel shows a bar chart with "Number of Pixels" on the y-axis (0 to Max) and "Gray Level" on the x-axis (0 to 255). The histogram shows a distribution of pixel intensities, with a prominent peak around 128.

On the right side, there is a book cover for "Digital Image Processing: Hands-On" by P. Strumillo, published by Wiley. The book cover includes the Wiley logo and the text "Elementary book - and Applications".

At the bottom of the software window, there is a dialog box with the text "and Automatrix, inc." and an "OK" button.