INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES ROUEN

Image processing and analysis

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INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES ROUEN

General Schedule

14 Slots

9 Lessons/exercices

3 evaluations

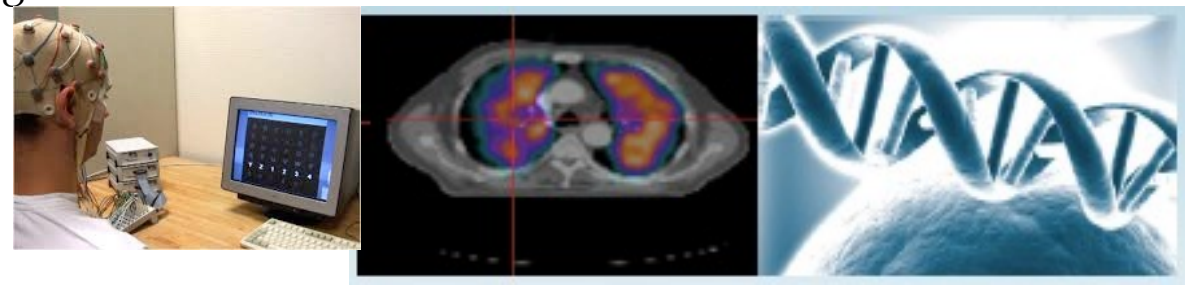
- MCQ (30%)
- Projects (30%)
- Final exam(40%)

LITIS Lab. (http://www.litislab.eu)

- **Access to Information**
  - Machine learning (Deep & kernels)
  - Information retrieval, knowledge
  - Document image processing

- **Ambiant Intelligence**
  - Intelligent vehicule
  - Complex systems

- **Biomedical Information Processing**
  - Medical image processing
  - Genomics

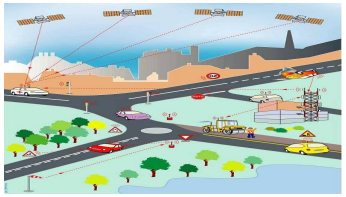


Ambient & Territorial Intelligence

Inteligent transportation system team (STI)

Main Interests

- Perception, localization, decision for ADAS
- Multimolality, fusion, incertainty
- ADAS, Intelligent systems (Robots, vehicles).



Approaches

- Vision Systems
- Multiple Sensors Fusion

Projects and Collaborations

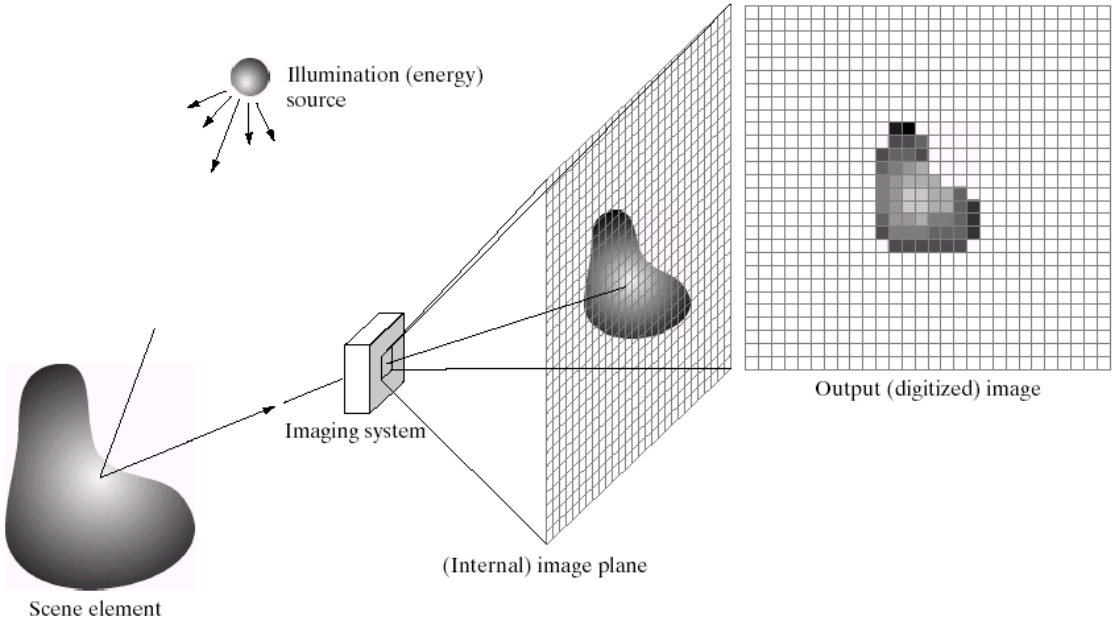
- Intelligent Vehicle (Valeo – Renault – CETE Normandie – NextMove)
- Alberto Broggi, VisLab, Intercontinental Challenge

Overview

- Image application and tasks
- Image digitization
- Contrast enhancement
- Image segmentation : edges/Moprhology, corners, and regions
- Optical flow estimation
- Application : Deep learning for images

Image

- Bi-dimensional representation of a scene
- Signal : 1D function of time
- Image : 2D function of space

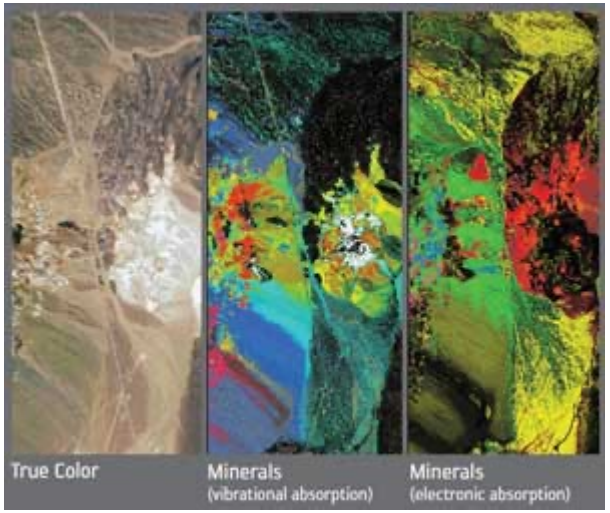


Natural images

Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Images examples

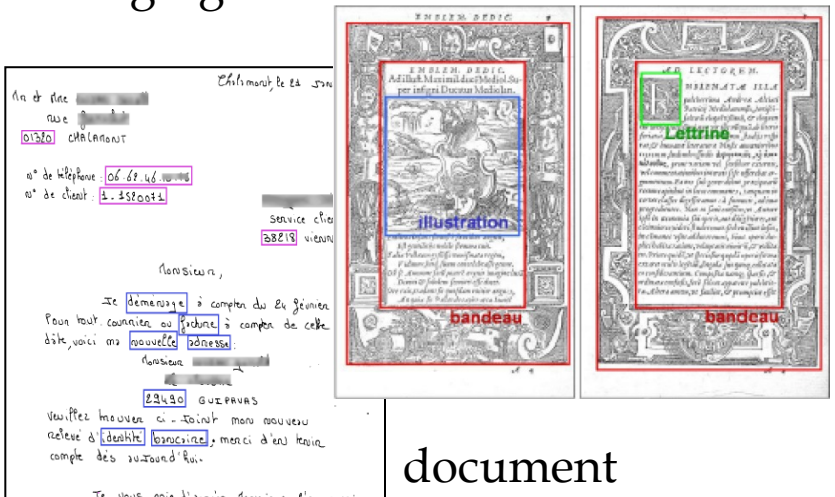
Satellite imaging



Hyperspectrale imaging

Medicale imaging

Video



document

Image processing tasks

- Low level:

Denoising, deblurring, compression, super-resolution, inpainting

- Mid-level:

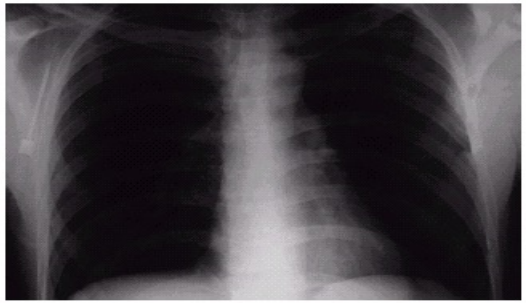
Segmentation registration

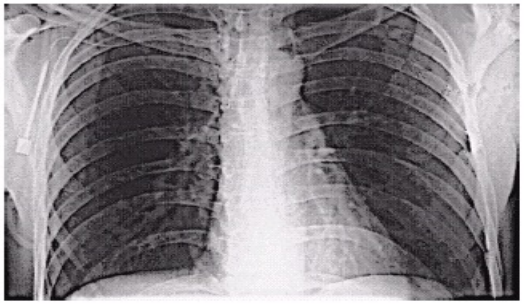
- High level:

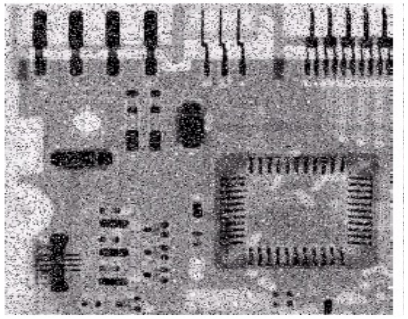
Object detection, object recognition

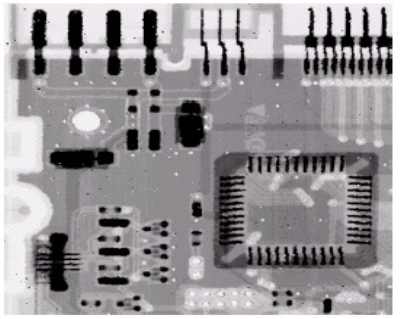
Contrast enhancement

Improve the image quality









Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Image compression

24Ko

4Ko

http://artic.ac-besancon.fr/sciences70/coin_technique/compresser_image.htm

Image inpainting

Image inpainting

Content based image retrieval

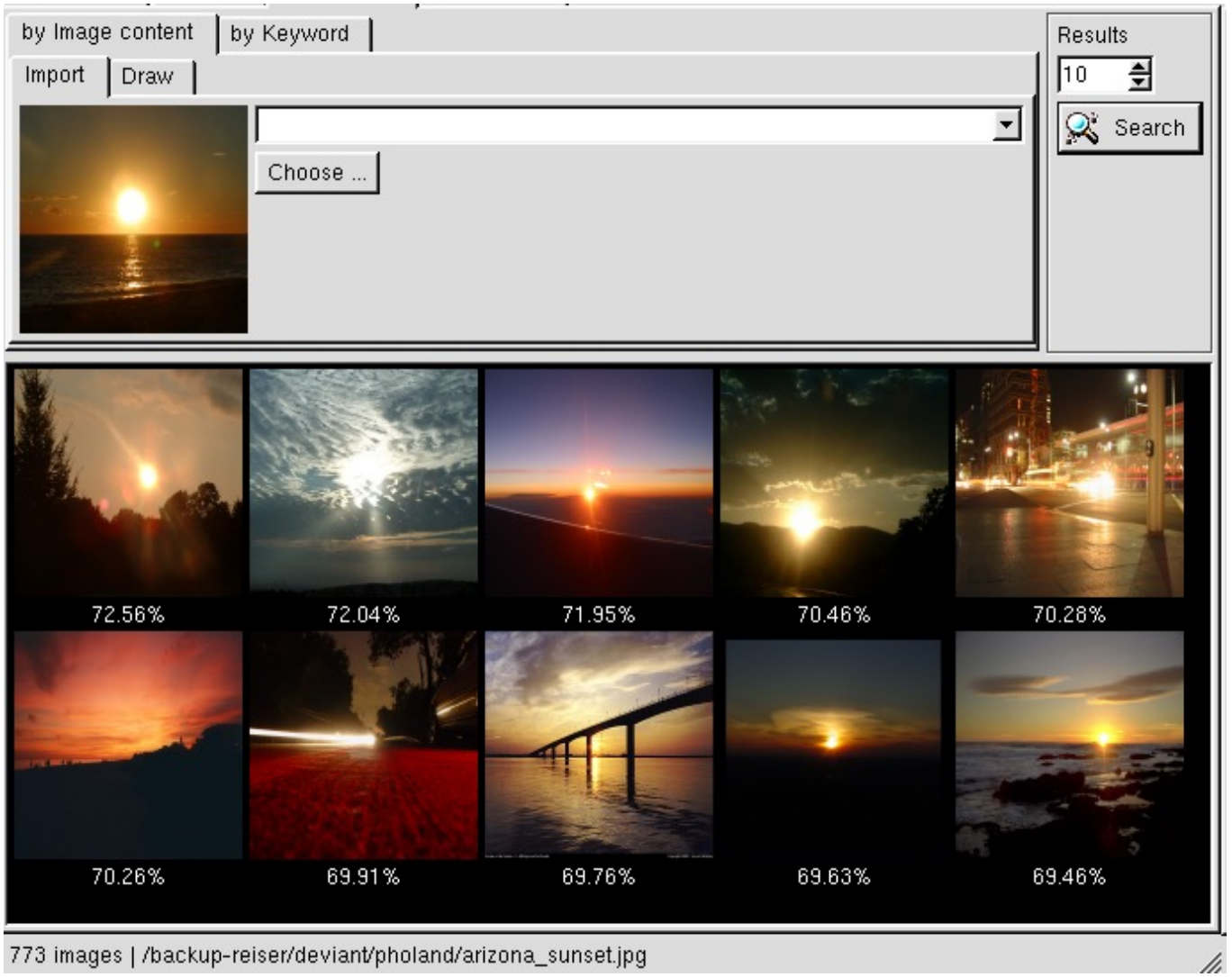


Image segmentation

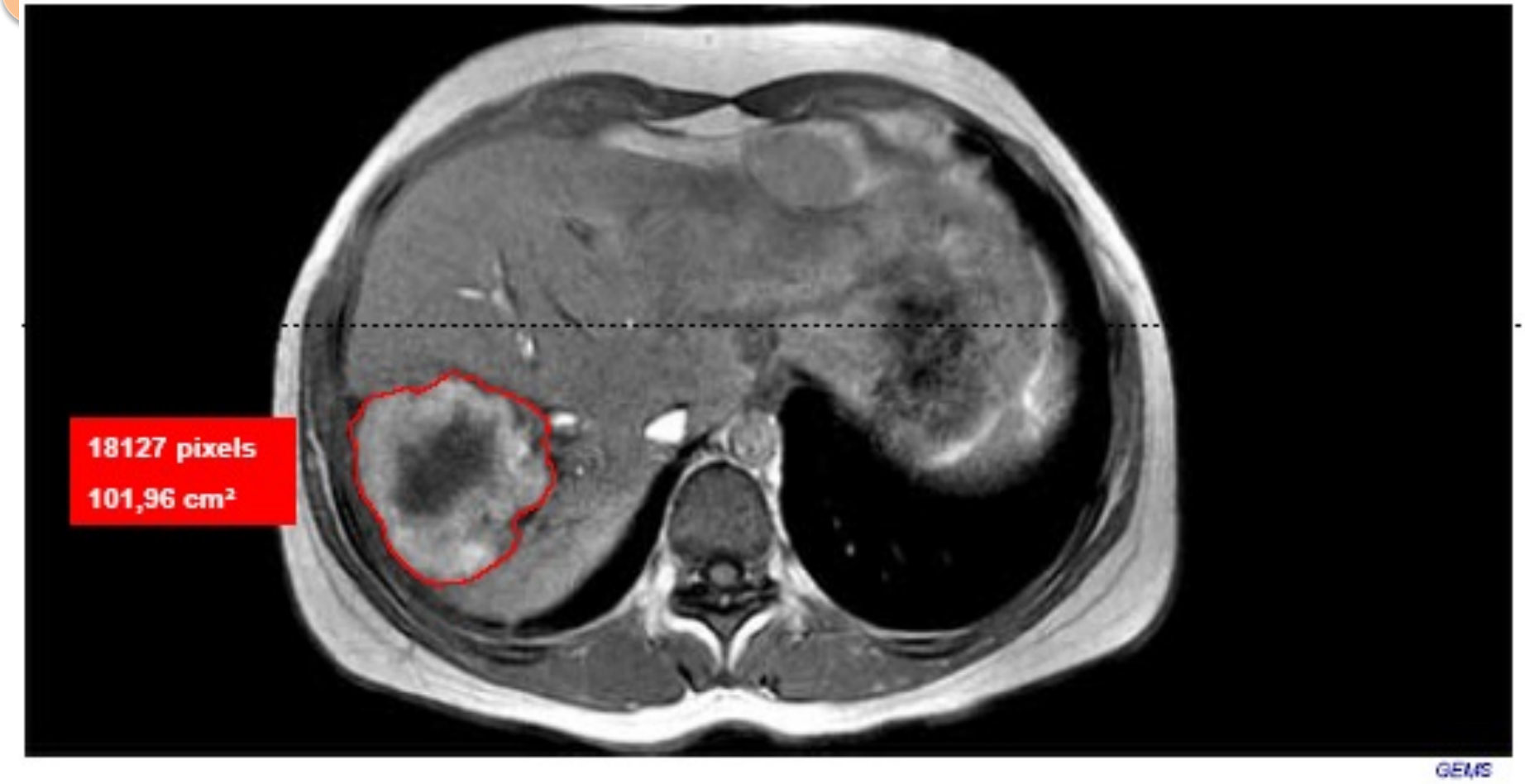


Image IRM d'une tumeur du foie

Semantic segmentation

Image registration

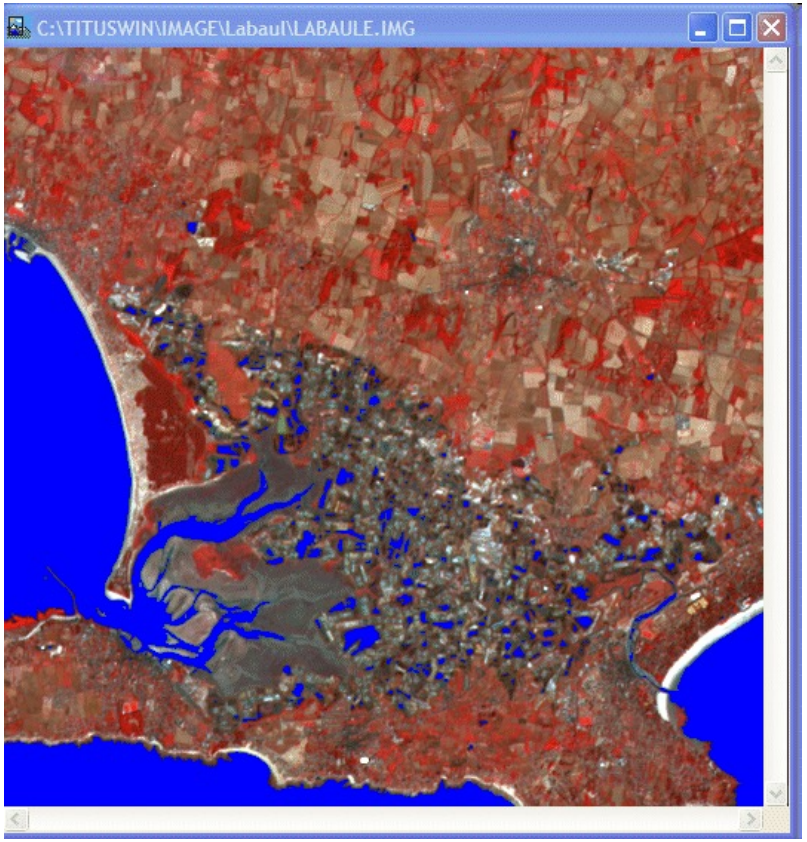
Source

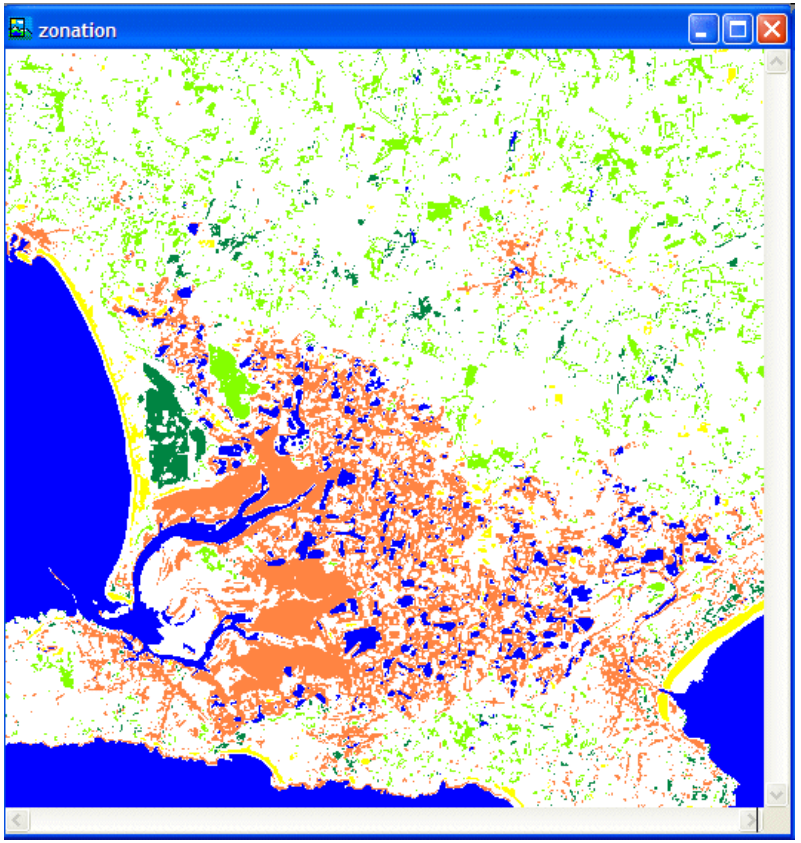
Target

Deformed source to match the target

Satellite image

Compare a new image with existing map

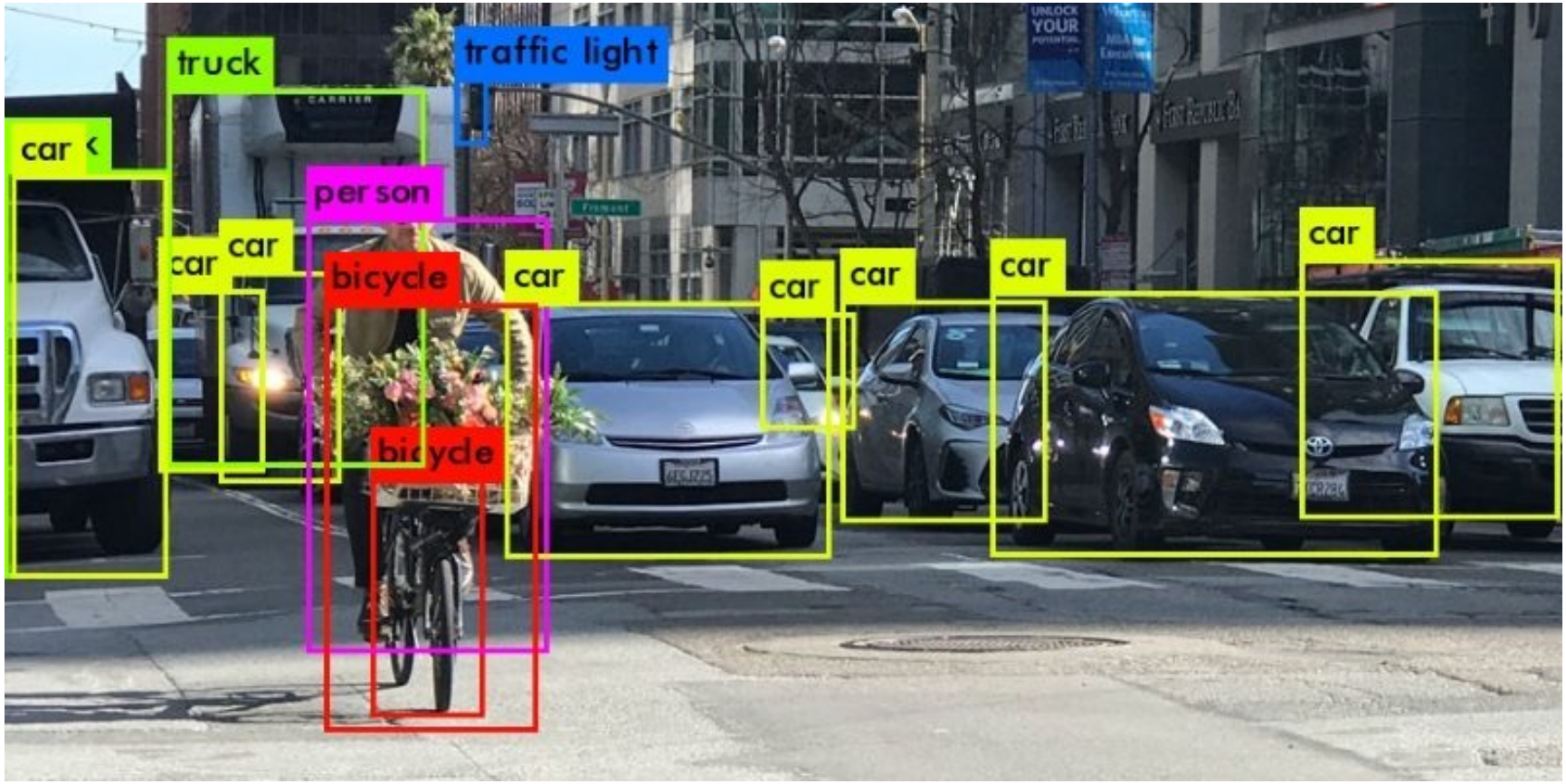




Source : http://www.pedagogie.ac-nantes.fr/1168527883328/0/fiche___ressourcepedagogique/&RH=1160730548828

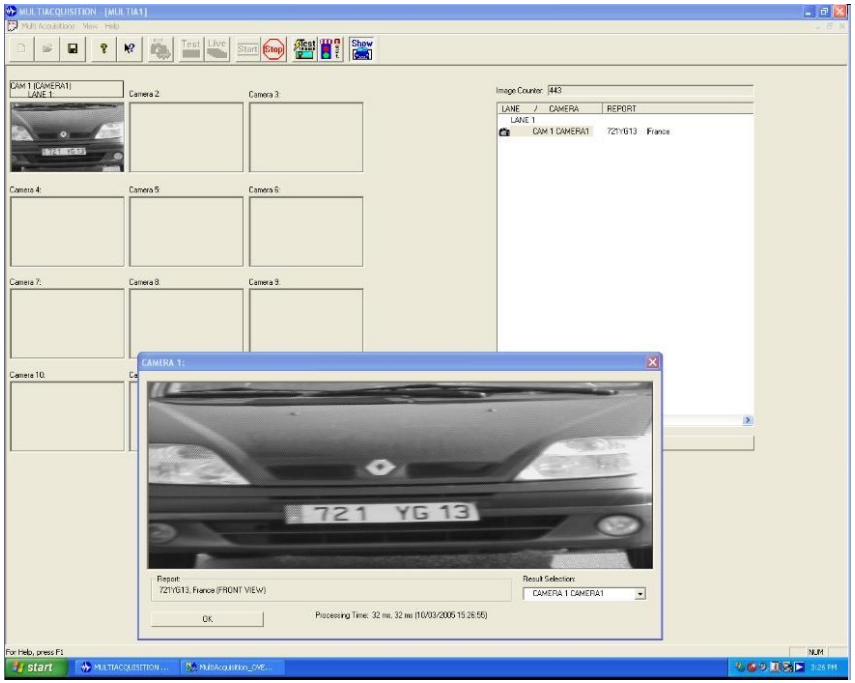
Object detection and recognition

Autonomous driving



Road scene analysis

- Traffic analysis

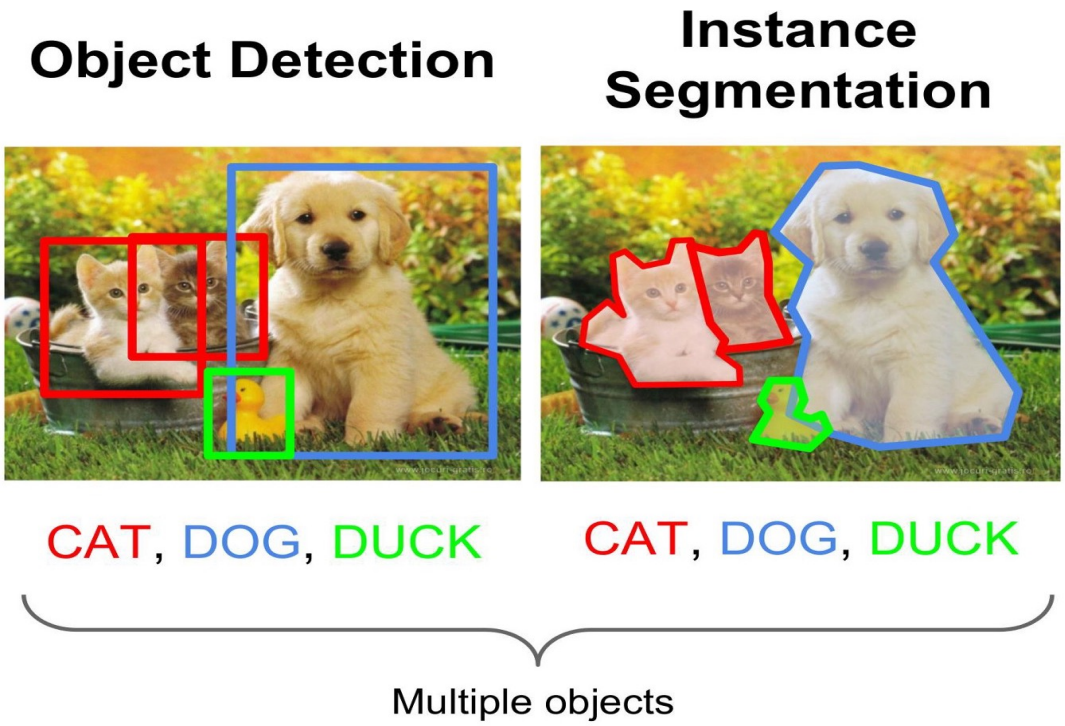


Source : www.macqel.fr

License plate recognition

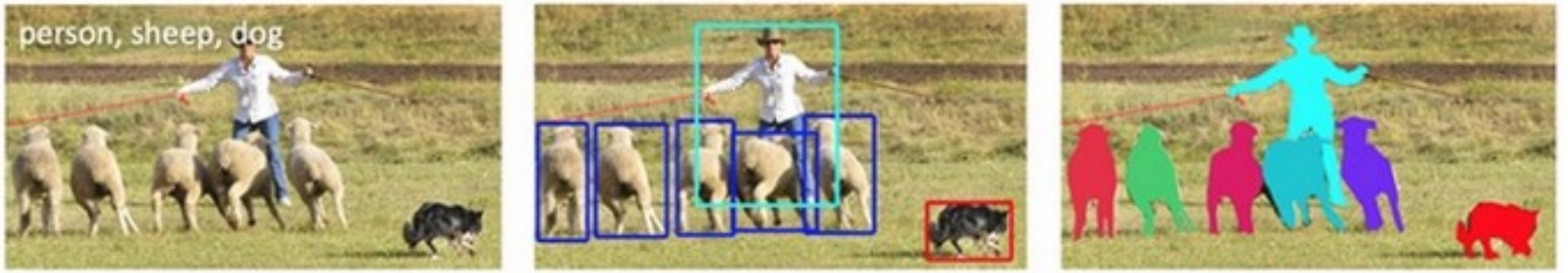
Object detection and recognition

Multi-label

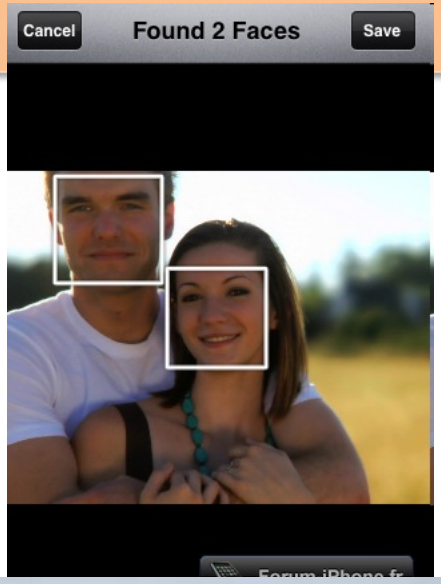


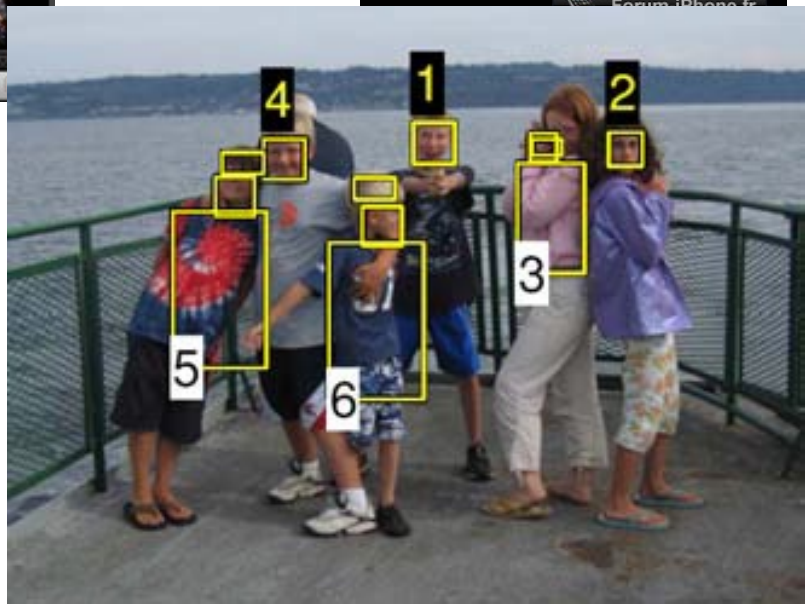
Object detection and recognition

Multilabel

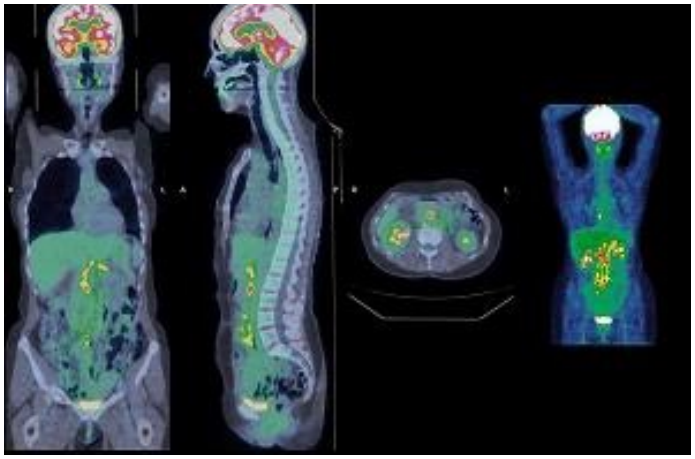


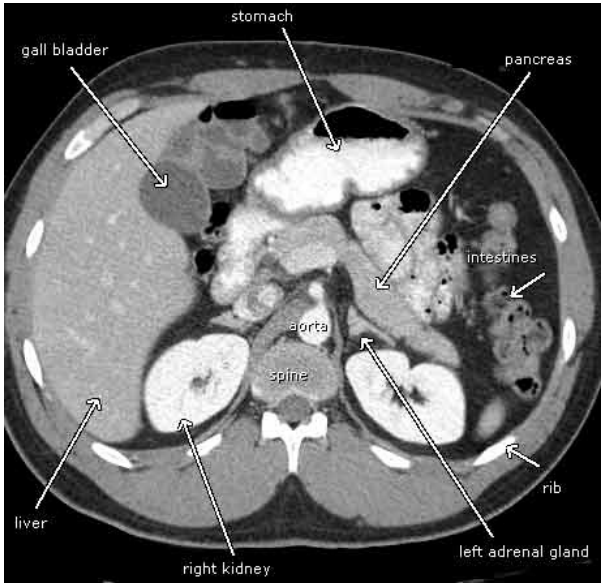
Facial recognition





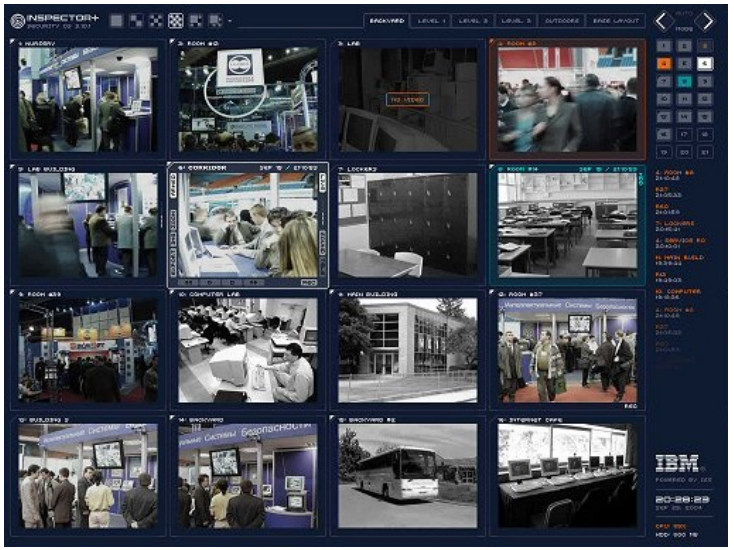
Medical images



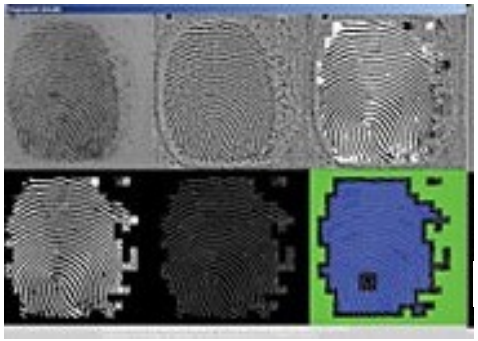


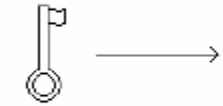
Security

- Videosurveillance
- Biometry (authentication)

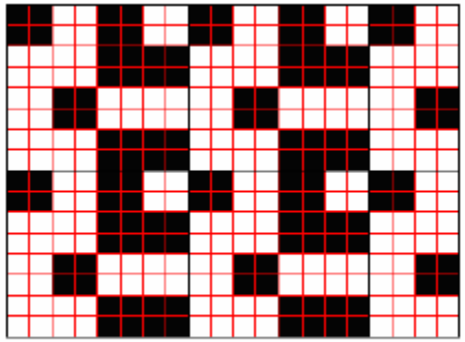


’i





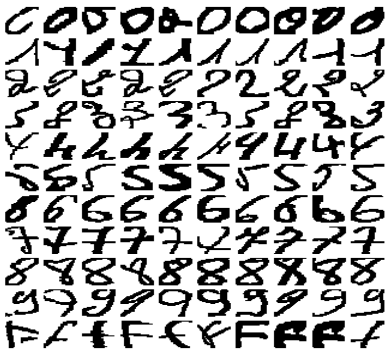
key K

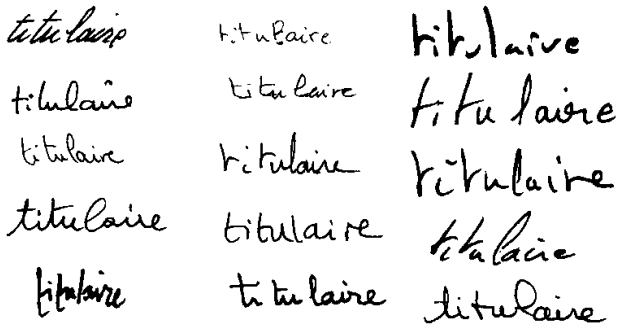


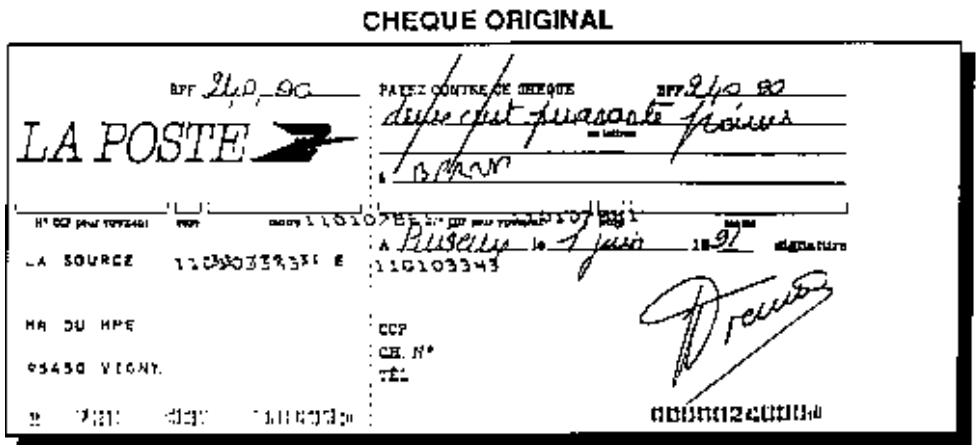
mark M

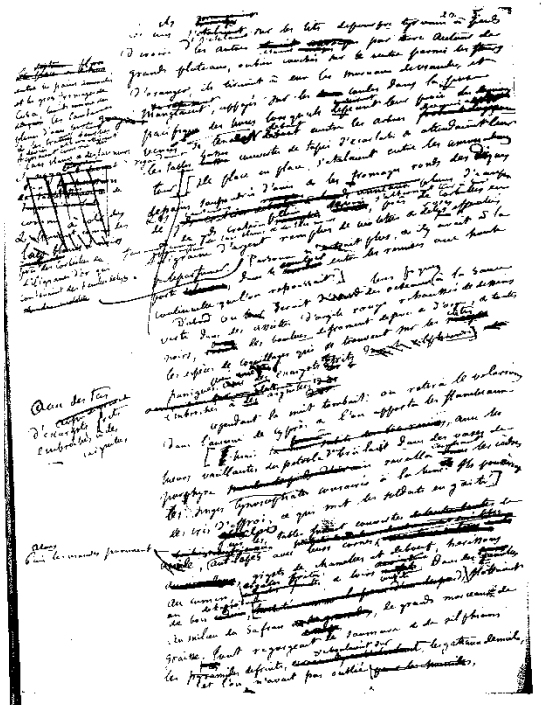
http://liris.cnrs.fr/tatouage/wp-content/uploads/2007/10/philippe_carre.pdf

Handwriting recongnition









Cours L. Heutte Université de Rouen

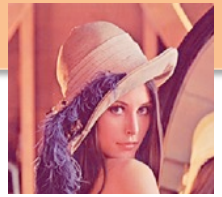
Sattelite images segmentation

Source : https://deepsense.ai/deep-learning-for-satellite-imagery-via-image-segmentation/

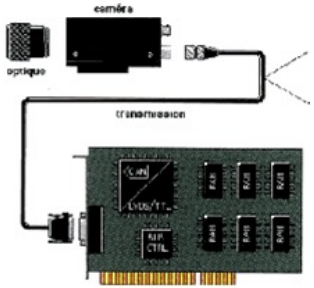
Overview

- Image acquisition and digitization
  - Image encoding
  - Gray level and pixels
  - Sampling and quantization
  - Image profile
  - Super-resolution

Image acquisition and coding

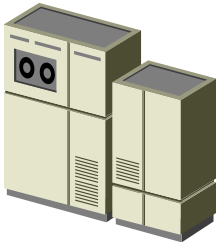


Acquisition



Digitization

Processing



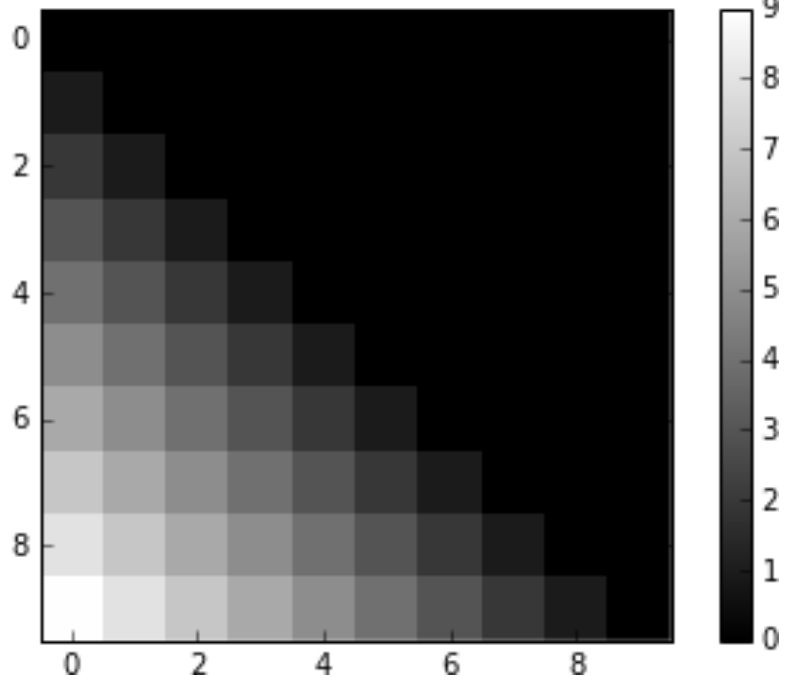
Storage

Visualization

Image encoding

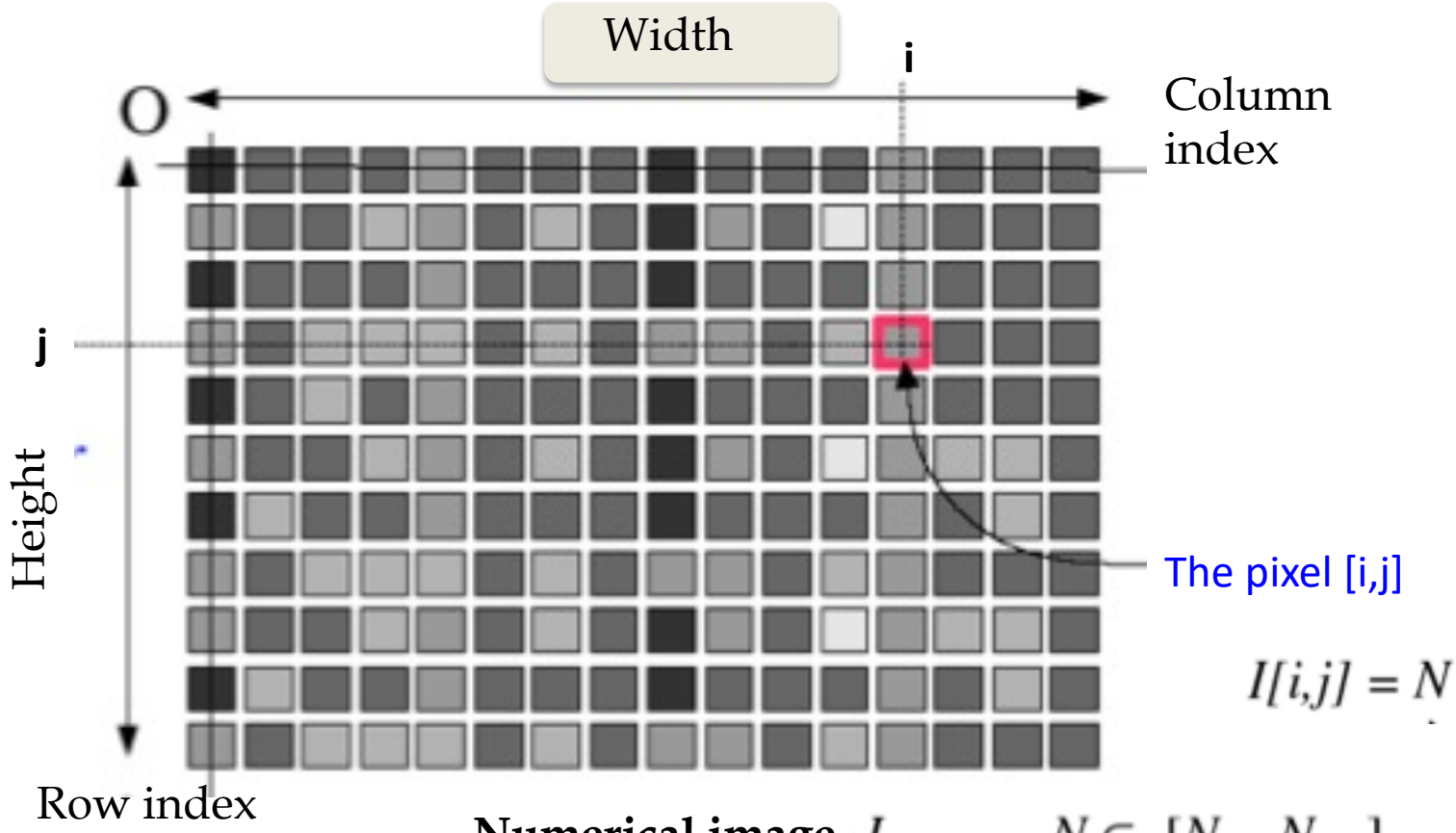
- An image is a table or a matrix
- Each cell is a **pixel** (picture element)
- Correspondance between the value and the color : given by the colormap

```
[[ 0.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 1.  0.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 2.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
 [ 3.  2.  1.  0.  0.  0.  0.  0.  0.  0.]
 [ 4.  3.  2.  1.  0.  0.  0.  0.  0.  0.]
 [ 5.  4.  3.  2.  1.  0.  0.  0.  0.  0.]
 [ 6.  5.  4.  3.  2.  1.  0.  0.  0.  0.]
 [ 7.  6.  5.  4.  3.  2.  1.  0.  0.  0.]
 [ 8.  7.  6.  5.  4.  3.  2.  1.  0.  0.]
 [ 9.  8.  7.  6.  5.  4.  3.  2.  1.  0.]]
```



Look-up table (LUT)

Grey levels and pixels

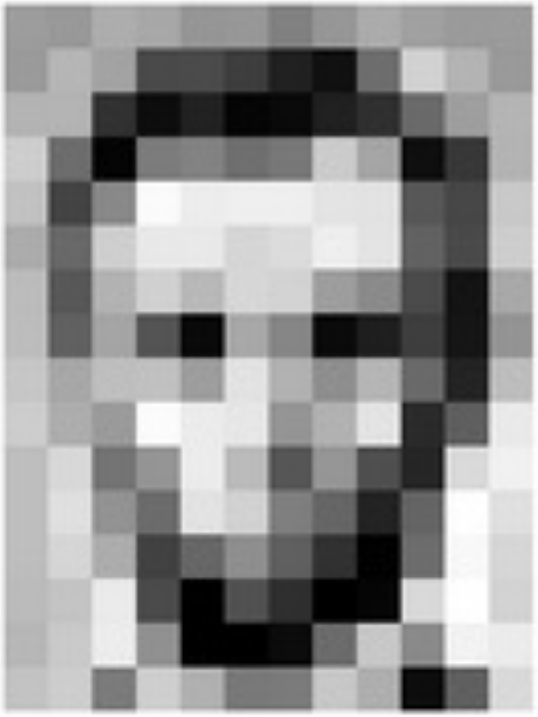


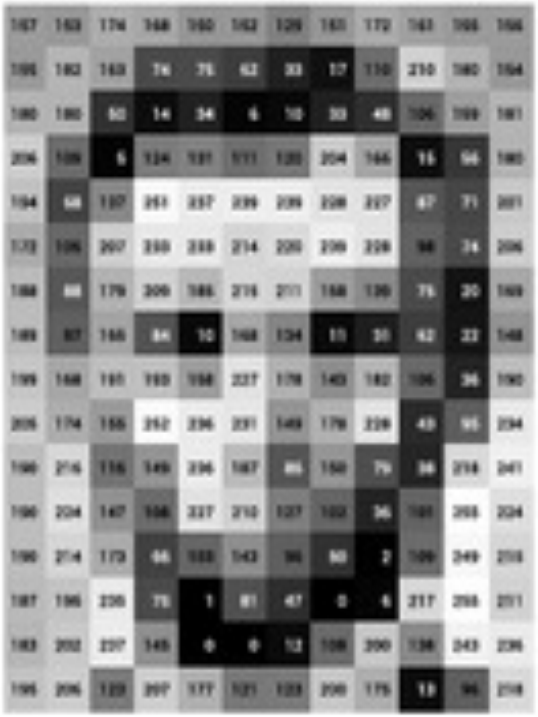
Numerical image I $\quad N \in [N_{min}, N_{max}]$

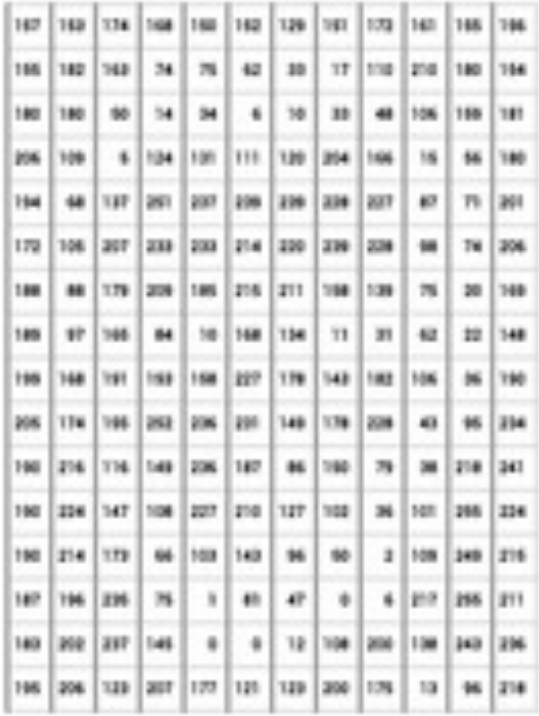
$1 + (N_{max} - N_{min}) =$ the number of gray levels

$Log_2(N_{max} - N_{min}) =$ the dynamic

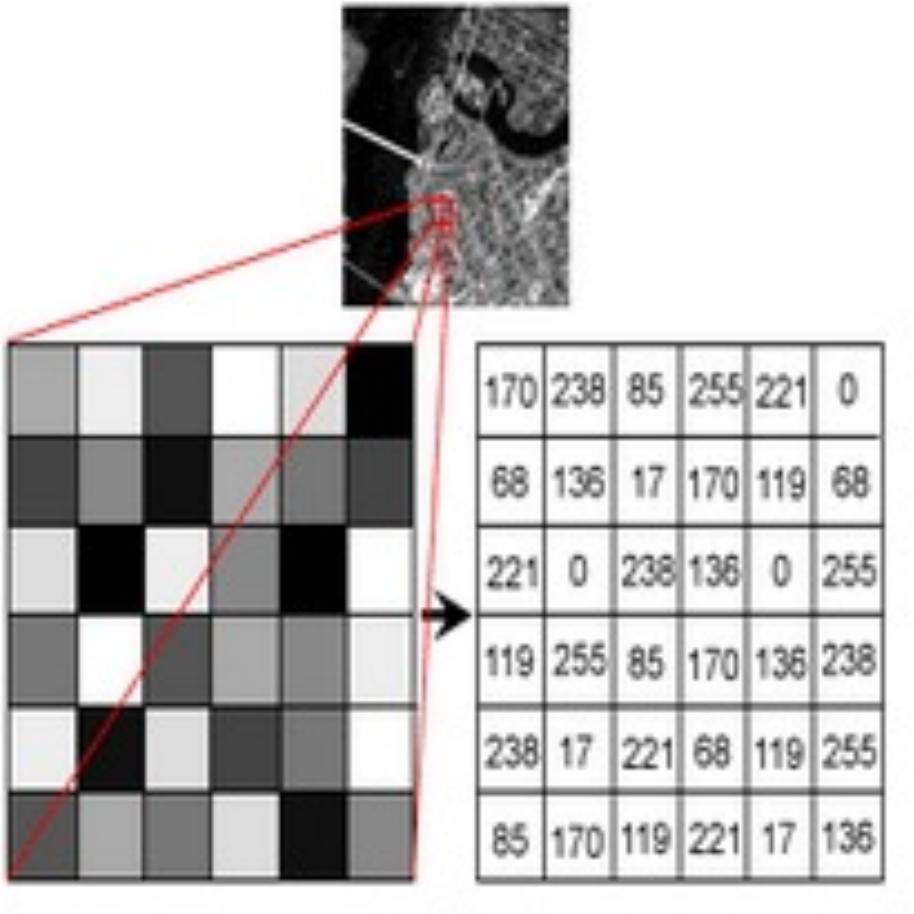
Grey levels and pixels







Grey levels and pixels



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

Grey levels and pixels

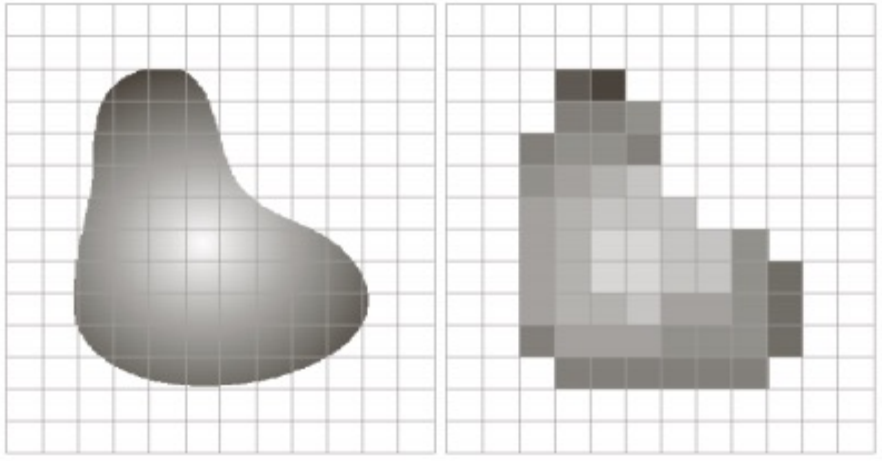
- In general, each pixel is coded on 8 bits
- There are 256 grey levels

- How much memory does it take to store this image?
  - Image size :

  200 x 300 pixels
  - Each pixel is coded on 8 bits

Digital image: sampling and quantization

- Sampling corresponds to a discretization of the space. That is, of the domain of the function, into $f : [1, \ldots, N] \times [1, \ldots, M] \longrightarrow \mathbb{R}^m$.



a b

FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

- Quantization : finite number of grey levels

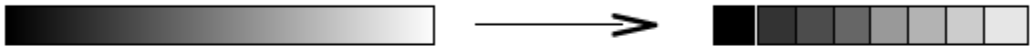


Image resolution

- Digital image implies the discretization of both spatial and intensity values.

- The notion of resolution is valid in any domain.

→ Usually refers to the resolution in sampling (nbr of pixels)

→ It also can refer to the number of quantization levels

(ex. 256 if coded on 8 bits)

Sampling and quantization

Résolution...

...spatiale : *Sampling*

256x256

128x128

64x64

32x32

...tonale : *Quantification*

6 bits

4 bits

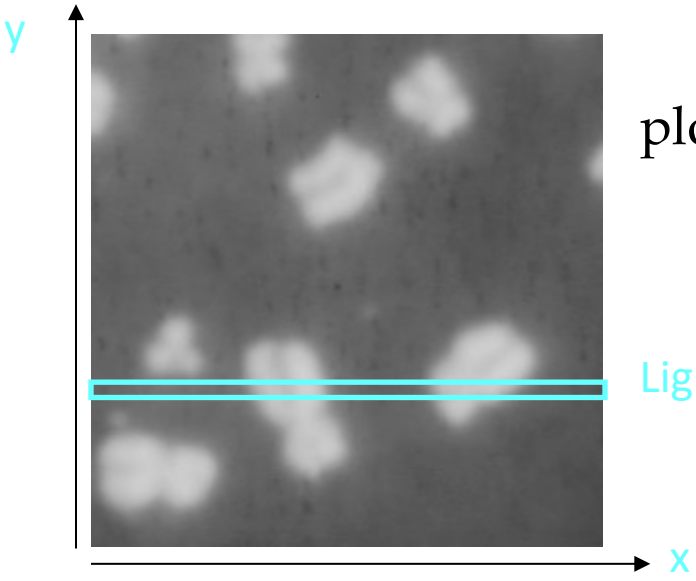
3 bits

2 bits

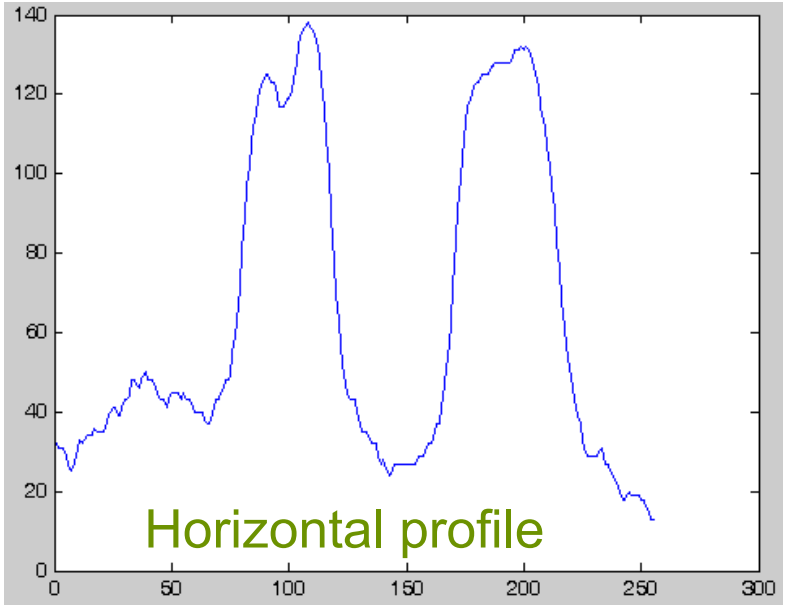
1 bit

Definition of an image profile

- Image 256 x 256, 8 bits per pixel



plot the intensity values of line 177 as a function of x

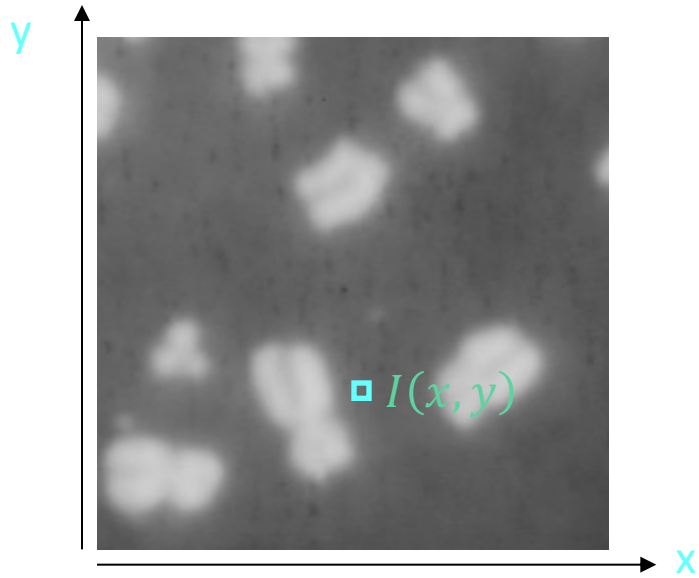


A profile can be taken anywhere in the image depending on the need

It can be horizontal, vertical, diagonal, etc

Image representation

For each pixel in (x, y) its grey level (or intensity) is given by $I(x, y)$



(x, y) domain ? $I(x, y)$ domain ?

I : [0, N-1] x [0, M-1] → [0,255]

$(x, y) \rightarrow I(x, y)$

An image is a bidimensional function:

$(x, y) \rightarrow I(x, y)$

To display the matrix or function as an image we use a colormap

What if we don't assign a color to $I(x, y)$ but a 3rd dimension (height)?

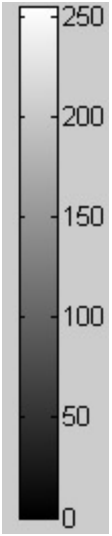
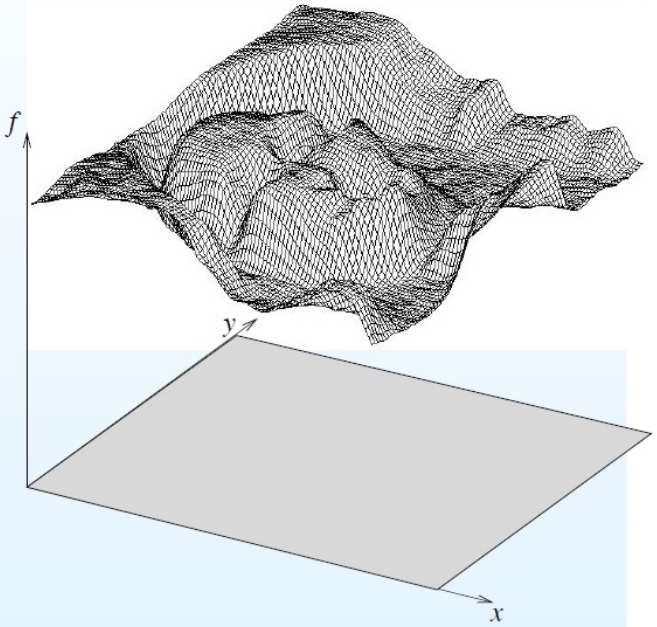


Image representation

Fonction 2-D

Image



Fonction

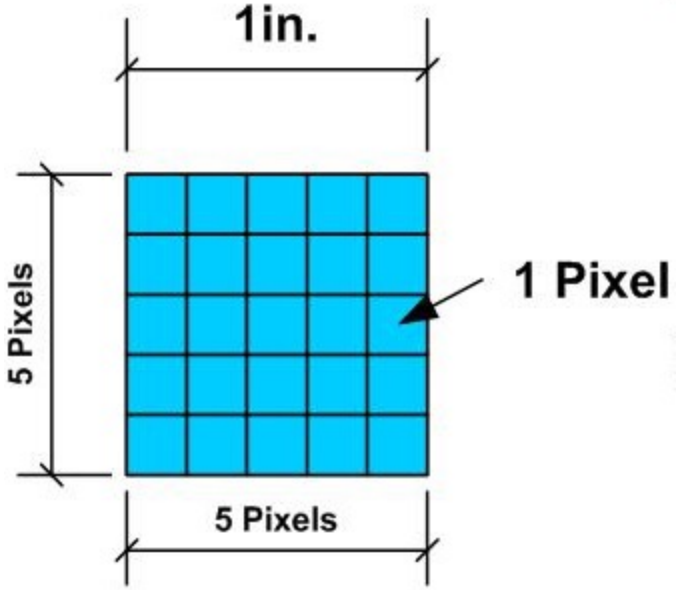
- The surface representation does not correspond to the relief perceived by our eye and our brain

DPI resolution: interface between digital and real world

- When the image of « real » dimensions (for example a paper photo), is digitized : dpi resolution
  - dot per inch (dpi) or pixel per inch (ppi)

    (1 inch = 2.54 cm)

- Example :
  - A photo of 15cm x 11cm
  - It is scanned with a 300 dpi
  - What is the size (in pixels) of the digital image?



http://www.minutemanbristol.com/images/dpi.jpg

Super-resolution

- Super-resolution is class of technics that aim to enhance the resolution of an imaging system

Ex : extracting signal from noise, processing at a sub-pixel level

References

- CS 4487/9587
- Algorithms for Image Analysis www.csd.uwo.ca/courses/CS4487a/
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- wikipedia
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- Lecture image processing of Caroline Petitjean : http://pagesperso.litislab.fr/cpetitjean/