Motivation:

Vision is more than a sense; it is an intelligence.

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Image Analysis

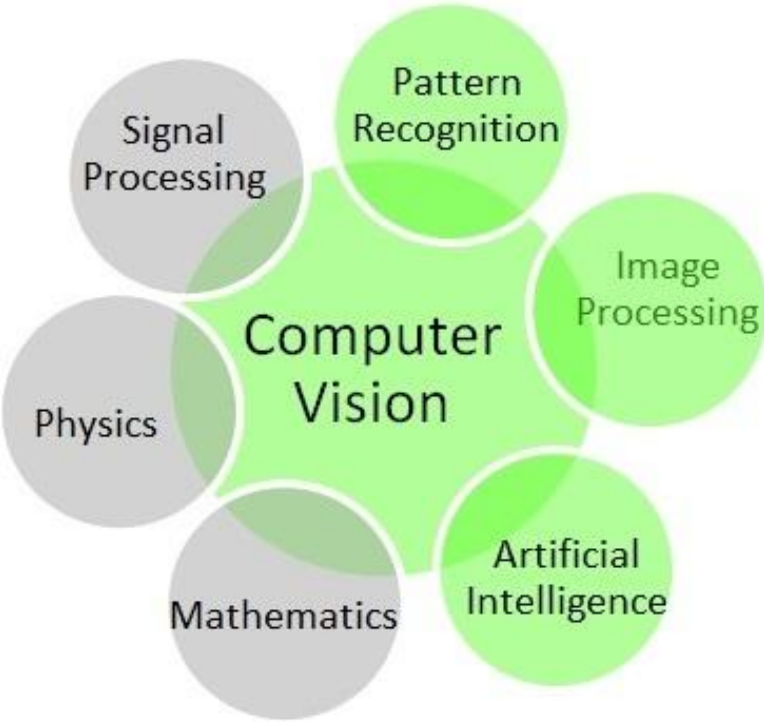
Visión Artificial

- La visión artificial o visión por computadora es una rama de la IA que estudia métodos para adquirir, procesar, analizar e interpretar imágenes del mundo real.

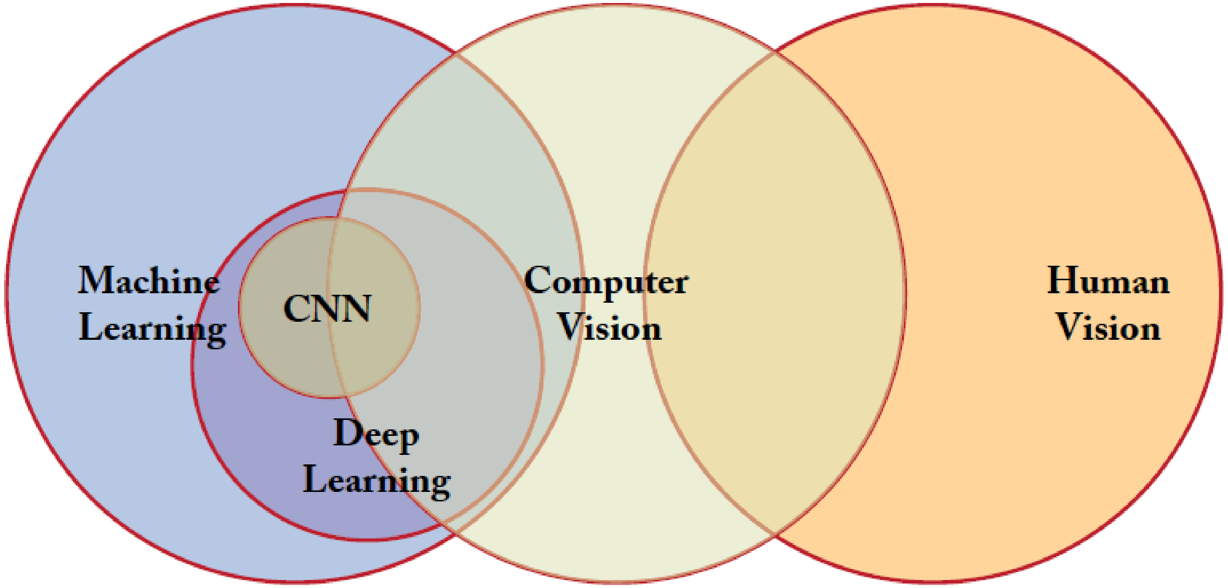
- Una imagen dice más que mil palabras.

>

Visión Artificial

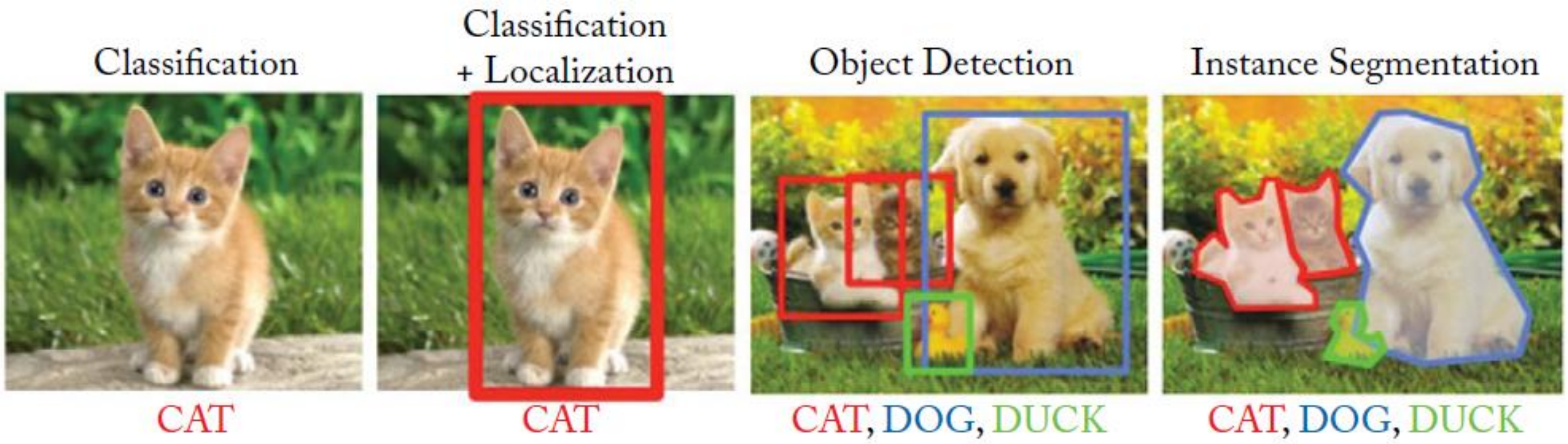


Visión Artificial



The relation between human vision, computer vision, machine learning, deep learning,and CNNs. Taken from
A Guide to Convolutional Neural Networks for Computer Vision. Salman Khan (2019).

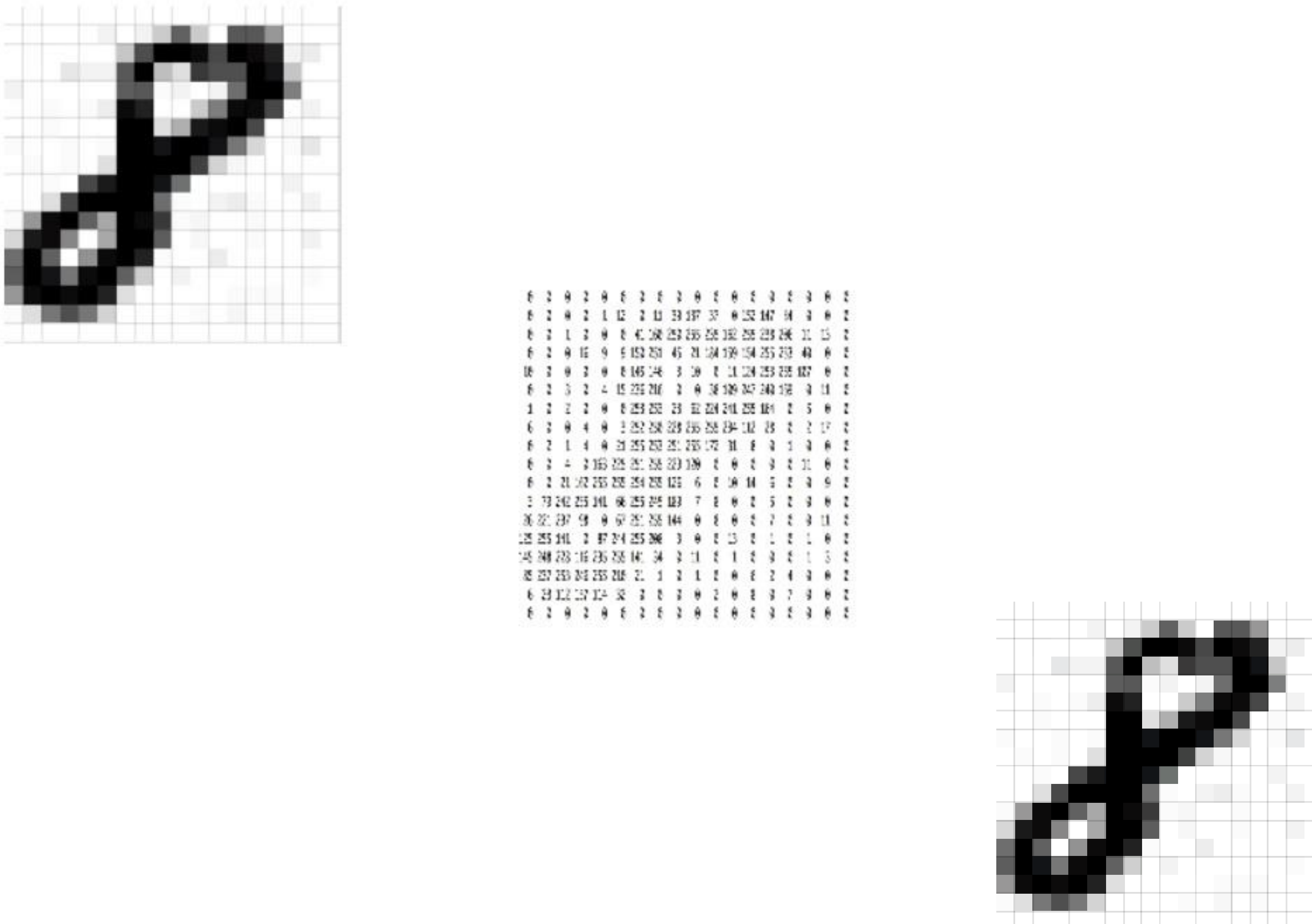
Visión Artificial



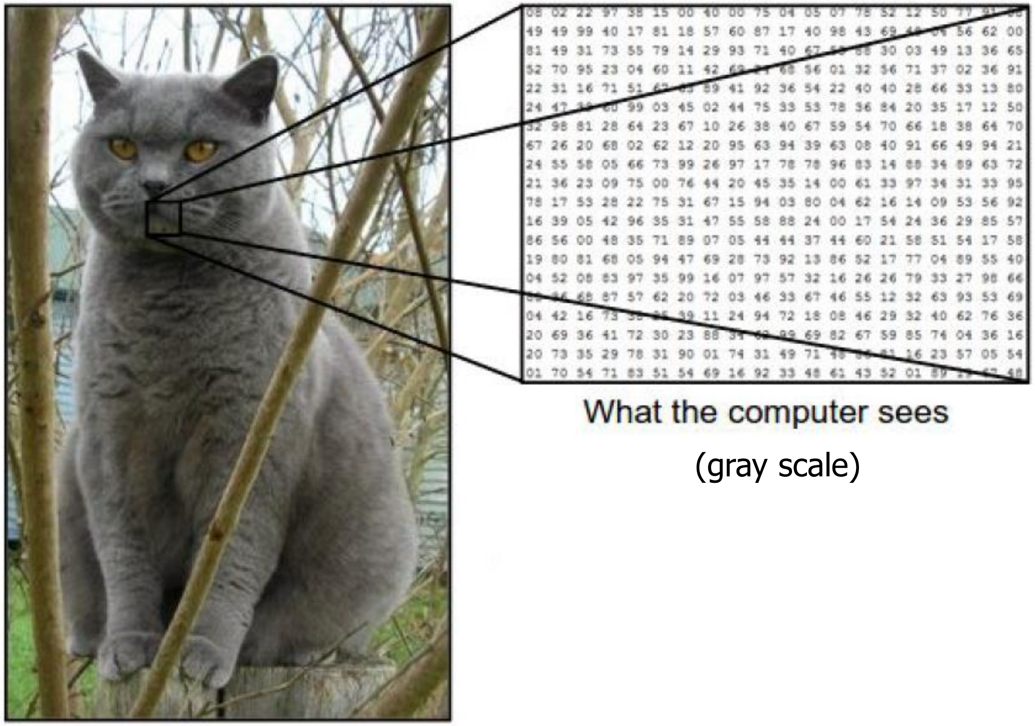
What is Digital Image Processing?

An image may be defined as a two-dimensional function, $f(x,y)$, where x and y are *spatial* (plane) coordinates, and the amplitude of f at any pair of coordinates (x,y) is called the *intensity* or *gray level* of the image at that point.

Representación



Representation



What the computer sees

(gray scale)

https://csfieldguide.org.nz/en/interactives/pixel-viewer/

Optical Illusions

- Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception.

- Visual perception is an illposed problem, subjetivity and general assumptions are allways considered.

http://www.123opticalillusions.com

- Content is in the eye of the observer.

Human Visual Perception

- Atención.
https://www.youtube.com/watch?v=MjsjqCR6xgw

- Visión periférica.
https://www.youtube.com/watch?v=0Aw0TIneKB8

- Información necesaria.
https://www.youtube.com/watch?v=UOgo01QaeO4

- Supuestos.
https://www.youtube.com/watch?v=SFqu7uUQVWI

- Resta de imágenes
https://www.youtube.com/watch?v=36f3WaPgP2M

- Asociación aprendida.
https://www.youtube.com/watch?v=sGWcdXPBXDU

What is Digital Image Processing?

There is no general agreement among authors regarding where image processing stops and other related areas, such as image analysis and computer vision, start. One useful paradigm is to consider three types of computerized processes: low-,mid-, and high-level processes.

What is Digital Image Processing?

Computer Vision
Machine Vision

- Digital Image Processing
  (image in $\rightarrow$ image out)
- Image Analysis
  (image in $\rightarrow$ measurements out)
- Image understanding
  (image in $\rightarrow$ high-level descriptions out)

What is Digital Image Processing?

The history of digital image processing is intimately tied to the development of the digital computer.

Digital image processing techniques began in the late 1960s and early 1970s to be used in medical imaging, remote Earth resources observations, and astronomy.

Applications

- Image processing in medical diagnosis
    - Computerized axial tomography
    - X-ray
- Study pollution patterns from aerial and satellite imagery
    - Enhancement and restoration to process degraded images of unrecoverable objects
- Restored blurred pictures damaged after being photographed

Applications

These examples illustrate processing results intended for human interpretation. The second major area of application of digital image processing techniques is:

machine perception

Extracting from an image information. Often, this information bears little resemblance to visual features that humans use in interpreting the content of an image.

Applications

Typical problems in machine perception are automatic character recognition, industrial machine vision for product assembly and inspection, automatic processing of fingerprints.

Examples of fields that use Digital Image Processsing

Images based on radiation from the EM spectrum are the most familiar, especially images in the X-ray and visual bands of the spectrum.

Electromagnetic waves can be conceptualized as propagating sinusoidal waves of varying wavelengths. Spectrum shown in figure 2 ranging from gamma rays (highest energy) at one end to radio waves (lowest energy) at the other.

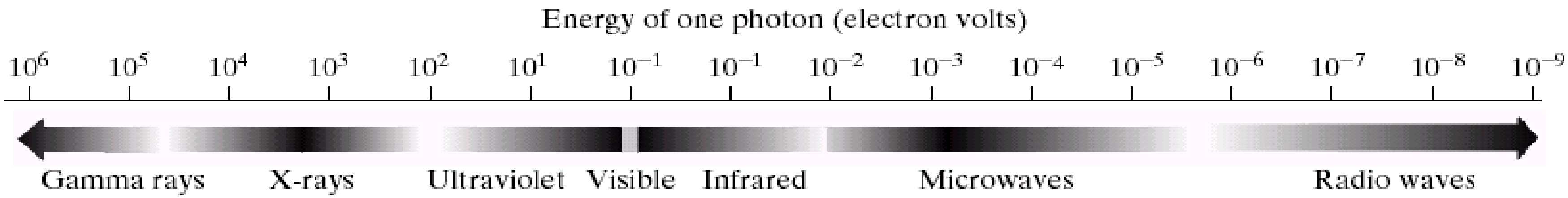


Figure 2. The electromagnetic spectrum arranged according to energy per photon

Examples of fields that use Digital Image Processsing

In nuclear medicine, the approach is to inject a patient with a radioactive isotope that emits gamma rays as it decays. Images are produced from the emissions collected by gamma ray detectors. Figure 3(a) and (b) show another major modality of nuclear imaging called positron emission tomography (PET).

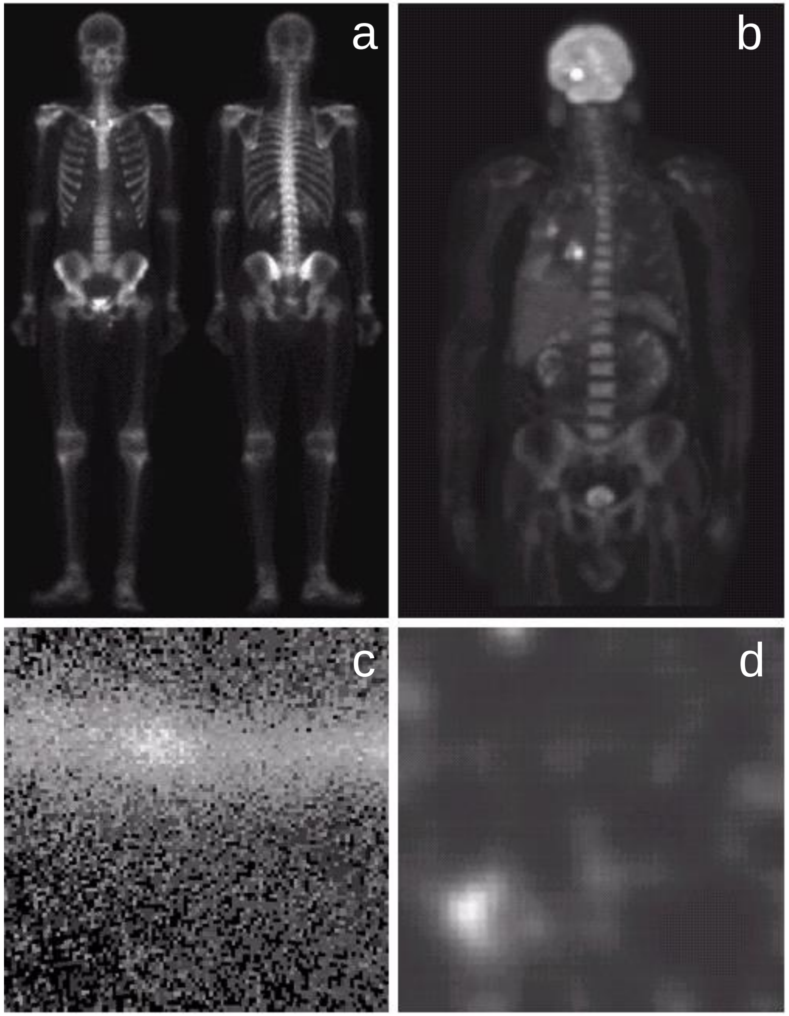


Figure 3. Examples of gamma-ray imaging.(a) Bone scan.(b) PET image.(c) Cygnus Loop.(d) Gamma radiation (bright spot) from a reactor valve.

Examples of fields that use Digital Image Processsing

Figure 3(c) shows the Cygnus Loop imaged in the gamma-ray band. Unlike the two examples shown in figures 3(a) and (b), this image was obtained using the natural radiation of the object being imaged. Finally, figure 3(d) shows an image of gamma radiation from a valve in a nuclear reactor.

Examples of fields that use Digital Image Processsing

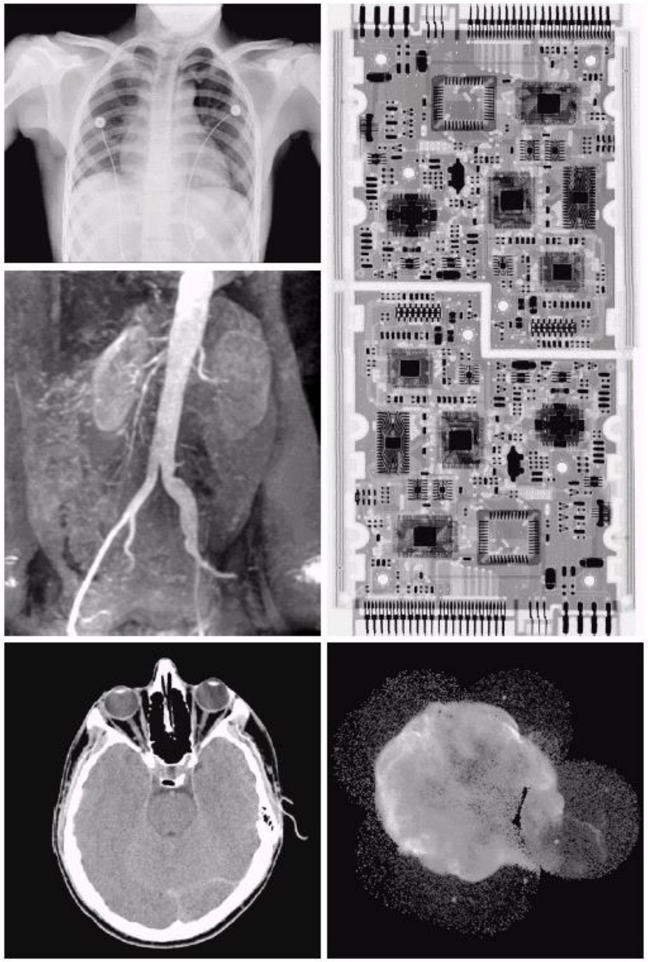


Figure 4(a) shows a familiar chest X-ray generated simply by placing the patient between an X-ray source and a film sensitive to X-ray energy.

Angiography is another major application in an area called contrast-enhancement radiography. Figure 4(b) shows an example of an aortic angiogram.

a d
b e
c

Figure 4. Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop.

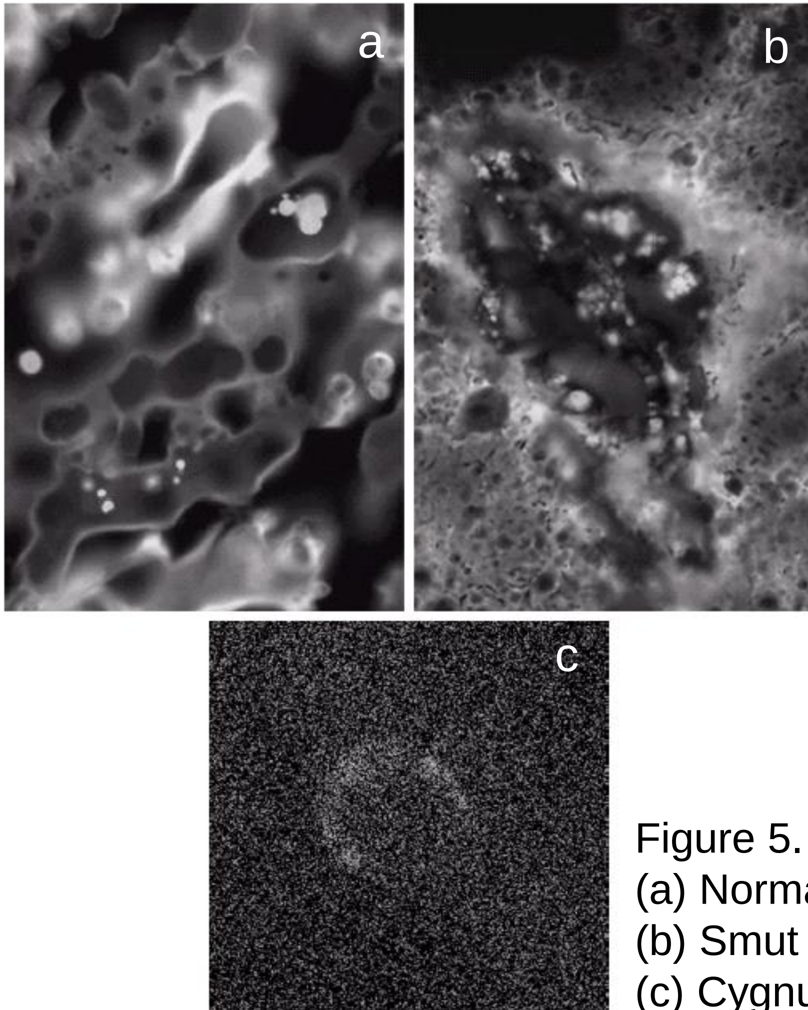
Examples of fields that use Digital Image Processsing

Perhaps the best known of all uses of X-rays in medical imaging is computerized axial tomography. Figure 4(c) shows a typical head CAT slice image.

Applications of ultraviolet “light” are varied. Ultraviolet light is used in fluorescence microscopy, one of the fastest growing areas of microscopy. The ultraviolet light itself is not visible.

The basic task of the fluorescence microscope is to use an excitation light to irradiate a prepared specimen and then to separate the radiating fluorescent light from the excitation light.

Examples of fields that use Digital Image Processsing



Figures 5(a) and (b) show results typical of the capability of fluorescence microscopy.

Figure 5. Examples of ultraviolet imaging.
(a) Normal corn.
(b) Smut corn.
(c) Cygnus Loop.

Imaging in the visible and infrared bands

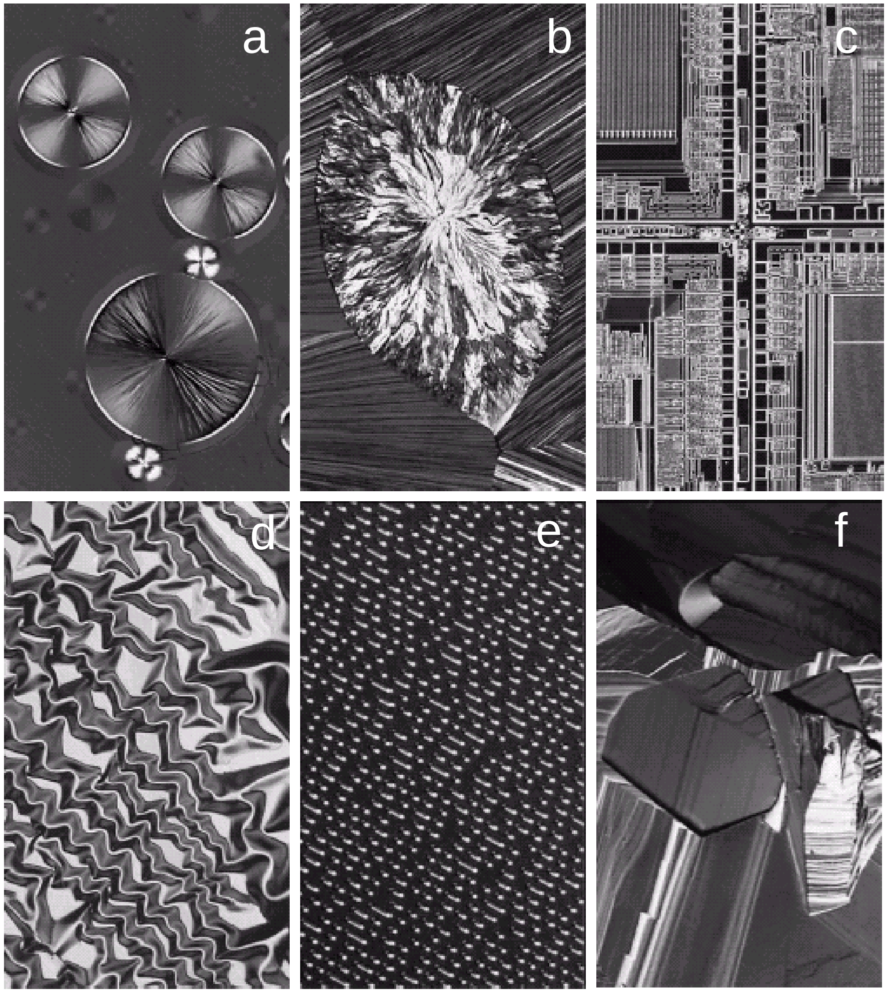


Figure 6 shows several examples of images obtained with a light microscope. It is not difficult to conceptualize the types of processes one might apply to these images, ranging from enhancement to measurements.

Figure 6. Examples of light microscopy images.
(a) Taxol (anticancer agent) magnified 250×.
(b) Cholesterol – 40×.
(c) Microprocessor.
(d) Nickel oxide thin film – 600×.
(e) Surface of audio CD – 1750×.
(f) Organic superconductor – 450×.

Imaging in the visible and infrared bands

Another major area of visual processing is remote sensing, which usually includes several bands in the visual and infrared regions of the spectrum. Table 1 shows the so-called *thematic bands* in NASA´s LANDSAT satellite.

Table 1. Thematic bands in NASA's LANDSAT satellite

Band No.	Name	Wavelength (μm)	Characteristics and Uses
1	Visible blue	0.45–0.52	Maximum water penetration
2	Visible green	0.52–0.60	Good for measuring plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.76–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content of soil and vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Middle infrared	2.08–2.35	Mineral mapping

Imaging in the visible and infrared bands

Figure 7 shows one image for each of the spectral bands in table 1.

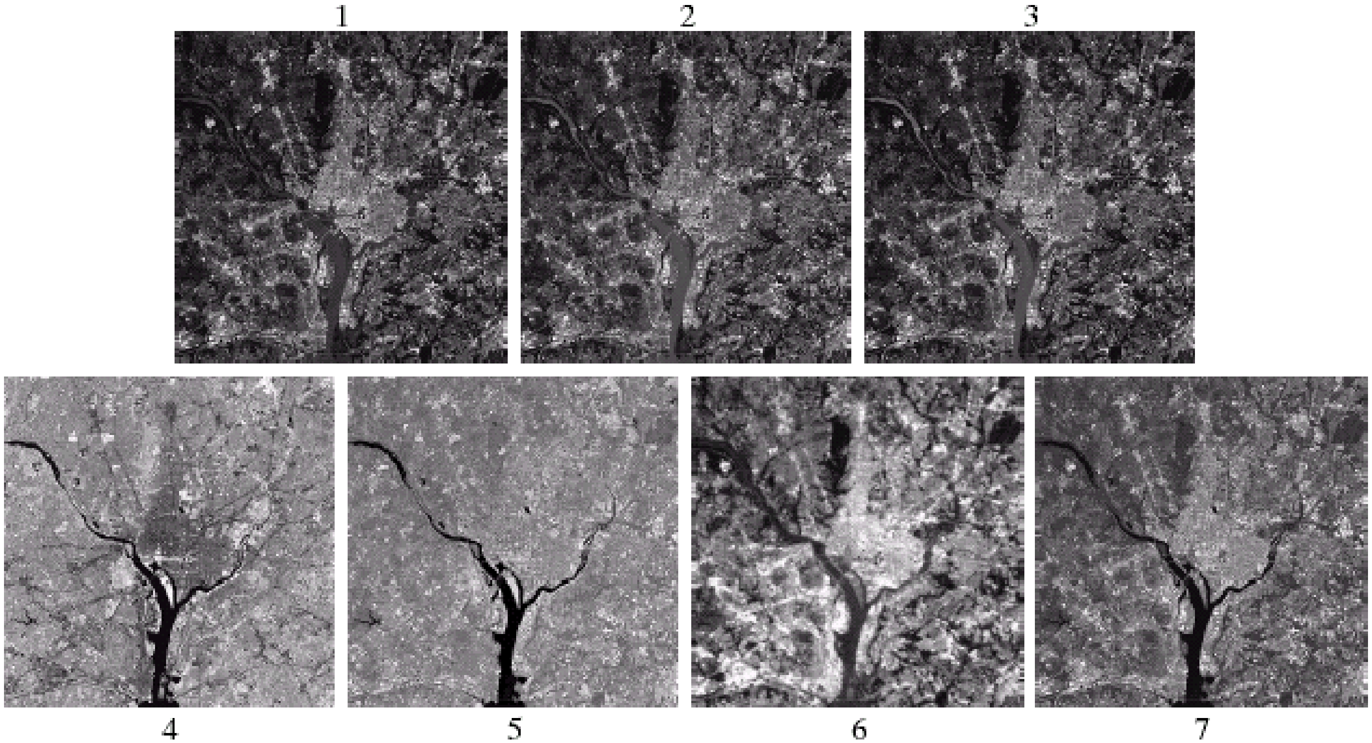
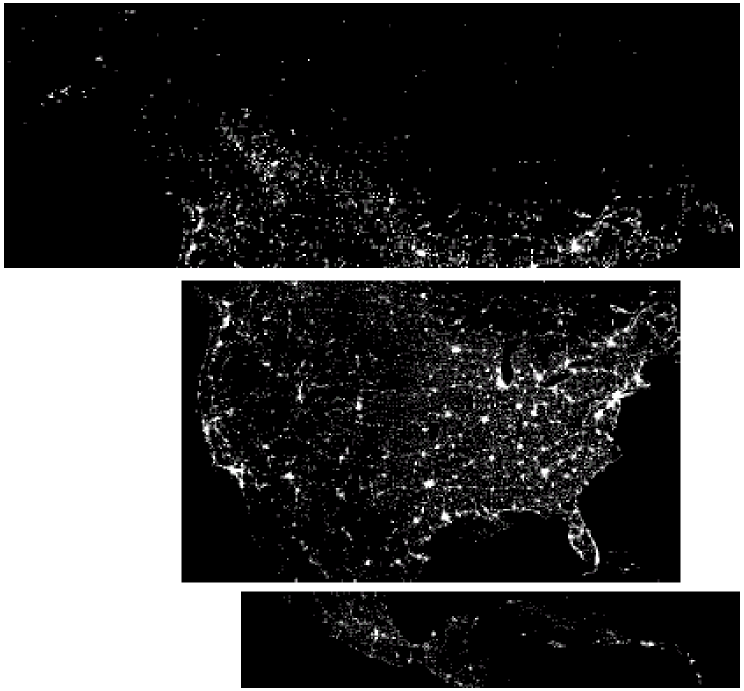


Figure 7. LANDSAT satellite images of the Washington, D. C. area. The numbers refer to the thematic bands in table 1.

Imaging in the visible and infrared bands



Weather observation and prediction also are major applications of multispectral imaging from satellites. Figure 8 and 9 show an application of infrared imaging. These images are part of the Nightime Lights of the World data set.

Figure 8. Infrared satellite images of the Americas. The small gray map is provided for reference

Imaging in the visible and infrared bands

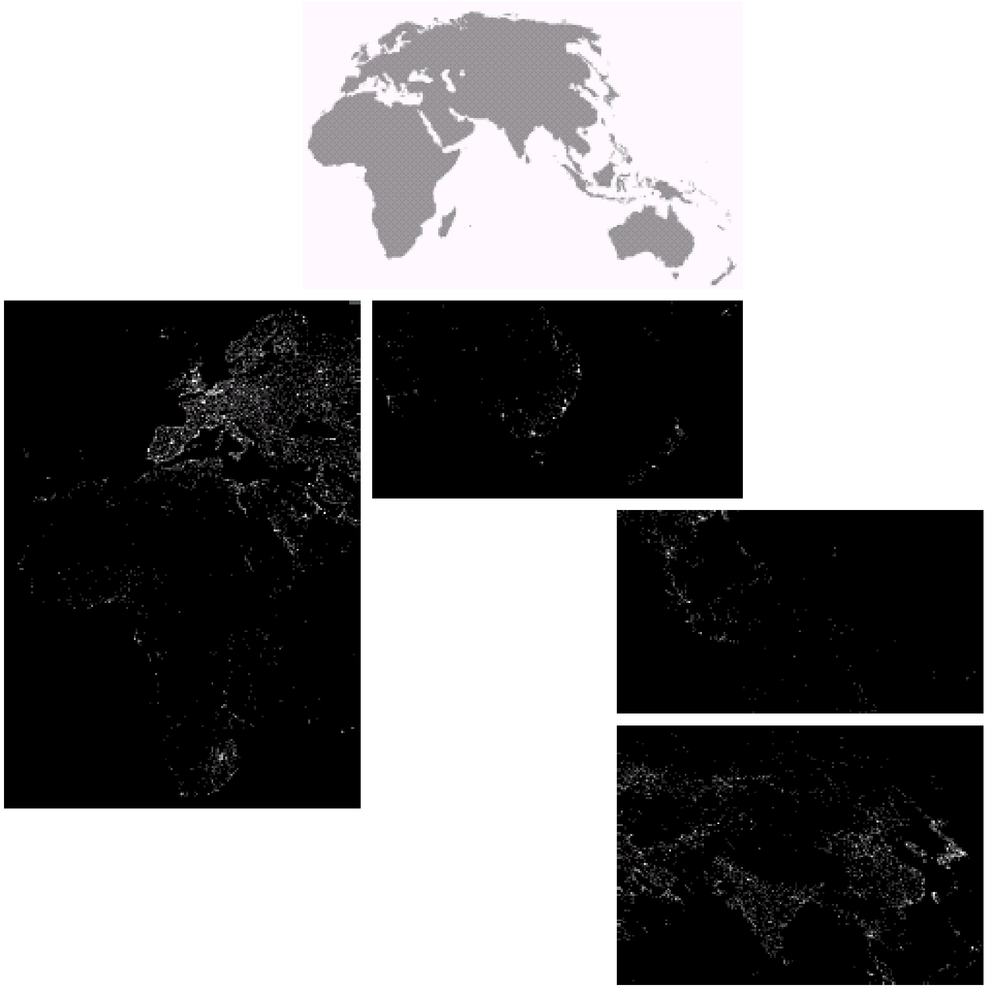


Figure 9. Infrared satellite images of the remaining populated part of the world . The small gray map is provided for reference

Imaging in the visible and infrared bands

A major area of imaging in the visual spectrum is in automated visual inspection of manufactured goods. A typical image processing task with productos like this is to inspect them for missing parts.

Figure 10(b) is an imaged pill container. Figure 10(c) shows an application in which image processing is used to look for bottles that are not filled up to an acceptable level.

Figure 10(d) shows a clear-plastic part with an unacceptable number of air pockets in it. Figure 10(e) shows a batch of cereal during inspection for color and the presence of anomalies such as burned flakes.

Imaging in the visible and infrared bands

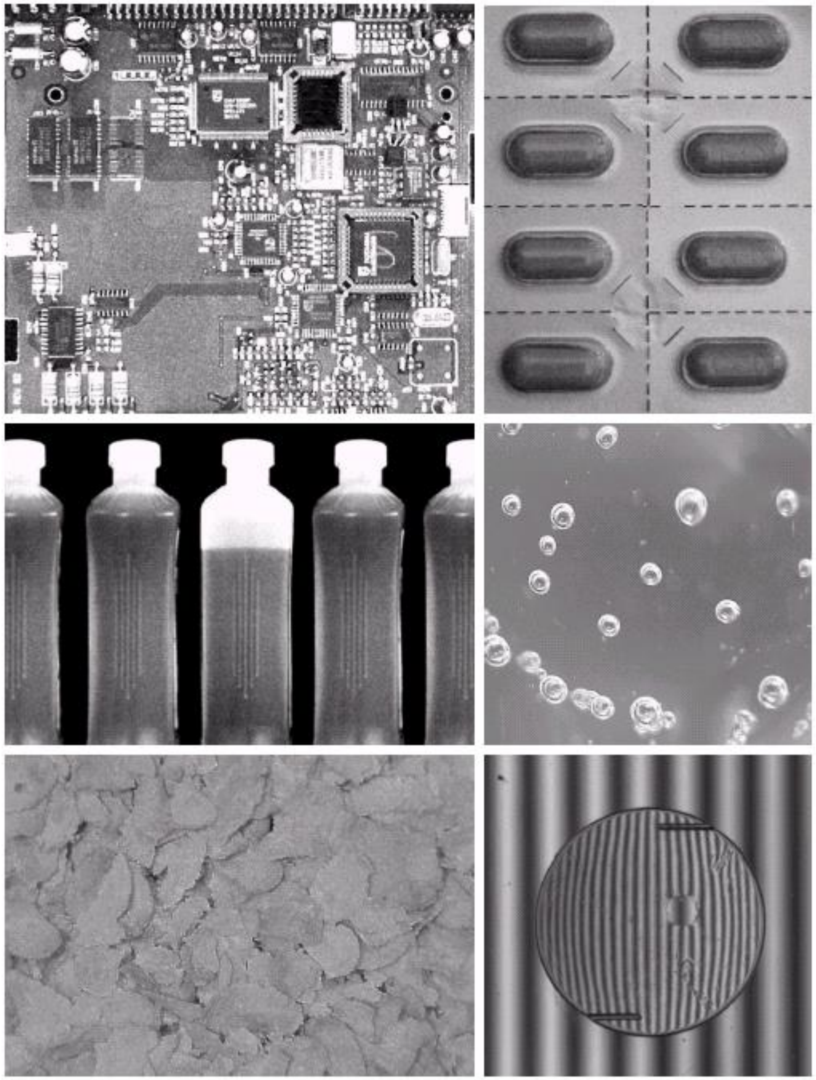


Figure 10. Some examples of manufactured goods often checked using digital image processing.
(a) A circuit board controller.
(b) Packaged pills.
(c) Bottles.
(d) Bubbles in clear-plastic product.
(e) Cereal.
(f) Image of intraocular implant.

a b

c d

e f

Imaging in the visible and infrared bands

As a final illustration of image processing in the visual spectrum, figure 11(a) shows a thumb print. Figure 11(b) shows an image of paper currency. Figure 11(c) and (d) are examples of automated license plate reading.

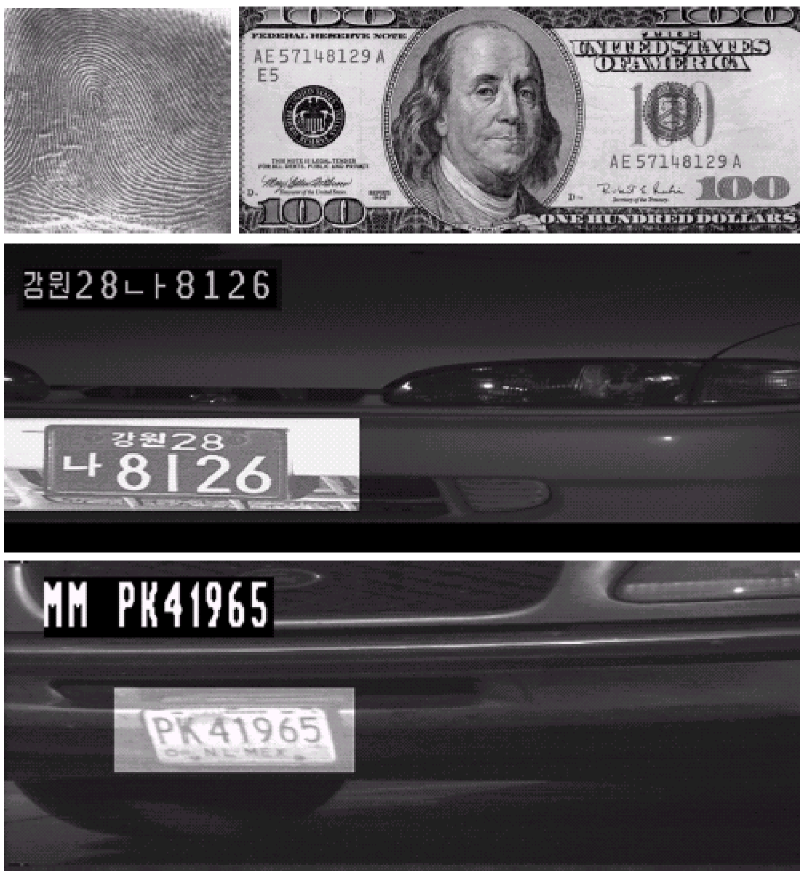


Figure 11. Some additional examples of imaging in the visual spectrum
(a) Thumb print
(b) Paper currency
(c) and (d) Automated license plate reading

a b

c

d

Imaging in the macrowave band

The dominant application of imaging in the microwave band is radar. Some radar waves can penetrate clouds, and under certain conditions can also see through vegetation, ice, and extremely dry sand.

Instead of a camera lens, a radar uses an antenna and digital computer processing to record its images. In a radar image, one can see only the microwave energy that we was reflected back toward the radar antenna.

Imaging in the macrowave band

Figure 12 shows a spaceborne radar image covering a rugged mountainous area of southeast.

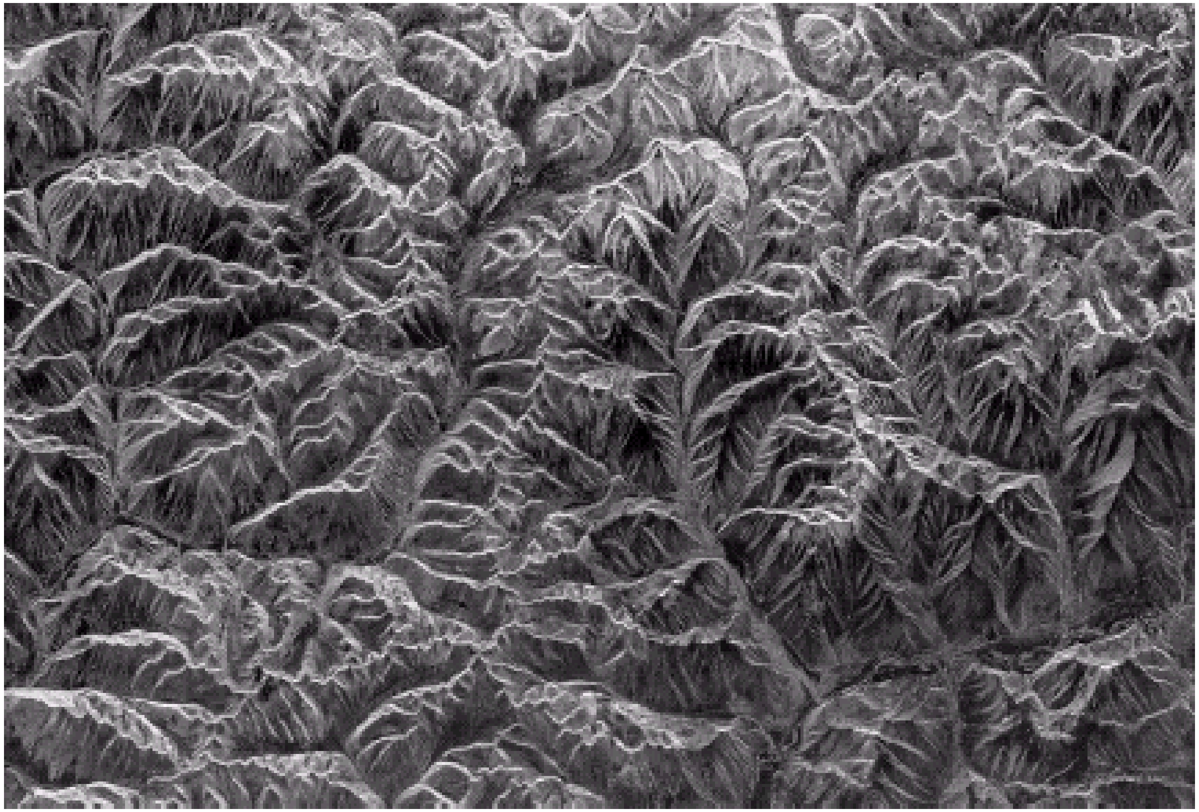


Figure 12. Spaceborne radar image of mountains in southeast Tibet

Imaging in the radio band

In medicine radio waves are used in magnetic resonance imaging (MRI). This technique places a patient in a powerful magnet and passes radio waves through his or her body in short pulses.

Each pulse causes a responding pulse of radio waves to be emitted by the patient´s tissues. The location from which these signals originate and their strength area determined by a computer.

Imaging in the radio band

Figure 13 shows MRI images of a human knee and spine.

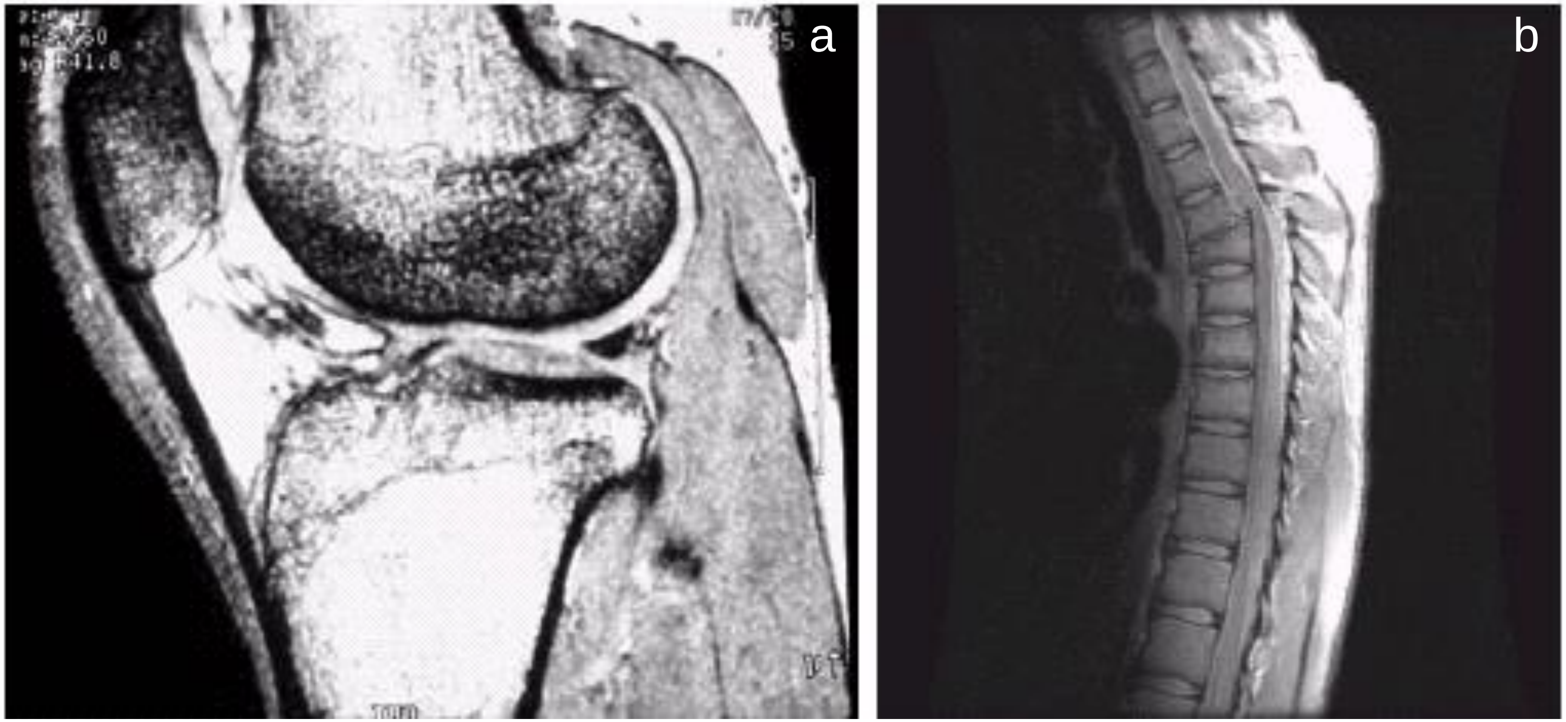


Figure 13. MRI images of a human (a) knee, and (b) spine

Examples in which other imaging modalities are used

Imaging using “sound” finds application in geological exploration, industry, and medicine. Geological applications use sound in the low end of the sound spectrum (hundreds of Hertz) while imaging in other areas use ultrasound (millions of Hertz).

Although ultrasound imaging is used routinely in manufacturing, the best know applications of this technique are in medicine, especially in obstetrics.

In a typical ultrasound image, millions of pulses and echoes are sent and received each second. Figure 14 shows several examples.

Examples in which other imaging modalities are used

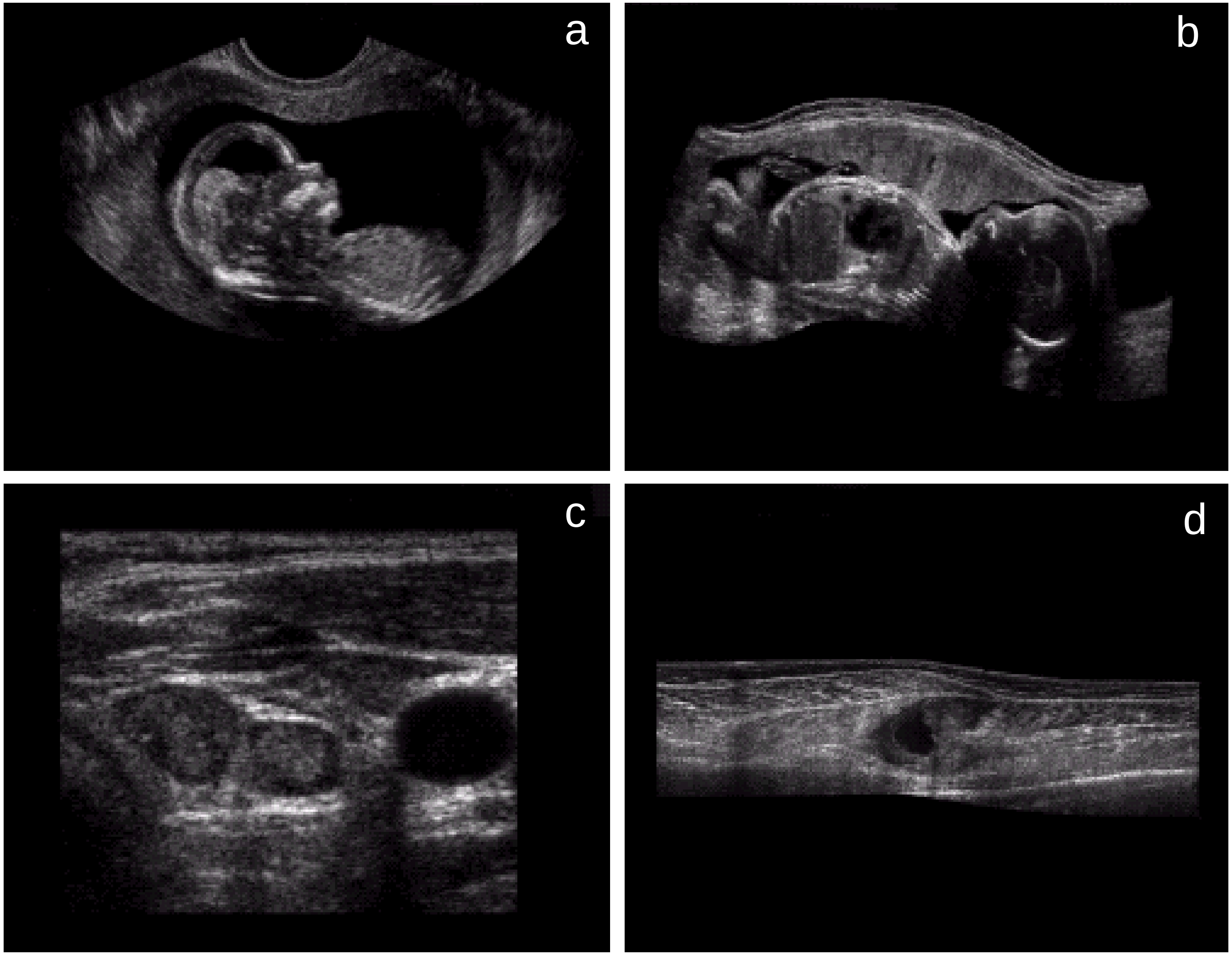


Figure 14. Examples of ultrasound imaging. (a) Baby. (b) Another view of baby. (c) Thyroids (d) Muscle layers showing lesion

Fundamental steps in Digital Image Processing

It is helpful to divide the material covered in two broad categories:

- Methods whose input and output are images

- Methods whose inputs may be images, but whose outputs are attributes extracted from those images.

Fundamental steps in Digital Image Processing

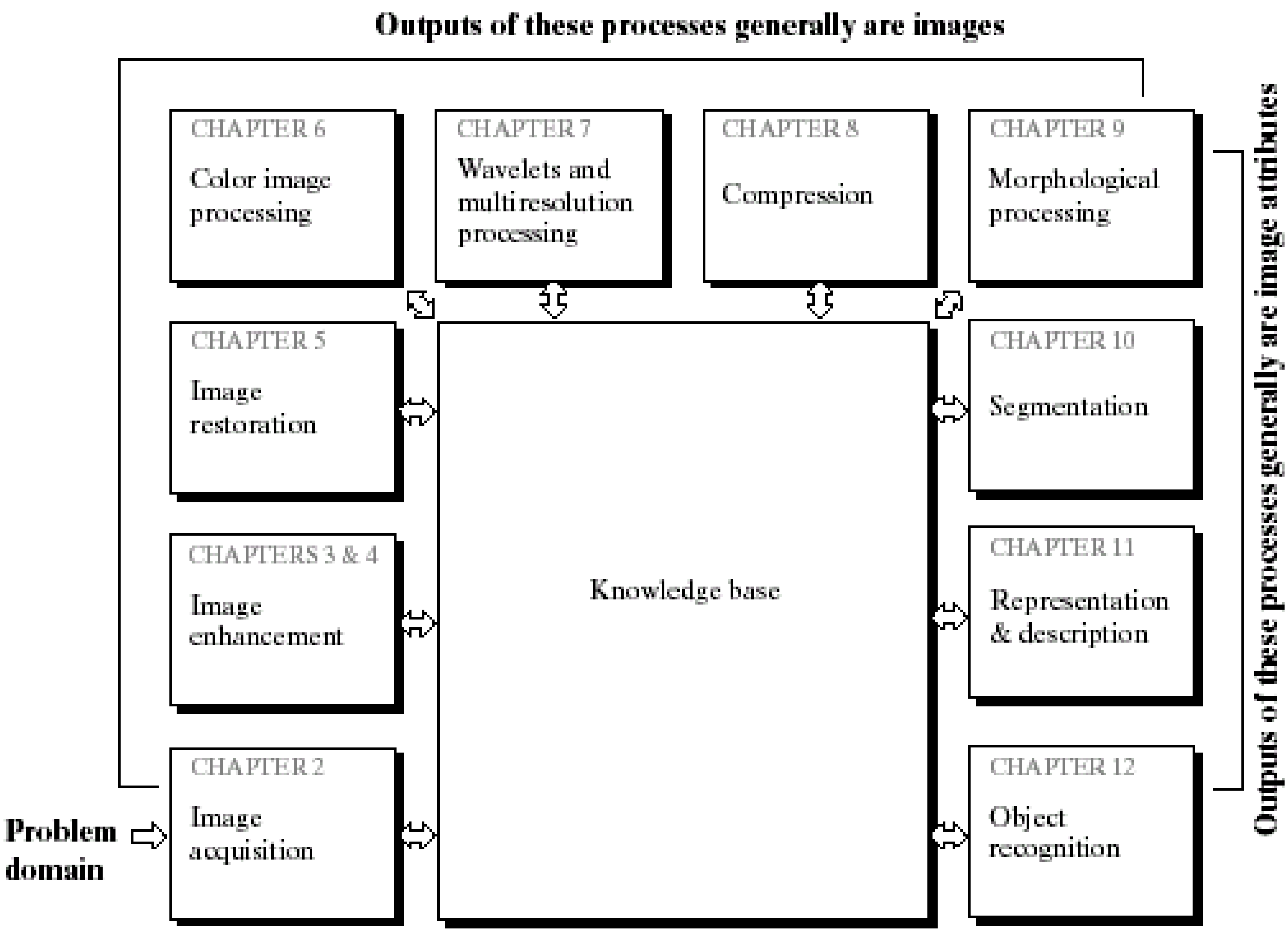


Figure 15. Fundamental steps in digital image processing

Fundamental steps in Digital Image Processing

- Image acquisition could be as simple as being given an image that is already in digital form.

- Image enhancement highlight certain features of interest in an image. Increase the contrast. Enhancement is a very subjetive area.

- Image restoration is objetive, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

Fundamental steps in Digital Image Processing

- Color image processing covers concepts in color models as the basis for extracting features of interest in an image.

- Wavelets for image data compression

- Compression

- Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape

Fundamental steps in Digital Image Processing

- Segmentation procedures partition an image into its constituent parts or objects

- Representation and description whether the data should be represented as a boundary or as a complete region. *Description*, also called *feature selection*, deals with extracting attributes that result in some quantitative information of interest.

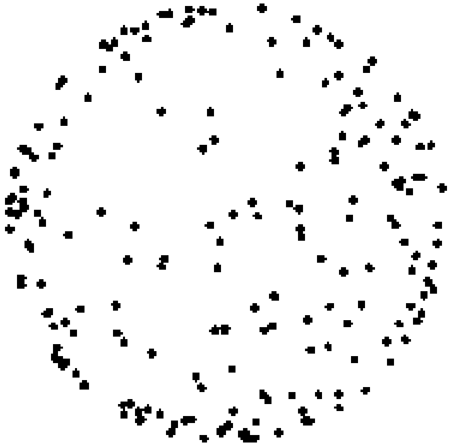
- Recognition is the process that assigns a label to an object based on its descriptors.

- Knowledge base.

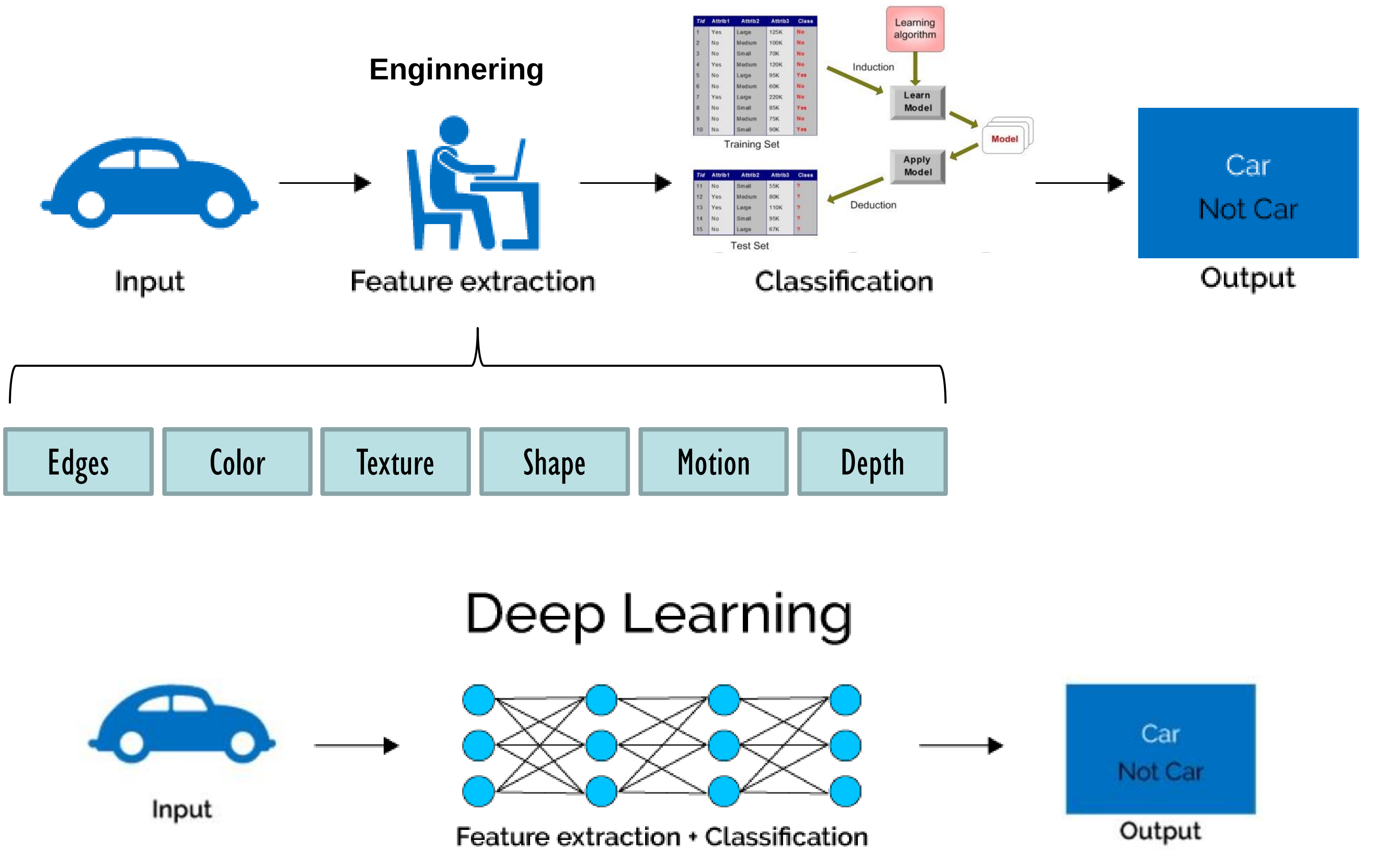
Fundamental steps in Digital Image Processing

- Knowledge about a problem domain is coded into an image processing system in the form of a knowledge database.

- In addition to guiding the operation of each processing module, the knowledge base also controls the interaction between modules.



Traditional value-based feature selection



Components of an Image Processing System

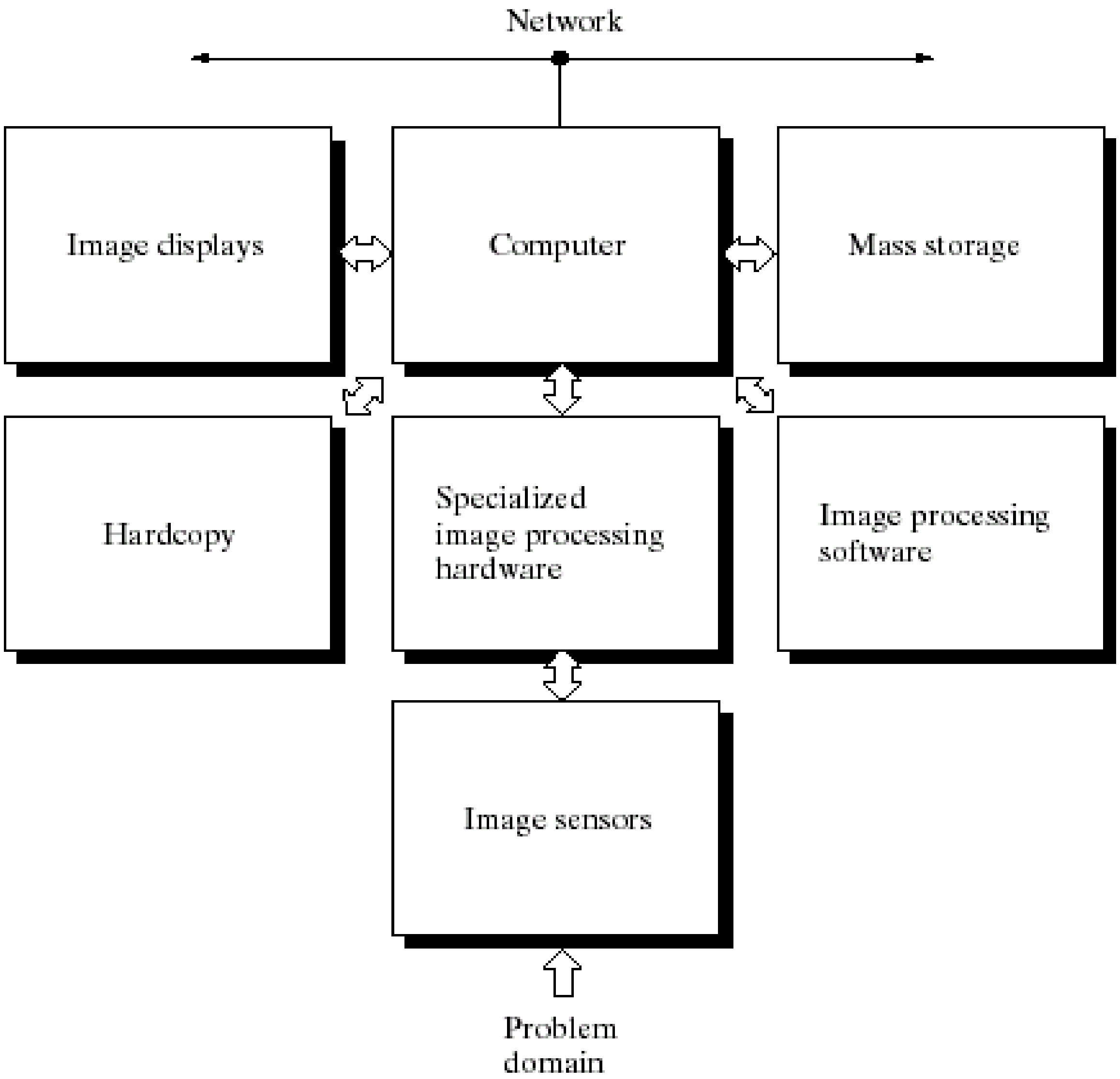
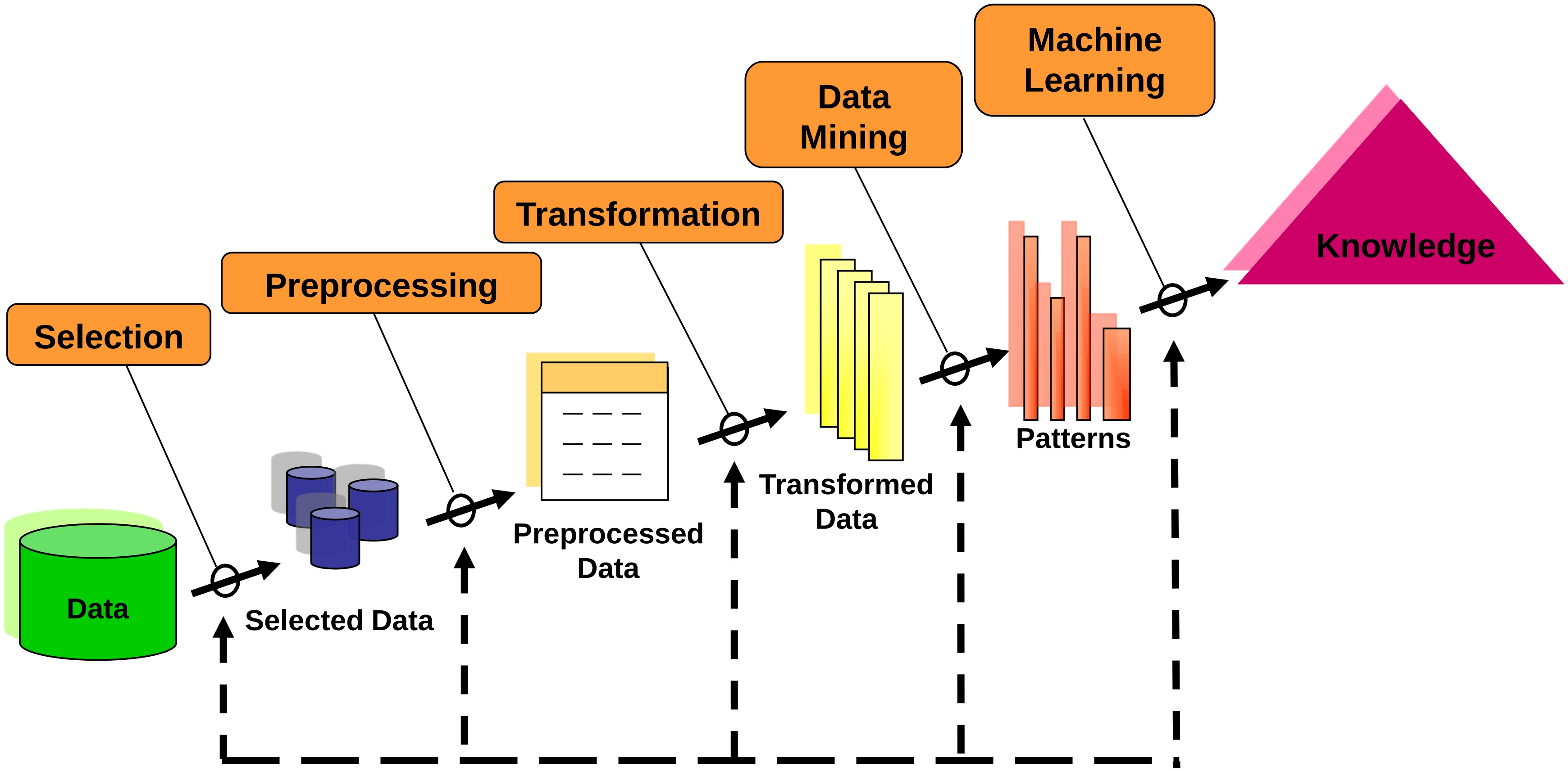


Figure 16. Components of a general purpose image processing system

KDD



Selection
Preprocessing
Transformation
Data Mining
Machine Learning
Knowledge
Data
Selected Data
Preprocessed Data
Transformed Data
Patterns

Homework

Reporte de lectura:

Haciendo que las máquinas (y la inteligencia artificial) vean. Capítulo 10. El nuevo debate sobre la inteligencia artificial. Stephen R. Graubard. Editorial Gedisa.

Motivation:
One picture is worth more than ten thousand words

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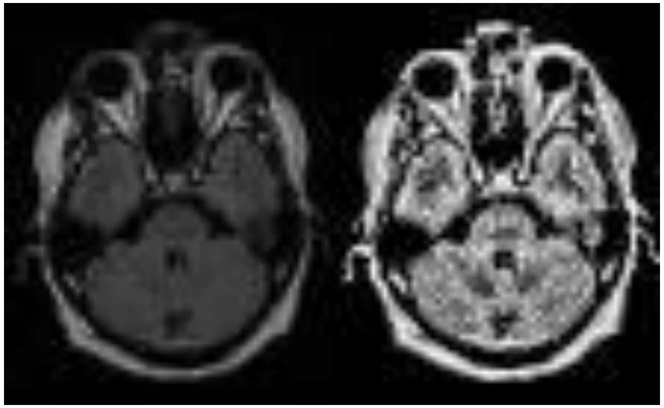
Computer Vision

Image Enhancement



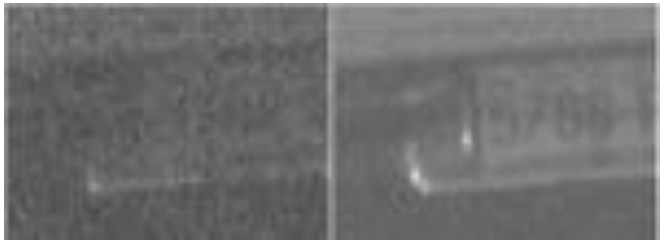
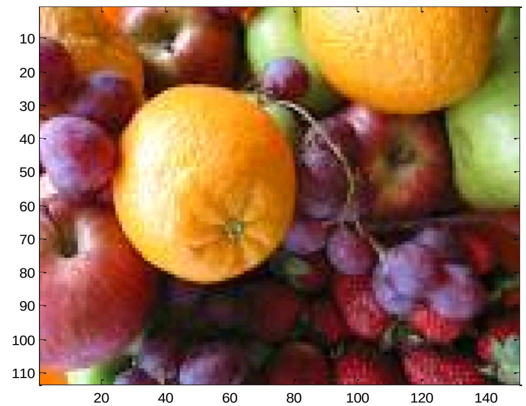
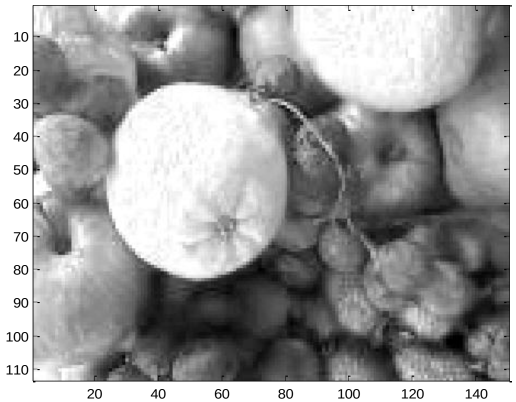
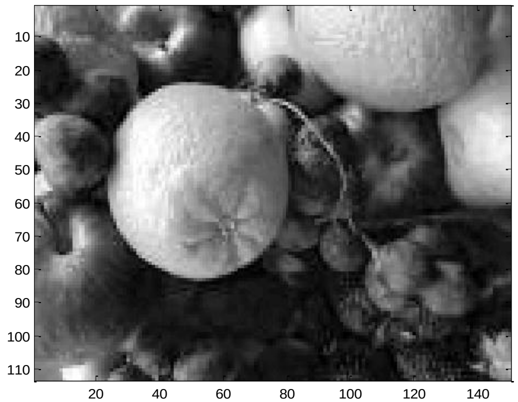


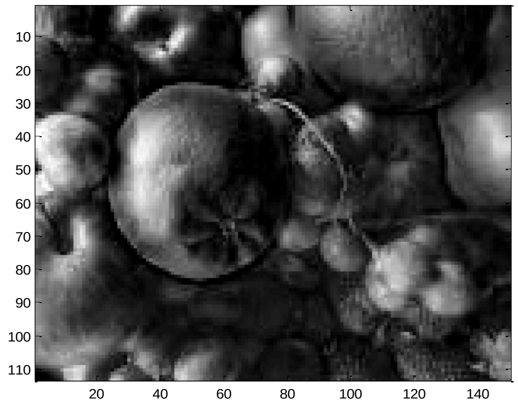
Image Restoration

Color Processing









R **G** **B**

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Morphological Processing

Image Segmentation

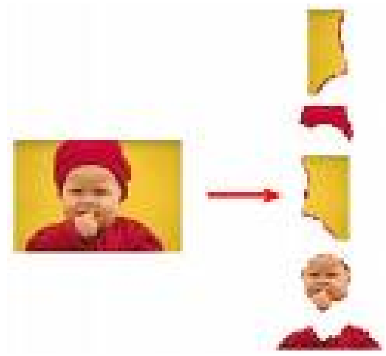
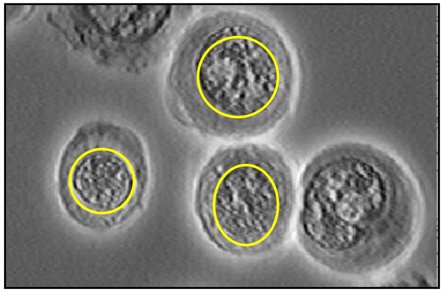
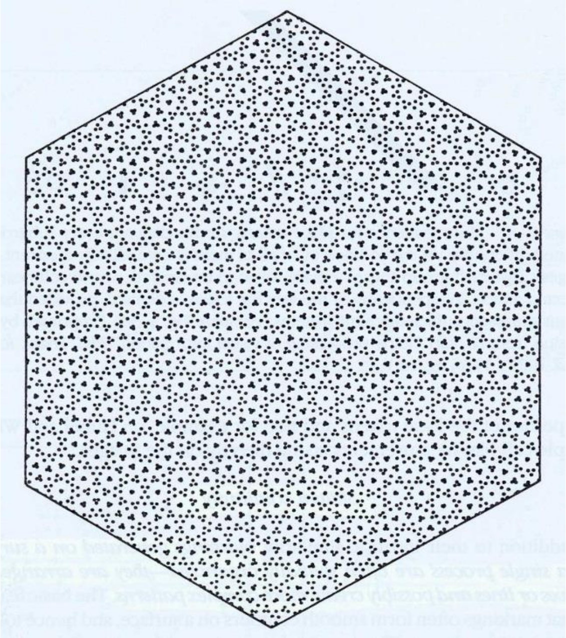


Image Description



Knowledge Base



[Grocery trip](https://www.youtube.com/watch?v=DgPaCWJL7XI)

https://www.youtube.com/watch?v=DgPaCWJL7XI

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