

DIGITAL IMAGE PROCESSING

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2020

Istilah

- DSP = Digital Signal Processing
- DIP = Digital Image Processing

Pengantar

(Sumber : Lecture Notes Wanasanan Thongsongkrit)

- Early days of computing, data was numerical.
- Later, textual data became more common.
- Today, many other forms of data: voice, music, speech, images, computer graphics, etc.
- Each of these types of data are signals.
- Loosely defined, a signal is a function that conveys information

Hubungan DSP dengan Bidang Ilmu yang Lain

- As long as people have tried to send or receive through electronic media : telegraphs, telephones, television, radar, etc. there has been the realization that these signals may be affected by the system used to acquire, transmit, or process them.
- Sometimes, these systems are imperfect and introduce noise, distortion, or other artifacts.

Hubungan DSP dengan Bidang Ilmu yang Lain

- Understanding the effects these systems have and finding ways to correct them is the fundamental of signal processing.
- Sometimes, these signals are specific messages that we create and send to someone else (e.g., telegraph, telephone, television, digital networking, etc.).
- That is, we specifically introduce the information content into the signal and hope to extract it out later.

Hubungan DSP dengan Bidang Ilmu yang Lain

- Sometimes, these man-made signals are encoding of natural phenomena (audio signal, acquired image, etc.), but sometimes we can create them from scratch (speech generation, computer generated music, computer graphics).
- Finally, we can sometimes merge these technologies together by acquiring a natural signal, processing it, and then transmitting it in some fashion.

What is Image Processing ?

- Image processing is a subclass of signal processing concerned specifically with pictures.
- Improve image quality for human perception and/or computer interpretation.



Beberapa Bidang Ilmu yang Berhubungan dengan Image

- Computer Graphics : the creation of images.
- Image Processing : the enhancement or other manipulation of the image – the result of which is usually another images.
- Computer Vision: the analysis of image content.

Pengolahan Data Berdasarkan Input/Output

INPUT	OUTPUT		
		IMAGE	DESKRIPSI
	IMAGE	Image Processing	Computer Vision
	DESKRIPSI	Grafika Komputer	Data Mining dll.

Dua Macam Aplikasi DIP

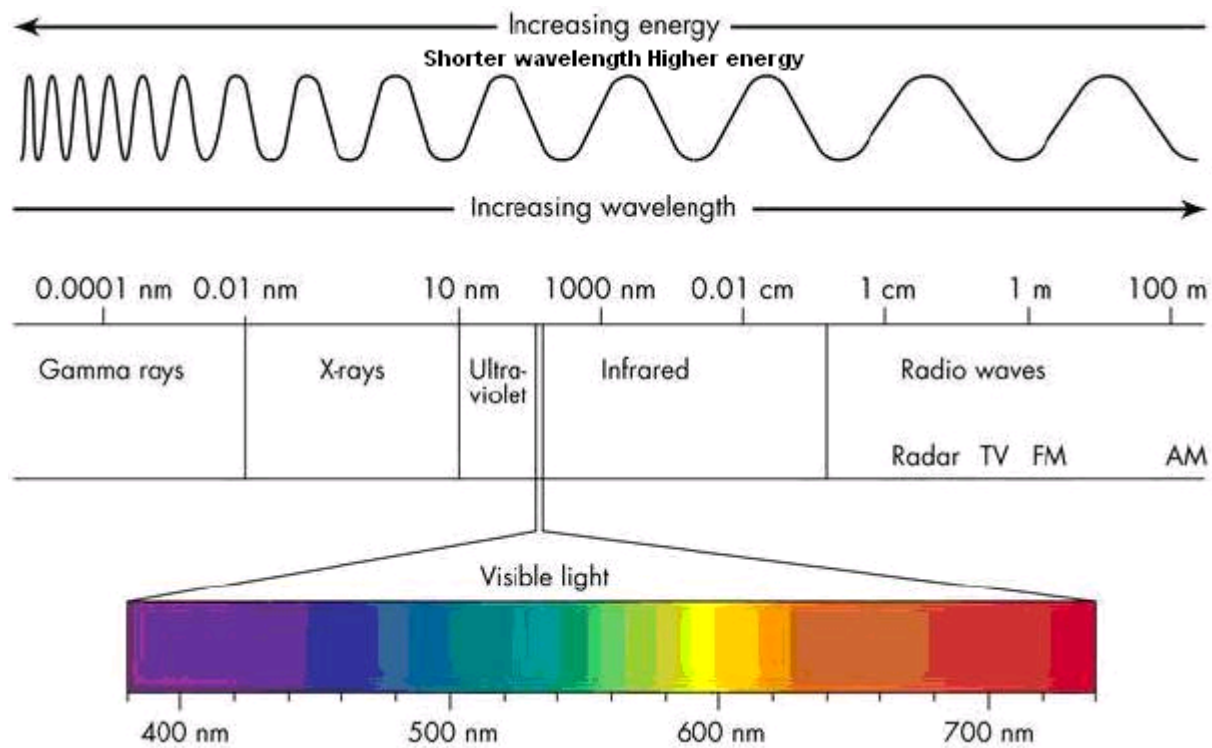
- Improvement of pictorial information for human interpretation
- Processing of image data for storage, transmission, and representation for autonomous machine perception

Bidang yang Memanfaatkan DIP

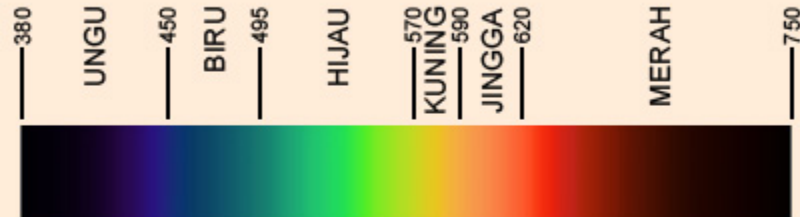
Dikelompokkan berdasarkan sumber dari gambar

Radiation from the Electromagnetic spectrum

- Acoustic
- Ultrasonic
- Electronic (in the form of electron beams used in electron microscopy)
- Computer (synthetic images used for modeling and visualization)

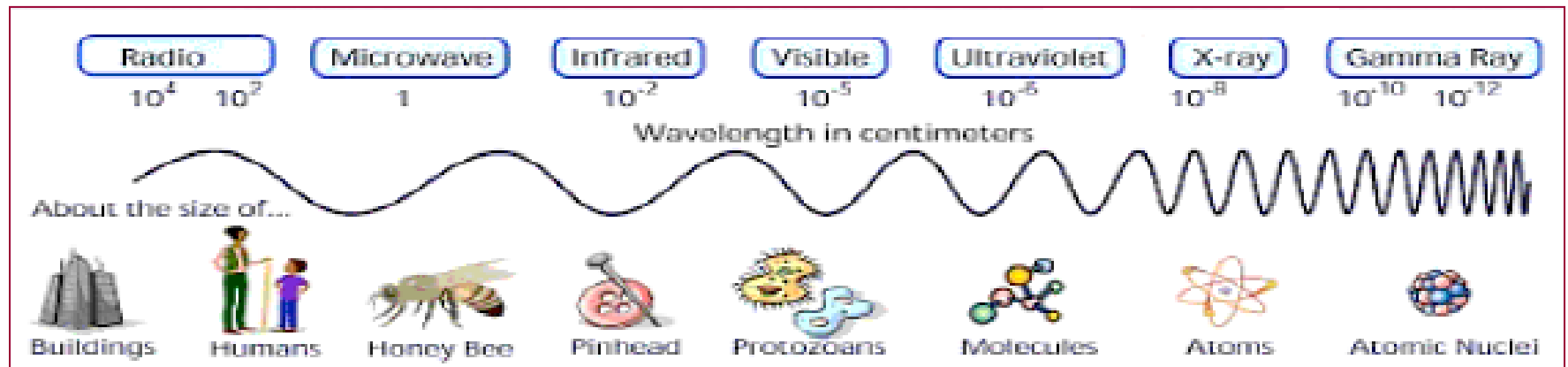


Warna-Warna pada Spektrum Cahaya Tampak

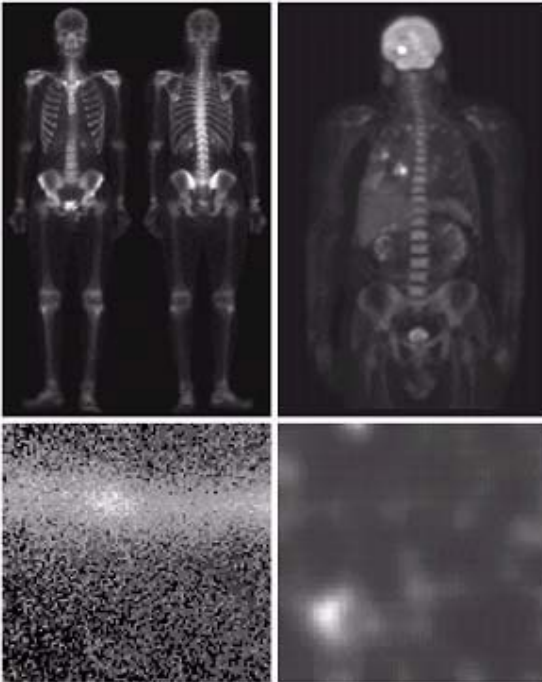


Warna	Panjang Gelombang	Frekuensi	Energi Foton
ungu	380–450 nm	668–789 THz	2.75–3.26 eV
biru	450–495 nm	606–668 THz	2.50–2.75 eV
hijau	495–570 nm	526–606 THz	2.17–2.50 eV
kuning	570–590 nm	508–526 THz	2.10–2.17 eV
jingga	590–620 nm	484–508 THz	2.00–2.10 eV
merah	620–750 nm	400–484 THz	1.65–2.00 eV

Alat-Alat Capture Sesuai Frekwensinya



Gamma-Ray Imaging



Nuclear Image

(a) Bone scan

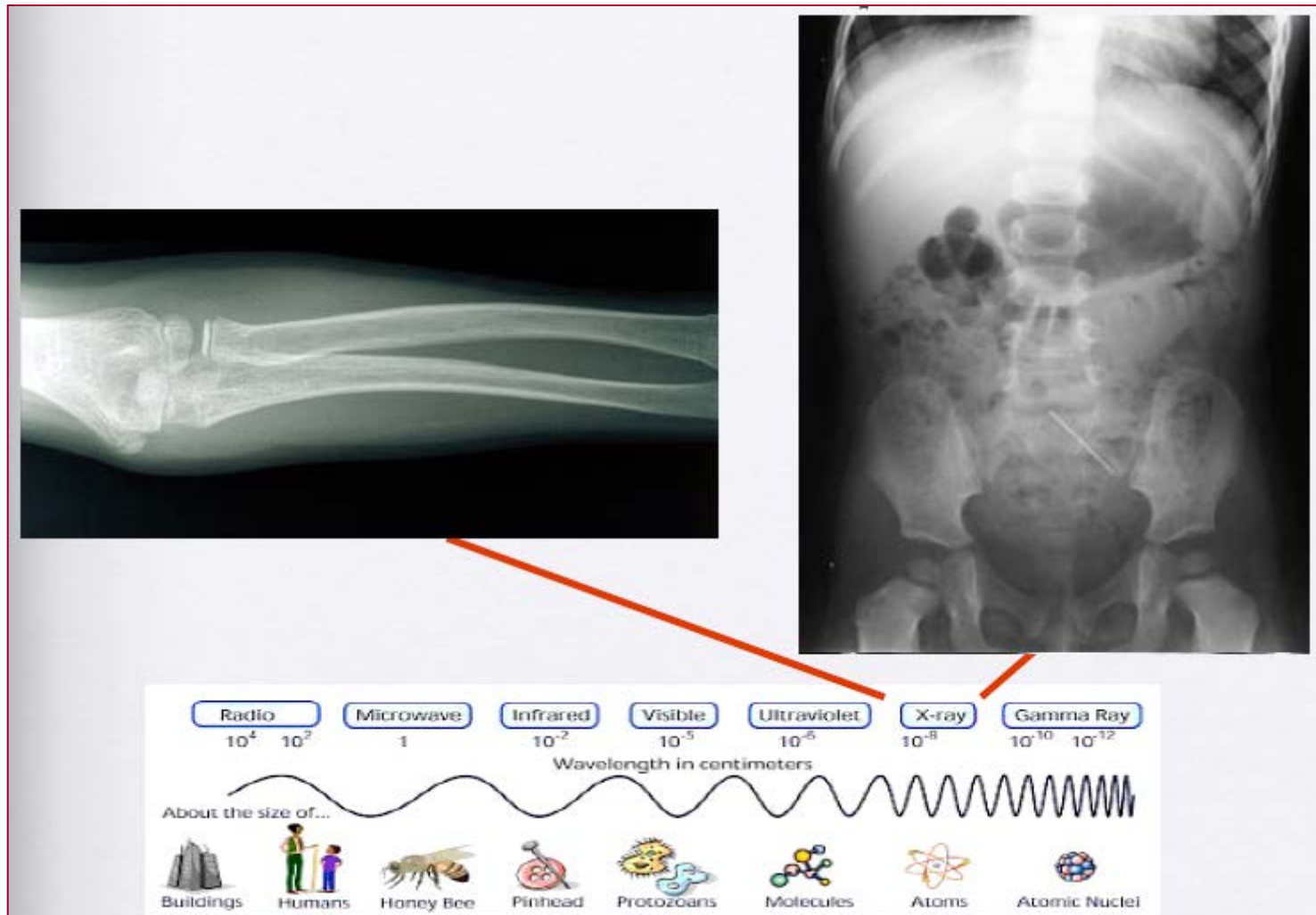
(b) PET (Positron emission tomography) image

Astronomical Observations.

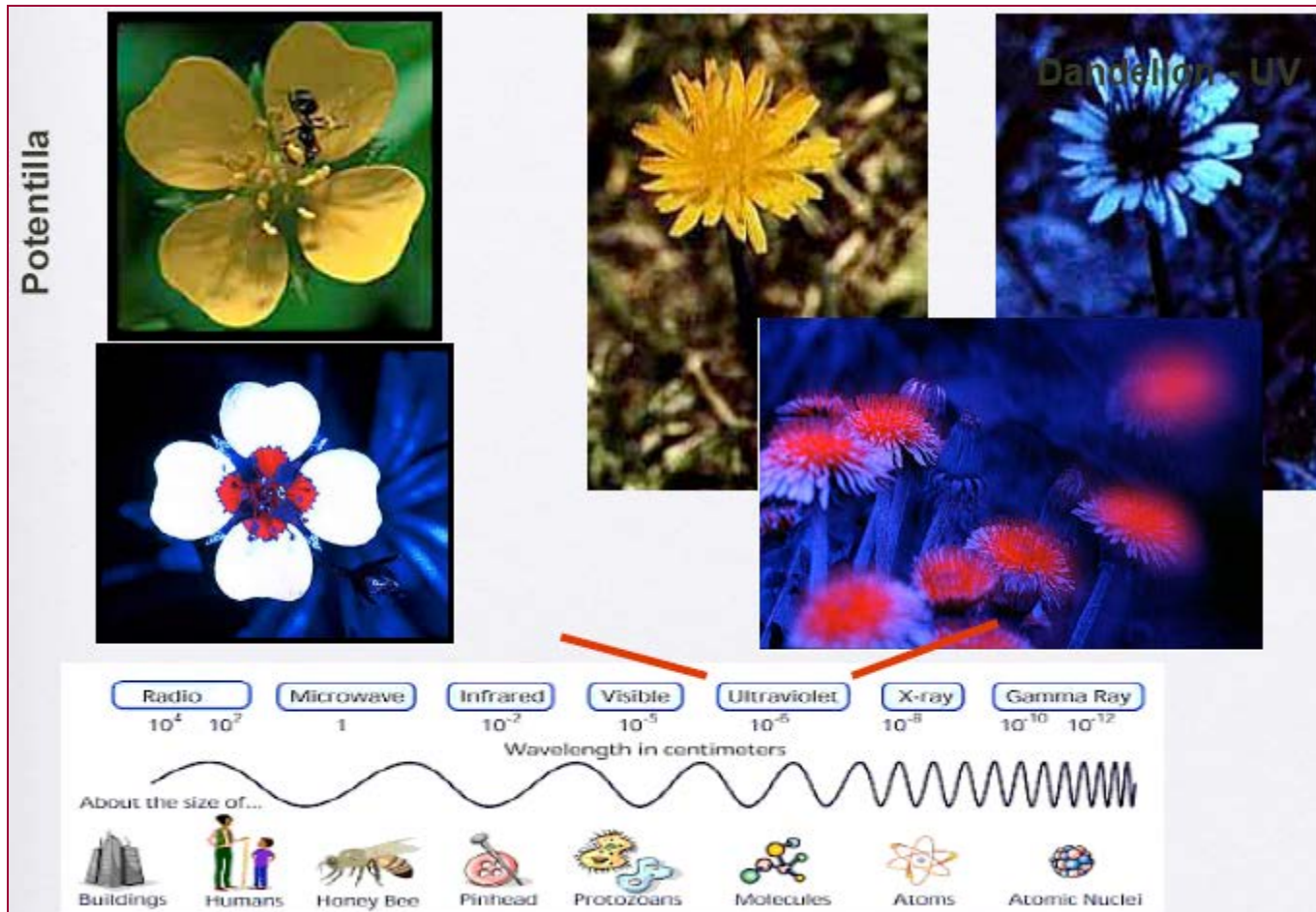
(c) Cygnus Loop Nuclear Reaction

(d) Gamma radiation from a reactor valve

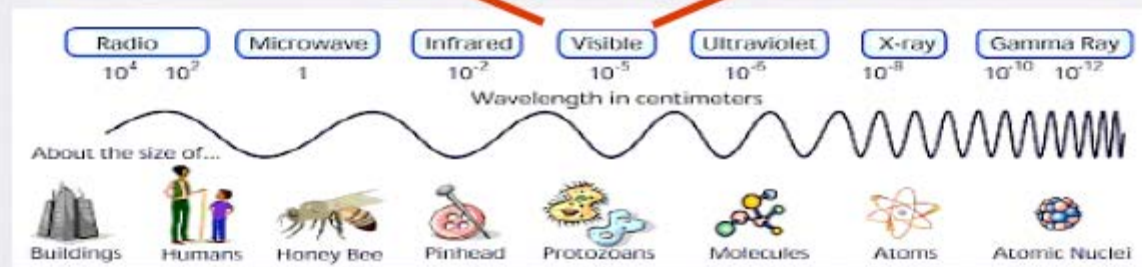
X-Ray Imaging



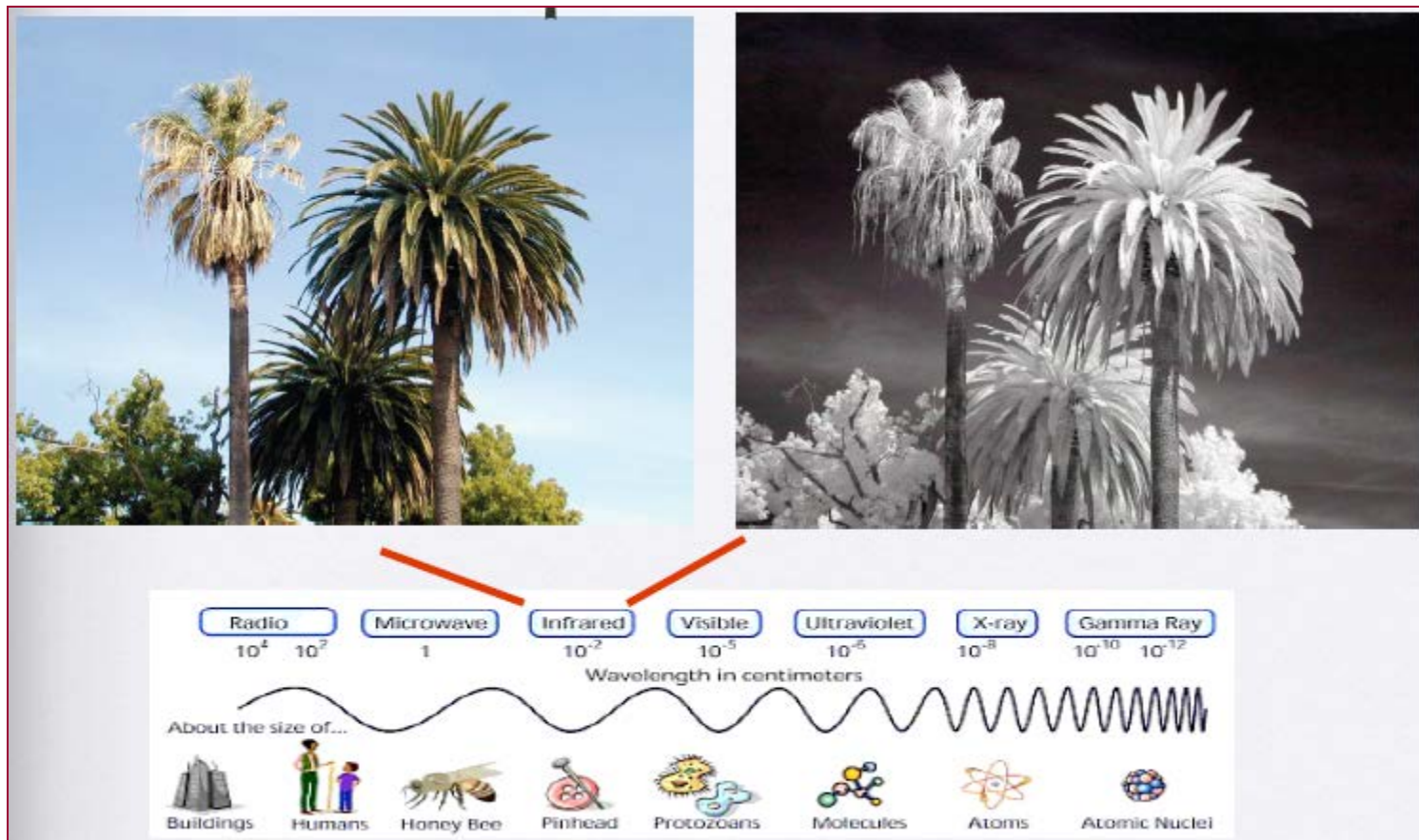
Ultraviolet Imaging



Visible Imaging



Infrared Imaging



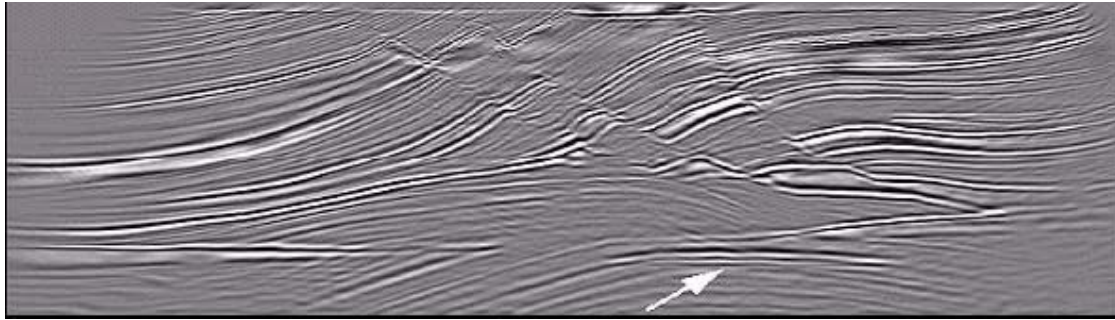
Imaging in Microwave Band



- Imaging radar : the only way to explore inaccessible regions of the Earth's surface
- Radar image of mountains in southeast Tibet
- Note the clarity and detail of the image, unencumbered by clouds or other atmospheric conditions that normally interfere with images in the visual band.

Imaging in Microwave Band

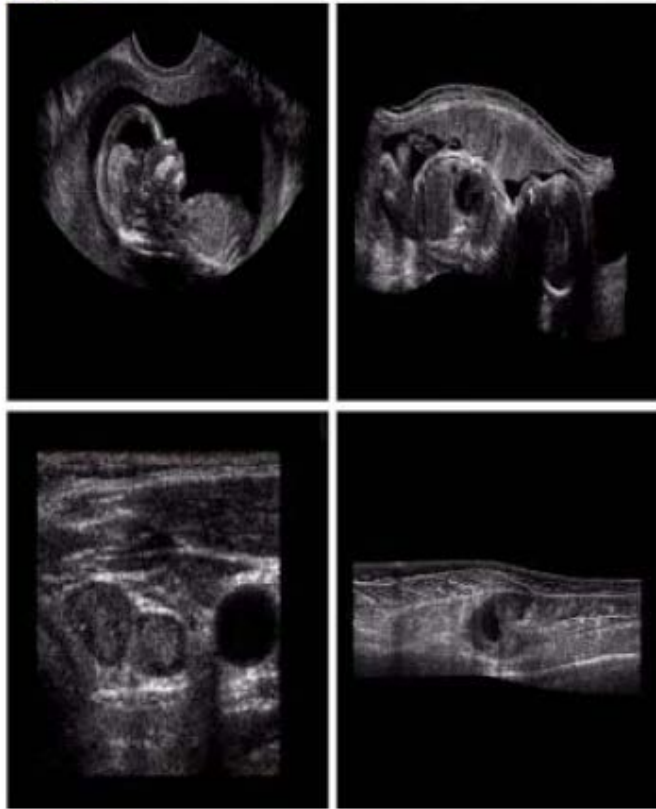
Geological applications : use sound in the low end of the sound spectrum (hundred of Hz) Mineral and oil exploration



Cross-sectional image of a seismic model.

The arrow points to a hydrocarbon (oil and/or gas) trap (bright spots)

Ultrasound Imaging



Manufacturing

Medicine

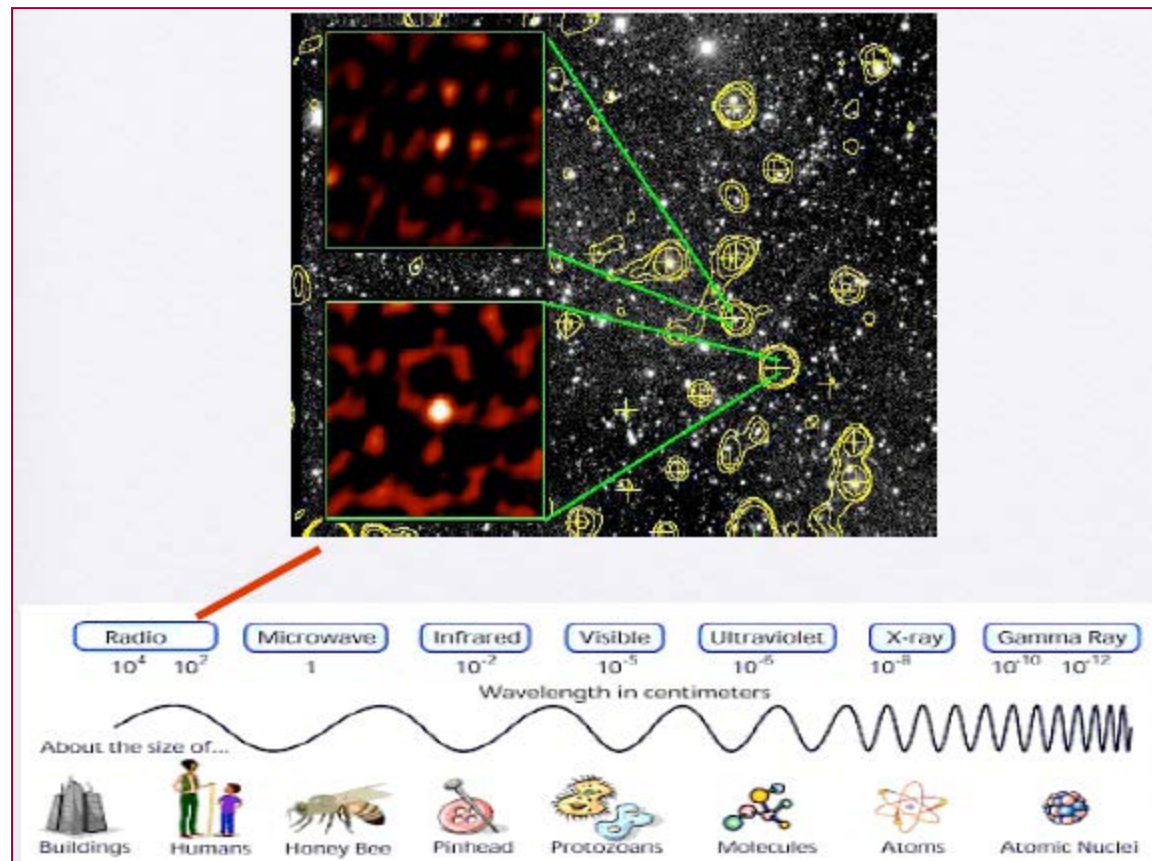
(a) Baby

(b) Another view of baby

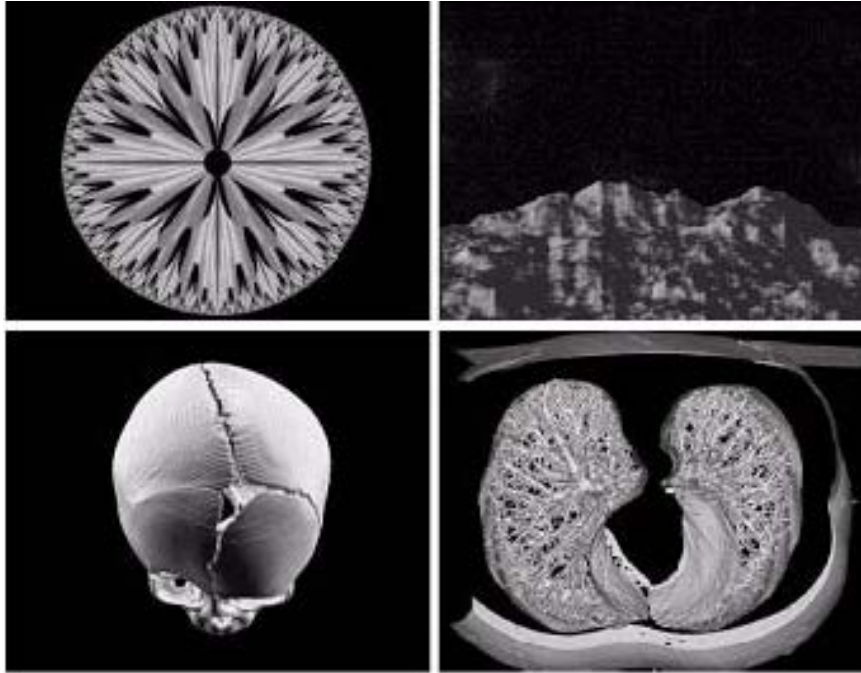
(c) Thyroids

(d) Muscle layers showing lesion

Imagin in Radio Band



Generated Images by Computer



- Fractals : an iterative reproduction of a basic pattern according to some mathematical rules (a) and (b)
- 3-D computer modeling (c) and (d)

3 Types of Computerized Process

Low-level : input, output are images

Primitive operations such as image preprocessing to reduce noise, contrast enhancement, and image sharpening

Mid-level : inputs may be images, outputs are attributes extracted from those images

- ☐ Segmentation
- ☐ Description of objects
- ☐ Classification of individual objects

High-level :

- ☐ Image analysis

Image Acquisition

An image is captured by a sensor (such as a monochrome or color TV camera) and digitized.

If the output of the camera or sensor is not already in digital form, an analog-to-digital converter digitizes it.

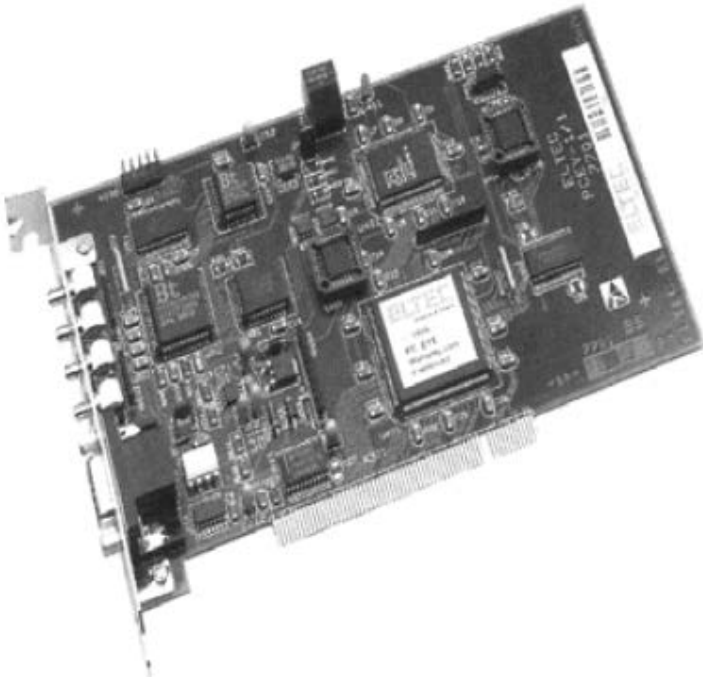
Camera



Camera consists of 2 parts

- A lens that collects the appropriate type of radiation emitted from the object of interest and that forms an image of the real object
- a semiconductor device – so called charged coupled device or CCD which converts the irradiance at the image plan into an electrical signal.

Frame Grabber

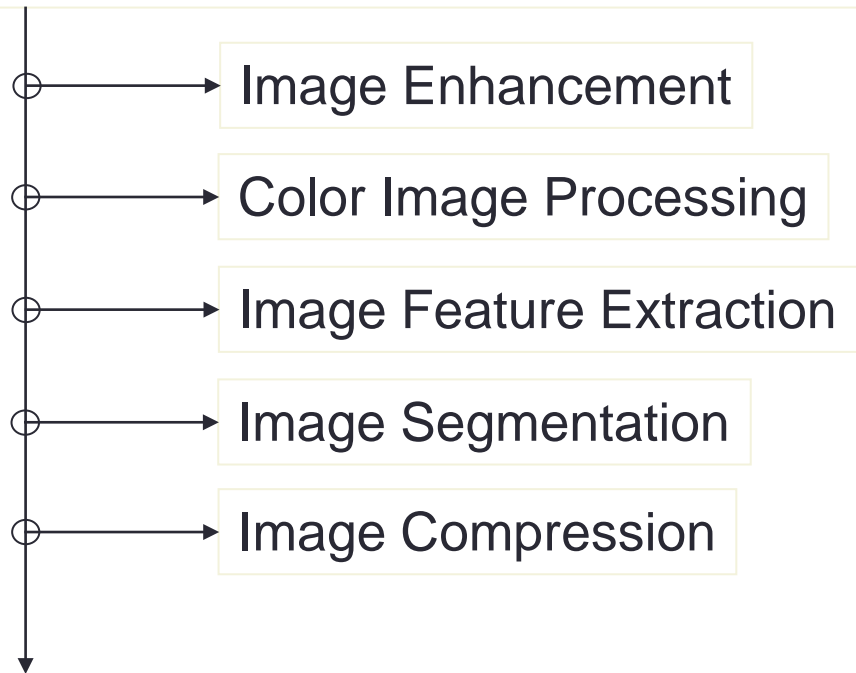


Frame grabber only needs circuits to digitize the electrical signal from the imaging sensor to store the image in the memory (RAM) of the computer.

Image Processing

Image processing adalah suatu pengolahan data yang masukannya berupa gambar dan luarannya juga gambar

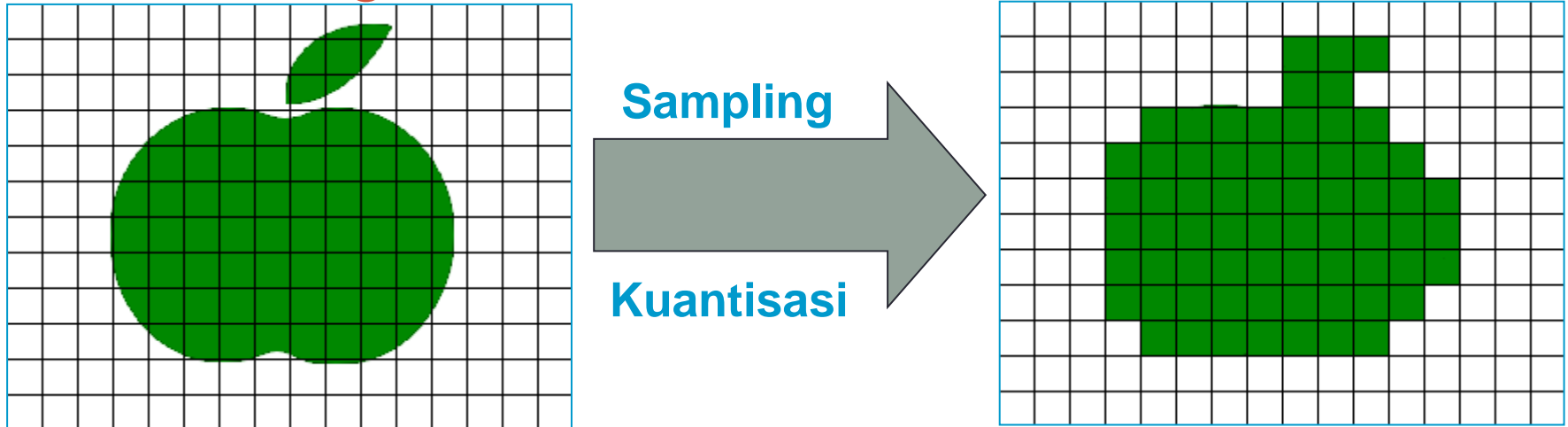
Tujuan dari image processing adalah memperbaiki informasi pada gambar sehingga mudah terbaca atau memperbaiki kualitas dari gambar itu sendiri



Computer Vision



Model Image



Sampling menunjukkan banyaknya pixel (blok) untuk mendefinisikan suatu gambar

Kuantisasi menunjukkan banyaknya derajat nilai pada setiap pixel (menunjukkan jumlah bit pada gambar digital → b/w dengan 2bit, grayscale dengan 8 bit, true color dengan 24 bit)

Image Enhancement

Proses untuk memperbaiki gambar seperti brightness, contrast, mengubah gambar menjadi gray-scale, inversi, reduksi noise, deteksi tepi dan sharpness

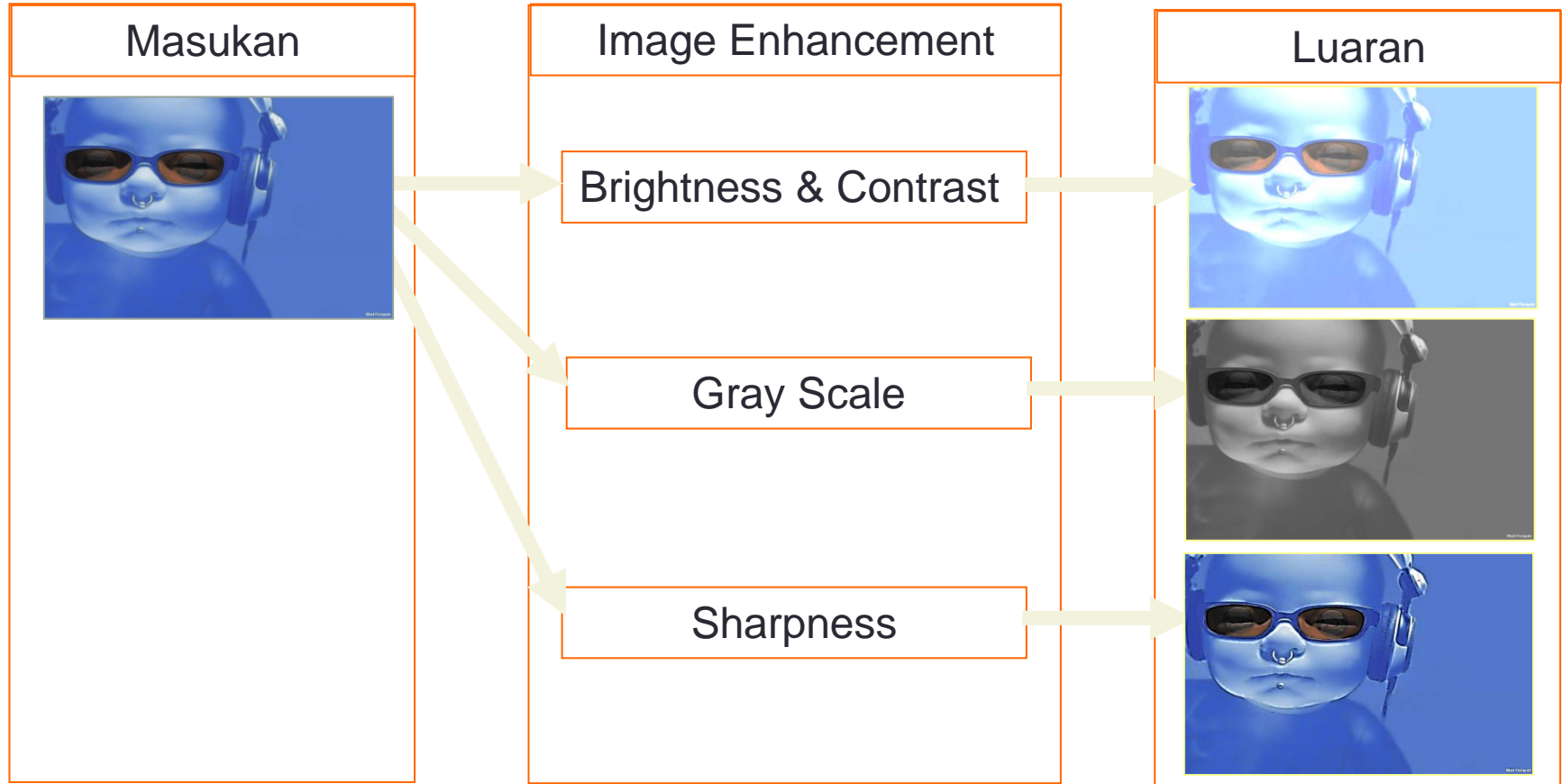
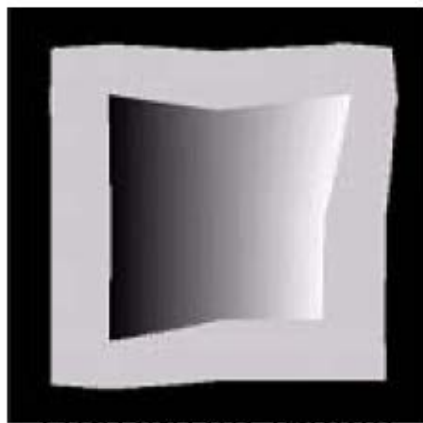


Image Restoration

Improving the appearance of an image

Tend to be based on mathematical or probabilistic models of image degradation



Distorted image



Restored image

Wavelet

Foundation for representing images in various degrees of resolution.

Used in image data compression and pyramidal representation (images are subdivided successively into smaller regions)

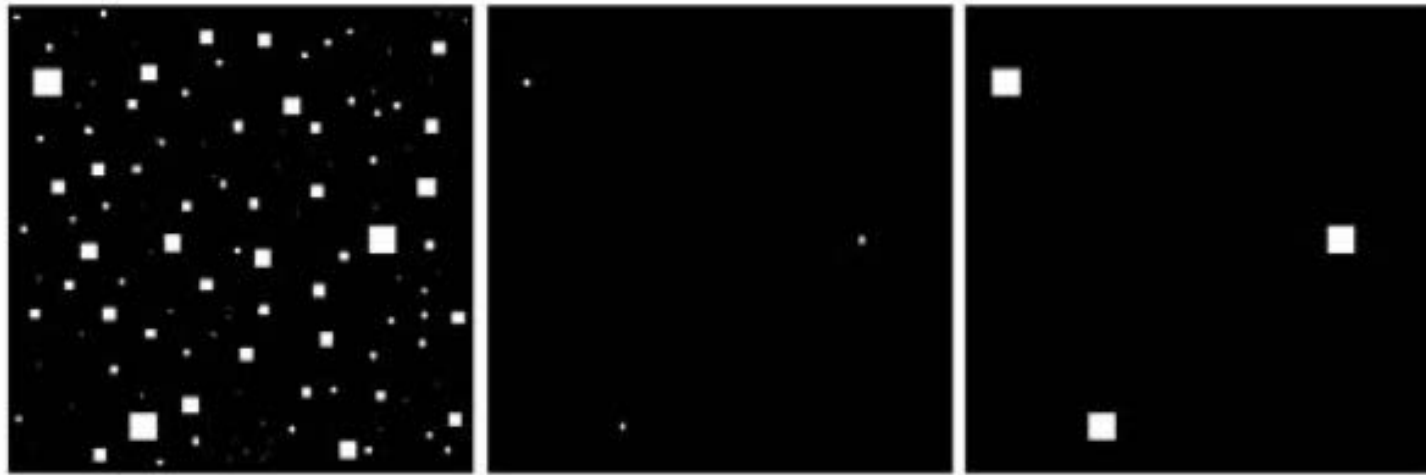
Compression

Reducing the storage required to save an image or the bandwidth required to transmit it.

Ex. JPEG (Joint Photographic Experts Group) image compression standard.

Morphological Processing

Tools for extracting image components that are useful in the representation and description of shape.



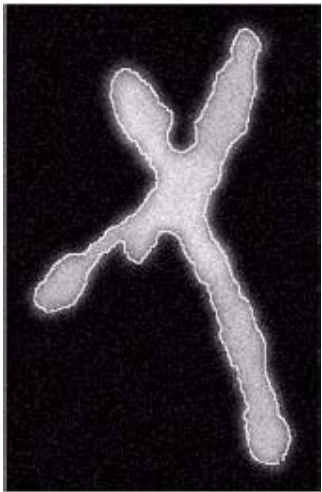
a b c

FIGURE 9.7 (a) Image of squares of size 1, 3, 5, 7, 9, and 15 pixels on the side. (b) Erosion of (a) with a square structuring element of 1's, 13 pixels on the side. (c) Dilation of (b) with the same structuring element.

Image Segmentation

computer tries to separate objects from the image background.

- ☐ It is one of the most difficult tasks in DIP.
- ☐ A rugged segmentation procedure brings the process a long way toward successful solution of an image problem.
- ☐ Output of the segmentation stage is raw pixel data, constituting either the boundary of a region or all the points in the region itself.



Contoh Image Segmentation

Proses untuk mengelompokkan gambar sesuai dengan onyek gambarnya

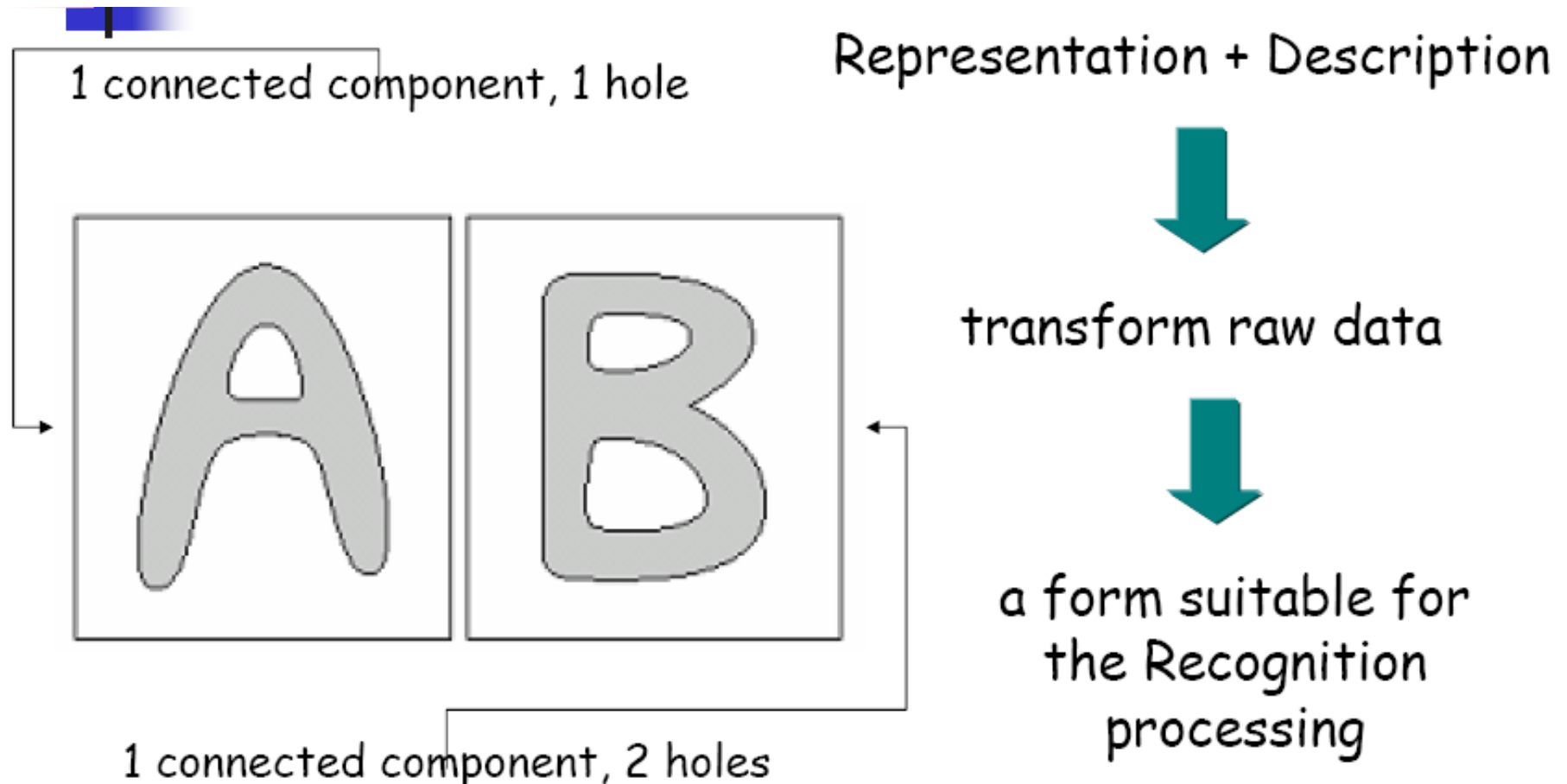


Representation dan Description

Representation -> make a decision whether the data should be represented as a boundary or as a complete region.

- Boundary representation -> focus on external shape characteristics, such as corners and inflections.
- Region representation -> focus on internal properties, such as texture or skeleton shape.

Representation dan Description



Recognition & Interpretation

Recognition -> the process that assigns a label to an object based on the information provided by its descriptors.

Interpretation -> assigning meaning to an ensemble of recognized objects.

Knowledge Base

a problem domain -> detailing regions of an image where the information of interest is known to be located.

Help to limit the search

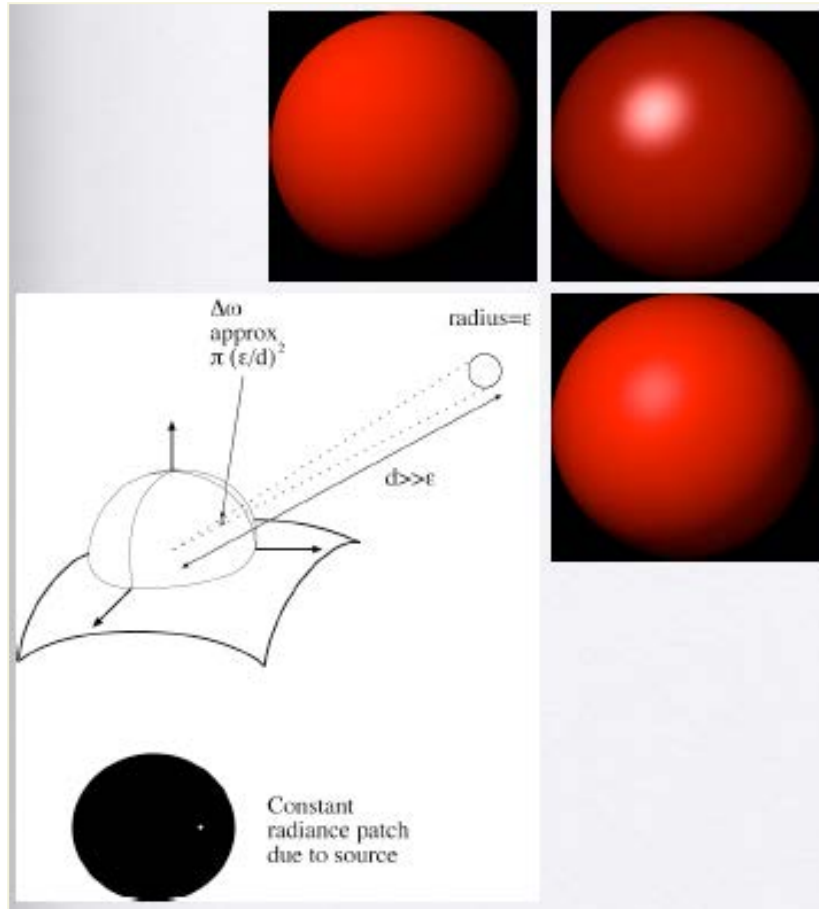
Persoalan di dalam Image Processing

- Capture
- Modeling
- Feature Extraction
- Image Segmentation

Permasalahan Capture

- Capture (Menangkap Gambar) merupakan proses awal dari image processing untuk mendapatkan gambar.
- Proses capture membutuhkan alat-alat capture yang baik seperti kamera, scanner, light-pen dan lainnya, agar diperoleh gambar yang baik.
- Gambar yang baik akan banyak membantu dalam proses selanjutnya.

Permasalahan Modeling

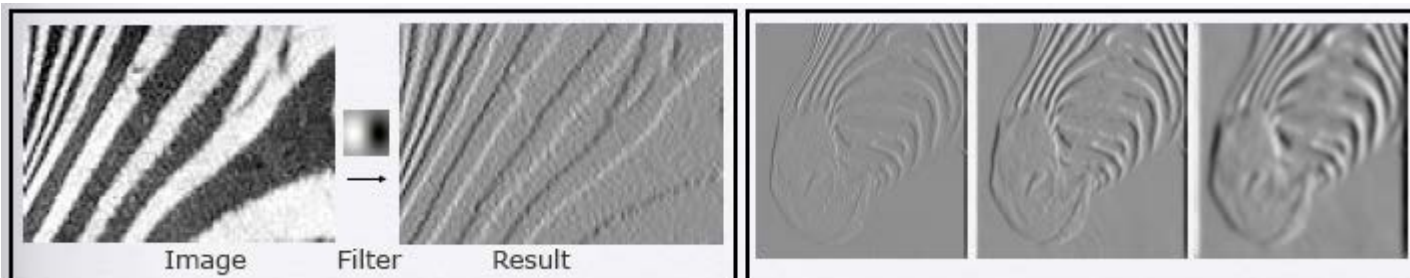


Dalam modeling diperlukan analisa matematika yang cukup rumit, khususnya pemakaian kalkulus, dan transformasi geometri.

(inilah sebabnya di jurusan TI mata kuliah matematika menjadi sangat penting!!)

Permasalahan Feature Extraction

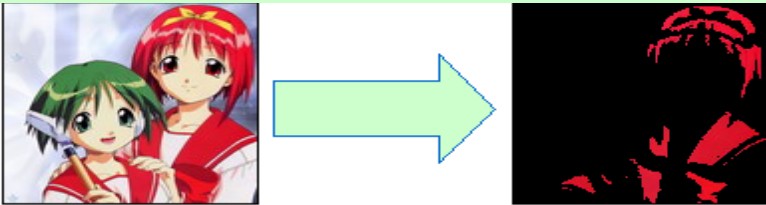
- Setiap gambar mempunyai karakteristik tersendiri, sehingga fitur tidak dapat bersifat general tetapi sangat tergantung pada model dan obyek gambar yang digunakan.
- Fitur dasar yang bisa diambil adalah warna, bentuk dan tekstur. Fitur yang lebih kompleks menggunakan segmentasi, clustering dan motion estimation.
- Pemakaian statistik dan probabilitas, pengolahan sinyal sampai pada machine learning diperlukan di sini.



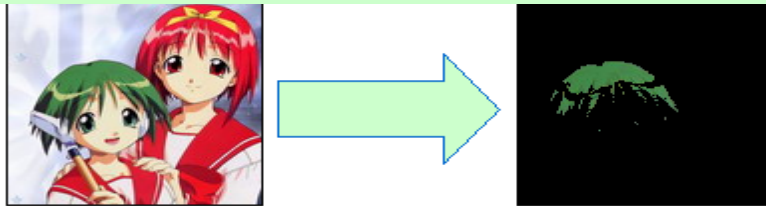
Fitur Warna

Fitur ini digunakan bila setiap obyek gambar mempunyai warna yang spesifik

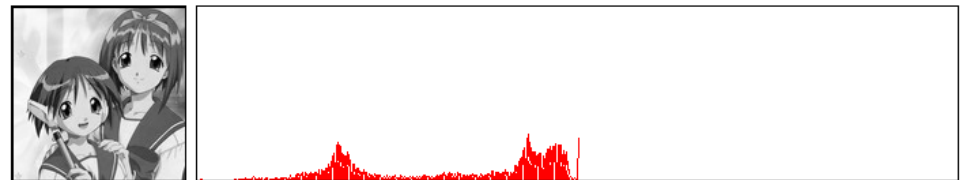
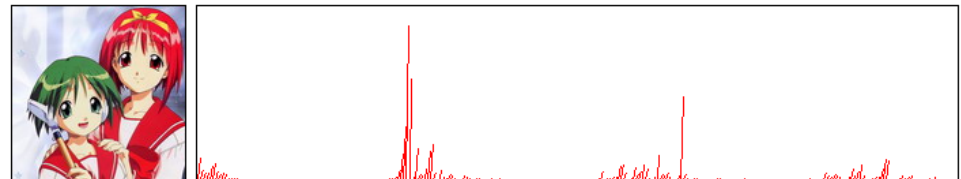
Color Thresholding Merah



Color Thresholding Hijau



Color Histogram

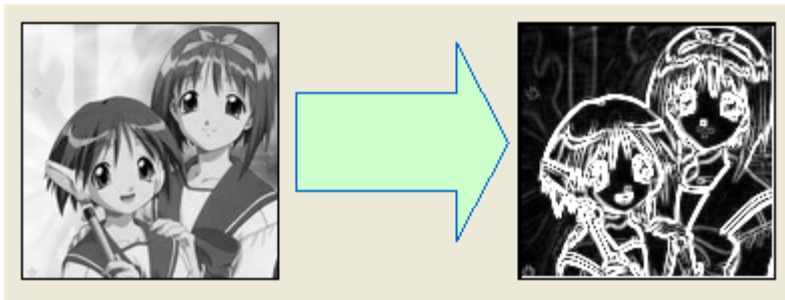


Gray-scale Histogram

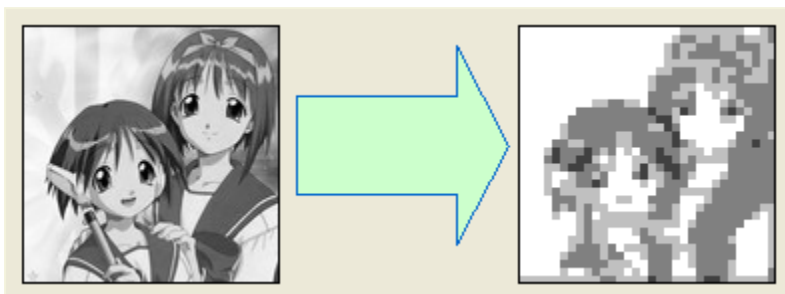
Fitur Bentuk

Fitur ini digunakan bila gambar setiap obyek mempunyai bentuk yang spesifik

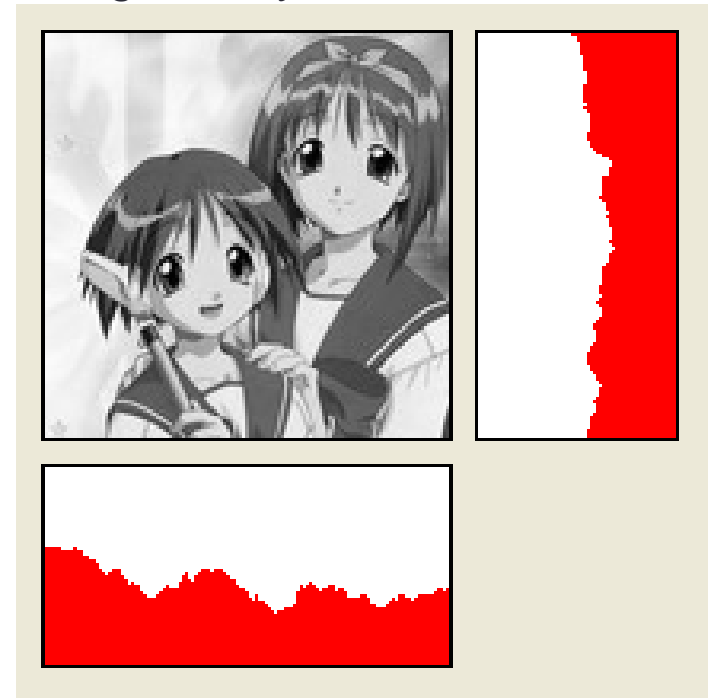
Deteksi Tepi



Kuantisasi Rata-rata



Integral Proyeksi

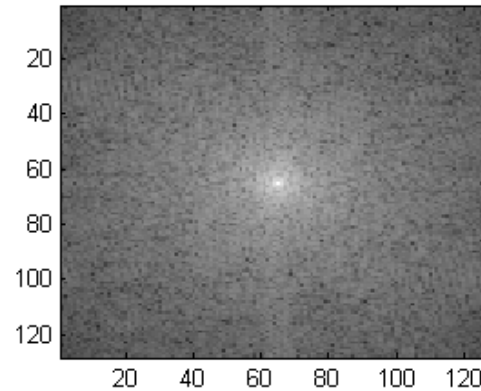


Fitur Tekstur

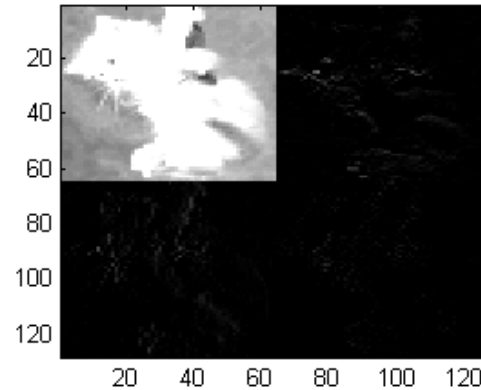
Image



FFT



Wavelets



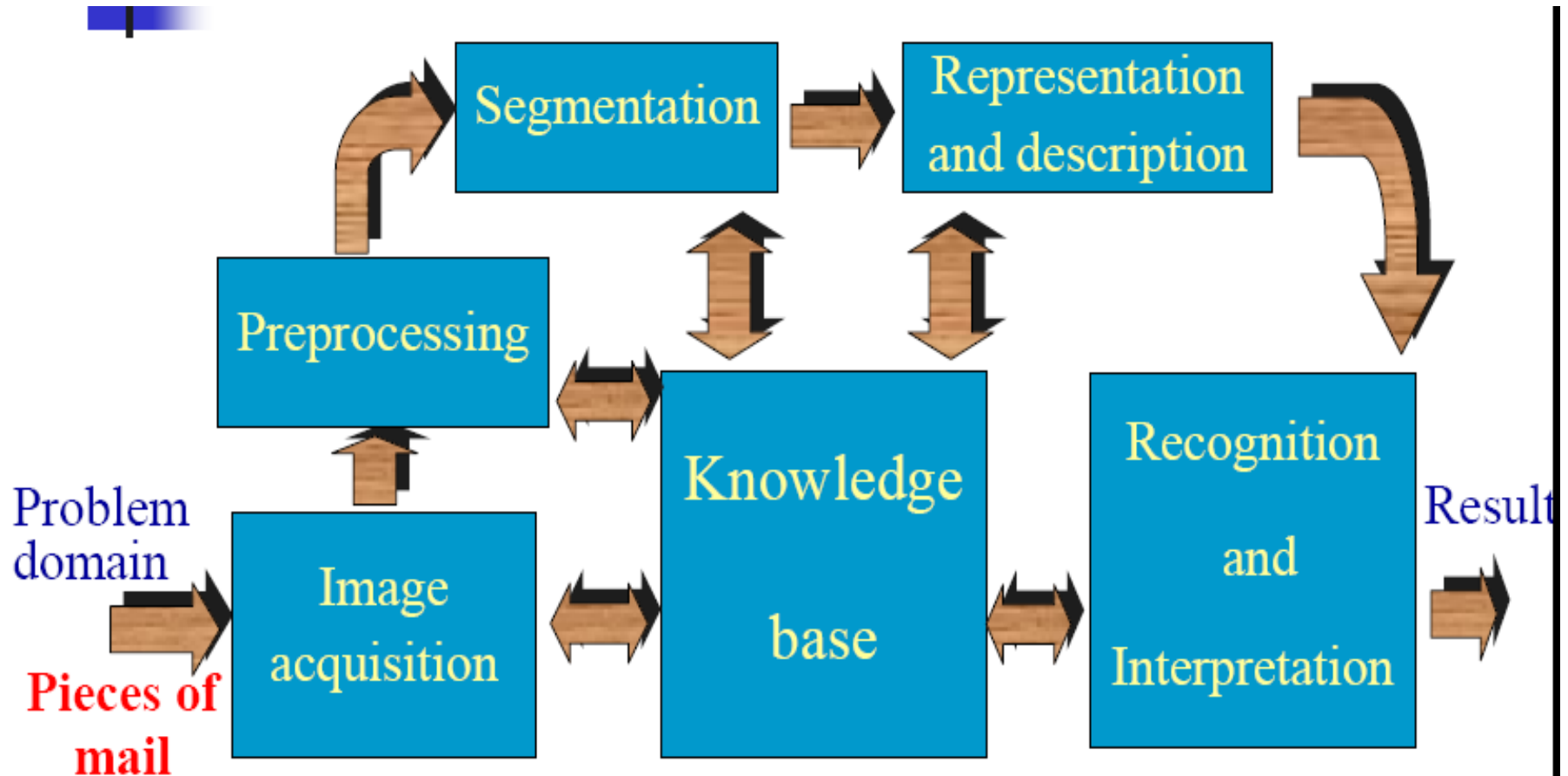
Beberapa algoritma untuk mendapatkan fitur tekstur:

- (1) FFT
- (2) Wavelets
- (3) Image Filter
- (4) Filter Gabor

Permasalahan Image Segmentation

- Bagaimana memisahkan obyek gambar dengan backgroundnya
- Bagaimana memisahkan setiap obyek gambar.
- Teknik clustering apa yang sesuai dengan model dan obyek gambar yang digunakan

Ex : Postal Code Problem



Desired output = alphanumeric characters

APLIKASI IMAGE PROCESSING

- Biometric
- Medical Image
- Image Databases
- Robot Vision
- Motion Capture
- Document Analysis

Biometric

Face recognition
Iris scanning
Fingerprint recognition
Activity recognition

Biometrics for Mainstream Computing
End-to-end solutions for home computers, corporate networks and Internet services.

ScanAccess PC
JAY PETERSEN
Username: Gina

Medical Image

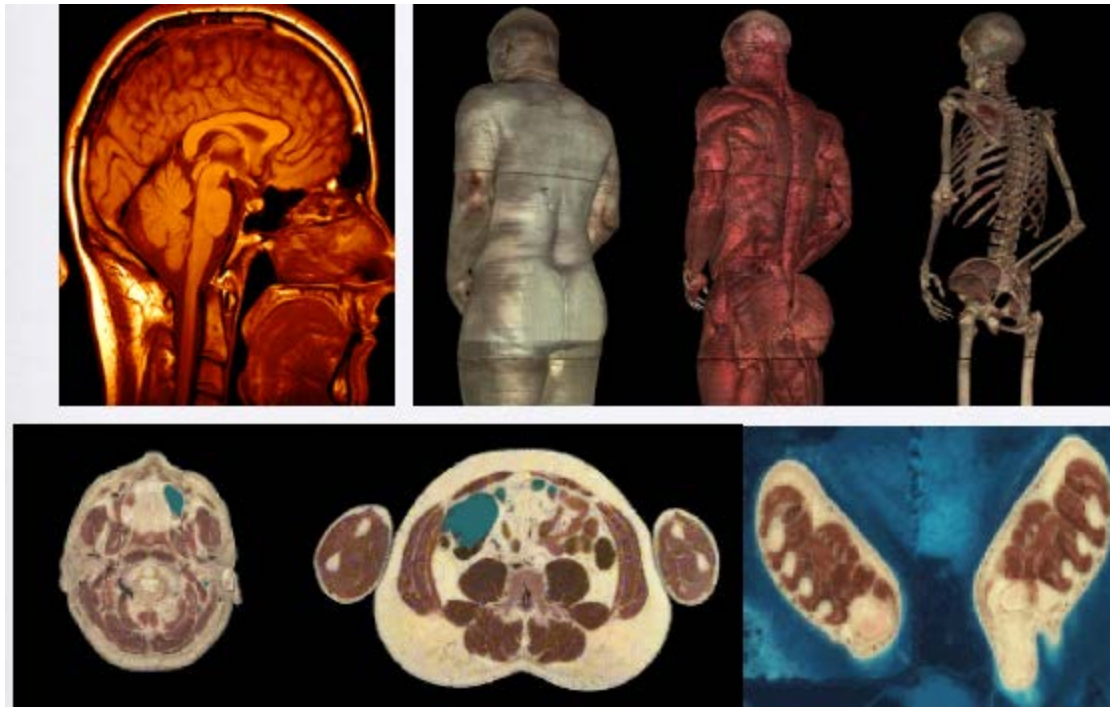


Image Databases

Image 1





Image 2




$d=7$

$d \geq 4$


$d=2$

$d \geq 1$



$d=6$


Query



Key

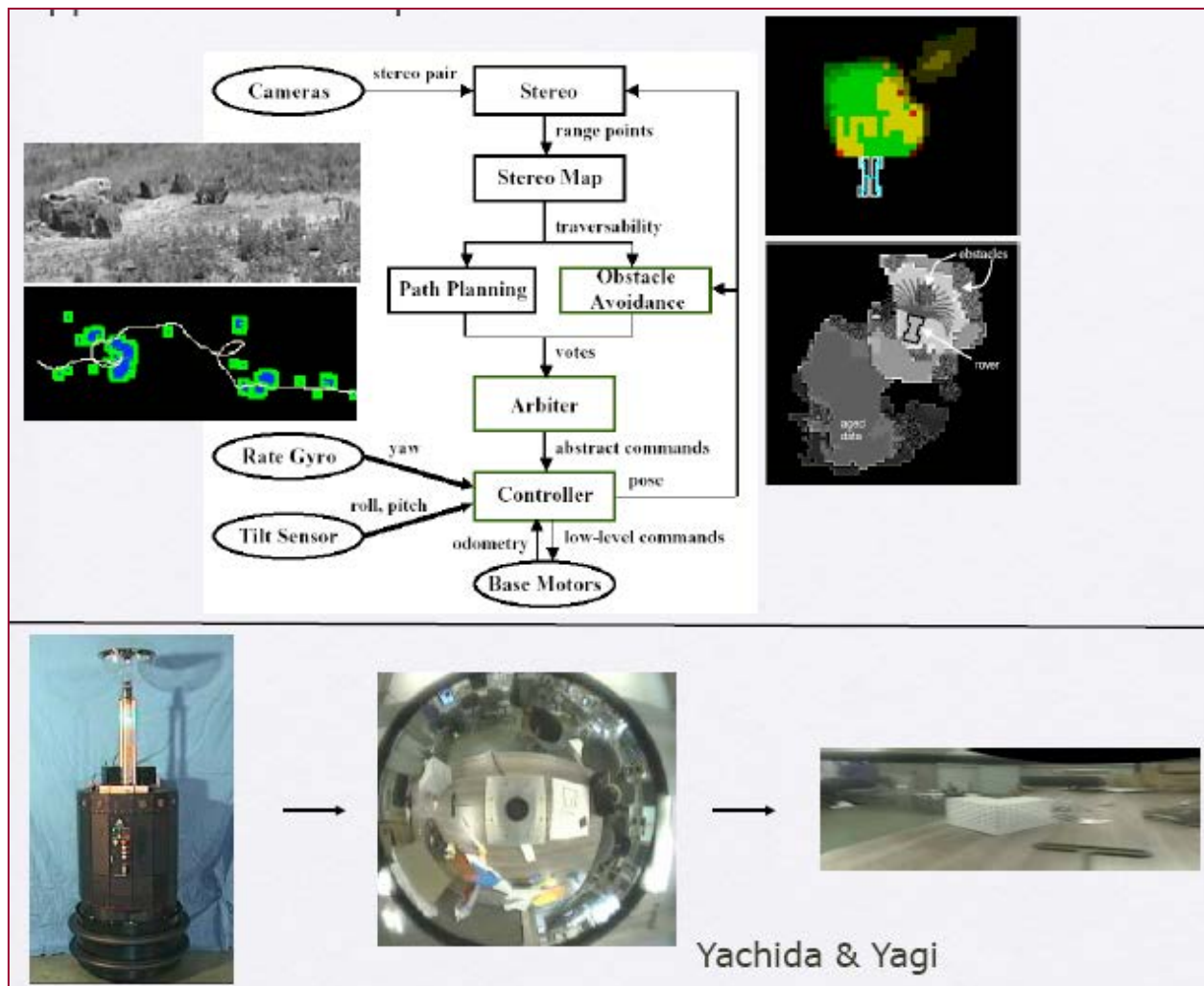
Image retrieval

From a search for horse pix in 100 horse images and 1086 non-horse images.

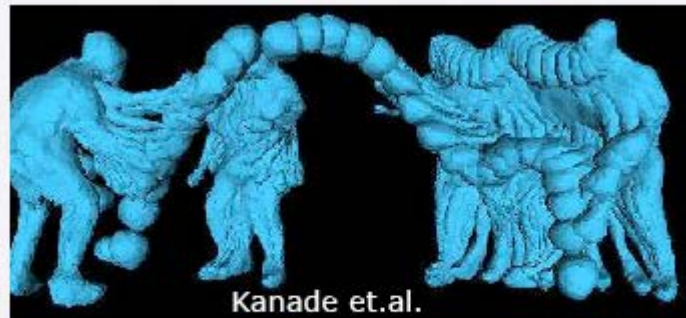


Forsyth & Ponce

Robot Vision



Motion Capture



Document Analysis

