Fundamentals of Digital Image Processing 1

Pengolahan Citra

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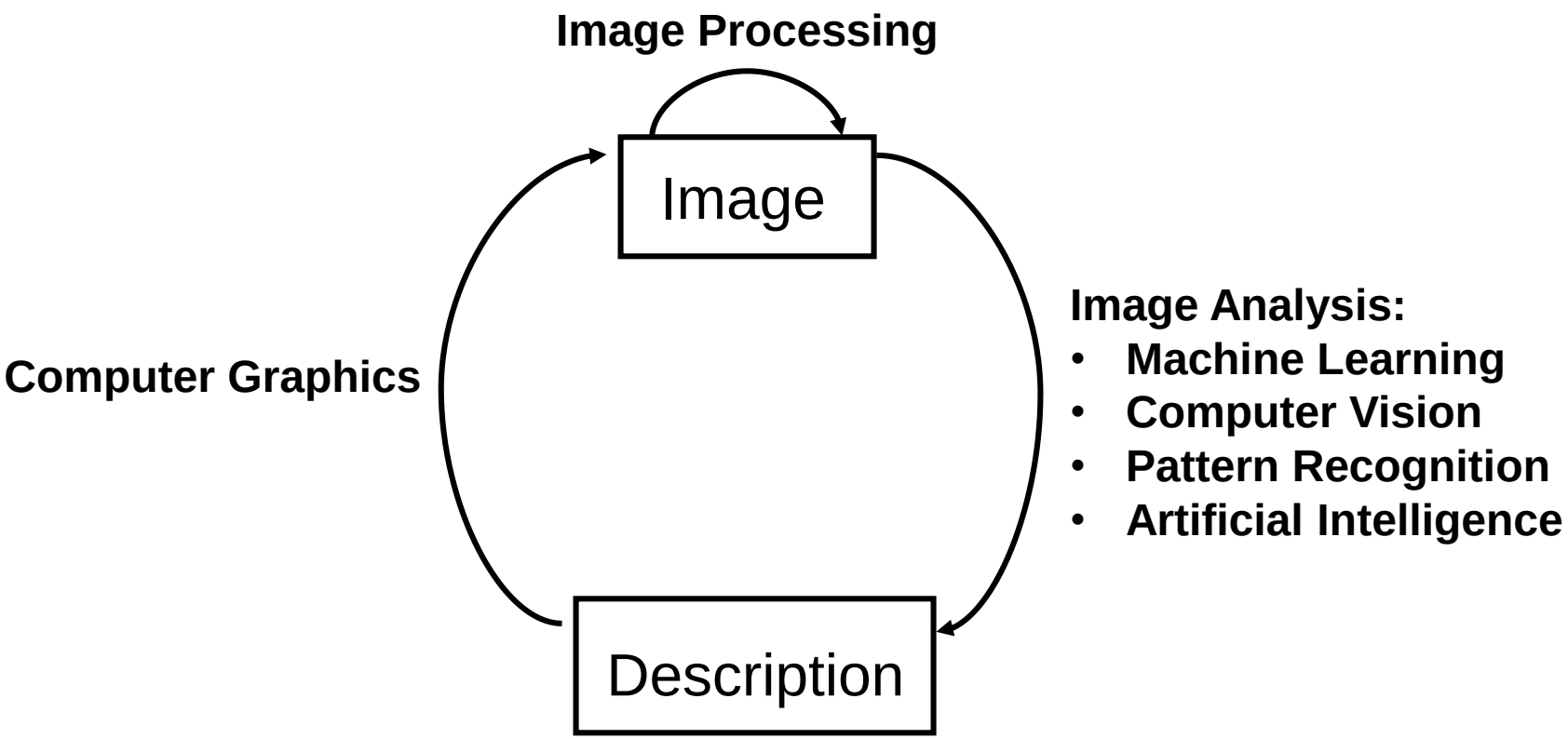
Image and Description

Kucing, Mamalia, Oranye

Image and Description (2)

Kucing, Mamalia, Oranye

Areas of Study



Areas of Study

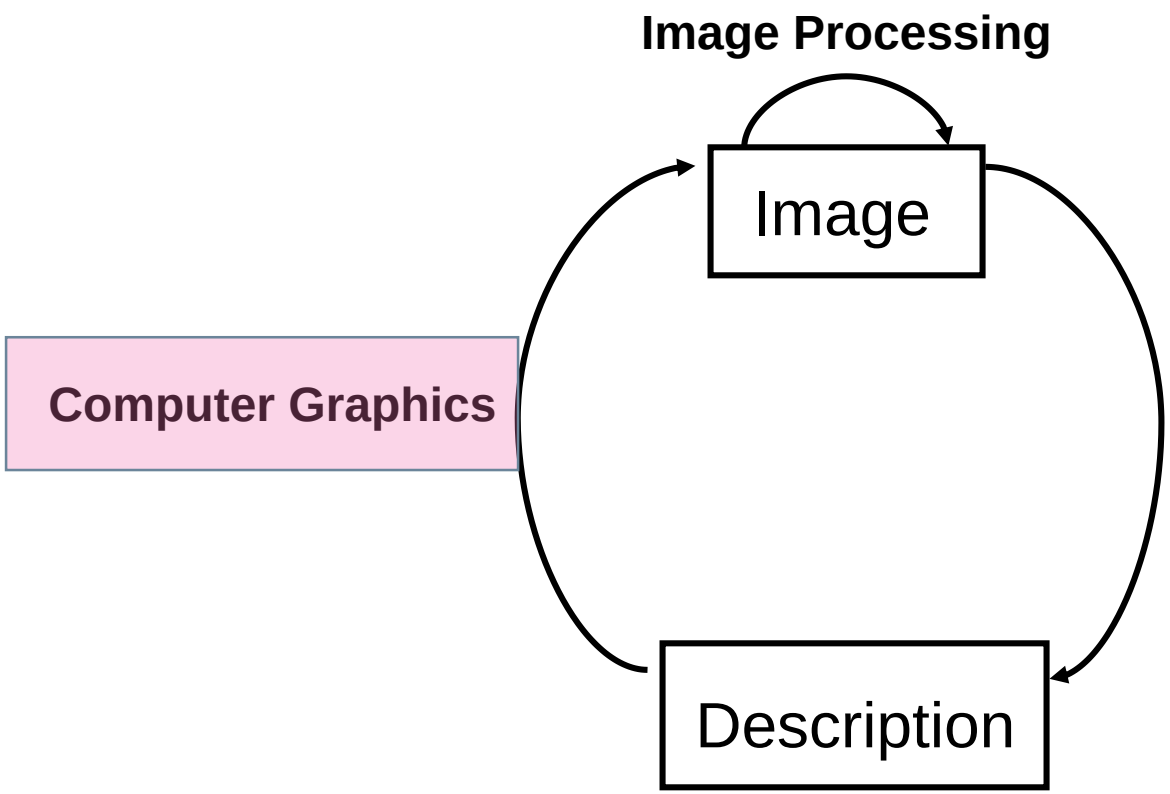
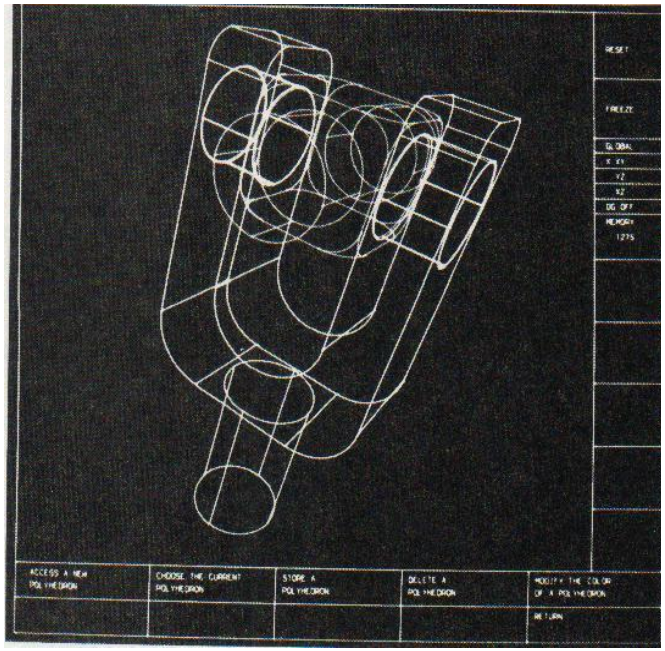


Image Analysis:

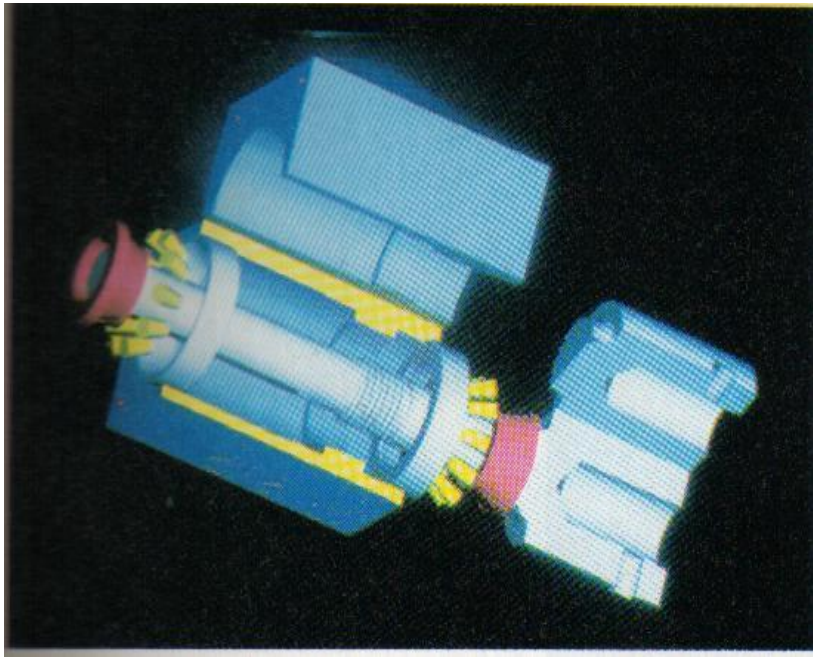
- **Machine Learning**
- **Computer Vision**
- **Pattern Recognition**
- **Artificial Intelligence**

Computer Graphics

- Description to Image



Wire Frame Drawing
(Hearn and Baker, 1986)



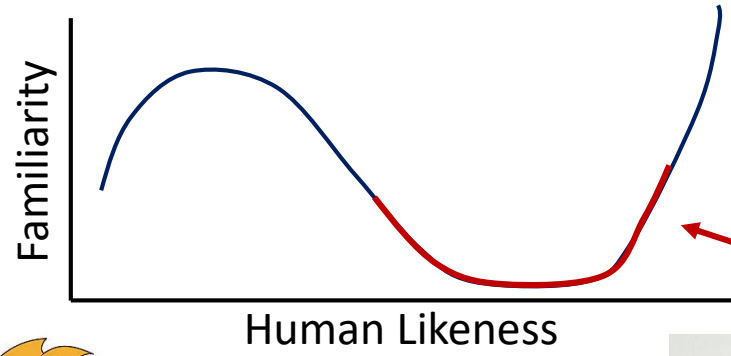
Realism Drawing

Computer Graphics (2)

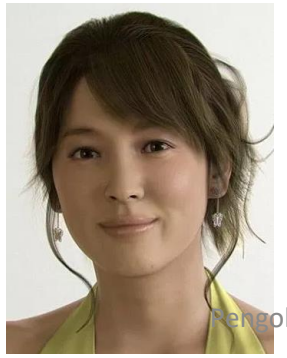
- Membuat citra dan menganimasikan obyek secara dijital pada komputer.
- Proses, teknik, dan metode untuk menghasilkan gambar berdasarkan deskripsi abstrak obyek dan lingkungan di sekitar obyek.
- Proses, teknik, dan metode untuk membuat efek riil *(realism effect*) pada obyek dan lingkungan sekitar obyek di dalam citra.

Realism

- Seberapa *riil* obyek yang ingin dihasilkan?
- *Uncanny valley* (Masahiro Mori, 1970)
  - Human's revulsion/uneasiness toward things that appear nearly human, but not quite right.

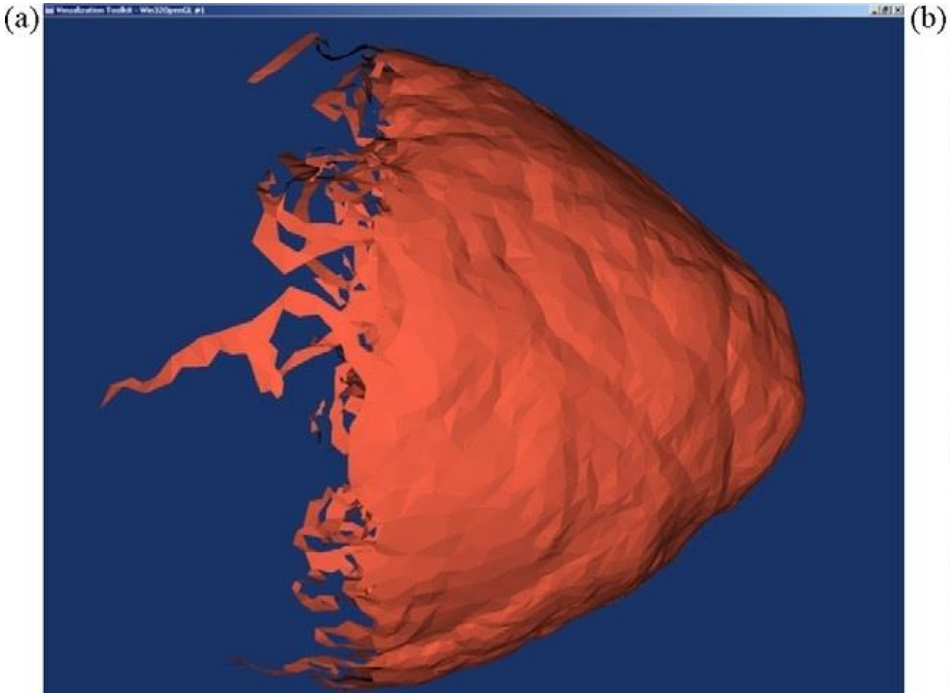


Uncanny valley



Graphics of A Heart

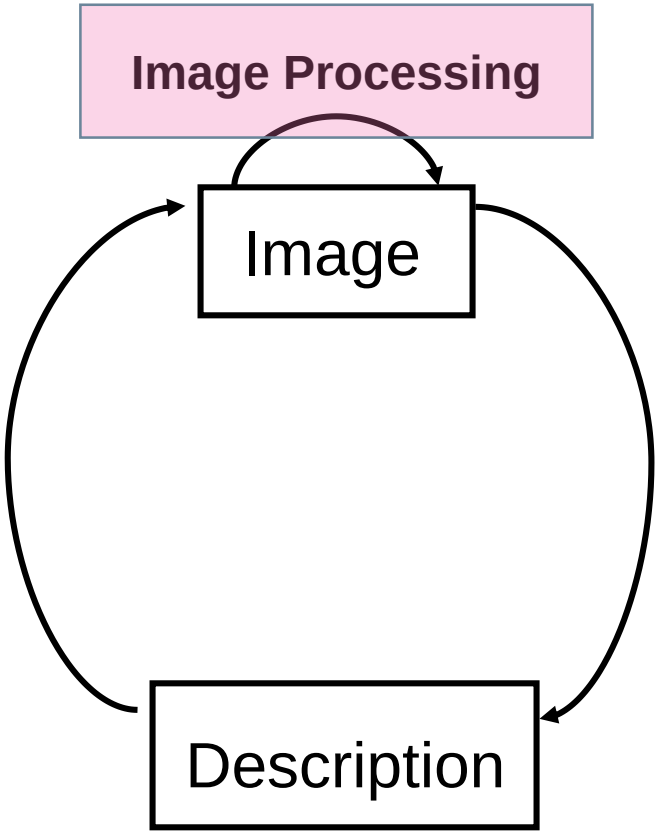
(Source: M. Fig *et al*., Image guidance for robotic minimally invasive coronary artery bypass, Computerized Medical Imaging and Graphics 34 (2010) 61–68, Elseiver)



(a) Truncated rendering surface

(b) Whole section

Areas of Study



Computer Graphics

Image Analysis:

- **Machine Learning**
- **Computer Vision**
- **Pattern Recognition**
- **Artificial Intelligence**

Image Processing

- Apakah anda bisa melihat dengan jelas citra ini?

Blur removal

Image Processing

- Apakah anda bisa melihat dengan jelas citra ini?

Color restoration

Brainstorming

- Metode apa lagi yang bisa dikategorikan sebagai image processing (image to image)?

Areas of Study

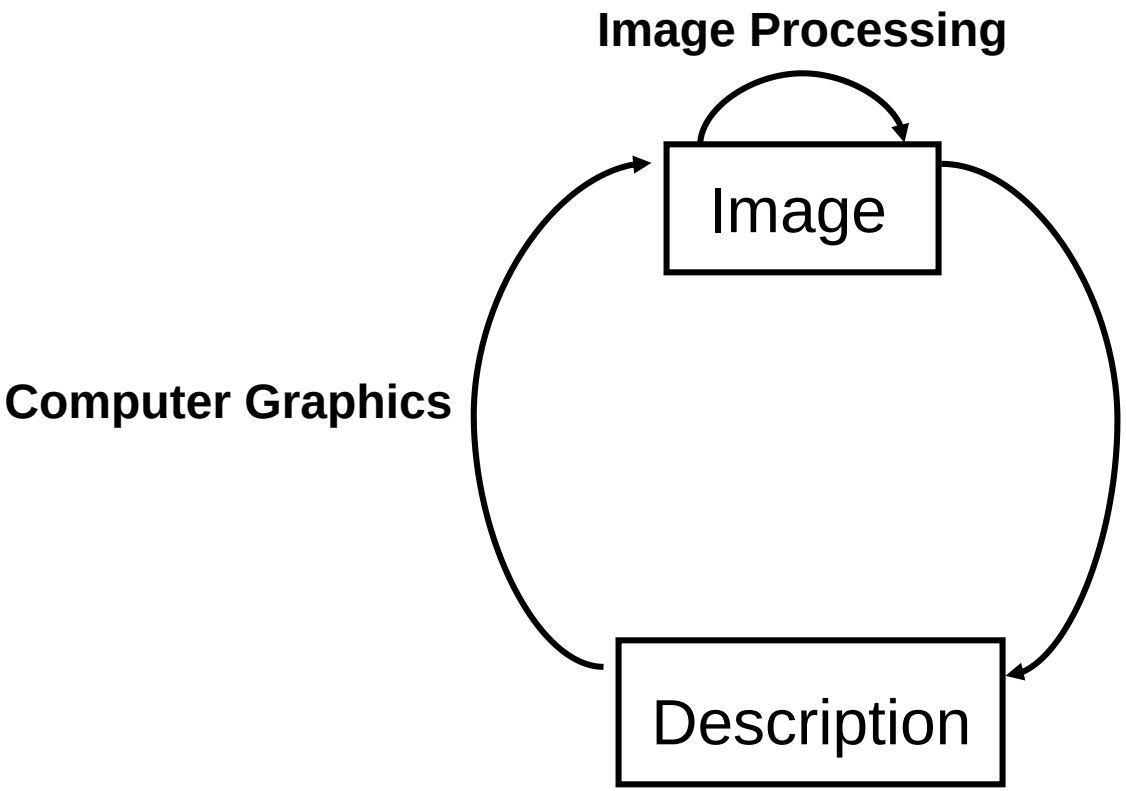
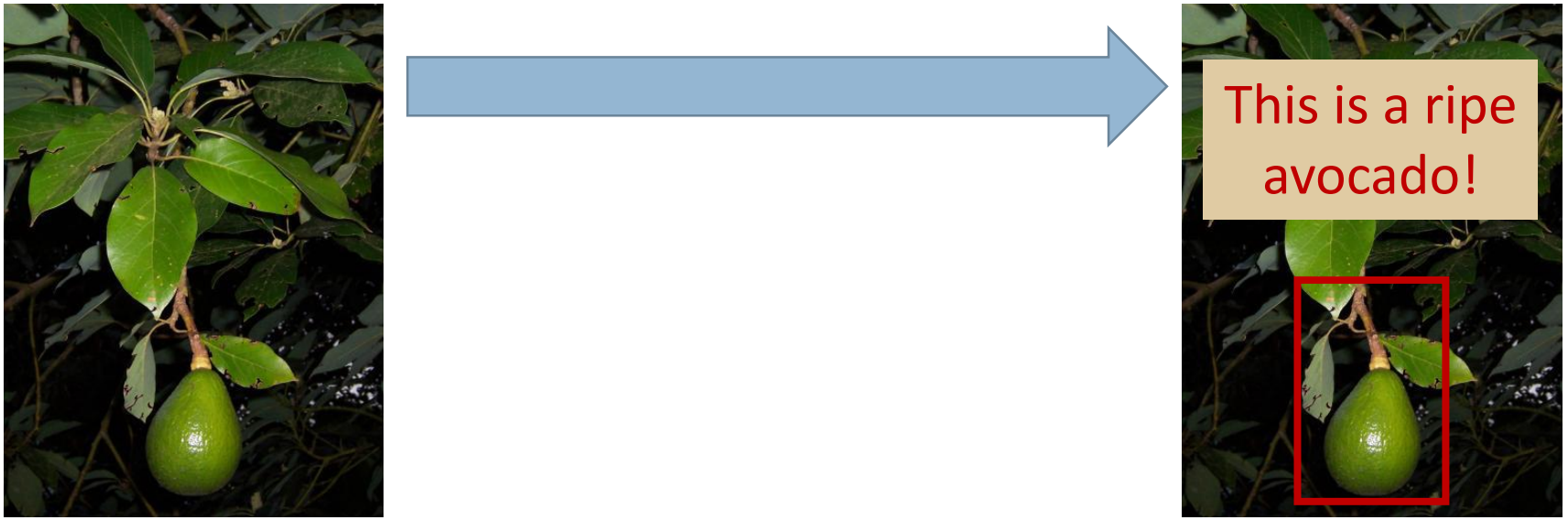


Image Analysis:
- **Machine Learning**
- **Computer Vision**
- **Pattern Recognition**
- **Artificial Intelligence**

Image Analysis

- Now that we have our digital image, what can we do with it?



Citra Dijital

- Yang dilihat oleh manusia

Citra Dijital

- Yang dilihat oleh komputer

$$\begin{bmatrix}
52 & 55 & 61 & 66 & 70 & 61 & 64 & 52 & 55 & 61 & 66 & 70 & 61 & 64 & 73 \\
63 & 59 & 55 & 90 & 109 & 85 & 69 & 63 & 59 & 55 & 90 & 109 & 85 & 69 & 72 \\
62 & 59 & 68 & 113 & 144 & 104 & 66 & 62 & 59 & 68 & 113 & 144 & 104 & 66 & 73 \\
63 & 58 & 71 & 122 & 154 & 106 & 70 & 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\
67 & 61 & 68 & 104 & 126 & 88 & 68 & 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\
79 & 65 & 60 & 70 & 77 & 68 & 58 & 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\
85 & 71 & 64 & 59 & 55 & 61 & 65 & 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\
87 & 79 & 69 & 68 & 65 & 76 & 78 & 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94 \\
63 & 58 & 71 & 122 & 154 & 106 & 70 & 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\
67 & 61 & 68 & 104 & 126 & 88 & 68 & 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\
79 & 65 & 60 & 70 & 77 & 68 & 58 & 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\
85 & 71 & 64 & 59 & 55 & 61 & 65 & 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\
87 & 79 & 69 & 68 & 65 & 76 & 78 & 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94
\end{bmatrix}$$

Image Analysis System

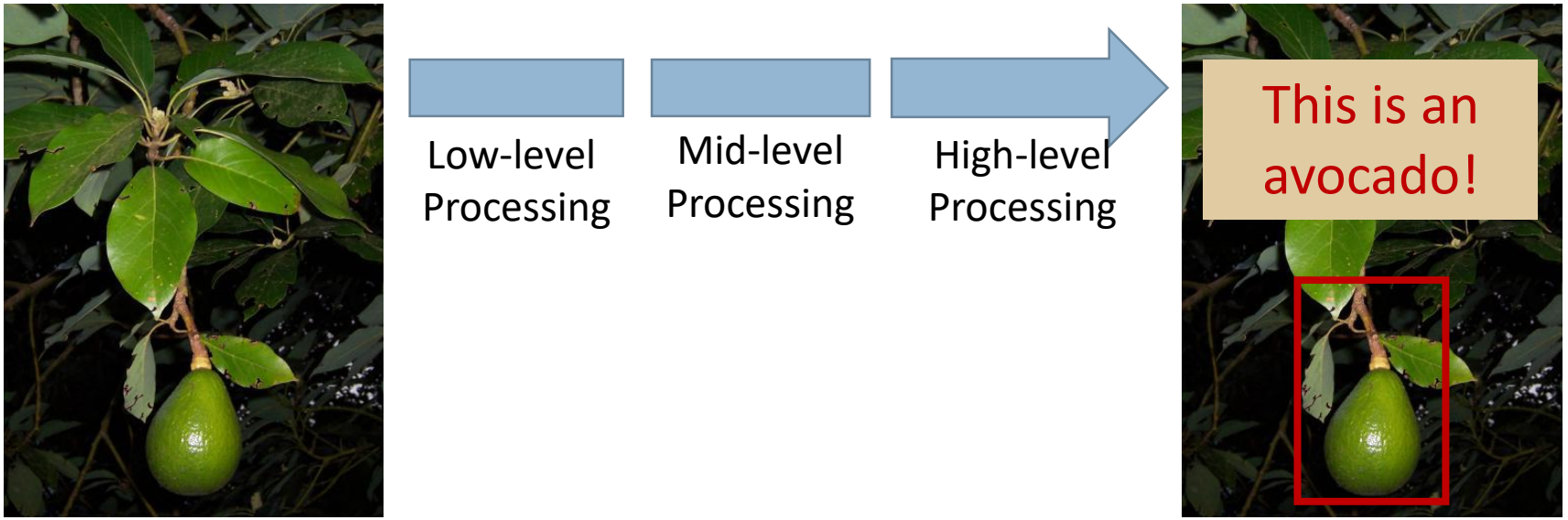
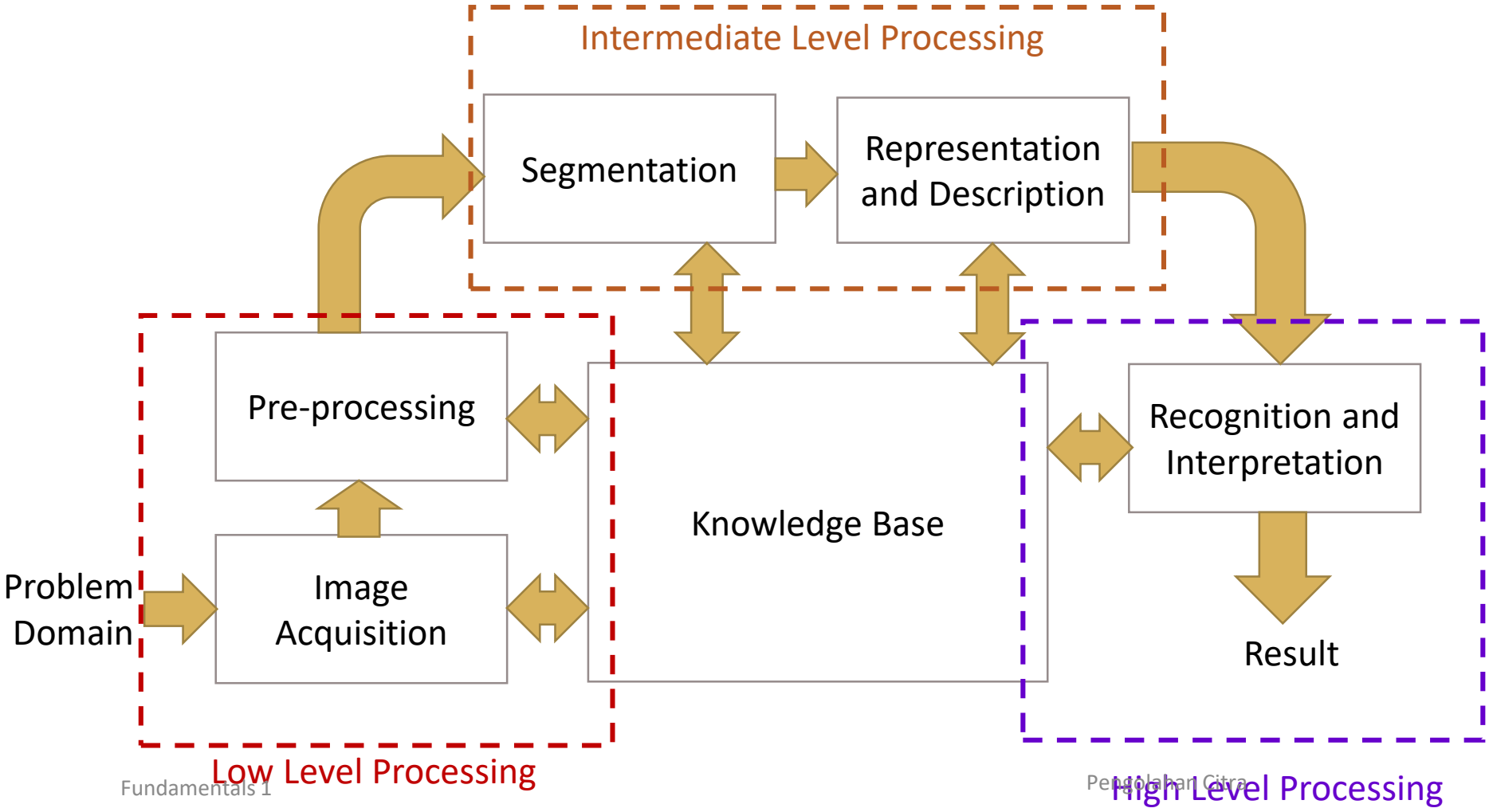
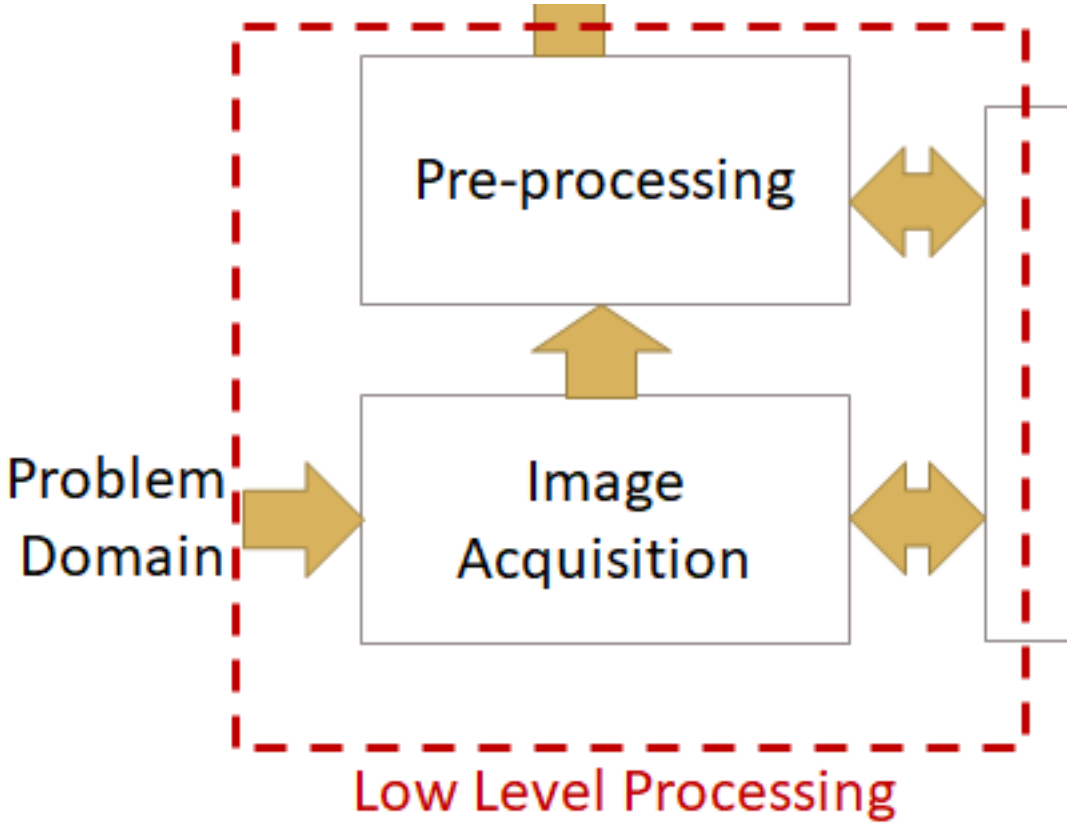


Image Analysis System (2)

(Source: Gonzalez & Woods, 1992)

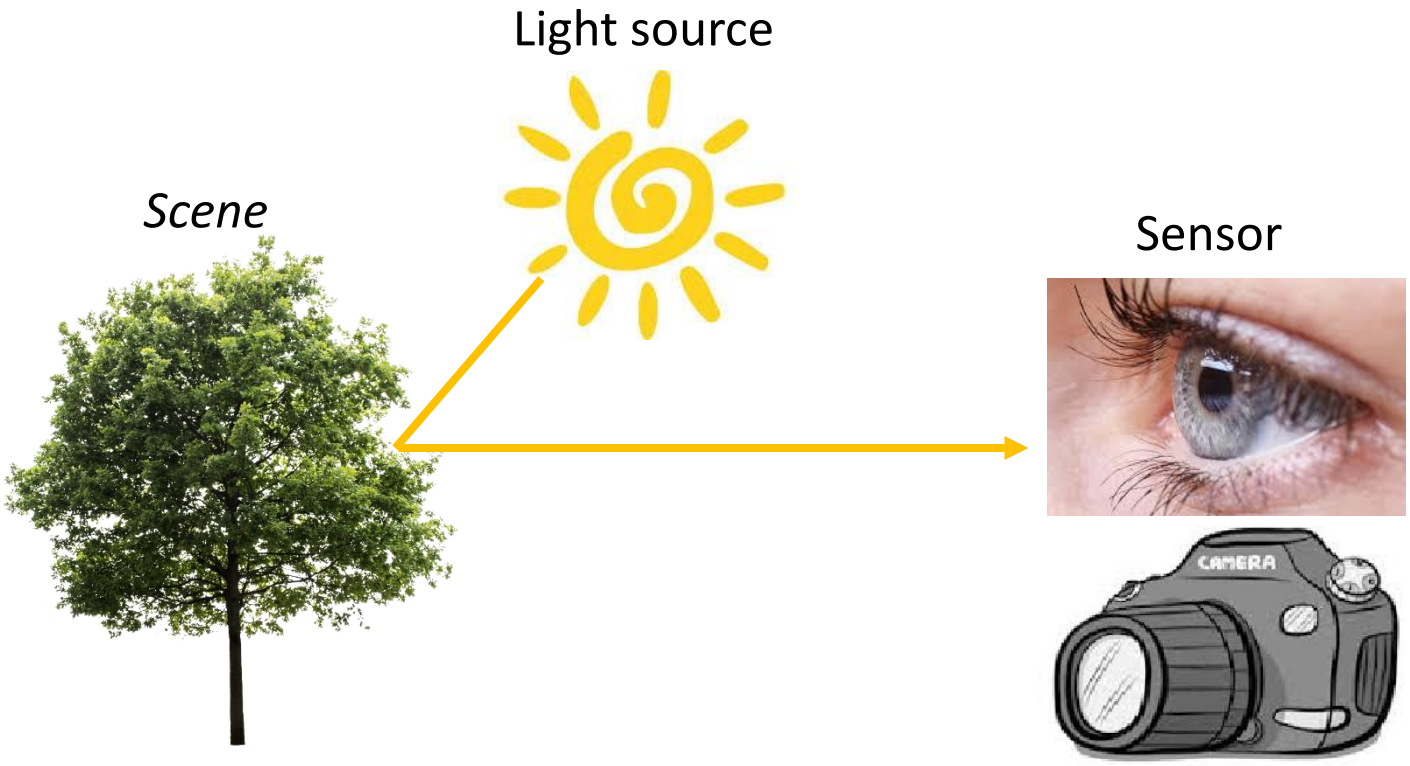


Low-Level Processing



Basic Image Acquisition

- Necessary components for basic image acquisition



Digital Image Acquisition

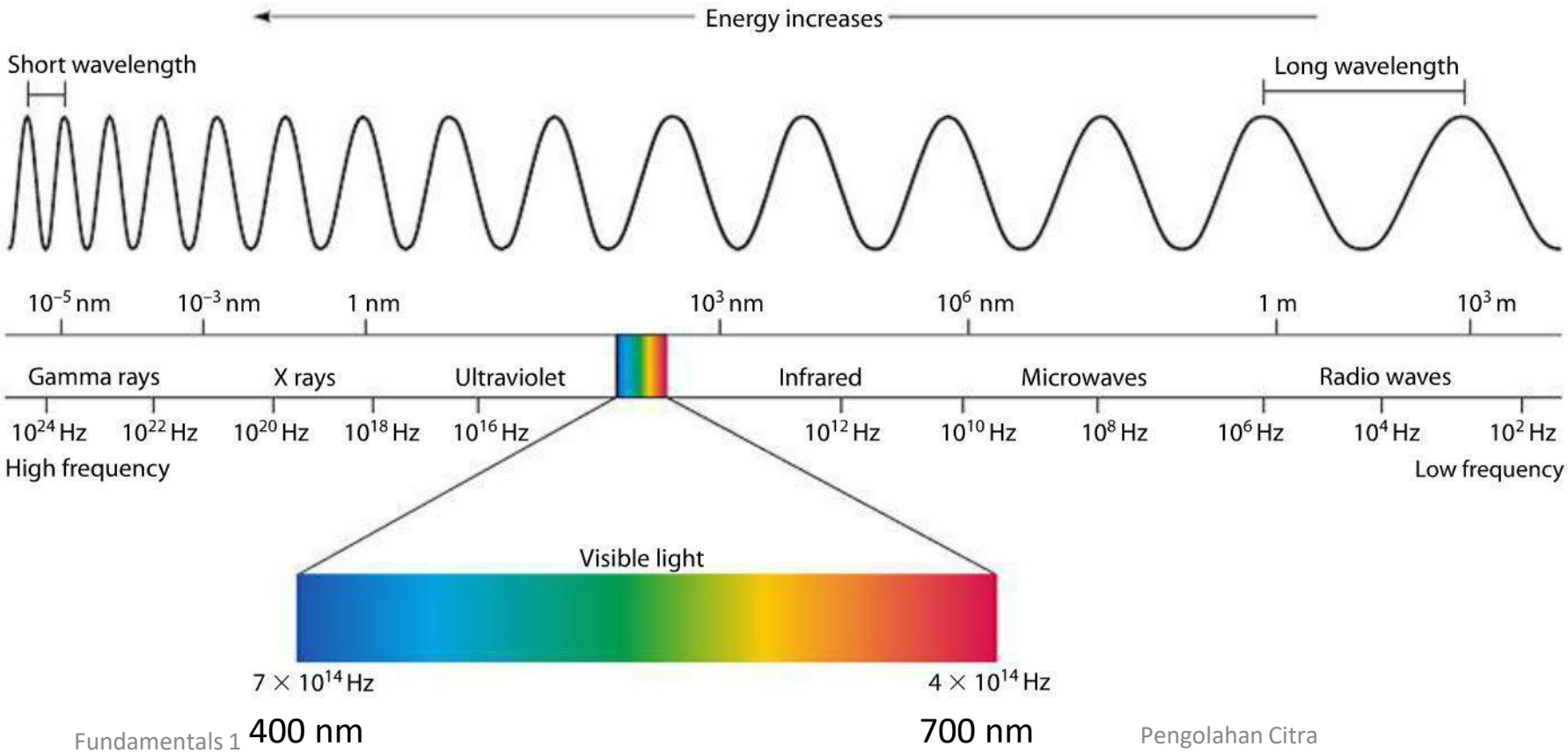
- Digital Sensor

Image Acquisition Tools

- Up till now we assumed a basic RGB camera
- Are there any other tools?

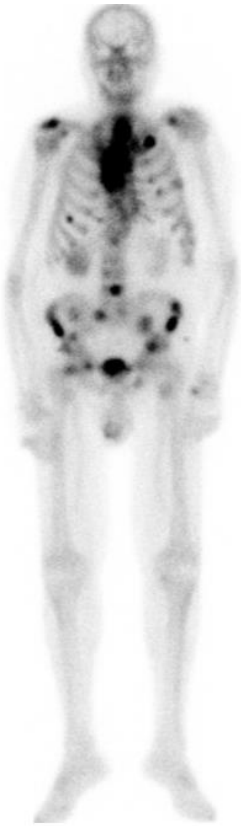
Digital Image Processing in Various Fields

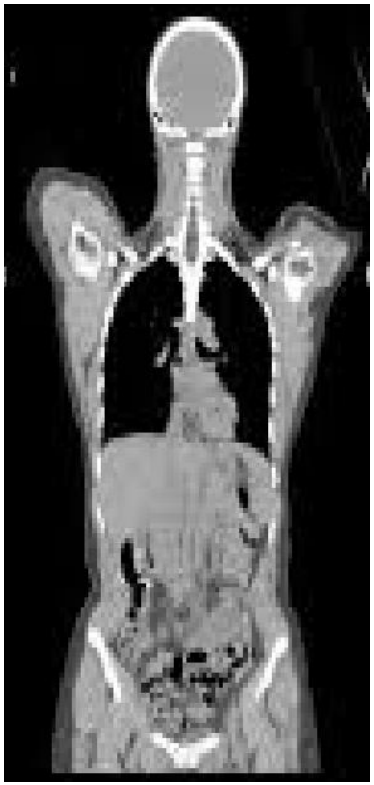
- The electromagnetic spectrum



Gamma Ray Imaging

- Bone Scan, PET Scan





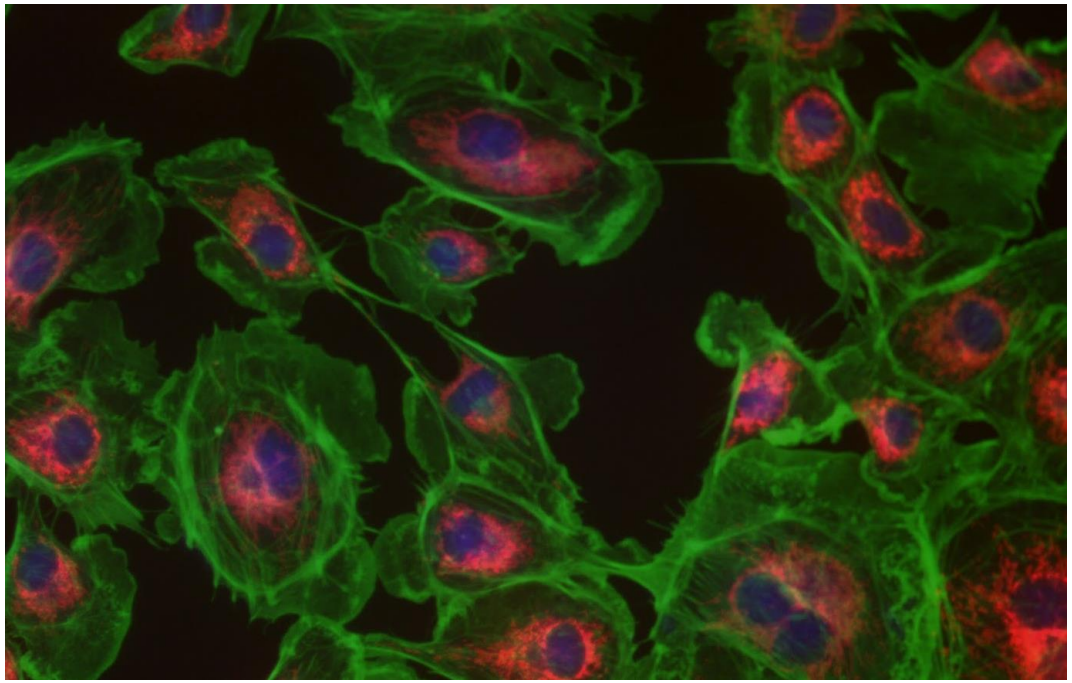
Images taken from: The Mayo Clinic, Brigham Women's Hospital

X-Ray Imaging

- X-Rays are among the oldest sources of electromagnetic radiation for imaging.
  - X-Ray radiation intensity
  - Contrast injections

Ultraviolet Imaging

- Fluorescence Microscopy
  - **Fluorescence** is the emission of light by a substance that has absorbed light or other electromagnetic radiation.



Infrared Imaging

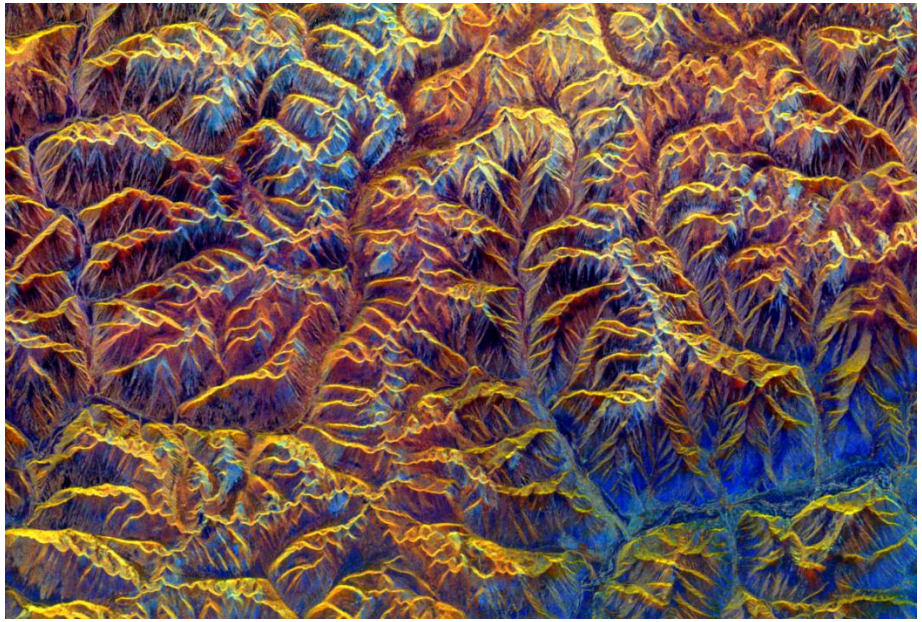
- Near Infrared vs Thermal Infrared
  - Near-infrared is very close to the visible spectrum, so it captures human features that closely resemble those taken in the visible spectrum, while thermal infrared captures only the temperature.

Near Infrared Thermal Infrared

B. Kresnaraman, et al. Reconstructing face image from the thermal infrared spectrum to the visible spectrum. Sensors, 16(4): 1–6, April 2016.

Microwave Imaging

- Mostly used for radar applications: it is not affected by weather and ambient lighting conditions.
- Spaceborne radar image of southern Tibet mountains (image by NASA)



Radio Wave Imaging

- Magnetic Resonance Imaging (MRI)
  - The human body is placed in a magnet.
  - Radio pulses are passed through the body, and the human tissue gives a response.

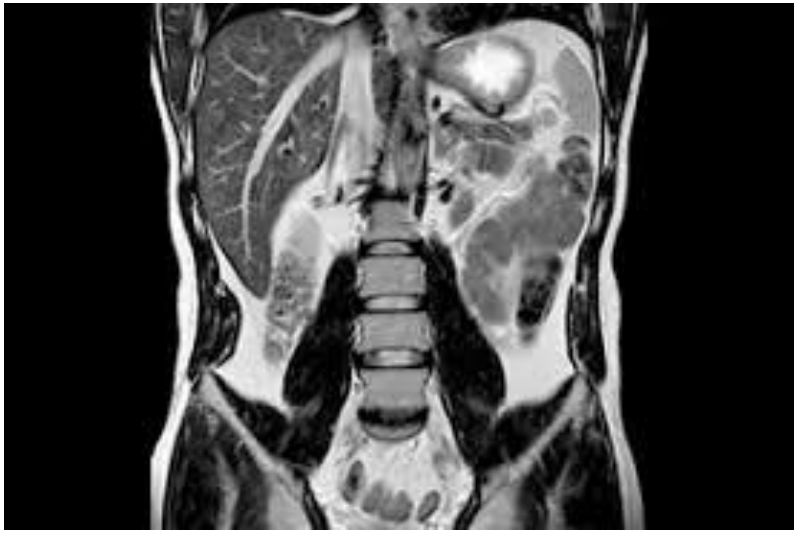
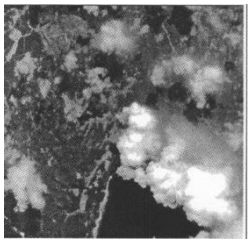


Image Acquisition

- Biomedical Instrument:

Pap Smear Image (Jantzen *et al.,* 2005)

- Remote Sensing Instrument:



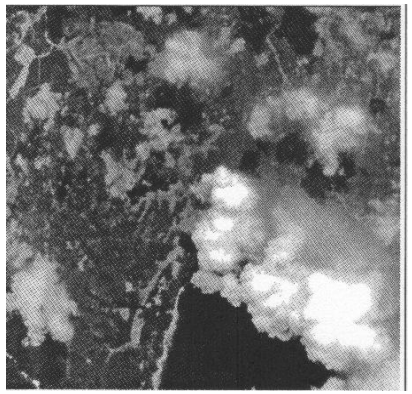
Optical-sensor image (Bakosurtanal RI, 1994)

- Basic RGB Camera

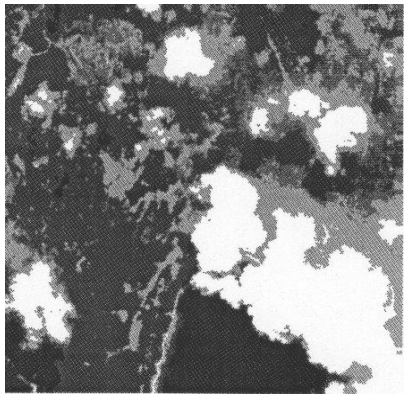
Batik Images (Rahadianti, et al. 2009)

Image Restoration (Cloud Removal)

(Source: Original Image of Teluk Belantung, BAKOSURTANAL RI;
Processed Images, A. Murni, 1996 and 2000)

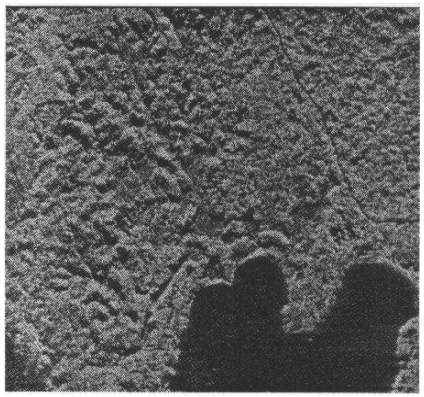


Registered Optical Image Containing of Cloud

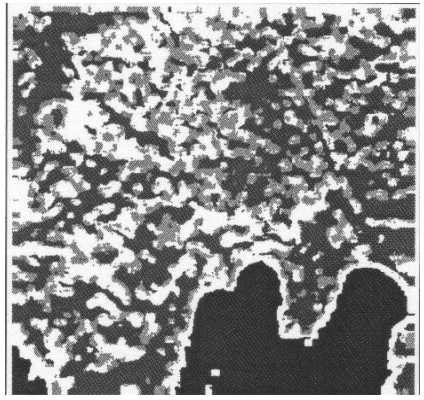


Classified Optical Image

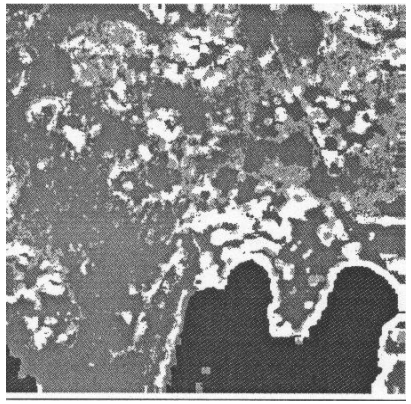
Restored Cloud Free Raw Optical Image Data



Registered SAR Image



Classified SAR Image



Cloud Free Classified Image Fused Optical and SAR Image

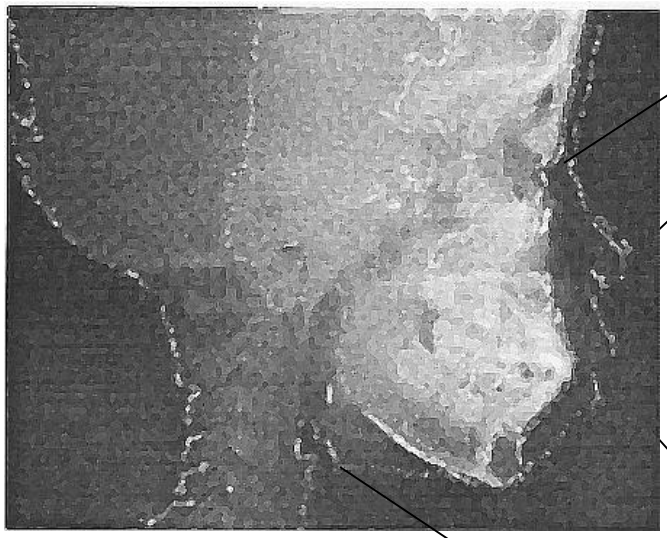
Fourier Transform & Image Restoration

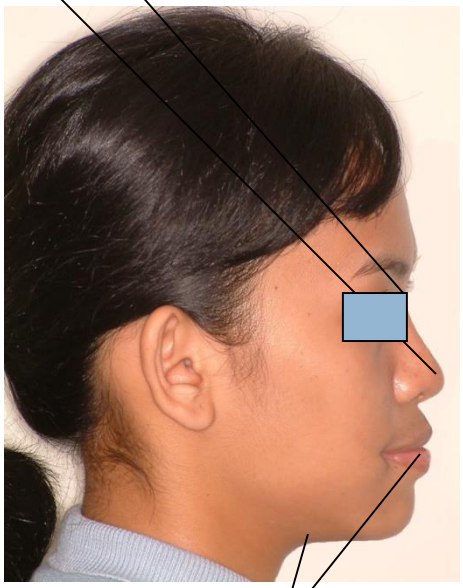
- Citra masukan dengan gangguan band stripes:

- Citra hasil perbaikan:

Image Registration

(Source: J. Kusnoto and A. Murni, 2007)

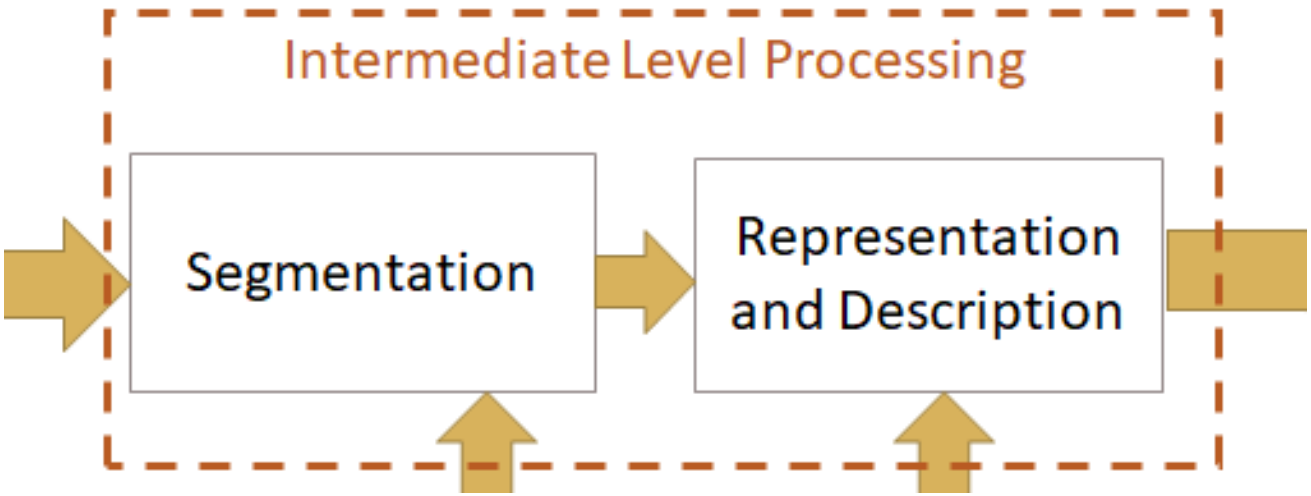




Multimodal data: Cephalo (X-Ray) image and Profile Photo image

Corresponding Control Points

Mid-Level Processing

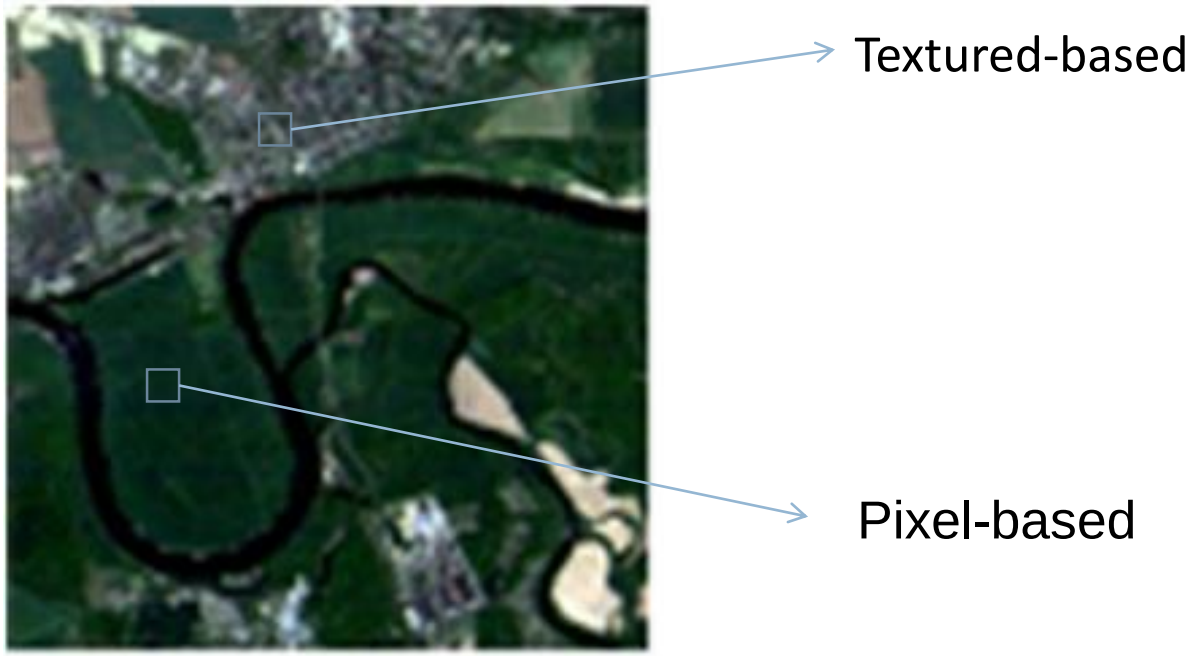


Feature Extraction

- How would you describe this image?
  - Color
  - Gray level textures

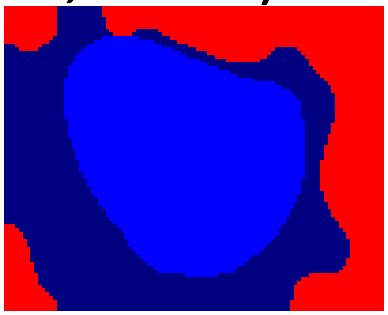
Feature Extraction (2)

- Pixel-based features
- Texture-based features



Feature Extraction (3)

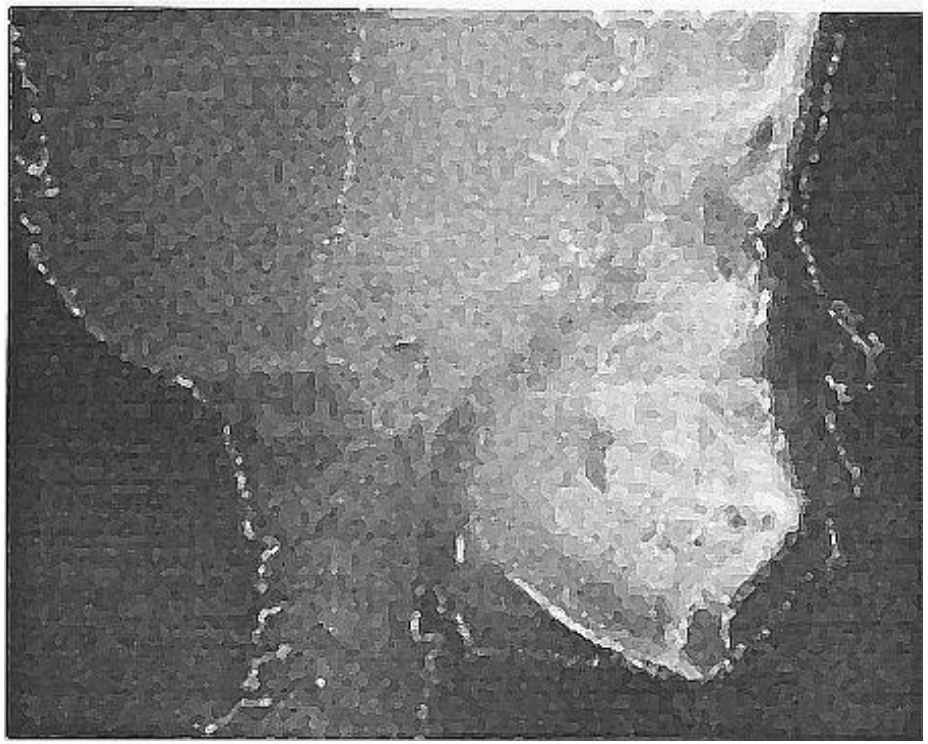
Shape extraction (Jantzen *et al.*, 2005):



nucleus area, cytoplasm area, ratio between nucleus and cytoplasm area, nucleus brightness, cytoplasm brightness, nucleus shortest diameter, nucleus longest diameter, nucleus elongation, nucleus roundness, cytoplasm shortest diameter, cytoplasm longest diameter, cytoplasm elongation, cytoplasm roundness, nucleus perimeter, cytoplasm perimeter, nucleus position, maxima in nucleus, minima in nucleus, maxima in cytoplasm, and minima in cytoplasm

Edge Detection
(Source: Budhiantini Bagyo, D. Hardianto, and A. Murni, 1993)

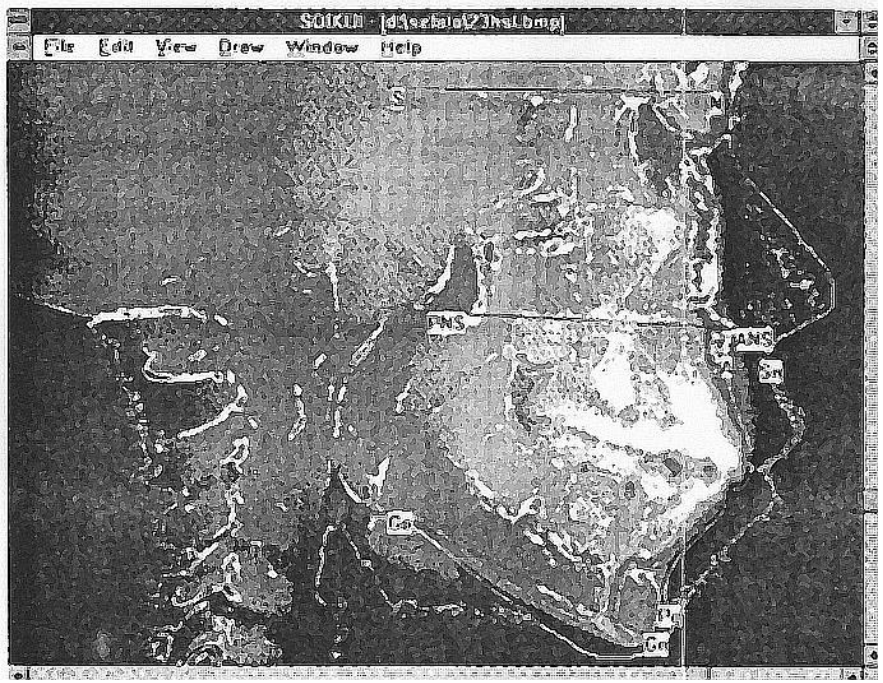
- **Edge detection** gives us the lines and limits of objects.

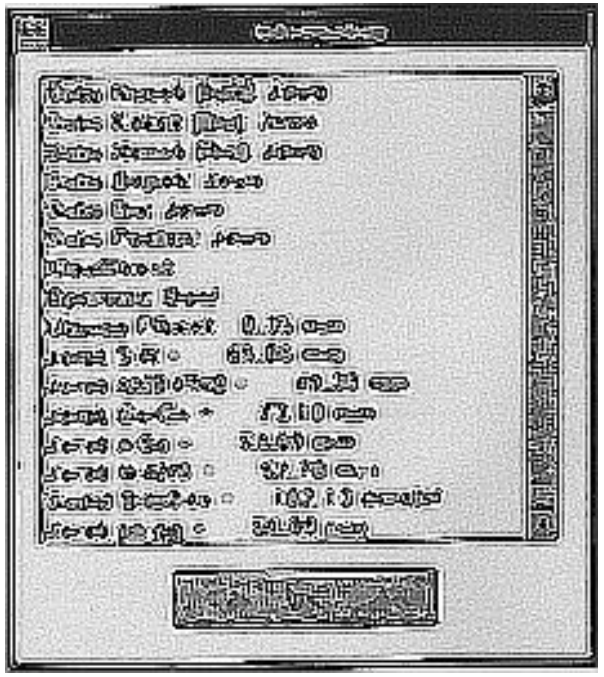


The result of composing the original cephalo image with the soft and hard tissue enhanced image.

Manual Tracing

(Source: Budhiantini Bagyo, D. Hardianto, and A. Murni, 1993)



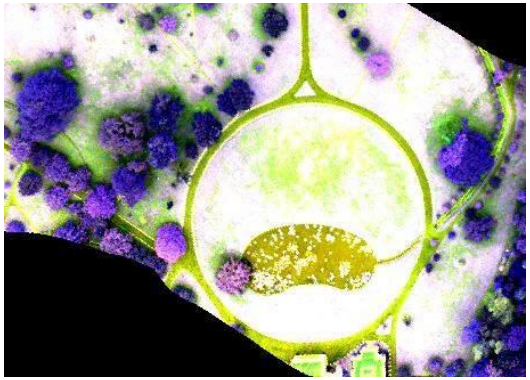


Orthodontic Measures

The doctor can do tracing on the enhanced image easily and ask the system to compute the distance between landmarks and the angle between two lines to get the orthodontic measures that will be used for further patient's treatment

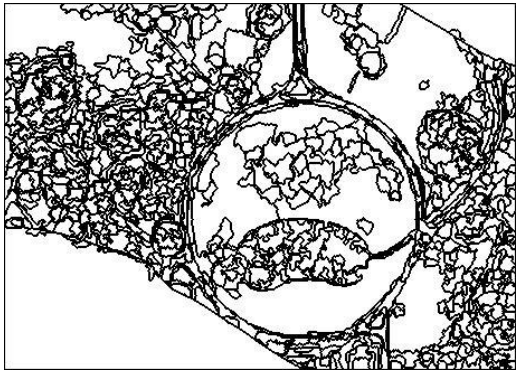
Image Segmentation
(Sumber: Wiweka, H. and A. Murni)

- Segmentasi citra: membagi suatu citra menjadi wilayah-wilayah yang homogen

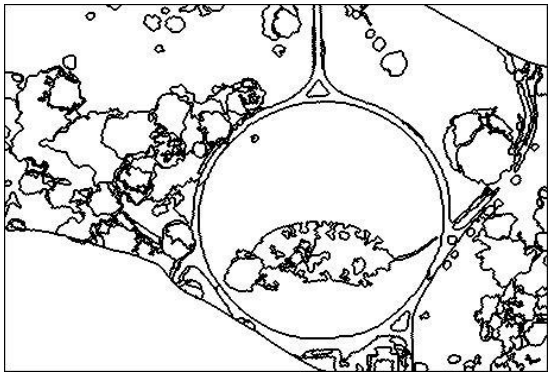


Citra CASI Kebun Raya Bogor

(PT. The Map Indonesia Data)



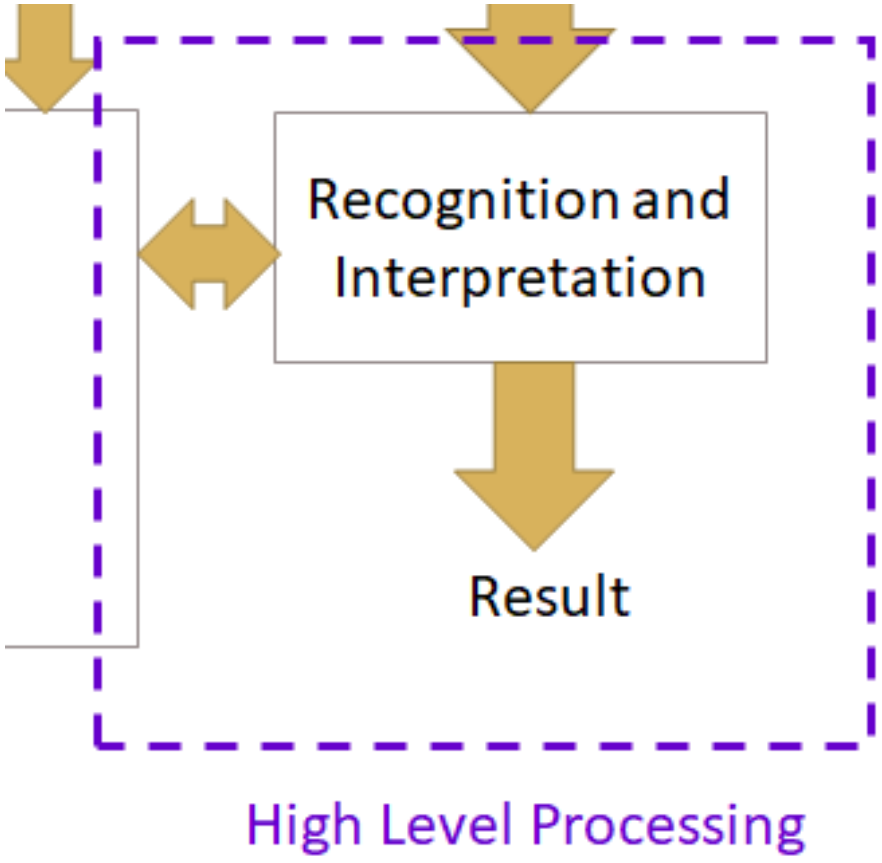
Jumlah cluster banyak



Jumlah cluster sedikit

(Source: Wiweka H. and A. Murni)

High-Level Processing

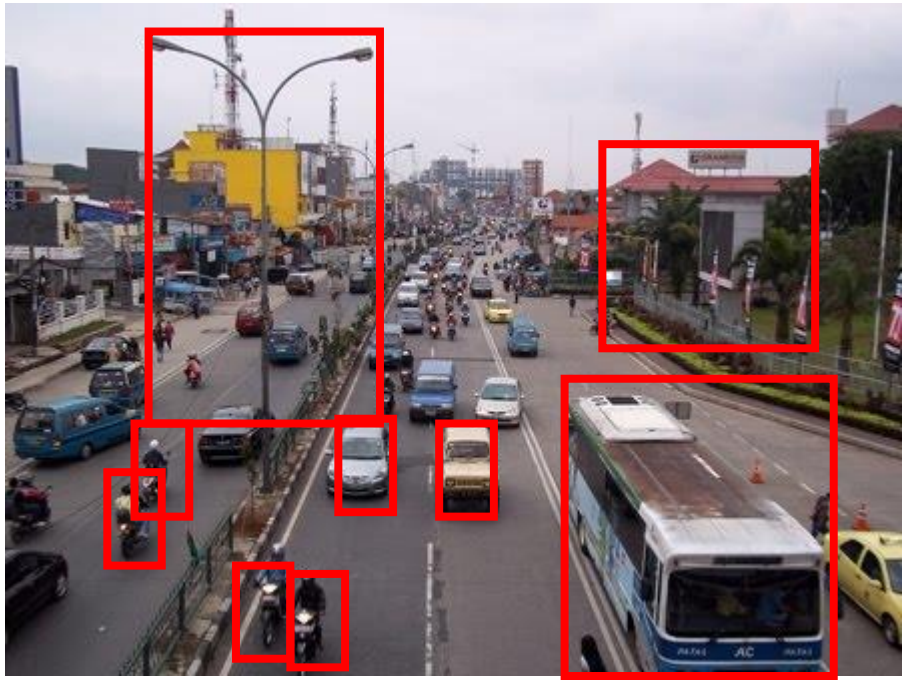


Studi Kasus: Menghitung jumlah motor yang melalui jalan Margonda Raya.

- Low-Level Processing

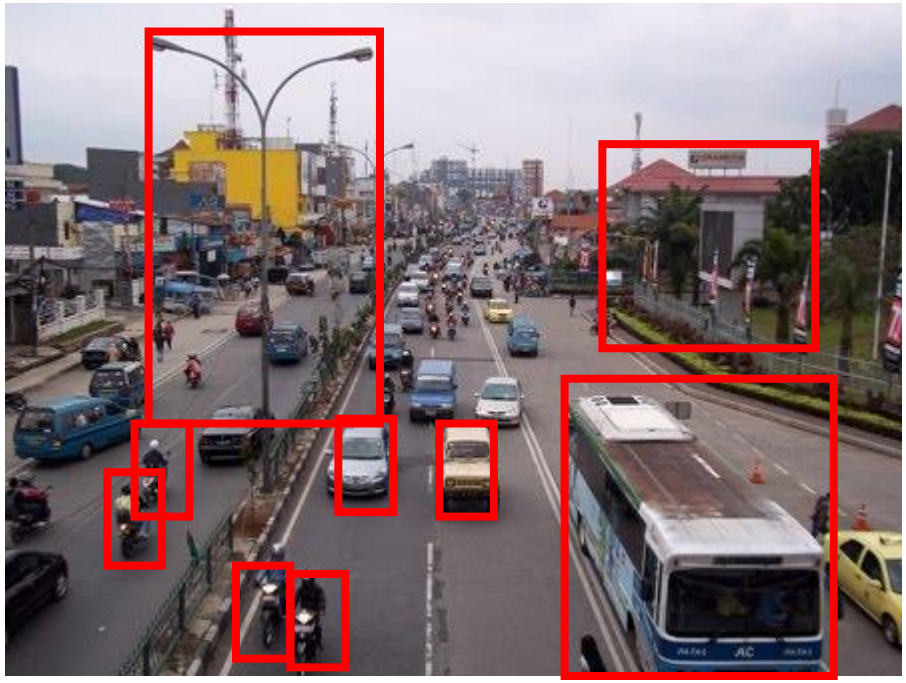
Studi Kasus: Menghitung jumlah motor yang melalui jalan Margonda Raya.

- Mid-Level Processing



Studi Kasus: Menghitung jumlah motor yang melalui jalan Margonda Raya.

- High-Level Processing



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