Image Processing
(Pengolahan Citra)

Semester Genap Tahun 2019-2020

Jam 08:00 s.d. 10:30

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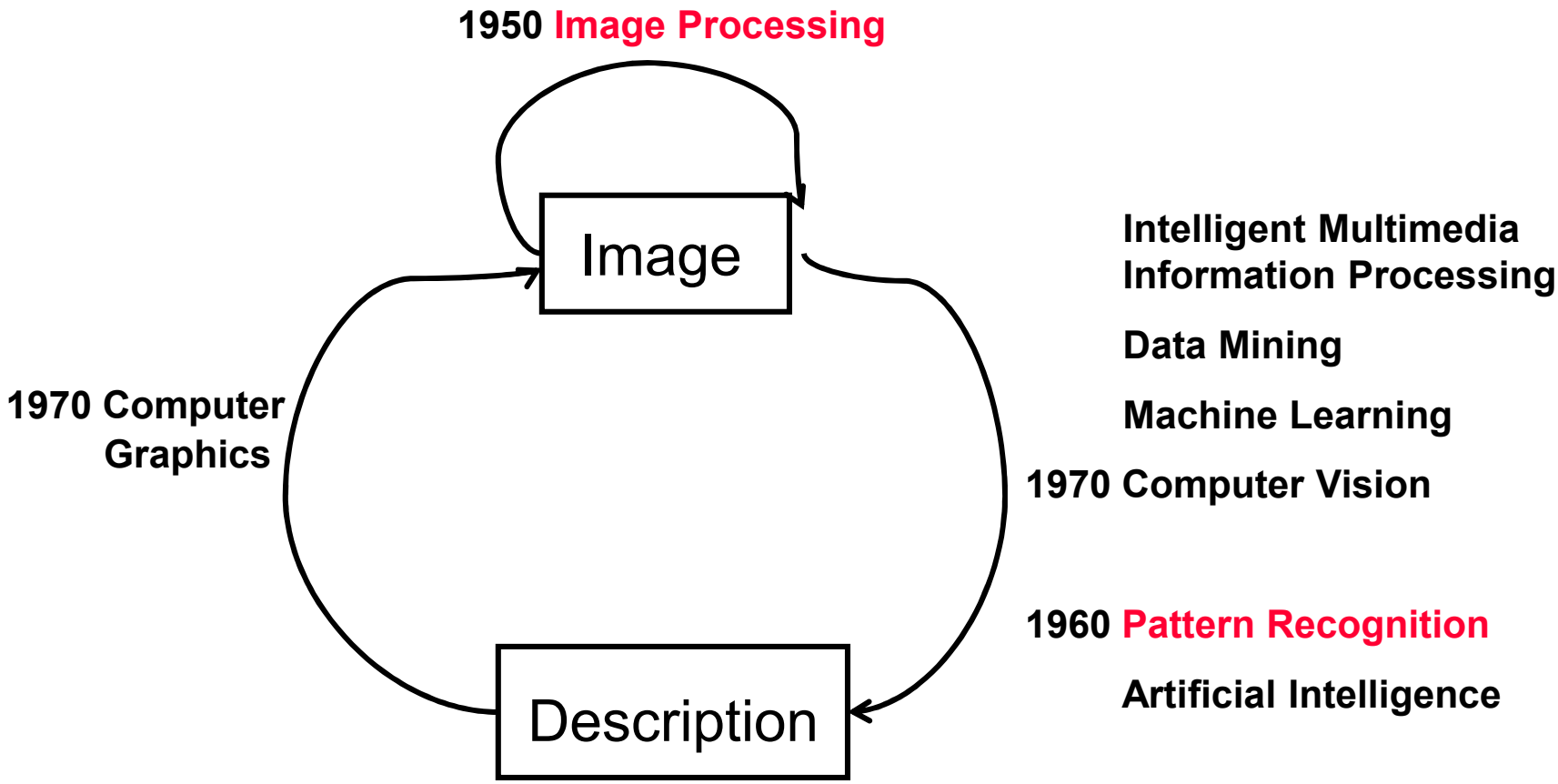
Topic 1:
Image Processing – Pattern Recognition – Computer Graphics

Bidang Terkait dengan Pengolahan Gambar

- 3 Bidang:
  - Image Processing,
  - Pattern Recognition, and
  - Computer Graphics
- Tambahan Bidang Terkait
  - Content-based Image Retrieval System
  - Spatial Data Analysis

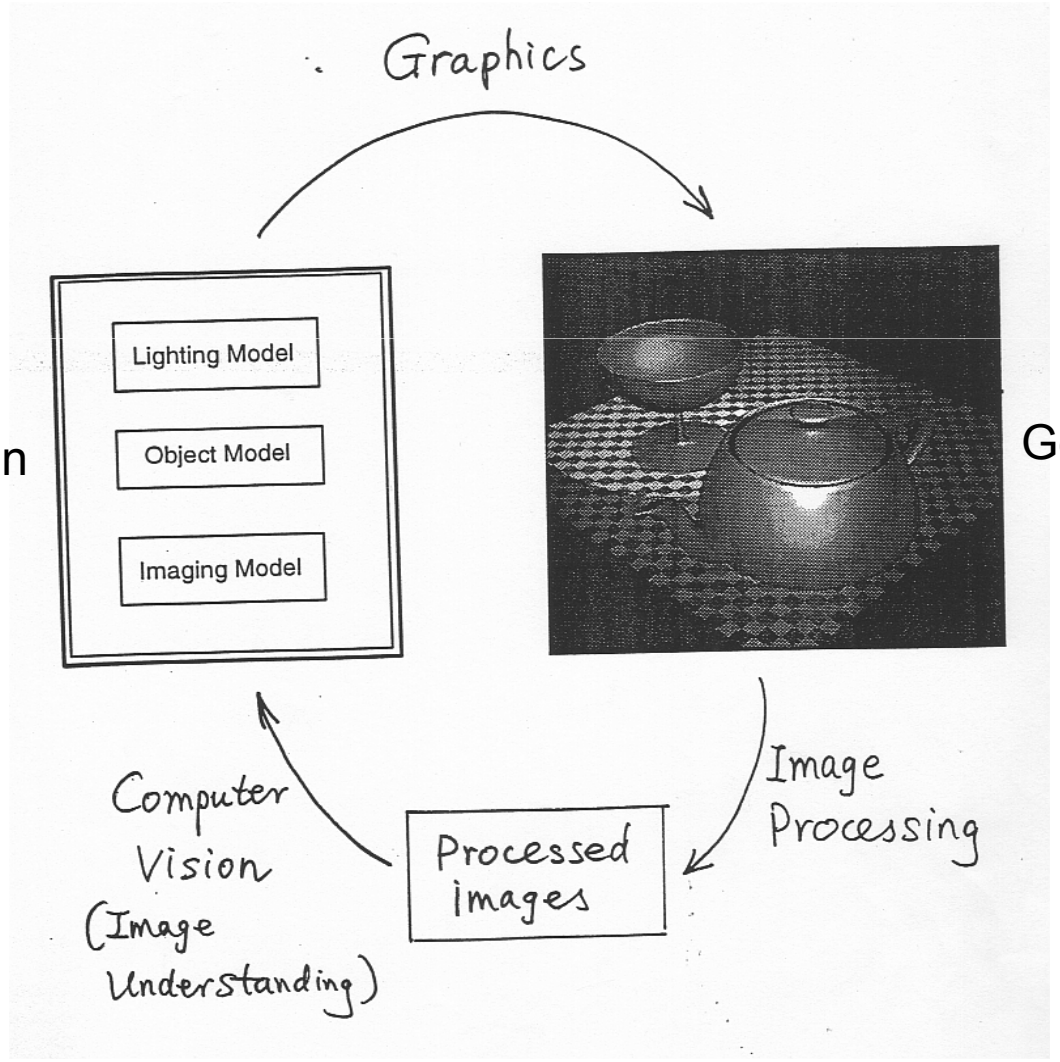
Three Areas of Study that Related to Image or Picture Processing

(Source: Pavlidis,1986)

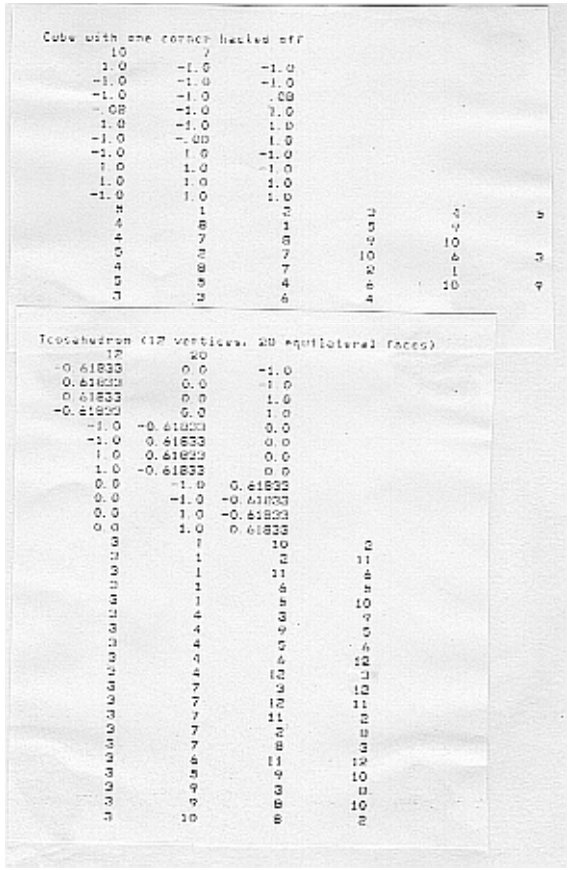


Three Areas of Study that Related to Image or Picture Processing

(Source: Pattern Recognition Course, MSU, 1990)

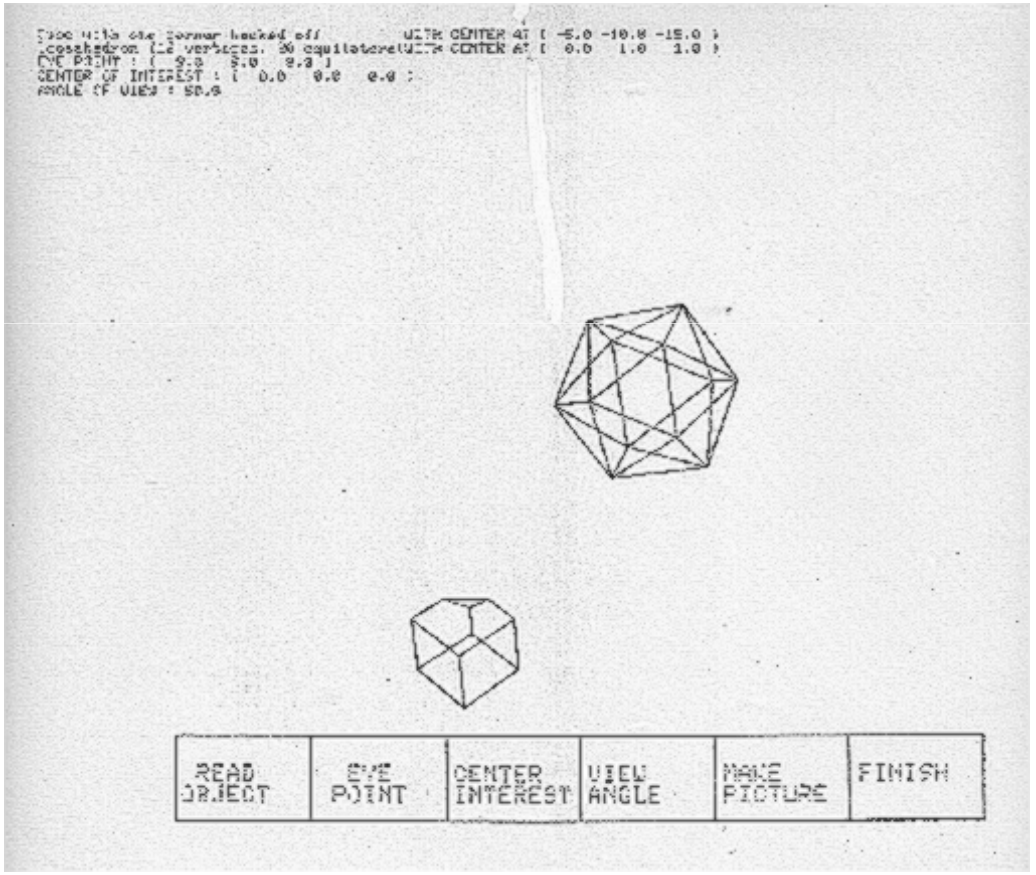


Computer Graphics (1)



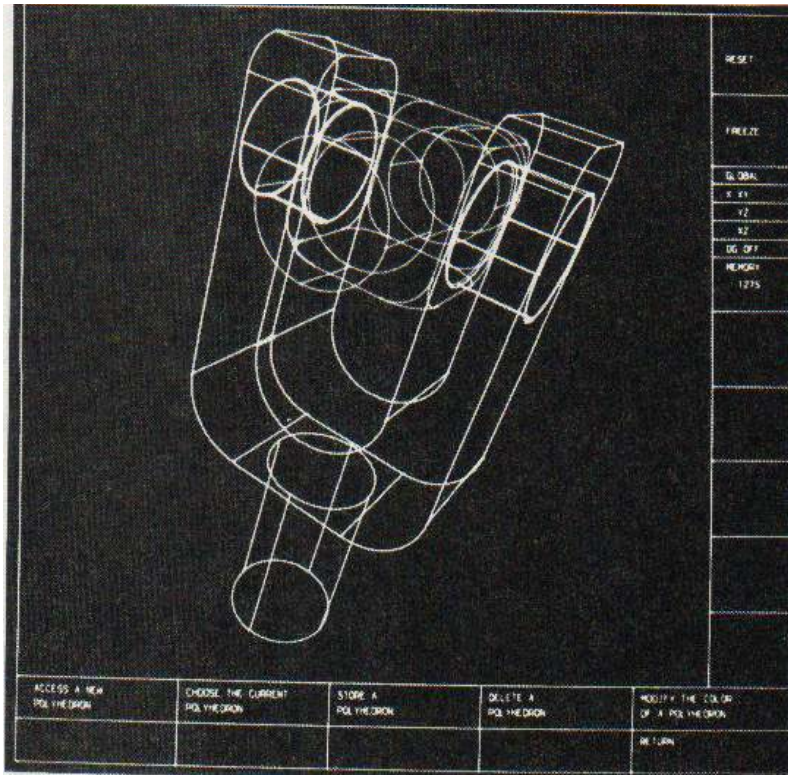
Object Description

(Murni, 1979)



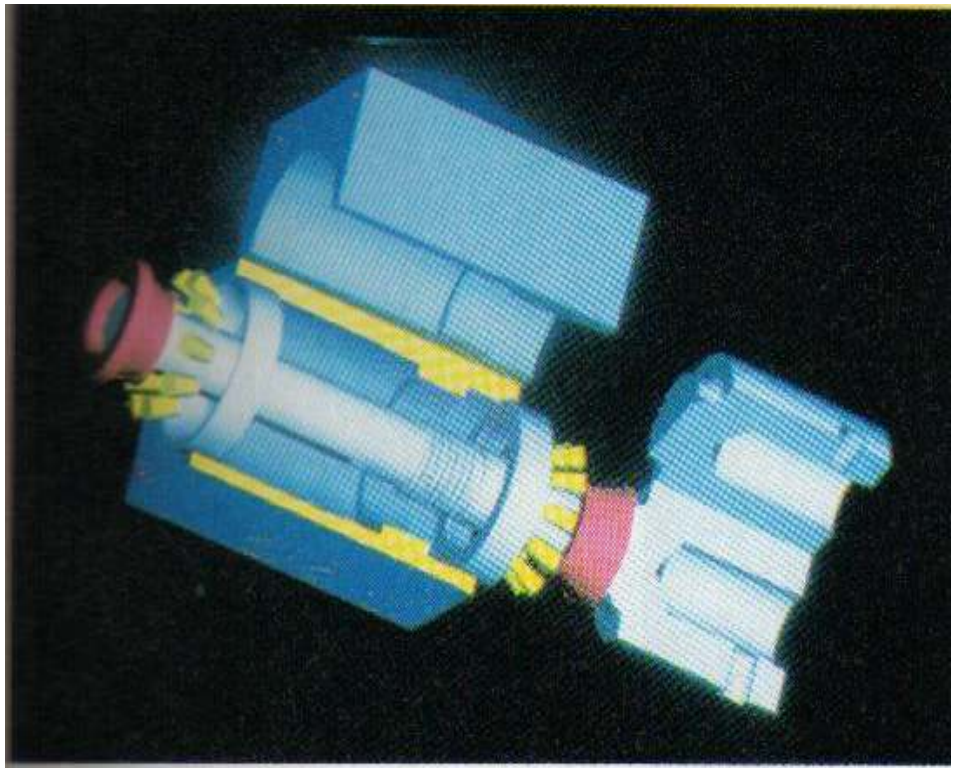
Generated Image

Computer Graphics (1)



Wire Frame Drawing

(Hearn and Baker, 1986)



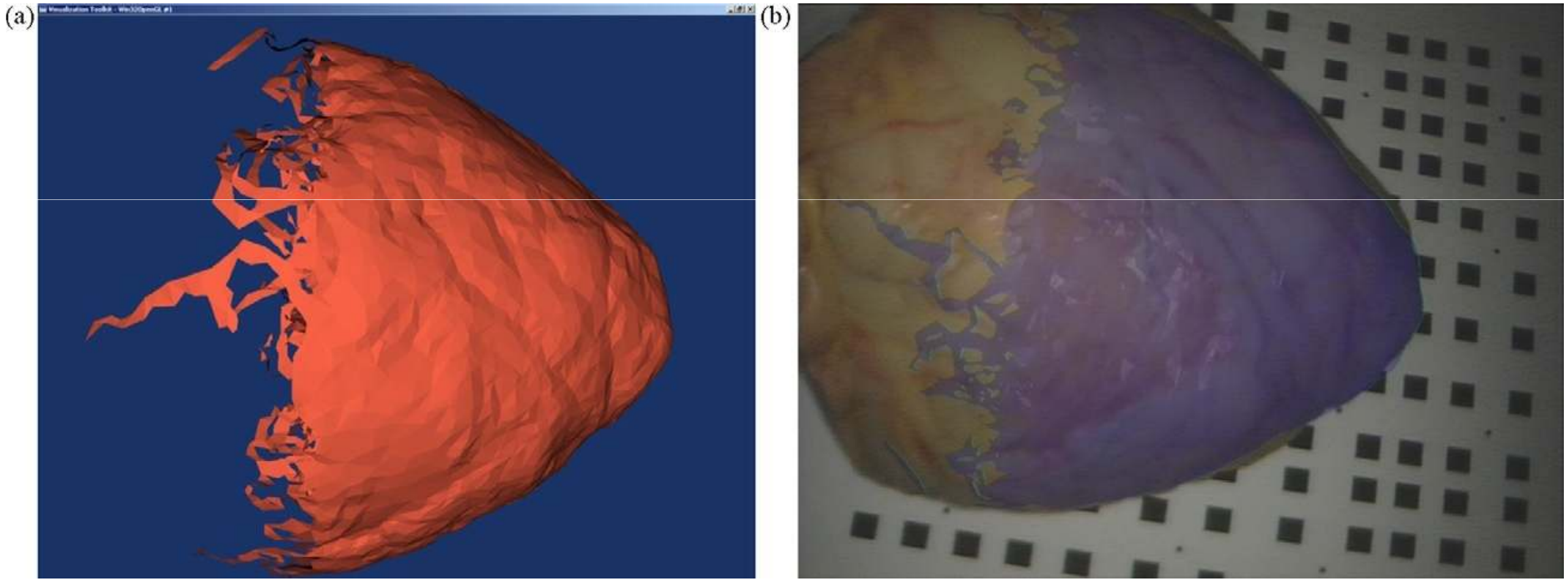
Realism Drawing

Computer Graphics (1)

- *A process, technique, and method to* ***generate a picture based on the description of both its objects and backgrounds****;*
- *A process, technique, and method to create a* ***realism effect*** *on the objects and backgrounds contained in a picture;*
- *Drawing a picture and* ***animating (game)*** *objects using a computer.*

Graphics of heart phantom (1)

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

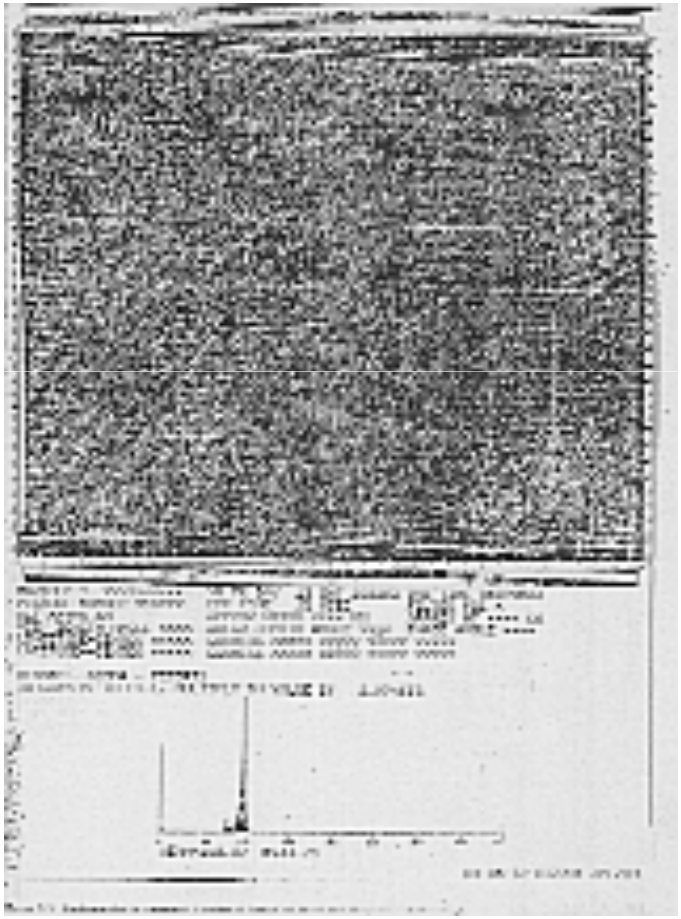


(a) Truncated rendering surface

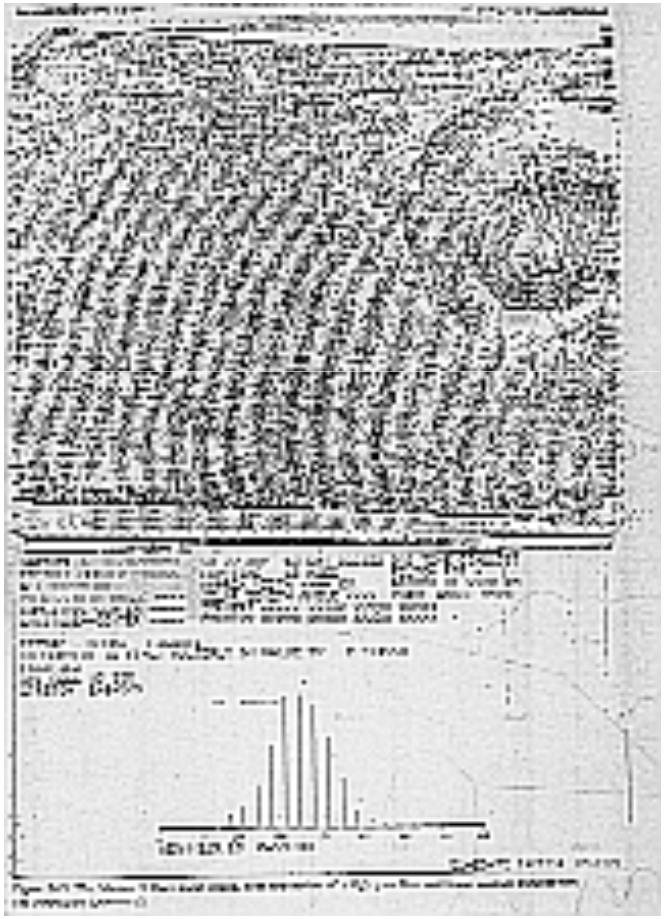
(b) Whole section

Image Processing (2)

Image Enhancement



Input/Degraded Image



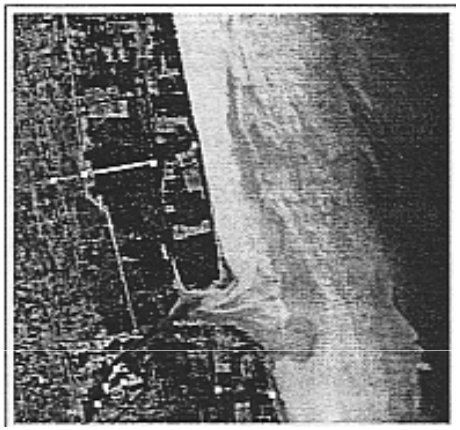
Output/Enhanced Image

(JPL, 1972)

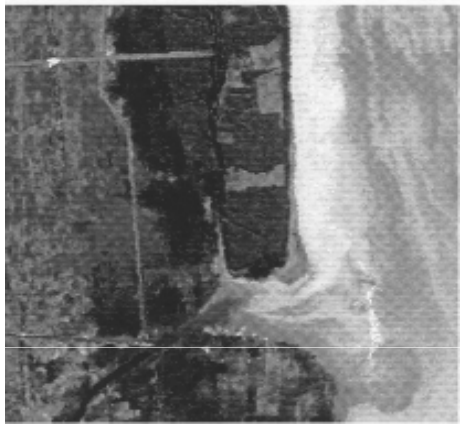
Image Processing (2)

Image Registration

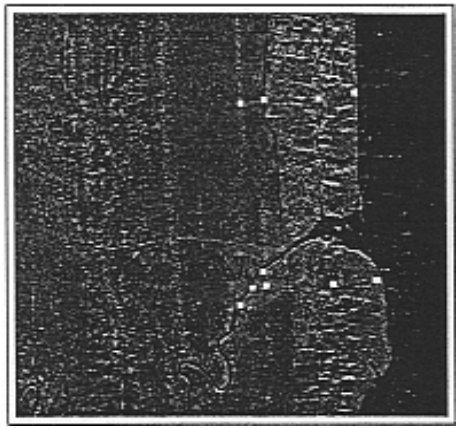
(Source: Original Image of Muara Sekampung, BAKOSURTANAL RI;
Processed Images, A. Murni, 1996)



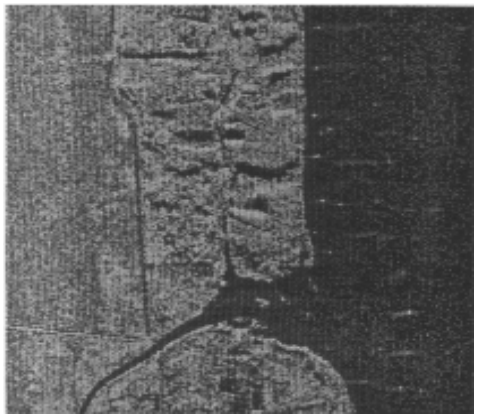
Optical Sensor Image



Registered Optical Sensor Image

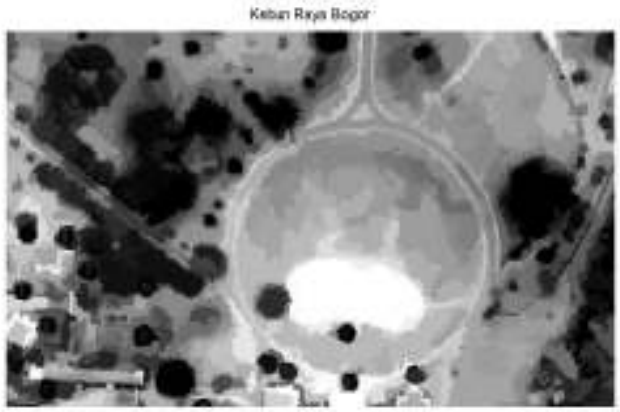


SAR Sensor Image



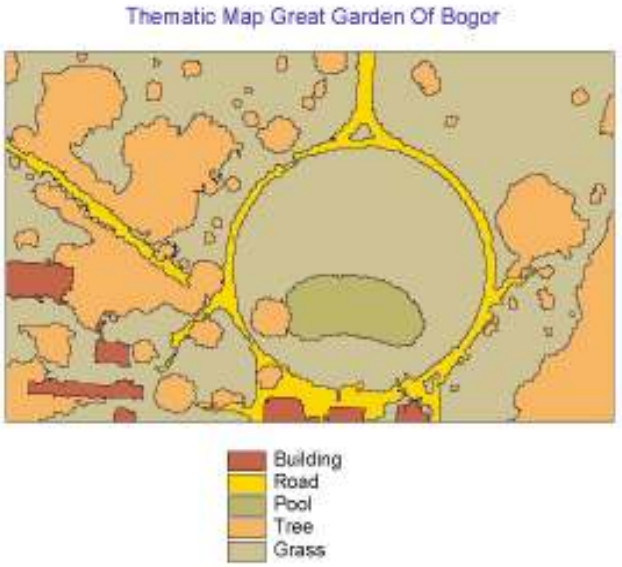
Registered SAR Sensor Image

Image Processing and Pattern Recognition (2)



CASI image of Bogor area

(Source: The Map Indonesia)



Classified / Thematic Image

(Source: Wiweka, 2006)

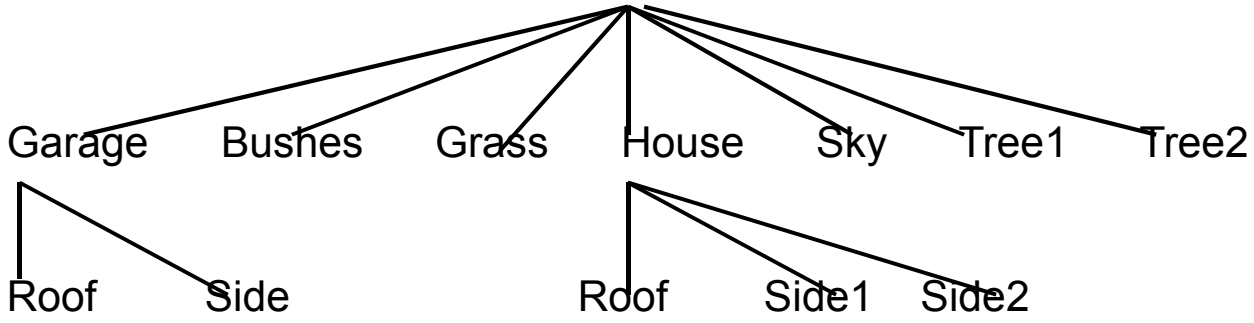
Digital Image Processing and Pattern Recognition (2)

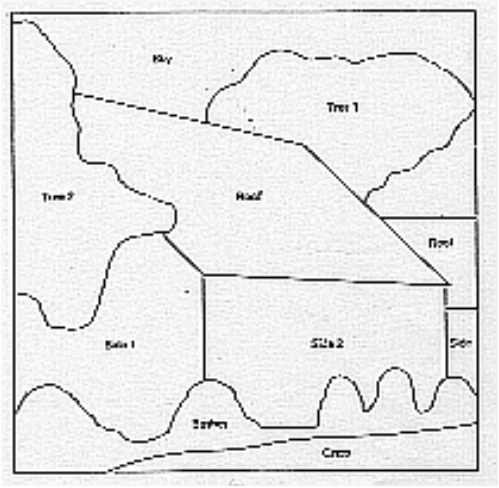
- ***Image quality enhancement****: (a) radiometric aspect (contrast enhancement, colour transformation, image restoration); and (b) geometric aspect (rotation, translation, scale, geometric transformation);*
- ***Feature/image extraction and selection*** *to obtain features/images that would be optimal for analysis purpose;*
- ***Data reduction and image compression*** *(for the purpose of efficiency in data storage, data transmission, and data processing time);*
- *Information extraction,* ***object recognition*** *and object description that is contained in an image.*

Computer Vision (3)

Input Images

(Ballard, 1992)





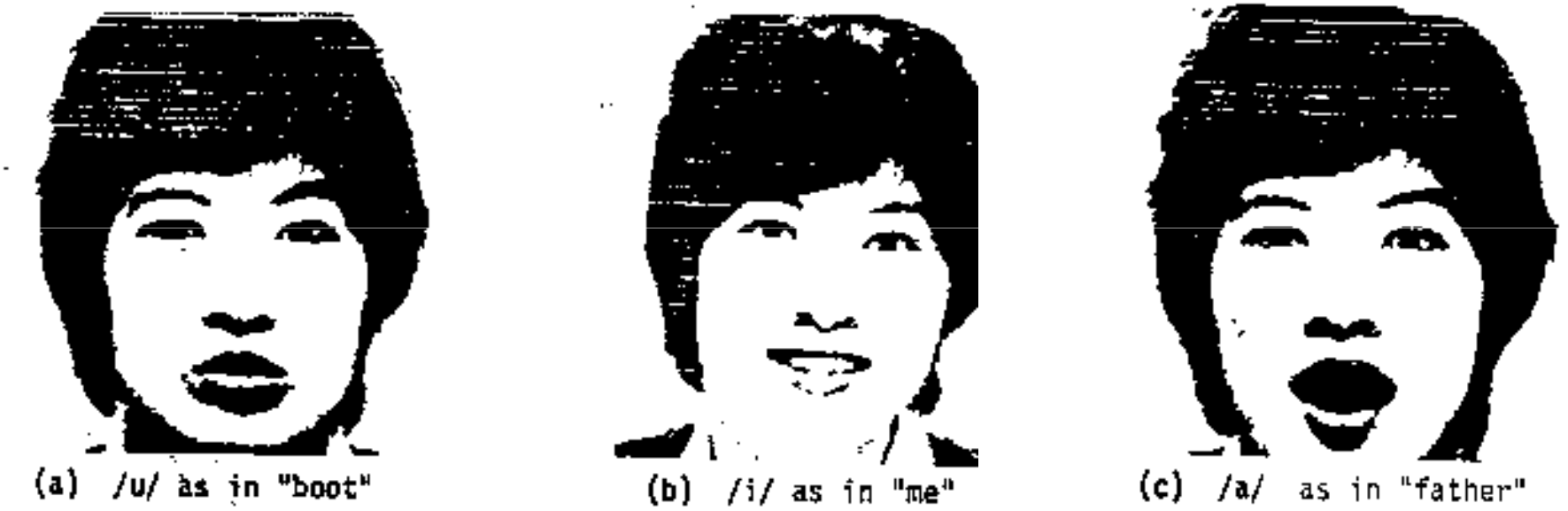
Descriptions

Computer Vision (3)

- Segmentasi citra
- Pemberian label setiap segment dengan mengamati gray scale ataupun texture setiap segment ataupun bentuk segment

Laki-laki dan Perempuan
(Source: Dina Chahyati)

Computer Vision (3)



Bahasa isyarat lainnya: menggunakan bahasa tangan dan ada juga yang disebut sebagai ‘body language’: mengangguk (jarak antara garis alis dan mulut mengecil), menggeleng (jarak antara garis mata kiri dan kanan mengecil).

PR, CV, dan AI (3)

- ***Pattern Recognition**:* Segmentation and Classification, **Speaker Recognition** (siapakah yang berbicara?)
- ***Computer Vision**:* Object Recognition and Description (Object Structure), **Word and Vowel Recognition** (kata-kata apa saja yang dikatakannya?)
- ***Artificial Intelligence**:* What is illustrated by this image, **Speech Understanding** (sedang memberi kuliah apa orang tersebut)

Pattern Recognition and Artificial Intelligence (3)

- ***Pattern Recognition*** *(Pengenalan Pola):*
  - *Thematic Image (2-D object recognition)*
  - *Speaker Recognition*

- ***Artificial Intelligence*** *(Kecerdasan Buatan):*
  - *What is seen by the robot? (3-D object recognition)*
  - *Speech Understanding*

Spatial Data Analysis (4)

- Konsekwensi dari penggunaan citra, misal citra area kota Jakarta pada aplikasi remote sensing (penginderaan jarak jauh). Piksel pada citra menyatakan letak geografis.
- Beberapa contoh aplikasi spatial data analysis: sekolah SD/SMP/SMA biasanya terletak dekat misalnya Puskesmas, Mall, Kantor Polisi, Bank dll.

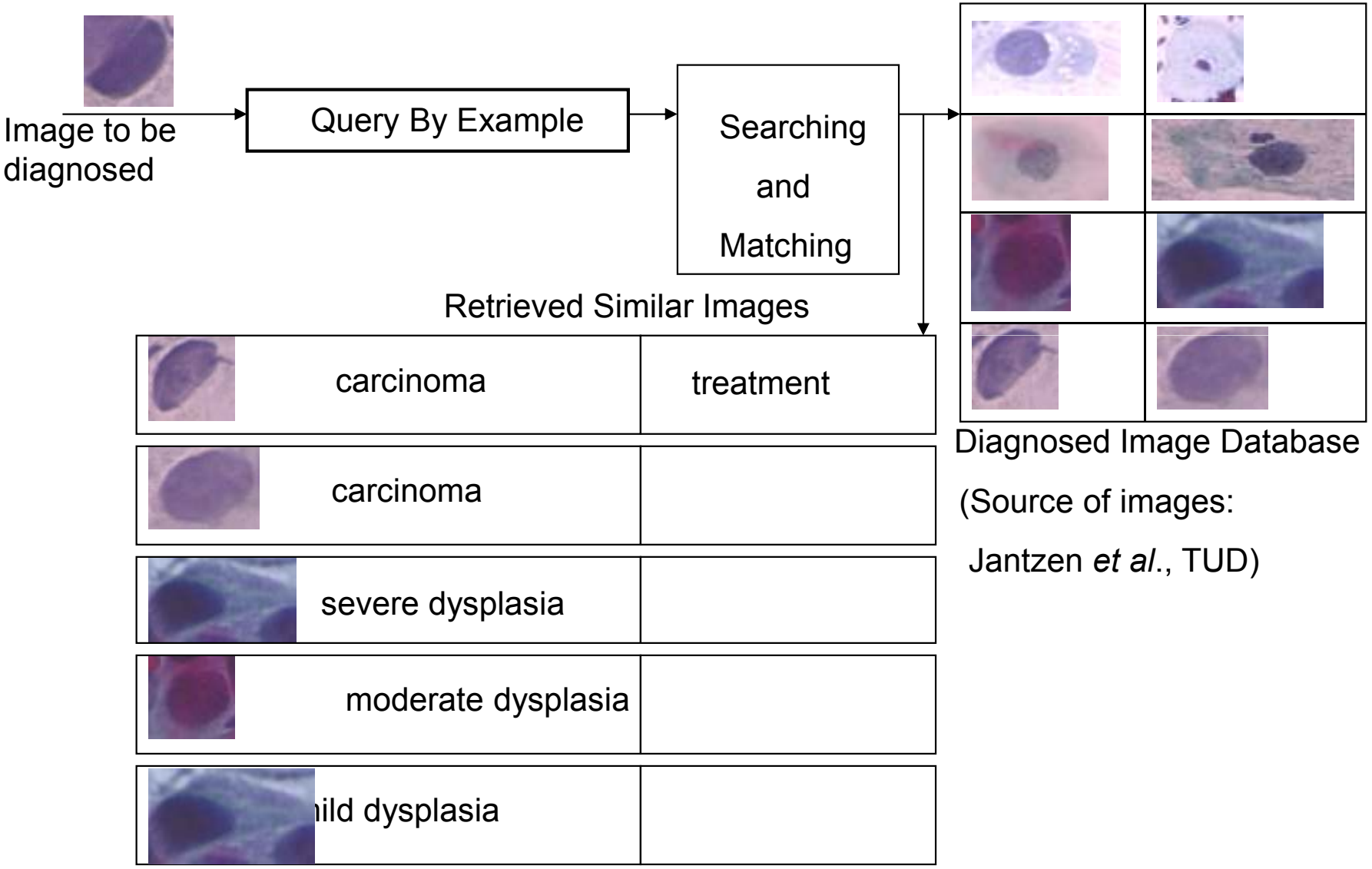
Image Retrieval System (5)

- Sama seperti Information Retrieval System
- Text Retrieval System: masukan berupa suatu text, dan dicari apakah ada text yang sama dengan text masukan
- Content-Based Image Retrieval System: masukan adalah citra penderita kanker paru, dan dicari apakah ada image yang sama dengan image masukan. Bila sama apakah citra tersebut juga citra penderita kanker?

Content-Based Image Retrieval System (5)

- An image is represented by a set of features
- We have a database of images with their representation based on set of features, and information about the image
- We have a query image, and would like to know the characteristic of the image
- The query image features are compared to the features of images in the database based on a similarity measure
- Similar images are provided to the user with their characteristic

Content-Based Image Retrieval System (4)

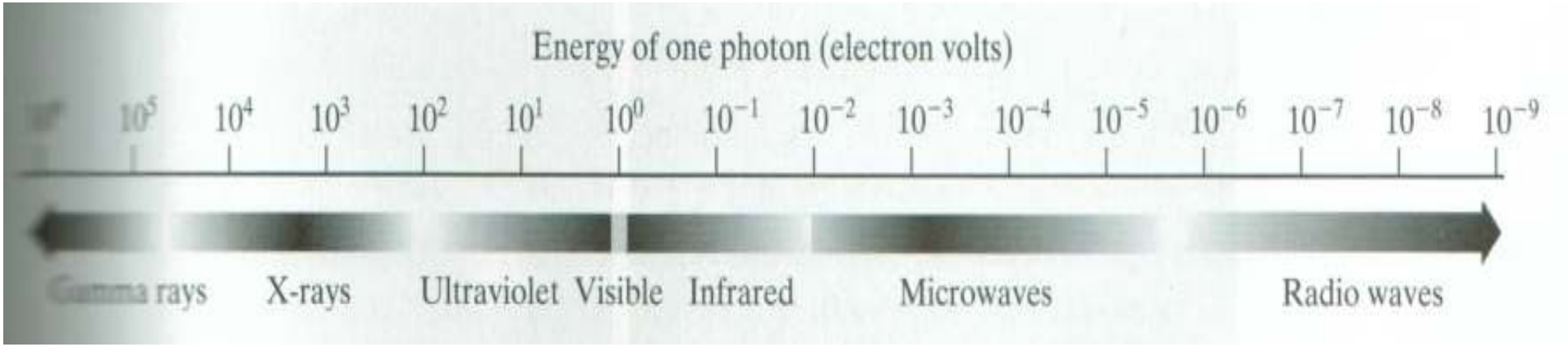


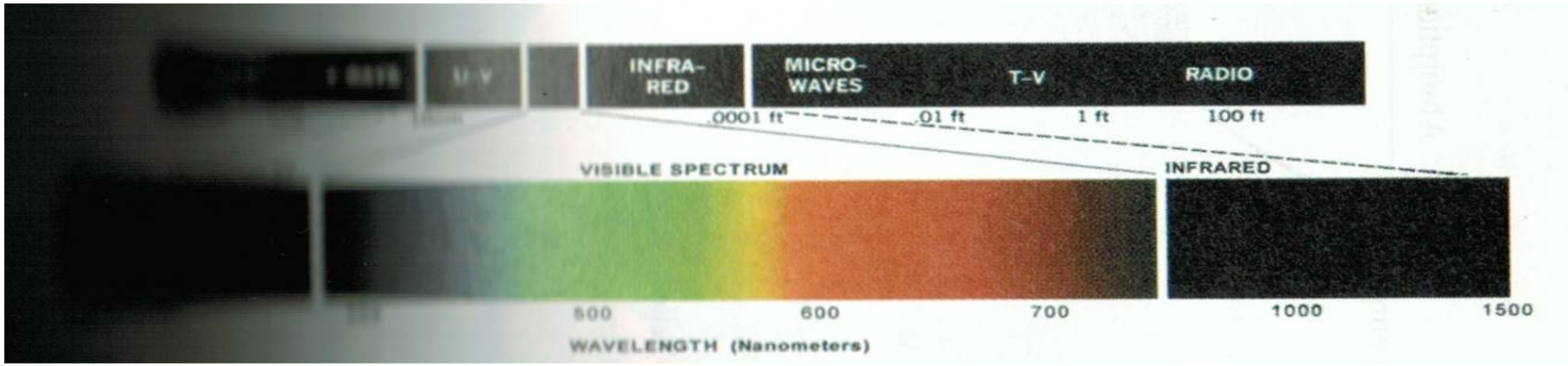
Other Related Terms

- Machine Learning – Soft Computing
  - Soft computing vs Hard computing
  - Fuzzy Logic System, Neural Network vs Conventional Statistical Classifier
- Data Mining – Data Exploration and Analysis
  - Clustering
  - Feature Selection
  - Soft Computing, Statistical, Hierarchical Classifiers
- Intelligent Multimedia Information Processing
  - Unimodal versus Multimodal data (sensors)
  - Fusion at data/feature level, score level, decision level
  - Multiple classifier, linear, parallel, and hierarchical mode of operation

Topic 2:
Several Sensors and Applications

EM spectrum arranged according to energy per photon





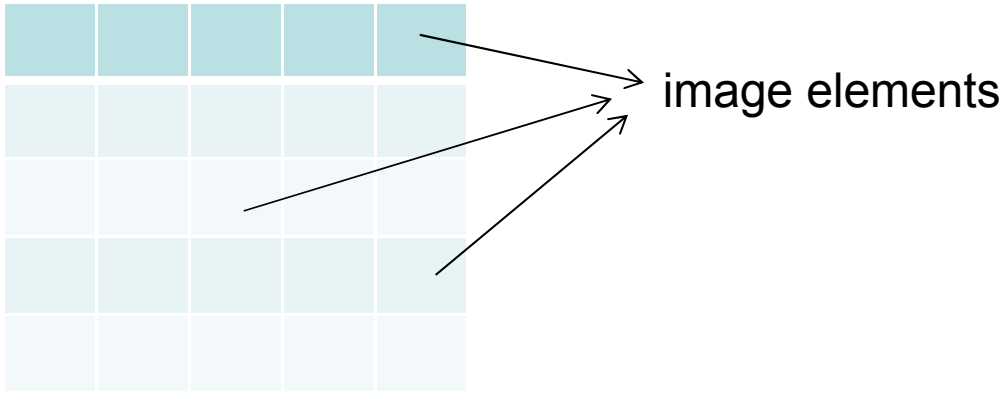
(Sumber: Gonzalez and Woods, 2008)

Digital Image

- Gonzalez dan Woods, 2008:

  An image may be defined as a 2-D function, *f(x,y)*, where *x* and *y* are spatial (plane) coordinates, and the amplitudo of *f* at any pair of coordinates (*x,y*) is called the intensity or gray level of the image at that point. When *x, y*, and *f* are all finite, discrete quantities, we call the image a digital image.

  A digital image is composed of a finite number of elements, and are called *picture elements, image elements, pels, and pixels*.



Beberapa Aplikasi

- Cultural Heritage
  - Painting Recognition
- Biomedical Applications
  - Forensic
  - EchoCardioGraphy/Arrythmia
  - Breast Cancer
- Remote Sensing Applications
  - Optical Sensor and Synthetic Sensor Images
  - Multisensor Classification
  - Cloud Cover Removal

Cultural Heritage Application

Painting Style and Artist Recognition

(Source: (1) Tieta Antaresti and Aniati Murni Arymurthy, Image Feature Extraction and Recognition of Abstractionism and Realism Style of Indonesian Paintings, *International Conference on Advanced Computer Science & Information Technology (ACT) 2010*, Jakarta, December 2, 2010; (2) T. Antaresti, H.M. Manurung, and A. Murni Arymurthy, Digital Painting Artist Identification Using Color and Texture Feature*, International Conference on Applications in Computer Science and Information System (ICACSIS)*, Bali, November 22-23, 2010)

Realism vs Abstractionism in Paintings

Correctly Recognized as Abstractionism painting (Left) and Realism painting (Right)

Incorrectly Recognized as Abstractionism painting (Left) and Realism painting (Right)

Average recognition accuracy is 66.23%

Features Yang Digunakan

- Texture feature: Gabor wavelet
  - Mean and standard deviation of energy in a subimage using 4 scales and 6 orientation
- Statistical feature: Histogram analysis
  - Mean, Entropy, Variance, Skewness, dan Kurtosis
- Edge (brushstrokes) feature: number-of-edge analysis
- Augmented feature vector

Hasil Pengenalan

- Gabor wavelet features: 59.74%
- Number-of-edge analysis features: 66.23%
- Histogram analysis features: 48.05%
- Gabor wavelet dan number-of-edge analysis features: 64.94%

Perbaikan Features Pengenalan Pelukisnya

Affandi (1907-1990)

Painting style:

expressionism

Brushstrokes style : hand, feet, and sun

“I want to die in simplicity without giving anyone unnecessary trouble, so I could go to Him in peace”

Affandi's famous paintings

- Barong Melis (1974)

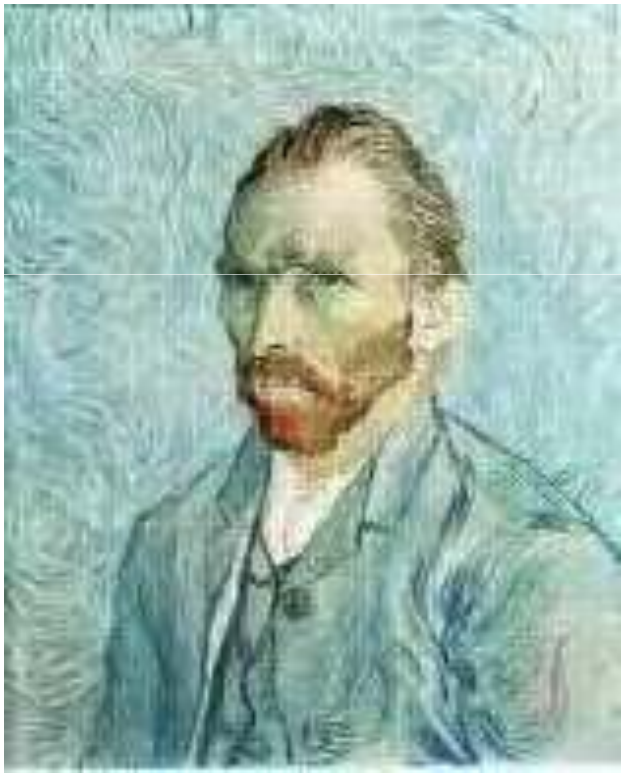
- Togog Penghalau Burung (1975)

Vincent van Gogh (1853-1890)

Style: post-impressionism

Often using earth color tones in his paintings & short continous thick brushstrokes

"I often think that the night is more alive and more richly colored than the day"



Van Gogh's Famous Paintings

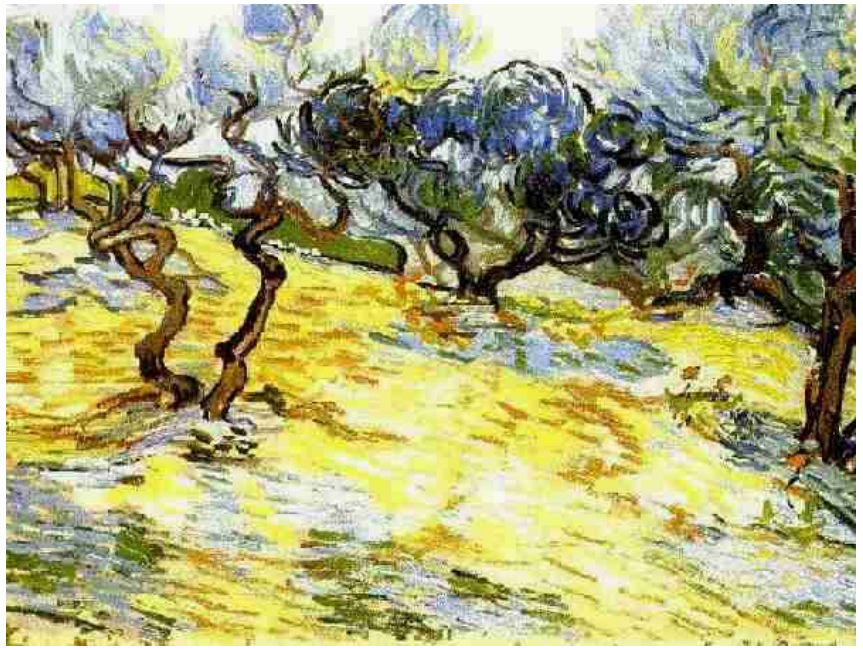
- Starry Night (1889)

- Wheat Field With A Cypress (1889)

‘Look Similar’ Paintings

Pohon & Andong (1975) by Affandi

Olive Tree (1889) by Van Gogh



‘Look Similar’ Paintings

Bunga Matahari (1969) by Affandi

Four Cut Sunflowers (1887) by Van Gogh

Several Experiment Result (Affandi vs. Non Affandi)

Method	Recognized	Error	Accuracy
Gabor wavelet (binary images)	31	9	78.46%
Gabor wavelet (raw images)	25	15	63.46%
Number of edges analysis	30	10	75%
Color histogram analysis	27	13	56.33%
ESH	33	7	83.08%
Gabor (binary) + number of edges	30	10	75%
Gabor (raw) + number of edges	30	10	75%
Gabor (binary) + color histogram	31	9	78.46%
Gabor (raw) + color histogram	26	14	67.31%
Number of edges + color histogram	26	14	67.31%

Several Experiment Result (Affandi vs. Van Gogh)

Method	Recognized	Error	Accuracy
Gabor wavelet (binary images)	13	27	33.59%
Gabor wavelet (raw images)	21	19	51.27%
Number of edges analysis	12	28	31.06%
Color histogram analysis	13	27	31.57%
ESH	22	18	55.81%
Gabor (binary) + number of edges	13	27	31.57%
Gabor (raw) + number of edges	19	21	47.98%
Gabor (binary) + color histogram	12	28	31.06%
Gabor (raw) + color histogram	13	27	31.57%
Number of edges + color histogram	19	21	47.98%

Examples of Unrecognizable Data

Affandi recognized as Non-Affandi

Affandi recognized as Van-Gogh

Examples of Unrecognizable Data

Van Gogh recognized as Affandi

Non-Affandi recognized as Affandi

Results

- This study found that **ESH** is the best method and efficient in impasto detection, and may be the most effective method in recognizing painter because it can detect long edge and short-yet-continuous edge. While in another study by Johnson *et al*. (2008), **Gabor wavelet** can recognize the texture feature on the painting's impasto as well. In this case, the aim of the impasto detection is to differentiate the van Gogh's from the non- van Gogh ones.

(a)

(b)

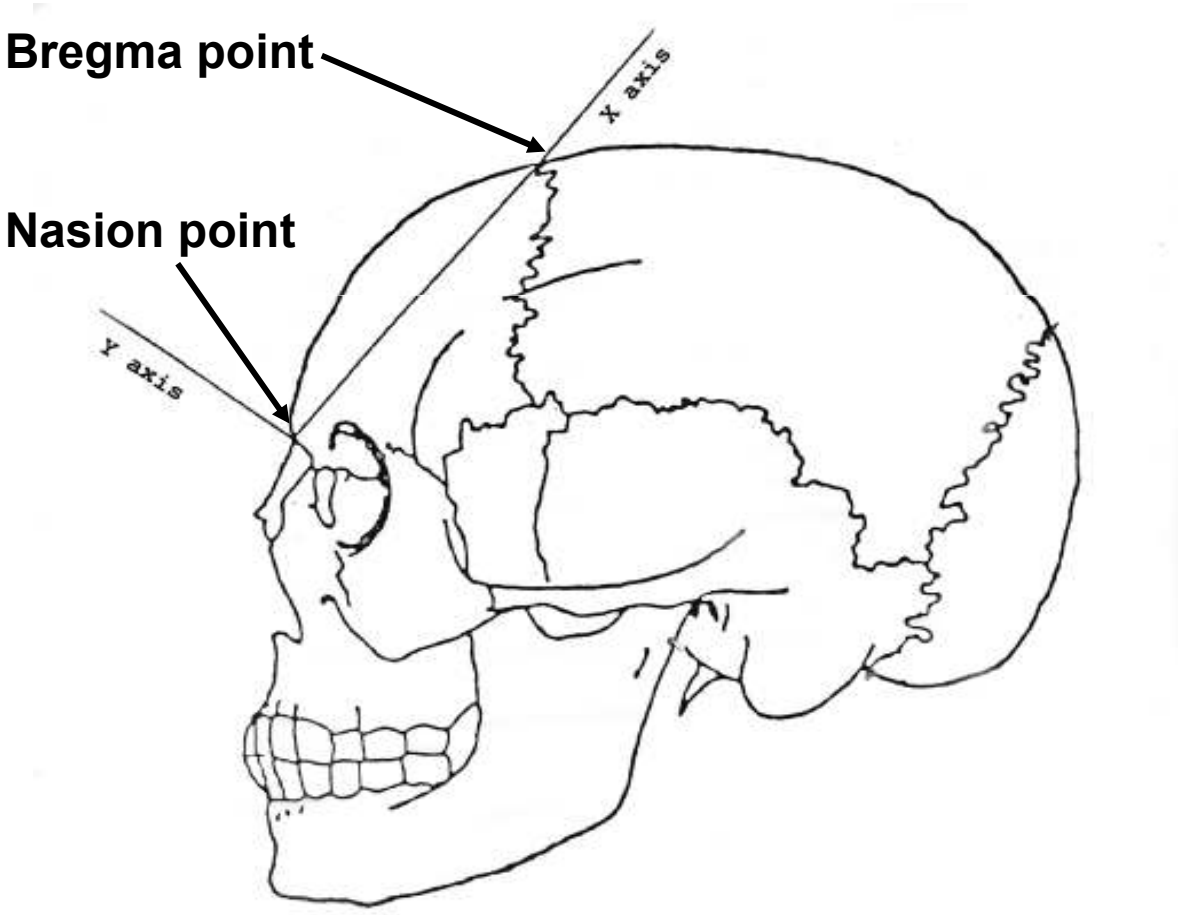
The difference between the *impasto* in a painting by (a) Affandi and (b) Van Gogh

- Affandi & Van Gogh is more difficult to differentiate
- Augmented vector of features can increase accuracy → **needs feature selection method or data mining**

Biomedical Applications

X-Y Axis of The Forehead

(Source of Image: M. Inoue, 1990)



Data and Methodology

(Source: D. Chahyati, T. Munisywara, M. Suharsini, A. Murni, 2005)

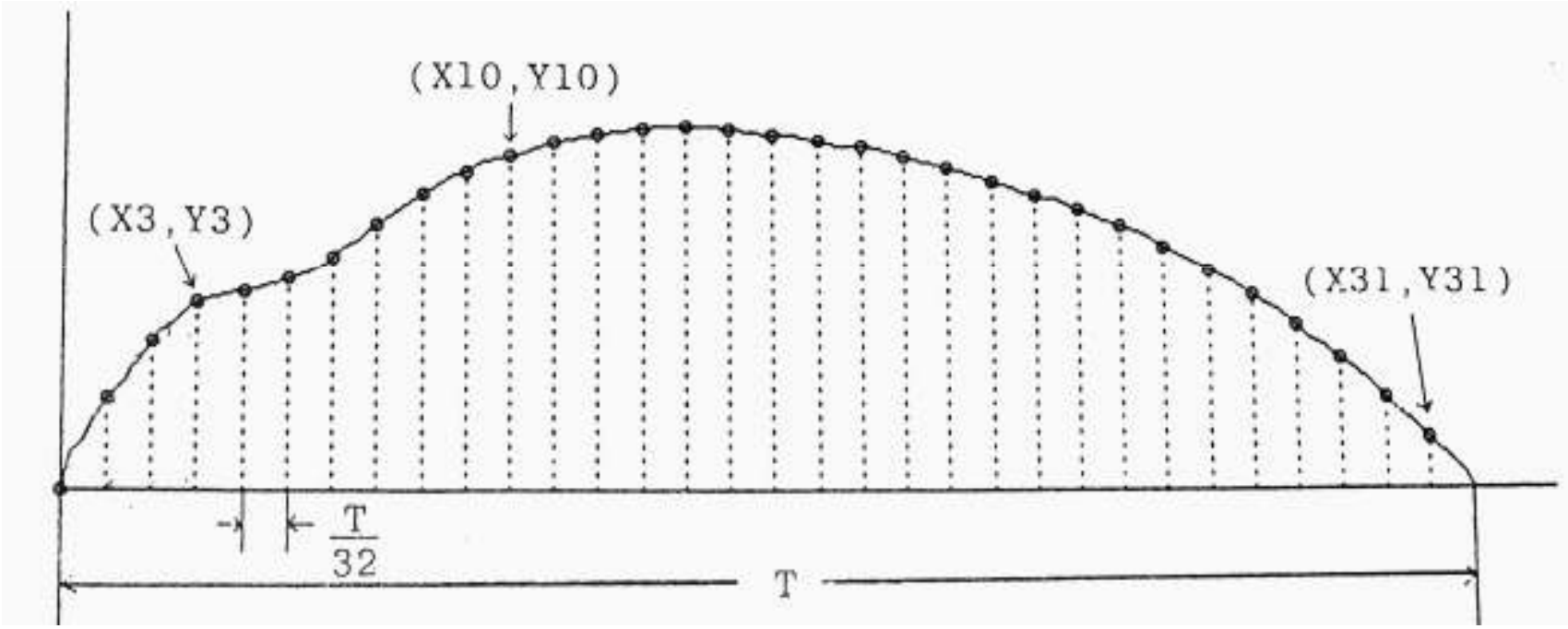
- Data: 30 male samples and 30 female samples

  (Source: M. Suharsini, Faculty of Dentistry, University of Indonesia)

- Methodology:
  - Display the observed radiography cephalometric image;
  - Define the forehead shape (from the landmarks *Nasion* point to *Bregma* point);
  - Draw the line from the *nasion* point to *bregma* point, and rotate the line to be a horizontal axis;
  - Divide the forehead contour into 32 points with the same intervals, and use these points to be the input data for Fourier or Haar wavelet analysis;
  - Compute the Fourier or Haar wavelet measures, and use these values as the input data to a discriminant analysis to find its discriminant function score.
  - Check the discriminant function score to the used thresholding values to decide weather it is categorized as male or female.

Sample points from (x0,y0) to (x31,y31)

(Source: Inoue, 1990)



Fourier and Wavelet Comparison

(Source: D. Chahyati, T. Munisywara, M. Suharsini, A. Murni, 2005)

Using Fourier Analysis			Using Wavelet Analysis		
Identification Average Accuracy			Identification Average Accuracy		
Male	Female	Total	Male	Female	Total
66.7%	70.0%	68.5%	76.7%	83.4%	80.0%

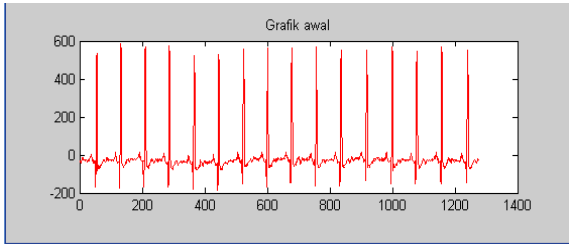
Conclusion:

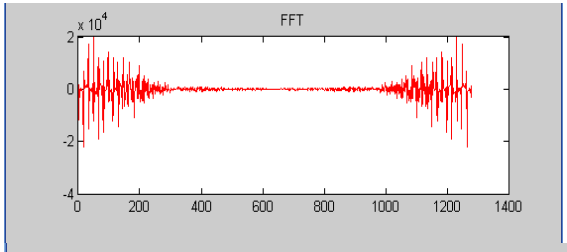
In this case, it is shown that the Haar wavelet analysis gave much better result compared to the Fourier analysis.

Biomedical Application

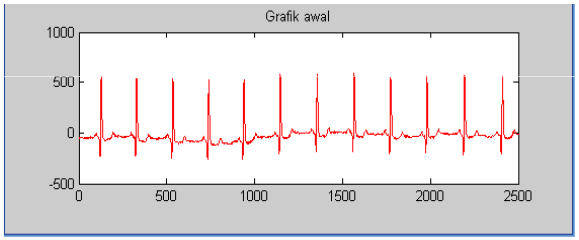
ECG Analysis and Arrythmia

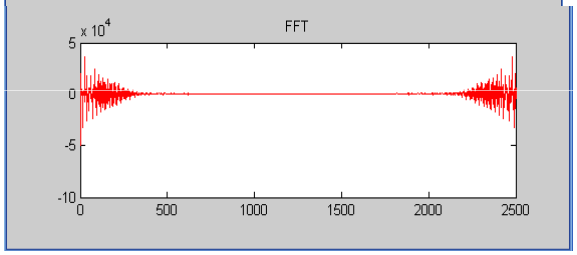
(Sumber: Asep Insani, 2010)



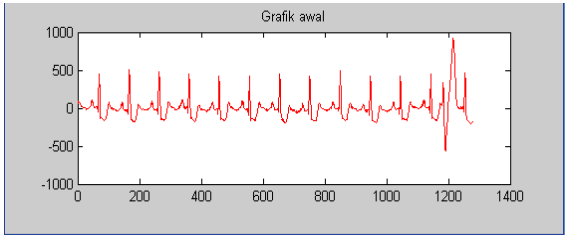


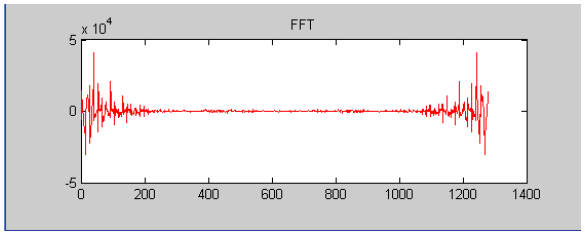
Normal



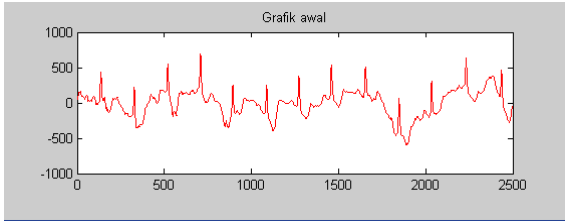


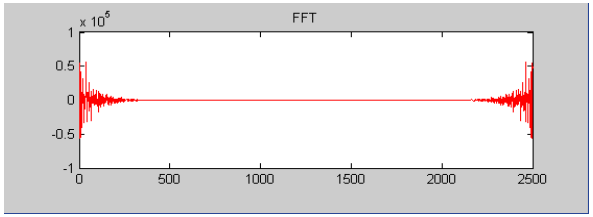
Bradycardia





Tachycardia





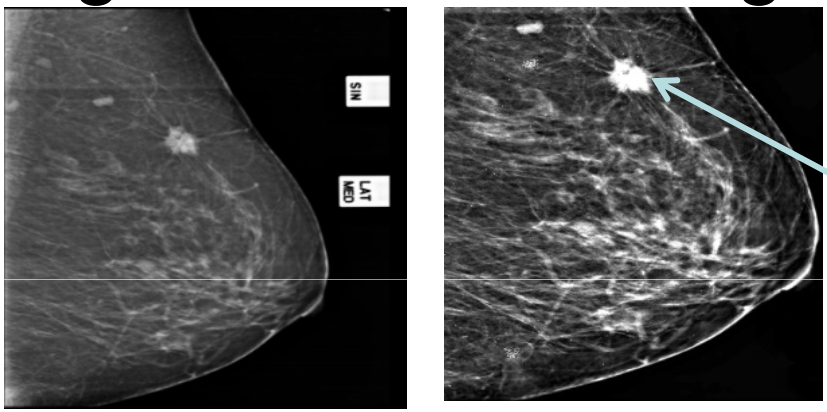
Sudden Cardiac Death

ECG Signal

Fourier Transform Spectrum

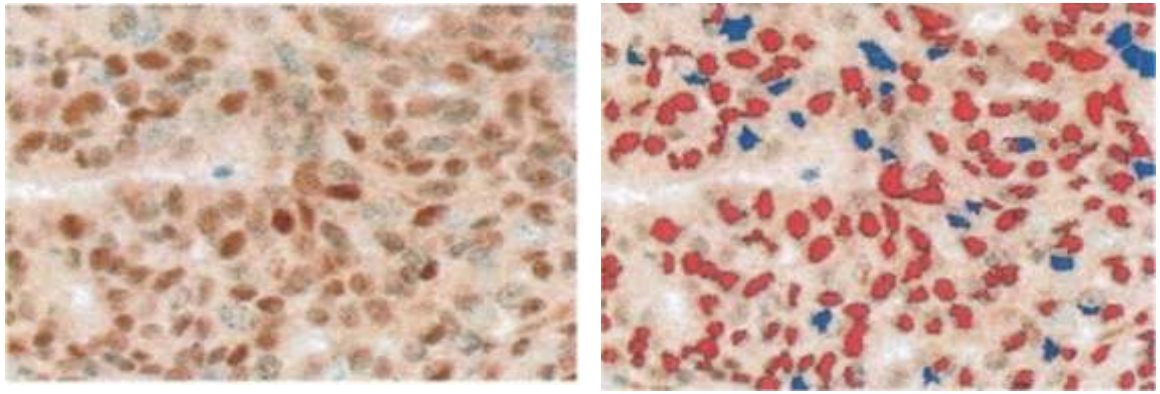
Multimodal Data for Breast Cancer Detection

- Segmented mammogram image



Region of abnormal cells
Putih = mass, microcalcification, cancer cell, saluran air susu
(Source: Herwanto, 2012)

- Segmented imunohistokimia image



Segmentasi terhadap model warna Hue-Saturation-Value
Total Positive cells (red) = 157
Total Negative cell (blue) = 25
(Source: L. Ma'luf, 2012)

Remote Sensing Classification
(An Example of using Multimodal Data)

(Source: A. Murni, A.K. Jain, and J. Rais, A Framework for Multidate Multisensor Image Interpretation, *Proceedings of IEEE International Geoscience and Remote Sensing Symposium (IGARSS'96),* Lincoln, Nebraska, pp. 1851-1854, IEEE Catalog Number 96CH35875, ISBN 0 7803 3068 4, Library of Congress Number 95-80706, 1996)

Outline

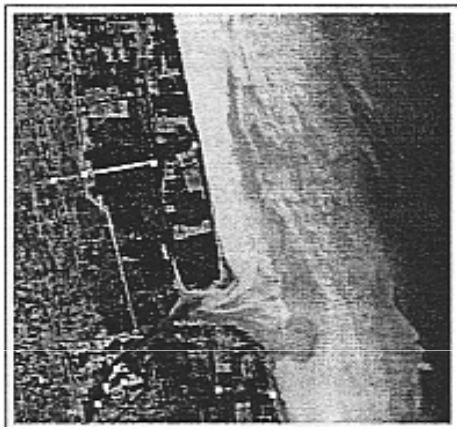
- Background
- Multisensor Optical and SAR Sensor Data Fusion for Land Cover Classification
- Multisensor Optical and SAR Sensor Data Fusion for Cloud Cover Elimination
- Conclusion

Background

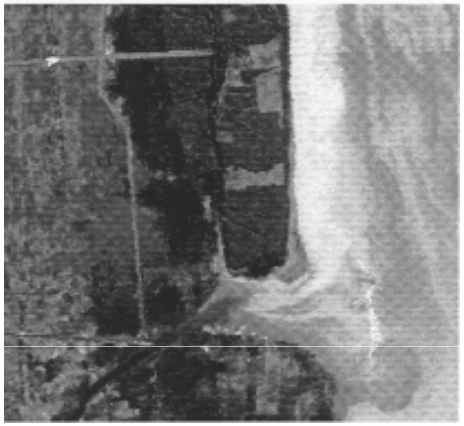
- Optical remote sensing images are **more reliable** for land cover identification. The problem is that sometimes **covered by clouds**.
- Synthetic Aperture Radar (SAR) image has speckle noise and geometric distortion and is **less reliable** for land cover identification, but **free of cloud**.
- This study has shown that multimodal data can give **better classification accuracy and can solve cloud cover problem**.

Multisensor Data Fusion for Land Cover Classification

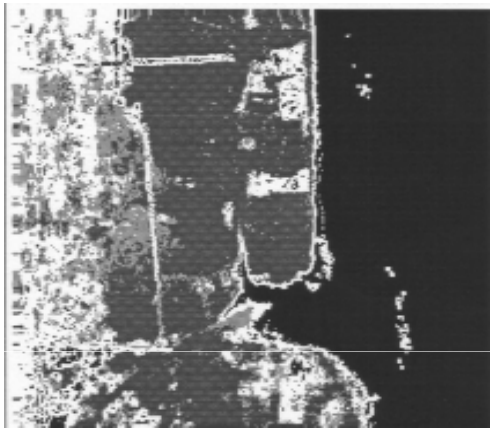
(Source: Original Image of Muara Sekampung, BAKOSURTANAL RI;
Processed Images, A. Murni, 1996)



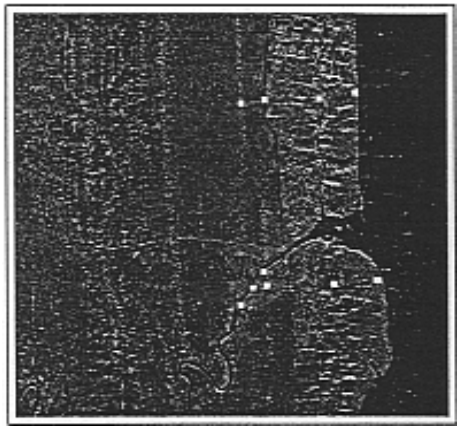
Optical Sensor Image



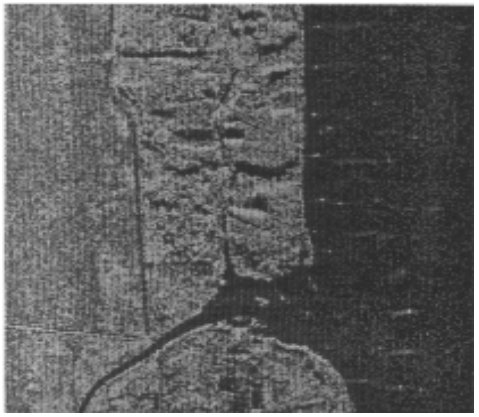
Registered Optical Sensor Image



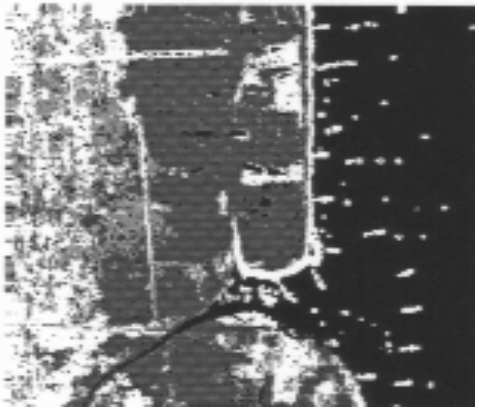
Classified Optical Sensor Image



SAR Sensor Image



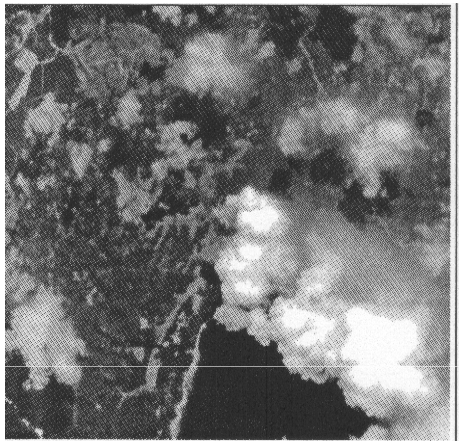
Registered SAR Sensor Image



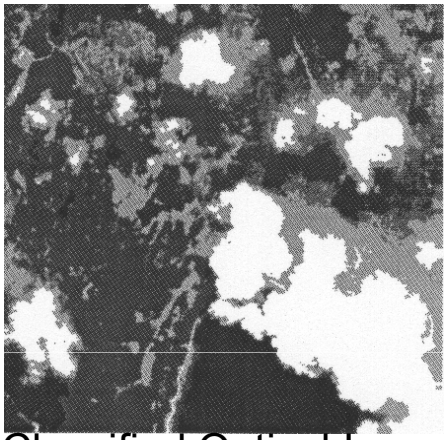
Classified Fused Optical and SAR

Multisensor Data Fusion for Land Cover Classification and Cloud Cover Elimination

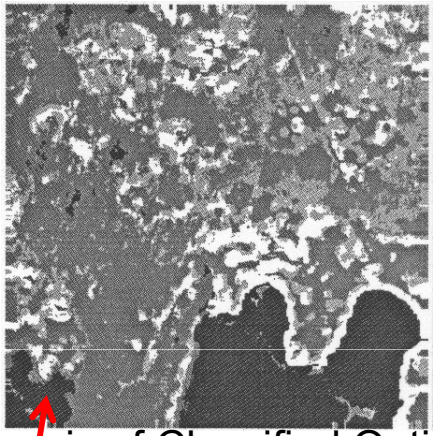
(Source: Original Image of Teluk Belantung, BAKOSURTANAL RI; Processed Images, A. Murni, 1996



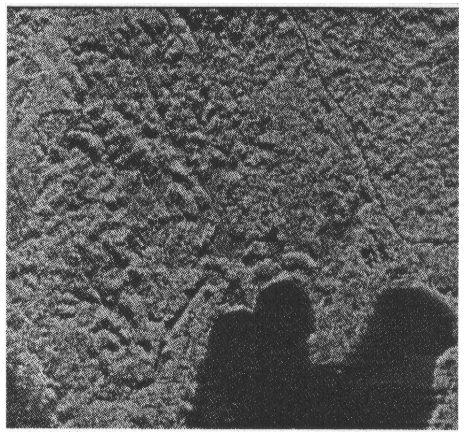
Registered Optical Image



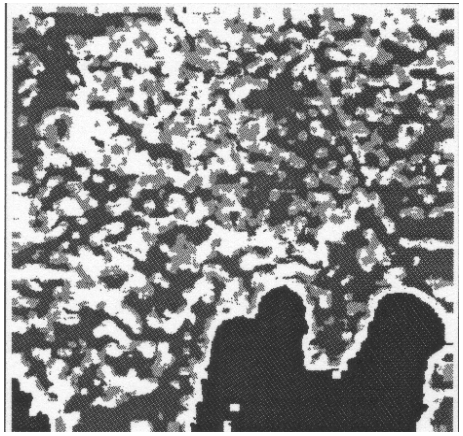
Classified Optical Image



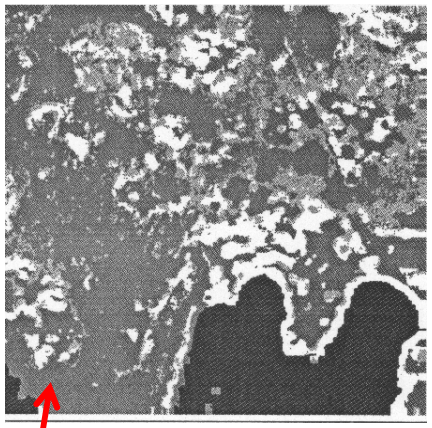
Mosaic of Classified Optical & SAR
Cloud shadow is classified as water



Registered SAR Image



Classified SAR Image



Classified Fused Optical and SAR
Cloud shadow is correctly classified as land

Classified Data Fusion of Optical and SAR Sensor Data

- **Classification results:**
  - Classified optical sensor image: water is **wrongly classified** as forest, the coastal shows **sedimentation**
  - Classified optical and SAR fusion: water is **correctly classified** as water, and the result shows **ships** near the coastal
  - Cloud cover regions are eliminated using **mosaic method** (there is a cloud shadow region which is classified as water)
  - Cloud cover regions are eliminated using decision based on SAR data and non-cloud cover regions are classified based on **joint posterior probability**
- **Classification of multisensor data fusion method:**
  - Compute the joint posterior probability using Maximum Likelihood Classifier of both sensor images
  - Pixel will be assigned to the class that give the maximum joint posterior probability

Fusion at Score Level

(Source: A.Murni *et al*., 1996)

- Multimodal data: Optical and SAR sensor data
- Multisource classification fusion (Benediktsson *et al.,* 1990)

$$F_i(X) = p(\omega_i) \prod_{s=1}^{n} \left(\frac{p(\omega_i|X_s)}{p(\omega_i)} \right)^{\gamma_s}$$

- Multitemporal Multisource classification fusion (Swain, 1992)

$$P(\nu_k, \omega_i|X_1, X_2) = \frac{P(\nu_k|X_1)P(\omega_i|X_2)P(\omega_i|\nu_k, \omega_i = \nu_k)}{P(\nu_k)}$$

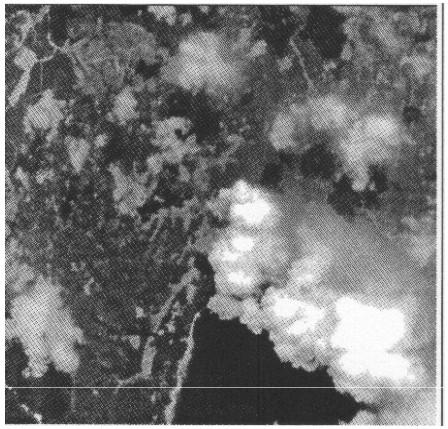
$$P(\nu_k, \omega_i|X_1, X_2) = \frac{P(\nu_k|X_1)P(\omega_i|X_2)P(\omega_i|\nu_k, \omega_i \neq \nu_k)}{1 - P(\nu_k)}$$

$P(\omega_i|\nu_k)$ is a transition probability

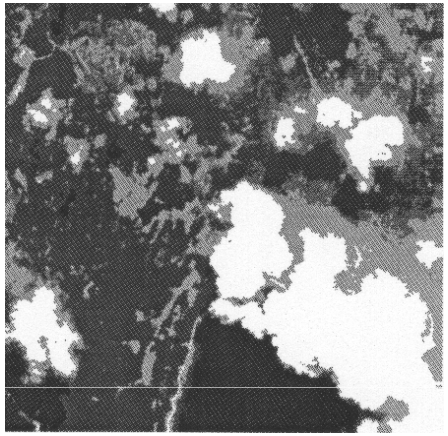
$$P(\omega_i|\nu_k, \omega_i = \nu_k) = 0.75 \quad P(\omega_i|\nu_k, \omega_i \neq \nu_k) = 0.25$$

Multisensor Data Fusion for Cloud Cover Elimination at Raw Data Level and Classified Level

(Source: Original Image of Teluk Belantung, BAKOSURTANAL RI;
Processed Images, A. Murni, 1996 and 2000; Rohmah and Murni, 1997 and 2001)

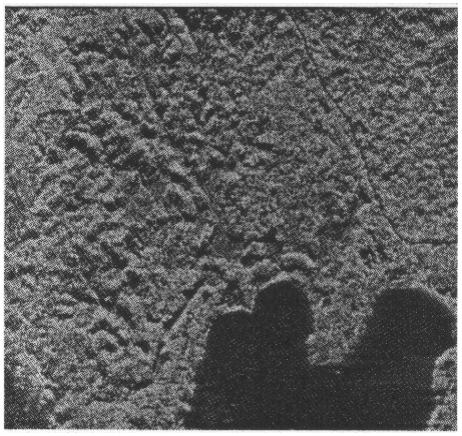


Registered Optical Image
Containing of Cloud

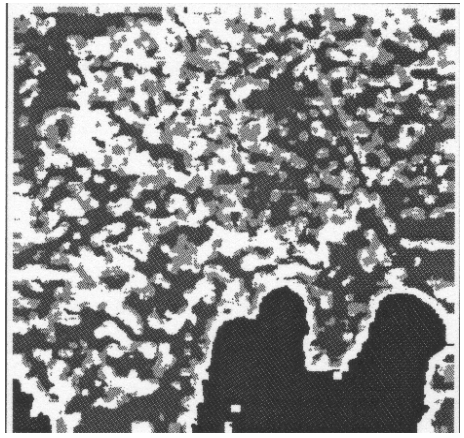


Classified Optical Image

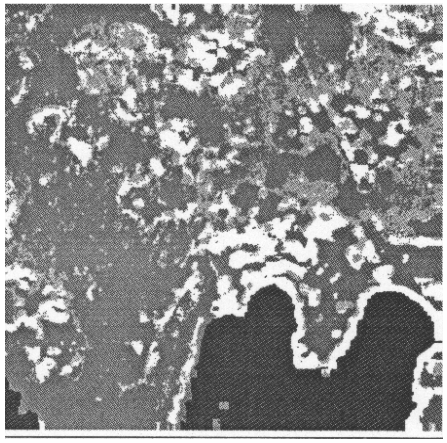
Restored Cloud Free
Raw Optical Image Data



Registered SAR Image



Classified SAR Image



Restored Cloud Free
Classified Optical Image Data

Multisensor Data Fusion for Cloud Cover Elimination

- Multisensor Data Fusion at Classified Level
  - Optical and SAR data are registered
  - Optical and SAR images are classified
  - Cloud cover regions are eliminated using **mosaic method** (there is a cloud shadow region which is classified as water)
  - Cloud cover regions are eliminated using decision based on SAR data and non-cloud cover regions are classified based on **joint posterior probability**
- Multisensor Data Fusion at Raw Data Level
  - Optical and SAR data are registered
  - Optical and SAR images are classified
  - Cloud cover regions at raw optical data is replaced by intensity value of object intensity distribution using **dithering technique** related to the corresponding object in classified SAR data

Results

- Multimodal Optical and SAR sensor data has shown to be **complementary** and could **improve the image classification** results.
- Multimodal Optical and SAR data has also shown its ability to solve cloud cover problem in optical sensor image both in **classified level and in raw data level**.

The End of Presentation