Pengantar Interpretasi dan Pengolahan Citra (Bagian 2 – Update 2022)

IF4073 Interpretasi dan Pengolahan Citra

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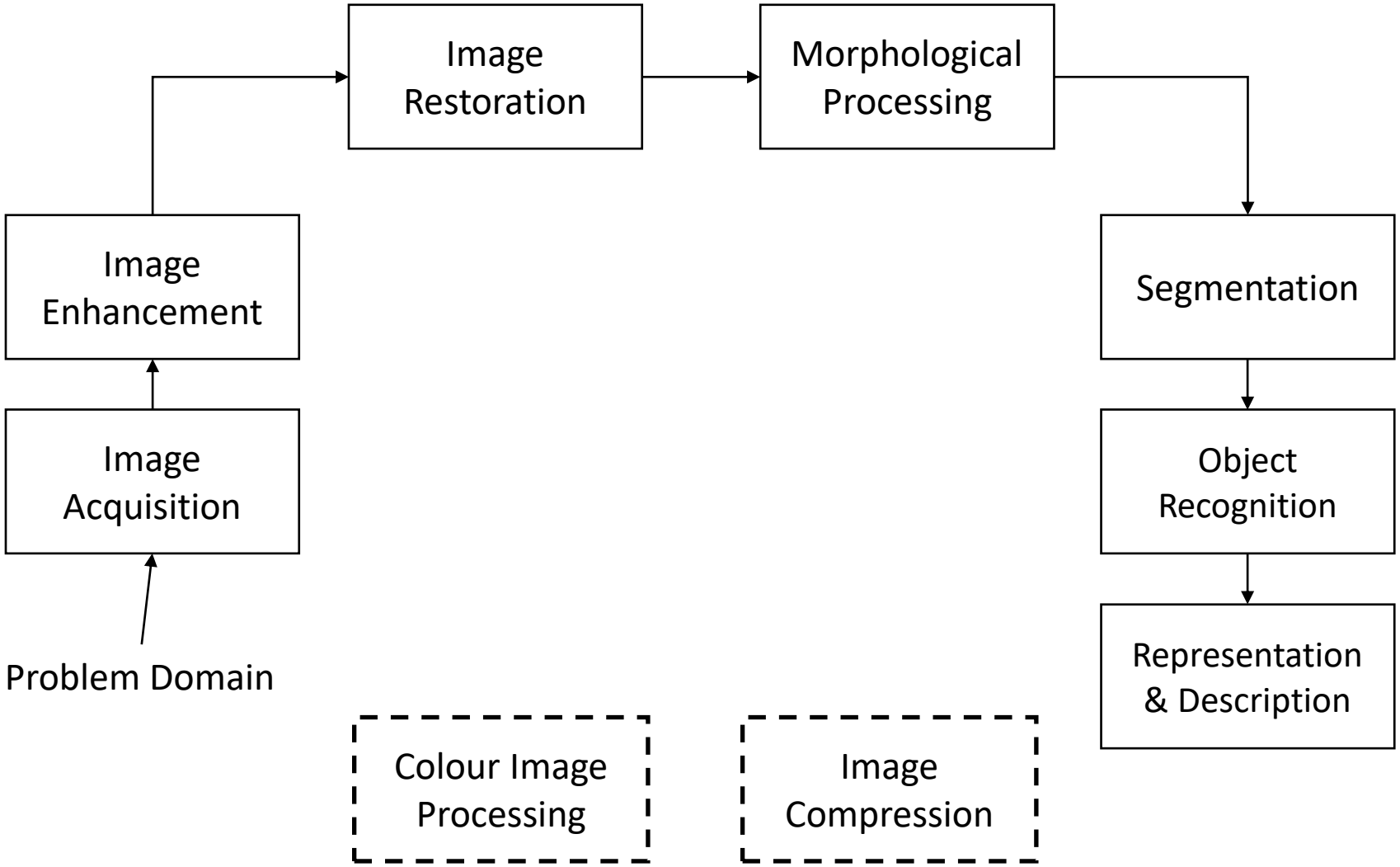
Program Studi Teknik Informatika
Sekolah Teknik Elektro dan Informatika
Institut Teknologi Bandung
2022

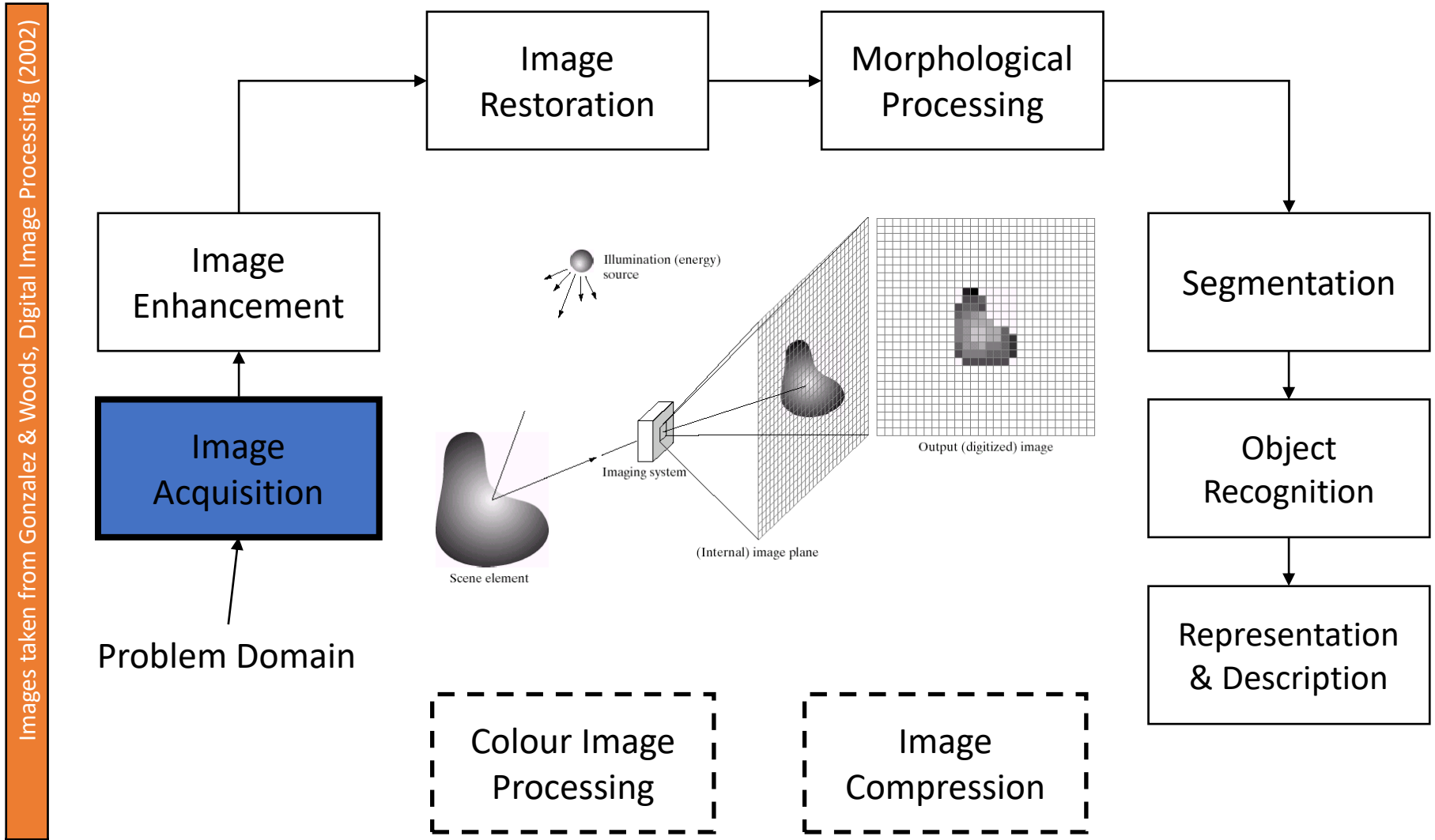
Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010

Key Stages in Digital Image Processing



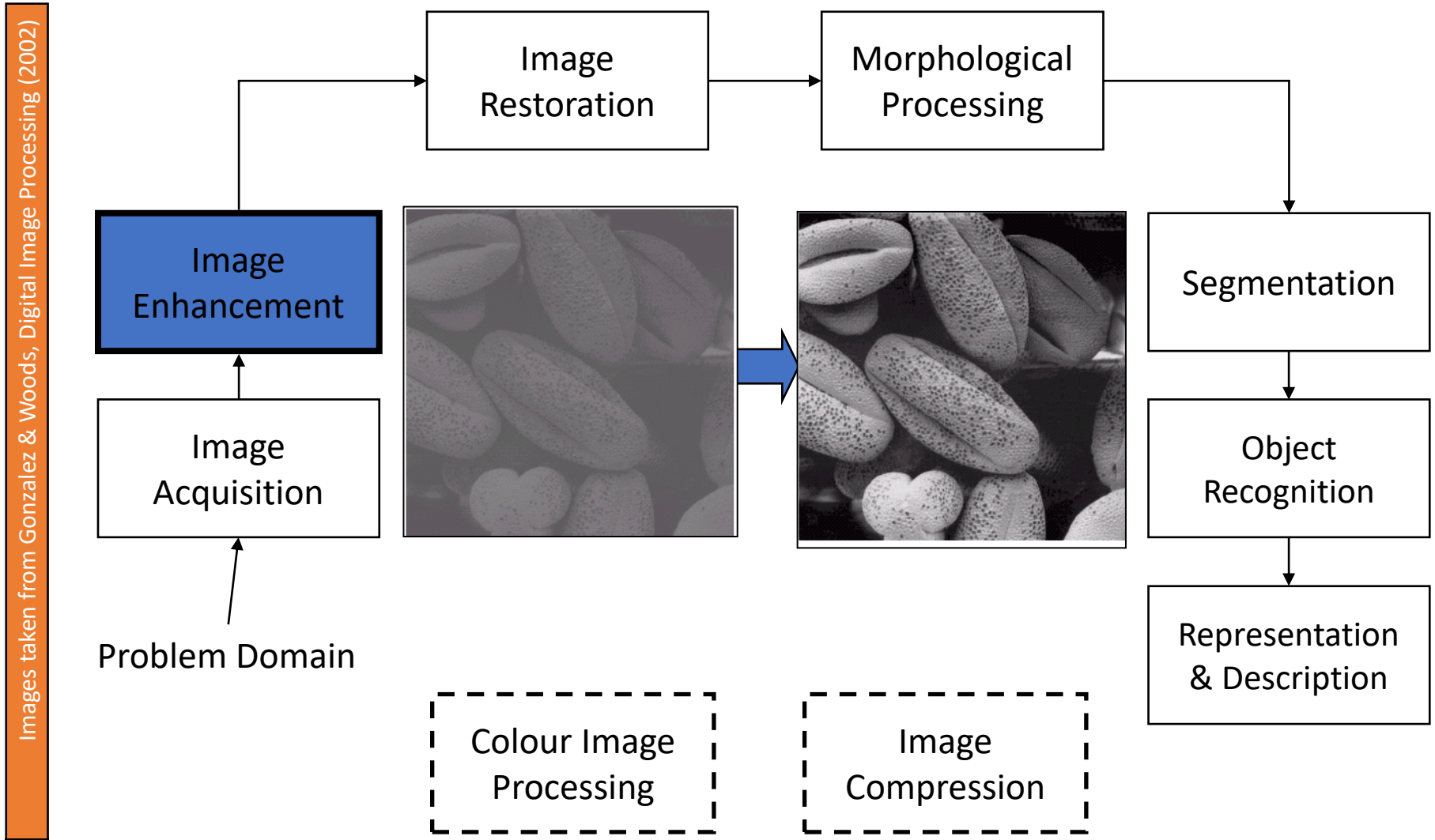
Key Stages in Digital Image Processing: Image Aquisition

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



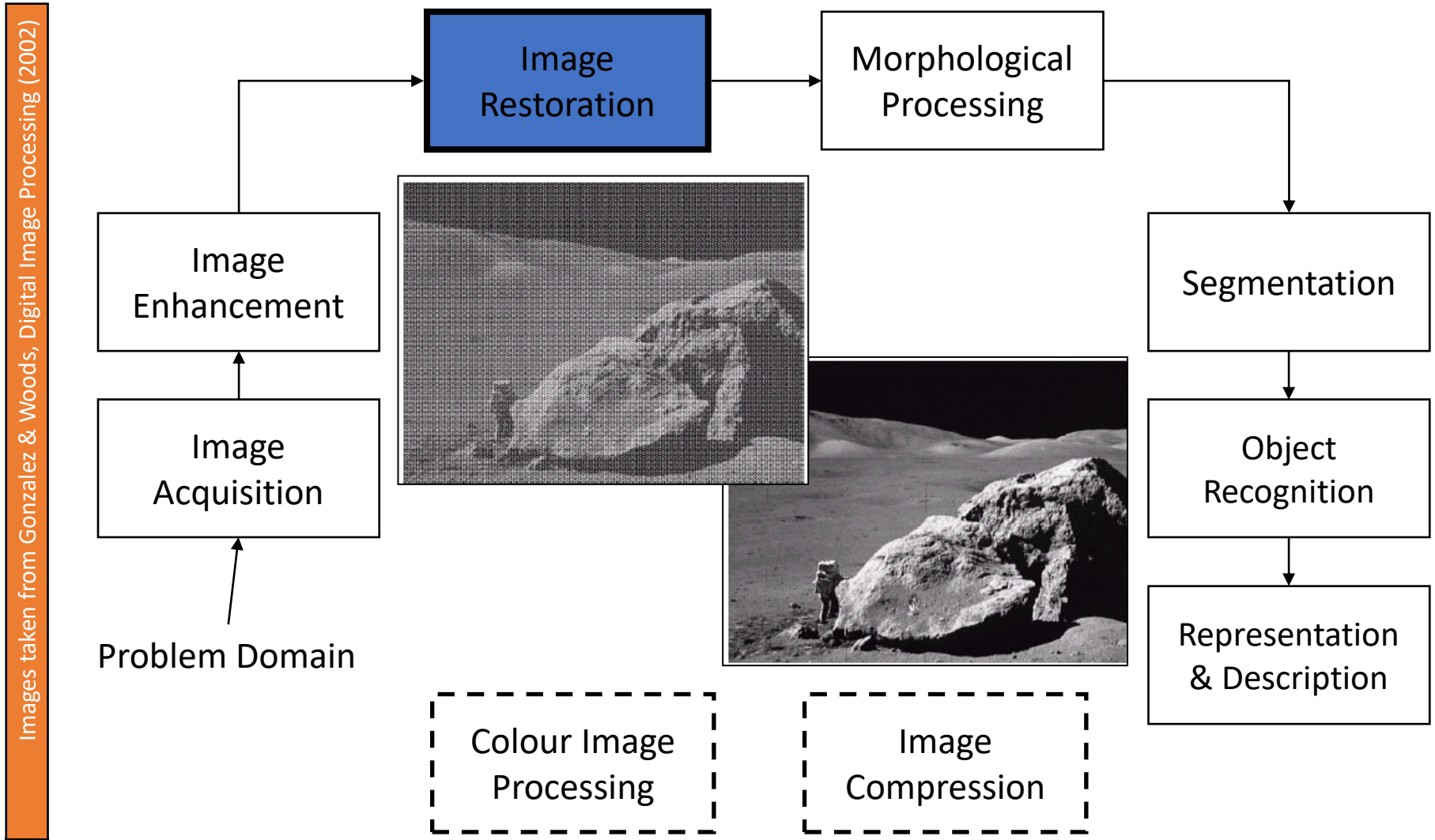
Key Stages in Digital Image Processing: Image Enhancement

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



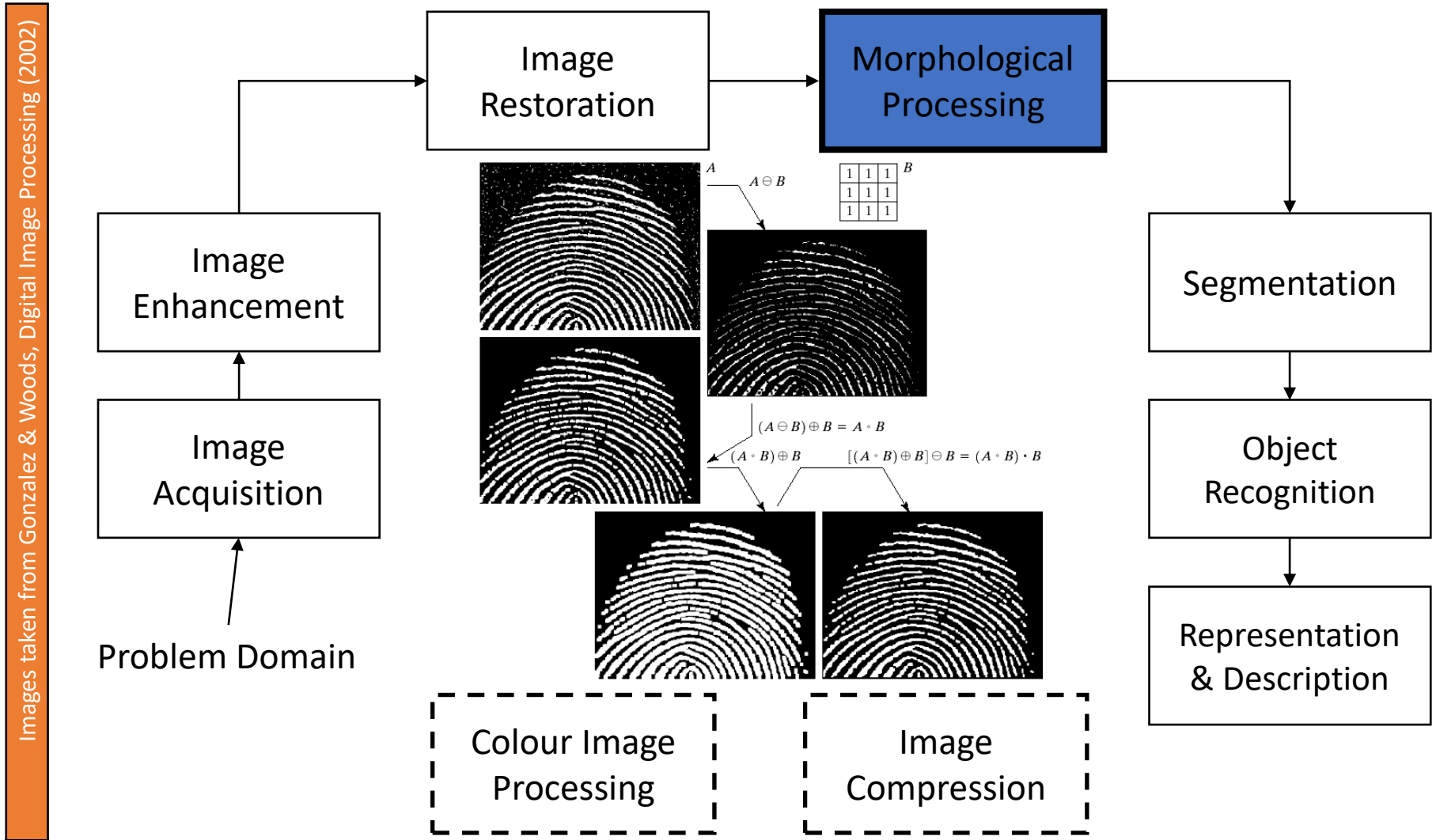
Key Stages in Digital Image Processing: Image Restoration

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



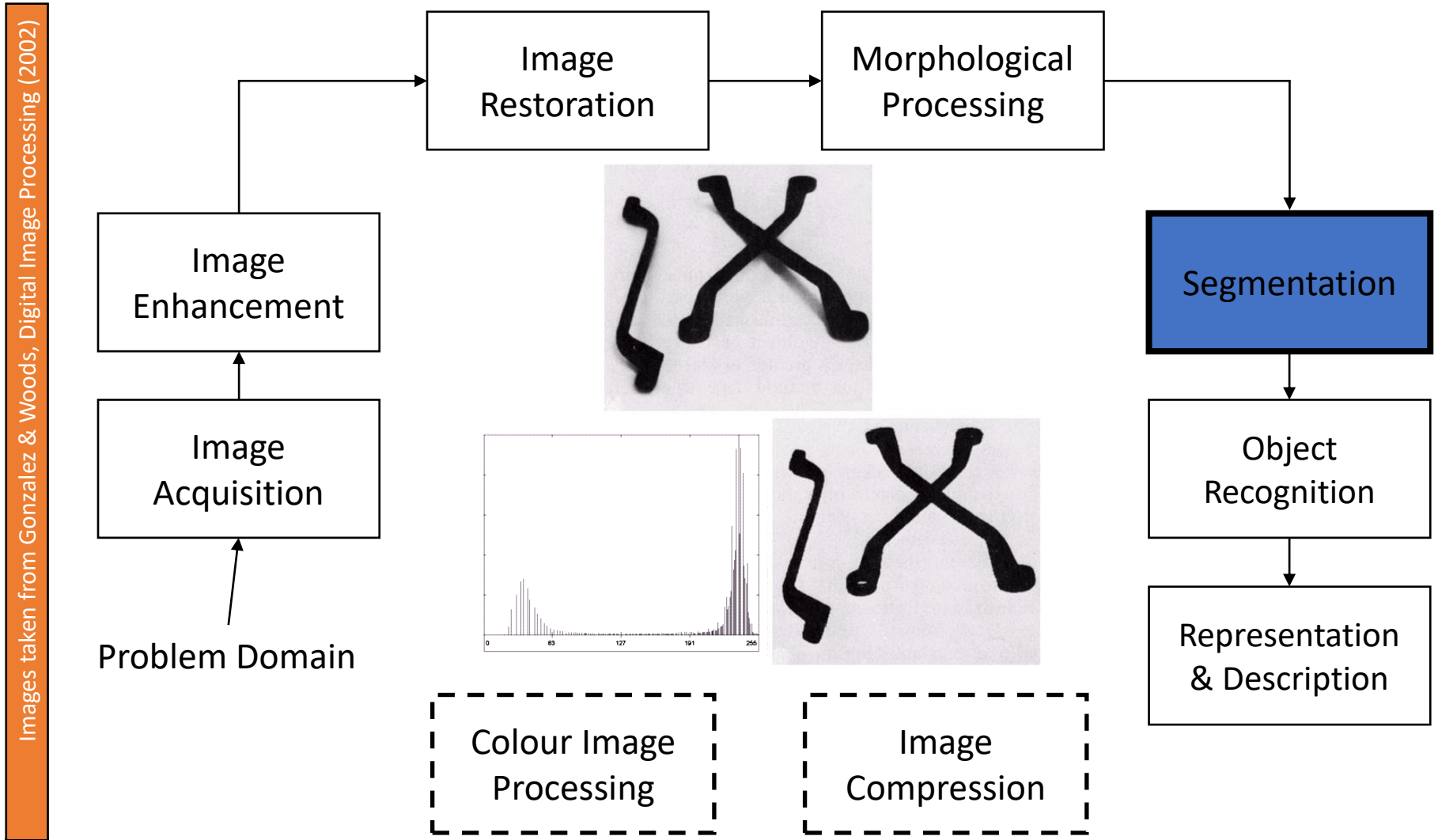
Key Stages in Digital Image Processing: Morphological Processing

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



Key Stages in Digital Image Processing: Segmentation

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



Key Stages in Digital Image Processing: Object Recognition

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010

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

Image Restoration

Morphological Processing

Segmentation

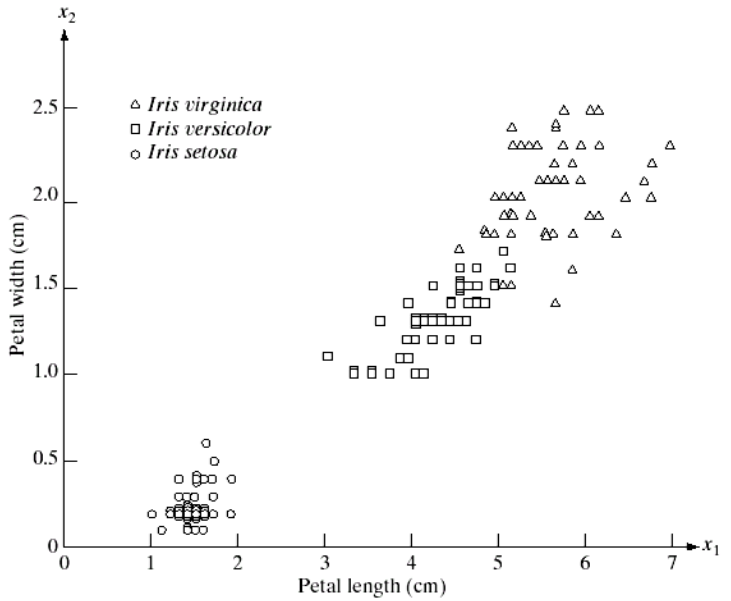
Object Recognition

Representation & Description

Image Enhancement

Image Acquisition

Problem Domain

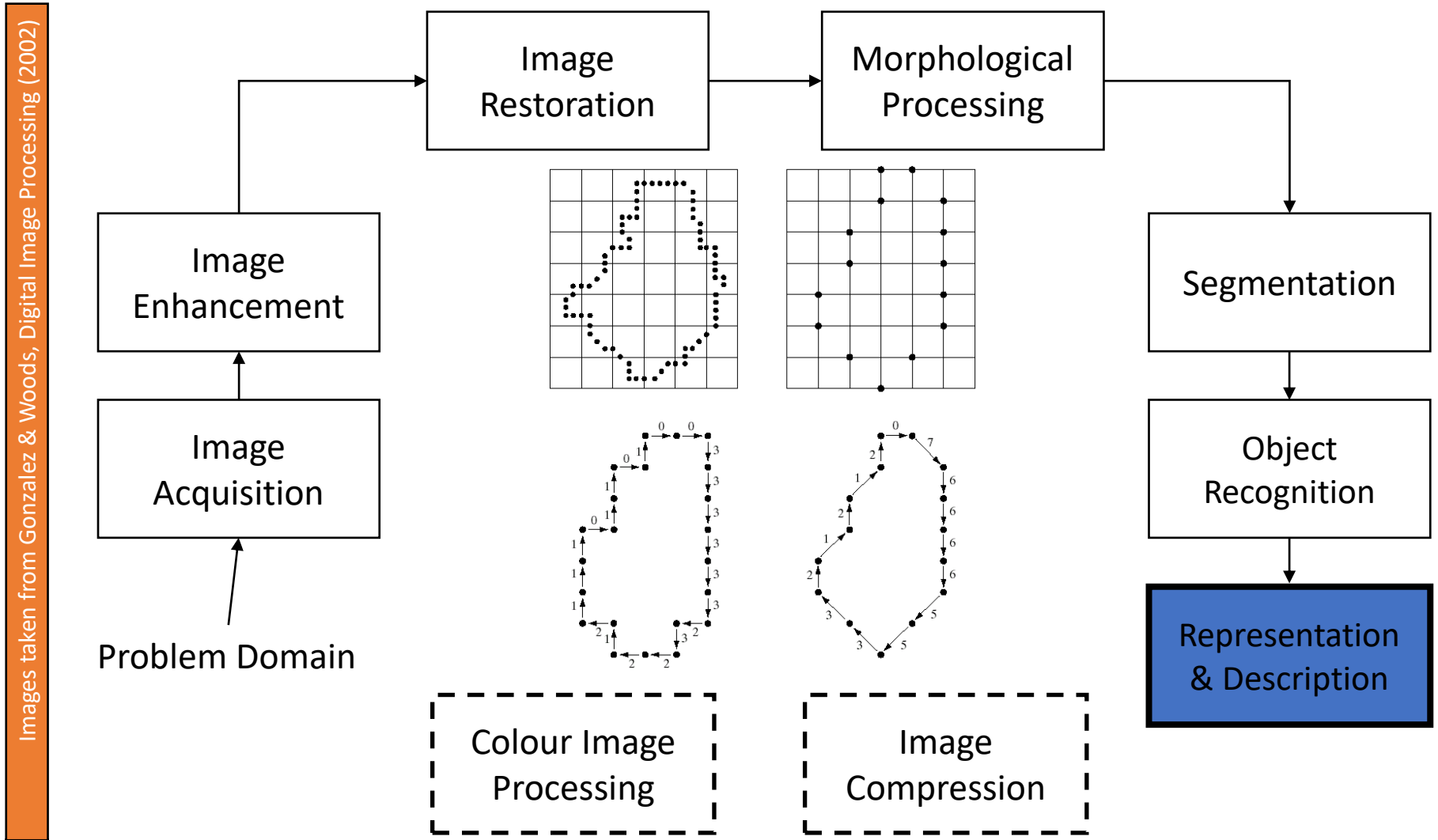


Colour Image Processing

Image Compression

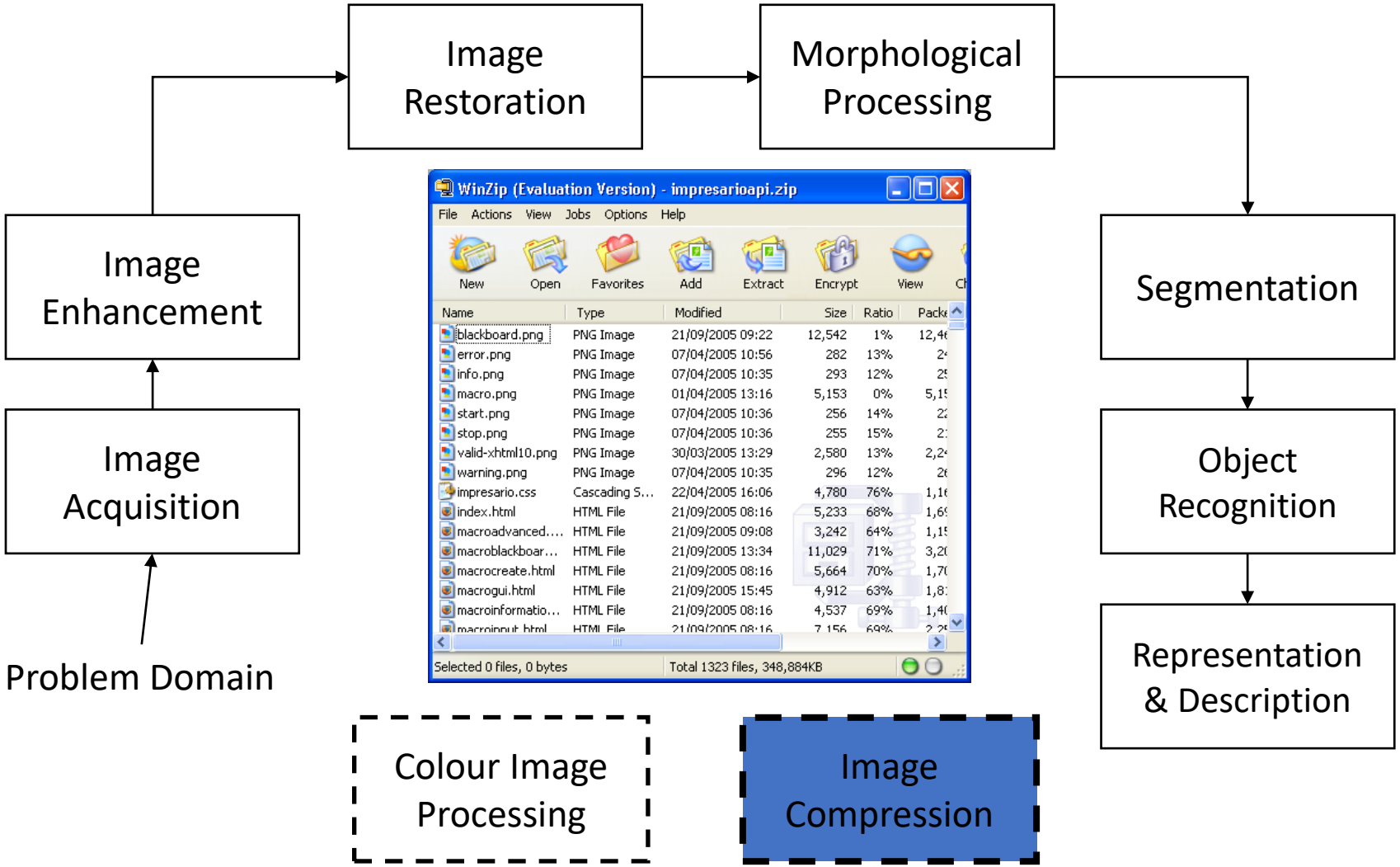
Key Stages in Digital Image Processing: Representation & Description

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



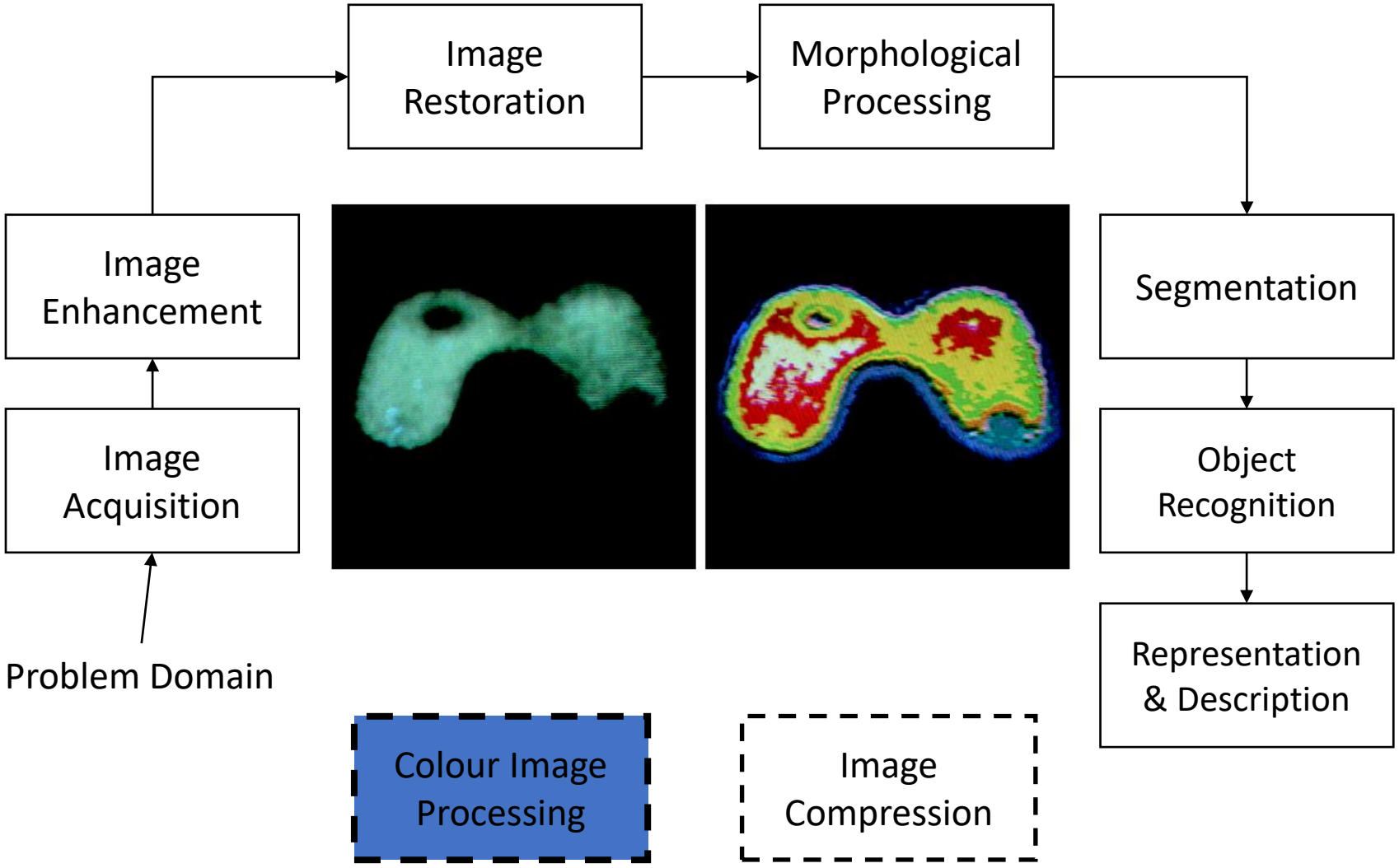
Key Stages in Digital Image Processing: Image Compression

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



Key Stages in Digital Image Processing: Colour Image Processing

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010



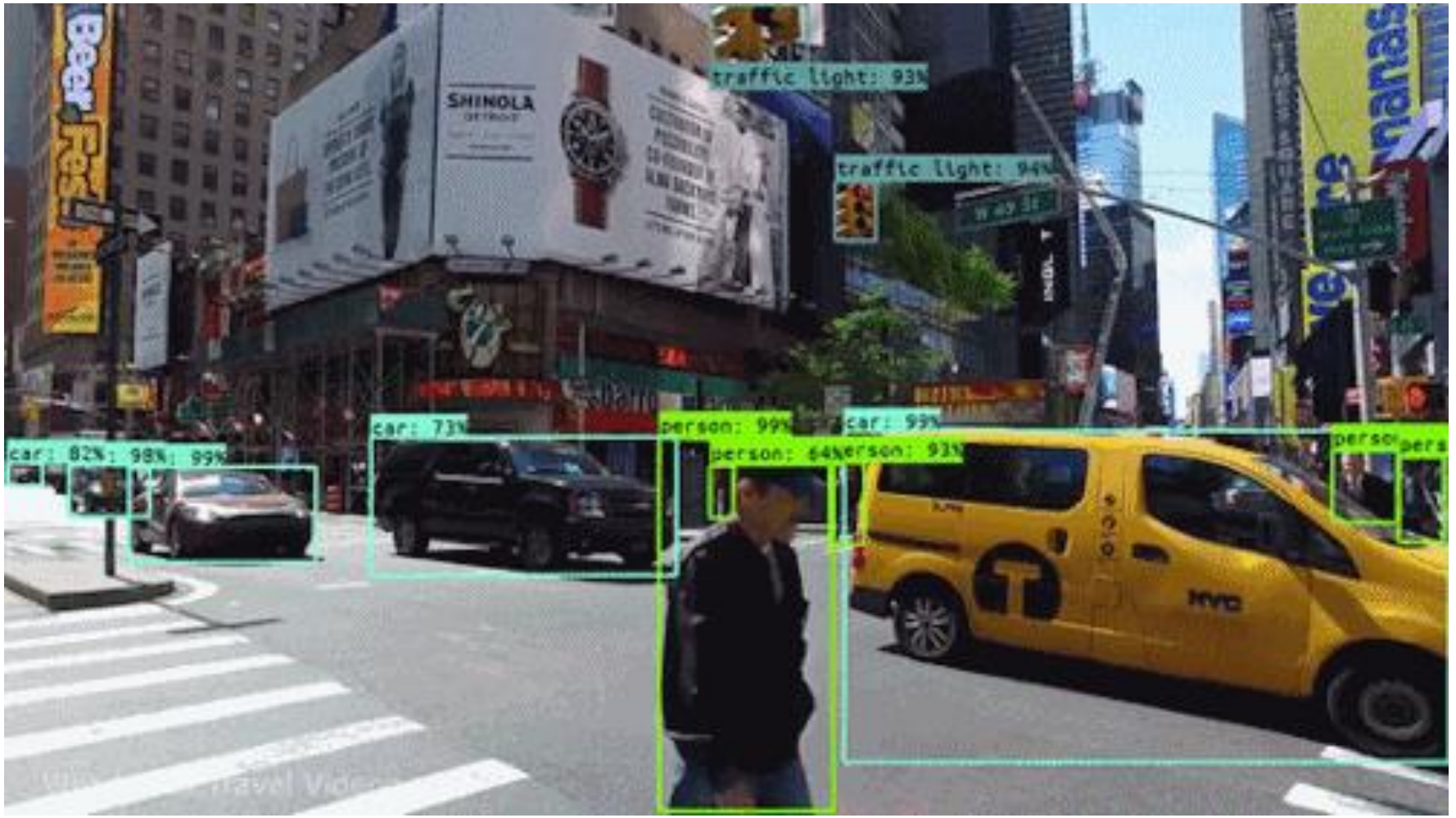
Computer Vision

- *Computer vision* merupakan proses otomatis yang mengintegrasikan sejumlah besar proses untuk persepsi visual, seperti akuisisi citra, pengolahan citra, klasifikasi, pengenalan (*recognition*), dan membuat keputusan.

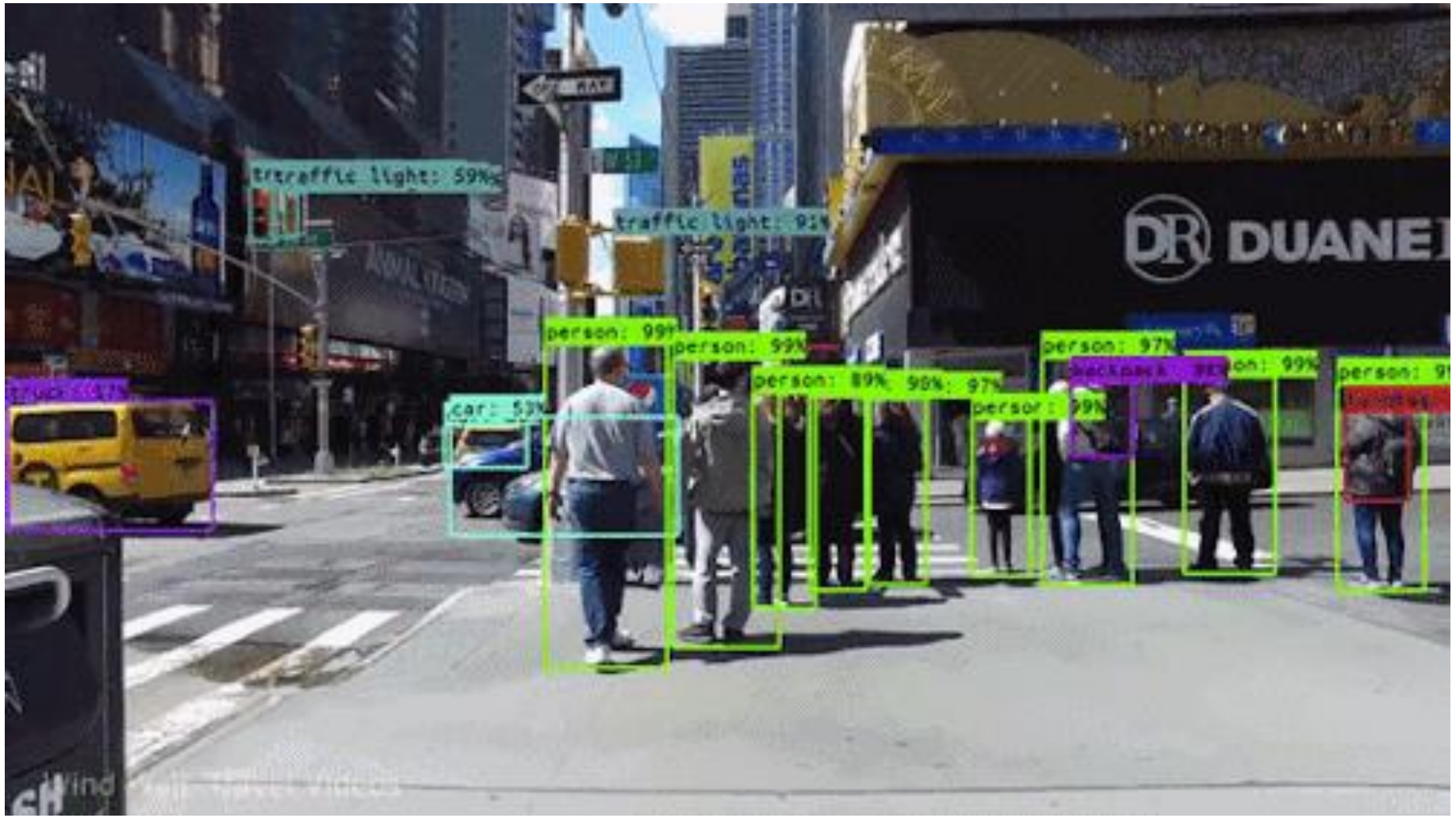
- *Computer vision* terdiri dari teknik-teknik untuk mengestimasi ciri-ciri objek di dalam citra, pengukuran ciri yang berkaitan dengan geometri objek, dan menginterpretasi informasi geometri tersebut.

- *Vision = Geometry + Measurement + Interpretation*

Computer Vision



Sumber: https://towardsdatascience.com/what-even-is-computer-vision-531e4f07d7d0



Sumber: https://towardsdatascience.com/everything-you-ever-wanted-to-know-about-computer-vision-heres-a-look-why-it-s-so-awesome-e8a58dfb641e

- Pada hakikatnya, *computer vision* mencoba meniru cara kerja sistem visual manusia (*human vision*).

- *Human vision* sesungguhnya sangat kompleks. Manusia melihat objek dengan indera penglihatan (mata), lalu citra objek diteruskan ke otak untuk diinterpretasi sehingga manusia mengerti objek apa yang tampak dalam pandangan matanya.

- Hasil interpretasi ini mungkin digunakan untuk pengambilan keputusan (misalnya menghindar kalau melihat mobil melaju di depan).

- Proses-proses di dalam *computer vision* dapat dibagi menjadi tiga aktivitas:
  1. Memperoleh atau mengakuisisi citra digital.
  2. Melakukan teknik komputasi untuk memperoses atau memodifikasi data citra (operasi-operasi pengolahan citra).
  3. Menganalisis dan menginterpretasi citra dan menggunakan hasil pemrosesan untuk tujuan tertentu, misalnya memandu robot, mengontrol peralatan, memantau proses manufaktur, dan lain-lain.

- Proses-proses di dalam *computer vision* dalam hirarkhi sebagai berikut :

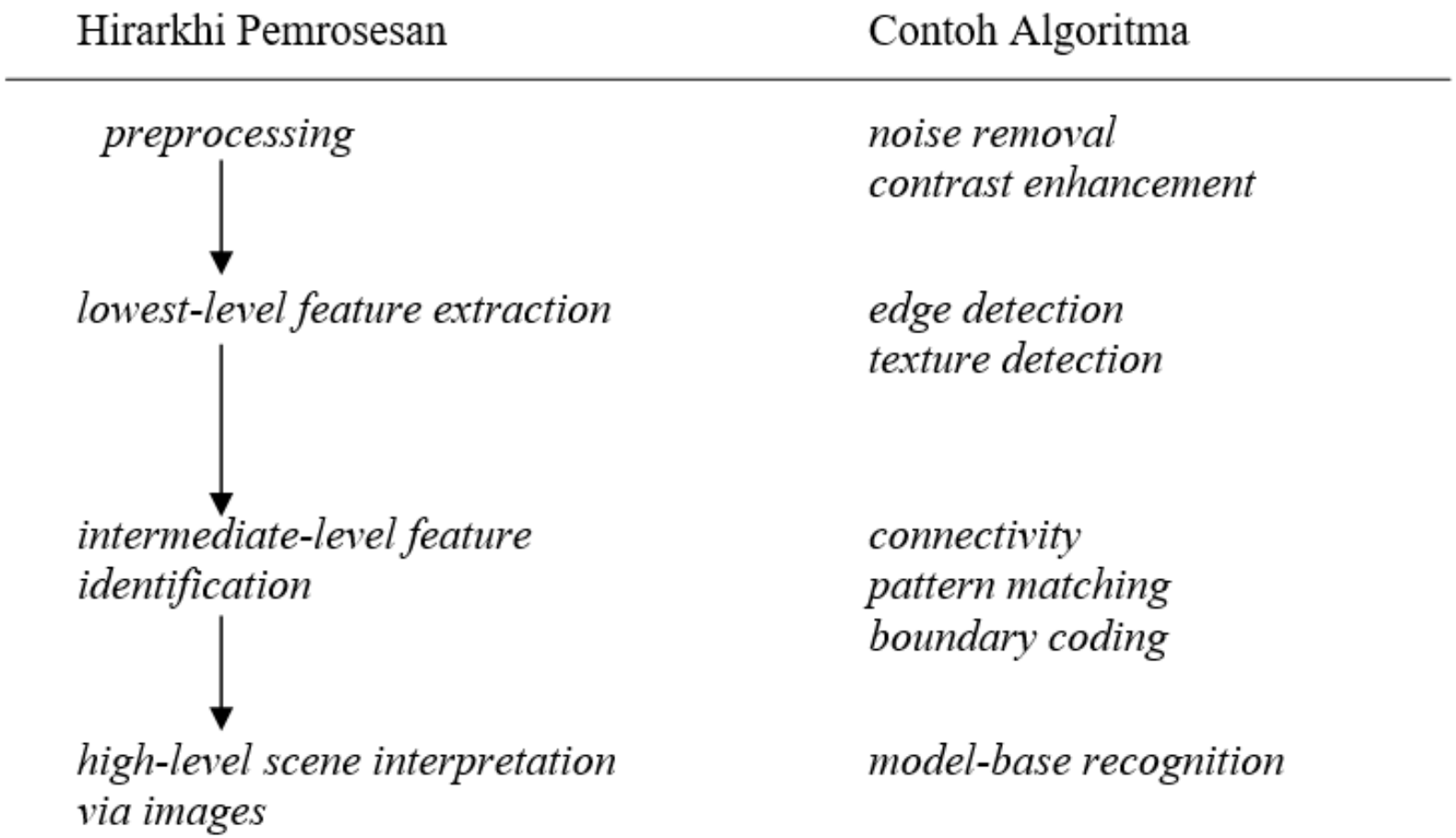
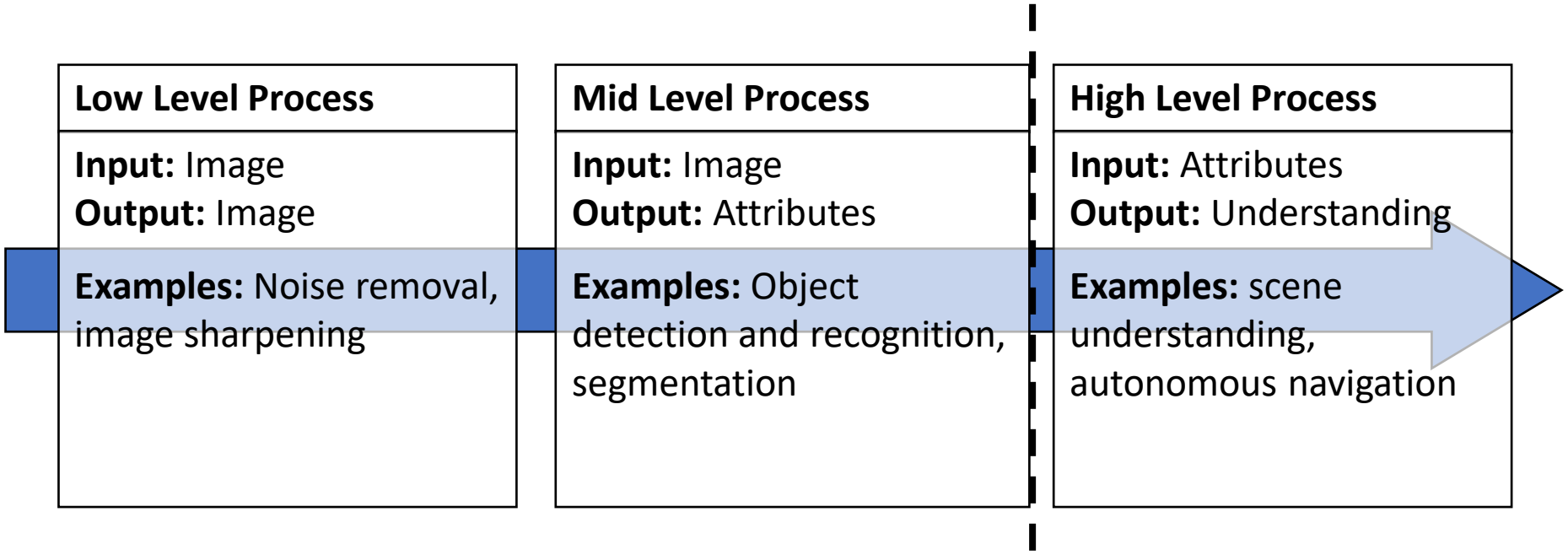


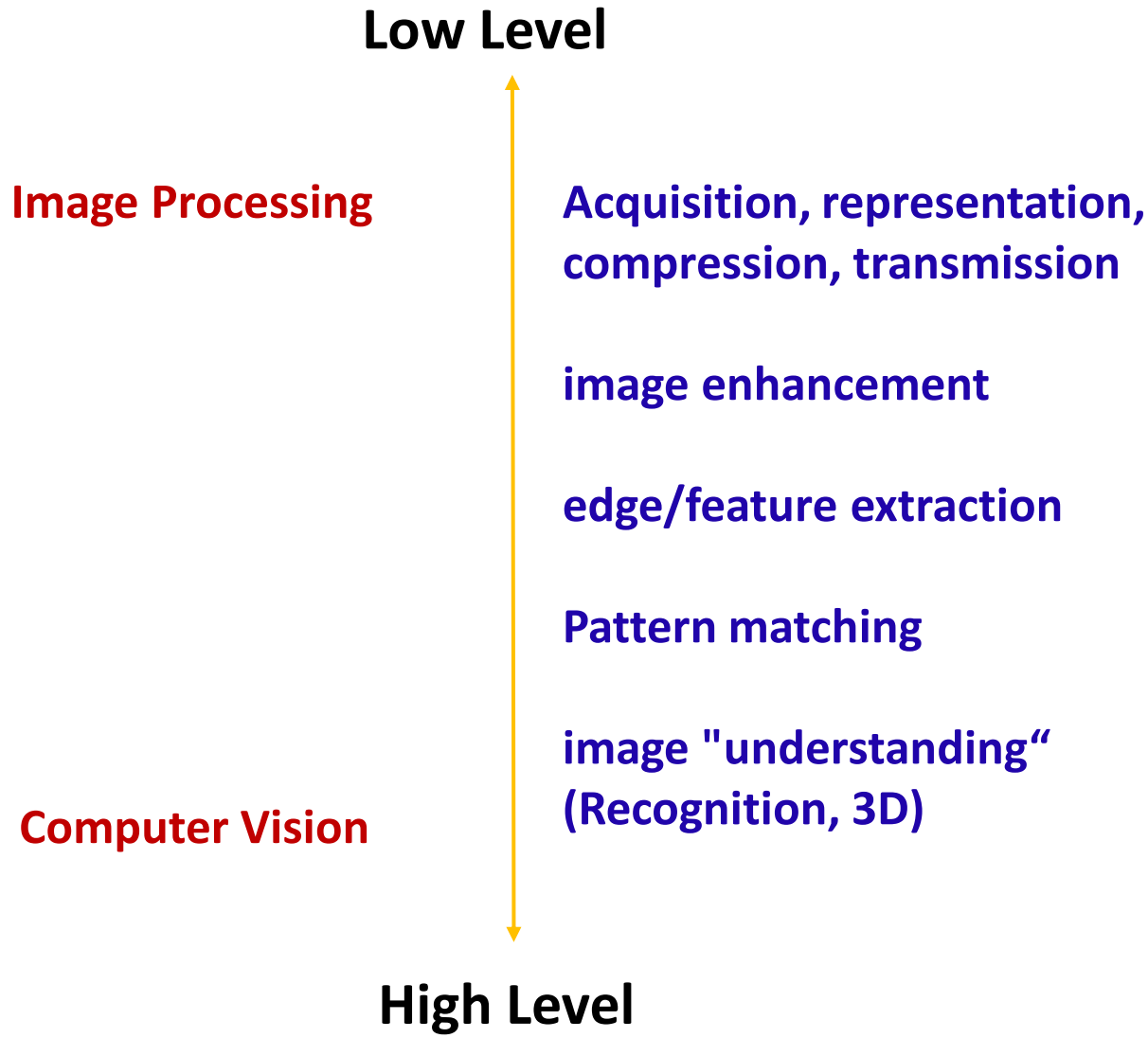
Image Processing → Computer Vision

• Rangkaian kesatuan dari *image processing* ke *computer vision* dapat dipecah menjadi *low-*, *mid-* dan *high-level processes*



Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010

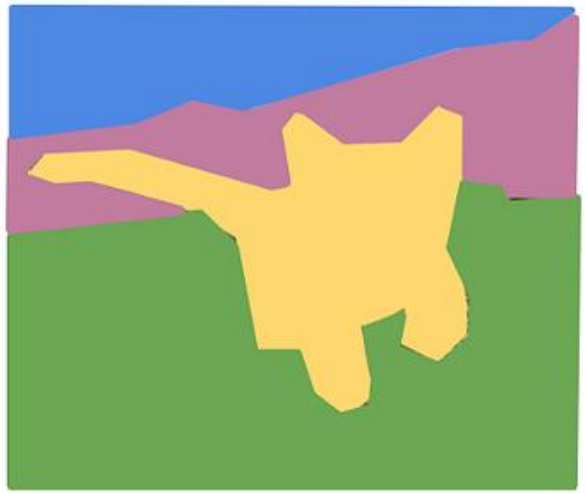
Image Processing v.s. Computer Vision



Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010


Image Acquisition
License Plate Extraction
License Plate Segmentation
Character Recognition
JRE·366
JRE366
JRE366

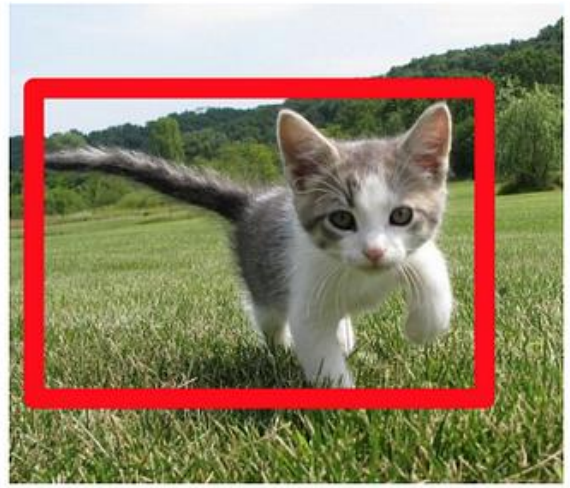
Semantic Segmentation



GRASS, CAT, TREE, SKY

No objects, just pixels

Classification + Localization



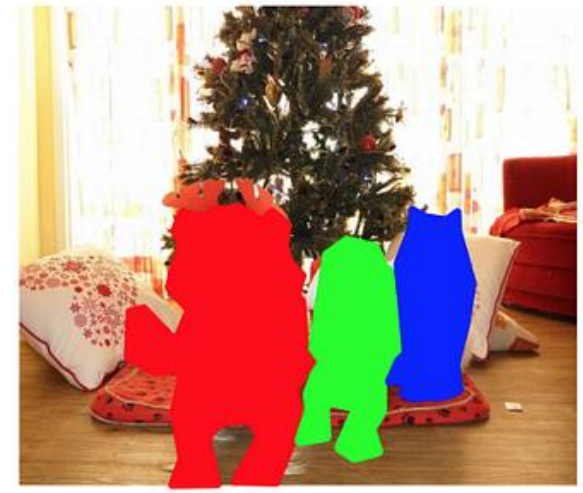
CAT

Single Object

Object Detection

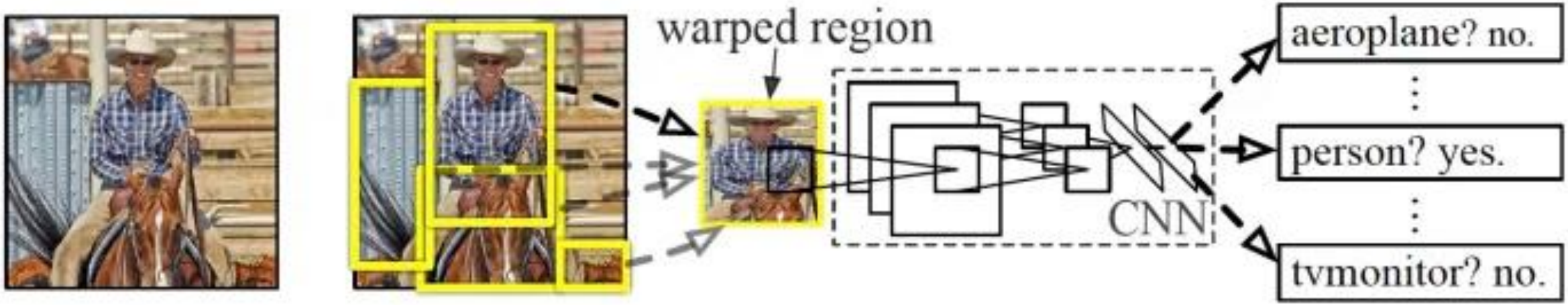
DOG, DOG, CAT

Instance Segmentation



DOG, DOG, CAT

Multiple Object



1. Input image

2. Extract region proposals (~2k)

3. Compute CNN features

4. Classify regions

Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Image editing …*

1. *Cropping*

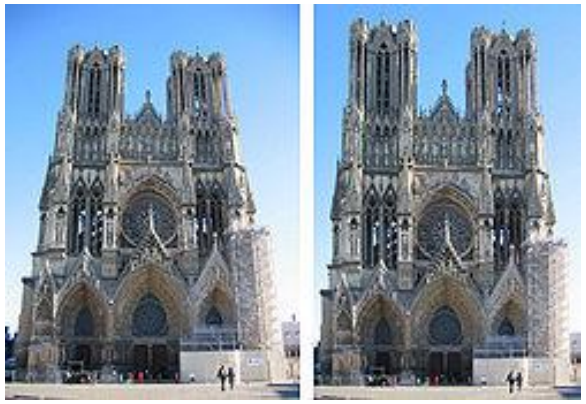
2. Removal of unwanted element

Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Image editing …*

3. **Selective color change**

4. **Perspective correction and distortion**



Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Image editing …*

5. **Selecting and merging of images**

Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Image editing*

6. Special effects

Aplikasi Pengolahan Citra (dan *Computer Vision*)

Image Inpainting 1

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010

Aplikasi Pengolahan Citra (dan *Computer Vision*)

Image Inpainting 2

Images of Venus taken by the Russian lander Ventra-10 in 1975

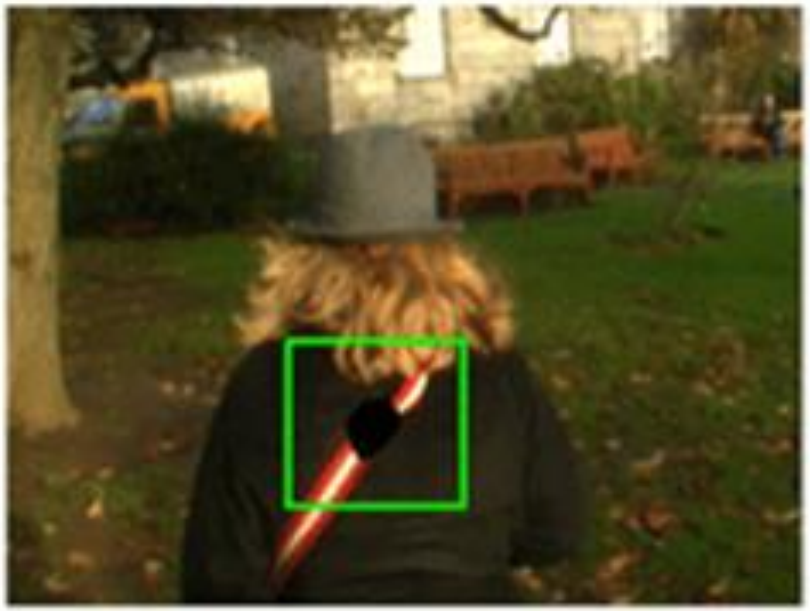
Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010

Aplikasi Pengolahan Citra (dan *Computer Vision*)

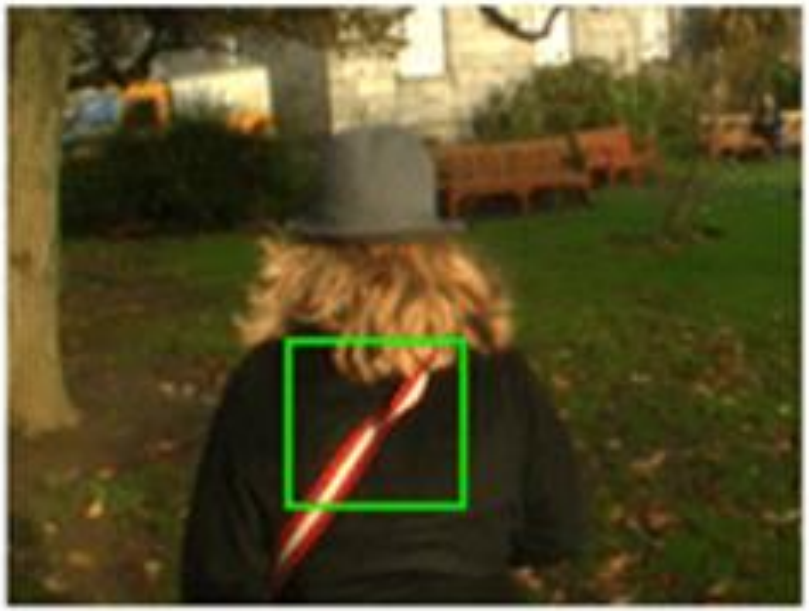
Video Inpainting

Y. Wexler, E. Shechtman and M. Irani 2004

Sumber: Yacov Hel-Or, *Image Processing*, Spring 2010

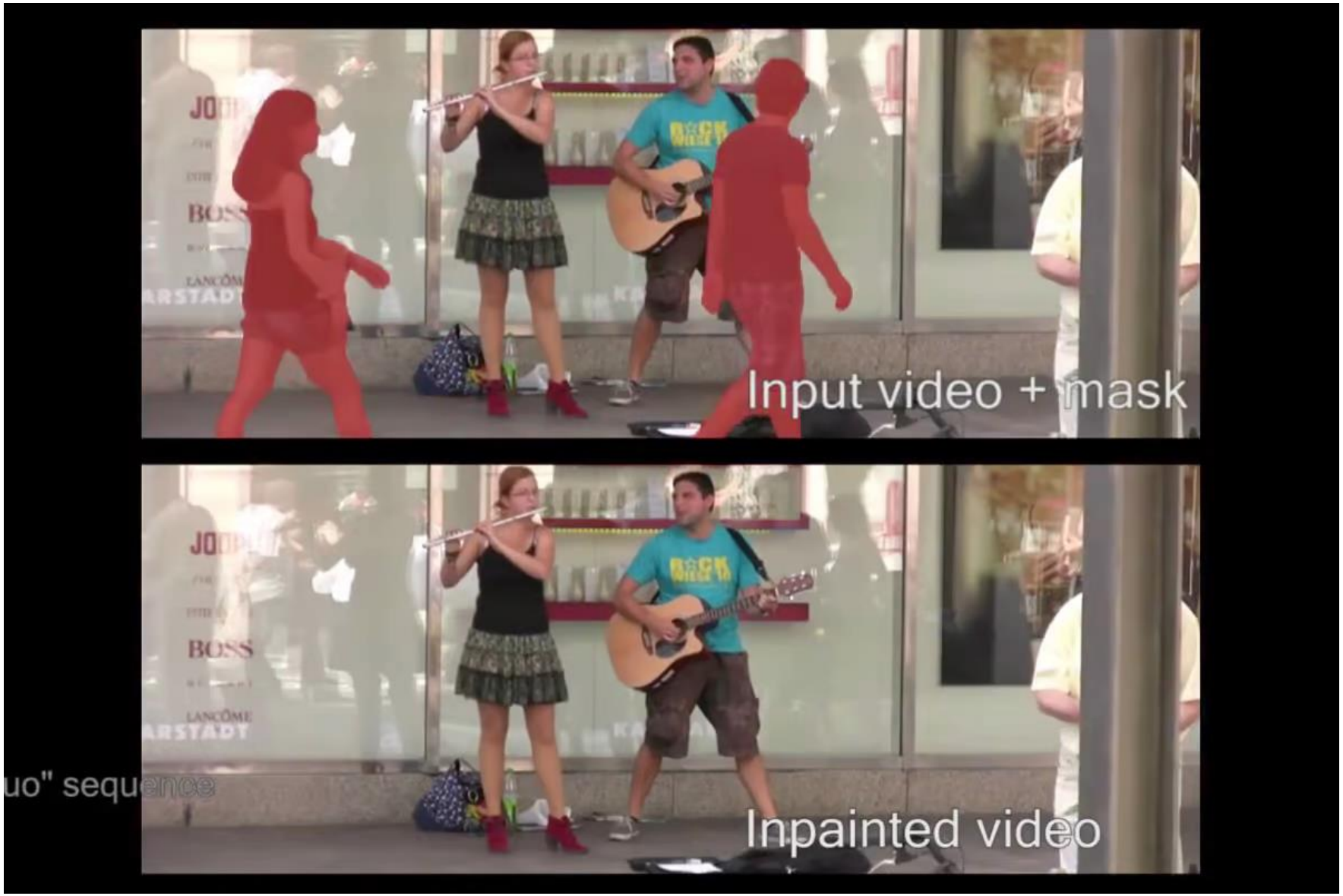


Degraded image with hole



Reconstruction

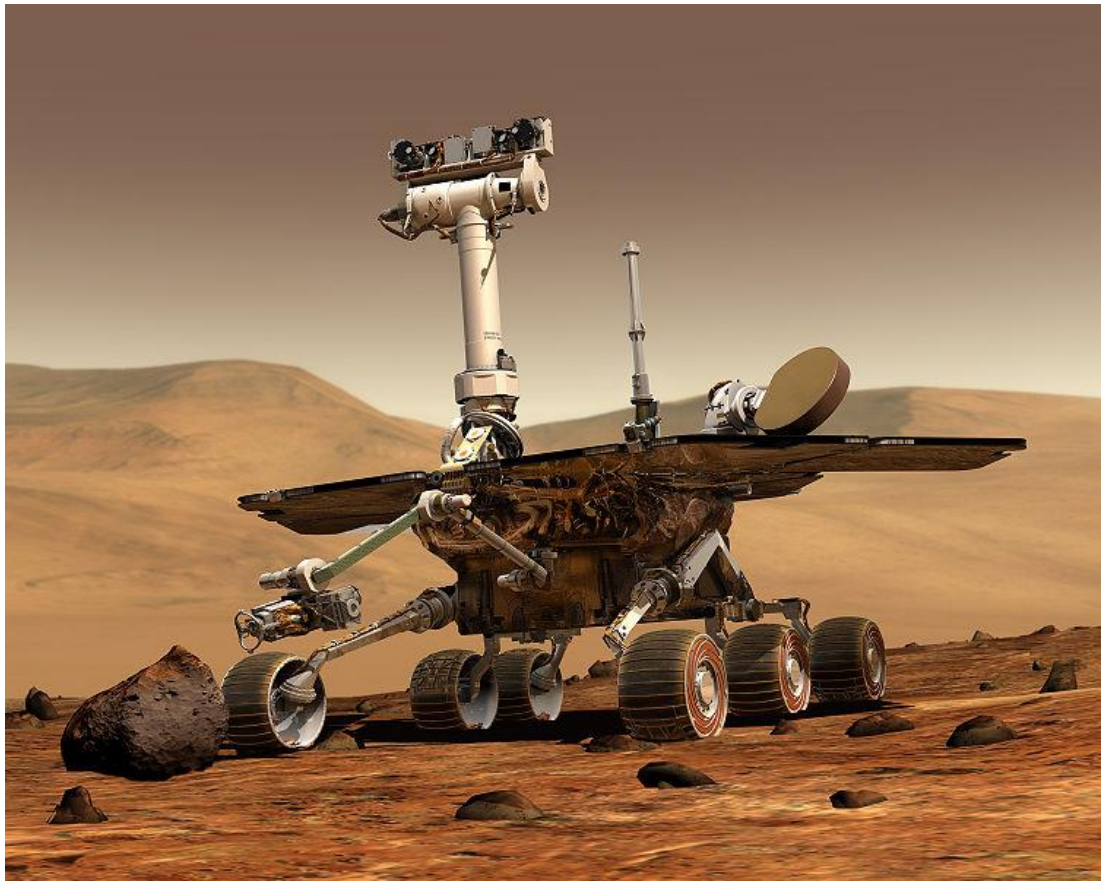
Video Inpainting



https://newatlas.com/video-inpainting-software-hd/26632/

Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Robotika*



Aplikasi Pengolahan Citra (dan *Computer Vision*)

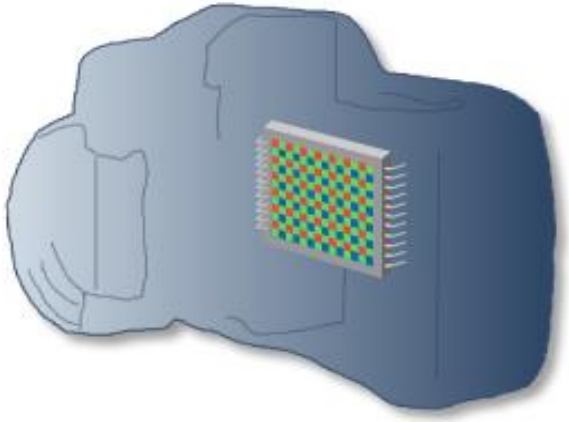
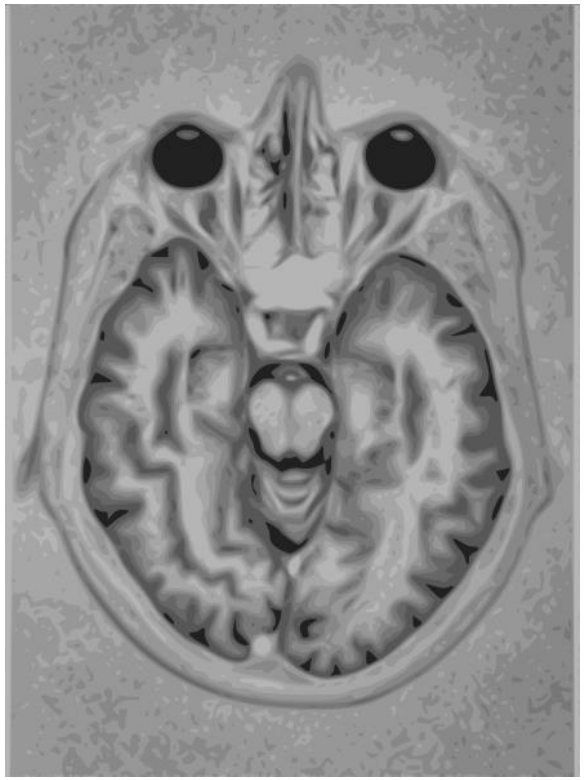


Image Demosaicing

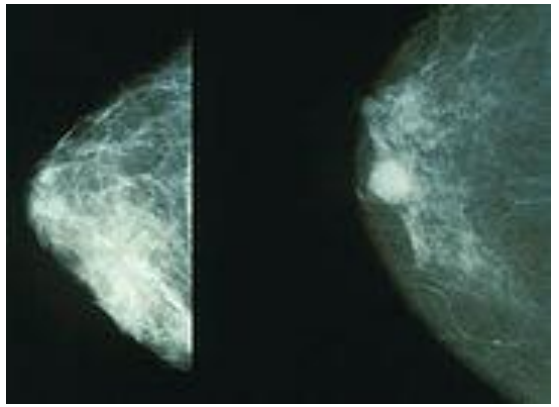
https://www.researchgate.net/figure/Comparision-of-common-demosaicing-methods-applied-to-an-image-of-a-brick-house-and-blue_fig2_220494111

Aplikasi Pengolahan Citra (dan *Computer Vision*)

- Medis



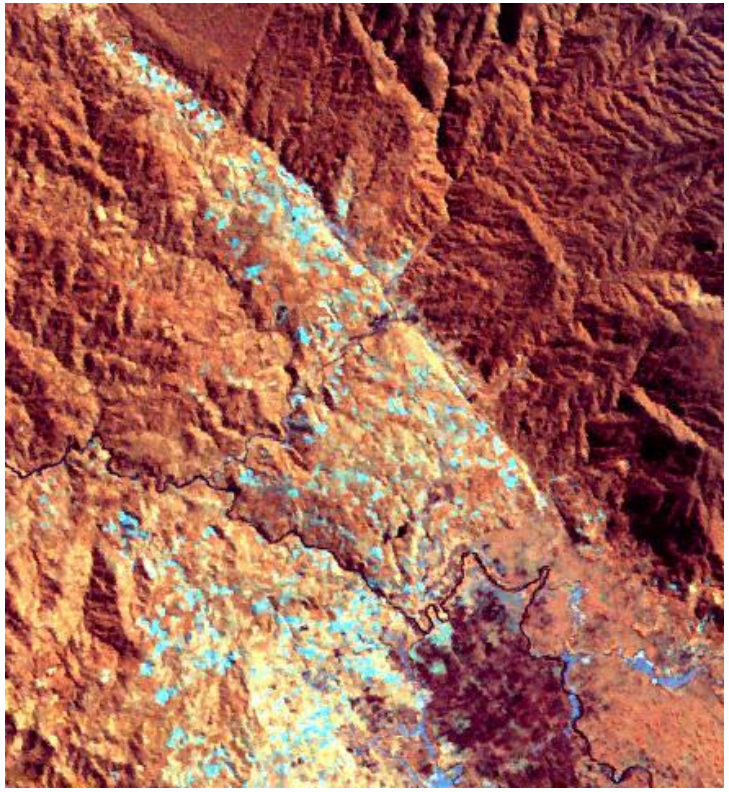
Magnetic resonance imaging (MRI) of brain



Normal (left) versus cancerous (right) mammography image.

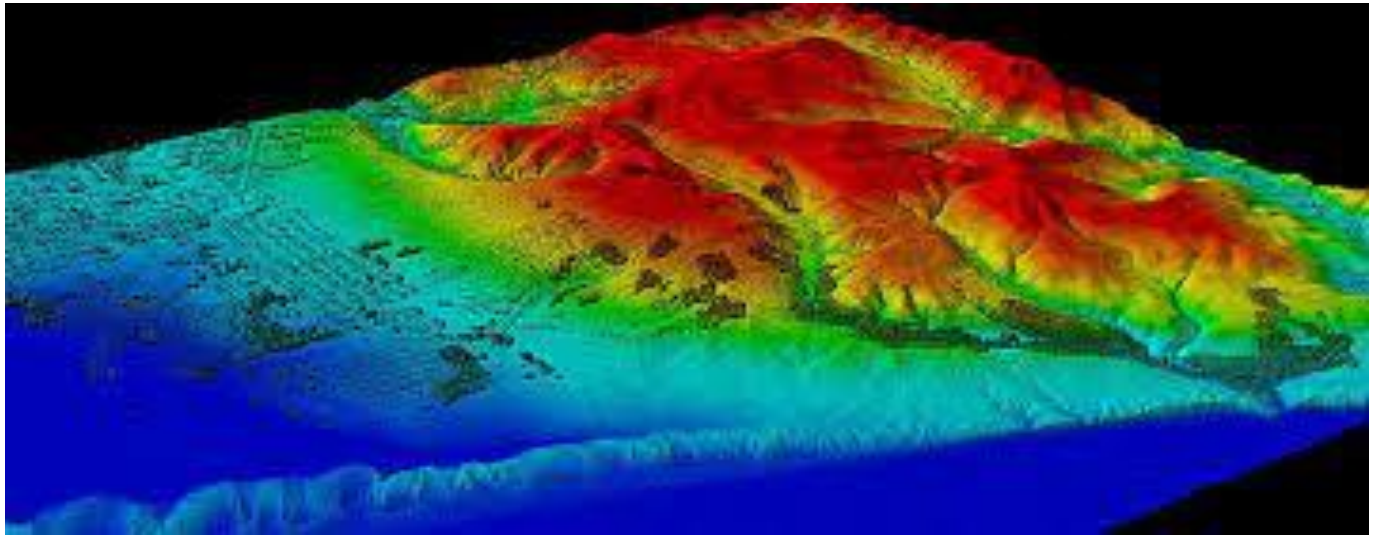
Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Remote sensing*

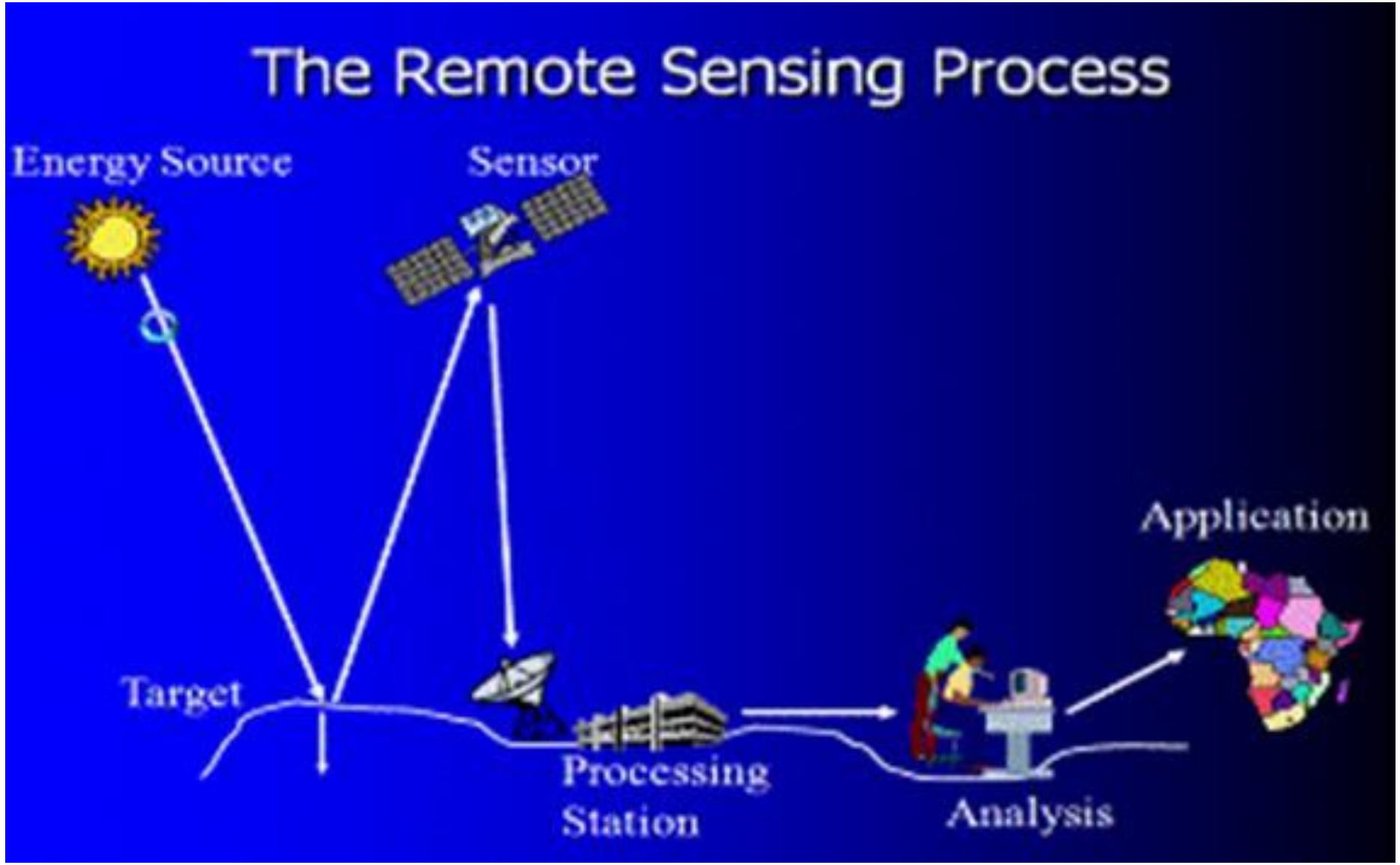


Remote sensing is **the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance** (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth.

https://www.usgs.gov/faqs/what-remote-sensing-and-what-it-used



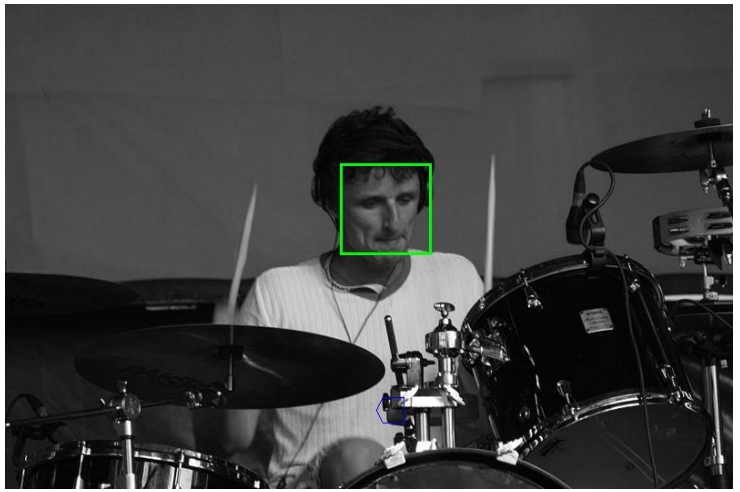
https://oceanservice.noaa.gov/facts/remotesensing.html



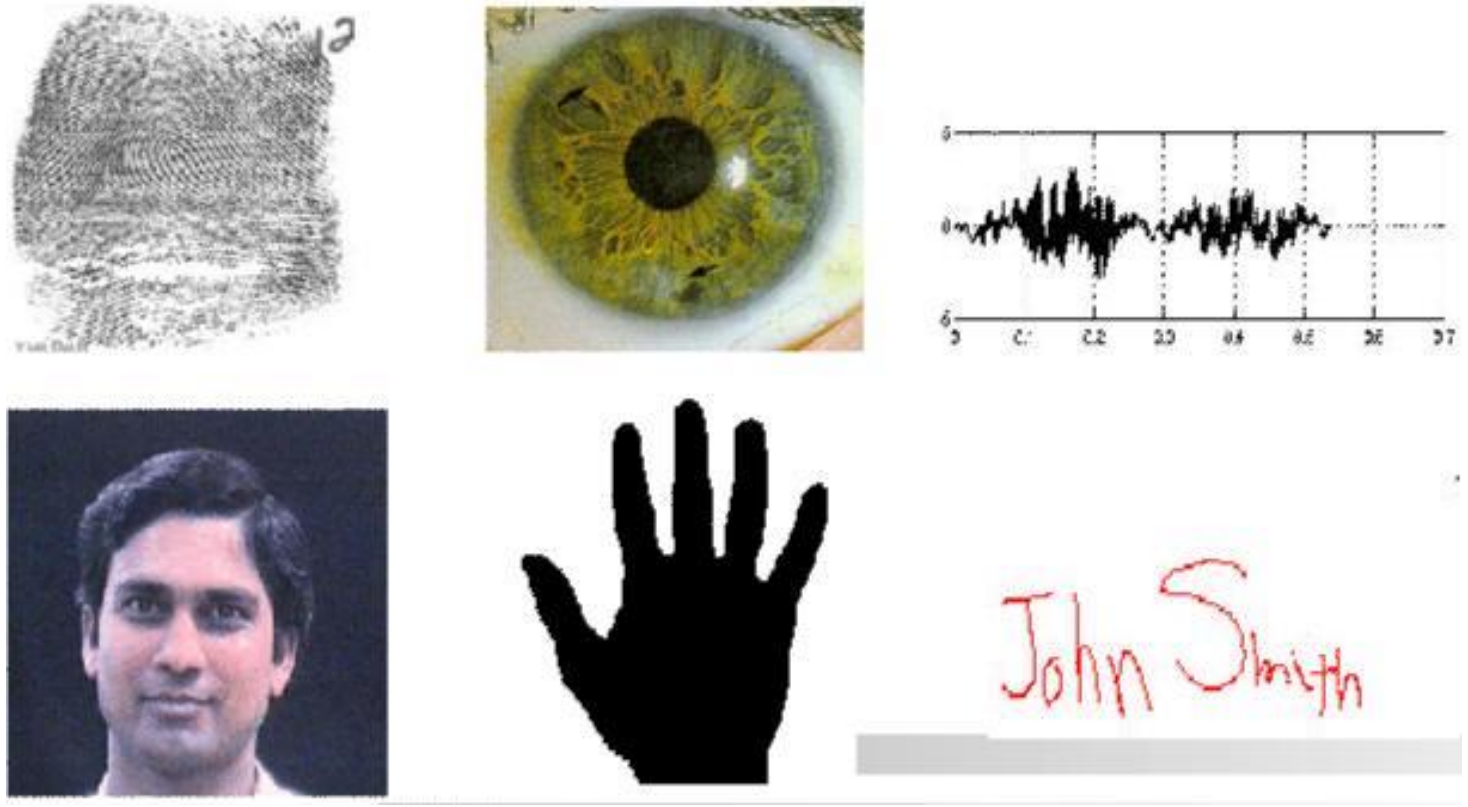
http://dgl.salemstate.edu/geography/profs/young/Imaging%20Earth/Glacier-webpage/home_Page301.htm

Aplikasi Pengolahan Citra (dan *Computer Vision*)

- *Face detection*



Aplikasi Pengolahan Citra (dan *Computer Vision*)



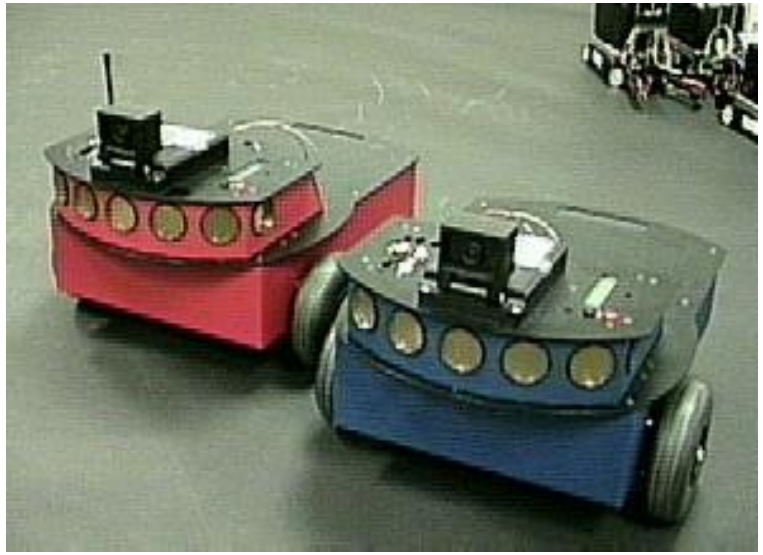
Biometrics

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Aplikasi Pengolahan Citra (dan *Computer Vision*)

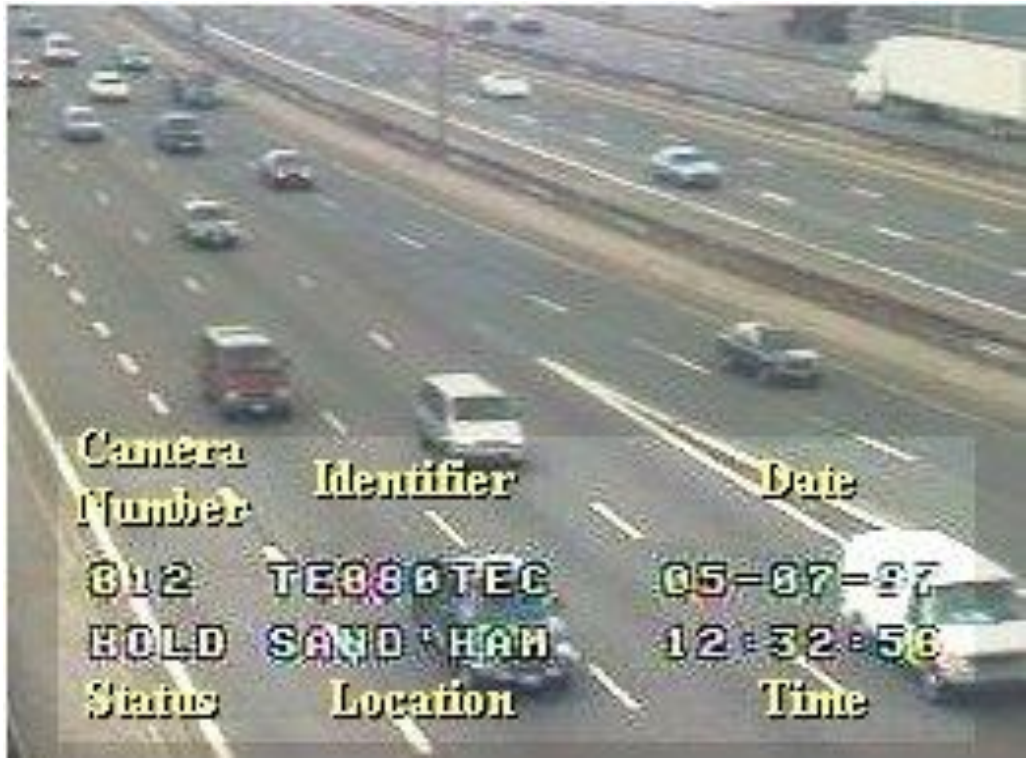
- Land, Underwater, Space

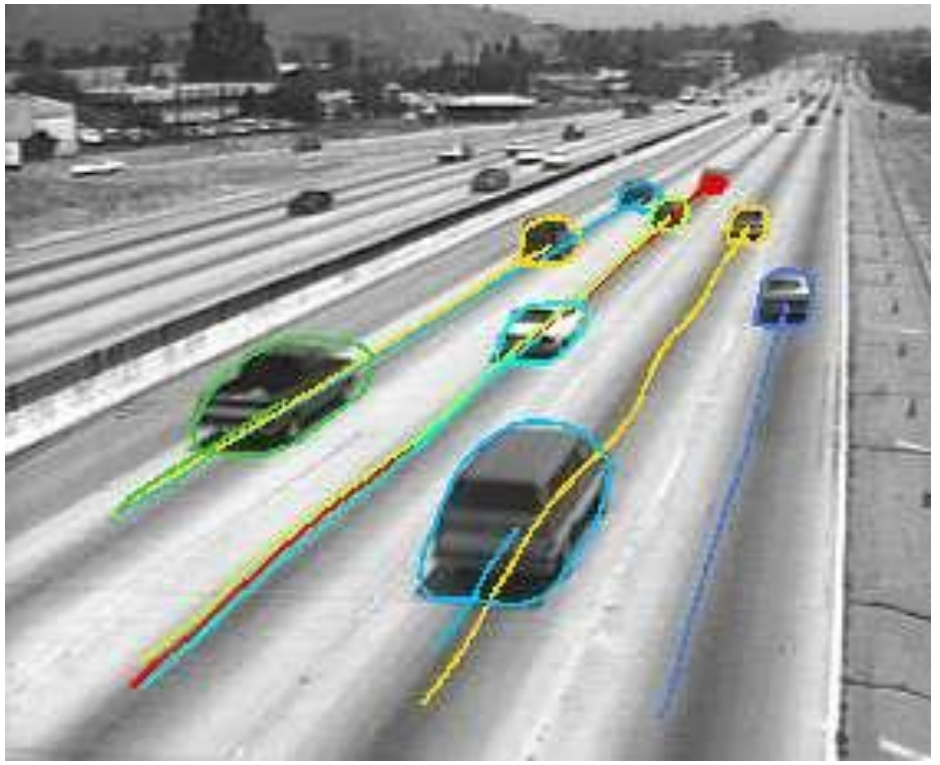
Autonomous Vehicles



Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Aplikasi Pengolahan Citra (dan *Computer Vision*)



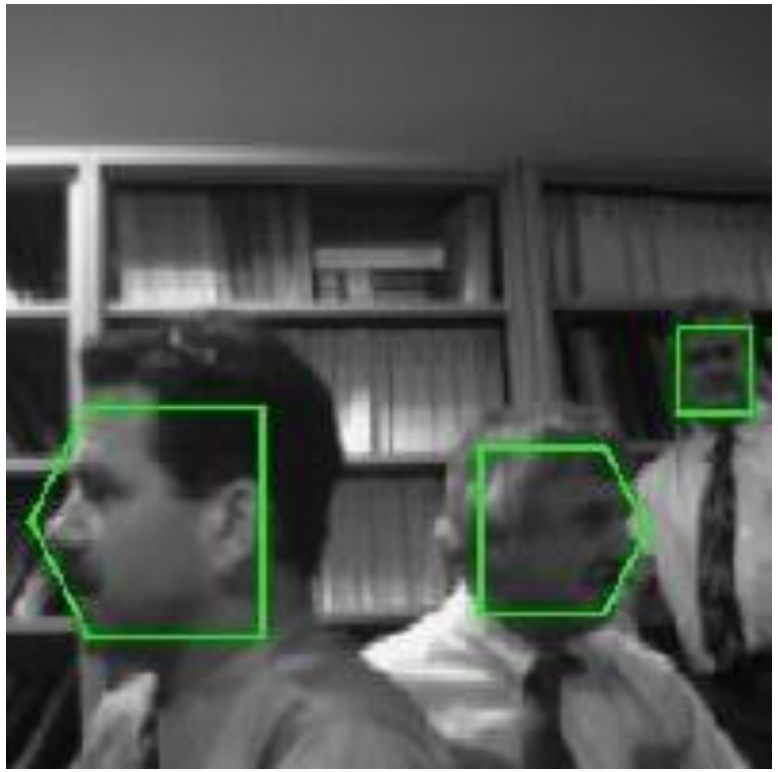


Kemacetan:
- Lancar
- Macet parah
- Macet ringan

Traffic Monitoring

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Aplikasi Pengolahan Citra (dan *Computer Vision*)



Face Detection

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

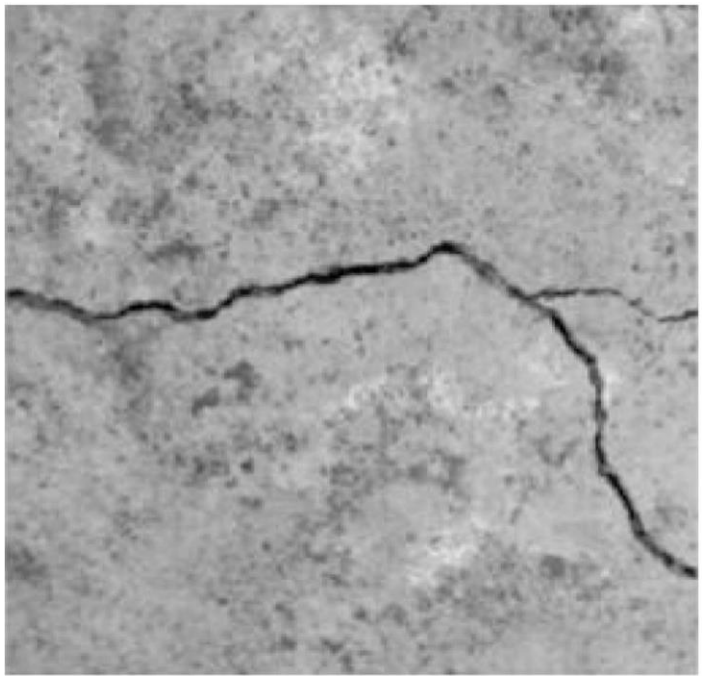
Aplikasi Pengolahan Citra (dan *Computer Vision*)

Face Recognition

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Aplikasi Pengolahan Citra (dan *Computer Vision*)

Original gray image



Binarized image

Crack detection image

Crack detection

Research Article | Open Access
Volume 2018 | Article ID 3924120 | https://doi.org/10.1155/2018/3924120

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Detection of Surface Crack in Building Structures Using Image Processing Technique with an Improved Otsu Method for Image Thresholding

Nhat-Duc Hoang [1]

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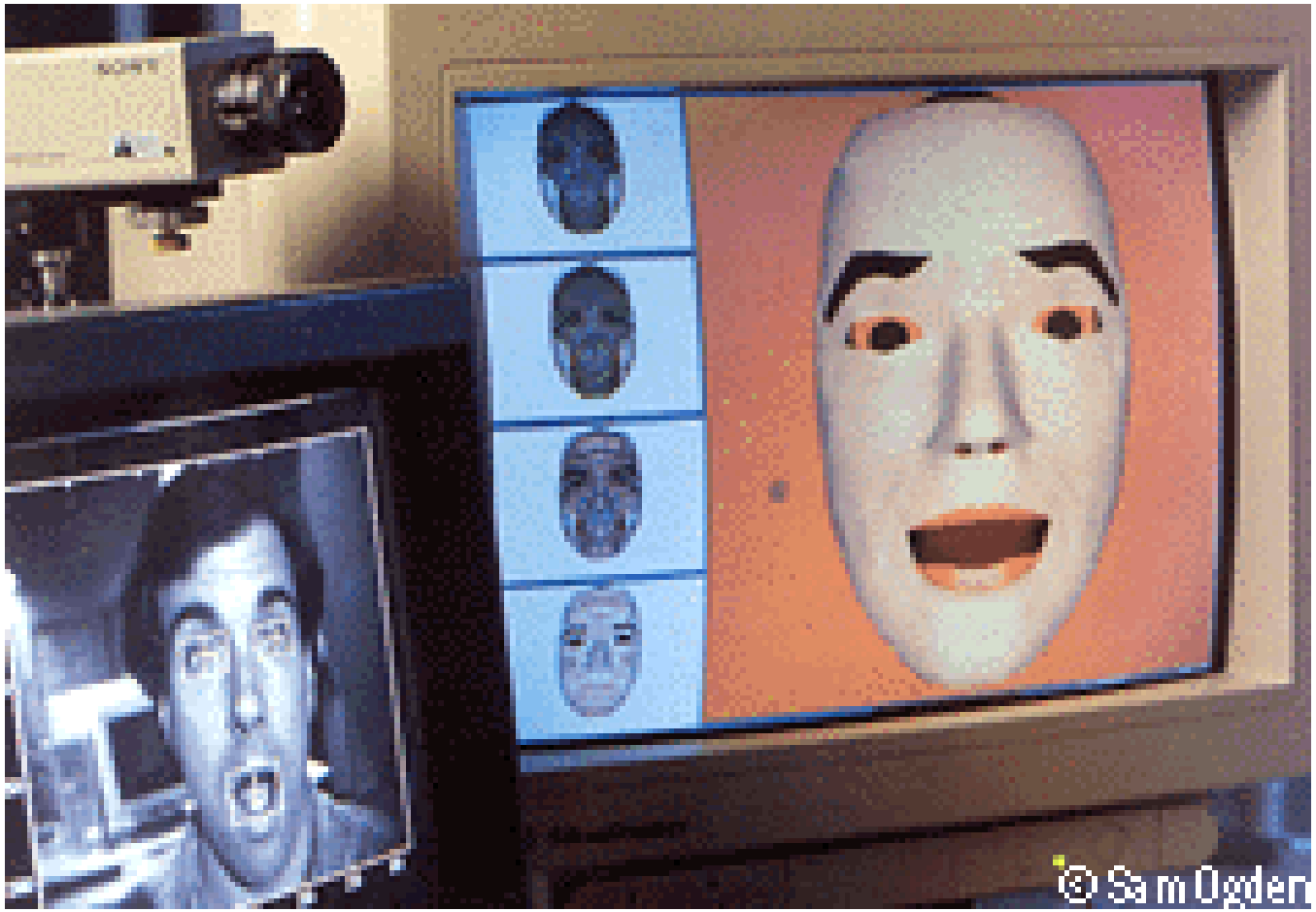
Academic Editor: Pier Paolo Rossi

Received	Revised	Accepted	Published
11 Oct 2017	03 Mar 2018	14 Mar 2018	02 Apr 2018

Aplikasi Pengolahan Citra (dan *Computer Vision*)



Facial Expression Recognition

Ekspresi:
- Sedih
- Gembira
- Marah
- Kaget
- Netral

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

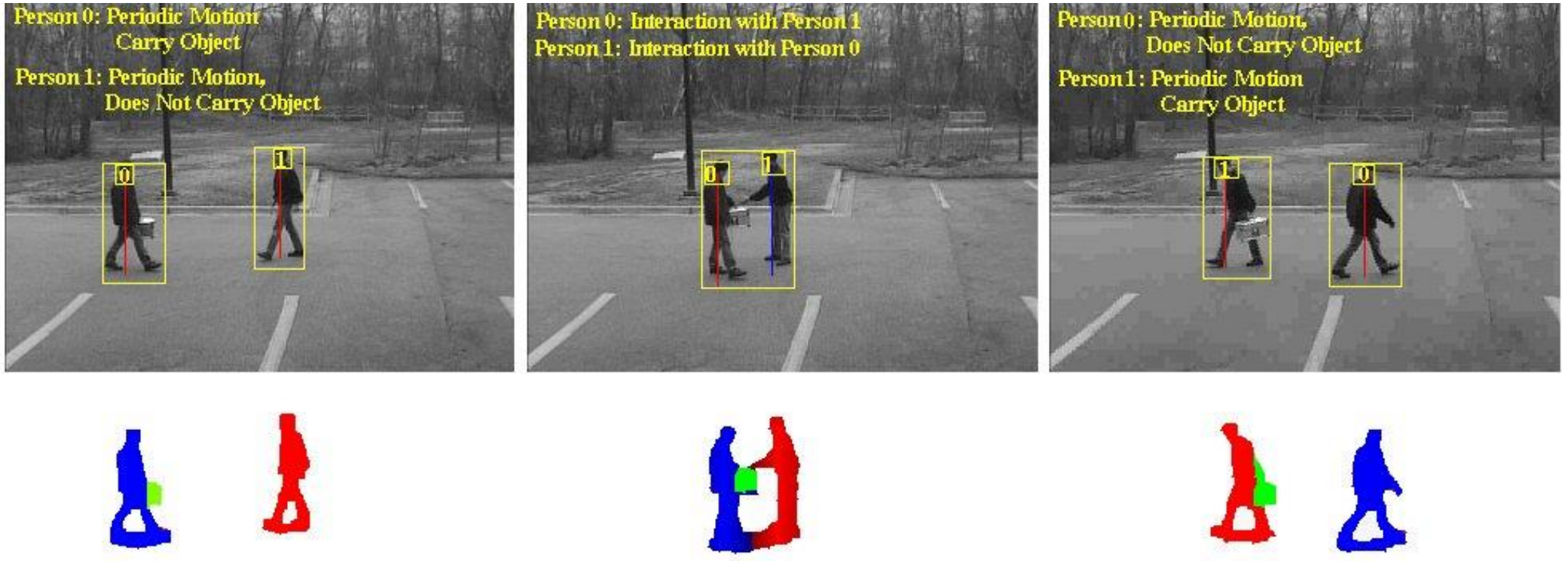
Aplikasi Pengolahan Citra (dan *Computer Vision*)

- Smart Human-Computer User Interfaces
- Sign Language Recognition

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Hand Gesture Recognition

Aplikasi Pengolahan Citra (dan *Computer Vision*)

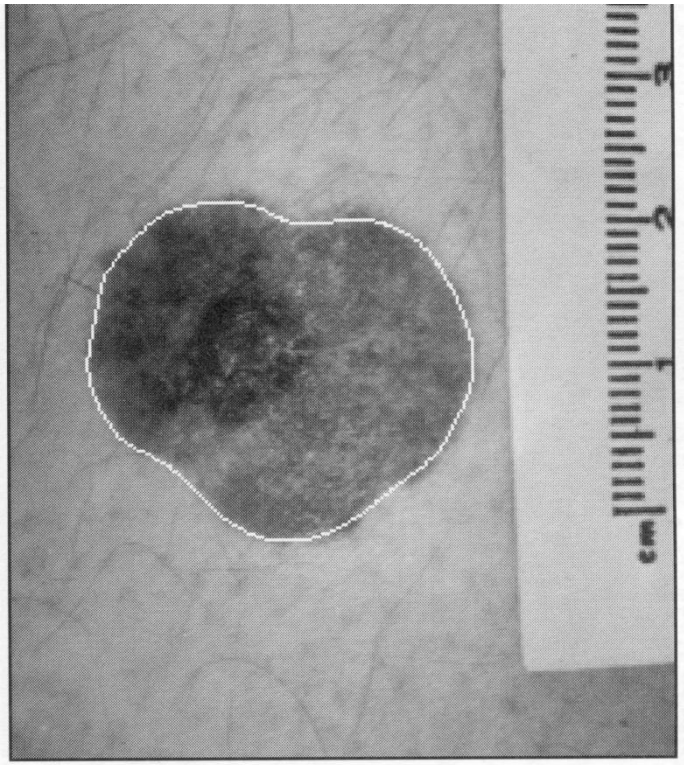


Human Activity Recognition

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Aplikasi Pengolahan Citra (dan *Computer Vision*)

skin cancer



breast cancer

Medical Applications

Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

Aplikasi Pengolahan Citra (dan *Computer Vision*)

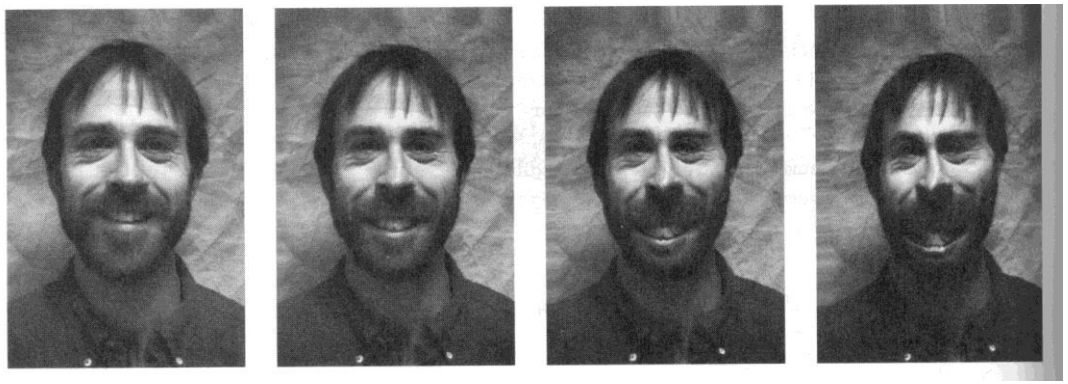
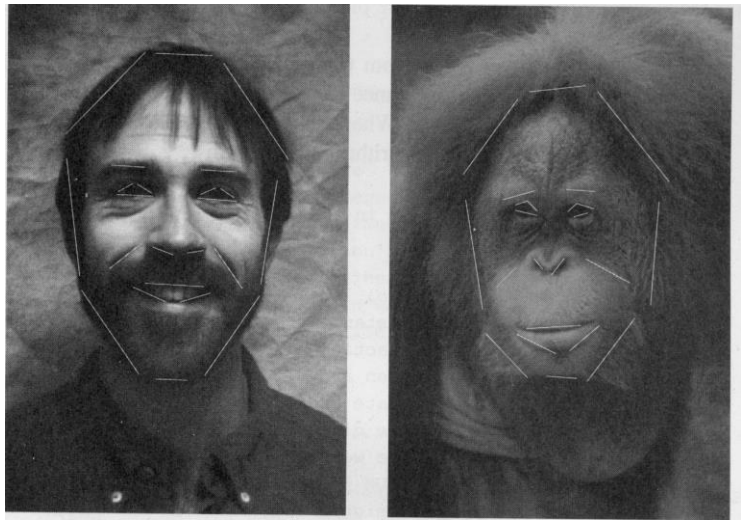


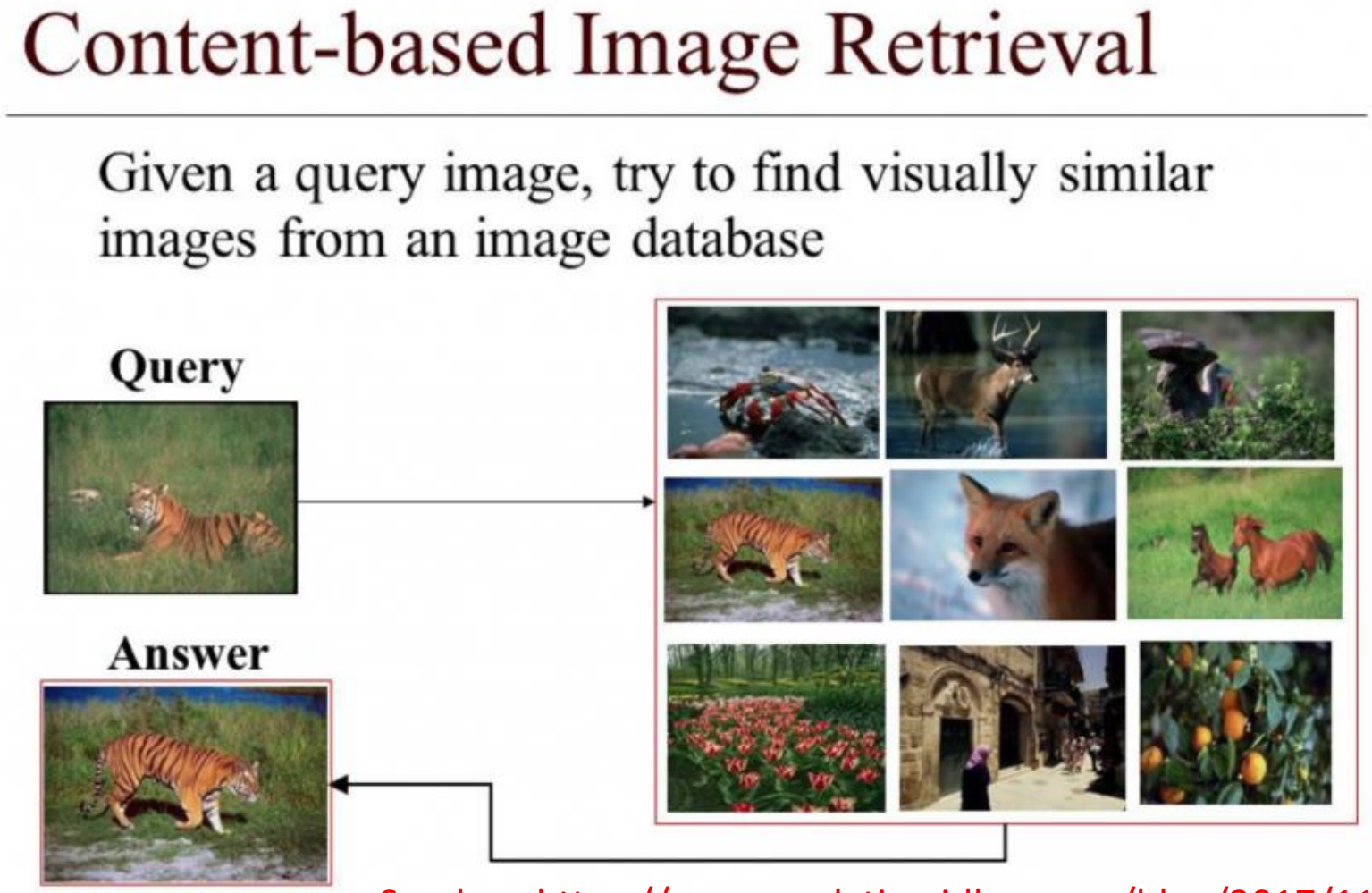
Image Morphing



Sumber: Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee

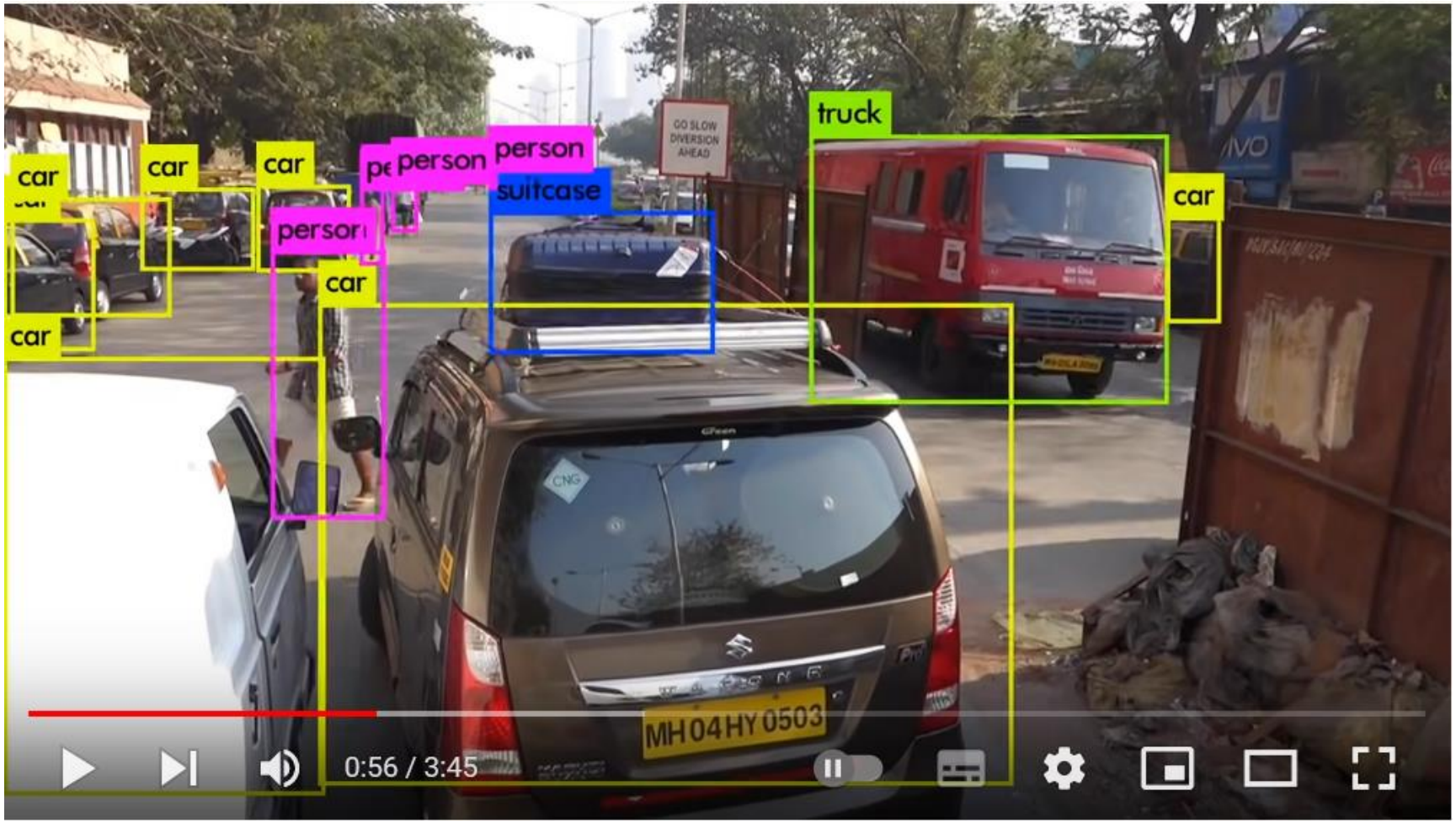
Aplikasi Pengolahan Citra (dan *Computer Vision*)

An image retrieval system is a computer system for browsing, searching and retrieving images from a large database of digital images



Sumber: https://www.analyticsvidhya.com/blog/2017/11/information-retrieval-using-kdtree/

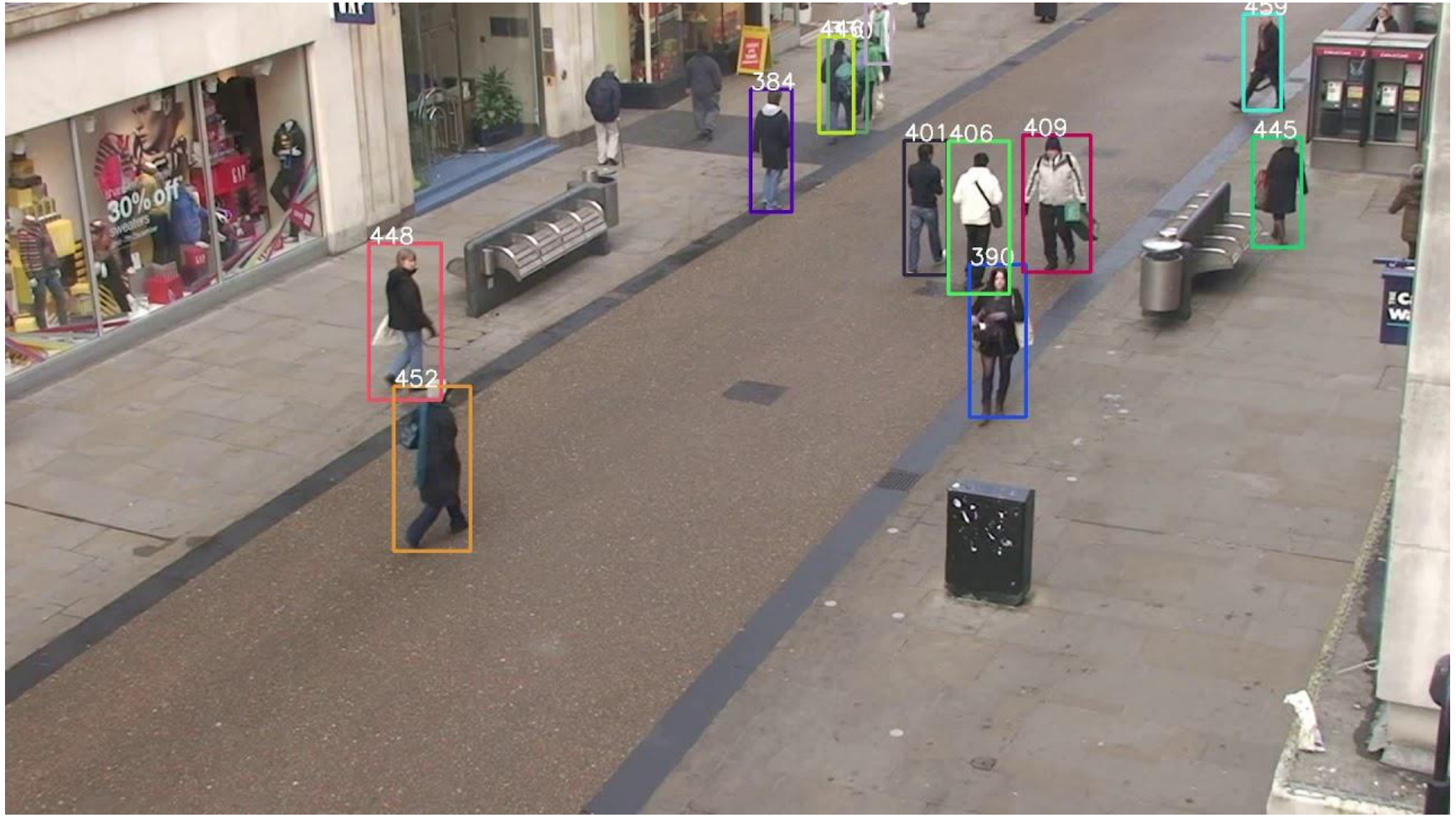
Aplikasi Pengolahan Citra (dan *Computer Vision*)



Object Detection

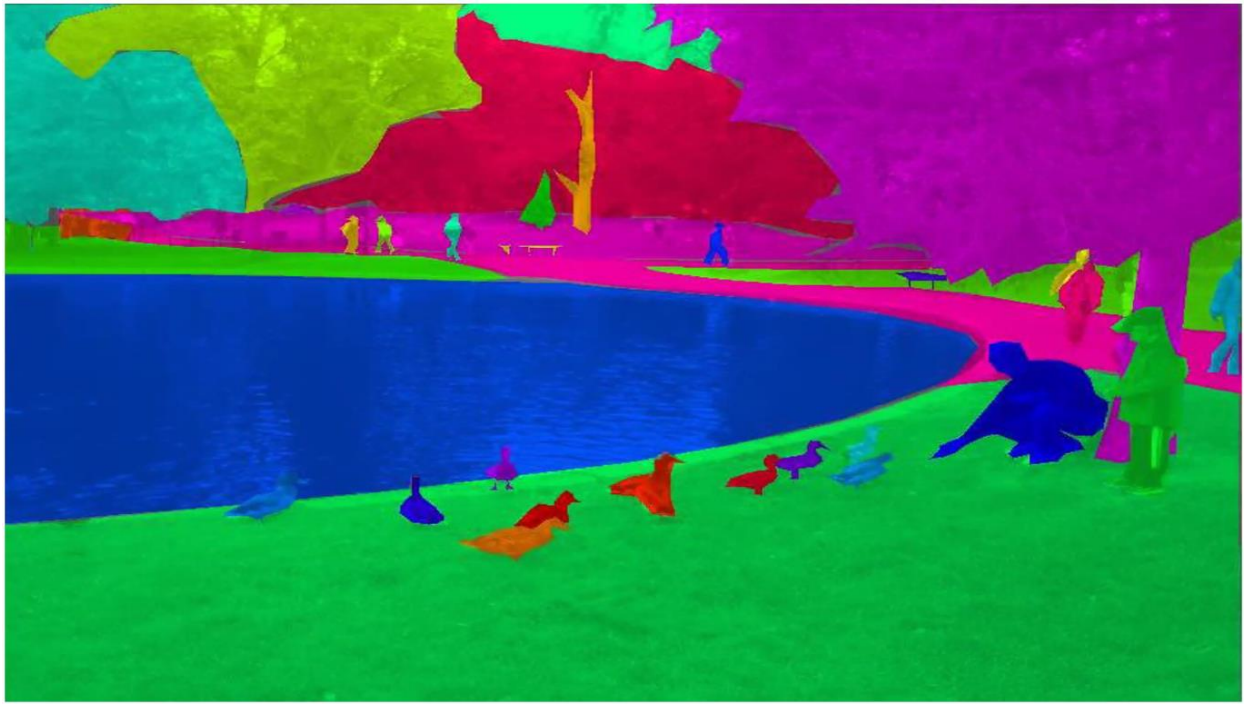
Video di Youtube: https://www.youtube.com/watch?v=MPU2HistivI&t=34s

Aplikasi Pengolahan Citra (dan *Computer Vision*)



Human tracking

Aplikasi Pengolahan Citra (dan *Computer Vision*)



Scene understanding

Scene understanding

Aplikasi Pengolahan Citra (dan *Computer Vision*)

Image forgery detection

Sumber: https://www.sciencedirect.com/science/article/pii/S266591072030061X

INTERNET

Spies turn to high-tech info ops

PCs, Internet used for manipulating images, public opinion

Altered Egos
The top photo, of a fictitious meeting between President Clinton and Saddam Hussein, was generated by digitally altering and combining elements from three photos, shown below the altered image. Intelligence agencies plan to use similar techniques to create images and then disseminate them via the Internet in their efforts to influence events in foreign countries, such as Iraq.

BY DANIEL VERTON

Federal intelligence agencies are studying ways to use computers and the Internet, rather than just leaflets and radio broadcasts, to shape and disseminate information designed to sway public opinion in the world's hot spots.

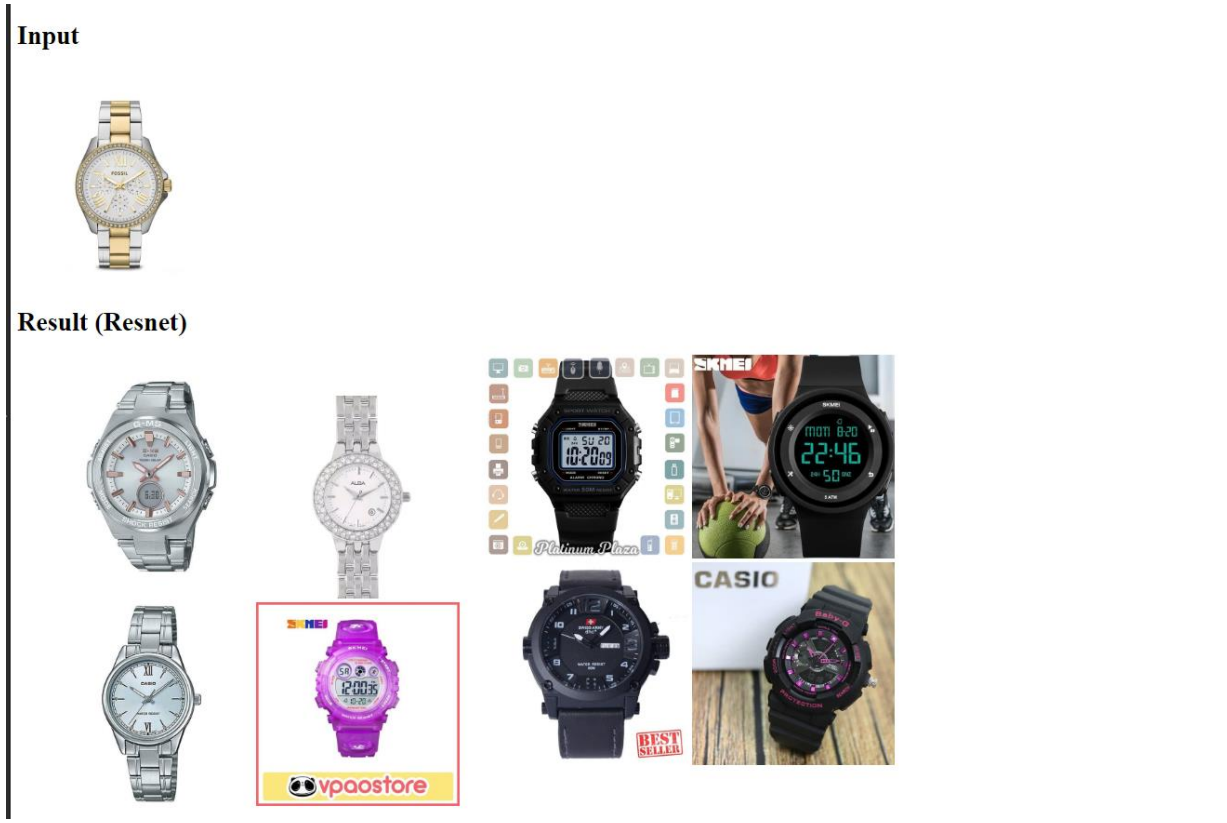
As part of its so-called "perception management" program, the intelligence community has for decades created misinformation to trigger political change without direct political or military involvement in countries where the United States has vested interests, such as Iraq and North Korea.

Acting on congressional recommendations to bolster research and development in information technology, intelligence agencies are turning to PCs to develop more sophisticated means of manipulating and delivering digital photos, video clips and recorded sound to portray fictitious events in hopes of provoking desirable outcomes.

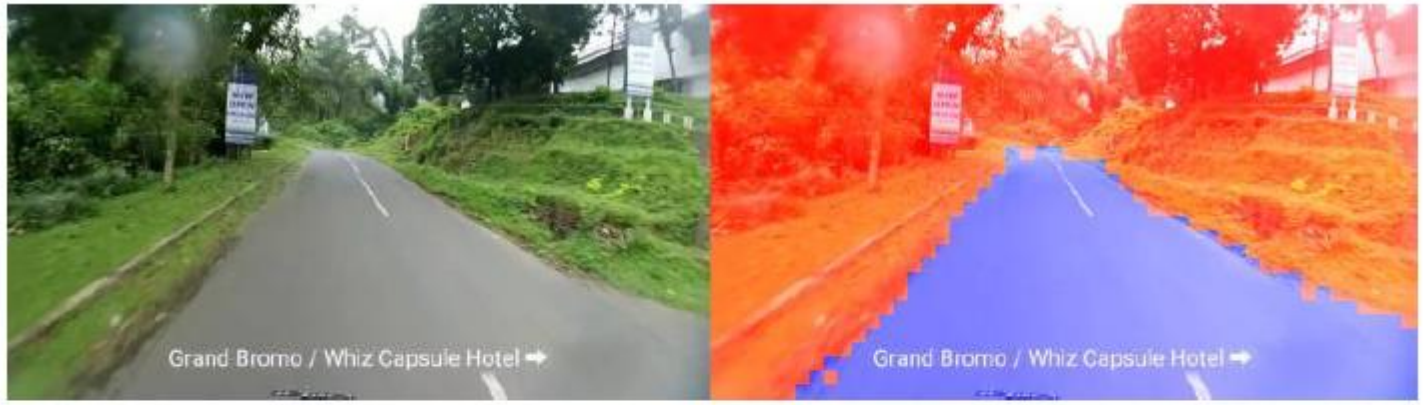
Image forgery detection

Beberapa TA/Tesis tentang Image Processing dan Computer Vision

1. Ahmad Faishol Huda (13516094): Pengembangan Sistem Pencarian Gambar Produk E-commerce Dengan Convolutional Neural Network



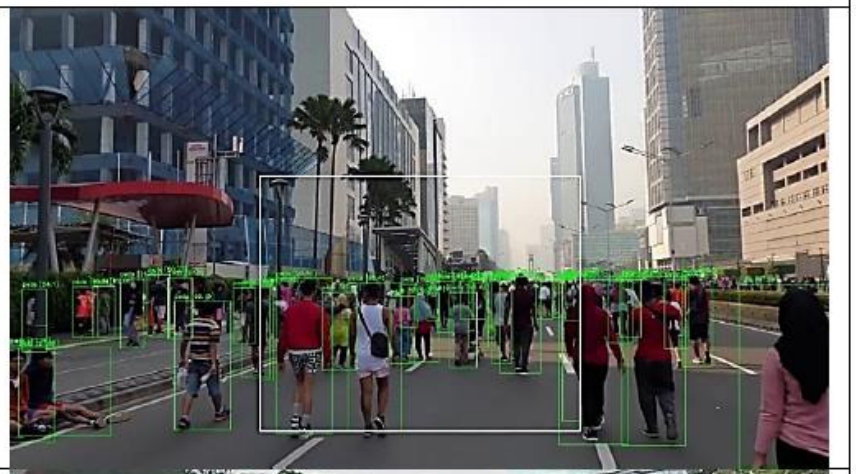
2. Hagai Raja Sinulingga (13516136): Sistem Pengenalan Jalan Raya Pada Sistem Autonomous Vehicle (Av) Dengan Metode Heuristik Dan Pembelajaran Mesin



Gambar IV.6 Deteksi pada citra dengan warna latar yang jauh berbeda

Gambar IV.7 Deteksi pada citra dengan warna kendaraan yang jauh berbeda dan

3. Renjira Naufhal Dhiaegana (13516014): Penerapan Convolutional Neural Network Untuk Deteksi Pedestrian Pada Sistem Autonomous Vehicle

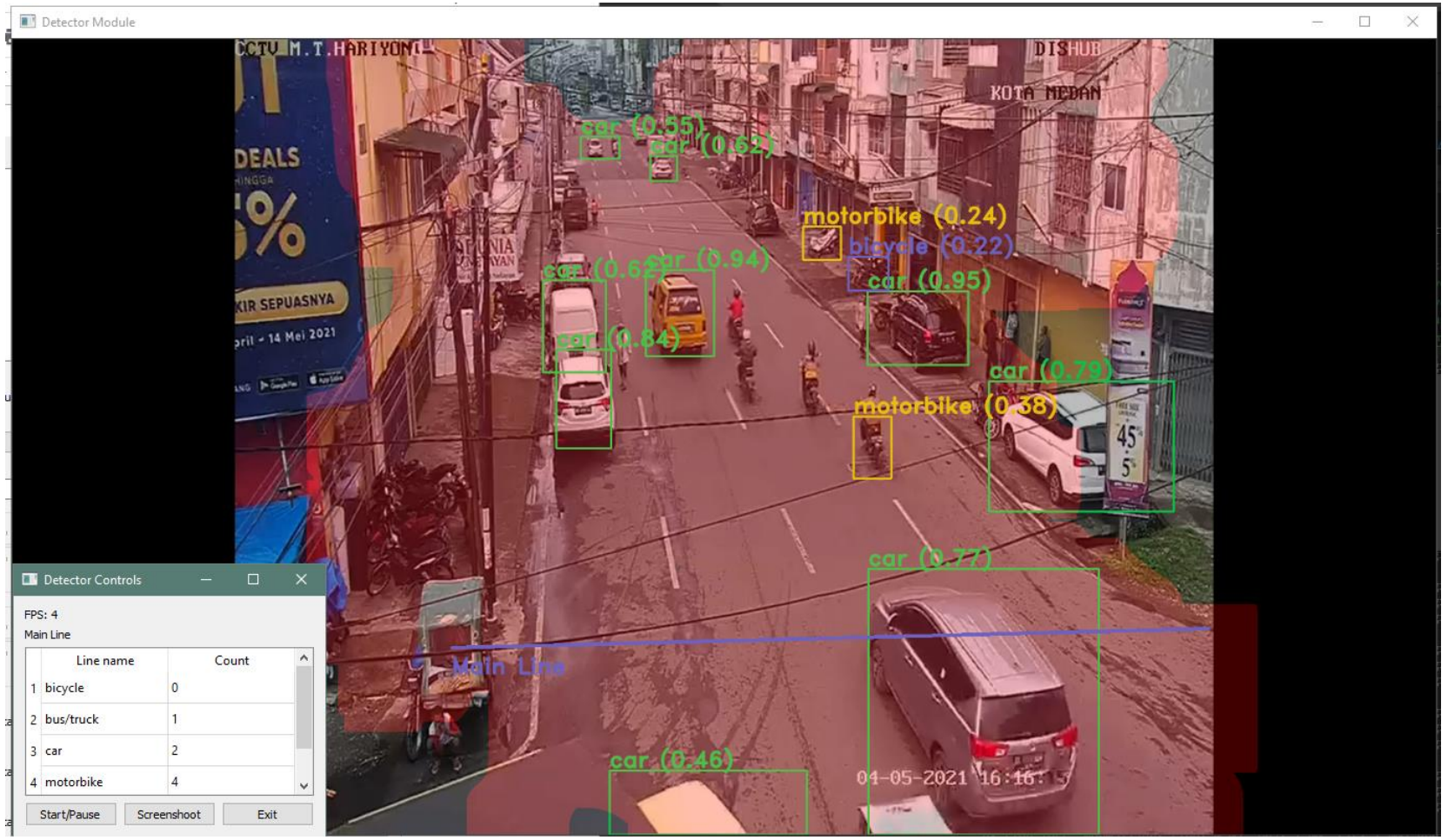
Kasus Uji	YOLOv4-416	YOLOv4-416-double
CFD		
Jalan Pasar		

4. Trian Annas Thoriq Sumarjadi (13516148): Pembangunan Model Clustering Untuk Pengelompokan Citra Near Duplicate

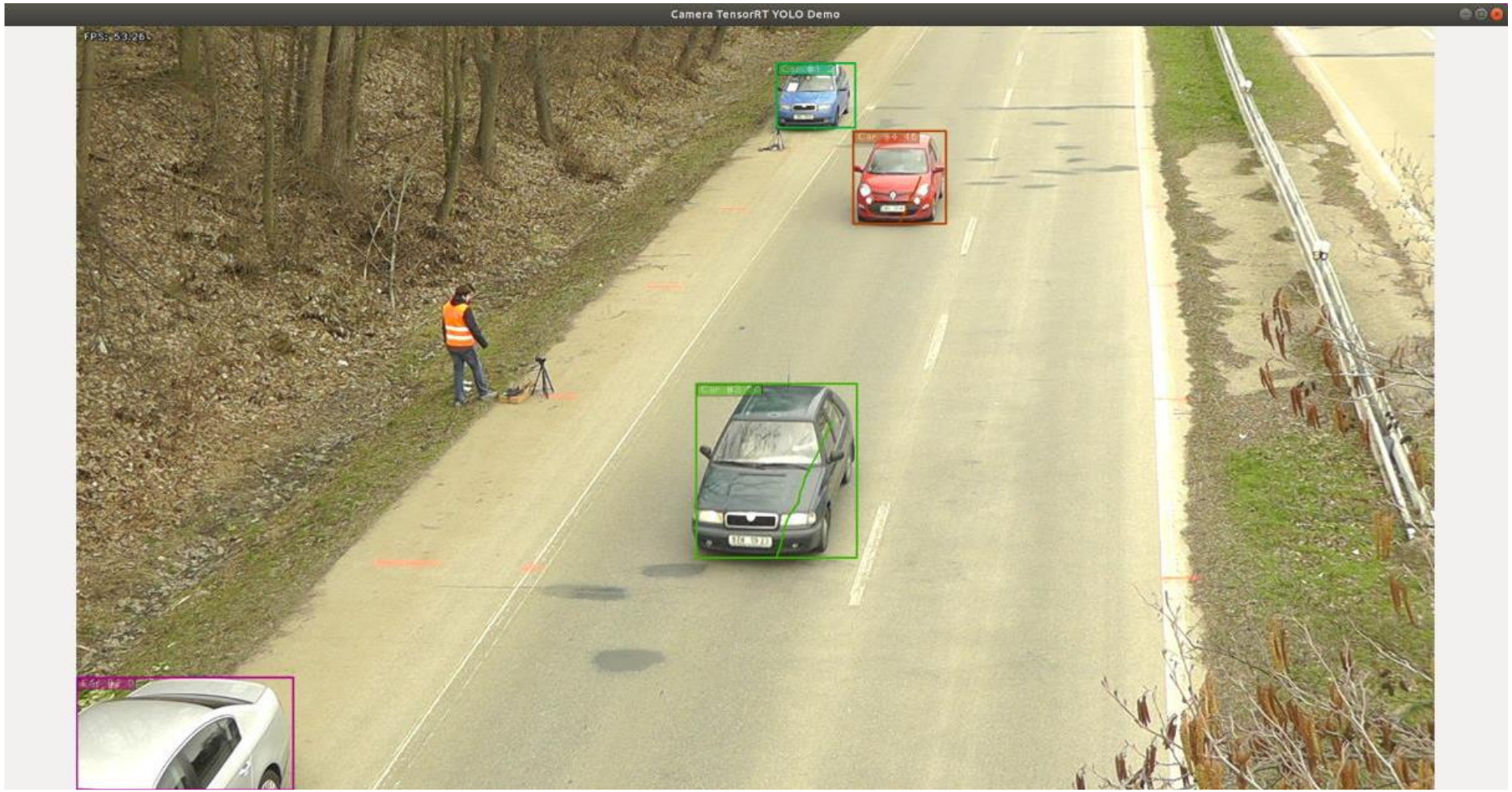
Input

Result

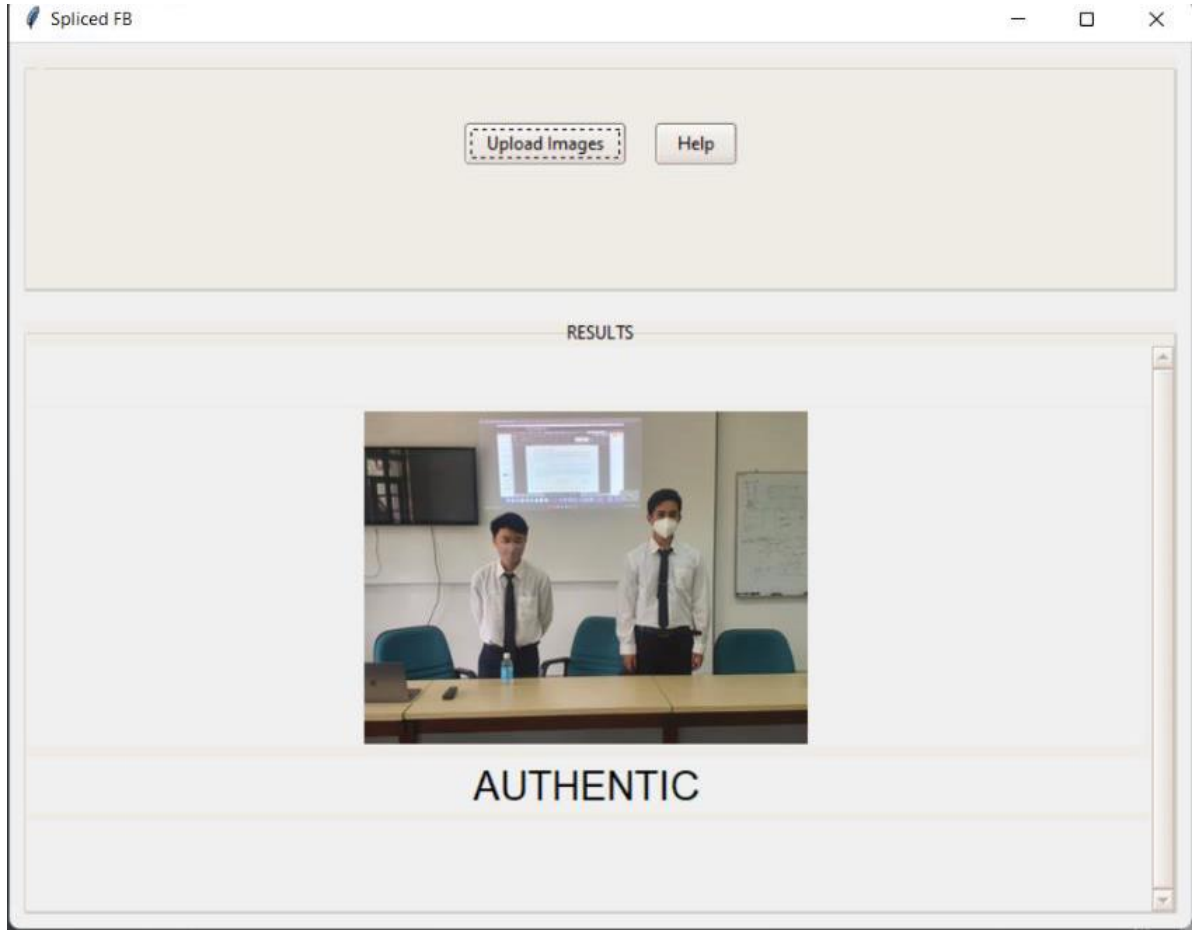
5. Abel Stanley (13517068): Pengembangan Sistem Penghitung Volume Kendaraan Lalu Lintas Pada Video Cctv Dengan Algoritma YOLO dan Segmentasi Semantik Berbasis Model Warna Hsv Jalan

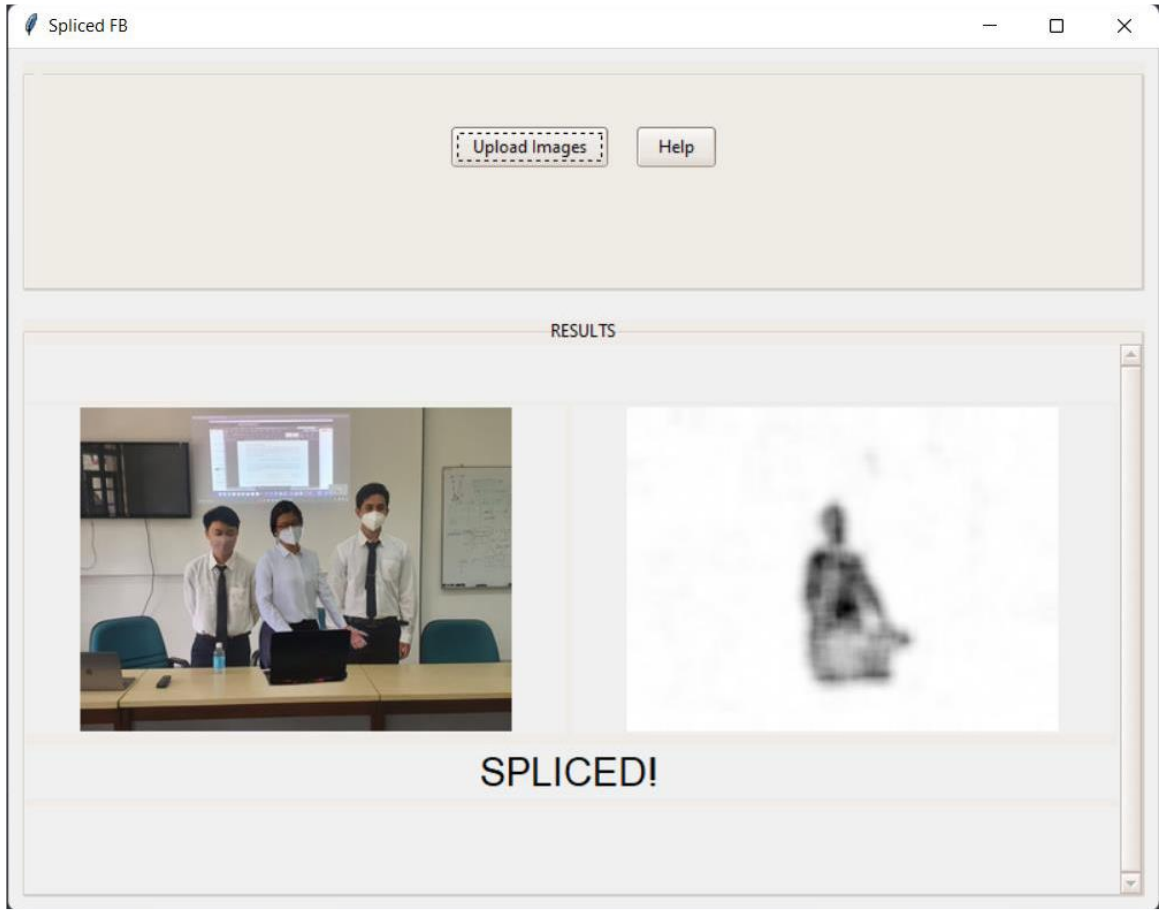


6. Asif Hummam Rais (13517099): Inferensi Kecepatan Kendaraan Menggunakan Yolo, Filter Kalman, Dan Pensampelan Bingkai



7. Michelle Theresia (13518050): Pendeteksian Image Forgery Kelas Spliced Image Pada Aplikasi Pesan Instan

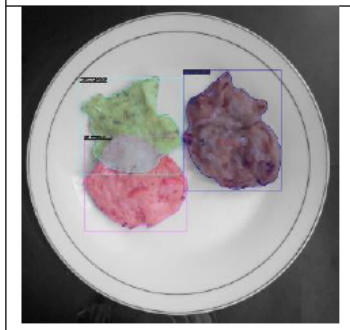




8. Fauzan Firdaus (23520011): Pengenalan Wajah Bermasker Menggunakan Deep Learning

9. Nadya Aditama (23520039): Estimasi Kalori Pada Jajanan Pasar Di Indonesia Menggunakan Mask R-cnn Dan Regresi Linear Berganda

Tabel IV.15 Evaluasi kalori terhadap gambar input pada kasus yang benar

Hasil Segmentasi	Informasi Sesungguhnya	Model Regresi Linear		
		Fitur Panjang Lebar	Fitur Panjang Lebar, Luas, Perimeter	Fitur Luas
	Kelas : bakwan Berat : 31.5 Kalori : 71.82	Berat : 30.79 gram Kalori : 70.21 kal Absolute Error : 1.60 Relative Error : 0.022	Berat : 32.48 gram Kalori : 74.06 kal Absolute Error : 2.24 Relative Error : 0.031	Berat : 34.31gram Kalori: 78.24 kal Absolute Error : 6.42 Relative Error : 0.08

Citra Uji Standard

- Terdapat sejumlah citra yang sering dipakai sebagai citra uji di dalam pengolahan citra atau *computer vision*.

- Citra-citra tersebut sering disebut sebagai *standard test image*, baik citra *grayscale* maupun citra berwarna.

- Umumnya citra uji berukuran persegi (N x N) untuk memudahkan beberapa operasi pengolahan citra yang mengasumsikan citra masukan sebagai citra persegi.

- Empat citra uji standard yang popular dan digunakan secara luas adalah citra *Lena*, *mandrill*, *camera*, dan *pepper*.

- Koleksi citra uji dapat dilihat di laman situs web saya: http://informatika.stei.itb.ac.id/~rinaldi.munir/Koleksi/Citra%20Uji/CitraUji.htm

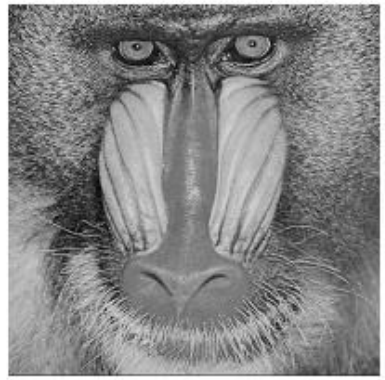
Lena, 256 × 256

Peppers 512 × 512

Zelda 512 × 512

Bird 256 × 256

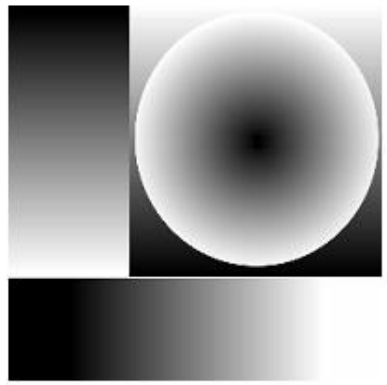
Camera 256 × 256



Mandrill 512 × 512

Barbara 512 × 512

Boat 512 × 512

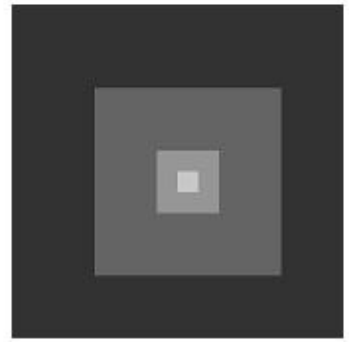


Slope 256 × 256

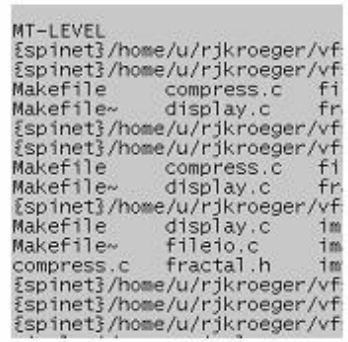
San Fransisco 256 × 256

Collie 256 × 256

Circle 256 × 256



Squares 256 × 256



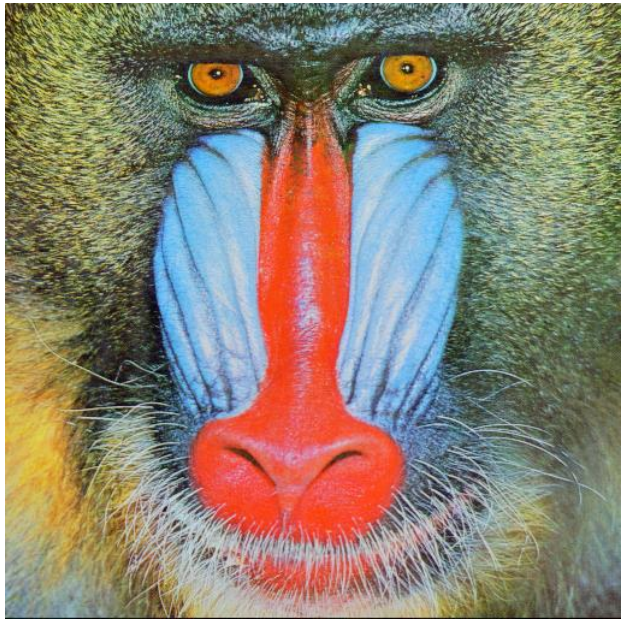
Text 256 × 256

Mountain 640 × 480

Goldhill 512 × 512

Eltoro 512 × 512

Girl 256 × 256



Empat citra popular dalam bidang *image processing*

Citra uji lainnya:

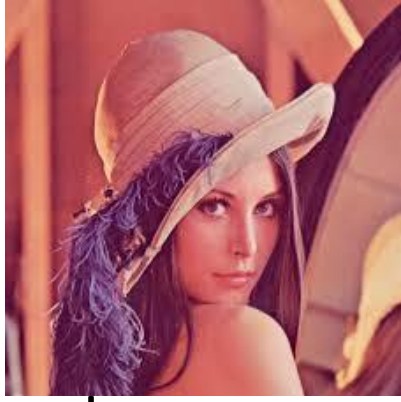
Koleksi standar citra uji lainnya:

1. The USC-SIPI Image Database
   https://sipi.usc.edu/database/

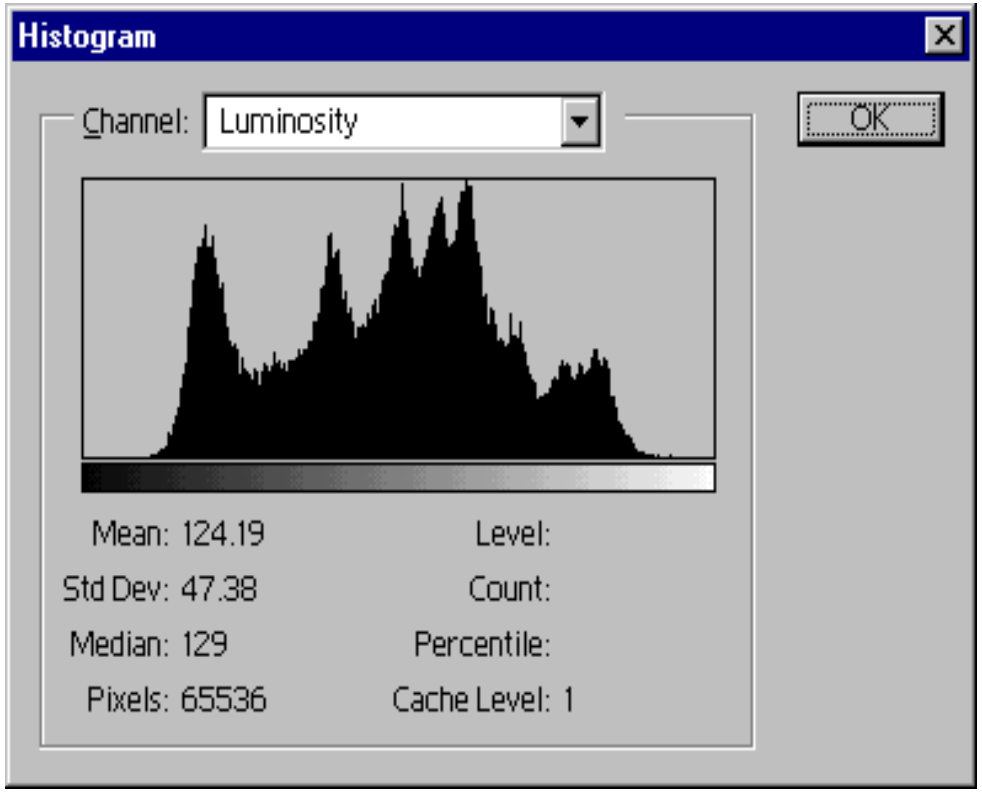
2. Computer vision test images
   https://www.cs.cmu.edu/afs/cs/project/cil/ftp/html/v-images.html

3. TESTIMAGES
   https://testimages.org/

Sejarah Citra Lena



- **Lenna** atau **Lena** adalah nama citra uji standard yang digunakan secara luas di dalam bidang pengolahan citra sejak tahun 1973.
- Lena adalah citra seorang model Swedia bernama Lena Söderberg, yang dipotong dari majalah *Playboy*.
- Foto Lena dari majalah tersebut dipindai oleh Alexander Sawchuk, dia memerlukan foto wajah untuk ditampilkan di dalam sebuah artikel ilmiahnya di sebuah konferensi IEEE.
- Alasan penggunaan citra Lena sebagai citra uji adalah karena citra ini memiliki detil yang bagus, tekstur, dan bayangan, tetapi yang paling penting adalah nilai-nilai *pixel*-nya tersebar secara merata (histogram).
- Tidak dipungkiri juga alasan karena ia seorang wanita cantik, seorang model, dan seorang artis.

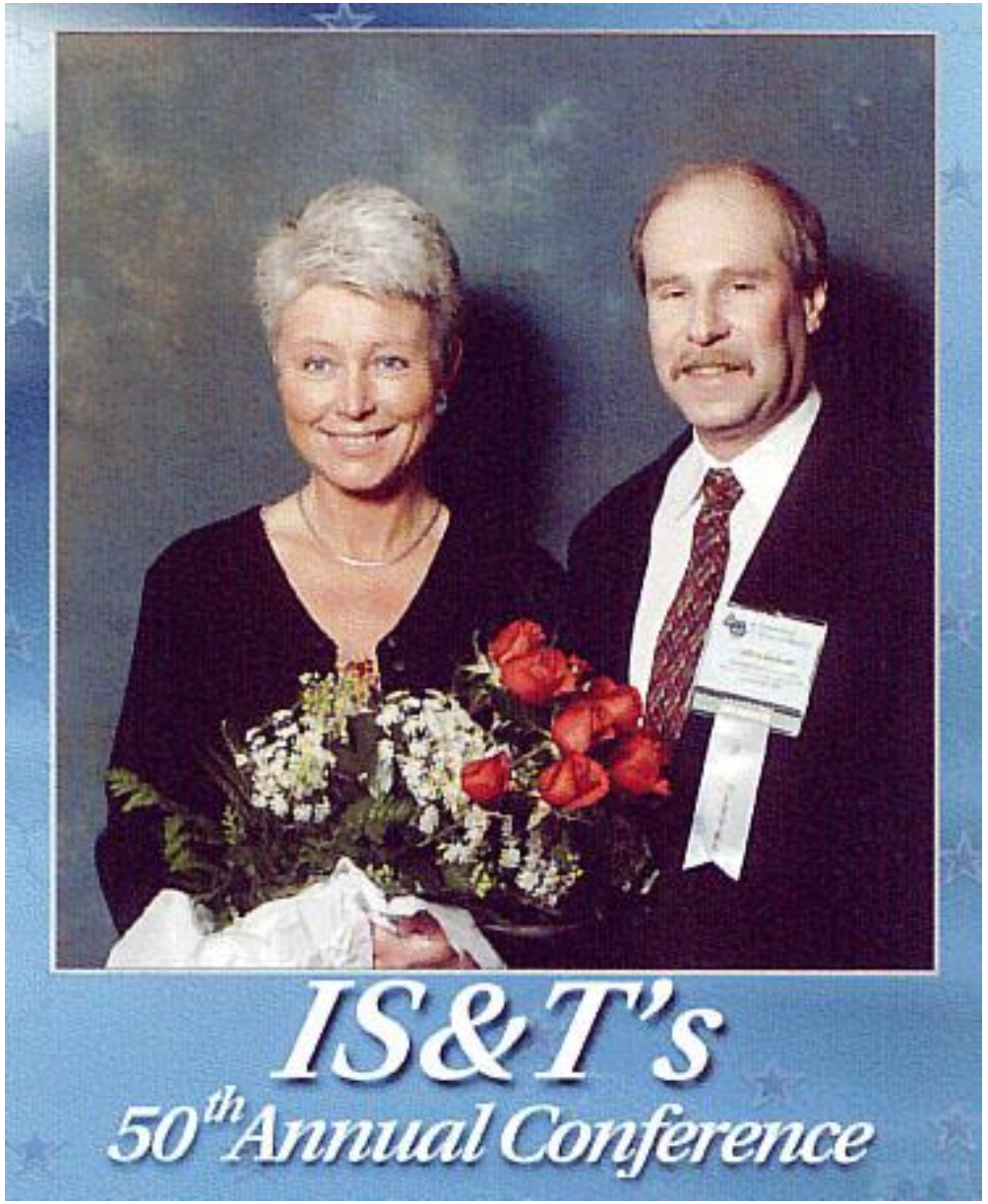

Histogram
Channel: Luminosity
OK
Mean: 124.19
Level:
Std Dev: 47.38
Count:
Median: 129
Percentile:
Pixels: 65536
Cache Level: 1

- Sejarah pertama kali citra Lenna dipakai sebagai citra uji ditulis sebagai berikut:

> Alexander Sawchuk estimates that it was in June or July of 1973 when he, then an assistant professor of electrical engineering at the University of Southern California Signal and Image Processing Institute (SIPI), along with a graduate student and the SIPI lab manager, was hurriedly searching the lab for a good image to scan for a colleague's conference paper. They got tired of their stock of usual test images, dull stuff dating back to television standards work in the early 1960s. They wanted something glossy to ensure good output dynamic range, and they wanted a human face. Just then, somebody happened to walk in with a recent issue of *Playboy*.
> The engineers tore away the top third of the centerfold so they could wrap it around the drum of their Muirhead wirephoto scanner, which they had outfitted with analog-to-digital converters (one each for the red, green, and blue channels) and a Hewlett Packard 2100 minicomputer. The Muirhead had a fixed resolution of 100 lines per inch and the engineers wanted a 512×512 image, so they limited the scan to the top 5.12 inches of the picture, effectively cropping it at the subject's shoulders.

Sumber: Wikipedia

Lena Söderberg tahun 1997:



Currently, Lenna lives near Stockholm and works for a government agency supervising handicapped employees archiving data using, appropriately, computers and scanners.

Sumber: http://www.ee.cityu.edu.hk/~lmpo/lenna/Lenna97.html

Lena saat ini:

I discovered that the last time she'd appeared in public was in 2015, as a "special guest" at an image processing industry conference in Quebec City.

"I'm just surprised that it never ends," Forsen says about her unusual fame.

Sumber: https://www.wired.com/story/finding-lena-the-patron-saint-of-jpegs/

Sumber bahan ajar ini

1. Yacov Hel-Or, *Image Processing*, Spring 2010
2. Dr. Sanjeev Kumar, *Mathematical Imaging Techniques*, Department of Mathematics, IIT Roorkee