35417:Image Processing & 35418:Topics in IT Ⅳ

Digital Image Processing
Lecture 1 Introduction

JAIN Rahul

Spring 2022

Course Staffs

- Instructor:
  - JAIN Rahul (r-jain@fc.ritsumei.ac.jp)
- Teaching Assistants:
  - REN Jiayu (gr0450ek@ed.ritsumei.ac.jp)
- For any questions regarding to the lectures and the exercises, feel free to come to us
  - Creation Core 4F (Intelligent Image Processing Lab)
  - Send an email to confirm a time slot before you come

Course Plan

- Organization of the course
  - 7 Lectures + 7 Exercises + 1 Test
  - Lectures: cover basic topics of digital image processing
    - Intensity transformation
    - Spatial filtering
    - Image segmentation
    - Object recognition
  - Exercises: implement Image Processing algorithms using MATLAB
  - Test: in the final week

Course Plan

- Course Schedule

Lecture/Instructor (When there are multiple instructors)	Theme Keyword, References and Supplementary Information
1	Introduction the scope, history and key steps of image processing, practical applications, basic skills for image processing using Matlab Exercises on Matlab
2	Intensity transformation sampling and quantization, image enhancement, contrast stretching
3	Exercises on intensity transformation Implementation of image enhancement and contrast stretching in Matlab
4	Spatial filtering correlation and convolution, smoothing, sharpening
5	Exercises on spatial filtering Implementation of image smoothing and sharpening in Matlab
6	Image segmentation 1 edge models, edge detection methods
7	Exercises on image segmentation 1 Implementation of edge detection in Matlab
8	Image segmentation 2 Hough transform, thresholding
9	Exercises on image segmentation 2 Implementation of Hough transform or Otsu's method in Matlab
10	Object recognition 1 the pipeline of object recognition, feature vectors, minimum distance, classifier, template matching
11	Exercises on object recognition 1 Implementation of k-NN method in Matlab
12	Feature detection scale-invariant feature transform (SIFT), histogram of oriented gradients (HOG)
13	Objection recognition 2 bag of visual words model (BoVW)
14	Exercises on object recognition 2 Implementation of k-NN based object recognition in Matlab
15	test

- Lectures will be given in CC501
- If you have difficulties to come, you can ask for permission to study online
  - Read course materials during the “lecture week”
  - If needed, Mr. REN Jiayu (TA) will provide online assistance during the "exercises week"

Grade Evaluation

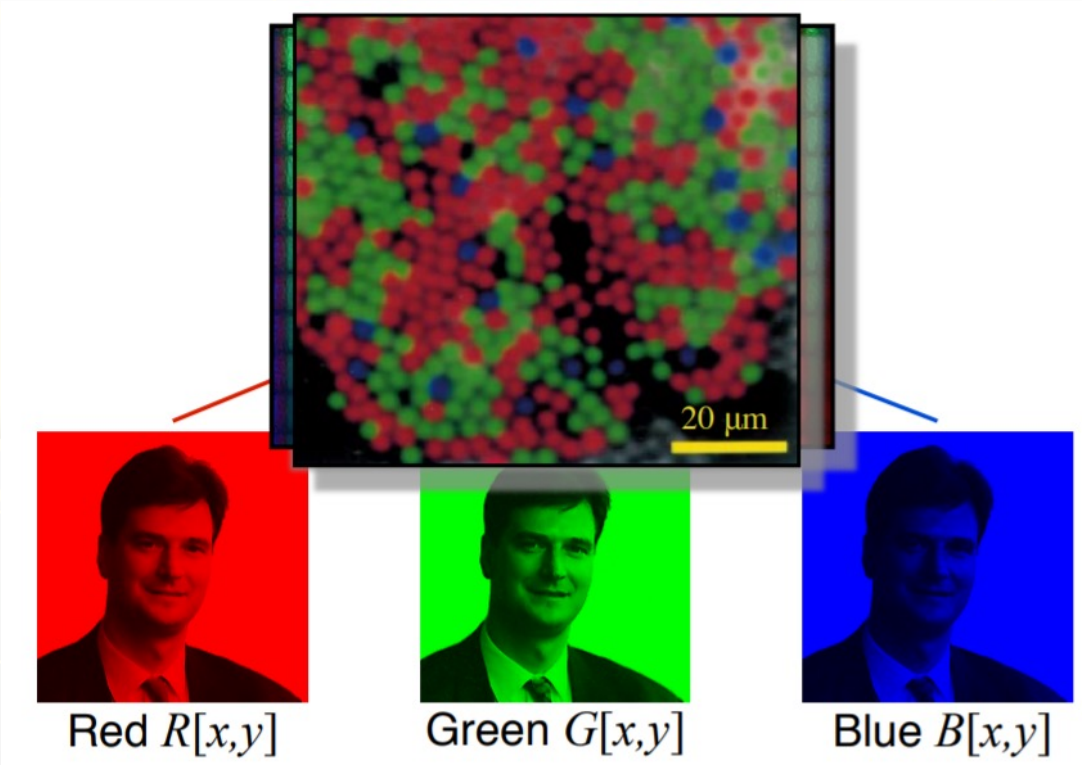
- Minimum requirement of attendance: 12/15
- Attendance
  - Answer the manaba-R survey within the lecture day
- Grade evaluation
  - Exercise reports: 60%
    - Intermediate report: May 25, 2022
    - Final report: July 29, 2022
  - Final test: 40%

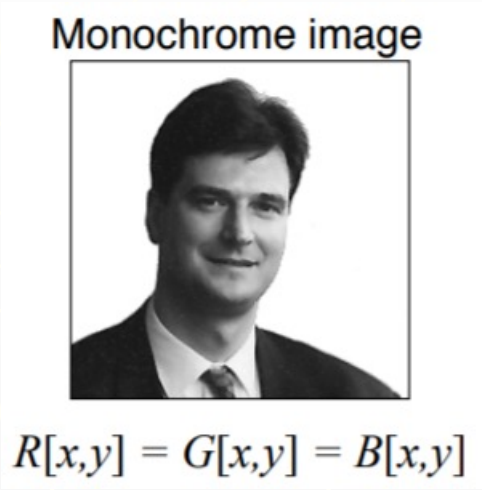
Requirement

- High school level mathematics
- Programing experience in any language

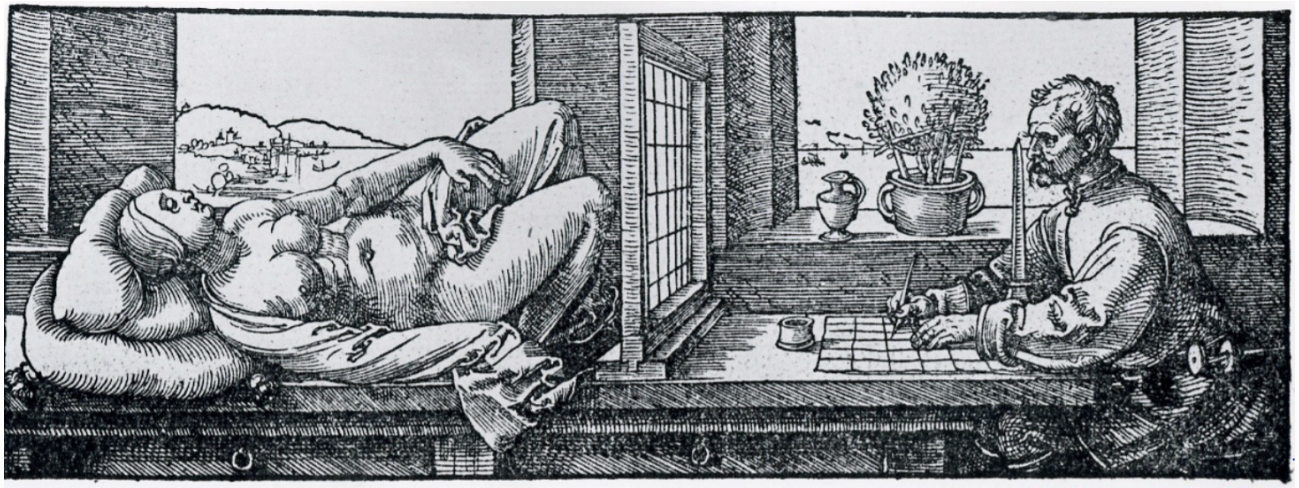
What is Digital Image Processing?

- Color Images
  - A color image is a digital image that has color information
  - In a color image of RGB format, each pixel has three values (or channels) of red, green and blue that measure the intensity and chrominance of light.





What is Digital Image Processing?

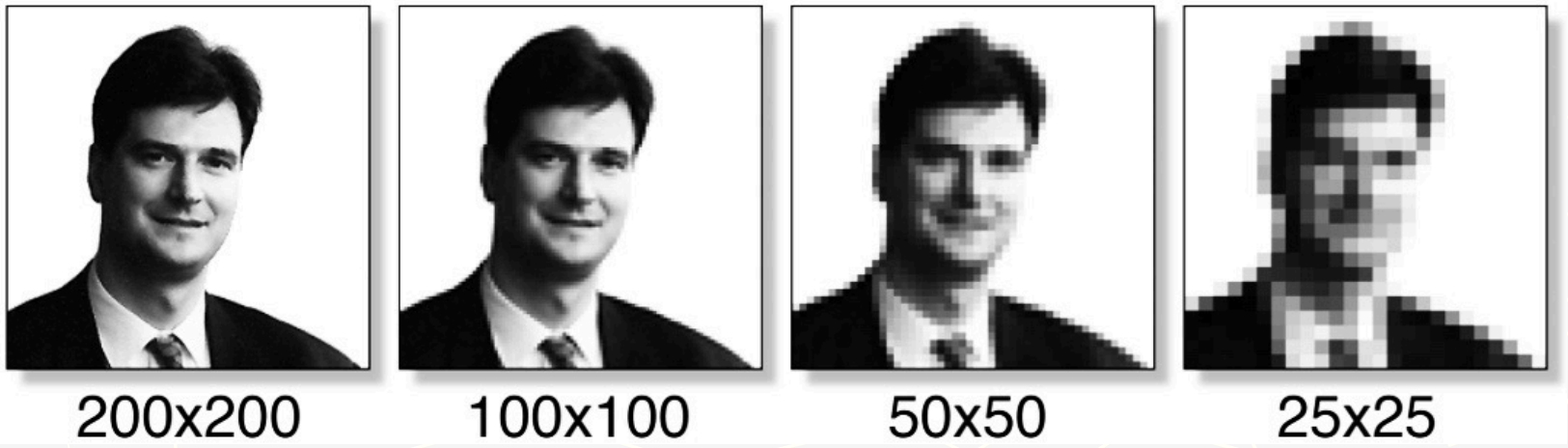


[Albrecht Dürer, 1525]

- Analog Image (in the Physical world)
  - A visual representation in the form of a function $f(x, y)$ where x and y are spatial coordinates, and f is related to the brightness at the location (x, y).
  - The amplitude of f is called intensity or gray level at the point (x, y).
  - Most images are defined by a rectangle.
  - They are continuous in both space and amplitude.

What is Digital Image Processing?

- Digital Image (in the Virtual/Digital world)
  - When x, y and f are all finite, discrete quantities, $f(x, y)$ is a digital image.
  - A digital image is composed of a finite number of elements, which are called *picture elements*, *image elements*, or pixels.
  - Each pixel has a particular location (x, y) and a value $f(x, y)$.
- Digital image is discretized (sampled) analog image
  - Pixels can be sampled under different degrees of control



Why Do We Process Images?

- Improve the quality of display or printing
  - Correct the aperture and color balance before sending images to monitors and printers
- Help picture storage and transmission
  - Store images in an efficient and safe way
  - Send an image from space.
- Extract information from images
  - Recognize number plate.
  - Estimate the categories of objects in images.
  - In Healthcare systems

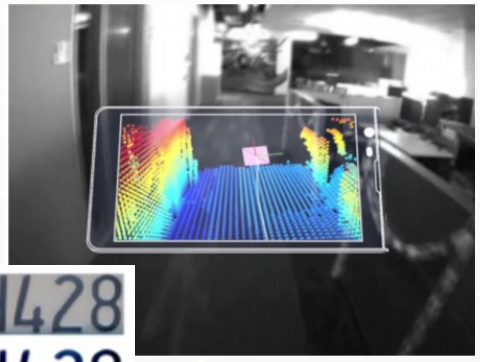


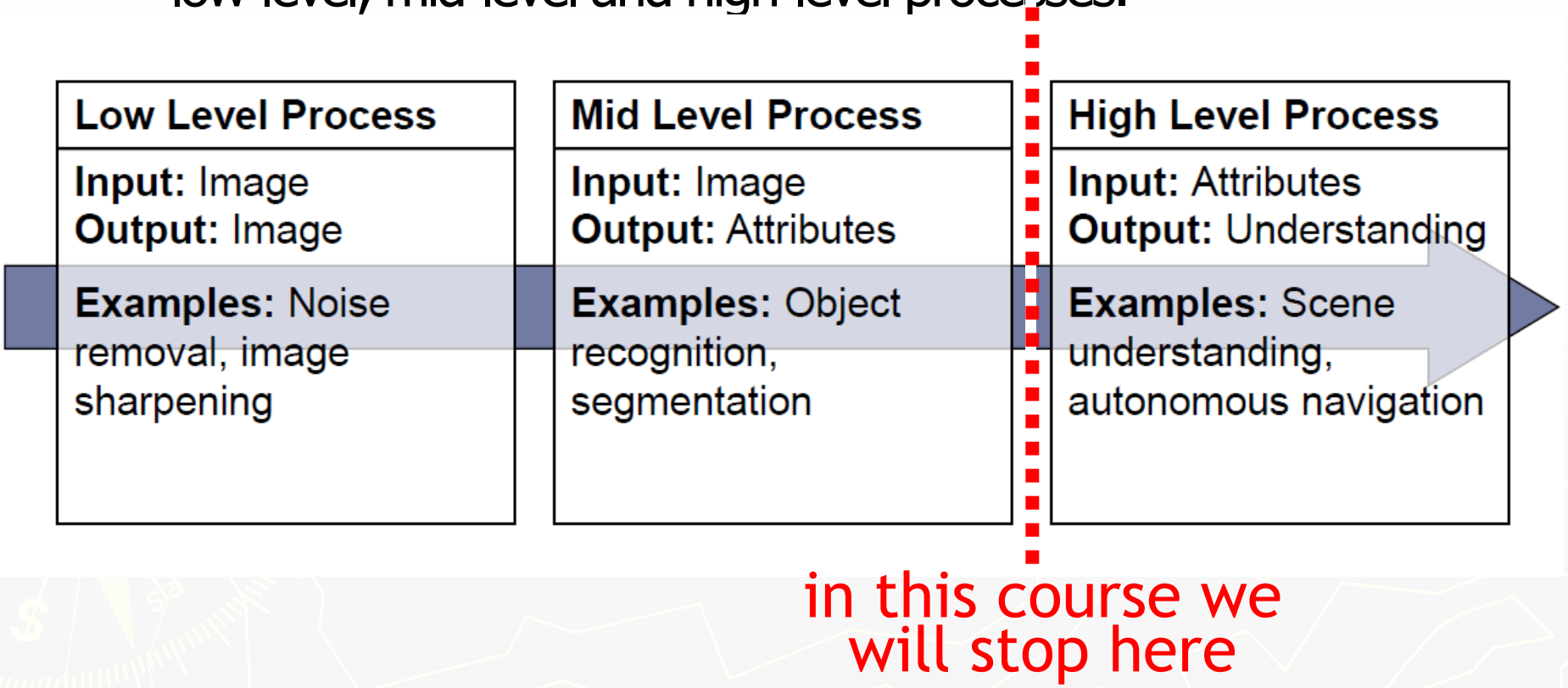
Image processing is ubiquitous!

Scope of Digital Image Processing

- Digital image processing focuses on two major tasks:
  - Improve the pictorial information for **human** perception.
  - Process image data for better storage, transmission and representation to facilitate **machine** perception.
- Related fields
  - Image processing is closely related to two other fields: image analysis and computer vision
  - Image processing includes low level processing to high level processing

Scope of Digital Image Processing

- The process of image processing to computer vision can be divided into three stages:
  - low-level, mid-level and high-level processes.



History of Digital Image Processing

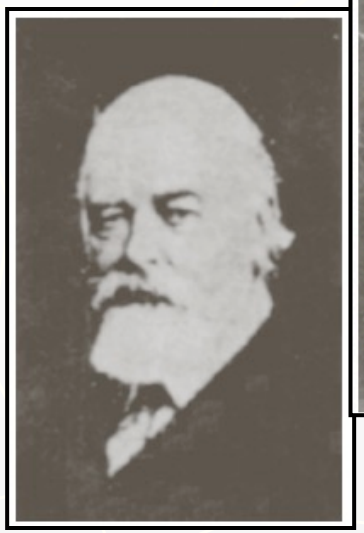
- **Early 1920s**: One of the first applications of digital imaging appeared in **newspaper industry**.
  - People developed Bartlane picture transmission system.
  - By this system, images were transferred by submarine cables between London and New York.
  - Pictures were **coded** for cable transfer and **reconstructed** at the receiving end on a telegraph printer.

The transportation time from London to New York was reduced to less than **three hours** from more than **a week.**

5-gray level digital image

History of Digital Image Processing

- **Mid to late 1920s**: People improved Bartlane by
  - Introducing new **reconstruction technology**, and
  - Increasing the number of gray levels.
- These improvements resulted in higher quality digital images:



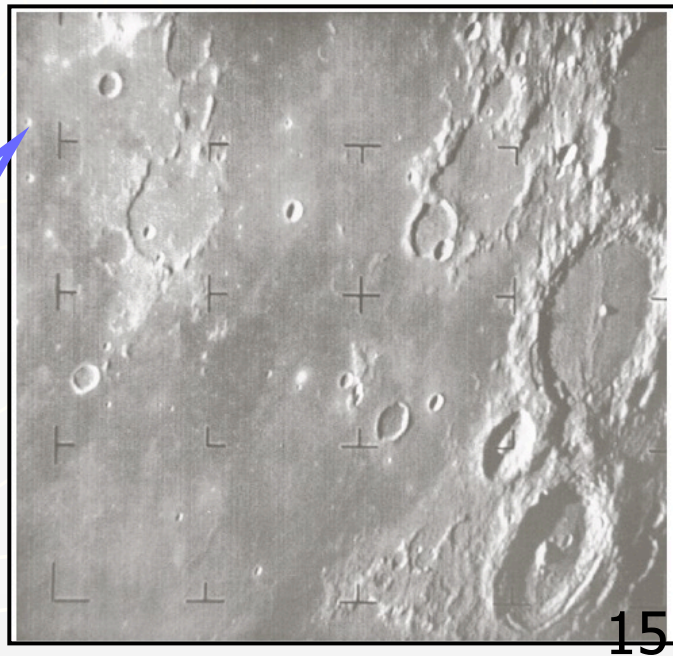
improved digital image

early 15-gray level digital image

History of Digital Image Processing

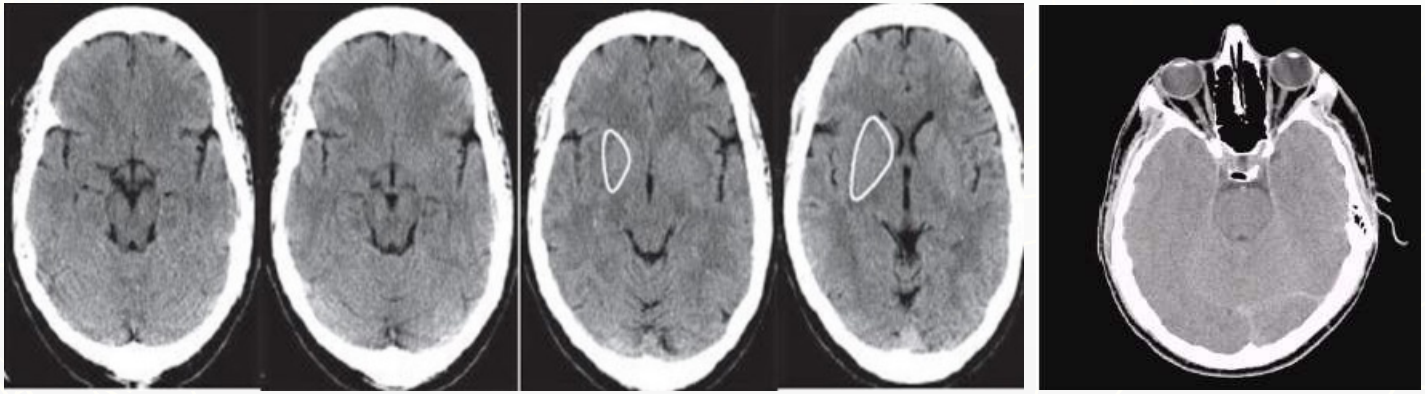
- Digital image processing needs lots of storage and computational power, so its progress depends on the development of digital computers.
- **1960s**: NASA carried out Ranger program to obtain the first close-up images of the surface of the moon.
  - Ranger spacecrafts were designed to take the images, and transmit the images to the earth.

- A picture of the moon taken by the Ranger 7 probe 17 min before destruction.
- Computers were used to improve the quality of the images.

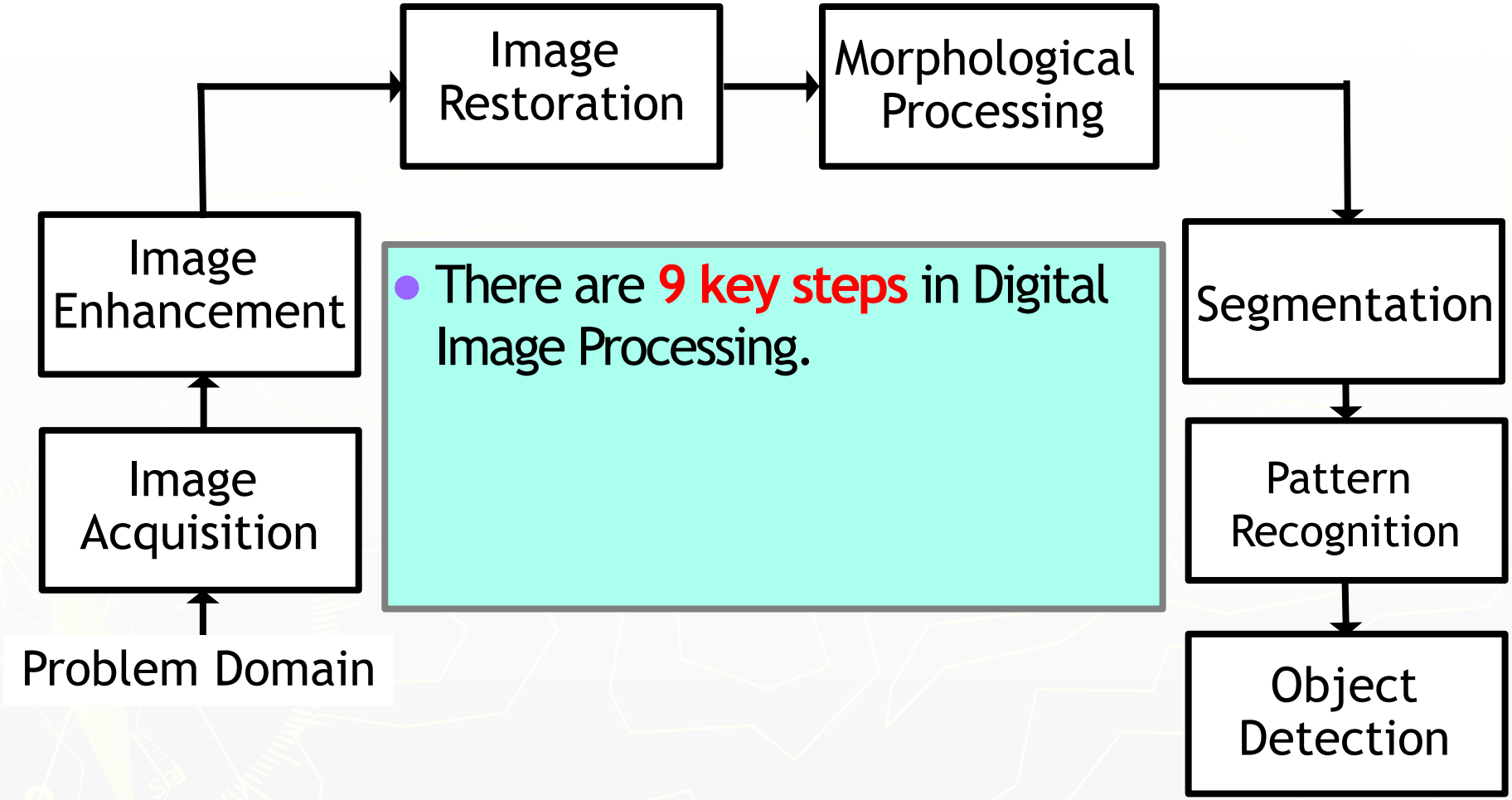


History of Digital Image Processing

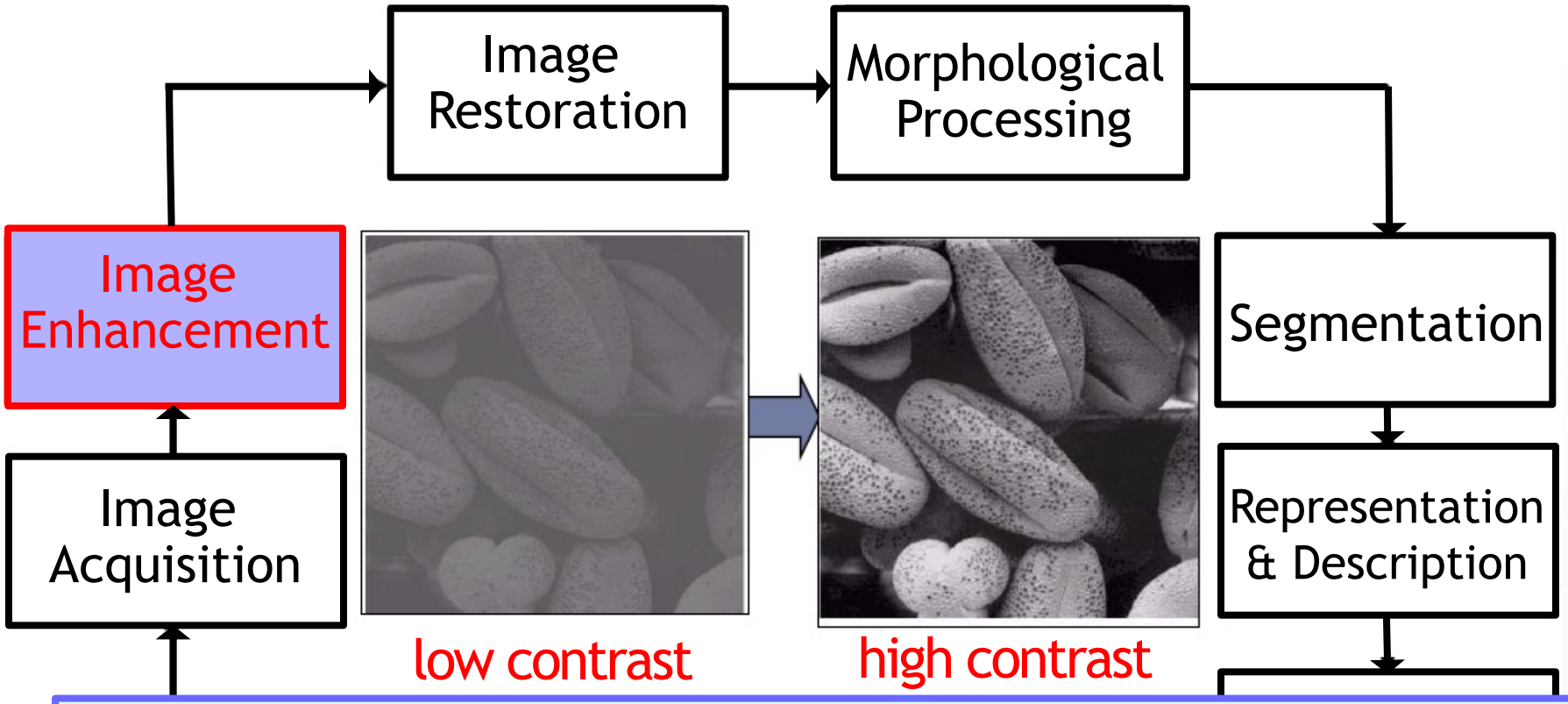
- **1970s**: DIP is being used in medical applications as well.
- IN healthcare different scanners are used such as X-Ray, MRI, CT.
- **Early 1970s**: Computerized tomography (CT), was invented.
  - This is one of the most important events in the application of image processing in medical diagnosis.



Key Steps in Digital Image Processing

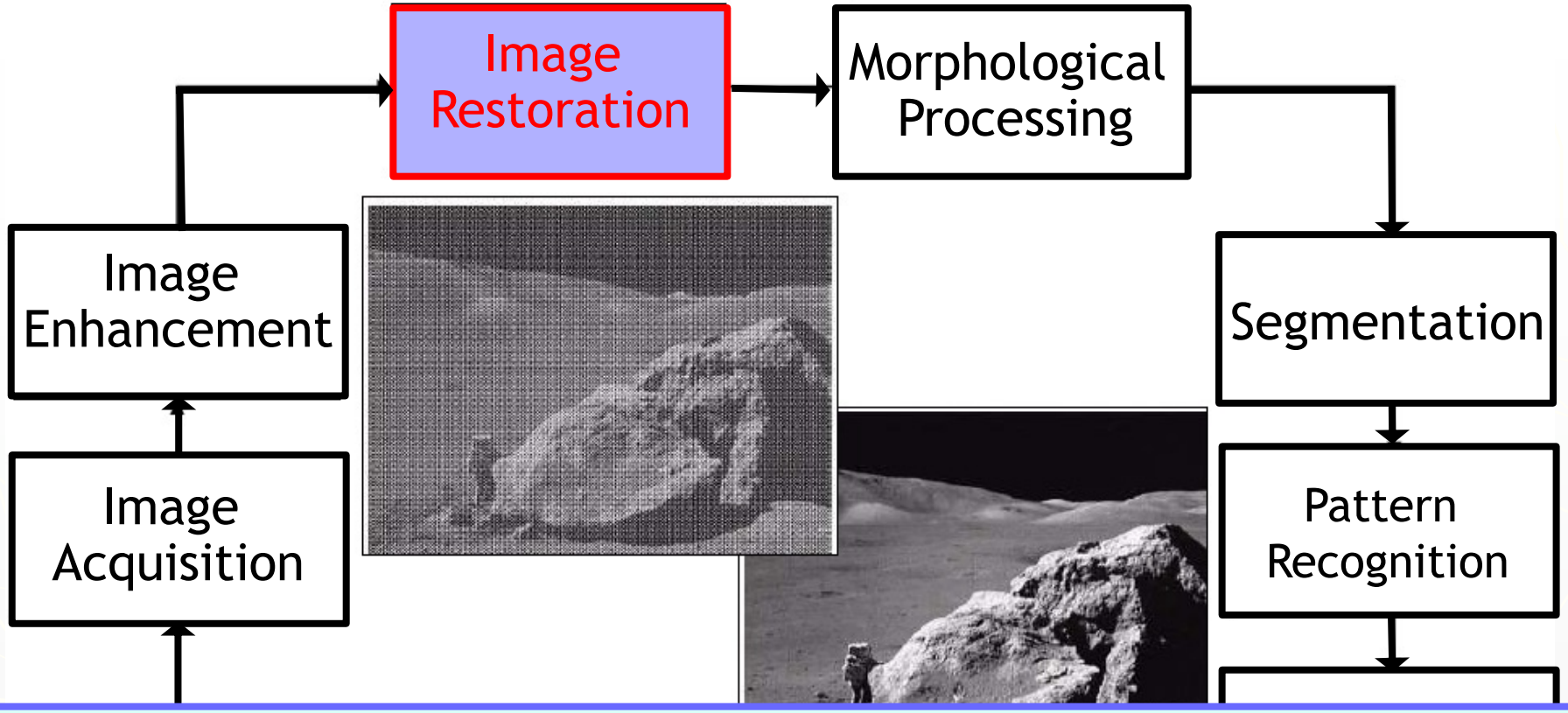


Key Steps in Digital Image Processing



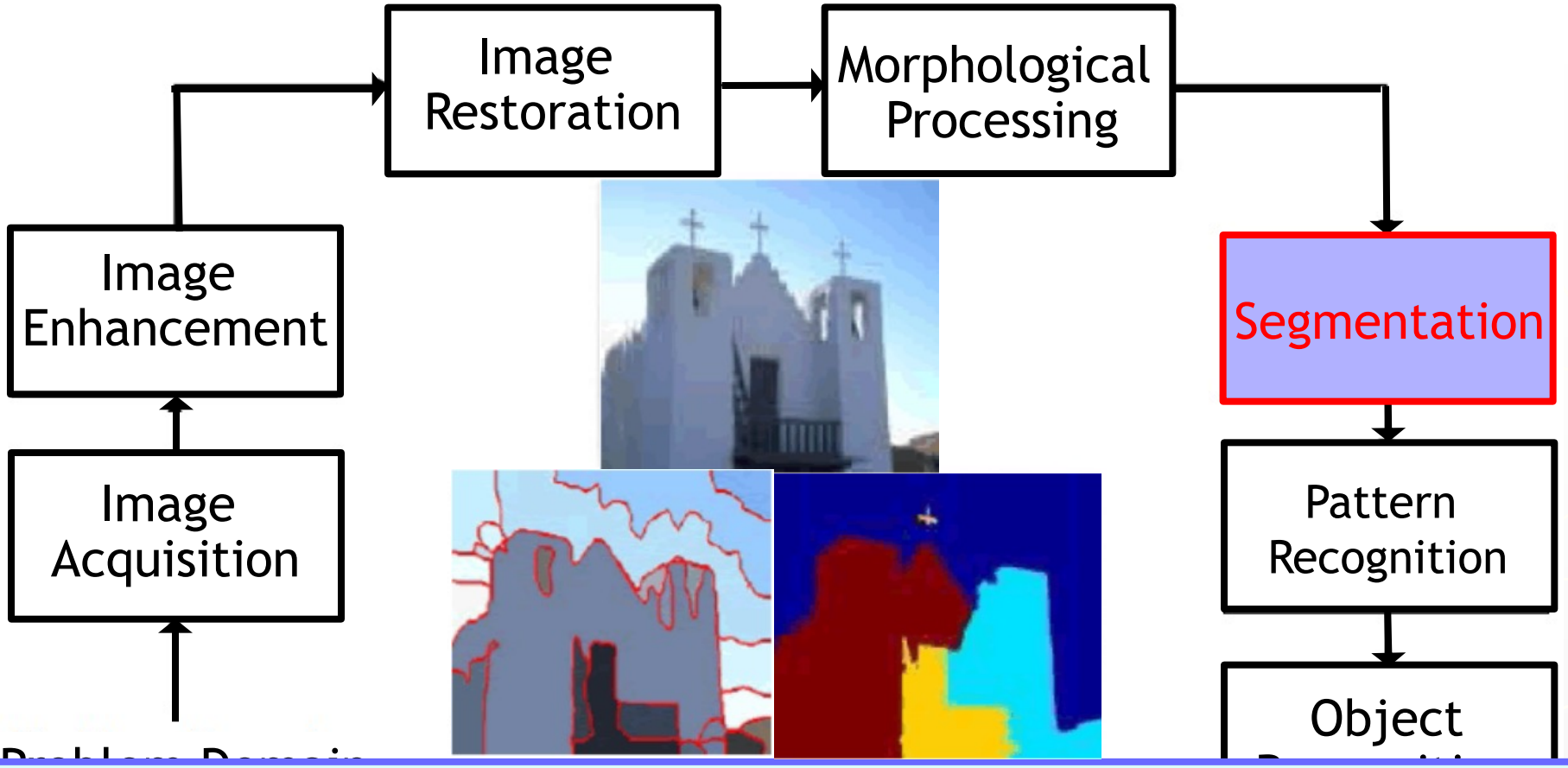
- This step focus on certain features of interest in the images.
- For example, increasing the **contrast** of an image to enhance the objects in the image.

Key Steps in Digital Image Processing



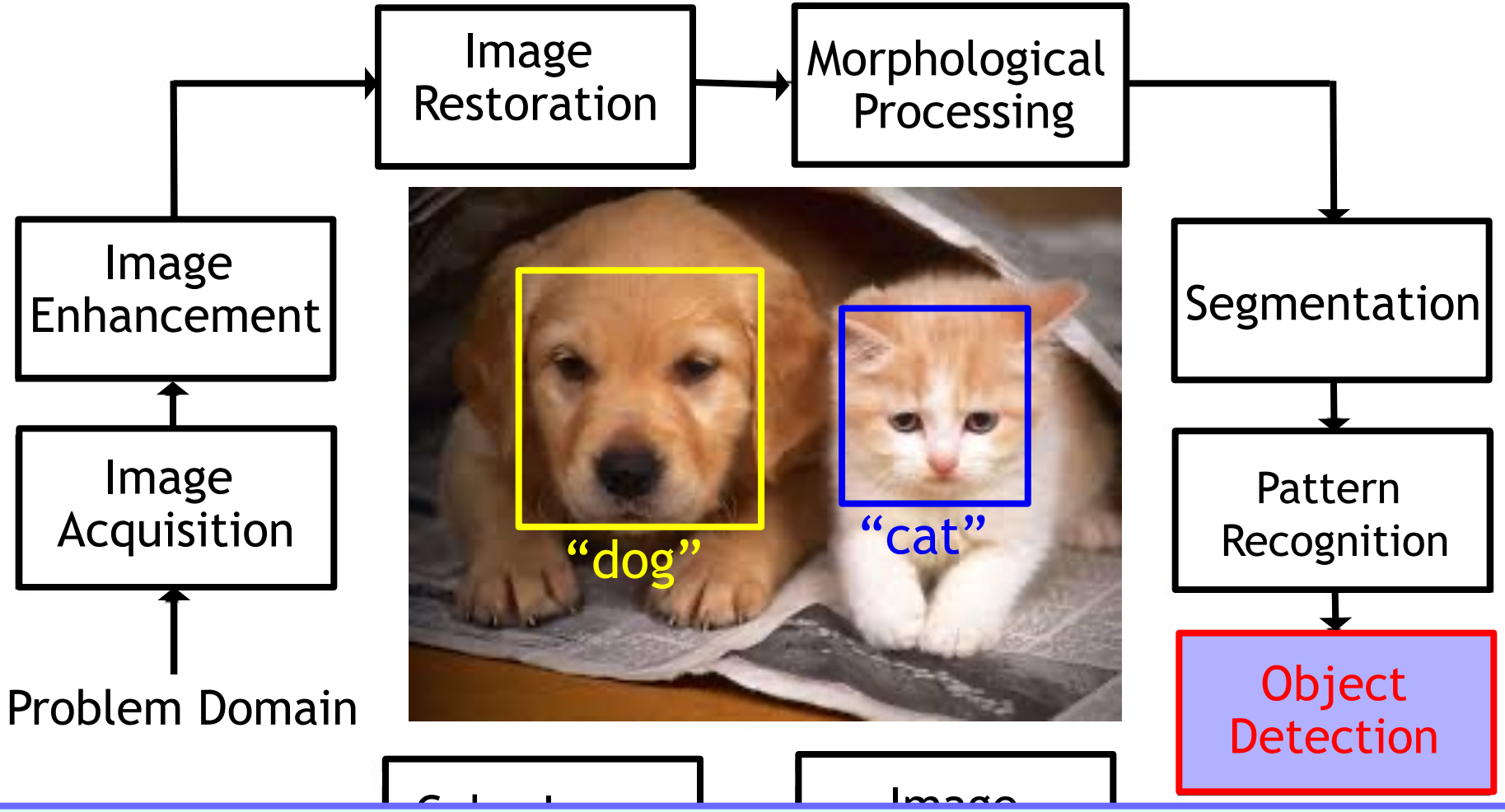
- This step is used to improve the appearance of images.
- For example, removing noise from images is a kind of restoration.

Key Steps in Digital Image Processing



- In this process, in any image, various objects are segmented.

Key Steps in Digital Image Processing



- Object detection is a technique that allows us to identify and locate the objects with their categories in images. (e.g. "dog" or "cat") .

Applications of Digital Image Processing

Face Expression Detection

- This technology has been already implemented in many digital cameras and smartphone applications
- Two steps processing:
  - Extract face regions in an image
  - Classify the face regions based on the expression

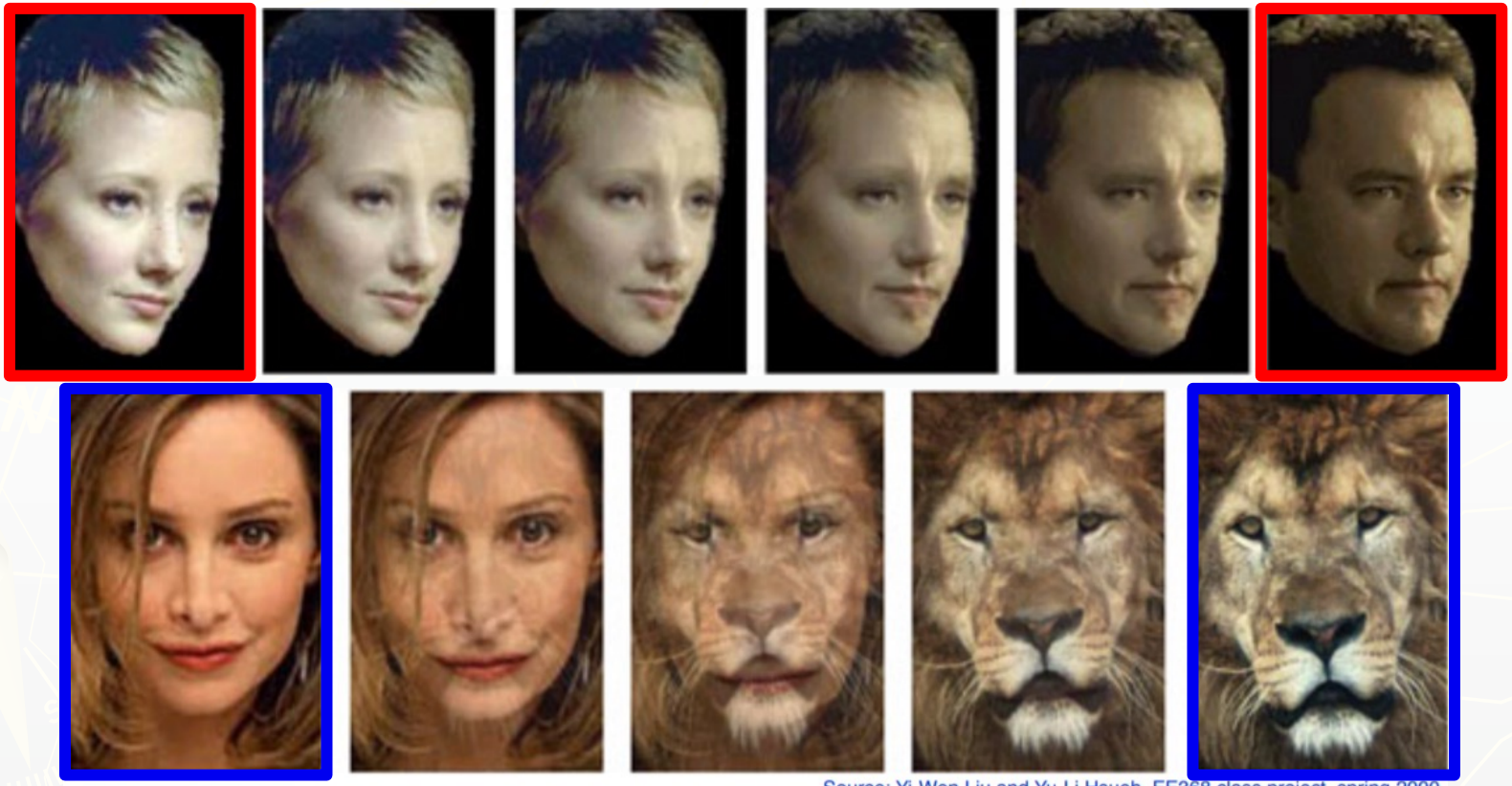
Object Detection in Supermarkets

- Detect and recognize the goods on the bottom of shopping carts

- The product code is sent to the POS, and automatically added to the final payment

Face Morphing

- The pictures generated in the middle show the transition between two images

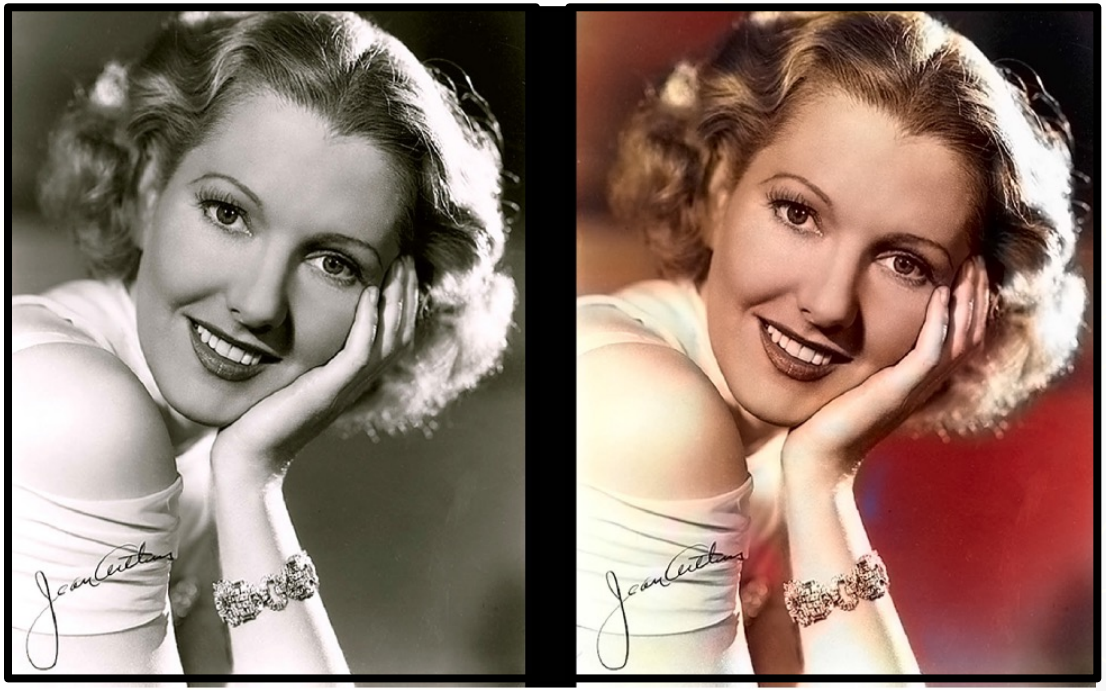


Source: Yi-Wen Liu and Yu-Li Hsueh, EE368 class project, spring 2000.

Colorizing Black and White Photos

- Given a grayscale (monochrome) image as input, generating a color version of the image.

grayscale image (input)



full color image (output)

Zhang et al, "Colorful Image Colorization", ECCV 2016

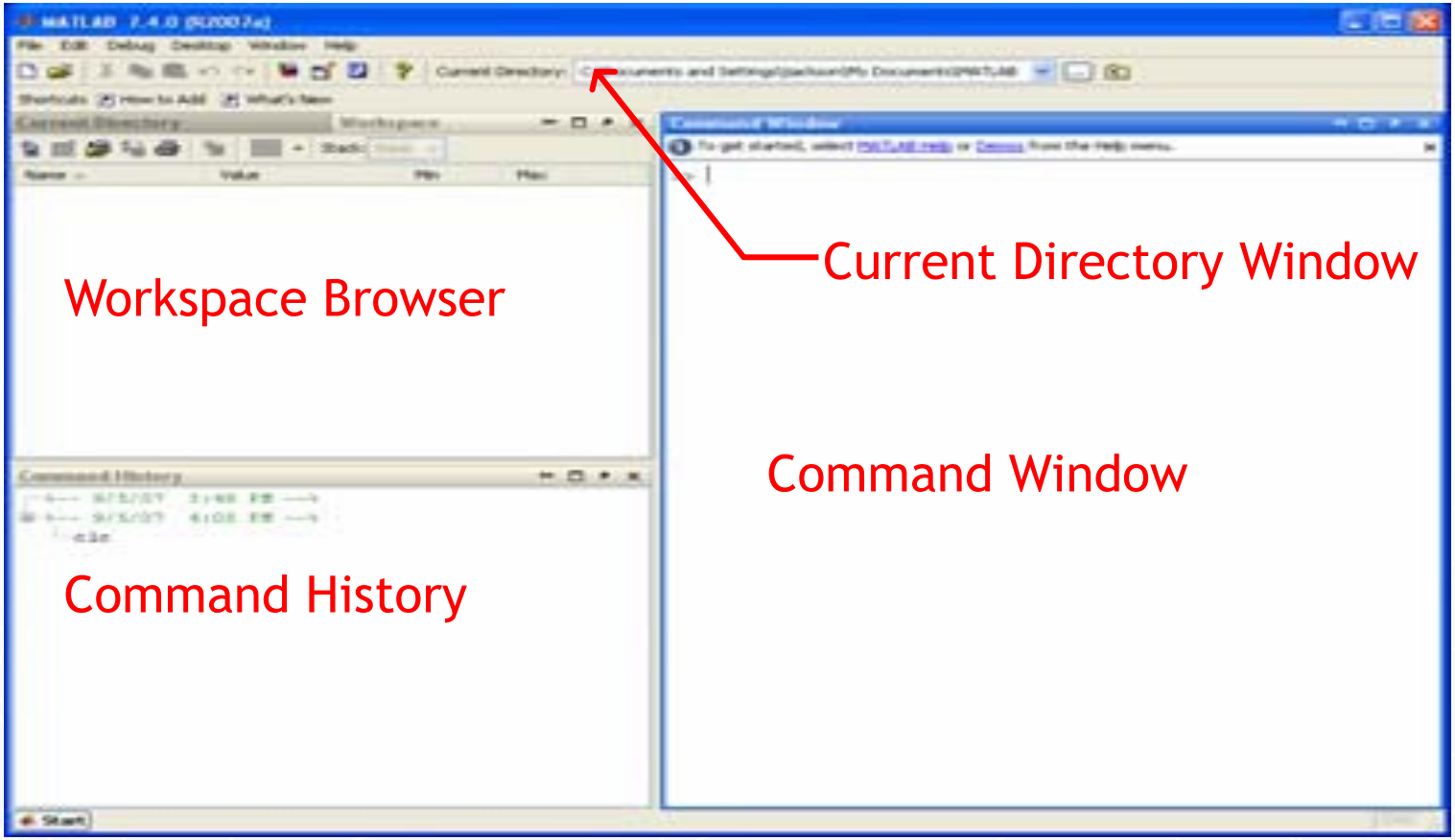
Image Processing using MATLAB

MATLAB

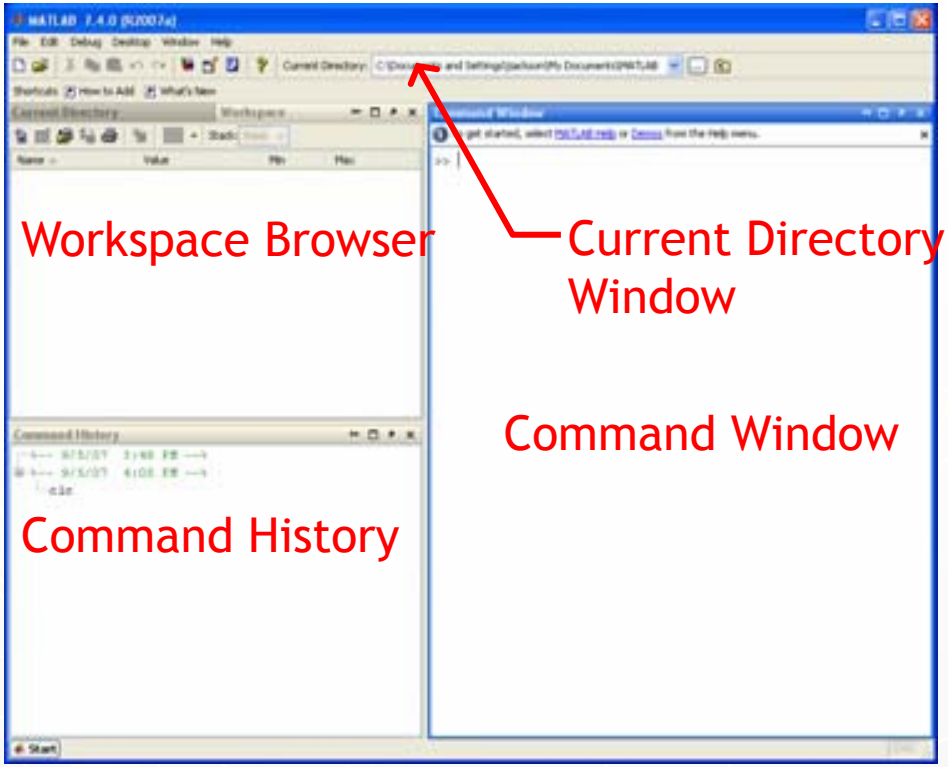
- This course uses MATLAB as the tool for programming
  - High-level programing language with high readability
  - There is a Image Processing toolbox to perform image processing tasks
  - Students in our University have access to MATLAB and Image Processing toolbox
- MATLAB is installed in these PCs.
- Today we will try some basic codes/functions for image processing using MATLAB

Launch the MATLAB

- The main interface has many sub-windows



Launch the MATLAB



- **Command window:** user types commands and expressions and outputs are displayed
- **Workspace browser:** shows the variables that the user creates in a work session
- **Current directory window:** shows the path of the current directory
- **Command history:** shows the record of previously executed commands

Using Editor to Create M-Files

- In MATLAB, functions and scripts are written in M-files and are usually edited using the MATLAB Editor
- To open the MATLAB Editor, simply type *edit* in the Command Window:

  >>edit

- Or type *edit filename*, which opens a specific M-file in the MATLAB Editor, which is ready for editing:

  >>edit filename.m

Digital Image Representation

- In MATLAB, IPT is usually used to miniplate images
  - IPT: *Image Processing Toolbox*
- A digital image can be represented as a 2D array

$$f = \begin{bmatrix} f(1,1) & f(1,2) & \cdots & f(1,N) \\ f(2,1) & f(2,2) & \cdots & f(2,N) \\ \vdots & \vdots & & \vdots \\ f(M,1) & f(M,2) & \cdots & f(M,N) \end{bmatrix}$$

- The notation f(p,q) denotes the pixel that located in row p and column q

Reading Images

- Reading images in IPT is straightforward by using the *imread* function
  - >>f=imread('lena.jpg');
    - Reads the file from the current directory into image array f.
  - >>f=imread('D:\myimages\lena.jpg');
    - As path information is included in filename, imread reads the image from the specified folder into image array f.
- The *size* function can then be used to check the resolution of the resulted 2D array
  - >>[M,N]=size(f);
    - Returns number of rows (M) and columns (N) in the image.

Displaying Images

- Images can be displayed using the *imshow* function
  - imshow(f, G)
    - f: image array
    - G: the number of intensity levels used to display it
- The codes below load and show an image on the screen
  - >>f=imread('lena.jpg');
  - >>imshow(f);
    - Show f in the first figure window
    - When G is omitted, imshow displays the image in 256 levels.
  - >>figure; imshow(f);
    - Creates a new figure window, and show f in the new window

Writing Images

- Images are written to disk using function *imwrite*
  - >>imwrite(f, 'lena.jpg');
    - The string contained in filename must include a recognized file format extension.
  - >>imwrite(g, 'lena', 'tif');
    - Or alternatively, the desired format can be specified explicitly with a third input argument.

Grayscale Image

- Reading grayscale images using the *imread* function retunes 2D arrays
  - $M \times N$: a pixel is defined by one element/value
- Reading color images using the *imread* function retunes 3D arrays
  - $M \times N$: a pixel is defined by three element/value (RGB)
- Color images can be converted to grayscale images by using the equation
  - *0.2989 * R + 0.5870 * G + 0.1140 * B*

Grayscale Image

- The follow codes convert a 3-channel color image to a 1-channel grayscale image
  - f=double(f);
  - im_gray=im(:,:,1)* 0.2989+ im(:,:,2)* 0.5870+ im(:,:,3)* 0.1140;
  - im_gray=uint8(im_gray);
  - figure, imshow(im_gray);
- Equivalent to the *rgb2gray* fuction in IPT

Today's Home Work

1. Install MATLAB follow the instruction below (optional)
   http://www.ritsumei.ac.jp/rainbow/service-softwarematlab/
2. Take the MATLAB online course offered by Mathworks.
   https://www.mathworks.com/learn/tutorials/matlab-onramp.html
   You can select preferred language. Registration is required.
3. Follow the instructions of Exercise 1 and try simple commands for image manipulation
   Instruction of Exercise 1 is available on manaba+R.

That’s all for today.