SCSV3213

FUNDAMENTAL OF IMAGE PROCESSING

INTRODUCTION TO IMAGE PROCESSING

Lecture 1

Dr. Md Sah Hj Salam

Acknowledgements

Most of the slide are taken and modified from other resources including books and slides from lectures from others universities. It is rearranged to suit the syllabus of the course.

SYNOPSIS

This is an introductory lecture on what is image processing(IP). Student is expected to be able to answer these questions upon the end of this lecture

1. What is Digital Image Processing ?
2. Image Processing Fields ?
3. Basic operations in Image Processing?
4. Application of Image Processing?
5. Fundamental Steps in Image Processing?
6. Components of Image Processing System?

1. WHAT IS IMAGE PROCESSING ?

Two Scholars on the Bridge
by Chen Hongshou
(陈洪绶, 1598-1652)
late Ming Dynasty.

An image worth thousands words

Basic Concept : Image

What is an Image?

A visual representation of an object, a person, or a scene produced by an optical device such as a mirror, a lens, or a camera.

- A few remarks:
  - This representation is typically 2D, although it usually corresponds to one of infinitely many projections of a real world, 3D object or scene.
  - This definition implicitly assumes the existence of a light source illuminating the scene, which is a requirement for the image to be produced.
  - An image means something, in other words, it is not a random arrangements of dark and bright points

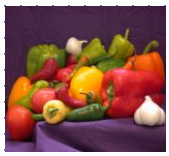
Basic Concept : Image

What is a Digital Image?

A digital image is a representation of a two-dimensional image using a finite number of points, usually referred to as *picture elements*, or *pixels*.

- A few remarks:
  - Each pixel is represented by one or more numerical values:
    - for monochrome (grayscale) images, a single value representing the intensity of the pixel (usually in a [0, 255] range) is enough;
    - for color images, three values (usually representing the amount of red (R), green (G), and blue (B)) are required.

Basic Concept : Image


Color Image

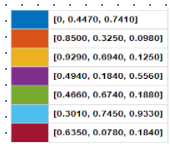

Gray Scale Image


Binary Image

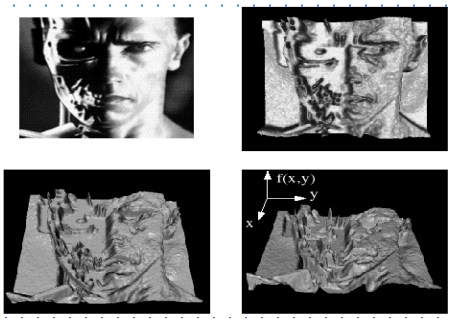
Basic Concept : Image

- We can think of an **image** as a function, f:
  - $f(x, y)$ gives the **intensity** at position (x, y)
  - Realistically, we expect the image only to be defined over a rectangle, with a finite range:
    - f: $[a,b]$x$[c,d]$ → $[0,1]$
- A color image is just three functions pasted together. We can write this as a "vector-valued" function:

$$f(x, y) = \begin{bmatrix} r(x, y) \\ g(x, y) \\ b(x, y) \end{bmatrix}$$



Basic Concept : Image as a function



Assuming this is an image segment as a function f(x,y) where x and y is the coordinate (yellow)

f(1,2) (Matlab corrdinate)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	143	137	113	88	69	30	39	62	41	44	68	67	33	17	15	14	14	14	15	11
2	163	145	119	84	55	20	24	40	26	22	38	30	14	6	5	4	4	3	4	4
3	166	139	108	73	47	20	16	26	21	15	22	14	15	10	1	4	6	7	9	5
4	152	122	91	65	44	23	21	21	23	16	20	17	20	15	6	10	10	6	12	10
5	128	97	75	61	47	34	24	22	26	23	15	16	20	16	12	12	14	7	10	18
6	103	80	64	56	51	45	26	20	28	30	15	12	21	24	20	15	16	15	9	20
7	96	65	61	52	51	51	33	23	29	34	14	11	20	29	27	20	18	23	15	17
8	97	69	65	53	53	57	36	28	30	38	20	14	16	26	27	24	17	24	24	16
9	102	75	68	65	63	64	39	21	28	41	24	18	17	20	24	23	17	28	33	24
10	96	74	78	72	67	59	39	22	33	47	36	32	23	18	24	24	26	44	40	29
11	82	81	87	73	65	41	38	36	46	55	44	38	30	17	22	28	36	44	36	30
12	85	90	81	69	55	39	40	57	69	63	46	40	35	18	20	33	41	32	30	38
13	94	87	76	65	46	47	51	74	85	75	51	35	33	18	23	38	36	26	30	46
14	98	74	76	67	49	58	87	88	90	80	58	35	34	22	29	43	34	30	36	58
15	97	79	74	56	63	99	114	97	92	82	64	43	40	35	32	41	34	32	46	84
16	99	75	62	59	97	138	126	105	96	88	70	50	46	41	35	39	39	36	59	103
17	98	68	57	90	137	145	137	119	104	86	74	53	50	49	36	38	46	43	72	115
18	92	61	75	125	156	143	139	135	119	92	81	61	51	52	40	38	49	47	80	123
19	82	64	105	146	168	147	139	140	123	99	85	68	62	59	41	38	49	58	86	129
20	82	88	137	166	173	158	140	129	108	96	91	72	65	62	44	44	52	72	91	129

Basic Concept : Image Processing

What is Image Processing?

It is the science of modifying digital images by means of a digital computer.

- A few remarks:
  - The changes that take place in the images are usually performed *automatically* and rely on carefully designed algorithms to carry out such tasks.

Basic Concept : Image Processing

- Image processing from this simple equation

$$H(f(x,y)) = f(x,y) / 2$$

  - f(x,y) : represent the image
  - H is the operation applied on the image
  - The operation is f(x,y) /2

6	8	2	0
12	200	20	10

→

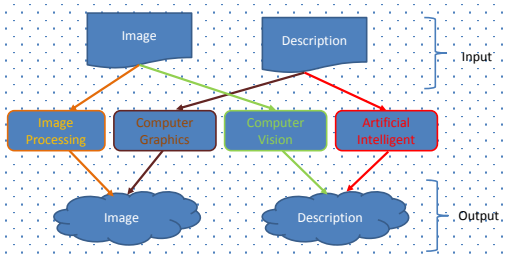
3	4	1	0
6	100	10	5

Basic Concept : Image processing

- What are the goals of image processing algorithms?
  - Image processing algorithms are usually designed to improve the suitability of the image in order to either:
    - enable human interpretation, or
    - make it more suitable to further analysis and automatic extraction of some of its contents.
  - Sometimes these goals can be at odds with each other.
    - Example:
      - **Sharpening** an image to allow inspection of additional fine-grained details (better for human viewing)
      - vs.
      - **Blurring** an image to reduce the amount of irrelevant information (better for a machine vision solution).

2. FIELDS OF IMAGE PROCESSING

Basic Concept : Fields of IP



Basic Concept : Fields of IP

- **Computer Graphics:** The creation of images
- **Image Processing:** Enhancement or other manipulation of the image
- **Computer Vision:** Analysis of the image content

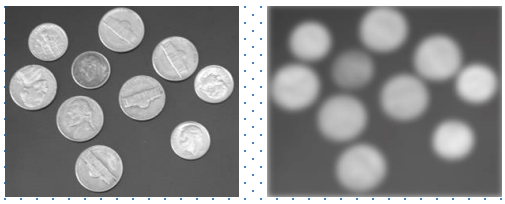
3. IMAGE PROCESSING OPERATION

Image Processing Operation

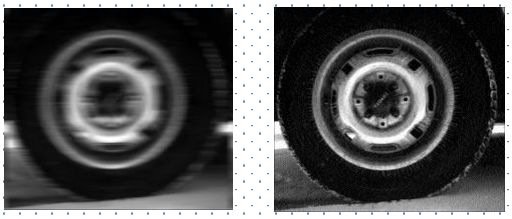
- 3 levels of image processing operations:
  - **Low- level**: primitive operations (e.g., noise reduction, contrast enhancement, etc.) where both the input and output are images.
  - **Mid-level**: extraction of attributes (e.g., edges, contours, regions, etc.) from images.
  - **High-level**: analysis and interpretation of the contents of a scene.

Example IP Operation: Sharpening

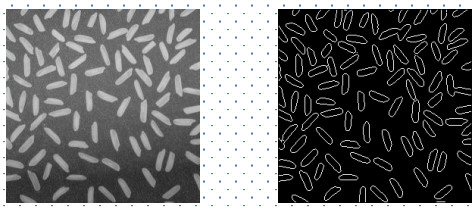
Example IP Operation: Blurring



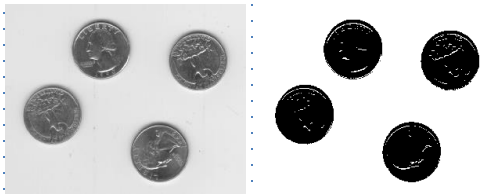
Example IP Operation: Deblurring



Example IP Operation: Edge Detection

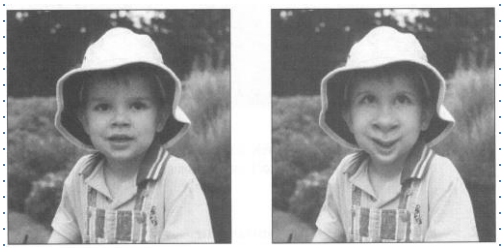


Example IP Operation: Binarization



Example IP Operation: Contrast Enhancement

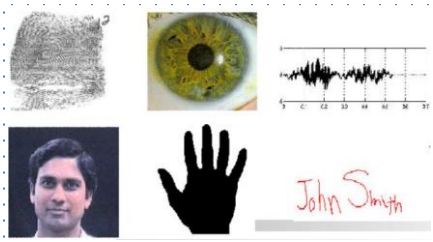
Example IP Operation: Image Warping



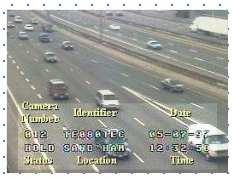
4. IMAGE PROCESSING APPLICATIONS

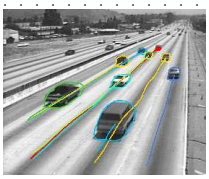
Application: Signature verification

Application: Biometric

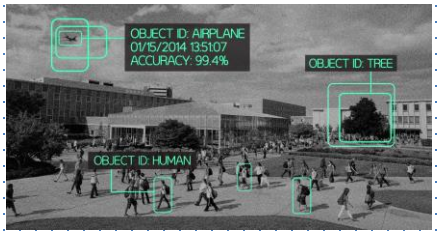


Application: Traffic Monitoring

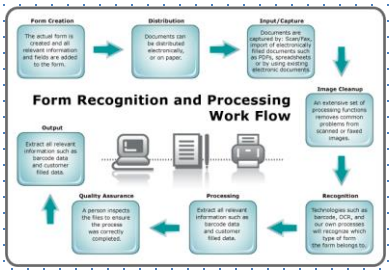




Application: Object Recognition



Application: Document Handling



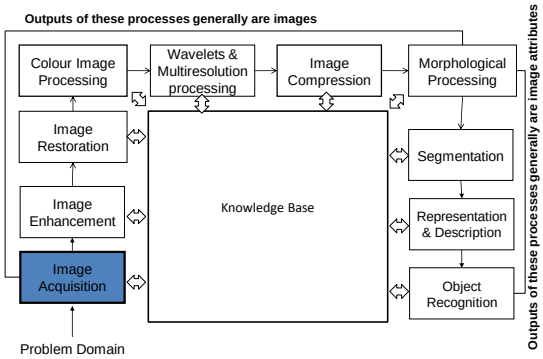
Application: Others

- Medical applications: PET, CAT scans, MRI and fMRI, etc.
- Industrial applications
- Consumer electronics
- Military applications
- Law enforcement and security
- Internet, particularly the Web.
- Etc..

Your 1st Assignment is to write no more than 5 slides (ppt) showing an applications of image processing for real life application either in industry, military, medical or security.

5. FUNDAMENTAL STEPS IN IMAGE PROCESSING

Fundamental Steps in Digital Image Processing:



Fundamental Steps in DIP: (Description)

Step 1: Image Acquisition

The image is captured by a sensor (eg. Camera), and digitized if the output of the camera or sensor is not already in digital form, using analogue-to-digital convertor

Fundamental Steps in DIP: (Description)

Step 2: Image Enhancement

The process of manipulating an image so that the result is more suitable than the original for specific applications.

The idea behind enhancement techniques is to bring out details that are hidden, or simple to highlight certain features of interest in an image.

Fundamental Steps in DIP: (Description)

Step 3: Image Restoration

- Improving the appearance of an image

- Tend to be mathematical or probabilistic models. Enhancement, on the other hand, is based on human subjective preferences regarding what constitutes a “good” enhancement result.

Fundamental Steps in DIP: (Description)

Step 4: Colour Image Processing

Use the colour of the image to extract features of interest in an image

Fundamental Steps in DIP: (Description)

Step 5: Wavelets

Are the foundation of representing images in various degrees of resolution. It is used for image data compression.

Fundamental Steps in DIP: (Description)

Step 6: Compression

Techniques for reducing the storage required to save an image or the bandwidth required to transmit it.

Fundamental Steps in DIP: (Description)

Step 7: Morphological Processing

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

In this step, there would be a transition from processes that output images, to processes that output image attributes.

Fundamental Steps in DIP: (Description)

Step 8: Image Segmentation

Segmentation procedures partition an image into its constituent parts or objects.

Important Tip: The more accurate the segmentation, the more likely recognition is to succeed.

Fundamental Steps in DIP: (Description)

Step 9: Representation and Description

- **Representation:** Make a decision whether the data should be represented as a boundary or as a complete region. It is almost always follows the output of a segmentation stage.
  - **Boundary Representation:** Focus on external shape characteristics, such as corners and inflections (انحناءات)
  - **Region Representation:** Focus on internal properties, such as texture or skeleton (هيكلية) shape

Fundamental Steps in DIP: (Description)

Step 9: Representation and Description

- Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing (mainly recognition)

- **Description:** also called, ***feature selection***, deals with extracting attributes that result in some information of interest.

Fundamental Steps in DIP: (Description)

Step 9: Recognition and Interpretation

Recognition: the process that assigns label to an object based on the information provided by its description.

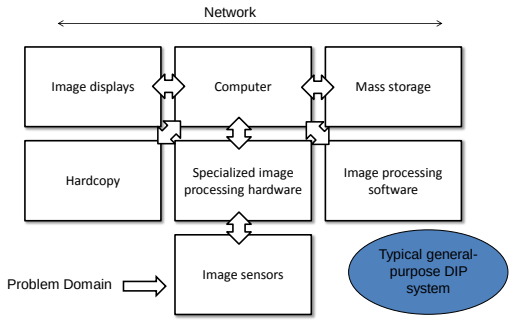
Fundamental Steps in DIP: (Description)

Step 10: Knowledge Base

Knowledge about a problem domain is coded into an image processing system in the form of a knowledge database.

6. COMPONENTS OF IMAGE PROCESSING SYSTEM

Components of an Image Processing System



Components of an Image Processing System

1. Image Sensors

Two elements are required to acquire digital images. The first is the physical device that is sensitive to the energy radiated by the object we wish to image (*Sensor*). The second, called a *digitizer*, is a device for converting the output of the physical sensing device into digital form.

Components of an Image Processing System

2. Specialized Image Processing Hardware

Usually consists of the digitizer, mentioned before, plus hardware that performs other primitive operations, such as an arithmetic logic unit (ALU), which performs arithmetic and logical operations in parallel on entire images.

This type of hardware sometimes is called a front-end subsystem, and its most distinguishing characteristic is speed. In other words, this unit performs functions that require fast data throughputs that the typical main computer cannot handle.

Components of an Image Processing System

3. Computer

The computer in an image processing system is a general-purpose computer and can range from a PC to a supercomputer. In dedicated applications, sometimes specially designed computers are used to achieve a required level of performance.

Components of an Image Processing System

4. Image Processing Software

Software for image processing consists of specialized modules that perform specific tasks. A well-designed package also includes the capability for the user to write code that, as a minimum, utilizes the specialized modules.

Components of an Image Processing System

5. Mass Storage Capability

Mass storage capability is a must in a image processing applications. And image of sized 1024 * 1024 pixels requires one megabyte of storage space if the image is not compressed.

Digital storage for image processing applications falls into three principal categories:

1. Short-term storage for use during processing.
2. on line storage for relatively fast recall
3. Archival storage, characterized by infrequent access

Components of an Image Processing System

5. Mass Storage Capability

One method of providing short-term storage is computer memory. Another is by specialized boards, called frame buffers, that store one or more images and can be accessed rapidly.

The on-line storage method, allows virtually instantaneous image zoom, as well as scroll (vertical shifts) and pan (horizontal shifts). On-line storage generally takes the form of magnetic disks and optical-media storage. The key factor characterizing on-line storage is frequent access to the stored data.

Finally, archival storage is characterized by massive storage requirements but infrequent need for access.

Components of an Image Processing System

6. Image Displays

The displays in use today are mainly color (preferably flat screen) TV monitors. Monitors are driven by the outputs of the image and graphics display cards that are an integral part of a computer system.

Components of an Image Processing System

7. Hardcopy devices

Used for recording images, include laser printers, film cameras, heat-sensitive devices, inkjet units and digital units, such as optical and CD-Rom disks.

Components of an Image Processing System

8. Networking

Is almost a default function in any computer system, in use today. Because of the large amount of data inherent in image processing applications the key consideration in image transmission is bandwidth.

In dedicated networks, this typically is not a problem, but communications with remote sites via the internet are not always as efficient.

End Introduction to the Fundamental of Image Processing SCSV 3213