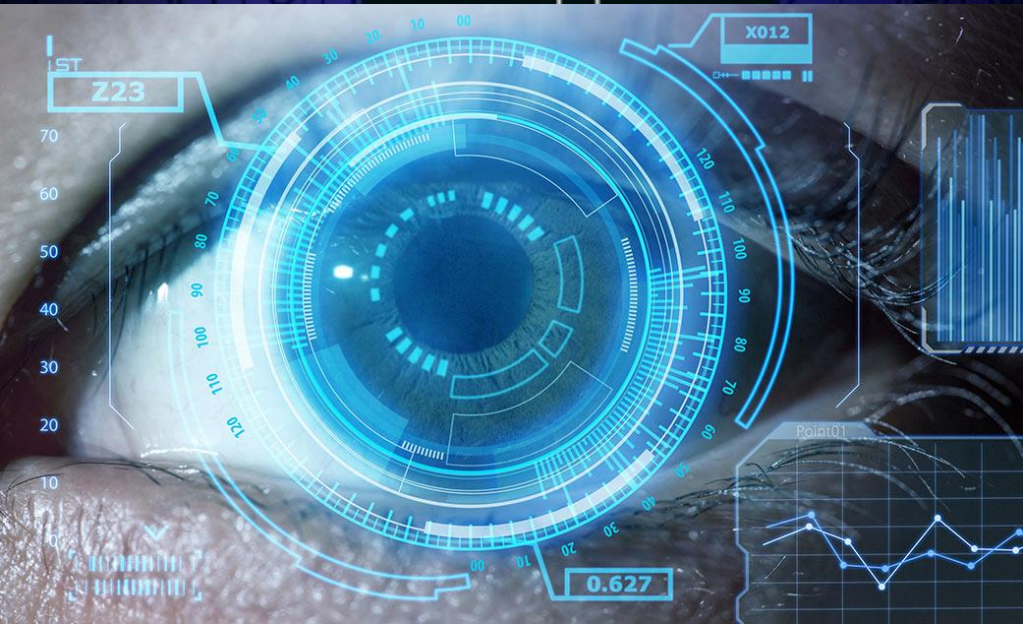

Digital Image Processing and Computer Vision

AINT 32012

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Dept. of Software Engineering

Faculty of Computing and Technology

University of Kelaniya

Course Aim/Intended Learning Outcomes:

On completion of this course, you should be able to:

- discuss the basic steps of Digital Image Processing System,
- describe types of noise in images and noise removal techniques,
- describe and apply image quality enhancement techniques,
- describe principles of image compression models and apply image compression techniques and standards,
- explain the principles of computer vision,
- apply mathematical techniques and related algorithms for image understanding.

Course Content

Digital Image Processing Fundamentals: Definition of Image and Digital Image Processing, Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Visual Perception, Digital Image Acquisition Methods, Zooming and Shrinking of Digital Image; Image Transforms and Enhancements in Spatial Domain and Frequency Domain;

Image restoration: Noise Models, Restoration in Presence of Noise, Periodic Noise Reduction by Frequency Domain Filtering, Inverse Filtering, Minimum Mean Square Error Filtering (Wiener Filtering);

Colour Image Processing: Categories of Colour Image Processing, Colour Fundamentals, Colour Models, Conversions between Colour Models, Colour Transformation, Colour Image Smoothing and Sharpening, Colour Segmentation; Wavelets and Image processing;

Image Compression: Image Compression Model, Compression Strategies, Lossless and Lossy Compression, Image Compression Standards;

Morphological Image Processing: Logic Operations Involving Binary Images, Dilation and Erosion, Hit-or-Miss Transformation, Basic Morphological Algorithm;

Feature Extraction and Image Segmentation: Classification of Features, Features of an Image, Attributes of Features, Complete Process of Feature Extraction, Image Segmentation; Approaches for Pattern recognition and Texture recognition..

Continuous Assessment

- Assessment Strategy:

End of semester examination, class test and assignments

Continuous Assessment 40%	Final Assessment 60%
Class Test – 20% Assignments – 20%	Theory (%) 60%

References/Reading Materials

1. Rafael, C. G., Richard, E. W. and Steven, L. E., (2004). Digital Image Processing using MATLAB, Pearson Education.

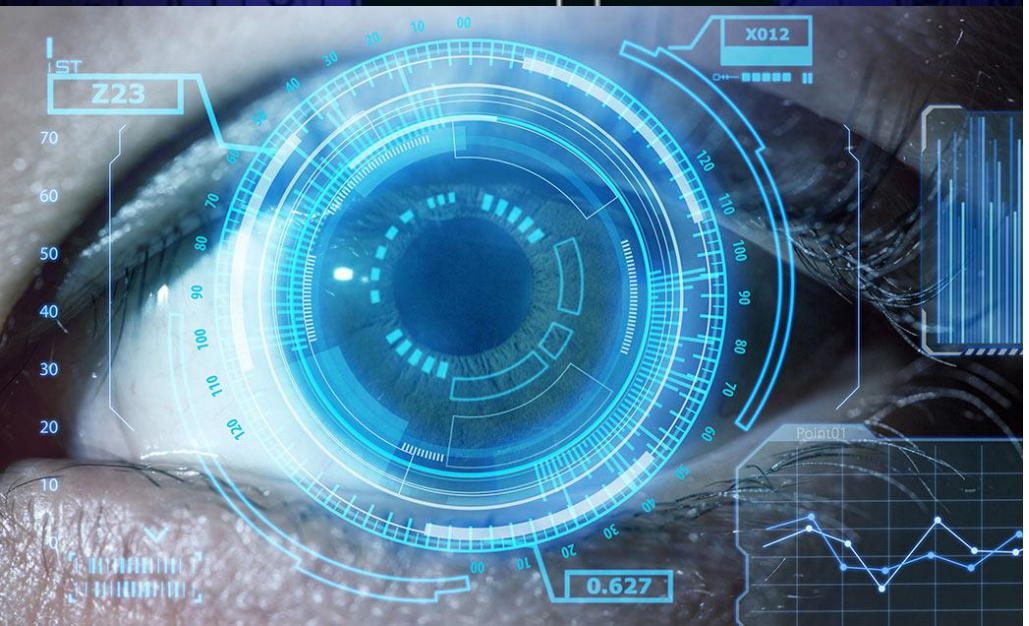
2. Fisher, R. and Dawson-Howe, K., Fitzgibbon, A., Robertson, C., Trucco, E., (2005), Dictionary of Computer Vision and Image Processing, John Wiley.

3. Tim, M., (2004). Computer Vision and Image Processing. Palgrave Macmillan.

4. Milan, S., Vaclav, H. and Roger, B. (1999), Image Processing, Analysis, and Machine Vision, PWS Publishing.

5. Maria, P. and Costas, P., (2010), Image Processing: The Fundamentals, 2nd Edition, Wiley.McFadden, F. R., Hoffer, J. A. and Prescott, M. B.(2006), Modern Database Management, 8th Edition, Pearson Education Series.

Additional Articles will be uploaded to LMS



Digital Image Processing and Computer Vision

AINT 32012

Lesson 1
Introduction

Introduction

- **Signal processing** is a discipline in electrical engineering and in mathematics that deals with analysis and processing of analog and digital signals , and deals with storing , filtering , and other operations on signals.
- These signals include transmission signals , sound or voice signals , image signals , and other signals etc.
- It can be further divided into **analog image processing** and **digital image processing**.

Digital Image and a Signal

- Any quantity measurable through time over space or any higher dimension can be taken as a **signal**.
- A signal is a mathematical function, and it conveys some information.
- A signal can be one dimensional or two dimensional or higher dimensional signal.
  - One dimensional signal is a signal that is measured over time.
    - The common example is a voice signal.
  - The two dimensional signals are those that are measured over some other physical quantities.
    - The example of two dimensional signal is a digital image.

Introduction

- Interest in digital image processing methods stems from two principal application areas:

1. improvement of pictorial information for human interpretation,
2. and processing of image data for tasks such as storage, transmission, and extraction of pictorial information.

WHAT IS DIGITAL IMAGE PROCESSING?

Digital Images in Early Era

1921 Telegraphing image

Printing industrial

Textile industrial

1922: image from Photographic reproduction Using punched tape

These images are not computerized processed.

Origin of Digital Image

A digital picture produced in 1921 from a coded tape by a telegraph printer with special typefaces. (McFarlane.) [References in the bibliography at the end of the book are listed in alphabetical order by authors' last names.]

- The first application of digital image was in the newspaper industry when the pictures were first sent by **submarine cable between London and New York**.
- The cable picture transmission in 1921 reduced the time required to transport a picture across the Atlantic for more than a week to less than 3 hours.

Digital Images in Early Era

FIGURE 1.3
Unretouched cable picture of Generals Pershing and Foch, transmitted in 1929 from London to New York by 15-tone equipment. (McFarlane.)

Digital Image Processing in Early Space Projects

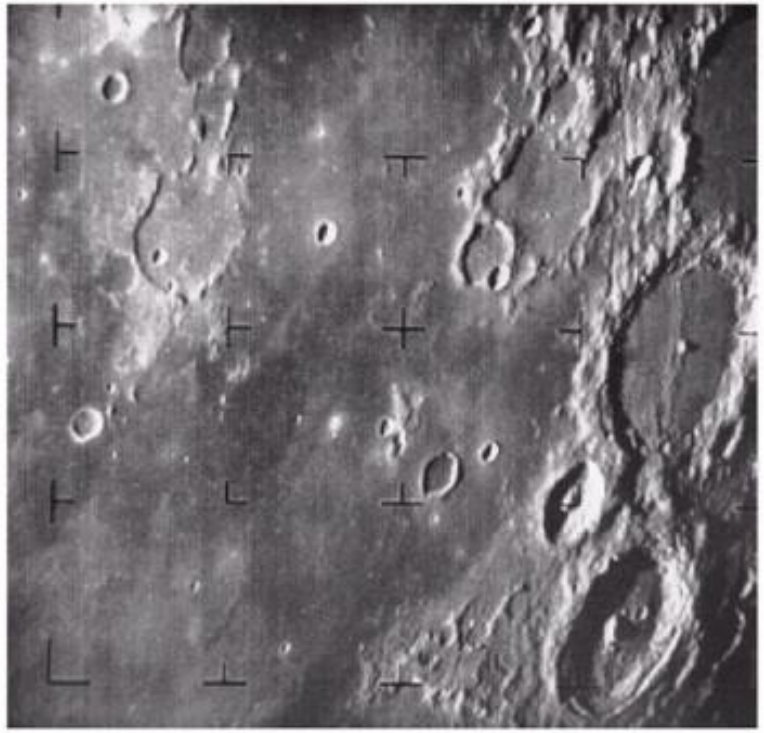
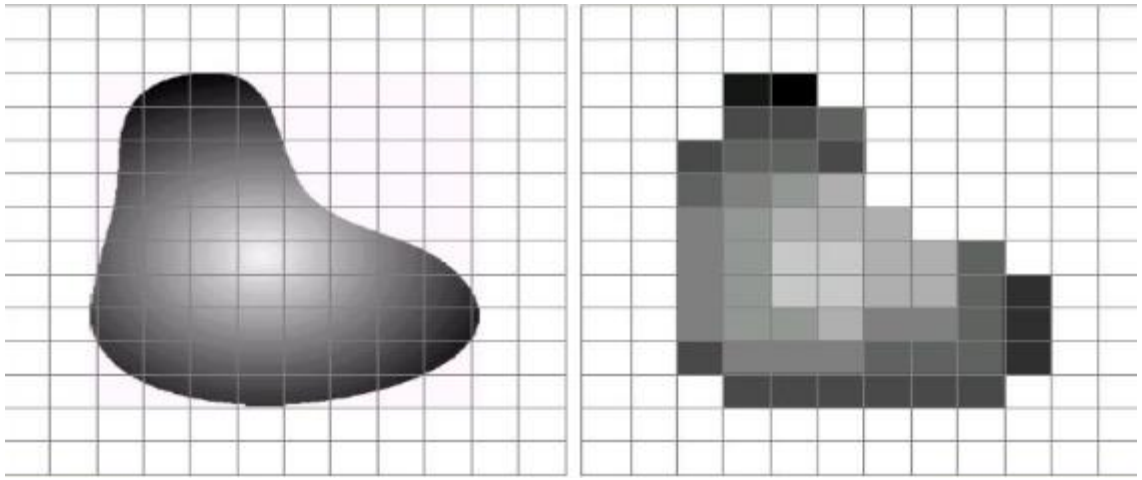


FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

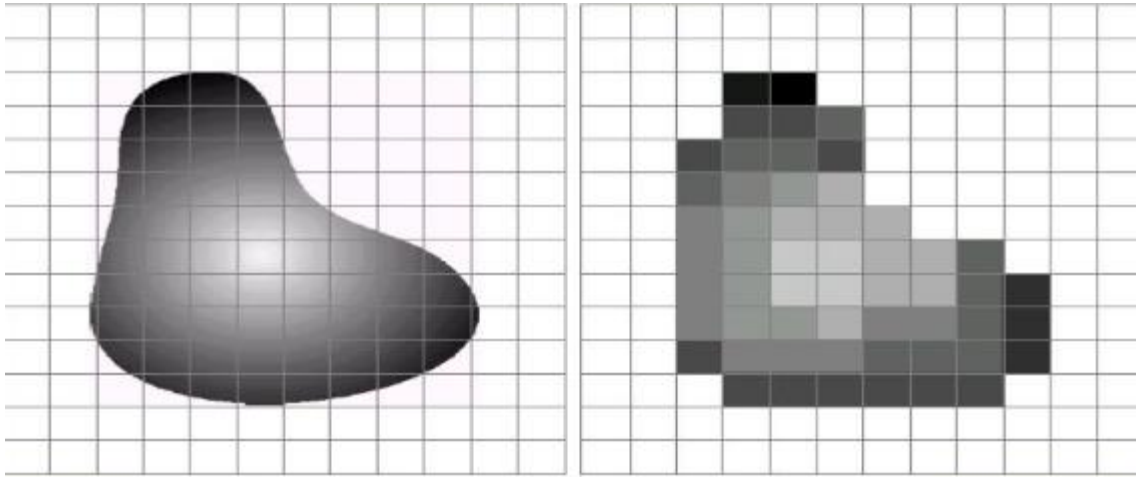
WHAT IS DIGITAL IMAGE PROCESSING?

- **An image** may be defined as a two-dimensional function, ***f* (*x*, *y*)**, where *x* and *y* are ***spatial* (plane) coordinates**, and the **amplitude** 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 the intensity values of *f* are all finite, discrete quantities, we call the image a ***digital image***.



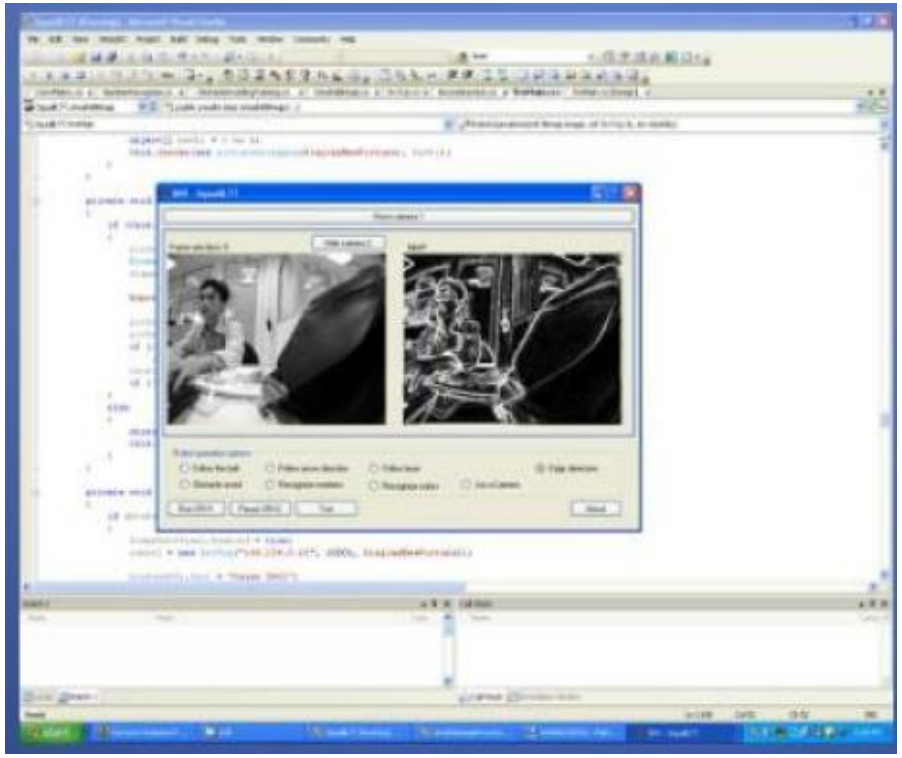
WHAT IS DIGITAL IMAGE PROCESSING Cont..

- Digital Image the representation of 2-D image as finite number of elements which called pixels.



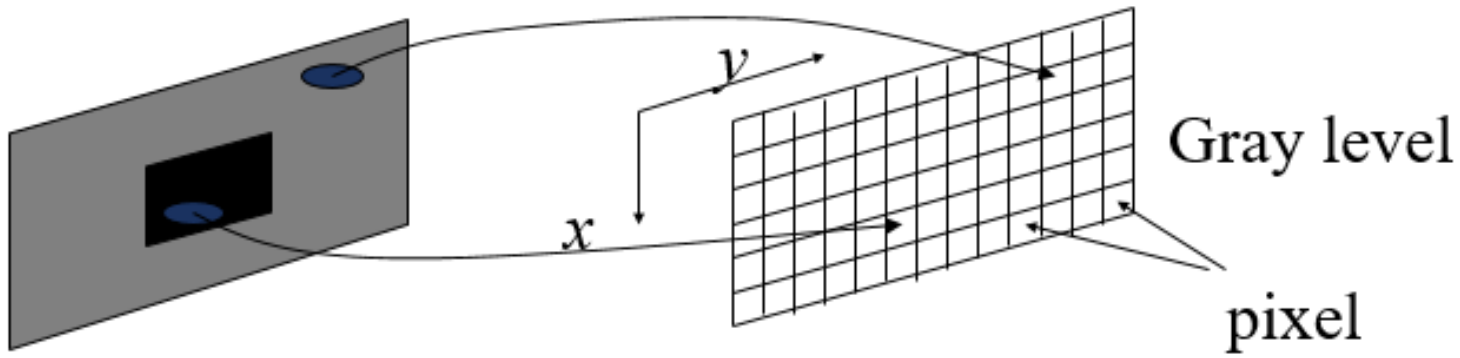
WHAT IS DIGITAL IMAGE PROCESSING Cont..

- DIP refers to processing digital images by means of a digital computer.
- DIP is the use of computer algorithms to perform image processing on digital image.



What is an Image? The bitmap representation

- Also called "raster or pixel maps" representation
- An image is broken up into a grid

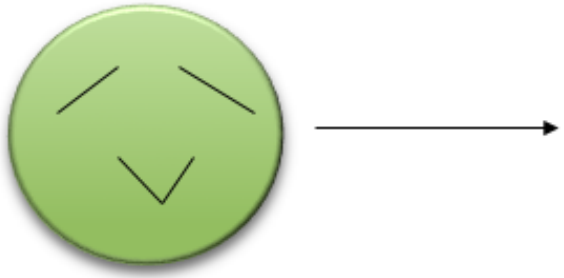


Original picture
$f(x, y)$

Digital image
I[i, j] or I[x, y]

What is an Image? The vector representation

- Object-oriented representation
- Does not show information of individual pixel, but information of an object (circle, line, square, etc.)



Circle(100, 20, 20)
Line(xa1, ya1, xa2, ya2)
Line(xb1, yb1, xb2, yb2)
Line(xc1, yc1, xc2, yc2)
Line(xd1, yd1, xd2, yd2)

Comparison

- Bitmap
  - Can represent images with complex variations in colors, shades, shapes.
  - Larger image size
  - Fixed resolution
  - Easier to implement

- Vector
  - Can only represent simple line drawings (CAD), shapes, shadings, etc.
  - Efficient
  - Flexible
  - Difficult to implement - mathematical complicity

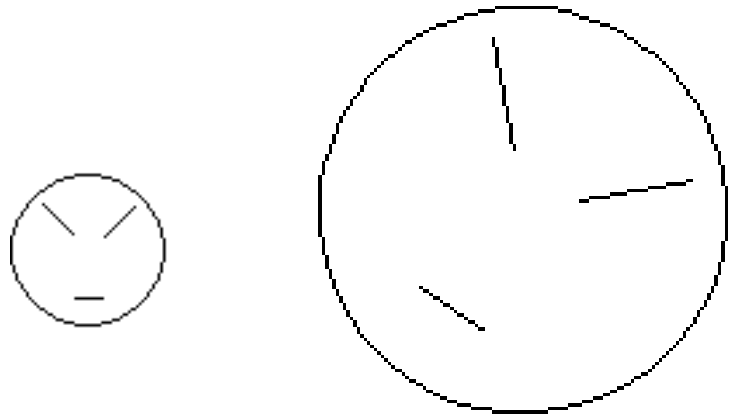
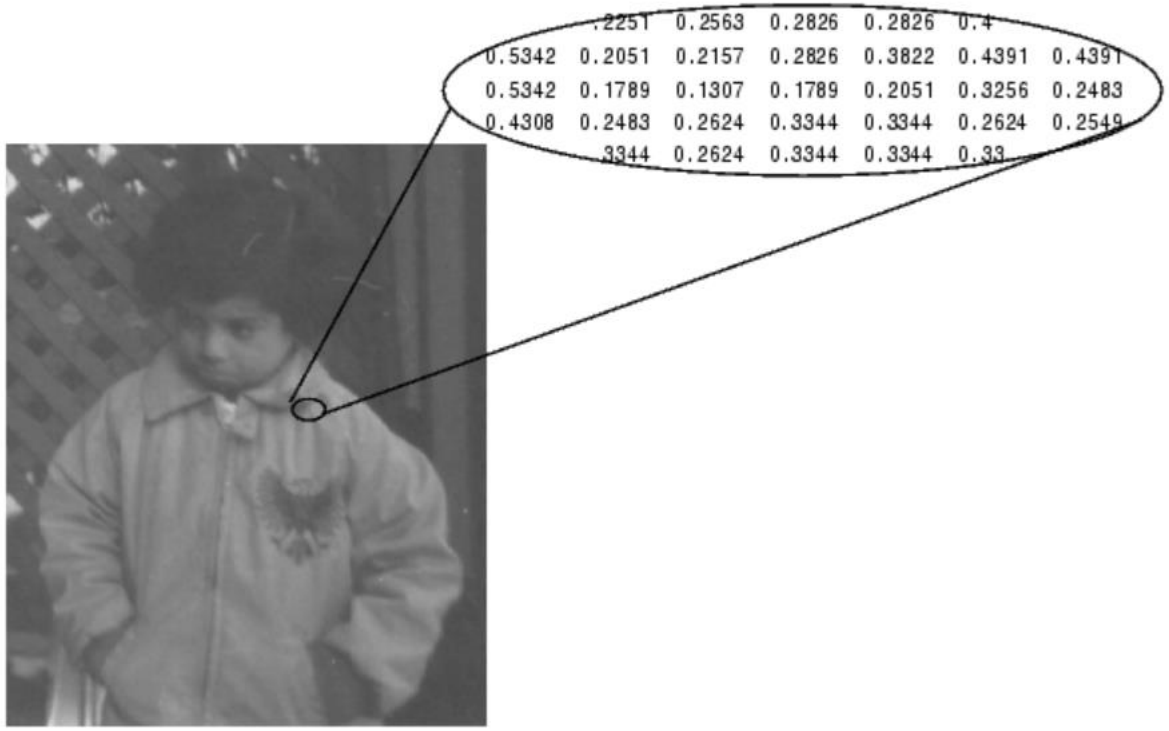


Image as a Matrix

- A digital grayscale image is presented in the computer by pixels matrix.
- The numeric values in pixel presentation are uniformly changed from zero (black pixels) to 255 (white pixels).
- When it comes to a binary or Boolean image that comprises of only two colours, *i.e*., black and white, the matrix represents the colour **black** as **0** and the colour **white** as **1**.



Pixel Values in a Grayscale Image Define Gray Levels

Image as a Matrix

Color Image:

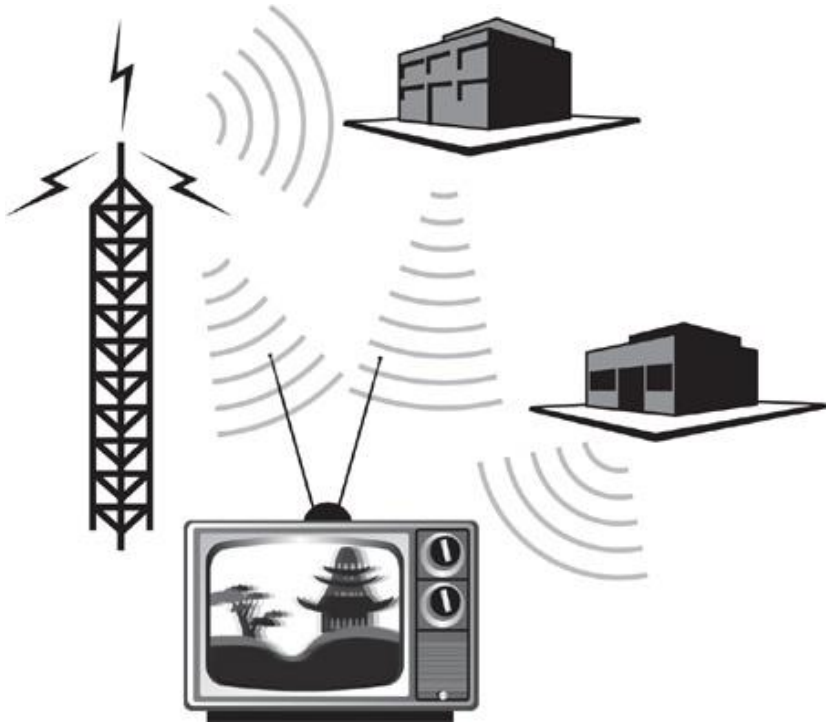
$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

128	30	123
232	123	321
123	77	89
80	255	255

- Each number represents the value of the function *f(x,y)* at any point. In this case the value 128 , 232 ,123 each represents an individual pixel value.
- The dimensions of the picture is actually the dimensions of this two dimensional array.

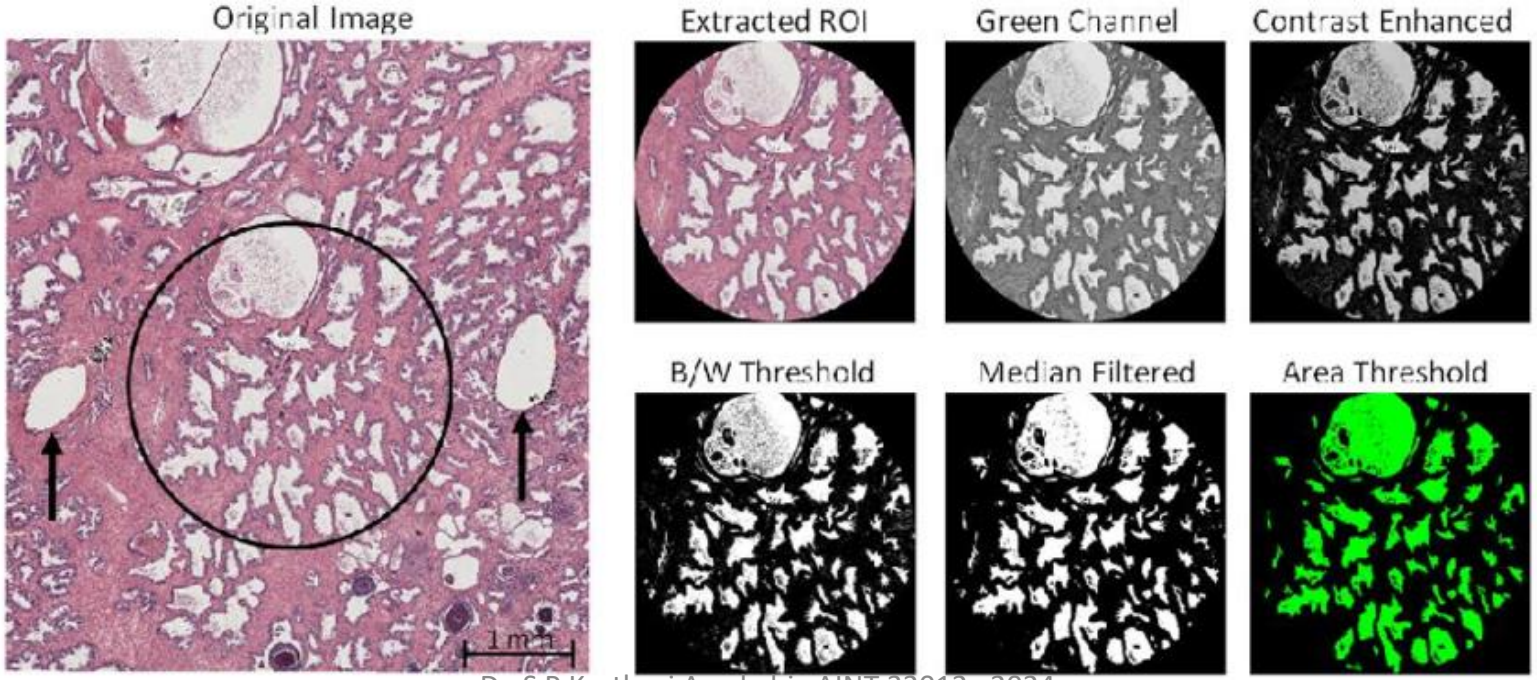
Analog Image Processing

- Analog image processing is done on analog signals.
- It includes processing on two dimensional analog signals.
- In this type of processing, the images are manipulated by electrical means by varying the electrical signal.
- .



What is Digital Image Processing (DIP)

- It is the manipulation of the digital data with the help of computer hardware and software to produce digital maps in which the specific information has been extracted and highlighted.



Why image processing?

- Applications
  - Fingerprint retrieval
  - Automatic Target Recognition(ATR)
  - Industrial inspection
  - Medical imaging
  - and more …
- Can commercial software do all the work?

More Applications of Digital Image Processing

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Color processing
- Pattern recognition
- Video processing
- Microscopic Imaging
- Others

Goals of image processing

- Image improvement
  - Improving the visual appearance of images to a human viewer
- Image analysis
  - Preparing images for measurement of the features and structures present

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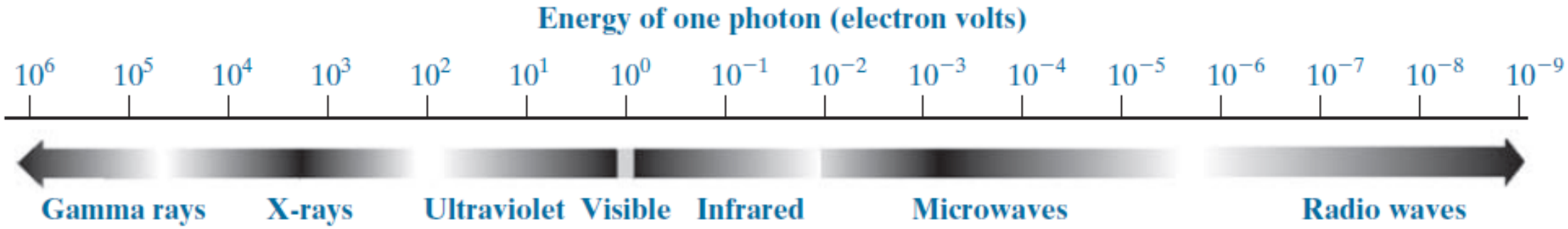
Applications and Usage

- Digital Image processing is not just limited to adjust the spatial resolution of the everyday images captured by the camera. It is not just limited to increase the brightness of the photo, e.t.c.
- Electromagnetic waves can be thought of as stream of particles, where each particle is moving with the speed of light. Each particle contains a bundle of energy. This bundle of energy is called a photon.



The electromagnetic spectrum arranged according to energy per photon.

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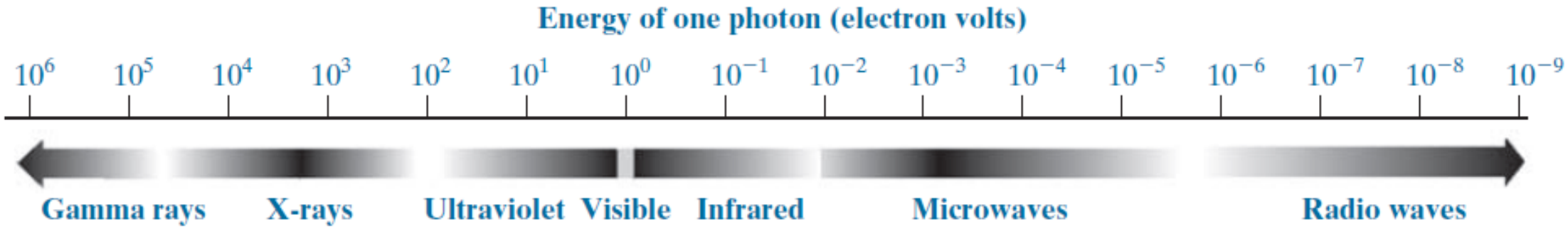

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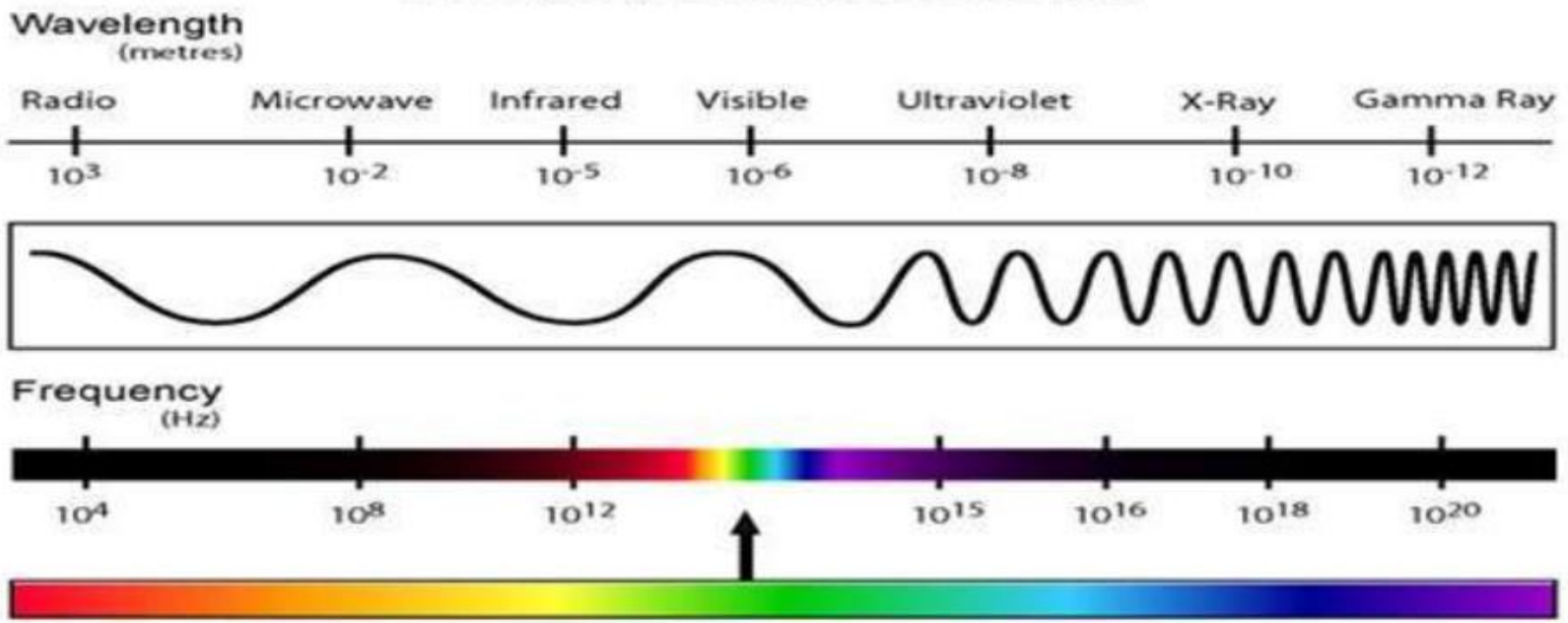
Applications and Usage

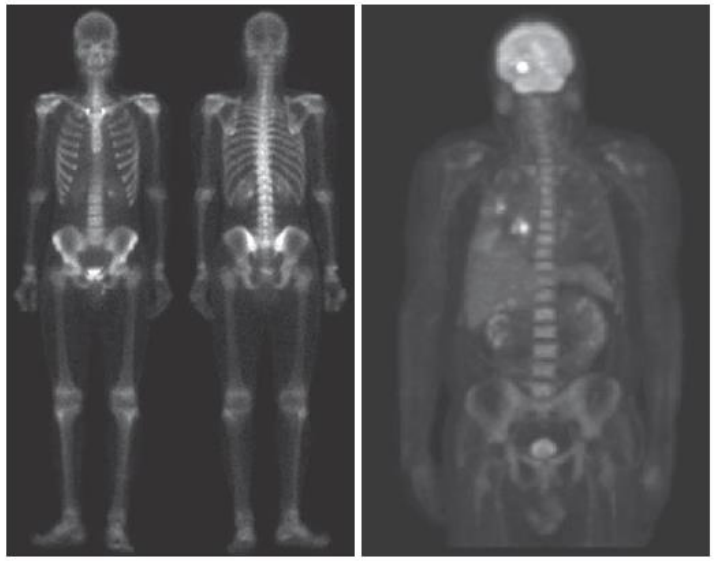


- Visible spectrum mainly includes seven different colors that are commonly term as VIBGOYR(violet , indigo , blue , green , orange , yellow and red).
- A camera can see the other things that a naked eye is unable to see. (ex: x rays , gamma rays , etc..)
- Hence the analysis of all that stuff too is done in digital image processing.

Medical field

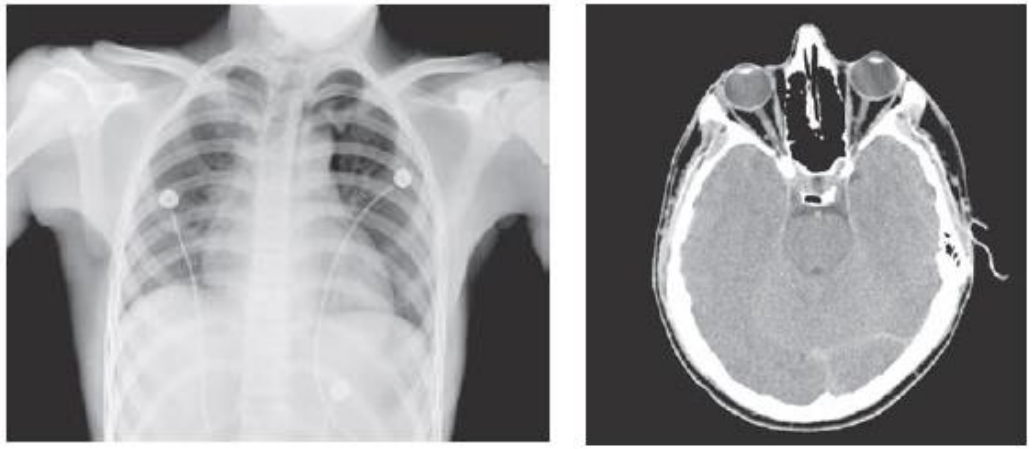
- Gamma ray imaging
- PET scan
- X Ray Imaging
- Medical CT
- UV imaging

Examples of gamma-ray imaging.



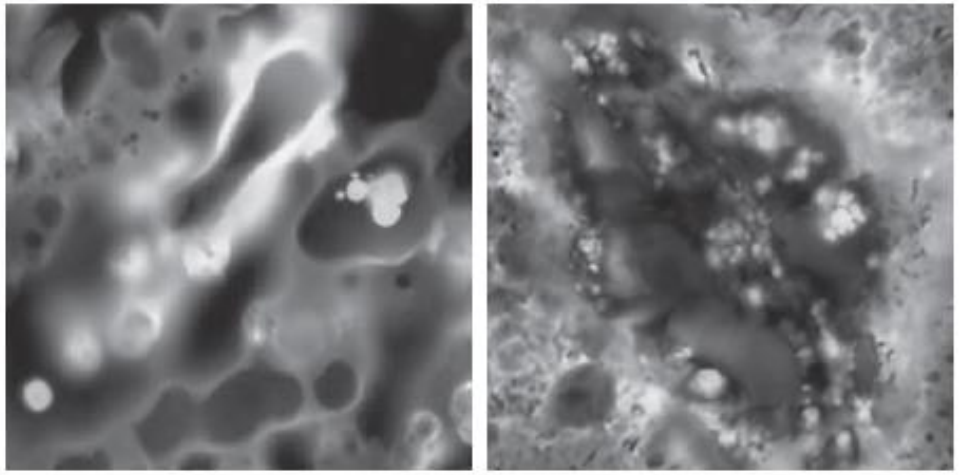
(a) Bone scan. (b) PET image.

Examples of X-ray imaging



(a) Chest X-ray (b) Head CT.

Examples of ultraviolet imaging



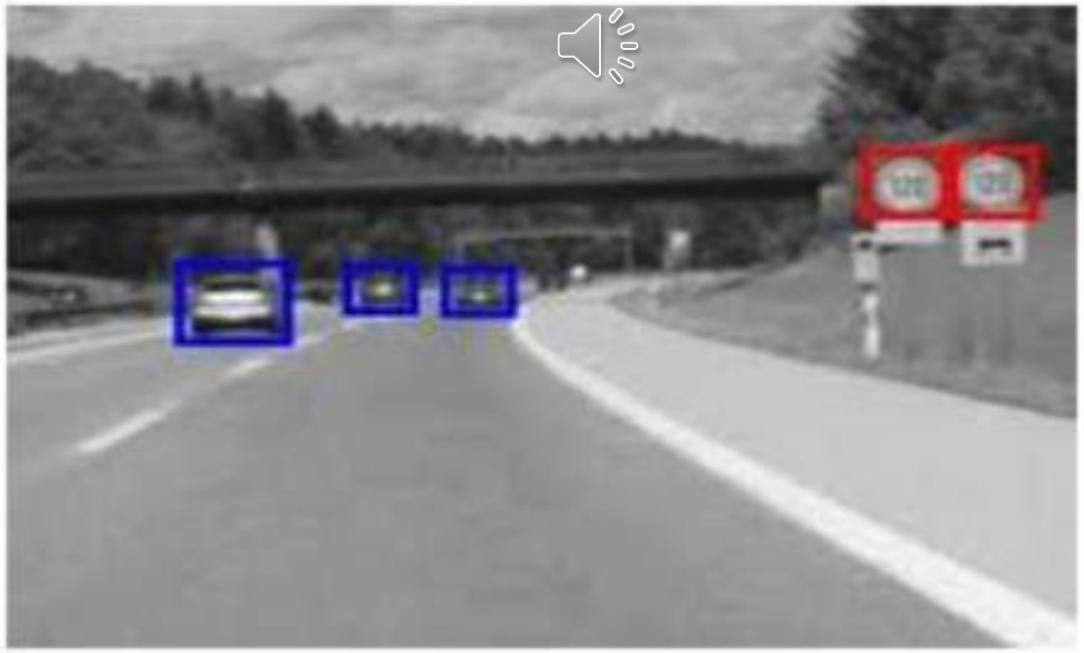
(a) Normal corn. (b) Corn infected by smut

UV imaging

- In the field of remote sensing,
- The key steps include in the analysis are
  - The extraction of edges
  - Analysis and enhancement of various types of edges

Hurdle detection

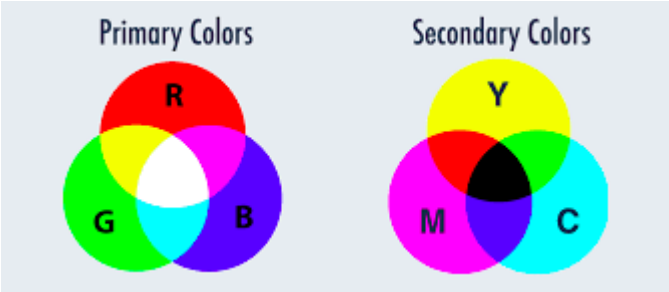
- Hurdle detection is one of the common task that has been done through image processing, by identifying different type of objects in the image and then calculating the distance between robot and hurdles.



Other

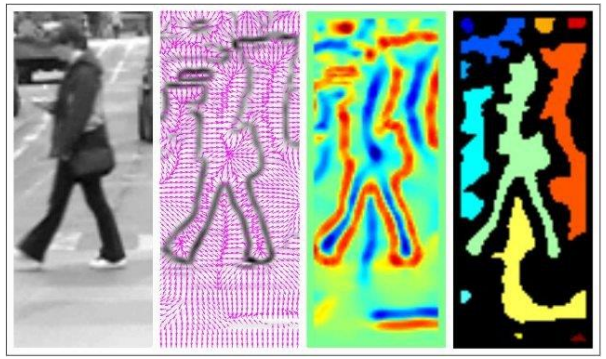
Color processing

Color processing includes processing of colored images and different color spaces that are used. For example RGB color model , YCbCr, HSV. It also involves studying transmission , storage , and encoding of these color images.



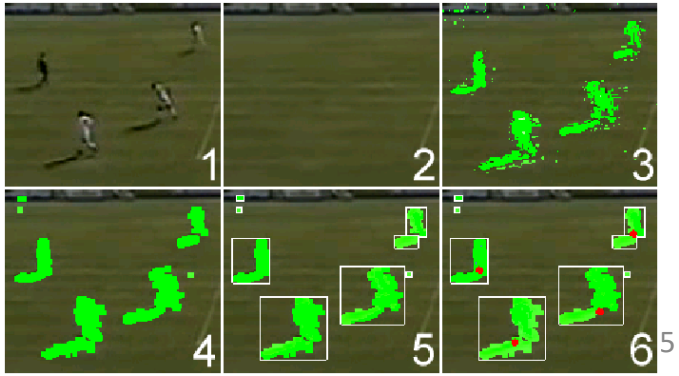
Pattern recognition

Pattern recognition involves study from image processing and from various other fields that includes machine learning (a branch of artificial intelligence). In pattern recognition , image processing is used for identifying the objects in an images and then machine learning is used to train the system for the change in pattern. Pattern recognition is used in computer aided diagnosis , recognition of handwriting , recognition of images e.t.c

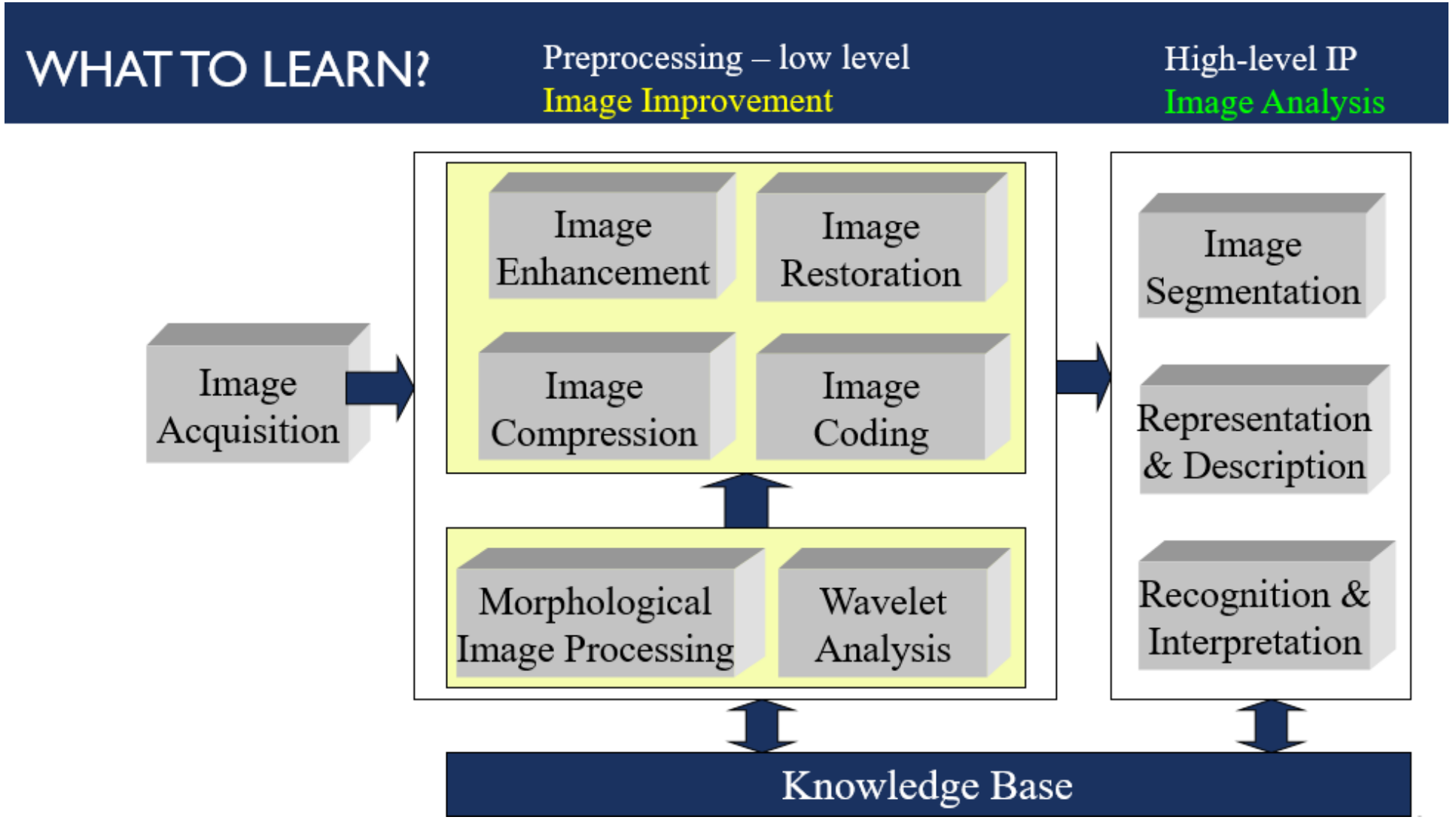


Video processing

A video is nothing but just the very fast movement of pictures. The quality of the video depends on the number of frames/pictures per minute and the quality of each frame being used. Video processing involves noise reduction , detail enhancement , motion detection , frame rate conversion , aspect ratio conversion , color space conversion e.t.c.



Fundamental steps in digital mage processing



Fundamental steps in digital mage processing cont……

You may contact me through CAL, or email *sandelik@kln.ac.lk*