Swami Keshvanand Institute of Technology, Management & Gramothan,
Ramnagaria, Jagatpura, Jaipur-302017, INDIA
Approved by AICTE, Ministry of HRD, Government of India
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Digital Image processing (DIP)

6 CS 3-01 & 6 CAI 3-01

Scheme — L - 2 hr./week
Exam - 3 hr.
Marks — IA - 30
ETE - 70
credit - 2

Book —
1. R.C. Gonzalez, R.E. woods "Digital image processing" pearson edition,
2. S. Jayaraman, S. Esakkirajan TMH, DIP.
3. A.k. Jain, Fundamental of DIP, PHI
4. Dr. Sanjay Sharma, DIP, Katson

Course objective :—

- Describe and Basic Principle of Digital Image processing
- Design & impliment for performing basic image processing (noise removing, image enhacement)
- Design & impliment for advance image analysis (e.g. image compression, image segmentation, image representation)
- Give the Students a useful skills that would allow them to carry out further study should they be intersted and to work in the field (Research work).

2. understand
3. apply
4. analyze
5 Evaluate
6 create

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Course outcomes:-

1. Identify (BL1) the fundamental elements of an image and Describe (BL2) the need of DIP.
2. Understand (BL2) different type of image transformation techniques and their properties.
3. Use (BL3) various noise model and Calculate (BL5) the values for restoration and degradation models.
4. Analyze (BL4) and evaluate (BL5) various image compression techniques.
5. Integrate (BL3) and demonstrate (BL3) various Image Transformation and segmentation Techniques.

Scope:- Automative sector, Image enhancing, Robotics, Gaming, Manufacturing, Improvement in Augmented reality, medical imaging, space & military application, fingerprint, Retinarecognization,

Digital image processing :—

The DIP refers to processing digital images by digital computer. This field process whose input and outputs are images and that extract attributes from images including the recongnization of the individual object.

- Image :— A Image may be defined as a two dimensional functional $f(x, y)$. Here x, and y are plane coordinates. Images is a set of Pixels.

Pixel :— It is used to denote the element of a digital image, which is composed of a finite number of elements, each of which has a particular location and value.

Application :—

i) office Automation :— optical characters recongnization, document processing, cursive script recongnization, logo recongnization etc.

ii) Desktop Publishing — flex, banner, visiting card. etc.

iii) IT industry — image transmission, videotex, video conferencing and videophone etc.

iv) Entertainment → HDTV, multimedia and video editing.

v) Military Application — To Guide and detect of missile target identification etc.

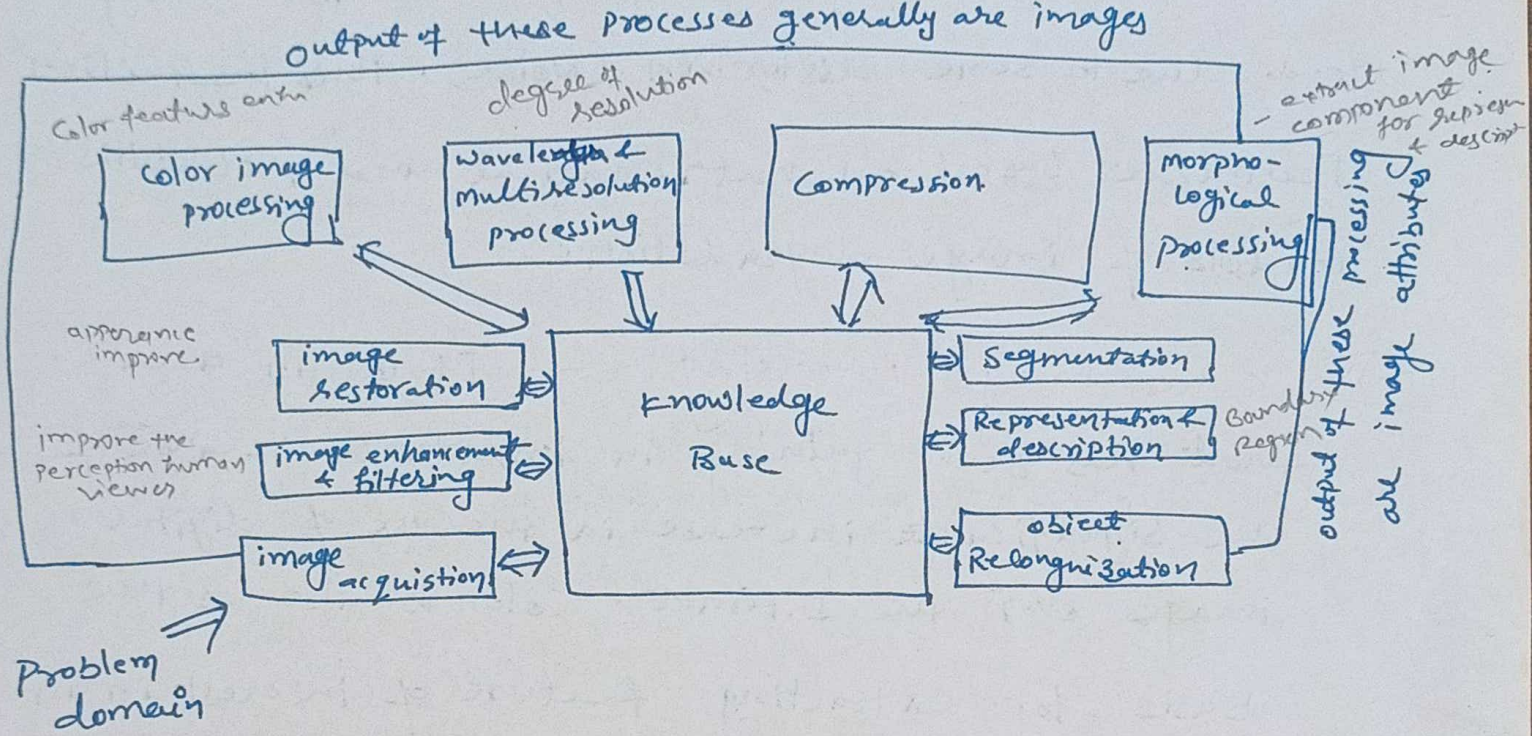
vi) forcasting :- - short term weather forcasting
- long term climatic change detection from setelite and and other remote sensing data
- cloud patterns etc.

vii) criminology → - Finger print identification
- face recognization and matching
- forensic investigation.

viii) Medical → ECG, EEG, EMG, X-Ray, MRI, USG, Cancer smears,

ix) Industrial Automation —
- VLSI manufacting
- PCB checking
- Robotics
- Oil and natural gas exploration

Fundamental Step's of Digital Image processing :-



step-1 Image Acquisition :— It is the first stage of any vision system is the image acquisition stage.

After the image has been obtainted, various methods of processing can be applied to the image to perform the many different vision Tasks. The image acquisition stage involves pre processing such as scaling

Step II → Image Enhancement :— It is improve the interpretability or perception of information in image, for human viewers. It is sometime required to highlight certain features of image

Step III Image Restoration :— It deals to improve the appearance of an image.

To restore an image that is not looking good due to some distortion (Noise). this ~~technition~~ Techniques based on mathematical and probabilistic models of image degradation.

Step-IV Color Image processing :— It is an area that has been gaining in importance because of the significante increase in the use of digital images over the Internet. Color is also as the basis for extracting feature of interest in an images.

Step V Wavelets and multiresolution processing :—

Wavelets are the foundation for representing ~~tion~~ images in various degree of resolution.

Wavelets is a kind of mathematical function used to divide a given function or continuous-time signal into different frequency component and study each component with a resolution that mathes its scale.

Step VI – Compression :— It is a techniques that is used for reducing the storage space for saving an image and reducing the band width required for transmission of image.

Mostly computer's users are used JPG file extension used in JPEG image Compressed standard.

Step VII Morphological processing :—

It deals with tools for extracting image component that are useful for representation and description of shape.

Step VIII Segmentation :— segmentation is the process in which images is Converted into small segment so that we are extract the more accurate image attributes. If the segments are properly identical then representation and description of image will be accurate. otherwise result will not be accurate.

Step IX Representation and Description :—

It always follow the output of a segmentation stage, which is usually raw pixel data.

Description — It is also feature slec selection, deals with extracting attributes that result in some quantitative information of

interest or are basic for different from one class to another class.

Step X Object Recognization :-

Recognization is a process that assign a label to an object based on its descriptors.

Step XI Knowledge Base :-

It is only the base that helps to synchronize all the processes to each other.

Knowledge base can be defined as software that may help user in proper image enhancement, restoration or compression techniques. It is also help uses in segmentation of an image.

Component of an Image processing system :-

The Basic components of a general purpose processing system are shown in below diagram -

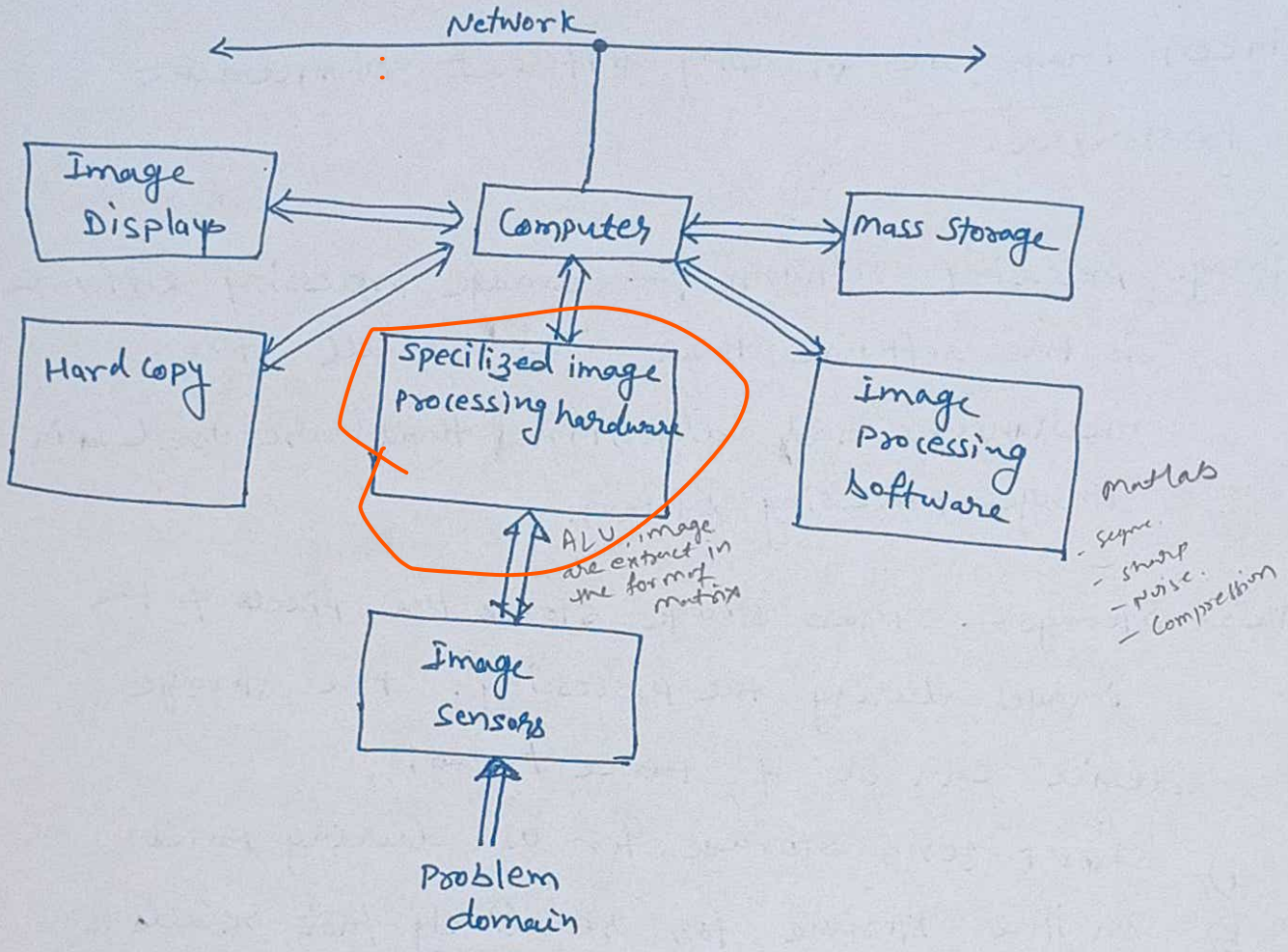


fig:- Components of DIP

i) Image sensor :- First Basic requirement is image sensoring image sensors senses the intensity, amplitude, co-ordinates and other features of the images and passes the result to the image processing hardware.

ii) Image processing hardware :- It is the dedicated hardware that is used to process the instructions obtained from the image sensors. It passes the result

to General purpose computes.

iii) Computer :— It is basically a general purpose PC accordingly to task to be performed. we have taken image, we can apply different enhancement techniques.

iv) image processing software :— image processing software is the software that includes all the mechanisms and algorithms that are used in image processing system.

v) Mass Storage — mass storage stores the pixels of the images during the processing. the storage device can be of three types;

a) short term storage for use during process
b) on line storage for relatively fast recalls
c) Storage for frequent use.

vi) Hard copy device :— Once the image is processed then it is stored in the hard copy device, It can be a pen drive, leser printers, or any external Rom device.

vii) Display Device :— It includes the monitor or display screen that display the processed images.

viii) Network :— Network is the connection of all the above elements of the image processing system. For image, we require high bandwidth so optical fiber and broadband technologies are better options.

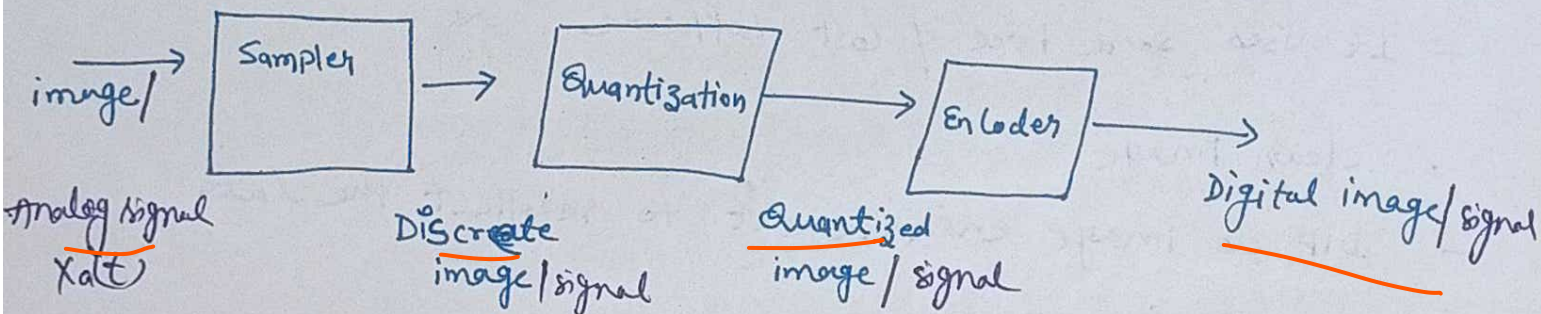
Characteristics of Digital image processing—

- It uses some free of cost software
- clear image
- DIP do image enhancement to recollect the data through images.
- It is used widely everywhere in many field
- It reduce the complexity of DIP.
- It is used to support a better experience of life.

Digital Image representation :—

An image may be defined as a two dimensional function $f(x, y)$ where x and y are plane coordinates and the amplitude of f at any point (x, y) is called the intencity of the image. at that point.

To create a digital image, we need to convert the continuous data into digital images form. this conversion from analog to digital involves two processes: sampling & quantization.



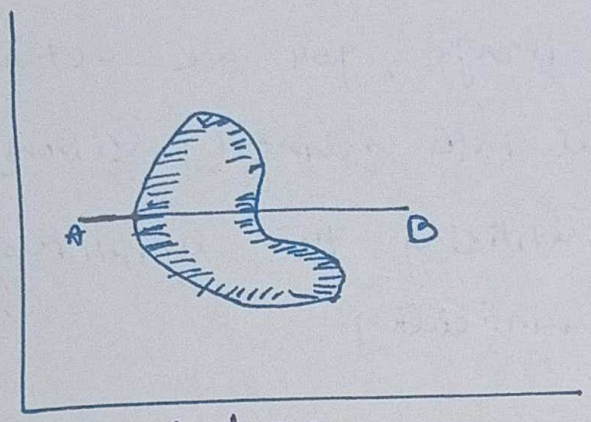
Sampling → • the process of digitizing the coordinates value is called sampling. Sampling is done on X-axis where infinite values are converted to digital values.

• Sampling is the reduction of continuous time signal to a discrete time signal.

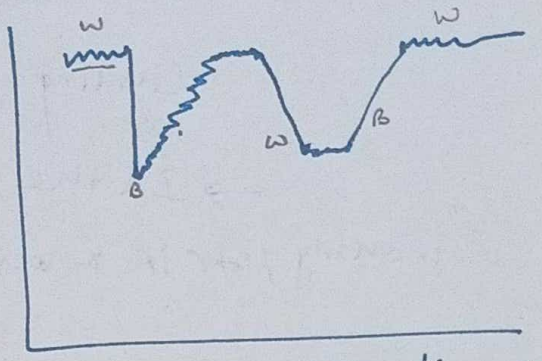
Sampling takes two forms;

a) Spatial and
b) temporal

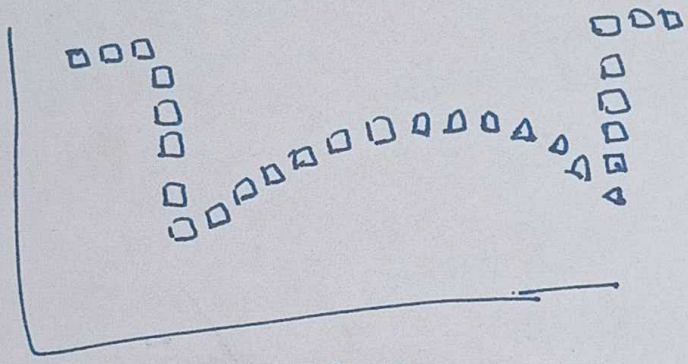
Digitizing Coordities values – Sampling
" Amplitude value. Quantization



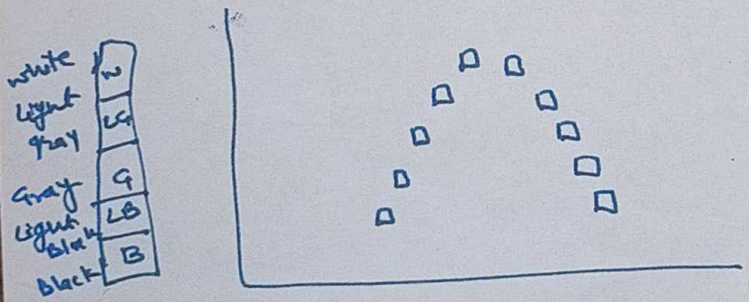
Analog Image



Scanning line AB



Sampling



Scale

Quantization

Quantization → It is done on 'Y' axis, when you are quantizing an image, you are actually dividing a signal into quanta (partitions).

→ In the, digitizing the amplitude or intensity of color is know an Quantization

Example of Digital Image processing-

- Gamma Ray imaging (nuclear medicine and astronomical diagonostic)
- X-Ray Imaging (x ray → medical industry, and astronomy)
- Imaging in ultraviolet band (lithography, microscopy, lases, biological)
- Imaging in the visible and in Infrared bands (light microscopy remote sensing, industry)
- Imaging in microwave band (Radder)
- Imaging in Radio Wave (medical, astronomy, MRI

Image Acquisition :—

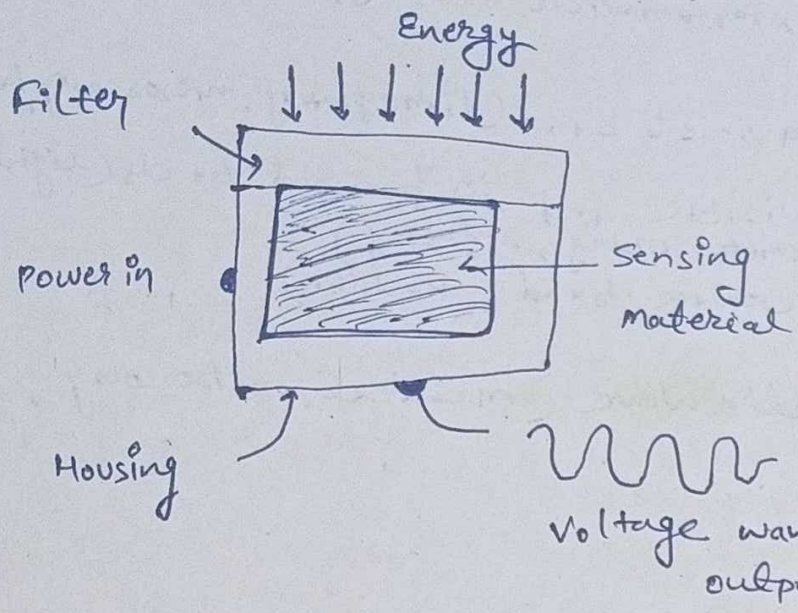
Image acquisition is the first step of any image processing System. The general aim of image acquisition is to transform an optical image (real world data) into an array of numerical data which could be later manipulated on a Computer.

Incoming energy is transformed into a voltage by the Combination of input electrical power and sensor material energy being detected.

There are three method to acquired an image.

i) Image acquisition using a single sensor.
ii) Image acquisition using sensor Strips
iii) Image acquisition using a array sensor.

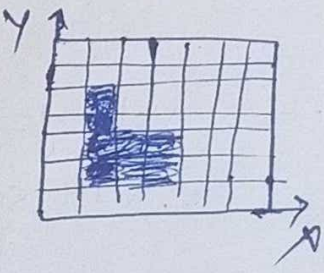
1) Image acquisition using a single sensor -

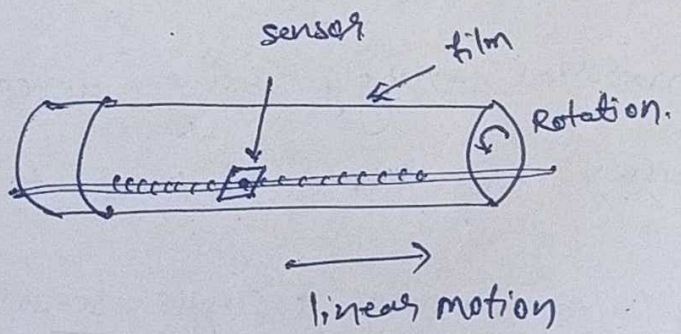


which is constructed of silicon materials and whose o/p voltage wave-form is proportional to light

Example of single sensor is a photodiode. Now to obtain a two dimension image using a single sensor, the motion should be in both x and y direction.

- Rotation provides motion in one direction
- and Linear motion provides motion in the perpendicular direction





This is an inexpensive method and we can obtain high resolution images with high precision control but the down side of this method is that it is slow.

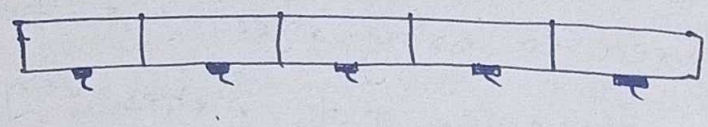
or strip sensors

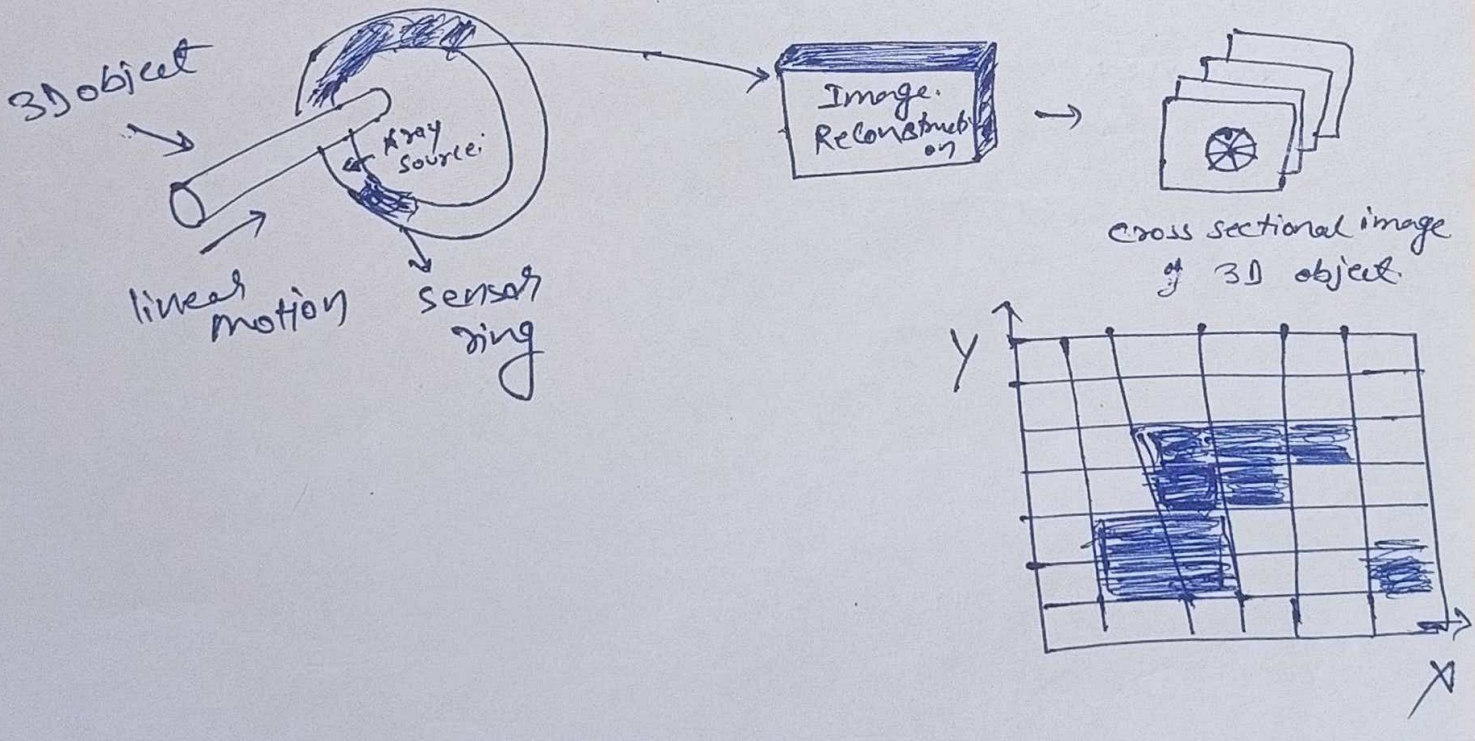
ii) Image acquision using a line sensors →

In this arrangement of sensors in the form of a senses strip. Strips provides imaging elements in the one direction.

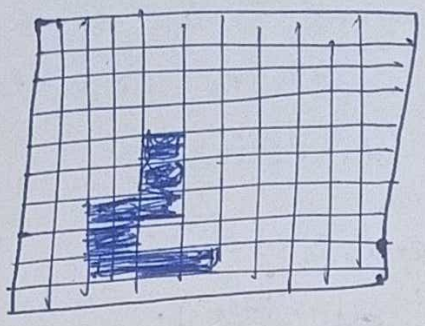
motion perpendicular to the strip provides imaging in the other direction.

Sensors strip mounted in a ring configuration are used in medical and industrial imaging to obtain cross sectional image of 3D object.





iii) Image Acquisition using a Array sensor →



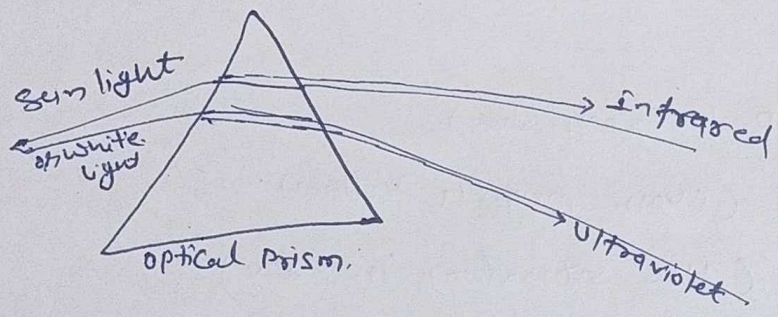
- Horizontal and vertical strips work together
- No motion required.
- It covers huge area of an object and sense the energy without motion
- Need to bring object just front of it and it is recognize and makes very comfortably.
- No need direction.

Color image representation :—

— A Color image is a digital image that includes Color information for each pixel.

— A Color image has three values per pixel and they measure the intensity and chrominance of light.

— In 1966, Sir Isaac Newton discovered that when a beam of sunlight passes through a glass prism, the emerging beam of light is split in to a spectrum of colors ranging from violet at one end to red at the other.



— With the help of Color image representation, the object identification and extraction from a scene in image processing is enhanced.

— We can divide Color image processing in two parts—

i) Full Color image processing

ii) Pseudo Color image processing.

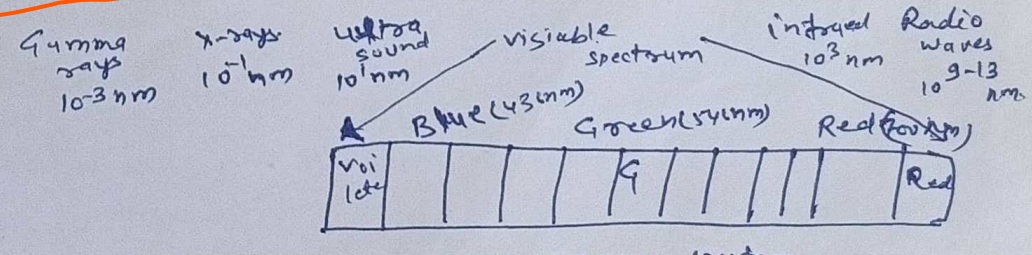


fig: visiable spectrum.

i) Full color image processing – In this, the image is acquired with the help of full color sensor for example, the full color sensor are a color TV camera, and color scanner.

– Used in publishing, visualization and the internet

ii) Pseudo color processing :–

– Assigning a color to a particulas monochrome intensity or range of intensities.

Color model

i) RGB – (Red Green Blue)

ii) CMY – (Cyan magenta Yellow)

iii) HSI – (Hue saturation intensity)

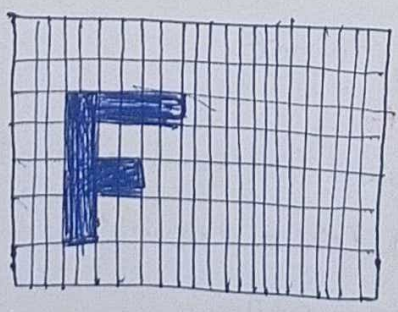
Types of Images :-

There are three type of Images -

i) Binary Images
ii) Gray scale images
iii) Color images.

i) Binary Images :-

- It is the simplest type of image.
- It takes only two values i.e. Black and white or 0 & 1
- The binary image consists of a 1-bit image and it takes only 1 binary ~~bin~~ digit to represent a pixel
- It is mostly used in general shape or outline.
- Example - optical character Recognization (OCR)
- The Binary images are generated using threshold operation when a pixel is ~~abo~~ above the threshold value, then it is turned white ('1'). and which are below the threshold value ~~then~~ then they are turned black ('0')



0 - white color
1 - Black color

ii) Gray scale images :—

- It is monochrome images means they have only one color
- Grayscale images do not contain any information about color
- each pixel determines available different levels.
- A normal grayscale images contain 8 bits/pixel data, which has 256 different grey levels.

In medical images and astronomy, 12 or 16 bits/pixel images are used.

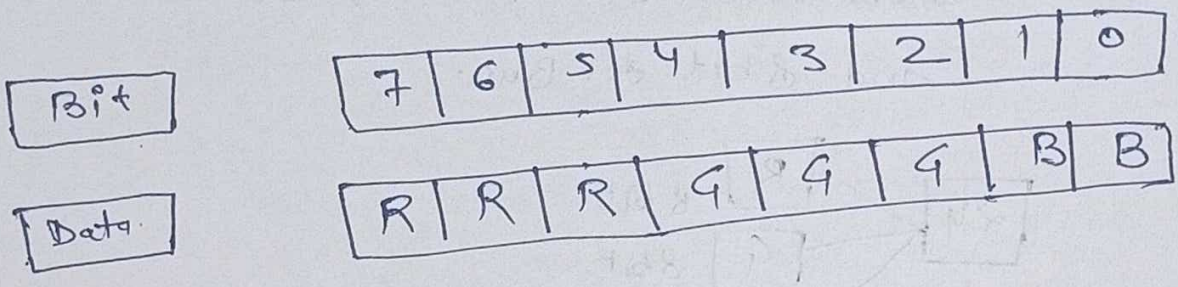
iii) Color images :—

- Color images are three band monochrome images in which, each band contains a different color and the actual information is stored in the digital image
- The images are represented as red, green and blue
- Each color image has 24 bit/pixel means 8 bit for each of the three color band (RGB).
- we have a three format for color images—
  - * 8 bit color format
  - * 16 bit color format
  - * 24 bit color format

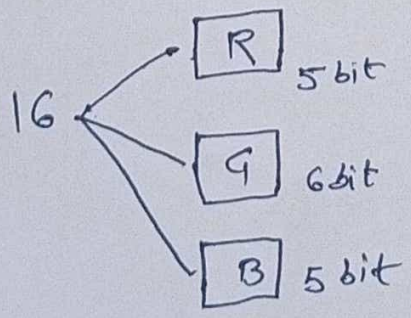
a) 8 bit color format

- 8 bit color is used for storing image information, in a computer's memory or in a file of an image.

- In this format each pixel's represents one 8 bit.
- It has 0-255 range of colors, in which 0 is used for black, 255 for white and 127 for gray color.
- It is also known as grayscale image.
- initially, it was used by UNIX operating system.

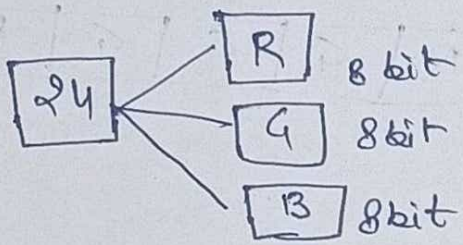


b) 16 bit Color format :—
- Also known as high color format
- It has 65536 (2^{16}) different color shades.
- It is used in the system developed by microsoft
- The 16 bit color format is further divided into three formats which are Red, Green & Blue also known as RGB format.
- In the RGB format, there are 5 bit for Red 6 bit for Green color and 5 bit for Blue color one additional bit is added in green because in all the 3 color green color is soothing to eyes



c) 24 bit color format :—

- Also known as true color format.
- 24 bit color format also distributed in Red Green and blue.
- As 24 can be equally divided on 8, so it is distributed equally b/w 3 different colors like 8 bit for Red, 8 bit for Green and 8 bit for Blue.



- It has the 16,777,216 (2^{24}) color shades.

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Mathematical Tool for Image processing—

(1) Array Versus Matrix operation—

$$\text{Image 1} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \qquad \text{Image 2} = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

The matrix operation is—

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

and array operation—

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} & a_{12}b_{12} \\ a_{21}b_{21} & a_{22}b_{22} \end{bmatrix}$$

(2) linear Vs non linear operation—

Linear operation- Addition, substraction, multiplication, Division,
non linear operation - Max, min, median, mode of the Image

(3) Arithmatic operation—

$$S(x,y) = f(x,y) * g(x,y)$$

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4) Set and logical operation—

- Null set / empty set
- Union
- Intersection
- dissjoint / mutually exclusive
- Complement

Logical
- AND
- OR
- NOT
- XOR

5) Spatial operation— spatial operation are performed directly on the pixels of a given image.

i) Single pixel operation → $s = T(z)$ where z = intensity of a pixel in the original img
s = intensity of the corresponding pixel in the processed image.

ii) Neighborhood operation → Express the operation in equation form.

iii) geometric spatial transformation. (They modify the spatial relationship b/w pixels and image)

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DIP unit I

RTU based important Question

Q.1 Define the image, Explain the step's of digital image processing with suitable diagram RTU [2020, 2019, 2018, 17]

Q.2. what are the application of DIP RTU [2020, 2019, 2018, 17]

Q.3. Explain image sensing & acquisition RTU [2020, 2018, 17]

Q.4. Explain Color vision model with suitable example. [RTU 2020, 17]

Q.5 what are the basic component of an DIP. ~~RTU~~ Explain all the component with block diagram. [RTU 2019]

Q.6. write down the uses of DIP. [RTU 2019]

Q.7. Explain different type of mathamatical tools whichare used in DIP [RTU 2019]

Q.8. Differentiate Image quantization and scalar quantization [RTU 2019, 2016]

Q.9. what do you mean by sampling, Explain with suitable example. [RTU 2018]

Q.10 How many type of Images.

Q. write short notes on sampling & Quantization