Computer-Graphics-Module-4-Important-Topics

For more notes visit

https://rtpnotes.vercel.app

1. Fundamental steps in image processing

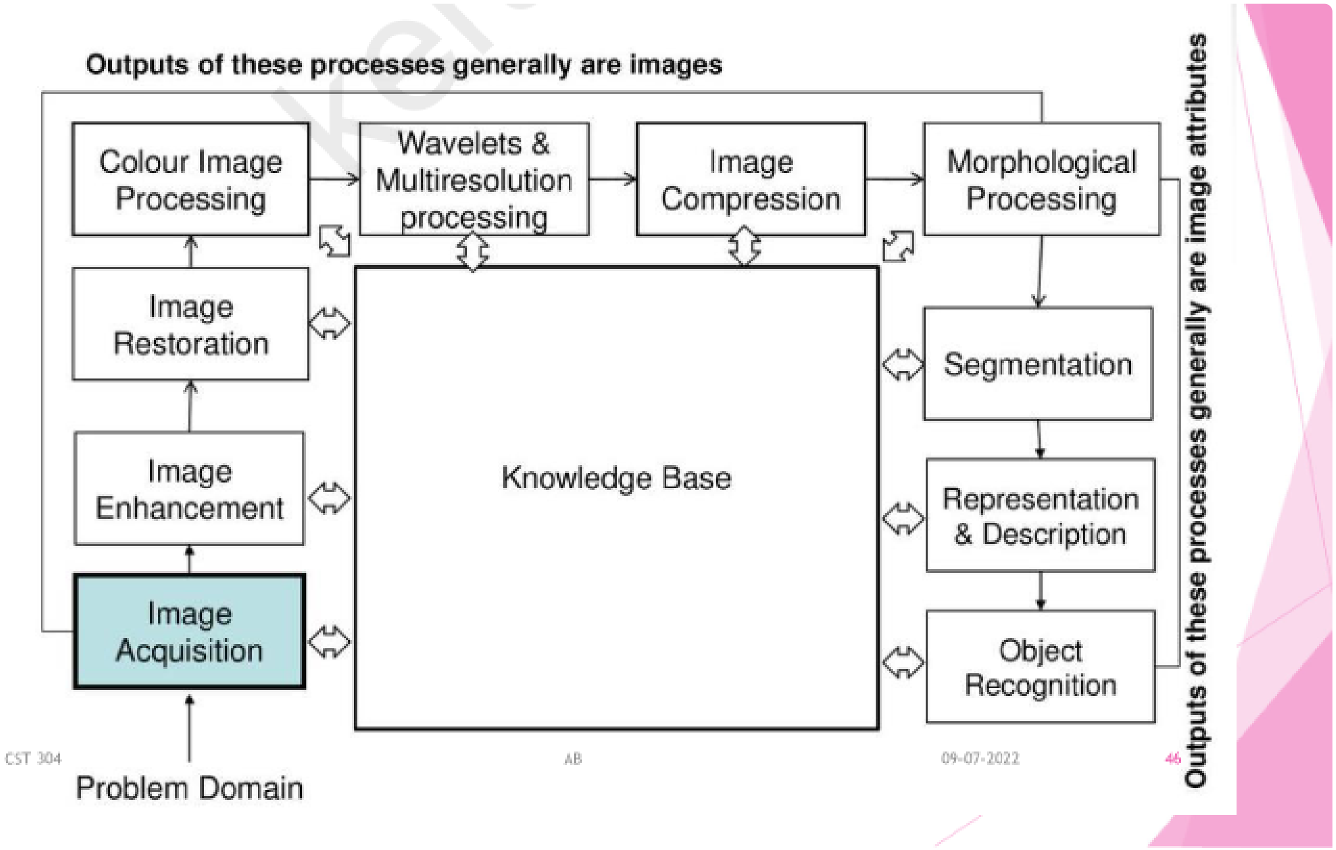


Image acquisition

- First fundamental steps in digital image processing
- Image is captured by a sensor and digitized
- Image acquisition stage involved pre processing like scaling
- The aim is to transform an optical image to an array of numerical data which could b later manipulated on a computer

Image enhancement

- Process of manipulating an image so that the result is more suitable than the original for specific applications
- Example, changing brightness, contrast etc.

Image restoration

- Image restoration is an area that also deals with improving the appearance of an image

Color Image Processing

- Color modelling, processing in digital domain, etc

Wavelets and Multi Resolution Processing

- In this stage, an image is represented in various degrees of resolution

Compression

- Compression is a technique which is used for reducing the requirement of storing an image

Morphological Processing

- This stage deals with tools which are used for extracting the components of the image

Segmentation

- In this stage, an image is partioned into its objects
- Segmentation is the most difficult task in Digital Image Processing

Representation and description

- Representation and description follow the output of the segmentation stage
- The output is a raw pixel data which has all points of region itself
- To transform the raw data, representation is the only solution
- Whereas description is used for extracting information to differentiate one class of objects from another

Object recognition

- In this stage, the label is assigned to the object, which is based on the descriptors

Knowledge Base

- Knowledge is the last stage in Digital Image Processing
- In this stage important information of the image is located

2. Components of image processing

The components of image processing system are

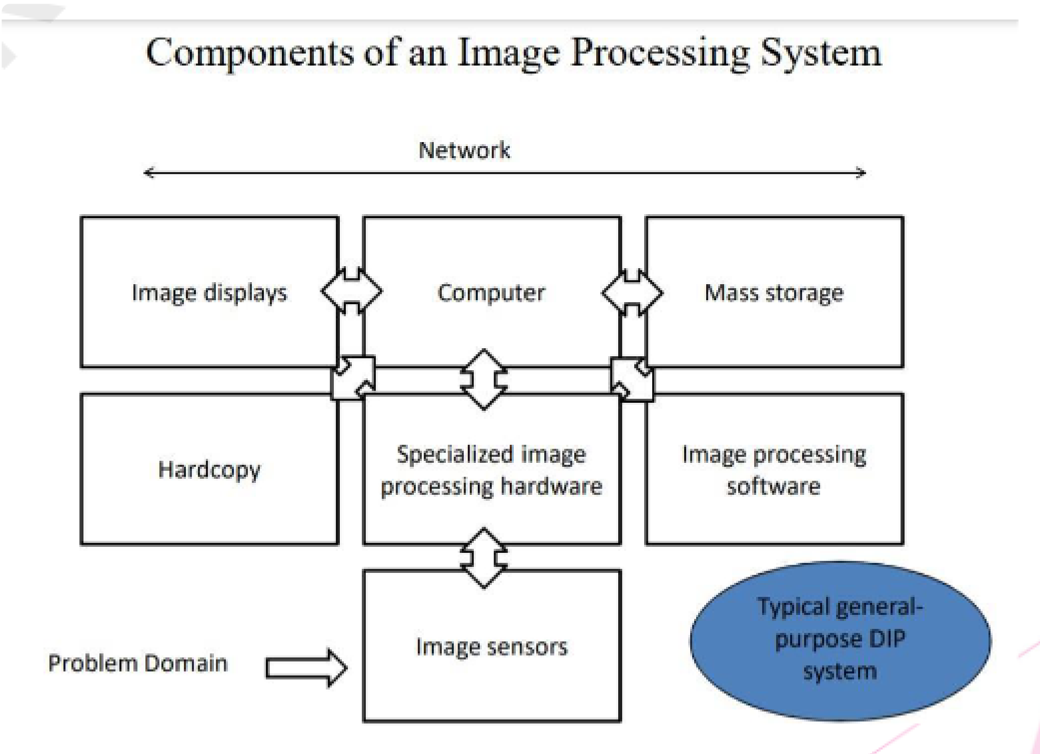


Image Sensors

- Image sensors senses the intensity, amplitude, coordinates and other features of the images and passes the result to the image processing hardware
-

Image processing hardware

- Image processing hardware is the dedicated hardware that is used to process the instructions obtained from image sensors
- It passes the result to general purpose computer.

Computer

- Computer used in image processing system is the general computer that is used by us in our daily life
- The computer in an image processing system is a general purpose

Image processing software

- Image processing software is the software that includes all the mechanism and algorithms that are used in image processing system

Mass storage

- Mass storage stores the pixels of images during processing
- Digital storage for image processing falls to 3 categories
  - Short term storage for use during processing
  - On line storage for relatively fast recall
  - Archival storage, characterized by infrequent access

Hard copy device

- Once the image is processed, its stored in hard copy device
- it can be pen drive or any ROM device

Image displays

- The displays in use today are mainly color TV monitors
- Monitors are driven by the outputs of the image and graphics display cards that are integral part of computer system

Networking

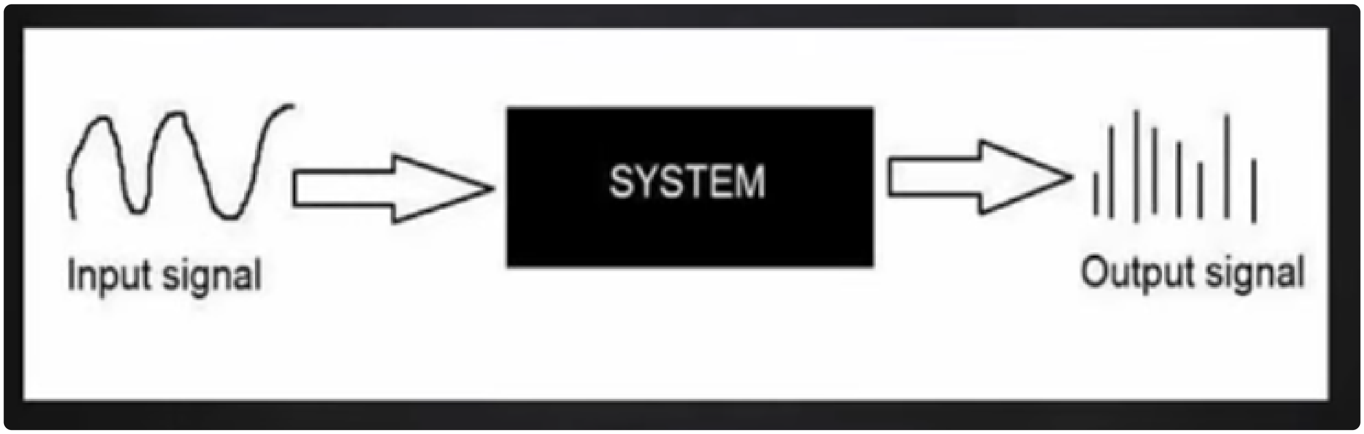
- Used to transmit images

---

3. Sampling and quantization

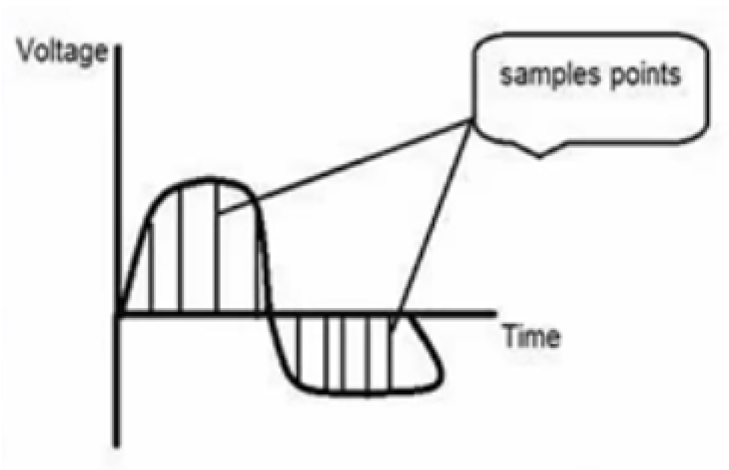
- The output of most of the image sensors is an analog signal, and we cannot apply digital processing to it because we cannot store it. We cannot store it becaused it requires infinite memory to store a signal that can have infinite values
- So we have to convert analog signal into digital signal
- To create an image which is digital, we need to convert continous data into digital form. There are two steps in which its done
  - Sampling
  - Quantization

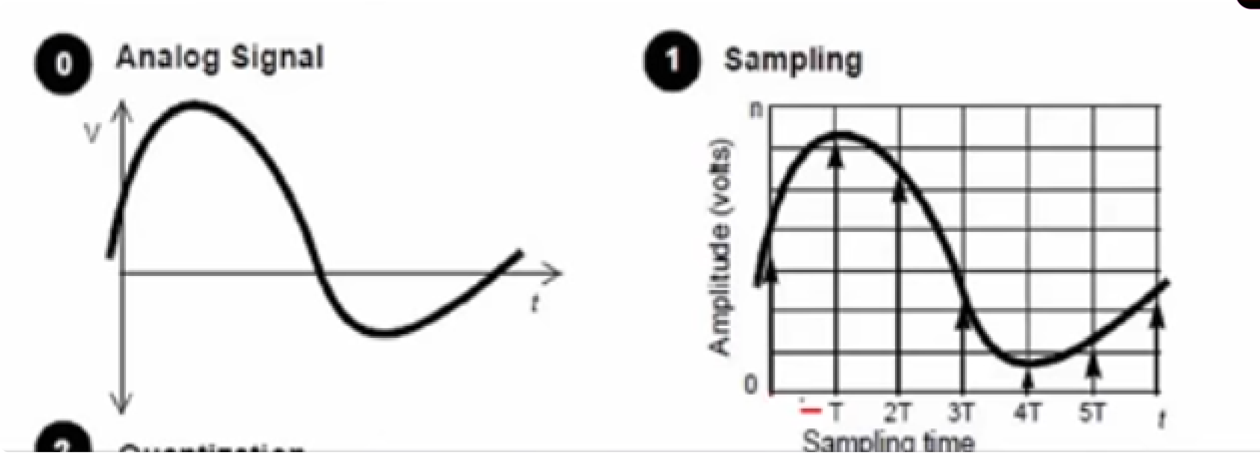
Basic idea



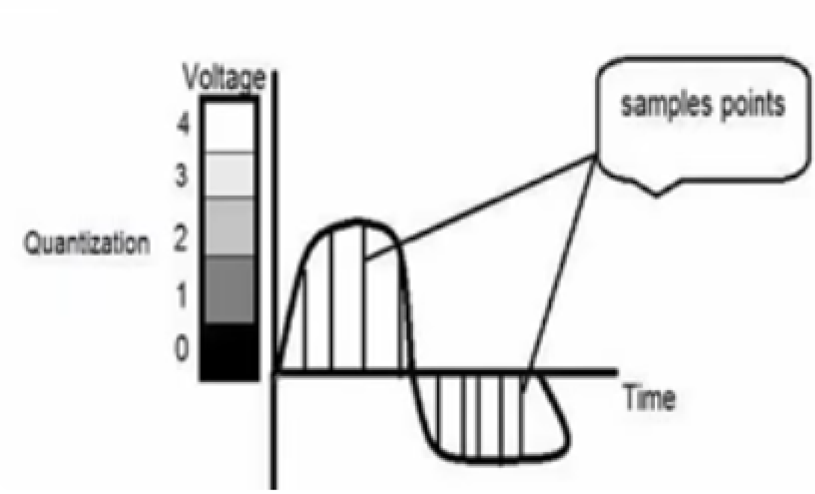
- Input has a continuous variation of signal, using digital convert we convert to finite values, which is discontinuous

Sampling

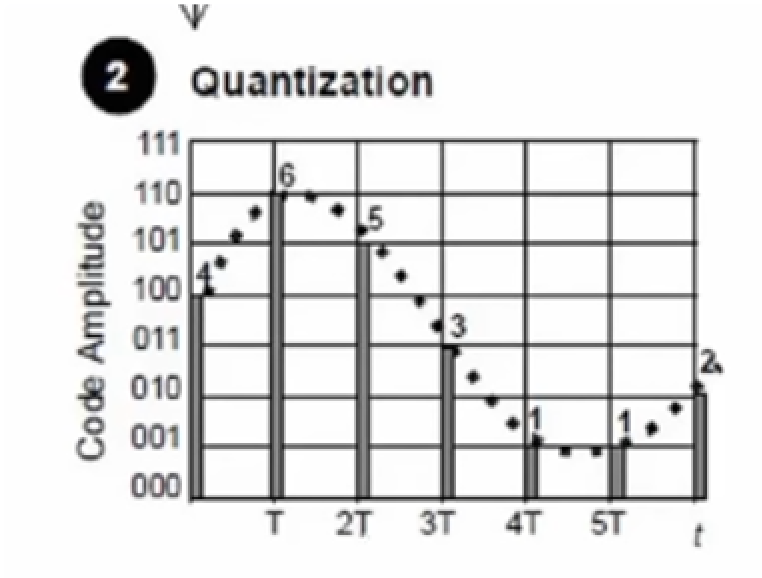
- Digitize x axis in sampling
- Our image is 2 Dimensional
  - X axis is time axis
  - Y axis is intensity
- Time axis is divided into samples of equal intervals
- 

- 

Quantization

- Quantizayion is the opposite of sampling. Its done on y axis. When you are quantizing an image, you are actually dividing a signal into quanta.
- Digitizing the amplitudes is known as quantization
- The signal is quantified into different levels
- 

- There are 5 different shades assigned to y axis

- 

- Here there are 8 different shades, with numbers assigned to them with 3 bits

4. Spatial and gray level resolution

Spatial Resolution

Definition:

- Spatial resolution refers to the smallest visible detail in an image. It measures how closely lines can be resolved in an image; the higher the spatial resolution, the clearer the image

Misconception About Pixel Count:

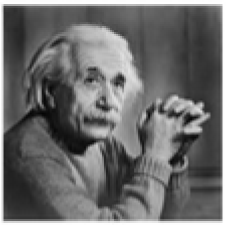
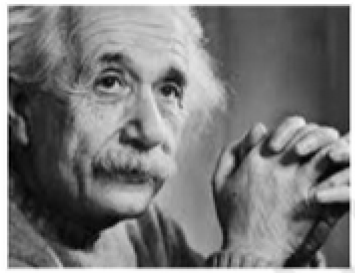
- The clarity of an image is not solely determined by its pixel resolution (the number of pixels in the image). A higher pixel count does not automatically mean a clearer image.
-

Independent Pixel Values:

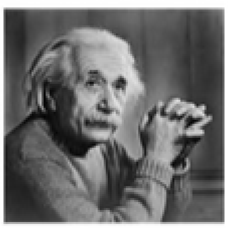
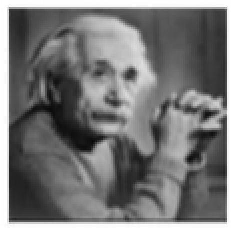
- Spatial resolution can be defined as the number of independent pixel values per inch. This indicates the level of detail that can be seen in an inch of the image.

Comparison of Images:

- To accurately compare the clarity or spatial resolution of two images, they must be of the same size. Comparing images of different sizes, even if they show the same subject, does not provide a valid assessment of their clarity.

- For example, comparing a zoomed-out image of Einstein (227 x 222 pixels) with a zoomed-in image (980 x 749 pixels) is ineffective for assessing clarity since the images are not of equal dimensions.
-  

Practical Example:

- Consider two images with identical dimensions (227 x 222 pixels). If one image appears clearer than the other, the one with higher spatial resolution is clearer. This can be due to one image being blurred while the other is sharp.
-  
- Here image on the left is having higher spatial resolution compared to the one on the right
- 

Measuring Spatial Resolution

1. **Dots Per Inch (DPI)**:
   - Commonly used for monitors, DPI measures the number of individual dots that can be placed within a linear inch.
2. **Lines Per Inch (LPI)**:

    - Used in laser printers, LPI measures the number of lines that can be printed in an inch.
3. **Pixels Per Inch (PPI)**:
    - Used for devices like tablets and mobile phones, PPI measures the number of pixels within an inch of the display. Higher PPI typically means a sharper image, as more pixels are packed into the same area.

Gray Level Resolution

Definition

- **Gray level resolution** refers to the number of different shades or levels of gray that can be represented in an image. It is determined by the number of bits used to represent each pixel.

Bits Per Pixel (BPP)

- The number of different colors or shades of gray in an image depends on the color depth, also known as bits per pixel (BPP).

Mathematical Relationship

- The relationship between gray level resolution and bits per pixel can be expressed mathematically as:
    - $L=2^k$
    - **L**: The number of gray levels or shades of gray.
    - **k**: The number of bits per pixel (BPP).
- - This means that the number of gray levels is equal to 2 raised to the power of the number of bits per pixel.

Example Calculation

- For a grayscale image with 8 bits per pixel (8 BPP):
- Using the formula $L=2^k$
    - $k=8$
    - $L = 2^8$
    - $L = 256$

- This means the image has a gray level resolution of 256, or 256 different shades of gray. The more bits per pixel, the higher the gray level resolution.

Finding Bits Per Pixel from Gray Level Resolution

- To find the number of bits per pixel from a given gray level resolution, we can rearrange the formula:
  - L = 2^k
  - Solving for k
    - $$k = \log_2(L)$$
- Example:
  - - If an image has 256 gray levels, the number of bits per pixel required is:
  - $$L = 256$$
    $$k = \log_2(256)$$
    $$k = 8$$
  - - So, the image requires 8 bits per pixels

---

5. Neighborhood, adjacency, connectivity

Neighbours of a Pixel

- Any pixel P(x,y) has two vertical and two horizontal neighbours specified by
  - [(x+1,y), (x-1,y),(x,y+1),(x,y-1)]
  - This set of pixels are known as 4 neighbours of P and is denoted by **N4(P)**
  - All of them are at a unit distance of P
- The four diagonal neighbours of p(x,y) are given by
  - [(x+1,y+1), (x+1,y-1),(x-1,y+1),(x-1,y-1)]
  - This set is denoted by **ND(P)**
- The points S are together known as 8 neighbours of the point P, denoted **N8(P)**

Adjacency

Definition

- **Adjacency** refers to the concept of pixels being connected or linked based on their positions and gray level values.

Set of Gray Level Values (V)

- **V** is the set of gray level values used to define which pixels are considered adjacent.
- In a **binary image**, V = {0, 1}, meaning pixels can only have values of 0 or 1.
- In a **grayscale image**, V can contain more elements, ranging from 0 to 255.

Adjacency in Grayscale Images

- For pixels with gray level values ranging from 0 to 255, the set V could be any subset of these 256 values. This subset defines which gray levels are considered for determining adjacency.

Conditions for Adjacency

- **Two pixels are considered adjacent if:**
  - They are neighbors (either 4-neighbors or 8-neighbors).
  - Their gray levels satisfy a specific condition of similarity.

Example in Binary Images

- In a binary image:
  - - Two pixels are connected if they are 4-neighbors and have the same value (either both 0 or both 1).

Connectivity

Definition

- **Connectivity** refers to the relationship between pixels in an image based on their positions and values, defining how pixels are grouped together.

Connected Pixels

- Let S represent a subset of pixels in an image.
- **Two pixels p and q** are said to be **connected in S** if there is a path between them consisting entirely of pixels in SS.

Connected Component

- For any pixel p in S
  - The set of pixels that are connected to p in S is called a **connected component** of S.

Connected Set

- If S contains only one connected component, it is called a **connected set**.4

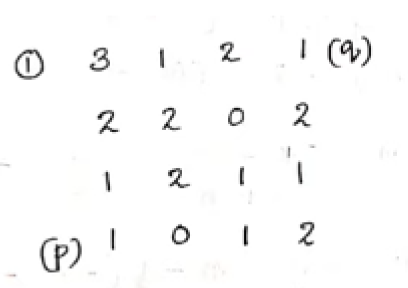
Example

- Consider a set of pixel values V={20,32,40,50}
- If we look at a center pixel with a value of 50, and its neighboring pixels have values 20, 32, and 40:
- The **connected component** for the center pixel 50 is C={20,32,40}

---

6. 4-adjacency, 8-adjacency, m-adjacency problem

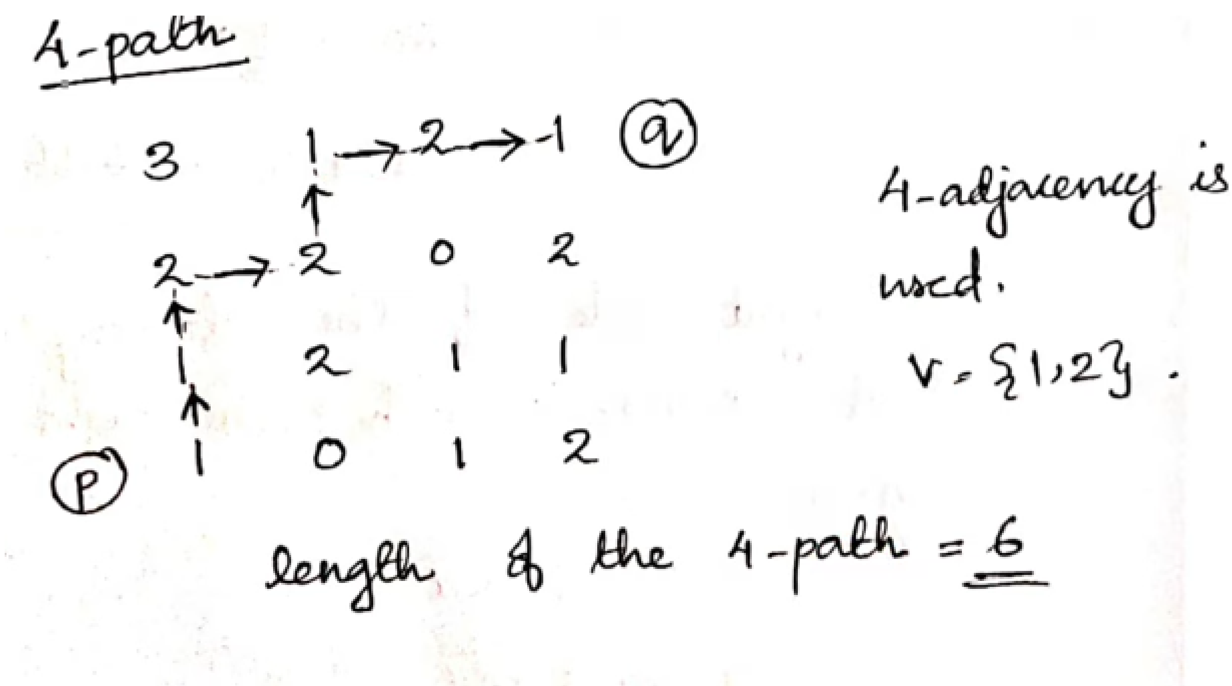
Consider the image segment shown, Let V{1,2} and compute the lengths of the shortest 4-path, 8 path and m-path, Between pixel p and q



4 path

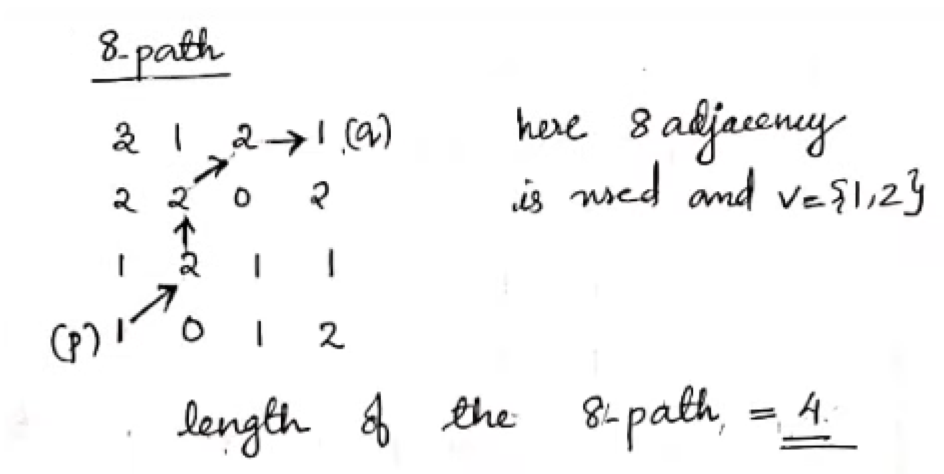
- We can only go in 4 directions
  - top
  - bottom
  - left
  - right
- We start with p
- 4 neighbour of p is

    - 1 and 0
    - The specified intensity is {1,2}
    - So choosing 1
- Next neighbours
    - 2 and 2
    - Choosing one of them
- Next neighbours
    - 3 and 2
    - Choosing 2
- Next neighbours
    - 1,2 and 0
    - Choosing 2
- Next neighbours
    - 2 and 3
    - Choosing 2
- Next neighbours
    - 1
    - Choosing 1

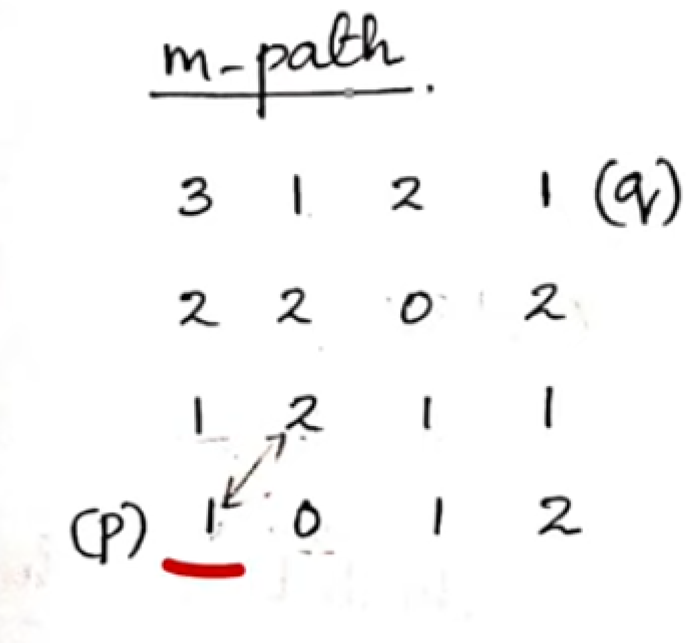


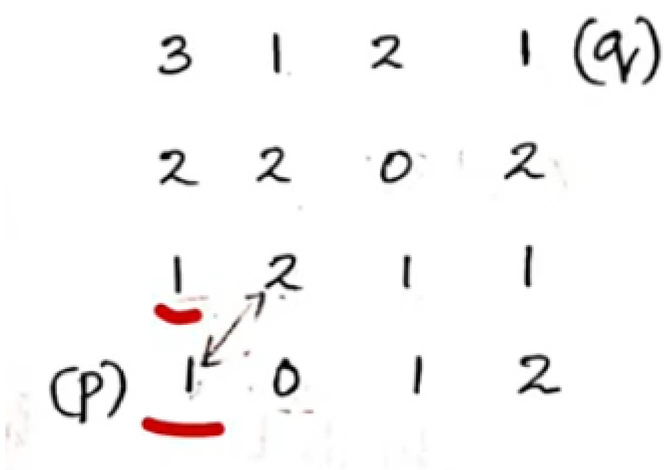
8 path

- We can go in 8 directions
  - Top
    - Top Left
    - Top Right
  - Bottom
    - Bottom Left
    - Bottom Right
  - Left
  - Right
- We start with 1
  - Neighbours are 1,0 and 2
  - Choosing 2

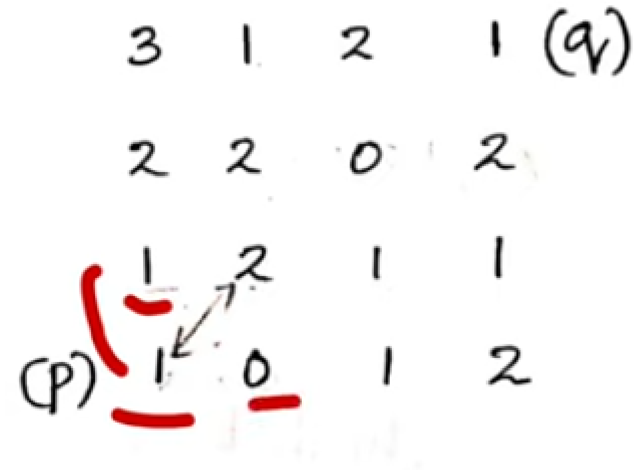


m-path

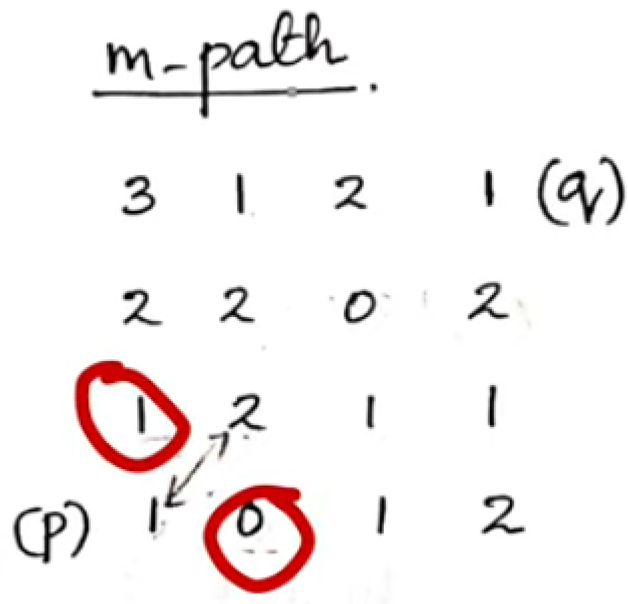


- We first start with 1
- Check its neighbours
  - 1
    

    - 4-neighbours of 1 = {0}
    - 4 neighbours of the other 1 = {2,2}
    - Both 1's doesnt have a common 4-neighbour, hence its not an M path
  - 0



    -
    - 0 cant be taken because its not in the set V{1,2}
  - 2



    -
    - When we taken 1 and 2, lets check their 4-neighbours
    - 1 = {1,0}
    - 2 = {1,0,2,1}
    - Here the common neighbours are 1,0
    - So 1 and 2 is an m-path
- Now we have to proceed from 2
  - Neighbours of 2
    - 0
      - Not in the set {1,2}
    - 2

        - No common neighbour
    - 1
        - No common neighbour
  - There is no m-path
- Since we are not able to find a path from 2, **m-path does not exist between p and q**