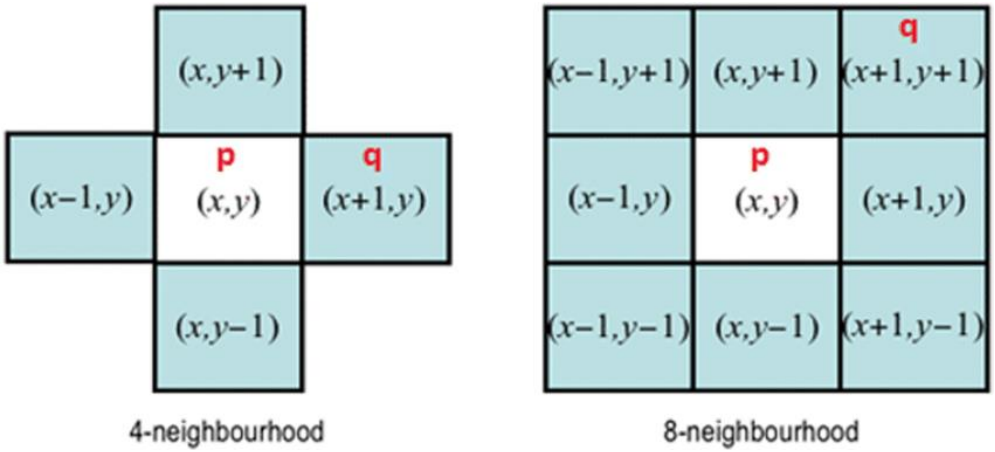
# Image Processing and Computer Vision

# Relationships between pixels

- **Neighbours of a pixel**
- A pixel p at (x,y) has 4-horizontal/vertical neighbours at (x+1,y), (x-1,y), (x,y+1) and (x,y-1). These are called the **4-neighbours of p : N4(p)**.

- A pixel p at (x,y) has 4 diagonal neighbours at (x+1,y+1), (x+1,y-1), (x-1,y+1) and (x-1,y-1). These are called the **diagonal-neighbours of p : ND(p).**




- The 4-neighbours and the diagonal neighbours of p are called **8-neighbours of p : N8(p).**

**N8(p) = N4(p) + ND(p)**

# Adjacency between pixels

- Let **V** be the set of intensity values used to define adjacency.
- In a binary image, V ={1} if we are referring to adjacency of pixels with value 1. In a gray-scale image, the idea is the same, but set V typically contains more elements.
- For example, in the adjacency of pixels with a range of possible intensity values 0 to 255, set V could be any subset of these 256 values.

- We consider three types of adjacency:
- **a) 4-adjacency:** Two pixels p and q with values from V are 4-adjacent if q is in the set N4(p).
- **b) 8-adjacency:** Two pixels p and q with values from V are 8-adjacent if q is in the set N8(p).
- **c) m-adjacency(mixed adjacency):** Two pixels p and q with values from V are m-adjacent if

➢ q is in N4(p), or

➢ 2) q is in ND(p) and the set N4(p)∩N4(q) has no pixels whose values are from V.

# Connectivity between pixels

- It is an important concept in digital image processing.
- It is used for establishing boundaries of objects and components of regions in an image.
- Two pixels are said to be connected:
  - If they are adjacent in some sense(neighbour pixels,4/8/m-adjacency)
  - If their gray levels satisfy a specified criterion of similarity(equal intensity level)
- There are three types of connectivity on the basis of adjacency. They are:
- **a) 4-connectivity:** Two or more pixels are said to be 4-connected if they are 4-adjacent with each others.
- **b) 8-connectivity:** Two or more pixels are said to be 8-connected if they are 8-adjacent with each others.
- **c) m-connectivity:** Two or more pixels are said to be m-connected if they are m-adjacent with each others.

# Connectivity between pixels

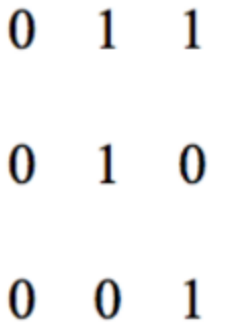



Fig: An arrangement of pixels

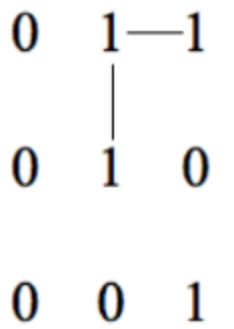



Fig: 4-connectivity of pixels

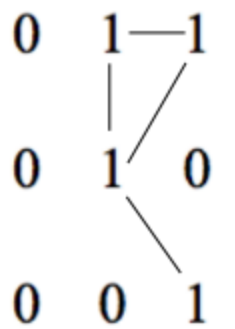



Fig: 8-connectivity of pixels

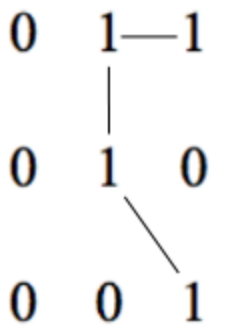



Fig: m-connectivity of pixels

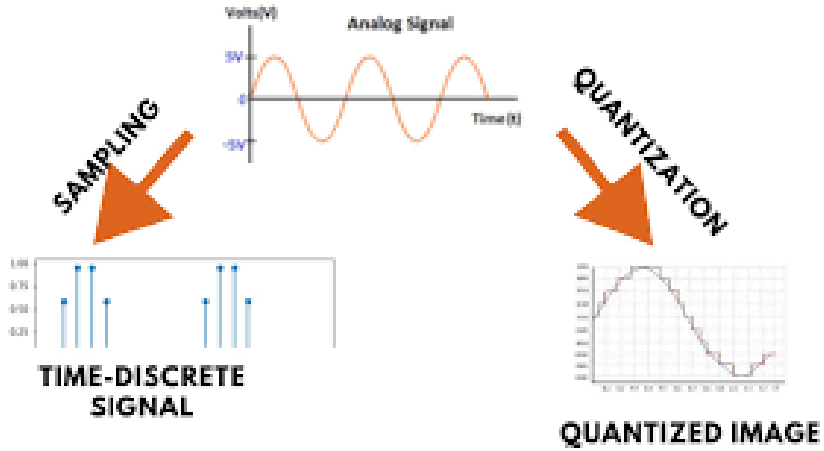
# Regions and Boundaries

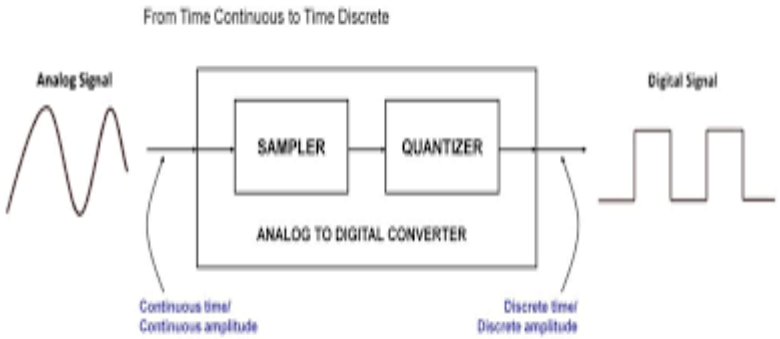
- A subset R of pixels in an image is called a **Region** of the image if R is a connected set.

- The **boundary** of the region R is the set of pixels in the region that have one or more neighbors that are not in R.

# Image Sampling and Quantization

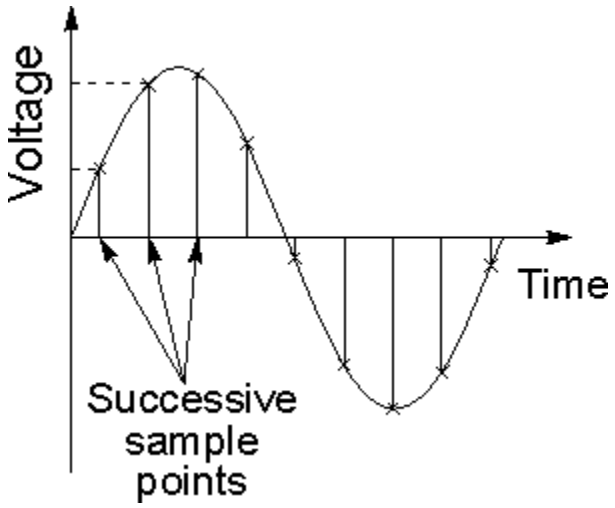
- To create a digital image, we need to convert the continuous sensed data into digital form.
  This process includes 2 processes:
- **Sampling:** Digitizing the co-ordinate value is called sampling.
- **Quantization:** Digitizing the amplitude value is called quantization.
- To convert a continuous image f(x, y) into digital form, we have to sample the function in both co-ordinates and amplitude.



# Sampling in Digital Image Processing

- In this we digitize x-axis in sampling.
- It is done on the independent variable.
- For e.g. if *y = sinx*, it is done on x variable.



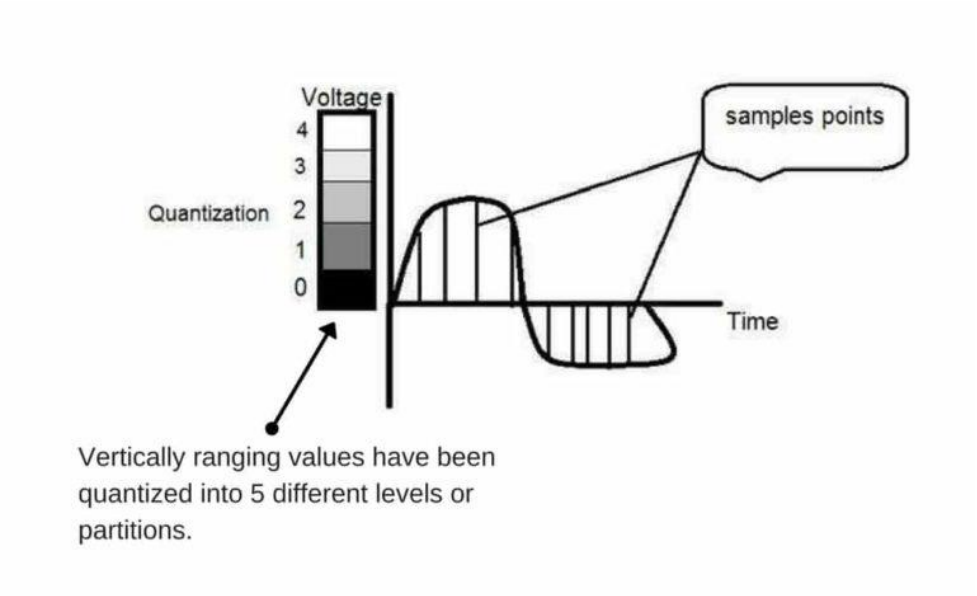

- There are some variations in the sampled signal which are random in nature. These variations are due to noise.

# Sampling in Digital Image Processing

- We can reduce this noise by more taking samples. More samples refer to collecting more data i.e. more pixels (in case of an image) which will eventually result in better image quality with less noise present.
- As we know that pixel is the smallest element in an image and for an image represented in the form of a matrix, total no. of pixels is given by:
- ***Total number of pixels = Total number of rows X Total number of columns***
- The number of samples taken on the x-axis of a continuous signal refers to the number of pixels of that image.
- ***For a CCD array,*** if the number of sensors on a CCD array is equal to the number of pixels and number of pixels is equal to the number of samples taken, therefore we can say that number of samples taken is equal to the number of sensors on a CCD array.
- ***No. of sensors on a CCD array = No. of pixels = No. of samples taken***
- Oversampling is used for zooming. The difference between sampling and zooming is that sampling is done on signals while zooming is done on the digital image.

# Quantization in Digital Image Processing

- It is opposite of sampling as sampling is done on the x-axis, while quantization is done on the y-axis.
- Digitizing the amplitudes is quantization. In this, we divide the signal amplitude into quanta (partitions).



# Relation of Quantization and gray level resolution

- ***Number of quantas (partitions) = Number of gray levels***
- Number of gray levels here means number of different shades of gray.
- To improve image quality, we increase number of gray levels or gray level resolution up.
- If we increase this level to 256, it is known as the grayscale image.

$$L = (2^k)$$

- Where,
  L = gray level resolution
  k = gray level
- ***Gray level = number of bits per pixel (BPP) = number of levels per pixel***

# Image File Formats

- **Image Format** describes how data related to the image will be stored. Data can be stored in compressed, Uncompressed, or vector format. Each format of the image has a different advantage and disadvantage. Image types such as TIFF are good for printing while JPG or PNG, are best for the web.
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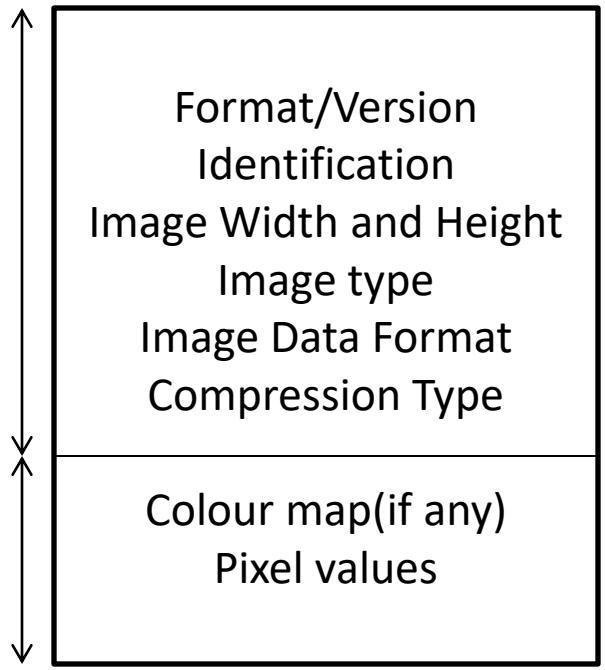


Header Information:-The header part contains some of the vital information like format or version identification, width and height of the image, type of the image and image data format.

The header also specifies the type of compression mechanism. The length of the file header is often fixed.

# Image File Formats

- **TIFF(.tif, .tiff):** Tagged Image File Format this format store image data without losing any data. It does not perform any compression on images, and a high-quality image is obtained but the size of the image is also large, which is good for printing, and professional printing.

- **JPEG (.jpg, .jpeg):** Joint Photographic Experts Group is a loss-prone (lossy) format in which data is lost to reduce the size of the image. Due to compression, some data is lost but that loss is very less. It is a very common format and is good for digital cameras, nonprofessional prints, E-Mail, Powerpoint, etc., making it ideal for web use.

- **GIF (.gif):** GIF or Graphics Interchange Format files are used for web graphics. They can be animated and are limited to only 256 colors, which can allow for transparency. GIF files are typically small in size and are portable.

- **PNG (.png):** PNG or Portable Network Graphics files are a lossless image format. It was designed to replace gif format as gif supported 256 colors unlike PNG which support 16 million colors.

# Image File Formats

- **Bitmap (.bmp)** Bit Map Image file is developed by Microsoft for windows. It is same as TIFF due to lossless, no compression property. Due to BMP being a proprietary format, it is generally recommended to use TIFF files.

- **Scalable Vector Graphics File Format (.SVG)** It is used for Internet use. This format is specifically based on XML, intended to create a smaller, scalable image file format for internet use. It is generally smaller than bitmapped file and scalable without any loss of resolution. The information for the image is stored in the text data so that it can be searched and edited.

- **Photoshop Default File Format (PSD)** PSD is the Photoshop's default format which is capable of supporting layers, editable text and millions of colours. It has the capacity to retain information related to layers, masking channels etc. , which tend to be lost when saved in another file format.