

IMAGE PROCESSING

WEEK-1

2. Concept of images and pixels

- **Image resolution -**
- Resolution refers to the number of pixels in an image and determines its clarity and detail.
- High resolution means more pixels and sharper images.
- Low resolution means less pixels and blurry image.
- The resolution of a digital image is measured in “**Pixel per inch**”



215 ppi



23 ppi

- **Image Aspect Ratio-**

- The proportional relationship of image's width and height.
- It is written as W:H, for example:- 16:9 where width is 16 units and height is 9 units
- Aspect ratio does not tell you the actual size but only represents the shape of the image.
- **Aspect ratio is important:**
 - Display consistency- images looks correct on different screens
 - Preventing distortion- as wrong aspect ratio causes: stretching , squishing , cropping
 - Used for web, UI/UX, social media templates.



- **Pixel matrix representation:**

- Pixel : A pixel is the smallest unit of digital image or display and stands for “picture element”. It is a very small , isolated dot that stands for one color. Each pixel stores the color or intensity information.
- A digital image is represented as matrix(2D array) of tiny dot called pixels

- **Pixel matrix for different types images:**

- Grayscale image(2D matrix):

- 0 -> black

- 255 -> white

- Between 0-255-> shades of gray

- Color image(3D matrix):

- the color image is represented as a 3D matrix - Height X width X channels

- Pixels -> [255,0,0] -> full red

- Pixels -> [0,255,0] -> full green

- Pixels -> [0,0,255] -> full blue

```
[ [ 0, 50, 150 ],  
[ 200, 220, 255 ],  
[ 100, 180, 30 ] ]
```

- **Channels(RGB):**

- Color images store colors by using three separate metrics called channels:
- R-Red channel
- G-green channel
- B-blue channel
- Each channel is a gray scale matrix
- For example:
- Red channel highlights red parts of the image
- Green channel highlights the green objects
- Blue channels highlights the blue objects.

- **Histograms:**

- A histogram is a graph that shows the distribution of pixels intensity values in an image.

- **Types of histograms:**

- a. Histogram for grayscale images:

- A grayscale images have pixel value from 0 to 255.
- A histogram counts how many pixels fall into each of these 256 values.

- b. Histogram for color images:

- Color images have 3 channels -> R , G , B
- Each channel has its own histogram:
- Red channel histogram
- Green channel histogram
- Blue channel histogram

- **Characteristics :**

- Brightness- defines brightness , right->bright image , left-> dull image.
- Contrast- narrow histogram-> low contrast image , wide-> high contrast
- Under-exposed or over-exposed- too many pixels on left-> underexposed , too many in the right-> overexposed.

- **Image intensity:**

- Image intensity refers to the brightness value of the pixels in an image.
- Intensity describe how light and dark a pixel is
- In grayscale images, intensity is determined by a single value(0-255)
- In color image it is derived from the color channels(R , G , B)

- a. Intensity in grayscale images:

- A grayscale pixel has a single value that ranges between 0-255
- 0 -> dark pixel , 255 -> bright pixel

- b. Intensity in color images:

- Color pixel has three values(R,G,B)
- Intensity in color image = combined brightness
- The formulae to calculate the intensity ->

$$I = 0.299R + 0.587G + 0.114B$$

- **Importance of image intensity:**

- a. Thresholding : separating foreground from background
- b. Edge detection : edges-> change of intensity
- c. Feature extraction : textures,corners and gradients depends on intensity variations.

- **Intensity range:**

- Most images uses 8-bit per pixel(0-255) but 16bit (0-65,535) is also used(medical)

- **Noise & gradients:**

- Noise are the unwanted random variation in pixel values.
- It makes an image look grainy, speckled or distorted.

- **Types of noise:**

- Gaussian noise : caused by temperature, low light , it looks like soft grain
- Salt-and-Pepper noise : appear as random black(0) and white(255) spots, caused by transmission errors, looks like scattered dots
- Poisson noise(shots noise) : caused by photon fluctuations(low light), common in astronomy , medical imaging
- Speckle noise : it is a type of multiplicative noise , occurs in ultrasound , radar images

- **Removal techniques:**

- Gaussian noise : gaussian blur
- Salt and pepper : median filter
- Speckle noise : adaptive or smoothing filters

- Gradients:
 - Gradients measure how intensity changes between pixels.
 - Gradient refers to -> rate of change

- **Gradients helps in:**

- Edge detection
- corner/feature detection
- Image sharpening
- Object recognition
- Segmentation

- **Gradient filters:**

- sobel operator - detects horizontal and vertical edges
- Prewitt operator - deals with simpler weights.
- scharr operator - improved for accurate gradients
- laplacian operator - detects edges in all direction

- Kernel operations:
 - A kernel is a matrix used for modify the pixels of an image
 - Ex: 3X3, 5X5 ,7X7
 - Kernel operations are the set set of operations that are used in image processing and computer vision

- How kernel works:

- A kernel slides over the image pixel-by-pixel.
- At each position:
 1. The overlapping pixels are multiplied with the kernel values.
 2. The results are added
 3. The sum is placed in the corresponding location in the resulting matrix.

- Types of kernel operations :

1. Blurring/Smoothing : removes noises, smoothen the image,reduces details
 2. Sharpening : highlighting edges, helps the image appear more crip/sharp
 3. Edge detection : used for detecting vertical and horizontal edges.
- Padding : is the addition of zeros to compensate the loss
 - Strides: how many pixels the kernel jumps each steps

- **codes:**
- Hands on -
 - <https://colab.research.google.com/drive/1Ix9h8H3uuINCDS-knwychZ9rHqbuzSGn#scrollTo=J-ZGL7-CTxm8>
- POC -

Show how changing a single pixel can impact:

- Edges
- Classification outcome
- - https://colab.research.google.com/drive/17ePsRw9o_TF3c-eNcLi7sB3n9Rb06sxt#scrollTo=ZxsA75pJVhRy