

# Fundamentals of Image Processing

# Topics to be covered

- What is an Image?
- Image Formation
- Digital Image
- Digital Image Processing
- Typical Image Processing System

# What is an Image?

An image is a visual representation of a person or an object produced by optical device through reflection or refraction. The optical devices are mirror, lens, prism or a camera.

This visual representation is usually 2D. However, Higher order representations are also possible like 3D.



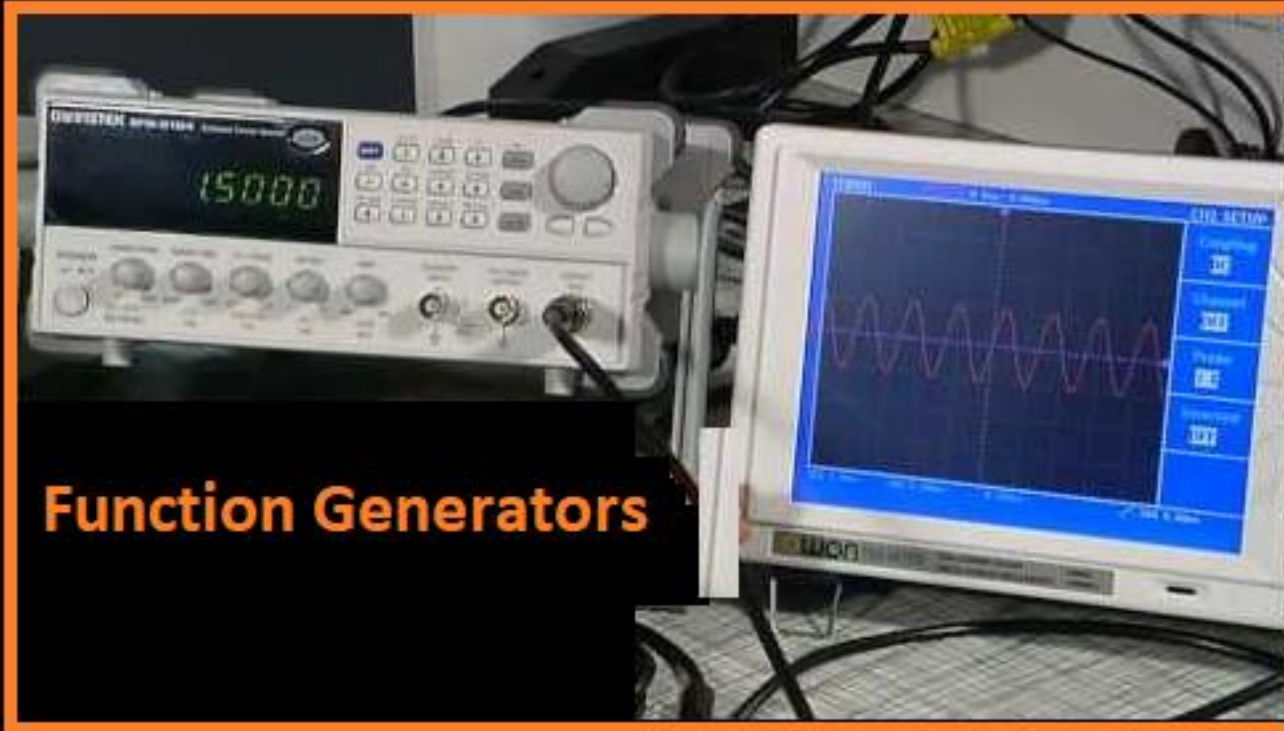
Gray Scale Image



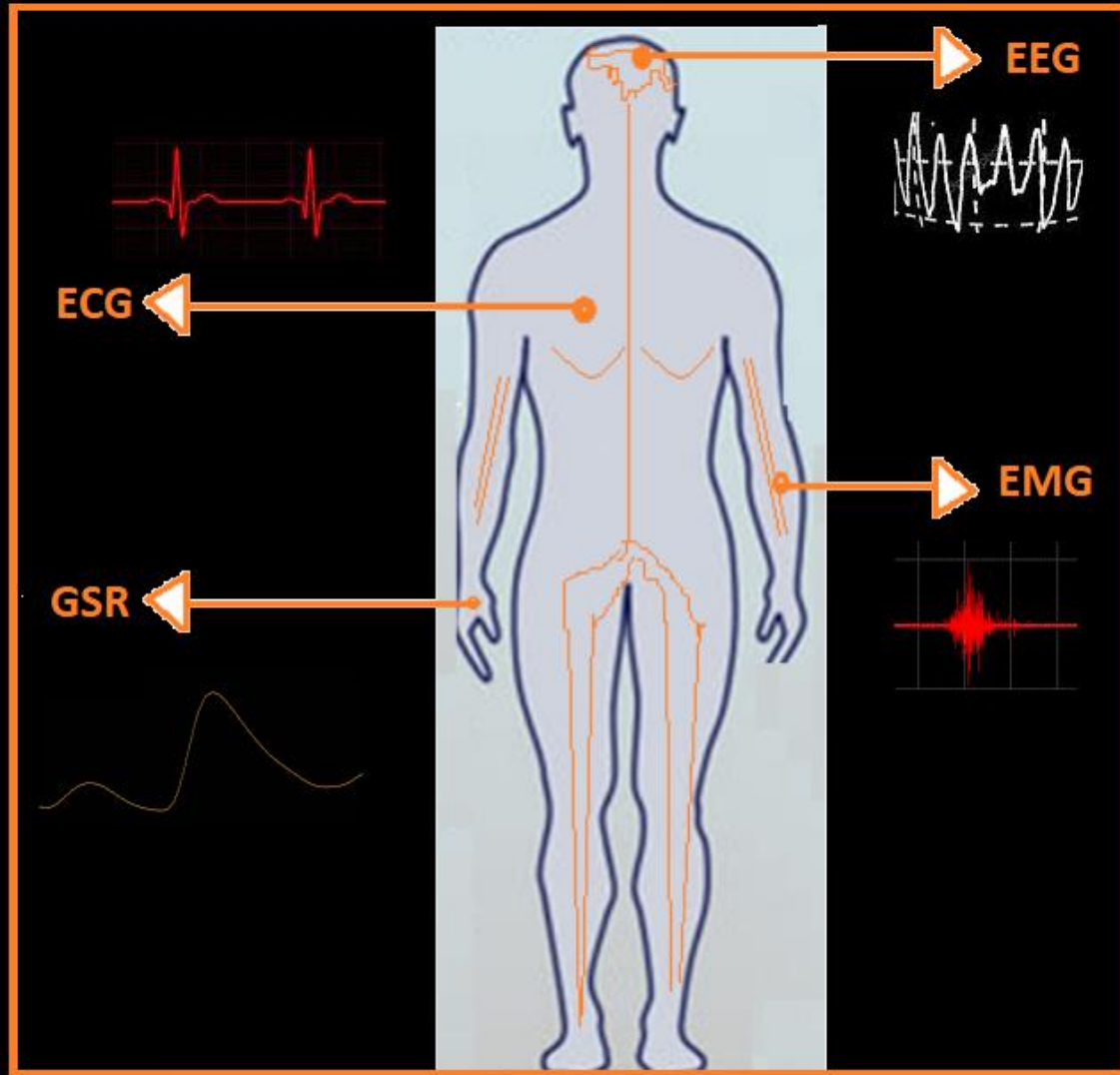
Color Image  
3-channel Image  
RGB Image

# Image Formation

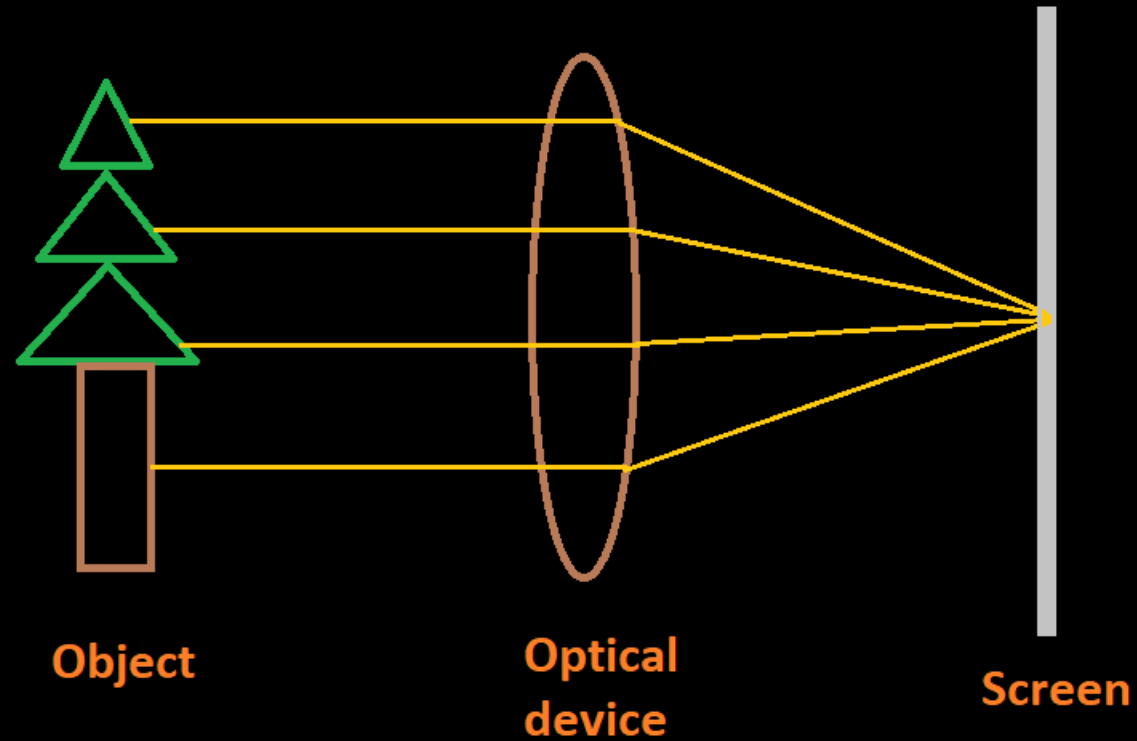
How are signals generated ?



# How are signals generated ?

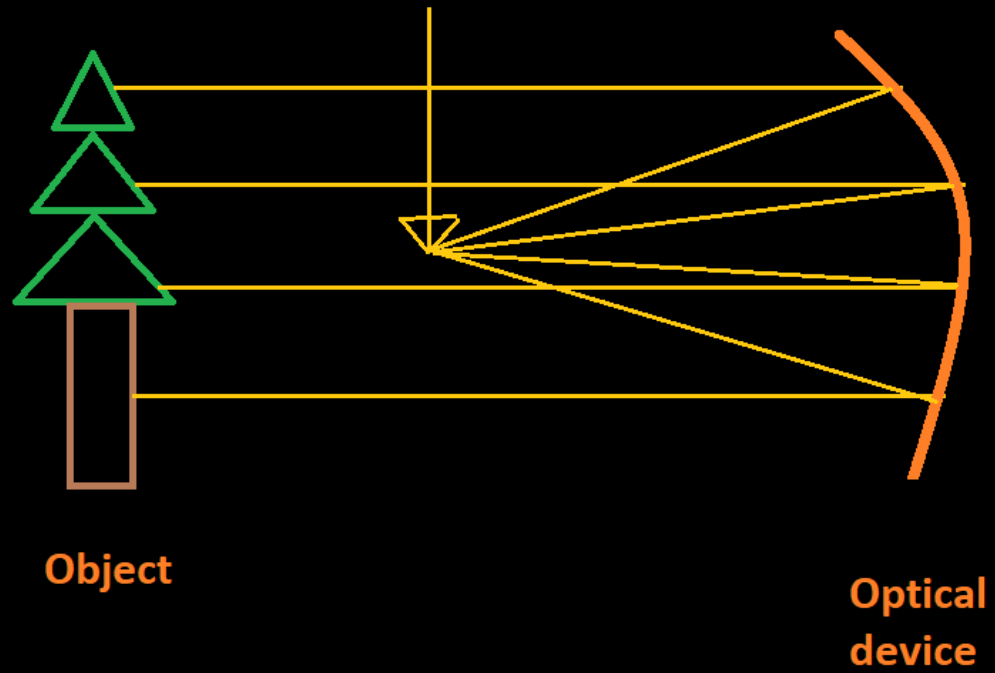


# Image Formation





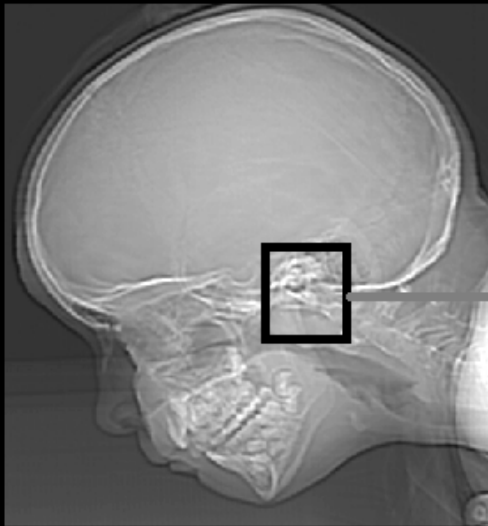
# Image Formation



# Digital Image

A digital image is a 2D representation having a finite number of display points. Each point is called picture element or pixel. Pixel is the smallest unit in a digital display of an image. Each pixel is represented by one or more numerical values. For gray scale images, every single value represents the intensity of the pixel (usually in a  $[0, 255]$  range). For color or 3-channel (red (R), green (G), and blue (B)) three values corresponding to each channel are used.

## Gray Scale Image



What we see

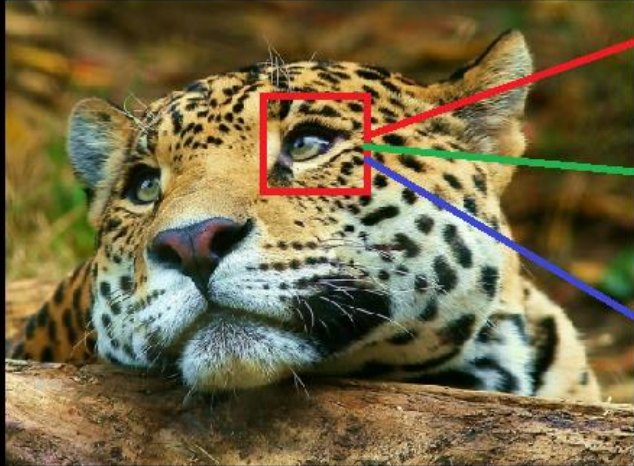
|     |     |     |    |     |     |     |
|-----|-----|-----|----|-----|-----|-----|
| 255 | 255 | 238 | 30 | 62  | 241 | 255 |
| 255 | 255 | 218 |    | 64  | 241 | 255 |
| 255 | 255 | 145 |    | 64  | 241 | 255 |
| 255 | 255 | 81  |    | 72  | 244 | 255 |
| 255 | 255 | 72  |    | 128 | 255 | 255 |
| 255 | 255 | 73  |    | 146 | 255 | 255 |
| 255 | 255 | 64  |    | 184 | 255 | 255 |
| 255 | 255 | 63  |    | 188 | 255 | 255 |

What computer sees

## Spatial Domain Representation of an Image

An Image of size  $M \times N$  can be spatially represented by the following way

$$I(x, y) = \begin{bmatrix} f(0, 0) & f(0, 1) & \dots & f(0, N-1) \\ f(1, 0) & f(1, 1) & \dots & f(1, N-1) \\ \vdots & \vdots & \ddots & \vdots \\ f(M-1, 0) & f(M-1, 1) & \ddots & f(M-1, N-1) \end{bmatrix}$$



3 Channel Image

|     |     |     |     |
|-----|-----|-----|-----|
| 35  | 36  | 37  | 38  |
| 46  | 47  | 48  | 49  |
| 101 | 102 | 103 | 104 |
| 131 | 132 | 133 | 134 |
| 65  | 66  | 67  | 68  |

R

|     |     |     |     |
|-----|-----|-----|-----|
| 121 | 122 | 123 | 124 |
| 33  | 34  | 35  | 36  |
| 77  | 78  | 79  | 80  |
| 213 | 214 | 215 | 216 |
| 19  | 20  | 21  | 22  |

G

|     |     |     |     |
|-----|-----|-----|-----|
| 251 | 252 | 253 | 254 |
| 71  | 72  | 73  | 74  |
| 181 | 182 | 183 | 184 |
| 39  | 40  | 41  | 42  |
| 113 | 114 | 115 | 116 |

B

# Digital Image Processing

Digital Image processing is the branch of Science and Engineering in which we transform or modify the image using algorithms and digital machines.

Few of the important processing or transformations are

- Image Deblurring OR Sharpening
- Noise Removal
- Contrast Enhancement
- Edge Detection

# Image Deblurring OR Sharpening



**Blurred Image**



**Sharp Image**

# Noise Removal



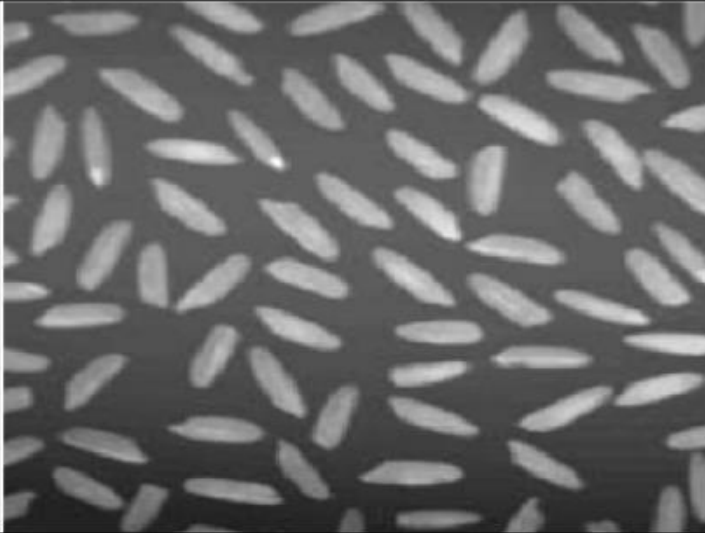
**Noisy Image**



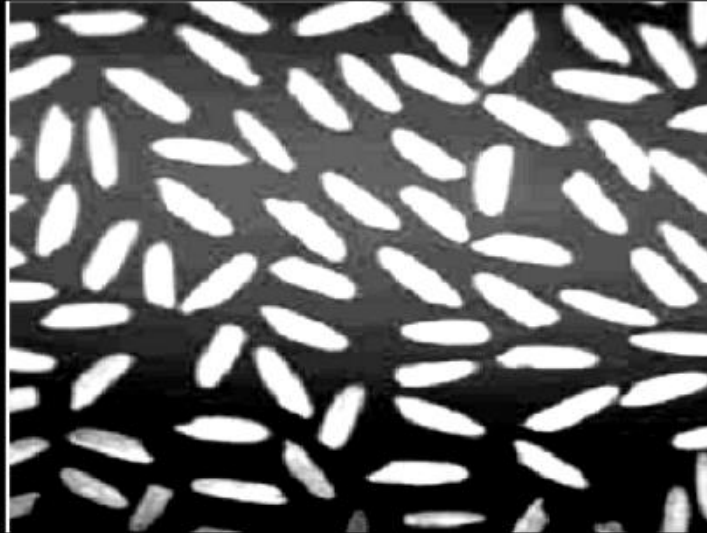
**Filtered Image**



# Contrast Enhancement



**Low Contrast Image**



**High Contrast Image**

Image from Practical Image and video processing by OGE MARQUES

# Edge Detection



**Original Image**



**Edge Detection**

# Typical Image Processing System



