



**Al-Mustaqbal University**

**College of Engineering & Technology**

**Biomedical Engineering Department**

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**Lecture No.:-1**

**Lecture Title: [Digital Image Processing ]**



# . Introduction

Digital Image Processing (DIP) is a computational technique used to manipulate, enhance, analyze, and extract meaningful information from digital images.

In medical imaging, DIP plays a critical role in:

- Disease diagnosis
- Tumor detection
- Organ segmentation
- Quantitative measurements
- Surgical planning

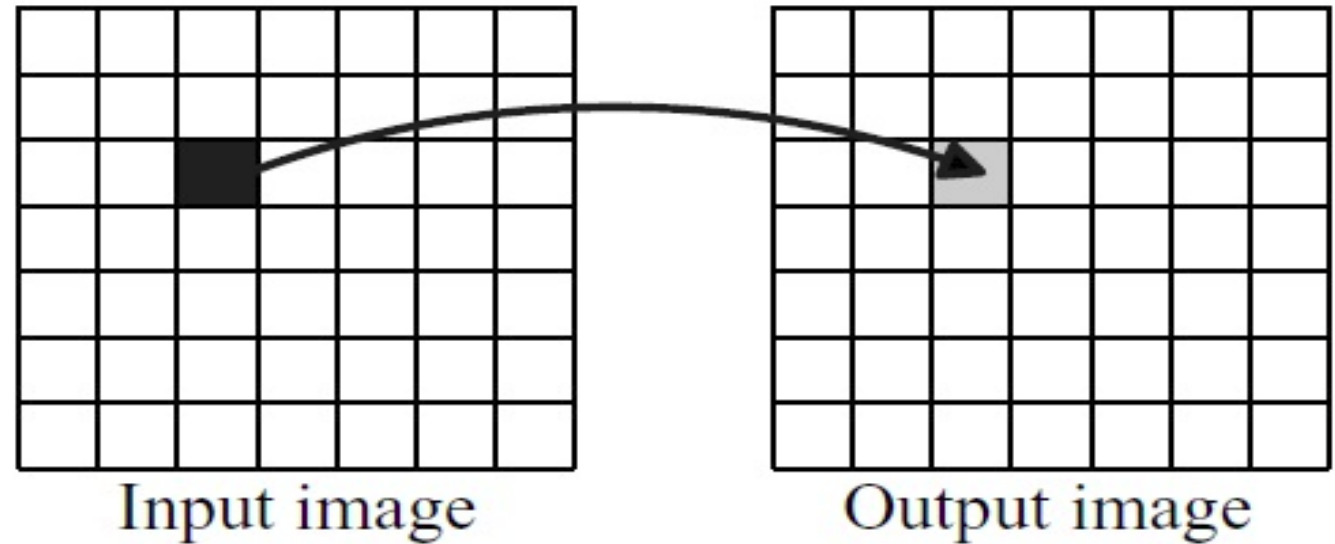
Medical imaging modalities include:

- X-ray
- CT
- MRI
- Ultrasound
- PET

# Main Tasks of Digital Image Processing

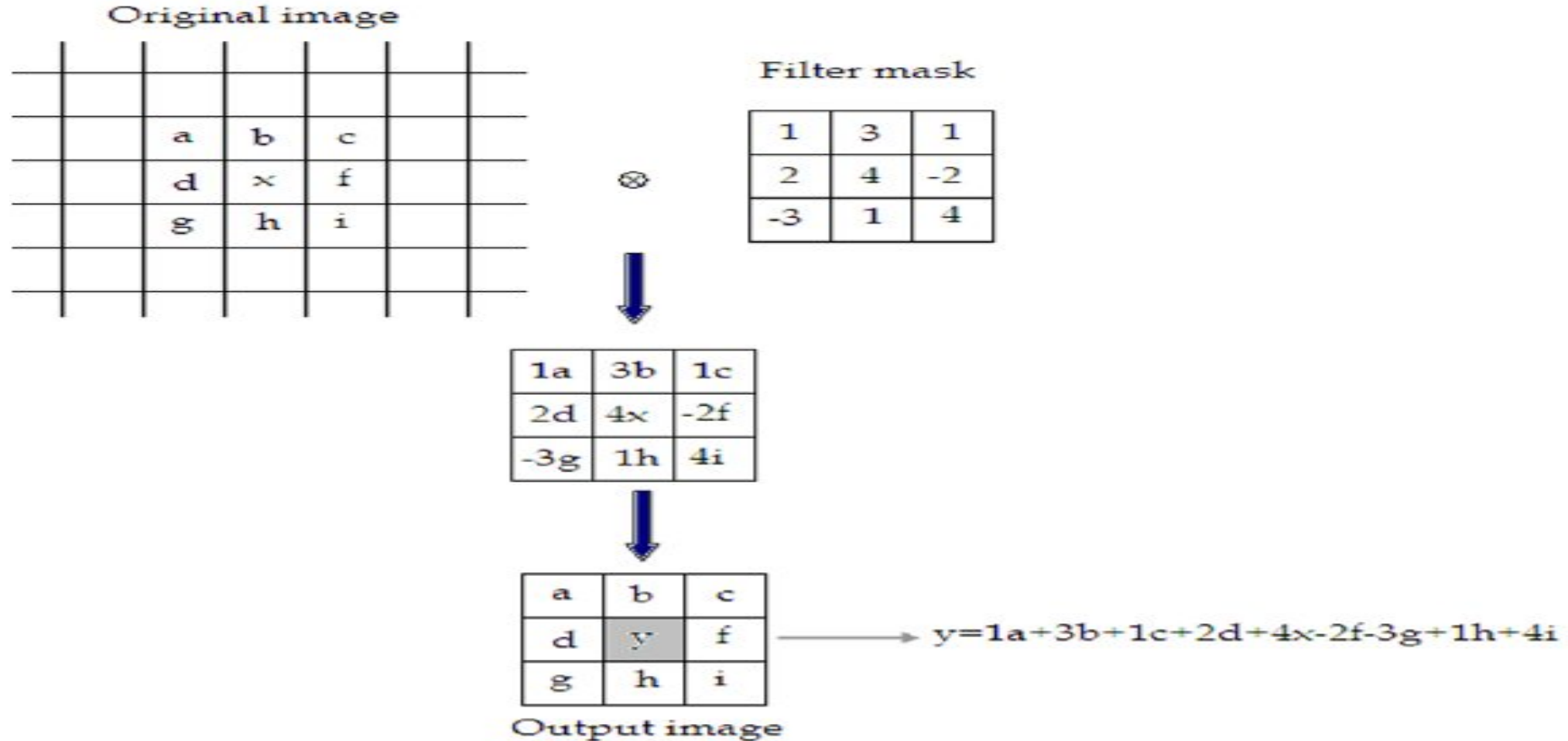
1. Point operations: it is pixel by pixel processing

- Examples:
- Image Negative.
- Brightness Enhancement.
- Log Transformation.



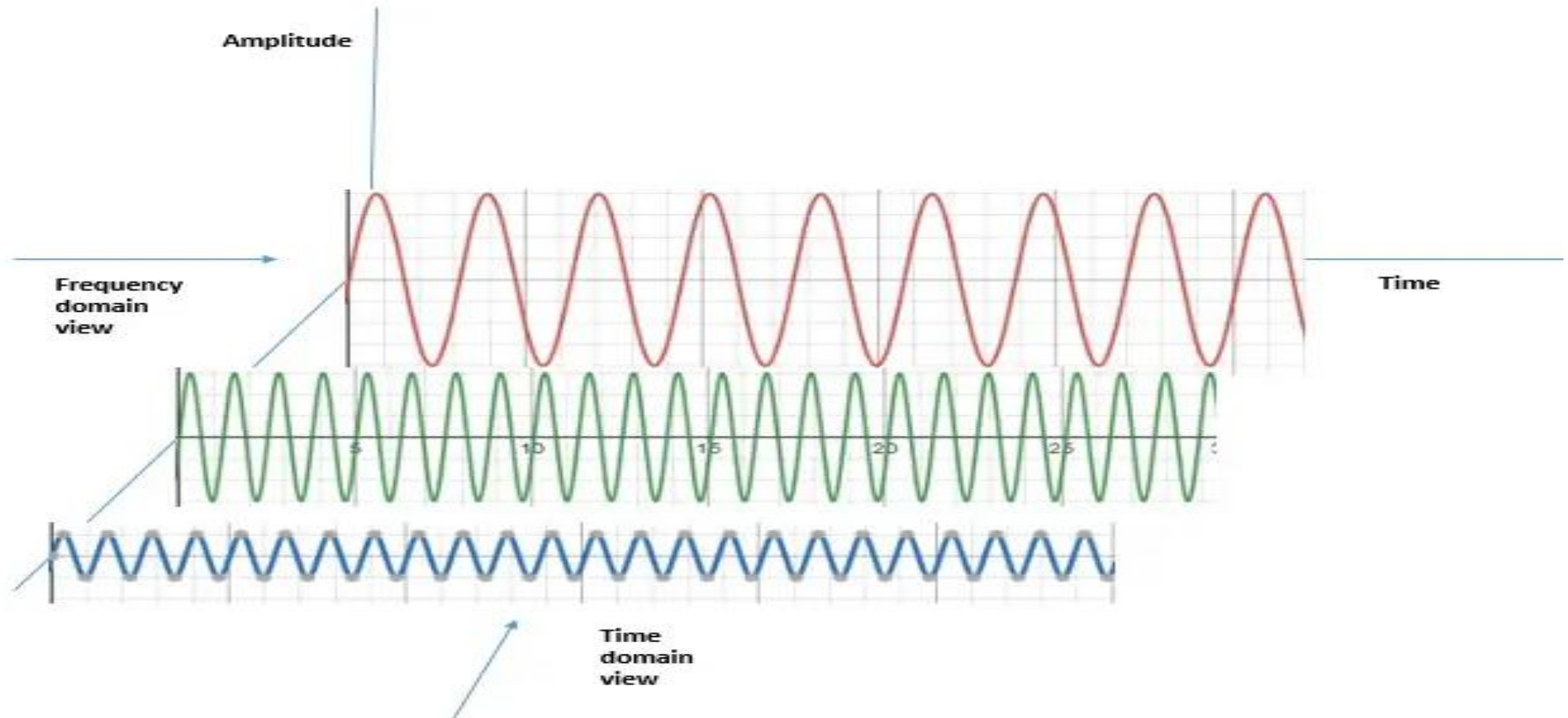
- **Point operations are used for contrast enhancement, highlighting fine anatomical details, visualizing low-density tissues, and improving the detection of tumors and vascular structures.**

2. Spatial filtering operation (mask operation):  
It is processing at spatial domain (grey level intensity image).



### 3. Frequency domain operation

- It is processing at frequency domain such as using Fourier transform or wavelet processing



## Medical image noises

- **Sources of noises in medical digital images**

Image processing is a dominant tool for many areas including robotics, biometrics, security and surveillance, remote sensing and medical imaging. The applicability and performance of a particular image processing depends on the quality of the test image. However, digital images are inevitably corrupted by noise due to acquisition, transmission and mathematical computation. Noise manifests itself in the digital image in a random uncorrelated manner, making it inescapable to degrade the visual quality of the images besides harshly limiting the precision and accuracy of image interpretation and examination. So, Variations of intensity that have no bearing on the information in the image are called noise. In case of medical imaging low light conditions and limited exposure types, leads to degradation of specimens by increasing the noise influence.

## **Noise Issues in Different Types of Images**

There are a variety of digital images available which provide valuable information in diverse fields of application like medical imaging

There are types of noise

- 1- Substitute noise
- 2- Additive noise
- 3- Mutiplicative noise
- 4- Other types of noise

### **1. Gaussian noise**

The Gaussian noise, also called additive noise, is caused by natural sources such as thermal vibration of atoms and discrete nature of radiation of warm objects .Gaussian noise generally disturbs the gray values in digital images. That is why Gaussian noise model essentially

designed and characteristics by normalizes histogram with respect to gray value. This is given as:

$$p(z) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(z-\bar{z})^2}{2\sigma^2}} \dots\dots\dots (1)$$

where z represents the intensity, z- is the mean (average) value of z, and σ is its standard deviation. The standard deviation squared is called the variance. Generally Gaussian noise mathematical model represents the correct approximation of real-world scenarios. In this noise model, the mean value is zero; variance is 0.1 and 256 gray levels in terms of its PDF (Probability Density Function), which is shown in Fig. (1)

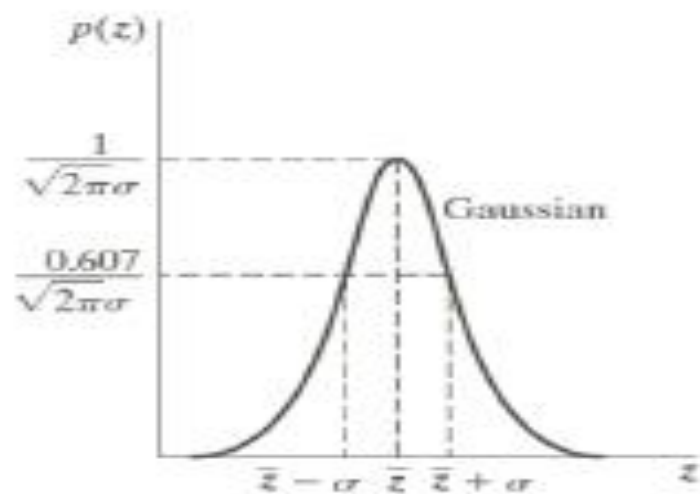


Figure (1), illustrates gaussian noise

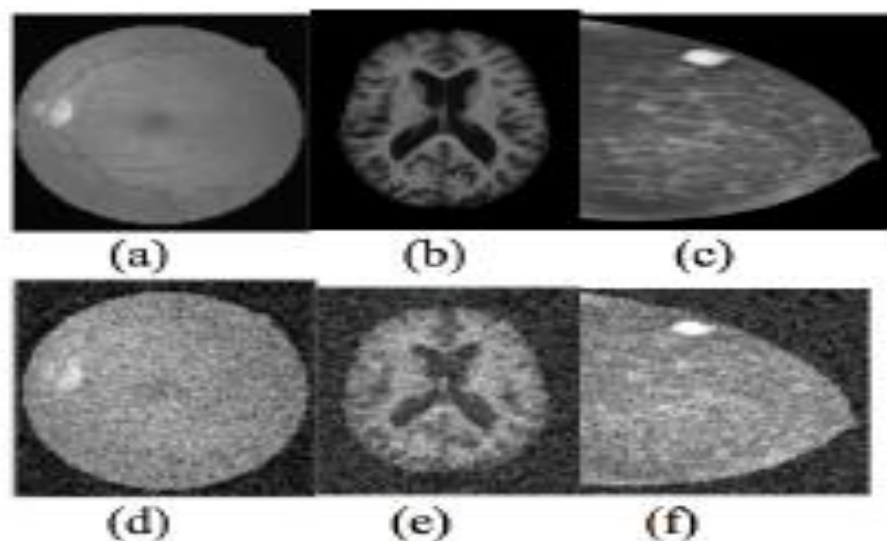


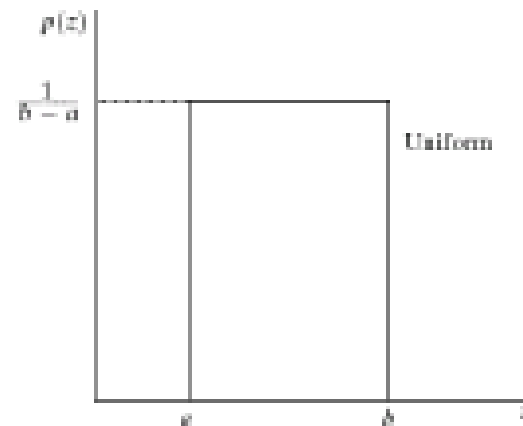
Fig. 1 (a), (b) & (c): Original images of retinal, MRI & Mammogram respectively. (d), (e) & (f) are Gaussian noise affected images.

## 2. Uniform noise

The uniform noise caused by quantizing the pixels of an image to a number of distinct levels is known as quantization noise. It has approximately uniform distribution. In the uniform noise, the level of the gray values of the noise are uniformly distributed across a specified range. Uniform noise can be used to generate any different type of noise distribution. This noise is often used to degrade images for the evaluation of image restoration

algorithms. This noise provides the most neutral or unbiased noise. [4] 
$$p(z) = \begin{cases} \frac{1}{b-a} & \text{if } a \leq z \leq b \\ 0 & \text{otherwise} \end{cases}$$

The mean and variance of this density are given by  $\mu = (a+b)/2$  and  $\sigma^2 = \frac{(b-a)^2}{12}$



### 3. Salt and pepper noise

Salt-and-pepper noise, also called **shot noise**, **impulse noise**, or **spike noise**, is usually caused by:

- Faulty memory locations
- Malfunctioning pixel elements in camera sensors
- Timing (synchronization) errors during image digitization or transmission

In salt-and-pepper noise, only **two intensity values** occur:

- **a** (salt)
- **b** (pepper)

The probability of each is typically **less than 0.2**. If the probability is higher, the noise can overwhelm the image.

For an **8-bit image**:

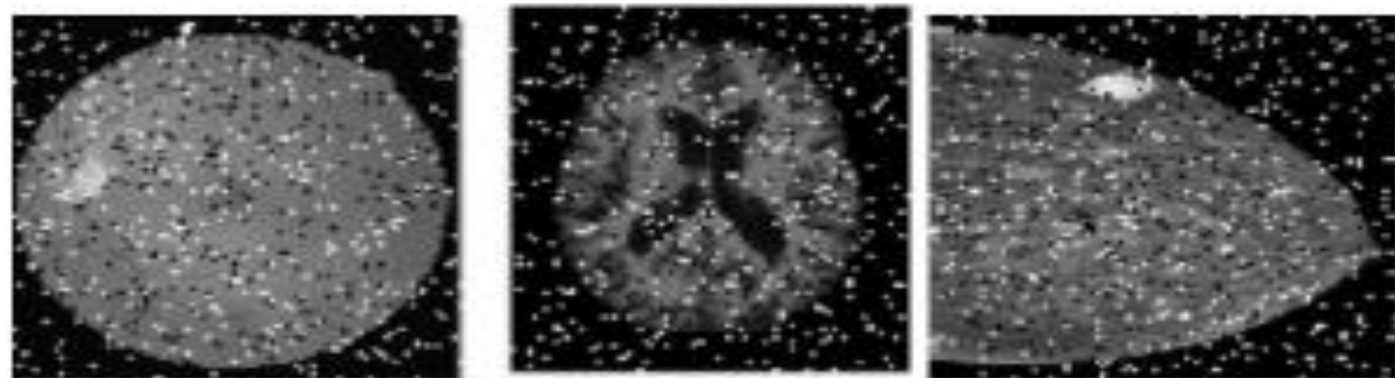
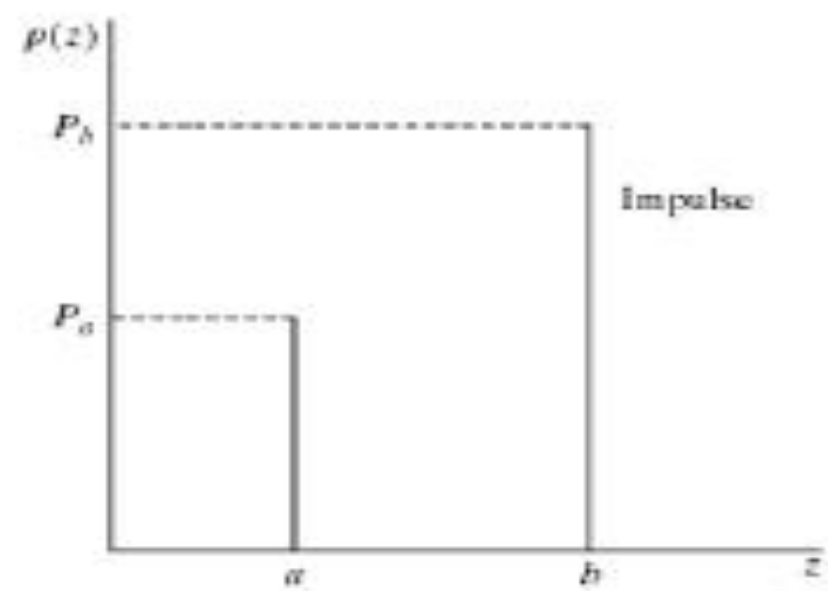
- Salt noise value = **255** (white)
- Pepper noise value = **0** (black)

**Probability Density Function:**

$$p(z) = \begin{cases} P_a & \text{for } z = a \\ P_b & \text{for } z = b \\ 0 & \text{otherwise} \end{cases}$$

If either  $P_a$  or  $P_b$  equals zero, the impulse noise is called **unipolar**.

Usually,  $a$  and  $b$  are extreme intensity values because impulse corruption is large compared to the original image signal. Salt-and-pepper noise is the only type of noise that can be easily distinguished visually from other noise types.



## 4. Speckle Noise (Multiplicative Noise)

The speckle noise is the type of multiplicative noises. In this random unwanted signal is multiplied into different relevant signal while capturing and transmission. The speckle noise is mainly recognized in radar imagery SAR (Synthetic Aperture Radar) images, medical images. The product of the mean value can be taken an exponential random variable. Speckle noise is generally defined based on medical survey is image texture. The speckle noise is represented as,

$$K(i,j) = x(i,j) * n(i,j) + k$$

It is the practical image,  $n(i, j)$  is the multiplicative factor and  $k$  is the additive factor of the speckle noise. Here  $i$  and  $j$  denotes the axial and neighbouring keys of an image samples. In radar applications the major problem is speckle noise. Speckle noise is mainly caused by the constructive and destructive interference of the ultrasonic waves that are passed in to the human body



## Periodic noise

- If the image signal is subject to a periodic, rather than a random disturbance, we might obtain an image corrupted by periodic noise (bars over the image).
- It is quite easy to create a periodic noise, by adding a periodic matrix (using a trigonometric function), to our image:

