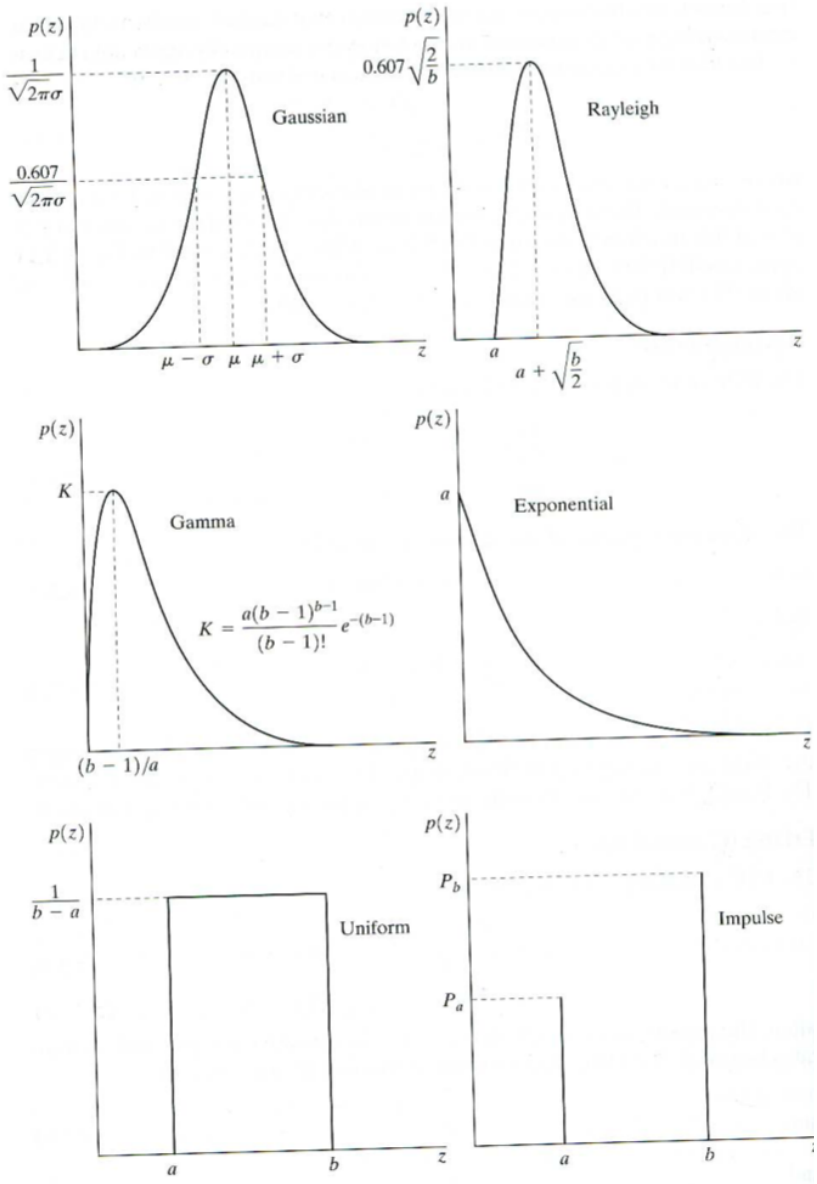
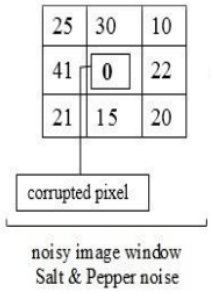
Morphology (Nonlinear Spatial Filtering)

De-Noising

Noise is always introduced into digital images during acquisition, coding, transmission, and processing steps. Image noise is random variations of Intensity (or colour) information which degrades the image. Images containing multiplicative noise have the characteristic that the brighter the area the noisier it, but mostly noise is additive. Various common noise models are available that approximate the random variations of intensity (for grayscale images). Most are described by their probability density functions



Salt-and-pepper (or Impulse) noise is a type of impulse noise where the original value of the pixels is lost and is taken equal to the extremes s_{min} and s_{max} of the dynamic range of the pixel values of an image. For an 8-bit grayscale image, for instance, s_{min}=0 and s_{max}=255.

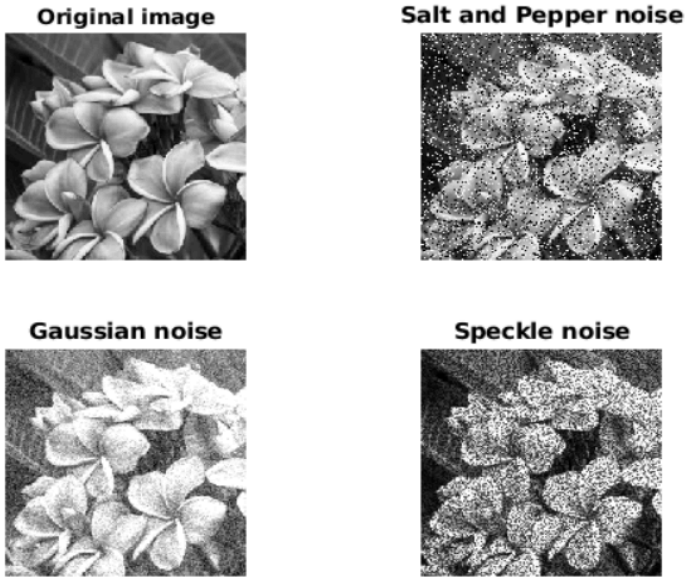


Gaussian noise generally disturbs the gray values in digital images. That is why Gaussian noise model essentially designed and characteristics by its PDF or normalizes histogram with respect to gray value, where g = gray value (Intensity), σ = standard deviation and μ = mean. Generally Gaussian noise 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. Due to this equal randomness the normalized Gaussian noise curve look like in bell shaped. The PDF of this noise model shows that 70% to 90% noisy pixel values of degraded image in between μ-σ and μ+σ.

$$P(g) = \sqrt{\frac{1}{2\pi\sigma^2}} e^{-\frac{(g-\mu)^2}{2\sigma^2}}$$

Speckle noise is a multiplicative noise that affects pixels in a grayscale image, and mainly occurs in low level luminance images such as Synthetic Aperture Radar (SAR) images and Magnetic Resonance Image (MRI) images.

Examples



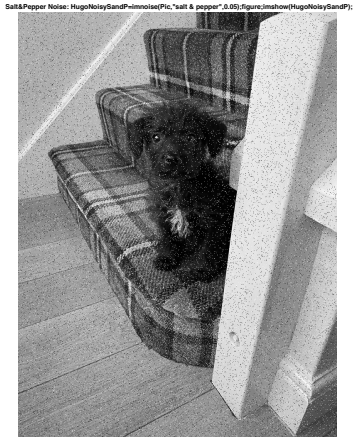
Matlab provides commands to impart various noise characteristics to images (using the *imnoise* command) so that we can apply and investigate the relative merits of de-noising techniques.

```
%%%% Noise Handling %%%%
%Read in image and change to grayscale
PicColour=imread("Hugo.jpg");
Pic = im2gray(PicColour);
```

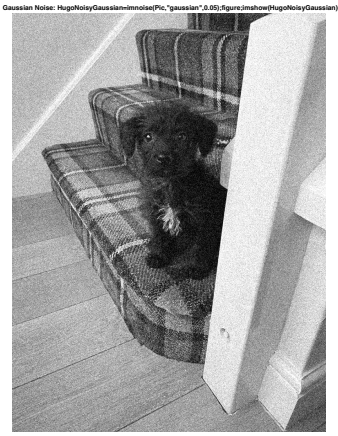
```
% Impulse (Salt and Pepper)
HugoNoisySandP=imnoise(Pic,"salt & pepper",0.05);
figure;
imshow(HugoNoisySandP);
title('Salt&Pepper Noise: HugoNoisySandP=imnoise(Pic,"salt &
pepper",0.05);figure;imshow(HugoNoisySandP);');

%Speckle
HugoNoisySpeckle=imnoise(Pic,"speckle",0.05);
figure;
imshow(HugoNoisySpeckle);
title('Speckle Noise:
HugoNoisySpeckle=imnoise(Pic,"speckle",0.05);figure;imshow(HugoNoisySpeckle
);');

%Gaussian
HugoNoisyGaussian=imnoise(Pic,"gaussian",0.05);
figure;
imshow(HugoNoisyGaussian);
title('Gaussian Noise:
HugoNoisyGaussian=imnoise(Pic,"gaussian",0.05);figure;imshow(HugoNoisyGauss
ian);');
```



Salt and pepper



Gaussian

Speckle

Median Filter to Remove salt and Pepper Noise

The median filter is a non-linear technique that takes the median value of a pixel's nearest neighbours. The principle is shown in the figure below.

123	125	126	130	140
122	124	126	127	135
118	120	150	125	134
119	115	119	123	133
111	116	110	120	130

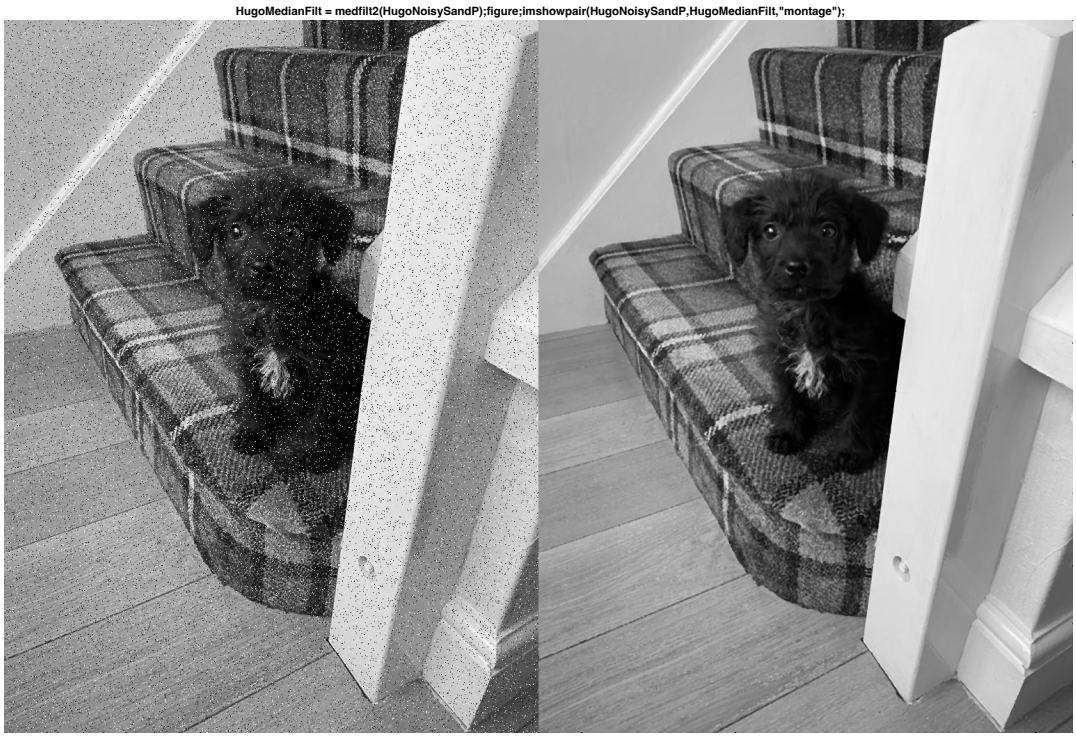
Neighbourhood values:

115, 119, 120, 123, 124,
125, 126, 127, 150

Median value: 124

Matlab can be used to apply the median filter to the noisy image. Notably, median filters are particularly effective for images corrupted by salt and pepper noise.

```
%Median Filter for removing noise
%removing salt and pepper noise (Excellent)
HugoMedianFilt = medfilt2(HugoNoisySandP);
figure;
imshowpair(HugoNoisySandP,HugoMedianFilt,"montage");
```



Noisy Image

Noisy Image after Median Filtering

Try the same processing method (Median Filtering) with images corrupted by Gaussian and Speckle noise.