PAM3012
Digital Image Processing for Radiographers

Noise & Image Restoration

Image Restoration

- Image Enhancement
  - Improve appearance of image
  - Subjective
- Image Restoration
  - Recover image after degradation
  - Objective
- Concentrate on Removal of Noise

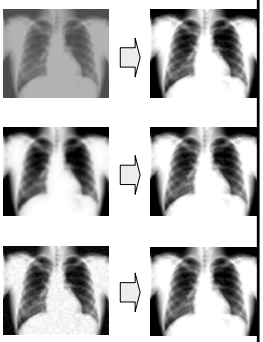
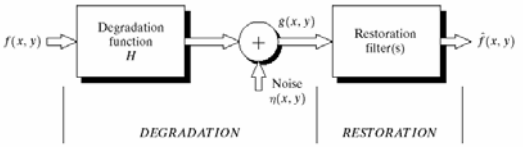


Image Restoration

- Some restoration techniques are better formulated in spatial domain and others in frequency domain
- Spatial
  - Additive noise
- Frequency
  - Periodic Noise
  - Blurring

Model Degradation/Restoration Process

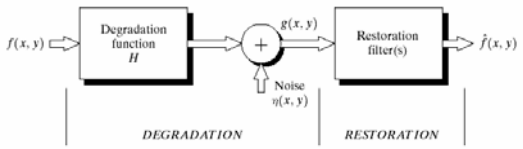
- To restore an image we must model degradation process so that reverse process can be applied
- Model: Degradation Function + Additive Noise



- Objective of restoration is to obtain estimate of $\hat{f}(x,y)$
- Given $g(x,y)$ and some knowledge about H & $\eta(x,y)$

Model Degradation/Restoration Process

- Model: Degradation function + additive noise



- Representation in frequency domain

$$G(u,v) = H(u,v) \times F(u,v) + N(u,v)$$

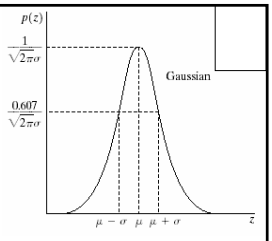
Noise Models

- Principle sources of noise in digital images arise during acquisition and/or transmission
  - Sensor noise
  - Transmission
  - Display
- Noise can be characterised by it's Spatial & Frequency Properties

Noise Probability Density Functions

- Statistical behaviour of grey-level values in the noise component of image, η(x,y)
  - Histogram of noise component
- Common PDF found in image processing…
  - Gaussian and Impulse

Gaussian Noise

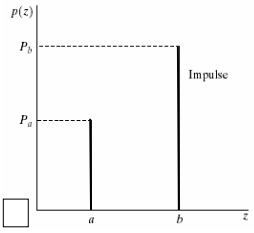


- PDF of Gaussian noise

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

- z = grey-level
- μ = mean value of z
- σ = standard deviation

Impulse Noise

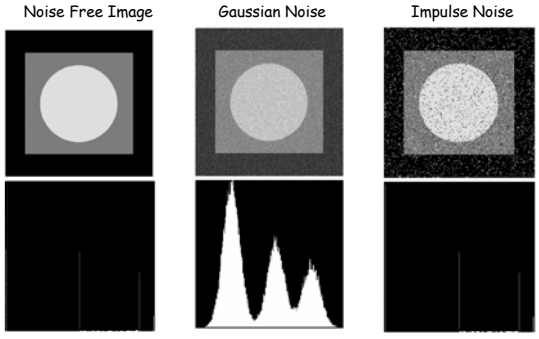


- PDF of Impulse noise

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

- Also referred to as *salt-and-pepper* noise
- Impulse noise is generally large
  - often digitised as black & white values in image

Effect of Noise on Image



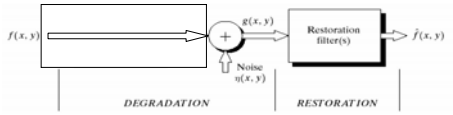
Periodic Noise

- Electrical or mechanical interference during acquisition
- The only type of spatially dependent noise

Estimation of Noise Parameters

- Periodic Noise
  - Inspection of Fourier Image
- Determining PDF
  - Sensor specifications
  - Inspection of histogram of 'flat' image
  - Determine shape of Gaussian by measuring μ & σ

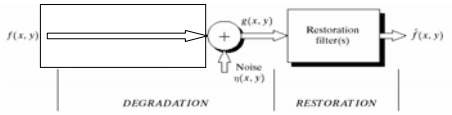
Restoration in the Presence of Noise Only



Restoration Processes:

- Spatial Domain Filtering
  - Additive Noise (Gaussian & Impulse Noise)
- Frequency Domain Filtering
  - Periodic Noise

Restoration in the Presence of Noise Only



- Noise only therefore no degradation term:

$$G(u,v) = H(u,v) \times F(u,v) + N(u,v)$$

Becomes $G(u,v) = F(u,v) + N(u,v)$

Now easier to represent in spatial domain $g(x,y) = f(x,y) + \eta(x,y)$

Restoration in the Presence of Noise Only – Additive Noise

Spatial Filtering

- Method of choice when only additive noise is present
  - I.e. Gaussian or Impulse
- Mean Filter
- Median Filter

Restoration in the Presence of Noise Only – Additive Noise

Spatial Filtering

- Mean (or Box) Filter

$$R = \frac{1}{mn}\sum_{i=0}^{nm} z_i$$

Image corrupted with Gaussian Noise

Restoration in the Presence of Noise Only – Additive Noise

Spatial Filtering

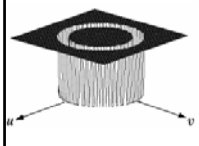
- Median Filter

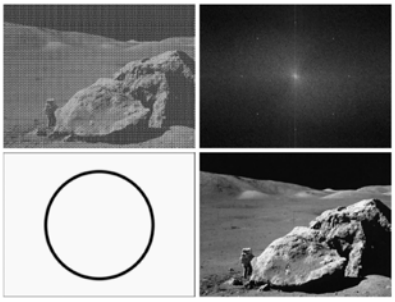
Image corrupted with Salt-and-Pepper Noise

Restoration in the Presence of Noise Only – Periodic Noise

Frequency Domain Filtering

- Band reject Filter

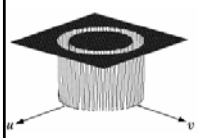


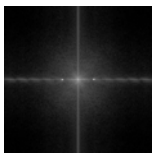


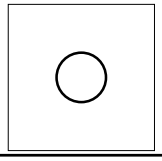
Restoration in the Presence of Noise Only – Periodic Noise

Frequency Domain Filtering

- Band-reject Filter







Restoration in the Presence of Noise Only – Periodic Noise

Frequency Domain Filtering

- Notch Filter