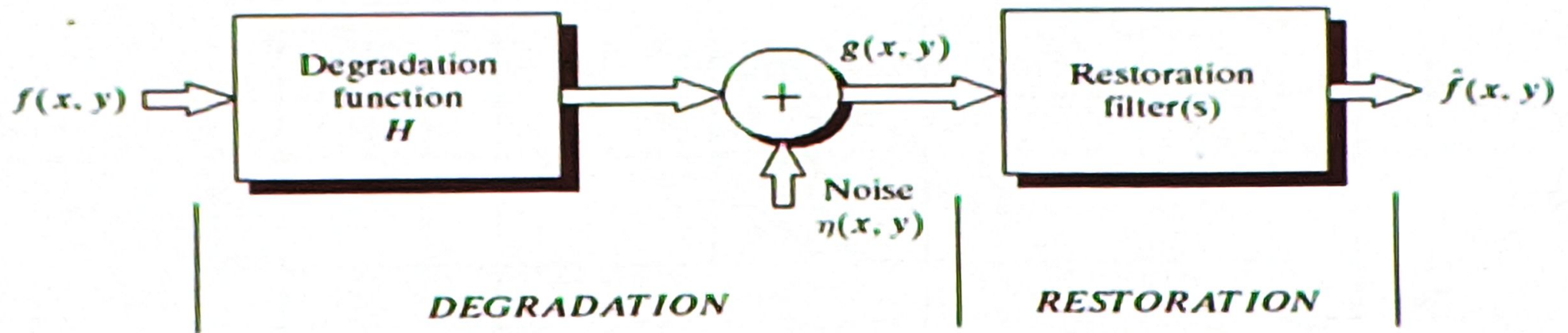


Noise Model



Spatial domain

Frequency domain

$$g(x, y) = h(x, y) * f(x, y) + \eta(x, y)$$

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

Image Restoration using Spatial Filters

$$g(x, y) = h(x, y) * f(x, y) + \eta(x, y)$$

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

- Assume the noise is only the degradation source
- Spatial Filtering



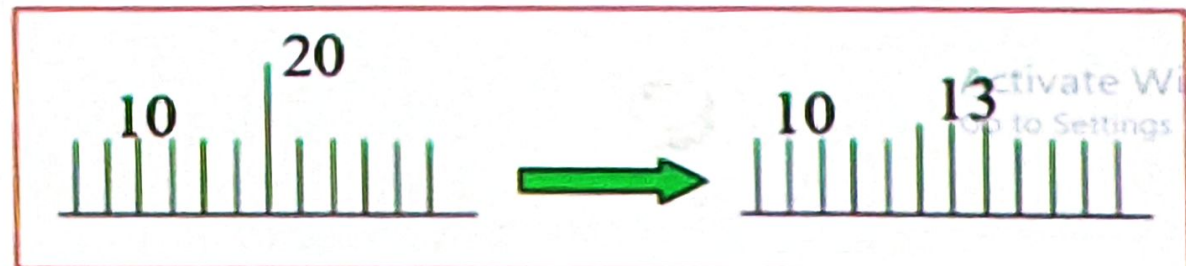
3x3

Arithmetic mean filter

- The arithmetic mean filter is same as smoothing filter. It removes the noise and blur the image.

$$\hat{f}(x, y) = \frac{1}{mn} \sum_{(s,t) \in S_{xy}} g(s, t)$$

- Change the values of pixels intensities to the nearby range based on the neighboring pixels intensities.
- Disadvantage: Image gets blur means pixels itself intensity value gets loose.
- Example



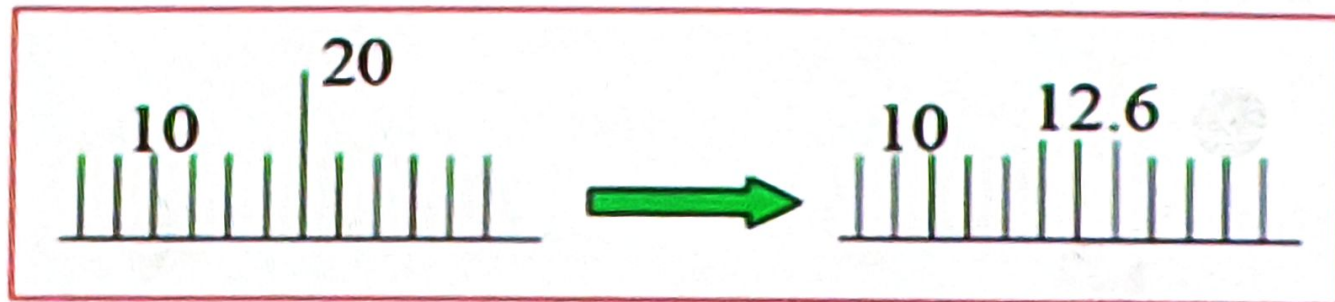
Types of Mean Filters

- Other types of Mean filters are:
 1. Geometric Mean
 2. Harmonic Mean
 3. Contraharmonic Mean
- Each filter has slightly different behavior

Geometric mean

- Tends to loose less image details as compared to the Arithmetic Mean

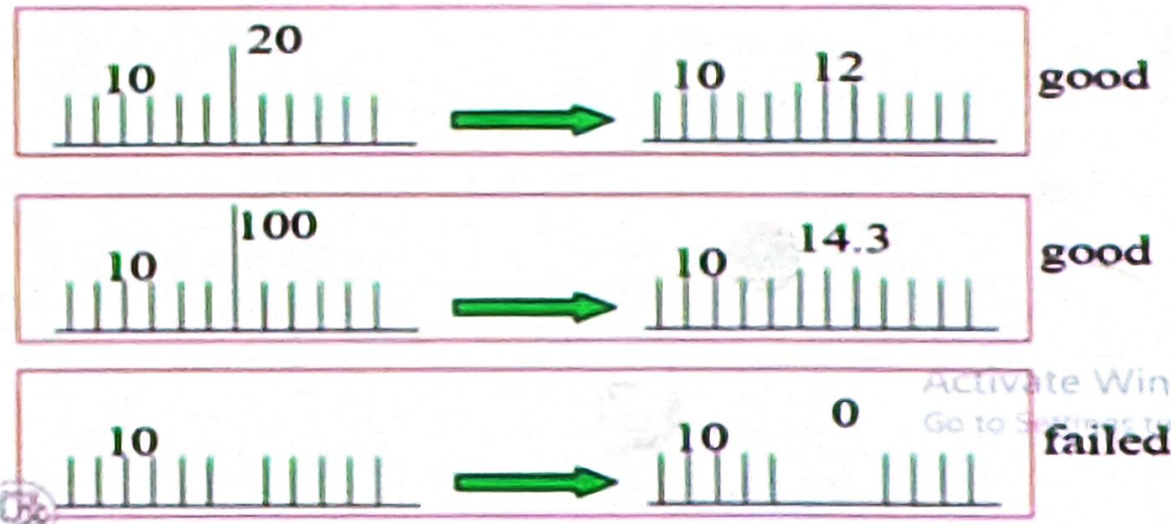
$$\hat{f}(x, y) = \left[\prod_{(s, t) \in S_{xy}} g(s, t) \right]^{\frac{1}{mn}}$$



Harmonic Mean

- As division, therefore for missing values it is unable to do perform, whereas Geometric Mean or Arithmetic Mean can handle missing values

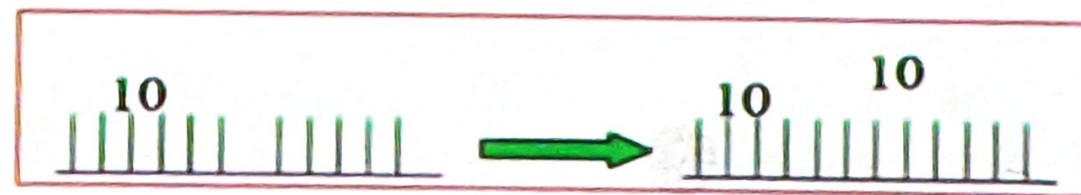
$$\hat{f}(x, y) = \frac{mn}{\sum_{(s,t) \in S_{xy}} \frac{1}{g(s,t)}}$$



Contraharmonic Mean

- Q is the order of the filter.
- Adjusting the value of Q, the filter's behavior changes
- Positive values of Q eliminates pepper noise
- Negative values of Q eliminates salt noise

$$\hat{f}(x, y) = \frac{\sum_{(s,t) \in S_{xy}} g(s, t)^{Q+1}}{\sum_{(s,t) \in S_{xy}} g(s, t)^Q}$$



Q=1

Other Statistical Filters

- Spatial filters that are based on ordering the pixel values and work in neighboring pixels.
- Useful spatial filters include
 1. Median filter
 2. Max and min filter
 3. Midpoint filter
 4. Alpha trimmed mean filter

Median Filter

$$\hat{f}(x, y) = \underset{(s, t) \in S_{xy}}{\text{median}}\{g(s, t)\}$$

- Excellent at noise removal, without adding smoothing effects that can occur with arithmetic mean filter.. Particularly good when **salt and pepper** noise is present
- Better than average filter because, it does not change the intensity value rather select the median value
- Best for both salt and pepper noise as picks the median value

Min and Max Filter

- **Max Filter:**
- Max Filter is best to find the brightest points in the image
- Good in reducing pepper noise. Minimum pixels values will be ignored as max values are towards white
- **Min Filter:**
- Best to find the darkest points in the image.
- Good in reducing salt noise. It selects low intensity values. Low intensities values

$$\hat{f}(x, y) = \max_{(s, t) \in S_{xy}} \{g(s, t)\}$$

$$\hat{f}(x, y) = \min_{(s, t) \in S_{xy}} \{g(s, t)\}$$

Midpoint filter

$$\hat{f}(x, y) = \frac{1}{2} \left[\max_{(s,t) \in S_{xy}} \{g(s, t)\} + \min_{(s,t) \in S_{xy}} \{g(s, t)\} \right]$$

- Middle between minimum and maximum filter.
- Useful for both salt and pepper noise
- Also useful for other types of noise including random Gaussian noise and uniform noise etc

Alpha trimmed filter

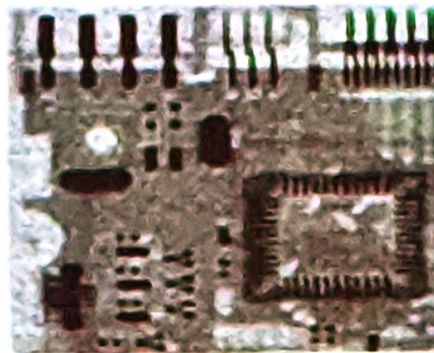
$$\hat{f}(x, y) = \frac{1}{mn - d} \sum_{(s, t) \in S_{xy}} g_r(s, t)$$

1. $d = 0 \rightarrow$ arithmetic mean filter
2. $d = mn - 1 \rightarrow$ median filter

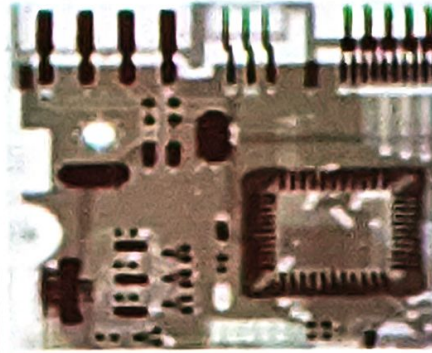
By tweaking the parameters, we can apply this filters to remove multiple types of noise

Noise Removal Examples

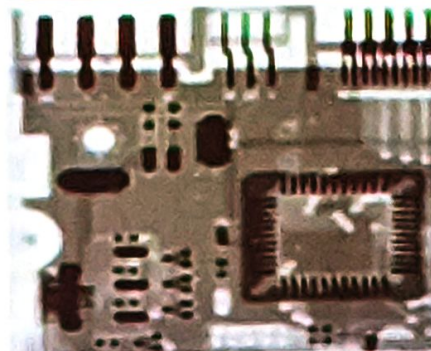
Image
Corrupted
By Salt And
Pepper Noise



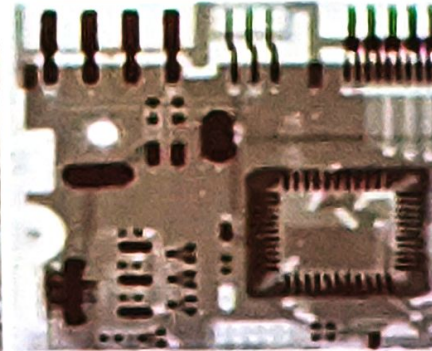
Result of 1
Pass With A
3*3 Median
Filter



Result of 2
Passes With
A 3*3 Median
Filter



Result of 3
Passes With
A 3*3 Median
Filter



- Repeated passes of median filter tend to blur the image. keep number of passes as low as possible
- Decide whether to apply different types of filter instead of applying same filter multiple times

Noise Removal Examples

Image
Corrupted
By Pepper
Noise

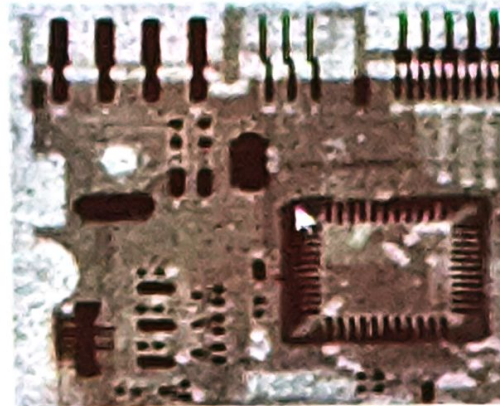
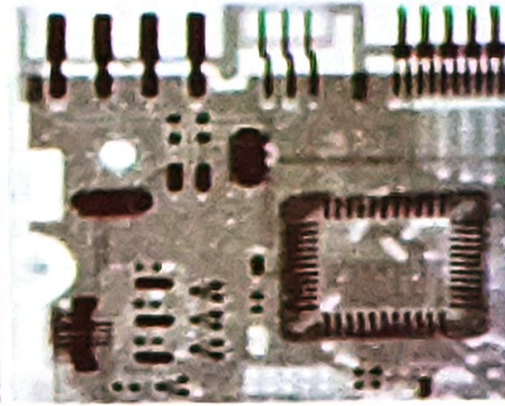
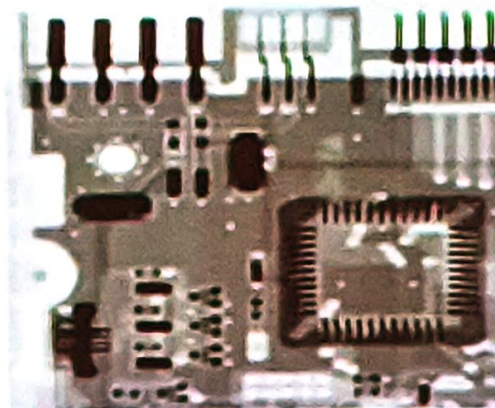


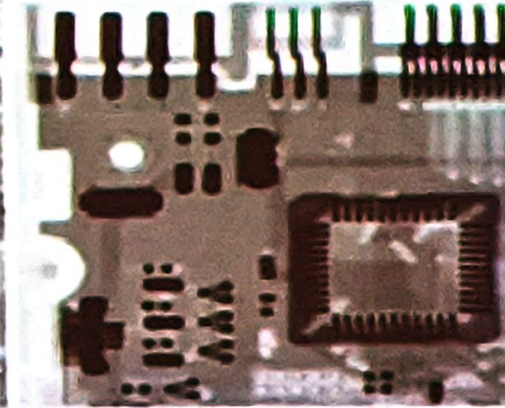
Image
Corrupted
By Salt
Noise



Result Of
Filtering
Above
With A 3×3
Max Filter



Result Of
Filtering
Above
With A 3×3
Min Filter



- Application of min filter and max filter

Image
Corrupted
By Uniform
Noise

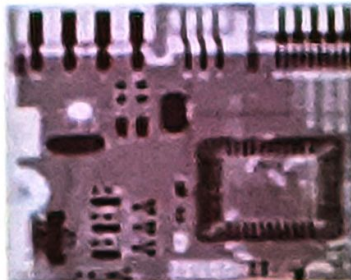
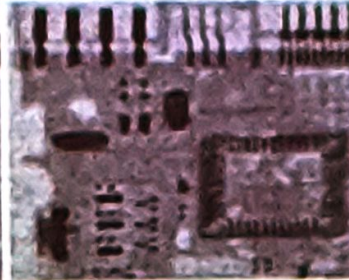
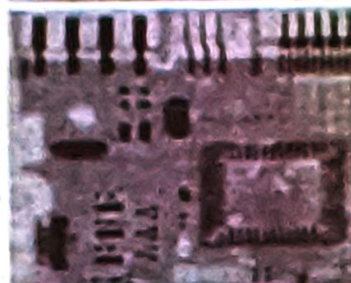


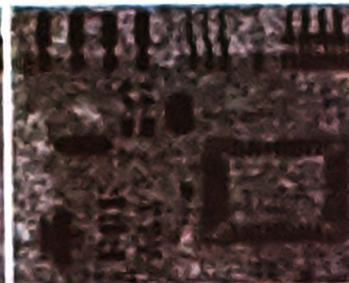
Image Further
Corrupted
By Salt and
Pepper Noise



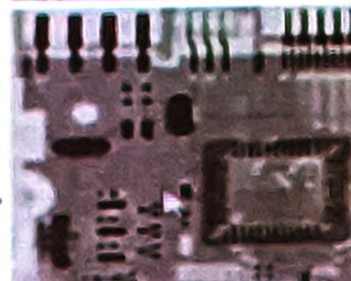
Filtered By
 5×5 Arithmetic
Mean Filter



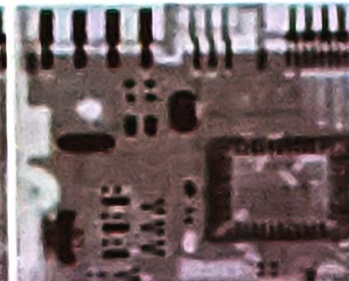
Filtered By
 5×5 Geometric
Mean Filter



Filtered By
 5×5 Median
Filter



Filtered By
 5×5 Alpha-Trimmed
Mean Filter



THANK YOU