Digital Image Processing

Median and Mean Filter

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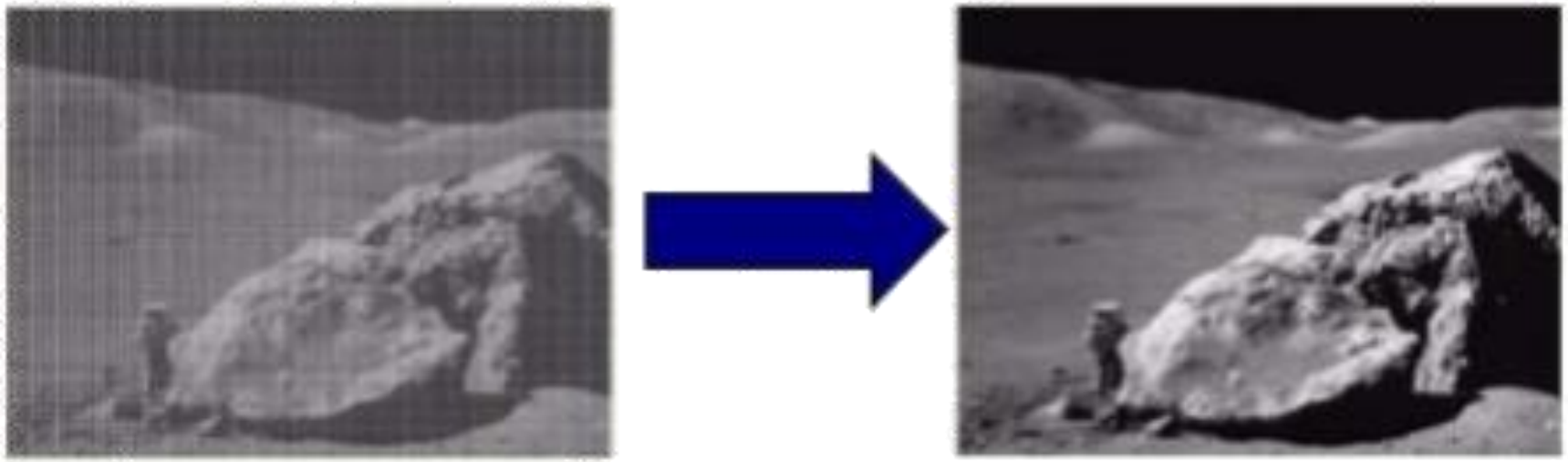
What is Image Restoration?

- Image restoration attempts to restore images that have been degraded.
  - Identify the degradation process and attempt to reverse it.
  - Similar to image enhancement, but more objective.



Noise and Images

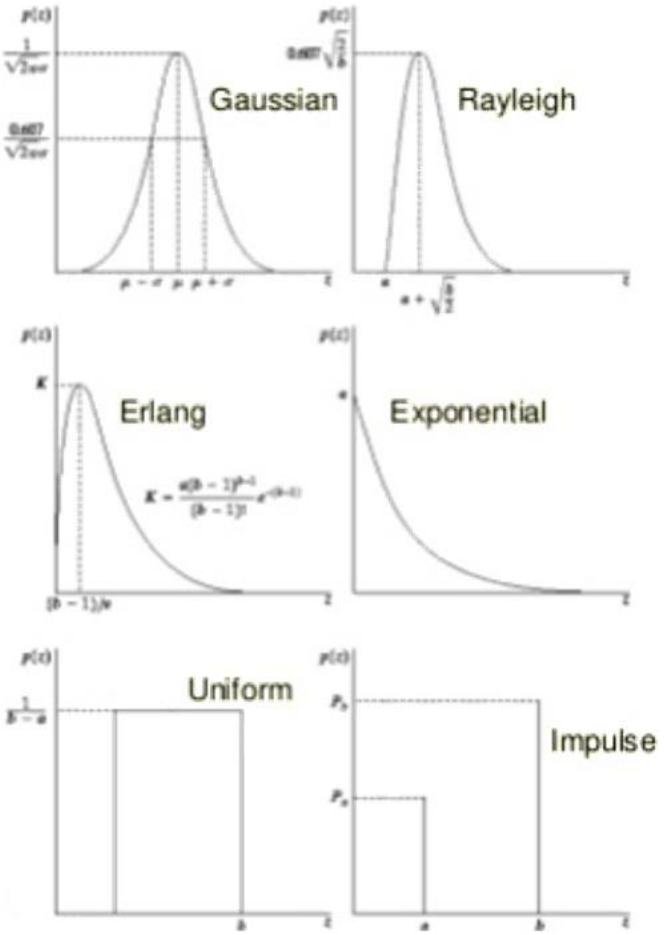
- The sources of noise in digital images arise during image acquisition (digitization) and transmission.
  - Imaging sensors can be affected by ambient conditions.
  - Interference can be added to an image during transmission.

Noise Model

- We can consider a noisy image to be modelled as follows:
- $g(x,y)=f(x,y)+\eta(x,y)$
- where $f(x, y)$ is the original image pixel, $\eta(x, y)$ is the noise term and $g(x, y)$ is the resulting noisy pixel.
- If we can estimate the model of the noise in an image, this will help us to figure out how to restore the image.

Noise Models

- There are many different models for the image noise term $\eta(x, y)$:
  - Gaussian
    - Most common model
  - Rayleigh
  - Erlang
  - Exponential
  - Uniform
  - Impulse
    - Salt and pepper noise



Mean Filter

- We can use spatial filters of different kinds to remove different kinds of noise.
- The arithmetic mean filter is a very simple one and is calculated as follows:
- $$\hat{f}(x,y) = \frac{1}{mn} \sum_{(s,t) \in S_{xy}} g(s,t)$$
- This is implemented as the simple smoothing filter Blurs the image to remove noise.

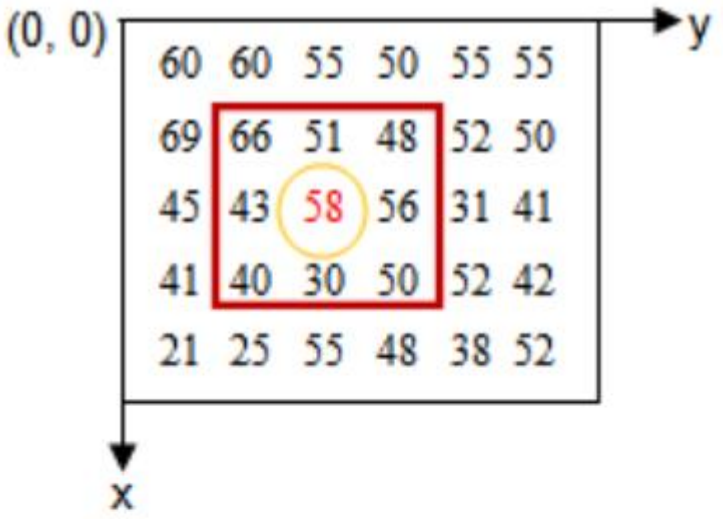
1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Median Filter

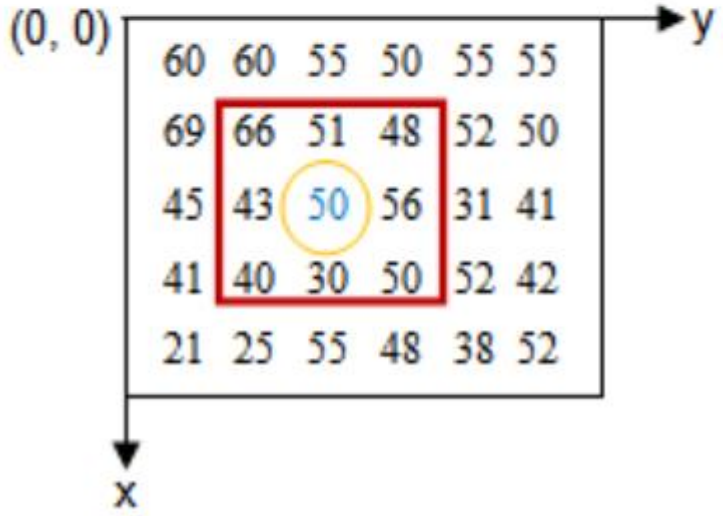
- Excellent at noise removal, without the smoothing effects that can occur with other smoothing filters.
- Particularly good when salt and pepper noise is present.
- $$\hat{f}(x,y) = \underset{(s,t)\in S_{xy}}{median}\{g(s,t)\}$$

Median Filter

- Median filter is a popular low-pass filter, attempting to remove noisy pixels.
- However, the median is a more robust average than the mean.
- Median filters are great at preserving edges and eliminating impulse noise.
- The values of the pixel in the window are stored and the median – the middle value in the sorted list.
- Unsorted array: 66 51 48 43 58 56 40 30 50
- Sorted array: 30 40 43 48 50 51 56 58 66
- Median of this array is: 50



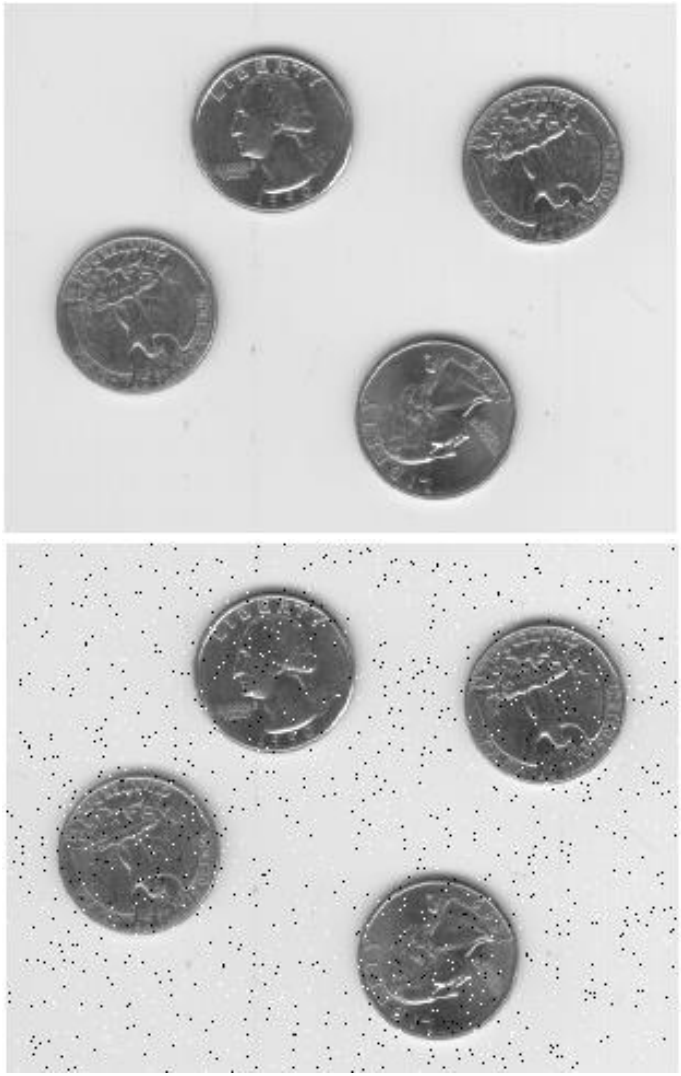
(a) Before median filtering



(b) After median filtering

Salt & Pepper

- Read a grayscale image and display it.
- I = imread('eight.tif');
- imshow(I)
- Add salt and pepper noise, with a noise density of 0.02, to the image. Display the result.
- J = imnoise(I,'salt & pepper',0.02);
- imshow(J)



Peak signal-to-noise ratio

- PSNR is most easily defined via the mean squared error (MSE). Given a noise-free *m*×*n* monochrome image I and its noisy approximation *K*, MSE is defined as:

$$MSE = \frac{1}{m\,n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

$$\begin{aligned} PSNR &= 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right) \\ &= 20 \cdot \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right) \\ &= 20 \cdot \log_{10} (MAX_I) - 10 \cdot \log_{10} (MSE) \end{aligned}$$

Quality estimation with PSNR

- Typical values for the PSNR in lossy image and video compression are between 30 and 50 dB, provided the bit depth is 8 bits, where higher is better.
- For 16-bit data typical values for the PSNR are between 60 and 80 dB.
- Acceptable values for wireless transmission quality loss are considered to be about 20 dB to 25 dB.
- In the absence of noise, the two images I and K are identical, and thus the MSE is zero. In this case the PSNR is infinite.

Original uncompressed image | Q=90, PSNR 45.53dB | Q=30, PSNR 36.81dB | Q=10, PSNR 31.45dB

Example luma PSNR values for a cjpeg compressed image at various quality levels.

References

- https://www.mathworks.com/help/images/ref/imnoise.html
- https://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio
- http://pubs.sciepub.com/ajmo/2/3/1/
- https://www.slideshare.net/MostafaGMMostafa/digital-image-processing-image-restoration-63529401