DIGITAL IMAGE PROCESSING

Image Restoration : Session 1

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Today’s Lecture

- **Image Restoration**
  - **Noise Model**

Image Restoration

- It is a process to recover an image that has been degraded by using a prior knowledge of the degradation phenomenon.
- Model the degradation and applying the inverse process in order to recover the original image.
- Image enhancement is largely a subjective process, while image restoration is mostly a objective process.

Image Restoration

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Image Restoration

Image Restoration

The model of the degraded image is given in the frequency domain

where the terms in capital letters are the Fourier transforms of the corresponding terms in the previous equation.

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Noise Sources

- The principal sources of noise in digital images arise during **image acquisition and/or transmission**

✔ **Image acquisition:** Depends on the quality of the sensing elements

e.g., sensor temperature, light levels etc.

✔ **Transmission:** Due to interference in the channel used for transmission

e.g., lightning or other atmospheric disturbance in wireless network

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Noise Model 1

- **White noise**
  - The Fourier spectrum of noise is constant
  - The terminology “white” comes from the physical properties of white light, which contains nearly all frequencies in the visible spectrum in **equal proportions.**

- With the exception of spatially periodic noise, we assume
  - Noise is independent of spatial coordinates
  - Noise is uncorrelated with respect to the image itself

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Noise Model 2

- **Gaussian noise**

  Electronic circuit noise, sensor noise due to poor illumination and/or high temperature

- **Rayleigh noise**

  Range imaging

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Gaussian Noise

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Gaussian Noise

- 70% of its values will be in the range

- 95% of its values will be in the range

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Rayleigh Noise

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Noise Model 3

- **Erlang (gamma) noise**: Laser imaging
- **Exponential noise**: Laser imaging
- **Uniform noise**: Least descriptive; Basis for numerous random number generators
- **Impulse noise**: Quick transients, such as faulty switching

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Erlang (Gamma) Noise

Here *a>0* and *b* is an integer

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Exponential Noise

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Uniform Noise

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Impulse (Salt-and-Pepper) Noise

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Examples of Noise: Original Image

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Examples of Noise: Noisy Images

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Examples of Noise: Noisy Images

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Periodic Noise

- Periodic noise in an image arises typically from electrical or electromechanical interference during image acquisition.

- It is a type of spatially dependent noise

- Periodic noise can be reduced significantly via frequency domain filtering

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Example of Periodic Noise

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Estimation of Noise Parameters

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Estimation of Noise Parameters

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Restoration in the Presence of Noise Only

Spatial Filtering

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Spatial Filtering: Mean Filters(1)

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Spatial Filtering: Mean Filters(2)

Generally, a geometric mean filter achieves smoothing comparable to the arithmetic mean filter, but it tends to lose less image detail in the process

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Spatial Filtering: Mean Filters(3)

It works well for salt noise, but fails for pepper noise.
It does well also with other types of noise like Gaussian noise.

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Spatial Filtering: Mean Filters(4)

Q is the order of the filter.

It is well suited for reducing the effects of salt-and-pepper noise. $Q>0$ for pepper noise and $Q<0$ for salt noise.

Spatial Filtering: Example(1)

Spatial Filtering: Example(2)

Spatial Filtering: Example(3)

Next Class

- **Image Restoration**
  - **More Filters**

Thank you:
Question?