EE 5806: Topics in Image Processing
Test 1 Review

General Information:

- This is an online open-book examination taken in Canvas.
- Scope: Chapter 1 to 4
- 1 hour in-class exam: Oct. 14, 2020. 8:50pm – 9:50pm.

Topics

1. Introduction to Digital Imaging

(a) Image Sensing and Acquisition

- Describe the operational principles of CCD and CMOS sensors.
- List the major differences between CCD and CMOS image sensors.
- Know how colour images are captured by CCD and CMOS image sensors.

(b) Digital Imaging Fundamentals

- Know the definitions of the digital image (pixel, gray level) and the colour map.
- Know the following terms relating to digitalization
  - Sampling
  - Quantization
  - Dynamic range
  - Spatial resolution
    - Pixelation
  - Brightness resolution
    - Brightness contouring
- Know the amount of storage required for an image.
- Know how nearest neighbor and bilinear interpolation work.

(c) Colour Fundamentals

- Know different colour models introduced and what they are good for.

2. Point Operations

- Define point operations.

(a) Common Point Operations

- Describe the following point operations:
  - Linear point operation
  - Logarithmic
  - Power law
  - Window and level
- Know when these point operations are used.

(b) Histogram Processing

- Know how to derive the expression for output histogram given input histogram and point operation in continuous gray-level domain.
- Know how to apply the expression.

(c) Histogram Equalization

- Histogram equalization for images with continuous or discrete gray levels. Expected to know formula.

(d) Histogram Specification (Matching)
- Obtain point operations achieving histogram specification in continuous and discrete domains.

3. Spatial Filtering

(a) Need to know how to perform convolution and correlation for 2D discrete images. Know the difference between *convolution kernel* and *computational molecule*.

(b) Know how borders are handled in the correlation operation.

(c) Smoothing spatial filters (Remove noise)
- Boxcar filter, Gaussian filter (involves convolution)
- Order-statistic filters (do not involve convolution)

(d) Sharpening spatial filters (Feature enhancement)
- First derivative filters (e.g., Prewitt filter, Sobel filter – need to know how they are defined). Need to know how to apply these filters in x and y directions and calculate gradient magnitude.
- Second derivative filters (Laplacian).

(e) Use Laplacian for image enhancement. Need to know how one correlation operation can be used to compute $I - \nabla^2 I$. Which property of linear filtering is used?

4. Transform Domain Filtering

(a) Fourier Transform in 1D and 2D
- Know Fourier transform for continuous signals and discrete signal.
- Describe sampling theorem in terms of the Fourier transforms of pulse samples and discrete samples.
- Know discrete Fourier transform
  - Know how to perform circular convolution
  - Describe why wraparound error occurs.
  - Know how to perform linear convolution via circular convolution.

(b) Frequency Domain Filtering
- Why do we filter in frequency domain instead of spatial domain?
- Know the effect of circular convolution in 2D filtering and how to mitigate the effect.
- Know ideal, Gaussian and Butterworth lowpass filters.
- Design lowpass filter using ideal, Gaussian and Butterworth filters.
- Know ideal, Gaussian, Butterworth bandpass and bandreject filters.
- Know how to construct a notch filters based on ideal, Gaussian and Butterworth filters.