• Image Processing/Intro
  o Goal of Image Processing and related fields (Computer Vision/Computer Graphics)
  o Key processes in image processing
  o Applications of Image Processing and Computer Vision
  o Light and EM spectrum
  o Image formation and representation
  o Image digitization (sampling and quantization)
  o Image file formats, read/write PGM images

• Intensity Transformation
  o Point processing transformations vs mask processing transformations
  o Contrast stretching, contrast compression, intensity level slicing, bit-level slicing, log/exp transformations.
  o Histograms and their properties, Histogram equalization. **You should know how to apply the steps of histogram equalization in the discrete case.** (Graduate Students Only): need to know the steps in the continuous case as well as the theory behind it.
  o Histogram specification. **You should know how to apply the steps of histogram specification in the discrete cases.** (Graduate Students Only): need to know the steps in the continuous case as well as the theory behind it.
  o Local histogram processing, histogram statistics

• Arithmetic and Geometric Transformations
  o Addition, averaging, subtraction
  o Scaling, Rotation, Translation, Shear, Affine
  o Forward vs Inverse transformation
- Interpolation (zero-order, first-order, bilinear, bicubic etc. - how does it work?)
- Image registration (why is it useful? - how does it work?)

- Spatial Filtering
  - Mask processing (neighborhood + operation)
  - Linear vs non-linear filters
  - Main linear filters: correlation and convolution
  - How do we choose the mask weights? How do we deal with image boundaries?
  - Properties of smoothing and sharpening filters
  - Smoothing filters: averaging, Gaussian, and median filtering
  - Sharpening filters: unsharp masking, high boost filter, derivatives
  - Properties of gradient, approximation using finite differences; implementation using masks.
  - Laplacian (2nd derivative), comparison with gradient

- Fourier Transform
  - Complex numbers, sin/cos functions, Euler's formula
  - FT definition and equations. **You should be able to explain the FT both in mathematical and non-mathematical terms.**
  - Why is FT useful? What are the main filtering steps using FT?
  - FT magnitude and phase
  - FT pairs of common functions (e.g., square, δ(x), sin(x), cos(x) etc.) **You should know how to derive them.**
  - Discrete Fourier Transform (DFT), DFT equations (both 1D and 2D). **You should know how to compute the DFT of a discrete function.**
  - DFT properties (i.e., separability, periodicity, symmetry, translation, rotation, distributive, scale, average value). **You should know how to prove them, especially the separability property.**
  - Magnitude/Phase – which one is most important and why?
• Fast Fourier Transform
  o Complexity of DFT and FFT You should know how to prove it.
  o What is the main idea behind FFT? (Graduate Students Only): need to know how to derive the FFT equations.

• Convolution
  o Definition and equations (both in the continuous and discrete 1D/ and 2D cases). You should be able to explain the convolution both in mathematical and non-mathematical terms. Also, you should know how to compute it in the discrete case. (Graduate Students Only): need to know how to compute it in the continuous case too.
  o Convolution theorem. You should know how to prove it. Why is it important?
  o When does the convolution theorem hold true in the discrete case? NOT INCLUDED in Midterm
  o What is the reason for padding a signal or an image with zeroes when computing the discrete convolution? NOT INCLUDED in Midterm

Comments
The midterm exam will be closed-books, closed-notes. It will include True/False questions (i.e., answers must be justified) and problems similar to the ones we have done in class and in the homework. Also, there will be 1-2 proofs.