

# CS 474/674 Image Processing and Interpretation

Fall 2015 – Dr. George Bebis

## Midterm Exam Study Guide

- **Image Processing/Intro**

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

- **Intensity Transformation**

- Point processing transformations vs mask processing transformations
- Contrast stretching, contrast compression, intensity level slicing, bit-level slicing, log/exp transformations.
- 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.**
- 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.**
- Local histogram processing, histogram statistics

- **Arithmetic and Geometric Transformations**

- Addition, averaging, subtraction
- Scaling, Rotation, Translation, Shear, Affine
- 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 (2<sup>nd</sup> 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,  $\delta(x)$ ,  $\sin(x)$ ,  $\cos(x)$  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**

- Complexity of DFT and FFT **You should know how to prove it.**
- What is the main idea behind FFT? (Graduate Students Only): **need to know how to derive the FFT equations.**

- **Convolution**

- 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.**
- Convolution theorem. **You should know how to prove it.** Why is it important?
- When does the convolution theorem hold true in the discrete case?
- What is the reason for padding a signal or an image with zeroes when computing the discrete convolution?

- **Sampling**

- What is the problem of sampling? Why it important?
- Definition and properties of band-limited functions.
- Expressing sampling mathematically (i.e., using a “train” of impulses)
- What is the spectrum of a sampled function? How does the sampling step affect the spectrum of a sampled function? (both in 1D and 2D)
- What is aliasing? Nyquist theorem **You should know how to prove it.**
- Practical issues (i.e., cannot sample an infinite duration signal), anti-aliasing

## **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.