

# CS474/674 Image Processing and Interpretation

Fall 2011 – Dr. George Bebis

## Final Exam Study Guide

- **Midterm material** (i.e., see Midterm Exam study guide)
  
- **Image Restoration**
  - What is the goal of image restoration? How is it different from previous image enhancement techniques?
  - Degradation model under the assumptions of linearity and shift invariance (**Graduate Students Only**): *need to know how to prove this.*
  - Noise models, methods for estimating noise model parameters
  - Noise removal filters (mean, order statistics, adaptive, frequency domain)
  - Modeling degradation function (e.g., atmospheric turbulence, linear motion) (**Graduate Students Only**): *need to know how to derive the degradation function due to motion blur.*
  - Inverse filtering (how it works, assumptions, practical problems, ways to address problems)
  - Wiener filtering (how it works, assumptions, how it compares to inverse filtering, practical problems, ways to address problems).
  - Least Squares filtering (how it works, assumptions, how it compares to Wiener filtering, what is its main advantage)
  
- **Short Time Fourier Transform**
  - Limitations of Fourier Transform (i.e., lack of simultaneous time-frequency localization, not useful for analyzing non-stationary signals, not efficient in handling discontinuities)
  - Windowed or Short Time Fourier Transform (STFT) – main ideas; how does it address the issue of simultaneous time-frequency localization?
  - Practical issues (i.e., window function, shape, width), Heisenberg (or Uncertainty) principle

- **Multiresolution Analysis**

- What is the purpose of multiresolution analysis? How is it related to the STFT?
- Pyramid coding – main ideas, approximation pyramid, prediction residual pyramid
- Subband coding – main ideas, how is it performed? (analysis/synthesis), properties of analysis/synthesis filters

- **Wavelets**

- What is a wavelet? How are wavelets different from other basis functions?
- Wavelet Transform (main steps); how is it related to FT and STFT? how is it different from the STFT?
- Properties of wavelet transform (i.e., simultaneous time-frequency localization, sparsity, linear-time complexity, adaptability)
- Discrete Wavelet Transform – definition, understand the idea of shifting/scaling “mother” wavelet to create basis functions.
- Efficient multiresolution representations (i.e., nested  $V_i$  and  $W_j$  spaces) – good understanding of the role of the  $\varphi(t)$  and  $\psi(t)$  functions
$$f(t) = \sum_k c_k \varphi(t-k) + \sum_k \sum_j d_{j,k} \psi(2^j t - k)$$
- Filter banks – good understanding of how a filter bank is used to represent a function at multiple levels of detail
- Derivation of Haar Wavelet basis functions
- Should know how to compute the 1D Haar-wavelet decomposition of a function as well as how to reconstruct it.
- 2D Haar Wavelet decomposition – both standard and non-standard decompositions; how are they different?

- **Image Compression**

- What is the goal image compression? Lossless versus lossy compression
- Data vs information, data redundancy (i.e., how is it computed?)
- Types of data redundancy (i.e., coding, interpixel, and psychovisual)

- How can we deal with coding redundancy? (i.e., variable length coding)
- How can we deal with interpixel redundancy? (i.e., mapping)
- How can we deal with psychovisual redundancy? (i.e., quantization)
- Modeling information generation process (i.e., probabilistically), measuring information (i.e., entropy), computing redundancy (i.e., using entropy information), different order estimates of entropy and their importance.
- Main components of image compression (i.e., encoder, decoder)
- Fidelity criteria (i.e., subjective, objective)
- Main components of encoders (i.e., mapper, quantizer, symbol encoder) and decoders (i.e., inverse steps)
- Lossless compression
  - Huffman coding, Arithmetic coding, LZW coding, Run Length coding, Bit-plane coding
- Lossy compression
  - Examples of mappers (i.e., FT, DCT, WT)
  - What are the properties of a "good" mapper?
- Main steps in JPEG compression
- Different modes of JPEG
  - Progressive spectral selection algorithm
  - Progressive successive approximation algorithm
  - Combined progressive algorithm
  - Hierarchical
  - Lossless
- Taxonomy of Lossy compression
  - Lossless/Lossy Differential Pulse Code Modulation (DPCM) Coding
  - Block Truncation Coding
  - Subband Coding
  - Vector Quantization
  - Fractal Coding
- Fingerprint compression
  - Issues with fingerprint compression
  - Issues with JPEG
  - Using wavelets for fingerprint compression

## Comments

The final exam will be closed-books, closed-notes. It will include several True/False questions (i.e., answers must be justified) as well problems similar to the ones you have seen in class and the homework. Make sure you that you review all the problems we have done in class and the homework. Also, there might be 1-2 proofs.