CS474/674 Image Processing and Interpretation
Fall 2018 – Dr. George Bebis
Final Exam Study Guide

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- **Midterm material** (i.e., see Midterm Exam study guide)

- **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

- **Frequency Filtering**
  - Low-pass, high-pass, and band-pass filters (time/frequency domain)
  - How should we specify a filter in the frequency domain?

- What are the **main steps** of filtering in the frequency domain? (page 263)
- Why low-pass filters cause blurring? (explain both in time/frequency domains)
- What is the “ringing” effect?
- How does high emphasis filtering work?
- How does homomorphic filtering work? What are the main assumptions?

Image Restoration

- What is the goal of image restoration? How is it different from image enhancement techniques?
- Degradation model under the assumptions of linearity and shift invariance (**Graduate Students Only)*****: <u>need to know the proof.</u>***
- Noise models, estimating model parameters
- Noise removal filters (mean, order statistics, adaptive, frequency domain)
- Modeling of degradation function (e.g., atmospheric turbulence, linear motion) (**Graduate Students Only)*****: <u>need to know how to derive the degradation function in the case of motion blur.</u>***
- 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?)

Image Compression

- What is the goal image compression? Lossless versus lossy compression
- Data vs information, compression ratio, data redundancy
- Types of data redundancy (i.e., coding, interpixel, and psychovisual)
- How can we deal with coding redundancy? (e.g., variable length coding)
- How can we deal with interpixel redundancy? (e.g., mapping)
- How can we deal with psychovisual redundancy? (e.g.,, quantization)

- Modeling the 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, Arithmetic, LZW, Run Length, Bit-plane
- Lossy compression
  - Examples of mappers (i.e., FT, DCT, WT)
  - What is the key property of a "good" mapper?
- Main steps in JPEG compression
- Fingerprint compression
  - Issues with fingerprint compression
  - Issues with JPEG
  - Using wavelets for fingerprint compression
- Different modes of JPEG
  - Progressive spectral selection algorithm
  - Progressive successive approximation algorithm
  - Hybrid algorithm
  - Hierarchical

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

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.