ECE 634: Digital Video Systems
Spring 2017
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PURDUE UNIVERSITY

Study Guide and sample questions

Spring 2017
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Classes of learning objectives: Remembering; Understanding; Applying; Analyzing; Evaluating; Creating. The study guide here provides some learning objectives to prepare you for the exam.

Study guide

- Fourier Transforms and Constrast Sensitivity Function
  - Compute maximum frequency that can be displayed for a given sampling rate
  - Describe the relationship between temporal frequency and spatial frequency, including the effect of smooth pursuit eye movement
  - Compute angular frequency from pixels per frame and viewing distance
  - Explain how Contrast Sensitivity is measured; describe the basic shape of the spatio-temporal contrast sensitivity function
- Motion
  - explain three things necessary to describe 2D motion of a 3D object
  - derive the model of the pinhole camera
  - apply perspective projection
  - apply orthographic projection
  - Given a 3D motion from (X, Y, Z) to (X', Y', Z'), and a planar object, compute the 2D motion from (x, y) to (x', y')
  - Derive the optical flow model
  - Describe the limitations of optical flow (what can be computed, what can not be computed, what creates inaccuracies)
- Lossless coding
  - Define entropy. Describe its role in lossless compression.
  - Compute entropy, joint entropy, and conditional entropy of one or two random variables (for example, for a Gauss Markov source)
  - Design a Huffman code for one (or several) random variables, based on a set of symbols and their probabilities
  - Calculate its average bit-rate
  - Design a conditional Huffman code
- Scalar quantization:

  - Define breakpoints and reconstruction levels
  - Describe the difference between overload noise and granular noise. Explain when overload noise can be ignored.
  - Compute the MSE for a uniform scalar quantizer
  - Derive the coding gain for a uniform scalar quantizer
  - Compute the MSE for a scalar quantizer with known breakpoints and reconstruction levels
  - Express the necessary conditions on breakpoints and reconstruction levels for an optimal quantizer

- More source coding methods:
  - Vector quantization
    * Explain necessary conditions for the optimal quantizer
    * Calculate these given a simple set of samples or PDF
  - Transform coding
    * Calculate the KLT for a few pixels
    * Compute the variance of transform coefficients
    * Derive the optimal bit allocation given the inter-pixel correlations
    * Compute the transform coding gain
  - Predictive coding
    * Derive the optimal predictor using up to 3 previous samples for prediction
    * Compute the coding gain
  - Explain the advantages and disadvantages of each of these

- Video coding standardization
  - Describe what the standards do (and do not) specify
  - Explain using examples why the standards do not always implement what source-coding theory predicts is optimal
  - Describe the evolution of the standards

Problems to practice

- Frequency analysis
  - Consider a horizontal bar pattern on a TV screen with 100 cycles/picture-height. If the picture-height is 1 meter, and the viewer sits 3 meters from the screen, what is the equivalent angular frequency in cycles per degree? What if the viewer sits 1 meter or 5 meters away. In either case, would the viewer be able to perceive the vertical variation properly?
  - Consider an object that has a flat homogeneously textured surface with maximum spatial frequency of $(f_x, f_y) = (3, 4)$ cycles/meter, and that is moving at a constant speed of $(v_x, v_y) = (1, 1)$ meters/second. What is the temporal frequency of the object surface at any point? What are the results for the following speeds (in meters per second): (4,-3), (4,0), (0,1)?
  - Suppose that the eye tracks the moving object with a speed that is equal to the object speed. What are the perceived temporal frequencies at the retina for the different speeds? What if the eye moves at a fixed speed of (2,2) meters/second?