# ECE 638 Exam No. 2 Fall 2013

This exam is closed book and closed notes. However, calculators are permitted. You have 50 minutes to work the following three problems. To obtain maximum partial credit, be sure to show the complete derivation of your answers. Also, be sure to budget your time; so that you have time to look at each problem.

1. (40 pts.) A print contains an ideal periodic, clustered-dot halftone pattern  with average absorptance 0.25 that consists of square dot-clusters placed with period 100 cycles/inch on a square lattice. Here ideal means that the paper substrate is assumed to have reflectance 1 and the colorant dots are assumed to have reflectance 0. You scan this print at 120 dpi, and display it using a continuous-tone display with resolution 120 dpi that can be modeled as a zero-order hold process, i.e. if represents the scanned halftone print, where inch, then the continuous-parameter displayed image is given by



1. (5) Sketch the continuous-parameter halftone pattern .
2. (20) Find an expression for the 2-D continuous-space Fourier transform CSFT of the continuous-parameter displayed scan  of the halftone image.
3. (10) Carefully sketch .
4. (5) Based on your answer to part c), comment on the expected appearance of .

1. (continued - 1)

1. (continued - 2)2. (25 pts.) Consider 3-color printing with colorants that have the ideal block spectral reflectance functions shown below.



Further, assume that if two colorants  and  are overprinted, then the resulting spectral reflectance functions is given by , where  and are, respectively, the spectral reflectances for the colorants  and . The spectral reflectance function that results when three colorants are overprinted is similarly the product of the spectral reflectance functions for all three colorants. Finally, we assume that the paper substrate is perfectly reflecting, i.e. it has unity spectral reflectance across the band of visible wavelengths.

Consider the halftone pattern for which one period is shown below:

a. (10) Find the spatially averaged spectral reflectance function for this halftone pattern.

Suppose that we modify the location of the colorant clusters in the above halftone pattern to maintain the same percent coverage of each of the primary colorants, while minimizing dot-on-dot printing.

b. (5) Sketch one period of the resulting hafltone pattern.

1. (10) Find the spatially averaged spectral reflectance function for this new halftone pattern.
2. (continued - 1)
3. (continued - 2)

3. (35 pts.) Consider a random variable  with density function  shown below

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Supposed that we wish to quantize this random variable to three levels using the quantizer . Let denote the output of this quantizer.

a. (5) Use the approximation developed in class to find an estimate of the mean-squared error , where the operator denotes expected value, assuming that there are three output levels -1, 0, and 1.

b. (20) Find the optimal thresholds and output levels for a 3-level quantizer that will minimize the mean-squared error . (Hint: by taking advantage of the symmetry in , and using the conditions developed in class for optimal quantization, there should be only one unknown for which you need to solve.)

c. (10) Determine the mean-squared quantization error for the quantizer that you designed in part b) above, and compare it with that based on the approximation for the quantizer in part a).

3. (continued - 1)

3. (continued - 2)

**1. \_\_\_\_\_\_\_**

**2. \_\_\_\_\_\_\_**

**3. \_\_\_\_\_\_\_**

**Total \_\_\_\_\_\_\_**