ECE 4132: Information Processing System Lab

Credits and contact hours: 3 Credits (One 4-hour lab per week)

Instructor: Bahram Javidi

Textbook: No Required textbook.
Suggested readings: Image Recognition and Classification: Algorithm, Systems, and Applications, B. Javidi (2002)
Fundamentals of Digital Image Processing, A. Jain (1989)
Digital Signal Processing: A Computer-Based Approach 2nd ed., Sanjit K. Mitra (2001)

a. *Other supplemental materials*: Students are encouraged to read various publications of IEEE and OSA related to signal and image processing.

***Specific course information*:**

a. *Catalog Description*: Laboratory experiments in signal processing, digital filters, image processing, imaging systems, pattern recognition, and system performance evaluation. Emphasis on information processing systems with interface between sensors and computers. Written and oral presentations of Laboratory results.
b. *Prerequisite*: ECE 4111: Communication Systems, ECE4112: Digital Communications and Networks
c. *Required, elective, or selected elective:* Selected elective

***Specific goals for the course*:**

a. *Specific outcomes of instruction*:
   - Students will be able to perform basic signal processing operations.
   - Students will be able to perform frequency domain and space frequency filtering, basic pattern recognition and detection of the images, and system performance evaluation.
   - This course is very project oriented. Each team will focus on a project and will present a proposal, progress reports every 2 weeks, and 2 midterm reports. Each team will submit a comprehensive final report at the end of the semester. At the end of the semester, students will have learned to carry out image processing projects independently, and present their work in a written report prepared to professional standards, and in PPT files.
b. *ABET Criterion 3 Student Outcomes addressed by the course*:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
Students learn to solve a real existing problem or an important application, then model, analyze, and experiment with signals and systems. Based on the model, they design a filter or a system, then simulate their design.

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

Students learn to design a system to optimize a design criterion, then implement the design using MATLAB.

(3) an ability to communicate effectively with a range of audiences
Students carefully document and present the methodology, testing, and verification procedures.

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
n/a

(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
Students are required to do project work in teams. Students learn to cooperate with other teammates and complete their individual responsibilities in order to finish the project. Also, they learn to acknowledge others' contribution.

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
Students learn to derive a solution based on the observation of the signal/image, and also learn to statistically analyze a noisy image, then design and implement a system or an optimum filter or an algorithm to satisfy the design criteria.

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
This lab teaches student how to research available literature and tools, approach an image-based problem mathematically, and derive the solution to optimize certain design criteria. Students use their system analysis skill to model a system or image, and then design an optimum solution systematically.

Topics covered:

- 1-dimensional and 2-dimensional Fourier Transforms and their properties
- Convolution and Correlation
- Linear systems and Transfer function
- Probability and Statistics
- Detection Theory (probability of detection and probability of false alarm)
- Design filters such as Matched filters, frequency domain filter, and wavelets
- Techniques to generate statistical noise to test the performance of designed filters
- Design filtering algorithms to process and filter (for example, enhance, restore, or detect possibly distorted objects) in a scene corrupted by noise such as minimum mean square error (Wiener) filters.
- Monte Carlo simulation technique to get statistical performance such as SNR (Signal-to-Noise Ratio) and other metrics
- ROC (Receiver Operating Characteristics) to compare different algorithms
- Performance evaluation using different metrics such as SNR, MSE, probability of error, etc.