Course Title: ECE 4670: Digital Communication System Design
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Credit Hours: 4 hours
Catalog Description:
The goal of this course is to understand how state-of-the-art digital communication systems are designed and why they are designed in the way they are. The course will cover communication theory, transceiver algorithms that enable reliable communication, wireless channels, and modern communication standards (such as 3GPP LTE and WiFi). The students will design a working audio-band communication system that relies on orthogonal frequency-division multiplexing (OFDM).

Course Frequency:
Once per year (Fall semester)
Prerequisites:
ECE 3100
Corequisites:
ECE 3250
Student Preparation Summary:
Probability: Comfort with conditioning, Bayes' rule, total probability and manipulating random variables. Exposure to random vectors helpful.
Systems: Comfort with linear algebra and LTI systems theory in discrete time.
Textbook(s) and/or Other Required Materials:
- None. Lecture notes will be provided.

ECE Open CourseWare Link [if available]:
Class and Laboratory Schedule:
Lectures: Two 75 min lectures per week
Recitations: One per week, which meets occasionally.
Assignments, Exams and Projects:
Homework: Weekly assignments. Approximately seven homework assignments per semester. Collaboration with students is encouraged.
Exams: Two preliminary exams.
Design Projects: There are five labs, which form the centerpiece of the course. Through these labs, students will develop a working MATLAB -based communication system using PC soundcards. The first two labs are designed to acclimate students with the hardware setup that we will be using. The third lab involves designing a communication system for a simple channel simulated in software. The fourth lab involves designing a basic communication system for the actual, hardware-based channel and submitting a related "standard" that one could use for designing compatible transmitters and receivers for this channel. The class will vote on which of the submitted standards to "adopt." In the fifth lab, students will design two communication systems, one that complies with the standard and one that aims for the highest performance. There will be a prize for the design with the highest performance. The first three labs must be done individually, though students are welcome to get help from anyone, including other students in the class. The fourth and fifth labs may be done individually or in pairs.

Course Grading Scheme: (for ECE 4670): 15% Homework assignments, 50% Labs, 35% Prelims

Details List of Topics Covered:

- Random vectors, jointly Gaussian random variables, covariance matrices
- MAP and ML detection
- Linear minimum mean-square error estimation
- The linear-algebraic approach to linear time-invariance systems theory
- Channel modeling: shot noise, thermal noise, deterministic effects
- Complex baseband communication
- Modulation techniques
- ISI mitigation techniques, with a particular focus on OFDM
- Methods for synchronization and channel estimation
- Coding
- Basics of wireless communication: channel modeling, classification of wireless channels, fading, diversity, MIMO.

Student Outcomes [ABET]:

- Attain an ability to compute the MAP and ML detection rules for a given detection problem and a recognition of when to apply them
- Understand how to model communication channels mathematically, including both deterministic and stochastic impairments and the physical phenomena that give rise to these impairments
- Attain an ability to optimally allocate bit-rate and power over a vector Gaussian channel with varying signal-to-noise ratios among its components
- Attain an ability to design a working OFDM system over a supplied audio-band channel
- Develop an appreciation of the importance of standardization in commercial communication systems design, the attention-to-detail necessary to write a successful standard, and the exactitude required to implement a standard properly
- **Academic Integrity:**

Students expected to abide by the Cornell University Code of Academic Integrity with work submitted for credit representing the student's own work. Discussion and collaboration on homework and laboratory assignments is permitted and encouraged, but final work should represent the student's own understanding. Specific examples of this policy implementation will be distributed in class. Course materials posted on Blackboard are intellectual property belonging to the author. Students are not permitted to buy or sell any course materials without the express permission of the instructor. Such unauthorized behavior will constitute academic misconduct.