ECE 420 - Embedded DSP Laboratory

Instructors:

This class is usually taught by Prof. Douglas Jones. Other professors in the area of DSP, such as Profs Bresler, Allen, Hasegawa-Johnson, and Do have taught this course in the past.

Prerequisites:

The only prerequisite listed for the class is ECE 310 (Digital Signal Processing). While ECE 310 is the only class that is absolutely essential, experience with assembly programming, C programming and MATLAB is a major plus. Students who have previously taken ECE 391 (Computer Systems Engineering) definitely have an advantage, but the exposure to assembly programming through ECE 190 (Introduction to Computing Systems) is sufficient before taking this class.

When to Take It:

This class is usually offered every semester. Taking this class within a couple of semesters of taking ECE 310 is a good idea, as solid understanding of the material in ECE 310 makes this class a lot easier. Each week's prelab and quiz typically involves questions from DSP theory. It might also be enjoyable to take this class after taking other electives in related areas such as imaging and communications so that you can do something cool for your final project.

Class Content:

This is a very enjoyable and rewarding lab for undergraduates. The class can be a substantial amount of work, but the skills taught are very applicable. The focus is on implementing most of what is taught in ECE 310 and students deal with practical issues of DSP implementation such as quantization error, memory usage, floating point precision; these few practical concerns are the main new concepts. Students don't need to remember all concepts from ECE 310, but they are expected to know or learn concepts necessary for implementation. Students must code in TI (Texas Instruments) Assembly code and C for this class, as well as some minor work in MATLAB--the assembly and C code are used to program the DSP chip, whereas MATLAB is mainly used for simulation before programming the chips. In weekly lectures, the professor introduces new theories related to DSP or reviews old concepts from ECE 310. What the lecture covers depends on the professor. The structured labs, which are available online on Connexions, walk you through implementing various DSP schemes. The final project gives you the freedom to explore a project of personal interest under the guidance of the professor and TAs. Students usually learn new concepts and algorithms related to their projects at that time.

Outlines of each lab are listed below (details can be found on course website):

- **Lab 0:** This lab is for hardware introduction, students will learn how to use Code Composer (IDE in this course) to program DSP chips. They also learn how to use MATLAB to design filters and check output error.
- **Lab 1:** In this lab, students implement FIR filters on chip. They will learn some basic instructions in TI Assembly Code.
- **Lab 2:** In this lab, students implement Upsampling and Downsampling with casaded FIR filters on chip using C, which interfaces with previously used Assembly code. The students are expected to figure out the syntax for passing values between the two languages.
- **Lab 3:** In this lab, students implement IIR filters on chip. The original IIR filter is 4th order and they are required to use two lower order filters to get the same output as the original filter. Since the chip can only represent numbers between -1 and 1, the main challenge is to use gain factors to avoid overflow and then compensate the reduced output amplitude caused by the gain factor. Another challenge is find a way to overcome the large filter coefficient problem. This lab is implemented entirely in C.
- **Lab 4:** From this lab, students start programming in C on the Android platform and learn how to process data in blocks of multiple samples. The main goal is to implement a spectrum analyzer application. Most of the analyzer code is given so students only need to write the C code that implements the analysis.
- **Lab 5:** In this lab, students are given code that takes camera input from the Android device and displays it on the screen in grayscale in real-time (as a video). The students' task is to take the color information from the camera input and map it from the YUV420sp colorspace into the RGB colorspace for color display, and also to implement a histogram equalization of color intensities in each frame of the video.

Work:

This is an open lab, meaning you will need to complete lab assignments at the DSP lab outside of class hours. The work required for this class is 5 required weekly labs, each of which includes a pre-lab assignment and a demonstration of the assignment (no write-ups). The pre-labs often deal with something from ECE 310. These weekly labs cover essentials such as implementation of FIR and IIR filters, FFTs, and up- and down-sampling. Before demonstrations of each lab, students take a written quiz. Each quiz has a few short questions related to the concepts introduced in the lab about to be demonstrated.

After the 5 labs, you'll have a final project. For the final project, you will present a project proposal, a helper lab assignment, a design review presentation, and a demonstration of the final project. The nice part about ECE 420 is that the weekly labs do not require you to spend time writing up reports, but instead require you to spend the time understanding the theory and practical considerations. The final projects in this class are usually substantial, and are very rewarding once completed. Some examples of past final projects include a guitar effects mixer, number-recognizing processors, and a modem. The average student can expect to devote between 6 to 10 hours per week on this class outside class hours.
Life After:

If you enjoy ECE 420, classes to check out include ECE 417, ECE 418, ECE 486 (Control Systems), and ECE 463. ECE 417 and ECE 418 are classes that teach further signal processing theory and have associated lab work. ECE 486, the control systems lab, and ECE 463, the digital communications lab, are related electives.