EEE 404/591: Real-Time Systems (4 credit hours)

Catalog Description
Design and implementation of real-time software for embedded systems through the programming of Digital Signal Processors (DSPs), with emphasis on fixed-point DSPs. This course provides hands-on experience in translating signals and systems concepts into real-time multimedia and communications applications.

Textbook
S.M. Kuo, B.H. Lee, and W. Tian, *Real-Time Digital Signal Processing: Implementations and Applications*, 2nd edition, John Wiley & Sons, 2006.

Prerequisites by Course & Topic
1. CSE 100: Principle of Programming, C Language, or equivalent.
2. CSE/EEE 230: Computer Organization and Assembly Language Programming, or equivalent.
3. EEE 203: Signals and Systems I, or equivalent.

Course Objectives
1. To gain experience using equipment commonly used in industry and in consumer product development such as digital signal processors, Analog-to-Digital and Digital-to-Analog converters, function and signal generators.
2. To gain the skill of translating signals and systems concepts into real-time software using digital signal processor technology.
3. To gain the skill of working with integer (fixed-point) arithmetics and dealing with finite-wordlength effects.
4. To develop multimedia and communication applications by implementing them on actual hardware in real-time.
5. To gain the skill of optimizing the real-time performance based on the used processor architecture.
6. To gain the ability of interfacing the processors to peripherals and external devices for test and measurement.
7. To gain hands-on experience in acquiring, analyzing, and processing real-time I/O.

Course Outcomes
1. Students can translate basic signals and systems concepts into real-time software for various applications.
2. Students can develop real-time C and Assembly language software optimized for the selected DSP architectures with emphasis on fixed-point DSPs.
3. Students can interface the processors to external devices for test and measurement and I/O.
4. Students can use tools to debug and profile the performance of the developed software.
5. Students can develop floating-point and fixed-point real-time implementations.
6. Students can work effectively on team-oriented design projects.

Major Topics Covered in the Course
1. Real-Time Systems: Introduction and Basics

2. Basic Concepts in Signals and Systems: signals, Analog-to-Digital/Digital-to-Analog conversion, sampling and aliasing, quantization, discrete-time representation, filtering
3. Digital Signal Processor Architectures: Harvard architecture, special addressing modes, parallel instructions, pipelining, real-time programming, modern digital signal processor architectures, hardware interfacing.
4. Computer Arithmetics: fixed-point and floating-point numbers and arithmetic
5. Finite-wordlength effects: quantization, overflow, saturation, scaling, rounding and truncation
6. Fixed-point Digital Signal Processors
7. Fast Fourier Transforms and Applications: DTFT, DFT, FFT, implementation complexity, linear convolution, circular convolution, fast convolution, Short-Time Fourier Transform and Spectogram
8. Real-Time Multimedia and Communication Applications: speech processing, and/or audio processing , and/or image processing, and/or adaptive filtering, and/or modulation/demodulation, and/or matched filtering, and/or equalization.

Class/Laboratory Schedule

Lecture: Two 75-minute lecture sessions per week
Lab: On-campus students meet weekly for a three-hour laboratory session under the guidance of a TA. On-line students can access the lab equipment, boards, and software remotely in real-time, and can develop and run real-time applications from their remote location using the lab equipment, hardware, and software through a user-friendly "virtual bench" interface.
Course (lectures and labs) can be taken on-line; more information at http://cpd.asu.edu

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