An Online Digital Signal Processing Course for Practicing Engineers

David V. Anderson, Joel R. Jackson and Thomas P. Barnwell

Center for Signal and Image Processing
School of Electrical and Computer Engineering
Georgia Institute of Technology

1. INTRODUCTION

Digital Signal Processing (DSP) has recently become an enabling technology in many areas. Many products that were historically based on analog or micro-controller systems are now being migrated to DSP microprocessor based systems. Until recently, however, DSP education was almost exclusively in the graduate curriculum and many currently practicing engineers graduated without studying DSP. Many of these engineers are now finding that the systems that they are required to design or implement are becoming increasingly DSP based. In order to assist engineers in making the transition to new DSP chips, Texas Instruments, Inc. has training available on the use of their digital signal processors. This training usually consists of one to four days of lecture and hands-on exercises. However, it does not attempt to teach DSP theory. This paper describes a project at the Georgia Institute of Technology to provide a complementary solution for teaching practicing engineers DSP theory with a focus on real-time, fixed-point applications.

2. PROJECT OVERVIEW

Georgia Tech is developing an internet-based course on the fundamentals of DSP and the implementation of DSP algorithms. This course is being developed with the cooperation and support of Texas Instruments, Inc. and it features lecture modules by experts and well-known professors in DSP; laboratory exercises using the TMS320c62x platform; and online feedback, testing, and exercises. The audience will consist of practicing engineers with disparate backgrounds. The idea is to teach basic DSP theory as well as principles specific to the implementation of DSP algorithms on a fixed-point processor. Thus, this course will offer a compromise solution that is applications-oriented yet still well founded in theory.

The course length is designed to be roughly equivalent to a one-semester university course. It will be delivered asynchronously over the Internet as described below and it will take about 12 weeks to complete. Due to the breadth of the material covered, students will gain a firm foundation in basic DSP principles and learn skills needed to implement DSP algorithms but they will not be expected to become experts in the field. However, it is expected that the background will be sufficient that the students can effectively continue individual study in areas of concentration.

3. COURSE TOPICS

Topics covered in the course are divided into three main areas addressing the following topics.

3.1 DSP SYSTEM THEORY

These modules will begin by presenting common notation and then reviewing linear, time-invariant (LTI) system theory. Basic DSP concepts are then taught, including:

1. sampling,
2. convolution,
3. FIR filters,
4. IIR filters, and
5. **z**-transforms.

In addition to these topics commonly covered in DSP courses, special attention will be given to:

1. quantization,
2. fixed-point arithmetic, and
3. fixed-point filters.

These additional topics provide assistance for those developing and implementing DSP applications.

3.2 DSP MICRO-PROCESSOR ARCHITECTURE

This course does not provide an intensive review of architecture or system specific training since it is meant to complement TI's training. However, enough information is provided about the unique aspects of digital signal processors in general and the TMS320c62x specifically, that the course can stand alone.

3.3 REAL-TIME IMPLEMENTATION PRINCIPLES

Although floating point DSP systems are now more common than in the past, the lower-power, lower-cost aspects of fixed point systems ensure that they will continue to flourish. It is often difficult to develop applications for fixed-point processors and this skill is seldom taught in university classes. To complement the theory taught in this course, real-time, fixed-point DSP implementation concepts are presented. Concepts covered will include:

1. buffering and direct memory access (DMA),
2. interrupts and I/O,
3. multi-tasking and scheduling,
4. multi-string environments and re-entrant code,
5. DSP development environments.

3.4 LABORATORY AND HOMEWORK EXERCISES

The concepts taught in the course are emphasized through homework exercises, drills, and lab experiments using a TMSc62x. The labs are designed to reinforce the material presented in the lecture modules and provide a foundation for the course project which is the development of a DTMF decoder system.

4. DELIVERY SYSTEM

One of the major drawbacks of many currently available online courses is the lack of a coherent course structure. To be effective, a course should provide materials that reinforce the lecture segments. These materials should be organized in such a way that the student is guided through the associated materials in the most convenient and effective path.

In order to provide such an environment, the course is packaged so that lecture modules are reinforced by drills, exercises, and quizzes that are associated with the lecture. The WebCT environment is used to provide an overall structure to the course, so that all materials associated with a particular lecture segment are available together. WebCT is a web-based tool for organizing and presenting courses developed by the University of British Columbia (http://www.webct.com). The primary advantage of WebCT as a course wrapper is that it contains integrated feedback mechanisms. Online quizzes will be scored immediately, feedback given to the student, and results submitted to the professor giving the course. Homework and drill questions also will be presented via WebCT to reinforce the topics presented in each lecture module.

The course will be delivered as a hybrid presentation from the internet and compact disk (CD) to allow for enhanced quality of streaming media such as video or animation. Navigation through the course will be performed with internet-based tools, and lecture modules will be loaded from CD when required. The student will also have the option of receiving lecture modules directly from the internet.

During presentation of the lecture, the overall interactivity of the course will not be lost. An outline of the material to be presented is displayed with the lecture slides and video. In addition to highlighting the current topic, the outline can be used to navigate through the lecture. This functionality allows students who are simply reviewing one or two topics from a lecture module to listen to only those portions of the lecture if desired.

5. COURSEWARE DEVELOPMENT

Since the course will contain a number of lecture modules by different lecturers, a number of considerations need to be addressed. Although there are several lecturers, the lecture modules should have a standardized appearance so that the course has a unified interface. To standardize the look of the materials, a written set of standards for the generation of course materials is made available to all participating faculty.

One of the primary goals of the development process is to make the course modules as easy as possible for the lecturers to create. To this end, a semi-automated production environment has been created. Lecturers are able to use familiar tools, such as Microsoft PowerPoint and LaTeX, for creation of the content of their lecture. Once the slides of the lecture material have been created, the lecturer will use the development environment to display them as the lecture is filmed. The synchronization of slides, video, and supplementary content will be performed automatically. The course outline will be generated and linked to the content as well.

The automated production environment has several advantages. In addition to greatly simplifying the task of lecture module construction, it allows content from a large number of faculty members and lecturers to be seamlessly integrated into the course. The lecturer is able to provide course content without any more preparation than would be done for a typical live lecture. This minimal preparation provides a great deal of flexibility to the course. Visiting lecturers can easily provide course content, and supplemental lectures can be developed and included quickly.

6. TESTING AND INITIAL DELIVERY

The course will be tested with a limited audience in the fall of 1999. Although the course is designed to stand-alone, a Georgia Tech professor will work with students to answer questions, help out in areas where difficulties arise, and to provide feedback on homework problems and quizzes.

Full delivery will begin January 2000 in cooperation with the Georgia Institute of Technology's continuing education program. Certificates of completion will be presented upon successful completion of the course.