Chapter 2.12
A Virtual Laboratory for Digital Signal Processing

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ABSTRACT

This work designs and implements a virtual digital signal processing laboratory, VDSPL. VDSPL consists of four parts: mobile agent execution environments, mobile agents, DSP development software, and DSP experimental platforms. The network capability of VDSPL is created by using mobile agent and wrapper techniques without modifying the source code of the original programs. VDSPL provides human-human and human-computer interaction for students and teachers, and it also can lighten the teacher's load, increase the learning result of students, and improve the usage of network bandwidth. A prototype of VDSPL has been implemented by using the IBM Aglet system and Java Native Interface for DSP experimental platforms. Also, experimental results demonstrate that our system has received many positive feedbacks from both students and teachers.

INTRODUCTION

Digital signal processing (DSP) (Mousavinezhad & Abdel-Qader, 2001; Texas Instrument, n.d.) is one of the most powerful technologies in the 21st century and is a growing subject area in Electrical, Computer Science, and other Engineering/Science disciplines. DSP is linked closely to our life and is widely applied in many fields such as telecommunications, robotics, consumer electronics, medicine, military, instrumentation, aerospace,

and automobile. Each of these areas has developed a deep DSP technology with its own algorithms, mathematics, and specialized techniques.

Although DSP is the trend of current technology development, the learning of DSP is not an easy task for novices. Not only the DSP hardware architecture but also the flexible and powerful instruction sets of DSP chips are difficult for students. Thus, fast and convenient CAI tools for DSP learning are necessary. However, most DSP learning tools are stand-alone. This kind of learning approach has only human-computer interaction and lacks human-human interaction (Dey, 2000; Dow, Lin, Shen, Lin, & Chen, 2002) such as teacher-to-student and student-to-student. In order to add human-human interactions, it is necessary to create network capability for DSP learning tools. A network-enabled DSP learning environment can support multiple users and allow them to interact with each other in order to increase their interests in learning DSP in any place and at any time via the Internet.

In addition to the network capability, a DSP virtual laboratory should support the features of multimedia and multilevel usage. The multilevel usage means that the same learning materials can be organized in different ways to be used in a regular semester course, a short course, an introductory exposition, an advanced seminar, and so forth, and by people with different linguistic, cultural, and perceptual preferences (Arndt, Chang, Guercio, & Maresca, 2002). Through multimedia demonstrations, students easily can understand various DSP theories. We can use the multimedia technology to enhance an experimental environment for students. Furthermore, DSP course material should be organized in multiple levels so students can select DSP studying materials according to their abilities in order to reduce the frustrations when learning and to deepen their impressions about DSP.

This work designs, develops, and implements a Virtual DSP Laboratory — VDSPL — using mobile agent and wrapper techniques. The autonomous feature of mobile agents can be used in the virtual laboratory to substitute for a teacher's behaviors and actions in a practical laboratory. Mobile agents could guide several groups of students in different places simultaneously. When a student needs to interact with the teacher, the virtual laboratory can dispatch a mobile agent to perform this function. For a student, the mobile agent can play a learning guide and arrange the learning activities in order to improve the learning efficiency in a virtual laboratory.

The rest of this article is organized as follows. First, in the second section, we discuss the background materials and related work. The third section describes the system architecture of our work. The system implementation and prototype are presented in the fourth and fifth sections, respectively. The sixth section shows our experimental results. Conclusions are finally offered in the final section.

RELATED WORK

There are many research areas related to our work, including virtual laboratory, digital signal processing, mobile agent techniques, and wrapper concept. These topics are described in this section.

Distance education can be done in a wide variety of styles via different learning models. The virtual laboratory is one of the important components for macro university architecture (Arndt, Chang, Guercio, & Maresca, 2002; Dow et al., 2002). Students are required to learn some courses through online experiments and simulations, and the virtual laboratory is provided in order for students to conduct course-related experiments and simulations via networks. Based on the equipment and user access in each experiment, laboratories can be classified into four types (Dow et al., 2002). The first type of laboratory is

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