The Design of Circuit-Measuring Collaborative Learning System with Embedded Broker

Fu-Chien Kao  
Computer Science and Information Engineering  
Da-Yeh University  
Changhua, Taiwan  
fuchien@mail.dyu.edu.tw

Siang-Ru Wang  
Computer Science and Information Engineering  
Da-Yeh University  
Changhua, Taiwan  
r9806020@mail.dyu.edu.tw

Abstract—Collaborative Learning System is a group learning method combined with pedagogy and social psychology. It allows group members to gain knowledge through collaborations and interactions. Nowadays, most Internet collaborative learning systems are designed to provide students mainly with a convenient online environment to study theoretical courses but rarely with an online environment to operate practical instruments. Hence, this paper describes the design of a 3D online collaborative learning system for operating virtual instruments with circuit-measuring function. The proposed system functions give learners not only a collaborative learning environment via networking to jointly operate the 3D virtual instruments but also the functions of instant messages and 3D puzzles to interact with one another by integrating with Virtual Reality, Remote Control Parameter Transmission and embedded system techniques. Therefore, learners can effectively improve learning interests and results. Besides, the proposed embedded Broker also provides service capabilities similar to that of a high-end server system, and significantly reduces the system costs.

Keywords: Collaborative learning system, embedded system, virtual instruments

I. INTRODUCTION

In the traditional learning, the learning process of the students is similar to photocopy. They catch the knowledge transferred by teachers. The teachers teach in one-way. Although the questions and suggestions from the students are important, the influence is in one-way. The teachers have been acting the models all the time. Starting from the putting forward of the questions, analysis, reasoning to answer, all of them are dominated and demonstrated by the teachers and the students are passive. They observe and simulate the content taught by the teachers and the learning results are not good. Under the traditional learning, the students are short of chance for discussion, communication and argumentation with colleagues. Therefore, they have no idea on how the others consider on solving the same problem, how they can clarify the own views through the interaction with others and how the others organize the knowledge and concept from the communication and argumentation. The traditional learning becomes an accumulation of knowledge. The teachers are responsible for inculcating the results of the evolvement to the students. This learning activity does not only drab but it is not meaningful.

In general, there are there learning modes, including Competitive Learning, Individualistic Learning and Collaborative Learning (Huang, 1996). In the Collaborative Learning, they must help each other. They discuss, ask and answer questions mutually, and feedback in groups in order to achieve the individual and group targets. This does not only benefit the individual students but also benefits to the group members. In the process of Collaborative Learning, all members are benefited from the groups. It is a kind of life community and is a learning trend that is suitable for team cooperation and innovation in the existing high-tech society.

There is a series of innovative teaching methods applied in educational domain recently. The results from many researches (Neo, 2006) also show that the teaching contents should interact with students regardless of the multimedia network teaching or the recent virtual reality auxiliary teaching system in order to reach the best learning performance. Many domestic and foreign researchers on network Collaborative Learning wish to establish a more effective learning environment through the Internet in order to improve the learning ability and performance of the students (Dong, 2004). The existing Internet Collaborative Learning system can roughly be classified into three types according to the tools and technologies of design. The first type is the network Collaborative Learning system that provides documents mainly (Maier, 1994). This type of Collaborative Learning system discusses the design of the shared document database and the system infrastructure of the network Collaborative Learning. The second type is the Collaborative Learning system that provides video conferencing function. The third type of Collaborative Learning system provides virtual reality environment (Maier, 1994). This type of Collaborative Learning system mainly provides a learning environment of simulated virtual reality to the members of the group. However, most of the existing network Collaborative Learning system a convenient network environment for the students to conduct online Collaborative Learning of theoretical courses. It is rarely to discuss how the Collaborative Learning environment of operation training of online-simulated instruments and the circuit current measurement can be established.
This paper has proposed a Web-based Collaborative Learning system for remote operation 3D virtual electronic instruments with circuit-measuring function. The chapters of this article also include embedded system and applications, virtual reality, and system infrastructure implementation, the Collaborative Learning of virtual instruments operation and circuit measurement, and conclusions.

II. EMBEDDED SYSTEM AND APPLICATION

The "Embedded system" integrates the application of information software and hardware. The application of embedded system can be found everywhere, including the life facilities such as mobile phone, electric toy and video-audio instrument, and transportation system and automation in factories. The trend of the functions of common embedded systems is simplification. The software and hardware only include the modules required for specific functions. The peripheral products from different manufacturers are combined to become an intact embedded system according to the provided Intelligence Property (IP). Comparing with the common computers, the building cost can be reduced significantly. Besides, due to the domain of the application, most of them include the characteristics of miniaturization and low-power consumption. Since the system only includes the specific functions, the design of the system will be optimized to ensure the stability of the system (Kao, 2007).

A. Improved Multimeter instrument

Since the embedded system is developed for specific functions, the developing tools include In-Circuit Emulator (ICE), Development Board, Integrated Development Environment (IDE) and compiler (Microtime Computer, 2004). The Development Board is the design sample provided by the hardware manufacturers. The debugging mechanism in the central processing unit of the In-Circuit together with the pre-set messages of the compiler can simulate the program running on the hardware. The product developers may refer to their circuit design and integrate to the corresponding developing environment. Therefore, most of the Development Boards have been built with many peripheral function modules such as network card, seven-segment display, parallel port, LED and dip switch, for the convenient of product development and speedup the product development cycle. The application integrating the development environment and compiler refer to the development software on the personal computer of the developer. Therefore, the system developers may design the working platforms and the corresponding applications of the embedded system on the personal computer, and complete the compiling. Through the parallel port or serial port, the corresponding software can be embedded to the target board and the cross-platform development process is finished. Since the common low-cost Multimeter cannot communicate with computer, this research made use of low-cost 8-bit 89C51 single chip to develop an Improved Multimeter with embedded RS-232 Module to capture the data shown on the panel of the Multimeter and transfer it to the computer, as shown in Figure 1.

B. Embedded RS-232 Module

Since most of the low-cost Multimeters used by students do not include the serial communication function with the computer, this research makes use of 8-bit 89C51 single chip to implement an Embedded RS-232 Module. It is then integrated with the low-cost Multimeter to replace the high-cost Multimeter. The 89C51 single chip includes the following advantages: (1) the program is easy to learn (2) low-cost (3) simple circuit (4) small size. The infrastructure of the single chip is shown in Figure 2.

C. The proposed Embedded Broker

As the network technology and applications are developed rapidly, large amount of servers for different network services are built. They include file server, web server and Email server. These servers are built on high-end servers. According to the functions built by the users, these powerful servers become the specific function servers. The hardware is very complicated and expensive, and it increases the building cost of the system directly. To build the network server by the embedded system, the relevant functions can be enhanced according to the requirement of the service. For example, the files operating performance and the space of the hard disks of the file server should be increased but the relatively low performance of CPU can be used. This can reduce the cost effectively and increase the competitiveness.
This research adopted ARM7 development board (as shown in Figure 3) to develop embedded Broker to replace the expensive server. The proposed Embedded Broker with connecting capabilities between users uses the Samsung S3C4510 ARM7TDMI development board. The development board is as indicated in Figure 3. The proposed Embedded Broker also is embedded with BOA Web Server, providing system administrators to monitor network flow conditions from the network anywhere anytime.

III. VIRTUAL REALITY

The Virtual Reality (VR) is the term for science and technology domain. The virtual reality includes many components such as vision, hearing, and even sense of touch and sense of smell. The users can determine the path for browsing the information freely in the virtual reality. Therefore, the virtual reality can be regarded as an intact multimedia system. The major characteristics of the virtual reality system are the interaction and the real time response. When it is applied on application, the users can operate the computers freely. They can observe the products in any angle and position. The virtual reality technology makes use of the computer drawing or image synthetic technology together with the virtual reality constructed by sound processing, sense of touch and sense of taste. In this virtual world, the 3D simulated object can be our famous things, or something that we cannot see, or a simulated imagined space. Virtual reality is an integrated technology in order to provide a higher level of man-machine interface (Kao, 2007). Dong (2004) has proposed three important topics for virtual reality. They are immersion, interaction and imagination (3I). The application and development of virtual reality technology on different professional domains are increasing gradually. One of the reasons is that the function of the software of virtual reality is enhanced. It is more important that the cost for virtual reality on personal computer (PC) is relatively low and it is widely accepted by all trades and professions. The 3D Webmaster and Virtools Dev 3.0 have been adopted in this study to develop the relevant virtual instruments. In order to increase the control of the 3D virtual object and flexibility of the interactive design of the 3D virtual object, the 3D Webmaster provides Superscape Control Language (SCL), which is similar to programming language C. Therefore, the users can write with the control language in the virtual scene designed by themselves, as shown in Figure 4.

IV. SYSTEM INFRASTRUCTURE AND IMPLEMENTATION

In order to recognize the characteristics of Collaborative Learning, the system of this study provides the functions including group real time discussion, real time interaction, operation of 3D virtual electronic instruments that include transmission technology of remote control parameters and circuit measurement.

A. System infrastructure

The functions of the system are divided into four major parts as shown in Figure 5.

1) Collaborative Learning system: the learners can download the installation file from the link of the portal website. After the installation, the Collaborative Learning system can be entered.

2) Collaborative Digital Learning: in the Collaborative Learning system, many items of Collaborative Digital Learning (system brief, 3D virtual lab, 3D puzzle that trains up initiative and interaction, 3D virtual Multimeter and 3D virtual power supply) can be found. The learners can click and start Collaborative Digital Learning.

3) Teaching material: after the learners have started the Collaborative Learning system, they can start learning from the digital teaching content. The users must study the operation of the electronic instruments first. Then they can make use of the real time discussion to practice operating the instruments and start Collaborative Learning with the group members.

4) Circuit measurement: the learners of the same group can progress Collaborative Learning of Multimeter instrument with embedded RS-232 module for circuit measurement. The members of the same group can see the data of the circuit obtained by the measuring team from the 3D virtual instrument simultaneously.
B. Collaborative Learning of 3D virtual instruments with circuit-measuring function

The proposed collaborative practice environment with circuit measurement function sends the measured value from the Multimeter Embedded RS-232 Module to the 3D virtual Multimeters of the learners in the same group. Any learner can operate the own Multimeter to progress collaborative practice. As shown in Figure 6, when the user sends the control command (or get the data from circuit measurement) to the 3D virtual instrument through the Operating Interface, it will be determined and processed by the embedded control program and a control parameter will be obtained. Then with the remote control parameter transmission technology, the embedded Broker transmits the control parameter to other learners of the same group so that the 3D virtual instruments of the learning partners can be updated simultaneously.

The main function of embedded Broker is to constantly listen to every user’s status. Any user changes the status, embedded Broker will immediately recognize user’s located group, duplicate the received information of the status and update the newest status to group members by sending them the duplicated information so that every member’s operation status of the same collaborative learning group would be identical. In this way, the users can interact with the 3D virtual instruments and the display on the instruments can be synchronized among the users in the same group. The simulated operation of the instruments and the measured data of the circuit among the members in the same group would display the same result as shown in Figure 7 and Figure 8.

C. Proposed 3D virtual instrument for Collaborative Learning of simulated operation training

The designed 3D virtual instrument interface for Collaborative Learning of simulated operation training is shown in Figure 9. The functions of the system include login, group study, 3D virtual object operating interface and real time discussion. The corresponding function blocks are described below:

1. The interactive 3D Virtual Instrument Appearance.
2. In the real time discussion, the users can transmit messages to the members of the group for real time discussion. The corresponding learning records can be saved for the teacher assessing the learning performance.
(3) User inputs the IP of the Embedded Broker and the assigned Port in order to connect to the Embedded Broker. (4) After grouping, team study via networking available in addition to login learning. (5) The users can make use of the virtual machine operating interface to operate the 3D virtual instrument.

V. PERFORMANCE EVALUATION

In the experiment, we adopt as the setting 40 learners with 3 users per group with 4 users in the 13th group, and connect into Embedded Broker to do collaborative learning by means of the collaborative learning materials offered by the system.

A. The Environment for system testing

The hardware specification used by the 40 learners is Intel Pentium 3 Processor as CPU, main memory 512 MB, and Microsoft Window 2000 Professional Operating System. Learners can be allowed to make use of the Internet browser and go into the portal to download and install the system. The testing is focused on the performance of getting curriculum materials against increasing the number of user connections (one group per unit) to further analyze the transmission efficiency reached by the system. In order to retrieve the packets communicated between Embedded Broker and each learner’s PC for analysis of data transmission, a professional network packet analyzer is utilized: Ethereal (Network Protocol Analyzer, version 0.10.10).

B. System performance testing

In Figure 10 and 11, the x-axis stands for the number of learners while the average response time for 3D virtual collaborative learning system (unit: ms, millisecond) is indicated by the y-axis. While 40 learners are using the system simultaneously, the response time for each learner will be different because the received status data calculated by averaging the sum of each learner’s response time are orderly updated via Embedded Broker into each learner’s PC. Under PC and Embedded Broker Architectures, the experimental results for the system’s response time against increasing the number of learners are listed below:

1. Under the system with PC Broker, while learning is done by grouping, the average response times for Group 1, 2, 3, and 4 are respectively “132ms,” “144ms,” “148ms,” and “152~155ms,” as illustrated in Figure 10.

2. Under the system with Embedded Broker, while learning is done by grouping, the average response times for Group 1, 2, 3, and 4 are respectively “130ms,” “141ms,” “147ms,” and “152~155ms,” as illustrated in Figure 11.

VI. CONCLUSIONS

Most of the existing network Collaborative Learning system provides a convenient network environment for the students to conduct online Collaborative Learning of theoretical courses. It is rarely to discuss how the Collaborative Learning environment of operation training of online-simulated instruments and the circuit measurement can be established. This causes the existing network Collaborative Learning system cannot implement the characteristics of Collaborative Learning in the learning environment on the Internet.

This research has broken through the traditional practice mode of lab operation. The Collaborative Learning environment of the instrument practice is implemented in the Internet. The Collaborative Learning environment for operation of instruments on Internet is established completely. It provides the Collaborative Learning practice of circuit measurement for the learners to operate online anytime. Besides, the simulating training provided by the 3D virtual instruments, and the online grouped discussion do not only increase the interests of the learners in practice courses and train up their initiative and interaction on Collaborative Learning. This also decreases the damage rate of the traditional instruments and reduces the
purchasing cost of school facilities. Besides, the proposed embedded Broker would also provide service capabilities similar to that of a high-end server system, and significantly reduce the system costs.

ACKNOWLEDGEMENTS

This paper has been supported in part by the grant NSC95-2520-S-212-001-MY3 from the National Science Council of Taiwan.

REFERENCES

[1] Dong, W. F. (2004). Applying Collaborative Learning on Teaching the English Class. http://www.chinaetr.com/.
[2] Huang, Z. J. & Lin, P. X. (1996). Collaborative Learning. Wu Nan Book Inc.
[3] Kao, F.C., Tseng, C.W. & Ji, J.H. (2007). The Design of Embedded LCMS Broker with Load-Balancing Function. ICMLC, 3770-3776.
[4] Maier, M. H. & Keenan, D. (1994). Teaching Tools Collaborative Learning in Economics. Economic Inquiry, Vol.32, 358-361.
[5] Microtime Computer Inc. "Implementation of Embedded uClinux on PreSOCes", Chuan Hwa Book Co., Ltd, ISBN 957-21-4533-9
[6] Neo, S. J. & Yang, G. X. (2006). The History and Existing Development Analysis of Network Education. http://www.edu.cn.
[7] Superscape(1996). SDK 3D Webmaster for Window Reference Manual, Superscape Inc.