AC 2011-399: VIRTUAL AND REMOTE FUNCTIONALITY DEVELOPMENT FOR UNDERGRADUATE LABORATORY

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Xuemin Chen received his academic degrees (B.S., M.S. and Ph.D.) from the Nanjing University of Science and Technology, China, in 1985, 1988 and 1991 respectively. His field of specialization was in Electrical and Computer Engineering, with emphasis on Stochastic Control Theory. He joined the Department of Engineering Technology at Texas Southern University (TSU) as an Assistant Professor in the fall of 2006. He initiated the Virtual and Remote Laboratory (VR-Lab) at TSU in 2008. With the support of NSF HBCU-UP, CCLI and IEECI programs, a state of the art virtual and remote laboratory has been established. Now, the VR-Lab website is being served as portal for students to conduct various virtual and remote experiments.

Virtual and Remote Functionality Development for Undergraduate Lab

Abstract:

A particular challenge for online education in engineering is how to extend the traditional hands-on laboratories over the Internet. Especially for Engineering Technology department, its lecture courses are always accompanied by corresponding laboratory sessions, in which hands-on experiments allow students to experience the nature of science and engineering, observe dynamic phenomena, test hypotheses, learn from mistakes, and reach conclusions. Generally online laboratories can be categorized in two approaches: the virtual laboratory allows students to log on a simulated environment residing on the server; the remote laboratory allows students to remotely control the real components or instruments through internet access. Simplified as VR-Lab (Virtual and Remote Laboratories), online laboratories can drastically reduce the cost of experimental facilities, and increase the availability of diversified setups. Also, VR-lab can be visited by students 7/24 via the internet, avoiding complex logistics like staff, scheduling, as well as commute. In response to the technology trend moving forward to online education, two faculty members in neighboring institutions are collaborating on the development of virtual and remote functionalities for Engineering Technology laboratories. This paper presents the current progress and implementation strategies of the projects.

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1. Background:

As a relatively new discipline emerged between traditional college engineering program and technical or vocational school, Engineering Technology (ET) is the application of engineering principles and modern technology to help solve or prevent technical problems. The programs are designed to meet the growing need created by the technology revolution for college-educated problem solvers who can support the engineering process [1].

Engineering technologists are more practically oriented in implementation than scientists and engineers. Thus, ET program is featured with its emphasis on hands-on skills training, to help ET students to develop the ability in solving implementation problems. Therefore, in order to cater for the industry requirements in the job market, the need for updating the educational infrastructure along with technology trend is more urgent in ET program. In response to this concern, two ET faculties from neighboring HBCUs (historically black universities) are collaborating in an NSF CCLI project to utilize the recent information technology to revamp a series of ET laboratories with virtual and remote functionalities.

Information technology has had an enormous impact on engineering by providing new tools across the range of engineering disciplines. Meanwhile, it facilitates the development of additional teaching strategies, including vivid and interactive ways of illustration, simulation, demonstration, experimentation, operation, communication, and so on [2]. The Sloan Survey of Online Learning, "Staying the Course: Online Education in the United States, 2008", shows that over 3.9 million students were taking at least one online course during the 2007 Fall semester, a 12 percent increase over the number reported the previous year [3]. A particular challenge for online education in engineering is how to extend the traditional hands-on laboratories over the Internet.

Especially for ET department, its lecture courses are always accompanied by corresponding laboratory sessions, in which hands-on experiments allow students to experience the nature of science and engineering, observe dynamic phenomena, test hypotheses, learn from mistakes, and reach conclusions. In the literature [4][5][6], online laboratories can be generally categorized in two approaches: the virtual laboratory allows students to log on a simulated environment residing on the server; the remote laboratory allows students to remotely control the real components or instruments through internet access [7]. These two approaches can be generalized as VR-Lab (Virtual and Remote Laboratory). By sharing VR-Labs with other institutions, it can drastically reduce the cost of experimental facilities, and increase the availability of diversified setups [2]. Also, VR-lab can be visited by students 7/24 via internet, avoiding complex logistics like staff, scheduling, as well as commute.

2. Project Activities:

A. Developed a Scheduler Web Server (SWS) for Sharing the Remote Experiment

With the help of the project consultant, a Scheduler Web Server (SWS) has been successfully developed. The scheduler web server bridges the physical laboratory experiments with the Internet end users. The SWS is responsible for user account managing, authenticating and experiment scheduling. With the SWS, a remote experiment developer can concentrate on the design of the experiment hardware and controller rather than the management of resources. In addition, the SWS is independent of the technology used by the experiment developers for remote lab development.

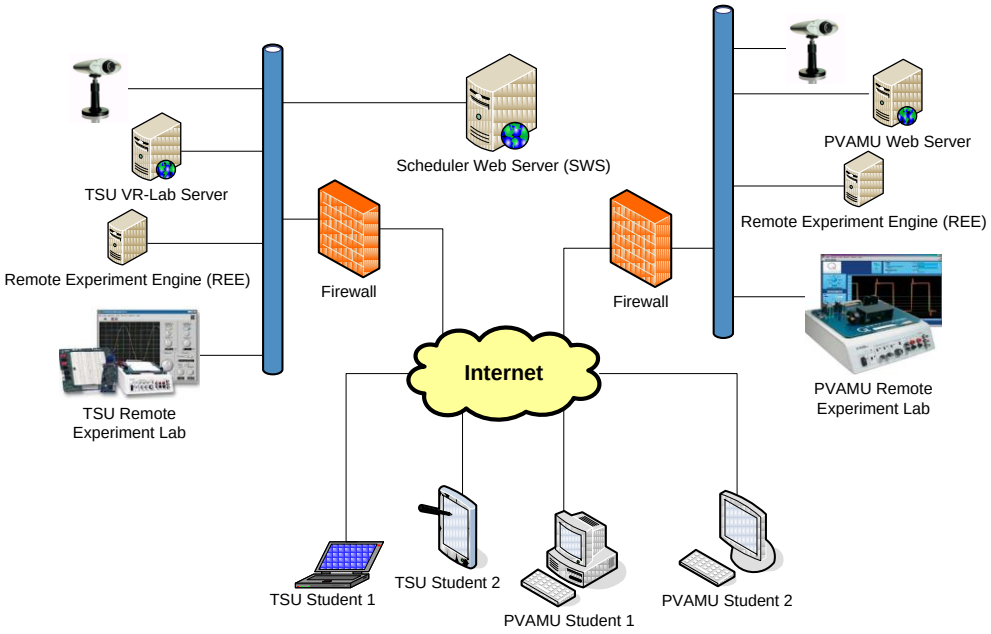


Figure 1. Remote experiment farm architecture.

Figure 1 shows the overall system architecture of remote experiment farm. A remote Internet client connects to the Scheduler Web Server (SWS) with the assigned credential. The user then schedules a future time slot with one of the available experiments listed on the scheduler web server. When the time comes, the user will be provided with a customized direct link to the chosen experiment. The SWS could be located in the same sub network of the web server or in a different one. This type of architecture allows for building decentralized experiment farm. In other words, it allows collecting currently running experiments into a single website. The experiment itself and the scheduler web server could be located anywhere there is Internet access. As a result, each experiment in the experiment farm itself must include a web service to provide the data and the interface to the client. On the other hand, the scheduler server provides access control and data logging.

The scheduler web server for the Department of Engineering Technology at the Texas Southern University (TSU) is hosted on a Linux computer with Apache web server. PHP and MySQL are used for generating HTML pages with dynamic data polled from the main database. The website, http://vr-lab.engineeringtech.tsu.edu/, is set up for Virtual and Remote Laboratory (VR-Lab). Currently, it is used only by students in the Texas Southern University and guests who have requested an account. The scheduler web server will be opened to the project collaborative university, Prairie View A&M University (PVAMU), next year. The remote experiments developed at PVAMU will be managed by a single scheduler web server which is located at TSU. The students from both universities can access any available remote experiment hosted in the scheduler web server.

A remote vibration control experiment is developed for the system pilot testing. A snapshot of the remote experiment is shown in Figure 2. User management in the Scheduler Web Server comprises of several levels because of the mixture of responsibilities and privileges of the users. In a common laboratory setting, a user could be a professor, a student, or a teaching assistant (TA). Experiments are managed by allowing web administrators, instructors, and teaching

assistants to create, modify and delete experiments. Each entry includes several important links that are shown selectively to users, in particular, links to webcams, data files, experiment front panel, manuals, and additional info. Every experiment can be selected to be open or close. When open, the administrator selects the date it start and the number of days of service.

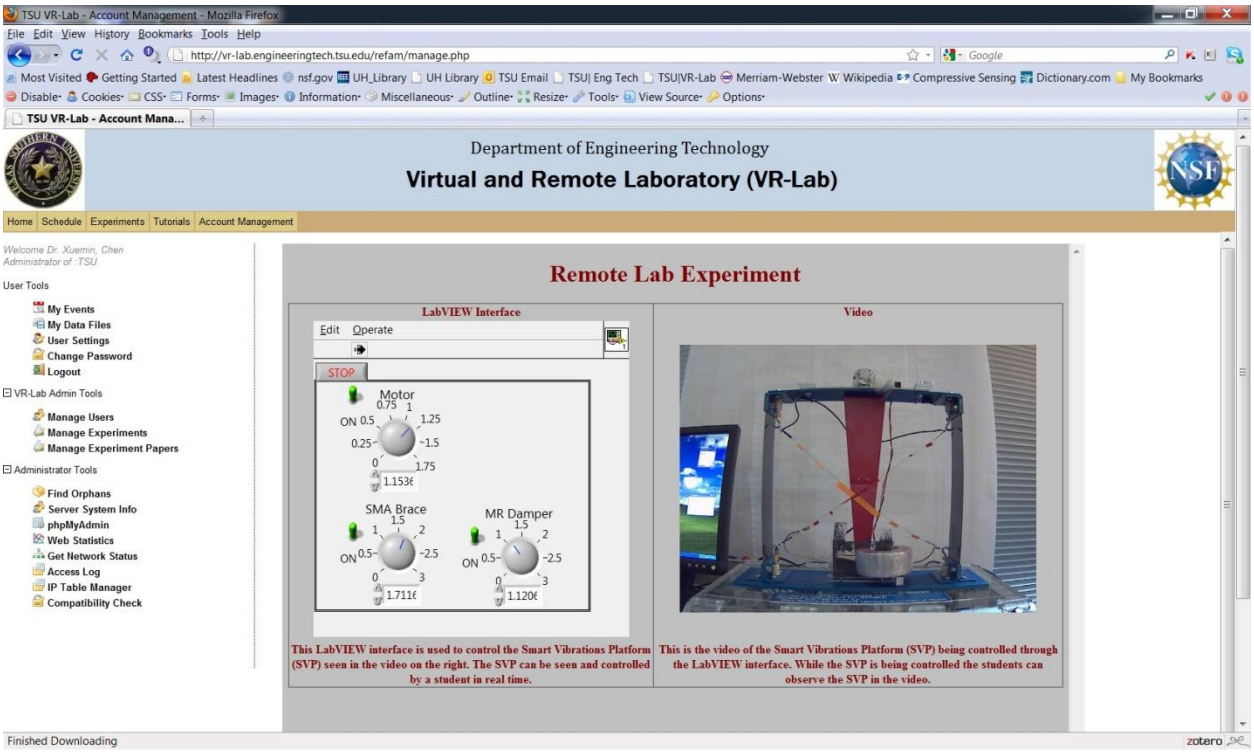


Figure 2. Screenshot of the remote vibration control experiment.

To allow users to perform real research or homework, collected data must be saved and retrieved in an easily accessible location. The web scheduler server has the ability to download files from the experiment link following a specific command by the experiment server. A user performing the online experiment can save the transferred data files to the web scheduler server under his own account. Centralizing the data files from multiple experiments into one location reduces the computation amount and storage requirements of the laboratory computers. All the files are saved on a SWS local folder and linked back to the user using a MySQL database table. The communication between the REE and the SWS for saving data files follows a similar authorization technique.

B. Developed a Virtual Signal Processing Experiment

Sponsored by this NSF project, an undergraduate student of TSU, Daniel Osakue, developed a virtual signal processing experiment (Pulse Code Modulation) which is suitable for demonstrating the signal sample and hold concept. The screenshot is shown in Figure 3.

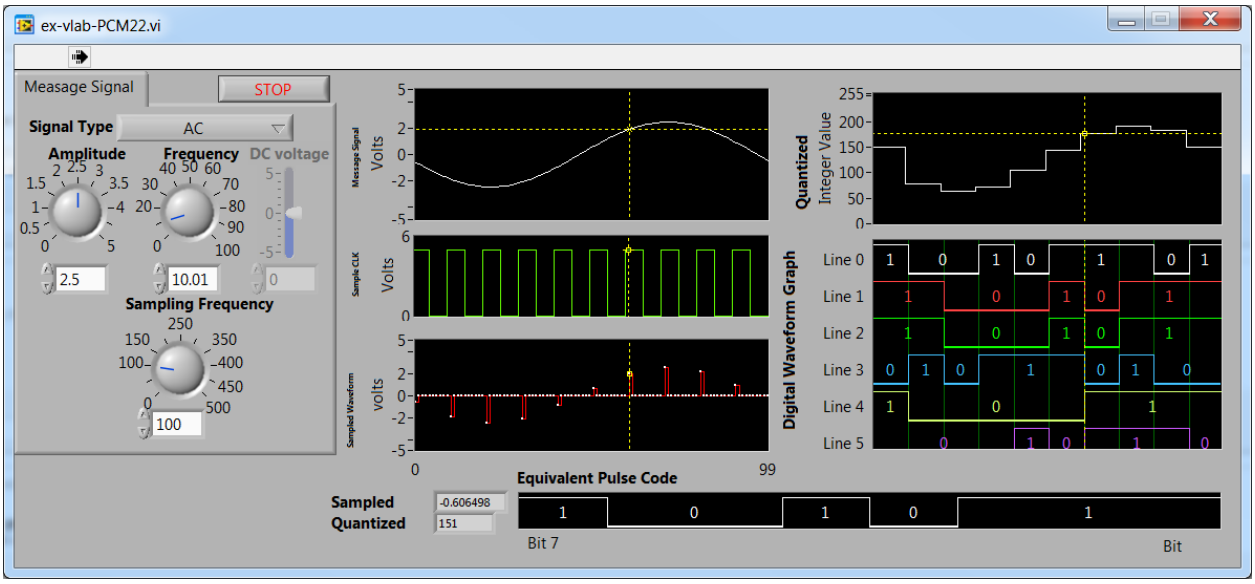


Figure 3 Screenshot of PCM.

C. Senior Project and Undergraduate Research

Senior design can function as a pilot project for instructor to prepare the courseware development. In 2009-2010 academic year, one group of four black students (Romie Phelps, Emmanuel Ekong, Joshua Adebayo, Jeremy Allen) worked with the instructor to develop online remote functionality on NI-Quanser QNET motor board, to extend the traditional hands-on laboratories over internet, such that students can visit 7/24 through internet, avoiding complex logistics like staff, scheduling and commute. One particular feature noticed is that senior students are very willing to involve in outreach activities, to expose their project in campus events, and help home department in recruiting.

D. Project Competition

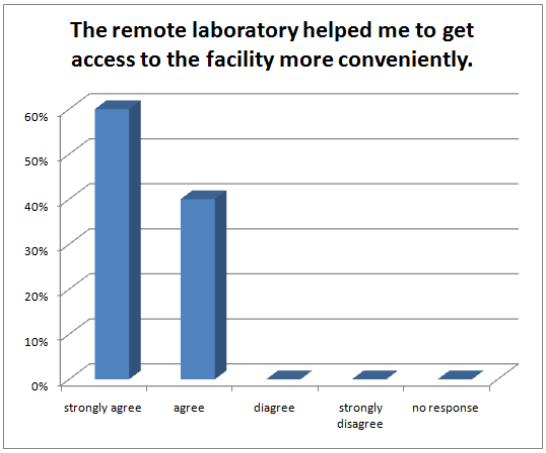
Two groups of black students (Emmanuel Ekong and Romie Phelps in Electrical Engineering Technology program at PVAMU, Daniel Osakue and Mr. André Seals in Computer Engineering Technology program at TSU) participated and won the third prize of Undergraduate Active Vibration Control Competition in ASCE Earth and Space Conference, Honolulu, Hawaii, Mach 14 - 17, 2010. The two teams were highly recognized by student competition organizers for their creativity and hard working.

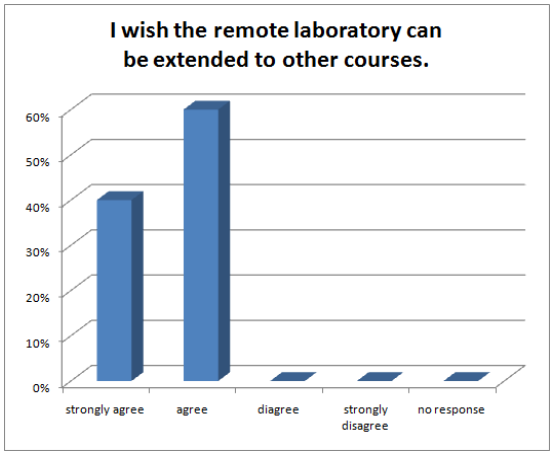
E. Faculty Workshop

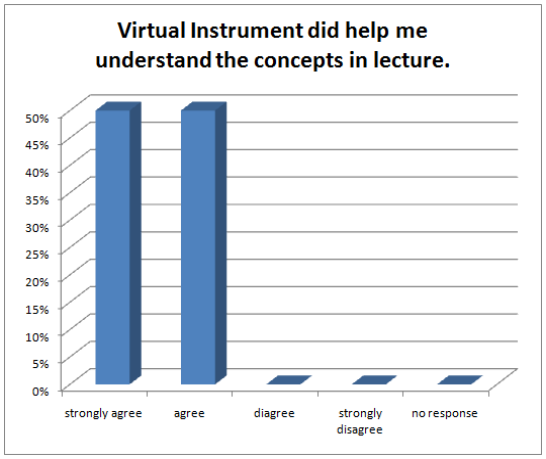
To achieve a sustainable development on the research funding, two authors from neighboring institutions attended the pre-conference faculty workshop in ASCE Earth & Space Conference on Mar 14, 2010. The workshop is organized by Dr. Gangbing Song at University of Houston. The related faculties in remote control project on Smart Vibration Platform, together with other potential collaborators, attended the faculty workshop for the preparation of next stage proposal. By seeking the further support, it is trying to expand the benefit for a broader community nation-wide.

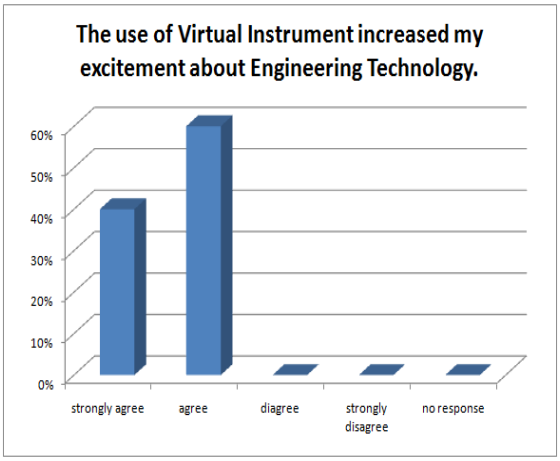
3. Evaluation:

The following is the survey analysis based on the student survey in ELET 3451 Robotics Lab in 2010 Fall. The student feedback indicate that the remote lab helped them in the study, and enhanced their confidence in the Engineering Technology program.









4. Future Plan:

This paper reviewed the first year activities for a collaborative NSF sponsored research project to develop remote and virtual undergraduate laboratories for Engineering Technology program. In the next project year, PVAMU will focus on the development of Scheduler Web Server to realize user management, and one faculty in Computer Science will join to help on this part; TSU will continue their efforts to enrich the virtual lab contents. The two neighboring institutions will share their courseware in corresponding lab courses. Meanwhile, the two collaborative faculties will seek further support to achieve a sustainable development.

Acknowledgement

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conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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