AC 2010-1574: DEVELOPING VIRTUAL AND REMOTE UNDERGRADUATE LABORATORY FOR ENGINEERING TECHNOLOGY

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Developing Virtual and Remote Undergraduate Laboratory for Engineering Technology

Abstract

In this paper, the development of virtual and remote laboratory (VR-Lab) for the enhancement of Engineering Technology (ET) program is presented. By utilizing the latest Information Technology, the VR-Lab is established through the setting up of an Internet-based laboratory for interactive learning. Faculties from two Historically Black Colleges and Universities (HBCU) collaborate on this project, with the aim of revamping some existing laboratories with virtual and remote functionalities. The objectives of this effort are to improve the learning of under-represented student population in the ET program; provide a platform to publish the VR-Lab courseware developed in senior projects; promote inter-institutional collaboration by developing and sharing VR-Lab courseware; develop faculty expertise through research and teaching initiatives; and disseminate results and findings of the project to other universities and colleges. In this paper, the authors intend to demonstrate their research plans as well as their latest progress in the NSF Course, Curriculum, and Laboratory Improvement (CCLI) Type 1 project.

Introduction

The following definition of Engineering Technology was established by the Accreditation Board for Engineering and Technology (ABET), and was approved by the Engineering Technology Council of American Society for Engineering Education (ASEE)[1].

> *Engineering technology is the profession in which a knowledge of mathematics and natural* sciences *gained by higher education, experience, and practice is devoted primarily to the implementation and extension of existing technology for the benefit of humanity.*
>
> *Engineering technology education focuses primarily on the applied aspects of science and engineering aimed at preparing graduates for practice in that portion of the technological spectrum closest to product improvement, manufacturing, construction, and engineering operational functions.*

As a relatively new discipline, emerging 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].

ET graduates usually work as technologists in industry. Among the 511,000 engineering technologist/technician jobs currently in the United States, 170,000 are electrical and electronic engineering technologists/technicians[2]. Therefore, the demands in job market for ET graduates are tremendous. Particularly in recent years, due to the aging workforce[3, 4, 5], and emerging

techniques[6], the need for fresh technologists is especially urgent. Despite industry openings always attracting enough applicants due to the decent wages compared with service sectors, employers are still frustrated by the unavailability of qualified ones[7]. This can be attributed to the transition towards technology-intensive production processes and the adoption of advanced manufacturing methods, which requires a workforce with higher levels of education, current technical skills, and the ability for greater decision-making in line with enterprise objectives[8]. According to Project Lead the Way (PLTW), a national non-profit organization established to involve high school students in Science, Technology, Engineering and Math (STEM) projects, there are estimated 1,300,000 engineering and engineering technology vacancies in the U.S. without skillful people to fill them. In a study conducted by Deloitte Consulting LLP and the National Association of Manufacturers, the results indicate that at least four of five companies are experiencing moderate to severe shortages in human resources[9]. 83% of the surveyed 800 companies report the shortages influence their ability to meet production levels and maintain customer service and satisfaction[10].

As industry procedure becomes more complex and more technology driven, it has increased challenges for the education system[8]. However, it seems that there is a gap between industry demand and current curriculum[11], and the current school system seems not to prepare students adequately and properly for their future workplace[12]. To address the problem encountered by the U.S. industry in finding technically competent and highly skilled employees to fill the vacancies of scientists, engineers, technicians, machinists, and operators[5], it is necessary to establish a productive and innovative partnership between the US Government including NSF, industry and academia to provide a well-prepared, highly trained, and intelligent workforce to maintain the global competitiveness of the US industry[13]. Minority institutions including HBCU can play a more active role in such a transition to keep pace with the new technologies.

Engineering technologists are more practically oriented in implementation than scientists and engineers. Therefore, the ET program is emphasized on hands-on skills training, to enable ET students solve production and system implementation problems and help them explain solutions. In order to cater to the industry requirements in the job market, the need for updating the educational infrastructure along with technology trend is more urgent in the ET program. In response to such a concern, two ET faculties from Texas Southern University (TSU) and Prairie View A & M University (PVAMU) are utilizing recent information technology to revamp a series of ET laboratories with virtual and remote functionalities.

Virtual and Remote Laboratory

Information technology has had an enormous impact on engineering, 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[14]. 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[15].

A particular challenge for online education in engineering is that of how to perform the traditional hands-on laboratories over the Internet. Especially for ET department, its lecture courses are always accompanied by a corresponding laboratory session, in which hands-on experiments allows students to experience the backbone of science and engineering, observing dynamic phenomena, testing hypotheses, learning from mistakes, and reaching conclusions. In literature[16, 17, 18], online laboratories can be generally categorized in virtual laboratory and remote laboratory. Virtual laboratories allow students to log on a simulated environment residing on a remote server. Remote laboratories allow students to remotely control real components or instruments from any place with Internet access[19]. These two approaches can be collectively 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[14]. Also, VR-Labs can be visited by students 24/7 via the Internet, usually avoiding complex logistics like staff, scheduling, as well as commuting.

A large amount of research on virtual and remote laboratory technologies has been recently reported, ranging from LabVIEW[20, 21, 22, 23], Matlab/Simulink[24, 25, 26], Java applet[27, 28, 29], Flash[30, 31], Web 2.0[32] and other techniques. In this project, Java applet and LabVIEW will be utilized to develop VR-Labs.

Among those software tools used to create virtual laboratory environments, Java applet prevails. Java was released in 1995 as a core component of Sun Microsystems' Java platform. It promised "Write Once, Run Anywhere" (WORA), providing no-cost run-time plug-in on popular platforms. Major web browsers soon incorporated the ability to run secure Java applets within web pages, and Java quickly became popular. Java has been adopted in many virtual and remote laboratories since then.

LabVIEW is a powerful graphical development environment developed on a novel concept of virtual instrumentation (VI), which utilizes computer technologies in combination with flexible software and modular hardware to create interactive computer-based instrumentation solutions. The graphical interface and automated tools in LabVIEW smooth the path for many users who lack programming expertise. With tremendous customers including 24,000 companies and 5,000 laboratories worldwide, LabVIEW has been proven valuable as an industrial tool for efficient prototyping, testing, real time analysis, and process control.

Courseware Development

Web-based Digital Signal Processing (DSP) laboratory experiments

The DSP laboratory will be developed at TSU, and initially it would be utilized in the Digital Signal Processing course (ELET 323). Then, it will be used in related DSP lecture and laboratory courses (CPET 4383/4381) at Prairie View A & M University (PVAMU).

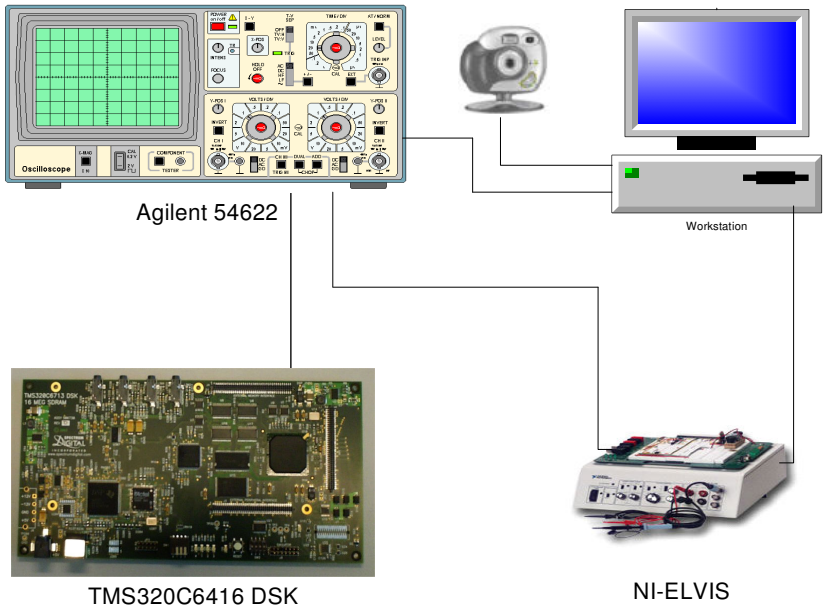

Fig.1. Web-Based Remotely Controlled DSP Laboratory

To implement remotely controllable experiments, network-enabled signal generators and measurement devices are needed. However, most traditional laboratory instruments like function generators, oscilloscopes or digital multi-meters are not equipped with a network interface. Instead, usually serial interfaces (RS-232) are provided.

By developing a remote control Java applet, Internet access can be provided to any instrument that is connected to a workstation through RS-232 as shown in Fig. 1. Users can get access to the remote lab setups through a web browser and URL address. This Java applet can easily be adapted to a 2-channel oscilloscope by changing the control word sentences associated with the generic parameter functions (e.g. how to set channel amplification or set time base). NI-ELVIS can be utilized as both signal generator and data acquisition. The web camera can provide the users with real time response. Based on this architecture, the web-based DSP Lab will contain the following experiments:

- FSK modem encoding and decoding
- Audio player/recorder system
- AM communication system
- FM synthesis for music tones
- Spectral analysis
- Fast Fourier transform (FFT)

Web-based robotics laboratory experiments

The robotics laboratory will be developed at PVAMU, and initially it would be utilized in Robotics Lab (ELET 3453/3451). Then, it will be used in related control lecture and laboratory courses (ELET 430/410) at TSU.

Currently this laboratory is based on NI ELVIS, together with Quanser QNET Motor Board and Rotary Inverted Pendulum Platform as shown in Fig. 2. The vendor has provided a series of LabVIEW programs for laboratory experiments.

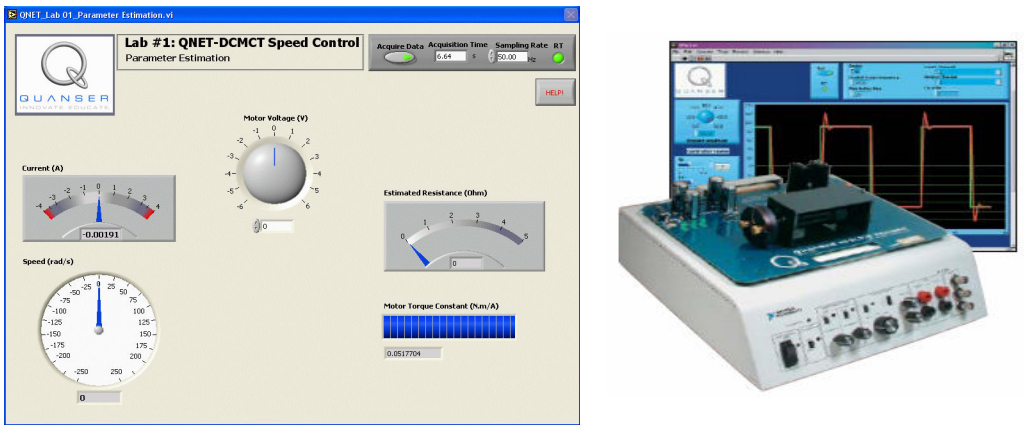

Fig.2. LabVIEW-based Experiment Series, provided by Quanser

Those LabVIEW programs will be extended with remote access functionalities, and the courseware also will be modified to satisfy the particular need in The ET program. The web-based Robotics Lab will contain the following experiments:

- DC motor parameter identification
- Open-loop speed control
- Close-loop speed control
- Torque control
- PID controller design
- Stability Analysis

Future Works

This is a two year project. This project began in Jan. 1, 2010. Now, the virtual and remote lab platform is being set up. As the hardware system is set up, the dedicated websites will be hosted on the servers on each campus. All course related materials will be housed at the course web site. These include general information, course outline, experiment setups, tutorials, remote-controlled experiments, and discussion forums. The open source software such as CentOS and MySQL will be used to build the website and database. The first lab will be available in the fall of 2010.

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