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A Step Towards *i*-Education in Control: Multimedia Coursewares and Virtual Laboratories

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Abstract

The Internet has grown to be tremendously successful in the areas of business and entertainment over the past few years. However, its application in education still lacks behind. A step towards *i*-education (*Internet Education*) is currently being developed in many countries and it will soon be available as an effective teaching tool in a few years from now.

Among the tools that are currently being developed for *i*-education are adaptive learning platforms and virtual laboratory packages. An Adaptive Learning Platform sits in the server and consists of a number of modules where self-learning and self-assessment can be done through the internet. Multimedia courseware would be part of the Adaptive Learning Platform where learning can be done at home or any place where the internet is available. Students accessing or studying each module could be automatically monitored and assessed by the Platform and also learning can be done according to each individual phase. An example of such platform is CALAT developed by NTT of Japan which is discussed in this presentation. An example of several multimedia courseware developed at the Center for Artificial Intelligence and Robotics (CAIRO) of Universiti Teknologi Malaysia will also be discussed.

Another kind of tool, complementing the above, which is much sought in *i*-education or distance learning is the virtual laboratory concept. New advances in technology enables remote access by linking instruments to the Internet where they can be monitored and controlled remotely. At CAIRO, a virtual laboratory concept has been implemented on a coupled-tank liquid-level control system and a servo-motor system which can be used for laboratory assignments for students engaging in distance learning programs. Experiments can be carried out without the student required to be present at the laboratory. The concept involved the design of a highly interactive graphical user interface that is displayed in a browser. The server periodically sends updated images of the panels. A digital camera is used to capture images of the real-time experiment where they are encoded before transmitted to the user. Experiments are performed by giving the appropriate information/setpoints to control the plant. Analysis can be done offline where the results of the experiments are stored in the remote hard-disks. This virtual laboratory system is an effective learning tool in many universities even for full-time students as they can log on to do their experiments at any time without the need to wait for their laboratory scheduled times where practical understanding can be achieved quickly to complement the theories taught in class.

1.0 Introduction

The concept of Digital University or E-learning (Electronic learning) is now among one of the most active research areas in many universities. This concept of E-learning does not not only involve the use of computers but also the use of the internet media in education. E-learning covers many courses in different disciplines and is not specific to engineering alone. In fact the introduction of the concept of E-learning in engineering discipline has just begun recently. The difficulty of using such concept in engineering is due to heavy involvement of mathematics in many engineering subjects which may be more difficult to be developed. Basically, the E-learning concept is very suitable for the distance learning program where students can register for any courses at the undergraduate or Master' s level. Such medium of education are becoming more popular recently especially for those who are already working and wishing to continue their studies for higher degree but at the same time are not willing to quit their jobs..

Research and developments in E-learning can be divided into three categories. The first category is in the core technology development, which includes Internet portals or server development which can

provide an environment for e-learning. It also includes research in development toolkits for developing multimedia courseware such as Macromedia's Authorware, Director, etc. The second category is more on development rather than research which involves the development of course contents and multimedia courseware for a specific subject or course using any of the courseware development toolkits. The third category is concentrated on the research and development of the virtual laboratory packages where students can run the laboratory experiments virtually through the Internet which may include design of new hardware such as laboratory equipment, interface units, etc. However, development of software for virtual laboratory environment has been quite extensively investigated over the past few years.

E-learning research has gained importance recently where courses can be offered through the Internet. This mode of education is still in its infancy and it is mainly targeted for distance learning program. However, the courseware and tools fro such purpose developed can be very much beneficial for full time courses as well. It can solve the problems of lack of academic staff as well as lack of laboratory equipment in many institutions of higher learning. Still more, it is a form of teaching aid where students can understand the subjects more effectively and dynamically.

This paper discusses the concept of E-learning in general and more specifically on virtual laboratory packages for teaching control subjects. The next section discusses briefly on E-learning servers based on NTT's CALAT server and followed by a short discussion on multimedia courseware. A virtual laboratory package developed at the Center for Artificial Intelligence and Robotics (CAIRO) of Universiti Teknologi Malaysia is next discussed followed by conclusion.

2.0 E-learning Servers and Multimedia Toolkits

Though many of the World-Wide Web (WWW) servers such as Netscape Navigator, MS Explorer, etc. can provide an environment for education, however, in order to provide a better environment for E-learning, specific servers have to be developed. Among the problems of using the WWW for E-learning environment are that it is stateless which means not adequate for individual adaptation, it is also not able to keep track of student's request history, and it cannot restrict students from looking at answers. There have been efforts to develop E-learning servers which can provide a better and suitable environment for learning, two examples are NTT's CALAT and WEBCT. It is important to not that these servers can be accessed via the WWW platform as there already exist numerous advantages which can be summarized as follows (Nakabayashi et. al., 1995):

- There already exist a huge amount of multimedia resources on the WWW and many servers offer electronic library and electronic museum facility. These resources can be quite easily included in courseware by just making a link to refer to them.
- No special tools are required to start learning. Student can access multimedia coursewares distributed all over the world with general-purpose browsers.
- Distribution cost and time delay for updating coursewares are negligible compared with using CDROM or floppy disk. This characteristic is very important especially for the coursewares relating to the quickly changing fields such as computer technology.
- By combining WWW coursewares with other realtime/non-realtime communication tools such as video conferencing system or mail/news system, it is possible to construct not only a single user CAI system but wide variety of distance education environment in which other students and teachers are involved.

Alongside the development of these E-learning servers, a number of multimedia toolkits have also been designed and commercially available such as Macromedia's Authorware, NTT's CAIRNEY and Director. Most of these tools are however, not developed, at the university level as their investment are high and are mainly generic in purpose.

3.0 Multimedia Coursewares

As discussed, many universities are engaged in the development of course contents and multimedia coursewares. Many academicians can provide good course contents from existing course notes, however, it is important to note that the development of multimedia coursewares must be looked at from a different perspective. It cannot be observed as an ordinary book, as there are huge amount of special multimedia

effects available using the computers such as animation, sound, movies, etc. Aspects of psychology and creative understanding should also be incorporated into the coursewares.

In the engineering discipline, the development of multimedia coursewares should also contain simulation exercises or examples especially where calculations are involved. As an example in a basic control course, simulations study such as those on, perhaps, a mass-spring-damper system, inverted pendulum, servo control, ship control, etc. can be easily designed to provide a better understanding of the subject. For example, students can be guided through a highly interactive animated simulation exercise where the dynamics of the plant is given and performance tests on different loads or dynamical parameters can be observed. It was observed that such simulation examples have increased interests among students taking control at our university.

4.0 Virtual Laboratory System

Virtual Laboratory is development of instrument' s technology which uses a computer to access a remote-based laboratory hardware system through a local area network or the Internet. This has become more important recently as more and more students are signing up for off-campus or distance learning programs. Though many of us believe that real hands-on laboratory experience are very much needed especially for control courses, but as class sizes increase and resources of time and money decrease, virtual laboratory could provide good learning opportunities for part-time and remote students to perform real time experiments by accessing the instruments through web browsers. Still more, such packages are also very much beneficial and applicable for full-time students as well as laboratory experiments can now be performed according to the students own preference such as at night or during off laboratory hours. These virtual experiments can also be carried out either as a teaching aid before actual physical lab experiments, or for comparison after these experiments. If some aspect of the process or system is not understood properly then simulations can be used for clarification.

Some other advantages of virtual laboratory are that students are introduced to engineering without the high costs, time constraints and space limitations associated with real-time laboratories. Professor Michael Karweit of John Hopkins University in the United States argues that "Even if it is only 80% effective, the cost may only be 10% of that of a real laboratory". Furthermore, the simplicity of virtual laboratory is such that it can be used by any student with a computer capable of accessing to the Web where time and location are immaterial. We discuss an example of a virtual laboratory system that we have designed on a coupled tank liquid-level control.

5.0 Coupled Tank Liquid-Level Virtual Laboratory

A coupled-tank liquid–level process control system developed by Kent Ridge Instruments Inc., Singapore and Augmented Innovations Pte. Ltd. Malaysia is used as the test-bed for the design of the virtual laboratory system (see Figure 1). The development of a virtual laboratory system involves two main parts: one for the server and the other for the client side. The server computer is linked to the coupled-tank while the client computer could be anywhere around the world with an Internet connection as shown in the illustration of Fig. 2.

At the Server end, the following hardware would be needed:

- a computer with a unique TCP/IP networking node address is required to operate as a server either on local area network (LAN) or Internet.
- Lab PC+ Data Acquisition Card to connect the server computer to the coupled-tank.
- a digital camera usually an internet camera to capture real-time images.

and at the Client side, the following hardware are required:

- a computer with Internet connection regardless of geographic location using Windows 95, 98 or NT.

Examples of the software that would be required at the server side can be as follows:

- LabWindows or CVI (C for virtual instrumentation)
- LabWindows/CVI Internet Developers Toolkit
- Hypertext Markup Language (HTML) with standard function "ismap".
- Webcam32 (Software for capturing digital image)

and just a Web browser supporting Server Push technology such as Netscape and Microsoft Internet Explorer at the Client side.

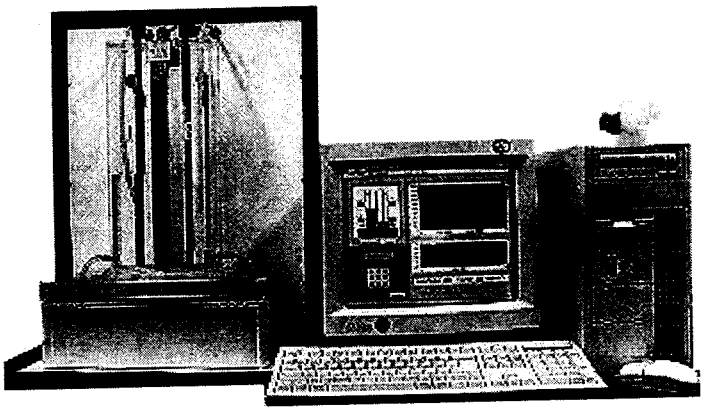

Fig. 1: A coupled-tank liquid-level laboratory system

We used the LabWindows/CVI toolkit which is a programming environment for developing instrument control, automated test, and data acquisition applications in ANSI C. It also has a User Interface Editor for creating a graphical user interface for application programs. Analog data will be captured from the process and sent to the client using the Internet. Another software which is the LabWindows/CVI Internet Developers Toolkit is used to set up a web server which displays the LabWindows/CVI user interface panels on the Internet. The toolkit provides a mechanism to automatically convert a user interface panel into an image such that any client using a World Wide Web (WWW, also called Web) browser can access. At the same time, the control signals from the client is also propagated through the Internet and finally as an input to the process. All images captured by the server computer can be viewed by the client through web pages which are developed using HTML (Hypertext Markup Language) and Javascript language.

Frames are implemented to integrate multiple panels enabling a client to view controller panels as well as output graphical panels in a page. All the panels are "clickable" images which is rather convenient and simple to use. A mouse click on the interactive images will generate a record of the location where the user had chosen using a standard function "ismap". The web browser will processes the click information and picks the appropriate destination for the click. The image map information is stored on a server such that users of web browsers can click on these panels to interact with LabWindows/CVI applications.

There are three requirements of the functional imagemaps :-

- A GIF or JPEG to base the map upon
- A Call to *.map from within HTML file
- The *.map file itself.

The Webcam32 software provides a video representation of the scene of action captured by digital camera and uploads these images onto the World Wide Web. These images are then converted into a JPEG encoded form and sent to the client over TCP/IP (the Internet or intranet). These images can then be accessed through HTML web pages through HTML IMG tags. Webcam32 is needed to be started initially and then HTTP requests submitted to Webcam32 will result in a formatted HTTP response containing the image being sent back to the browser. Webcam32 has a fully configurable port number and hence can coexist on the same machine as a regular Web Server without any port number conflict using ServerPush method. Figure 3 shows a GUI as seen from the client side when performing an experiment on the coupled tank system.

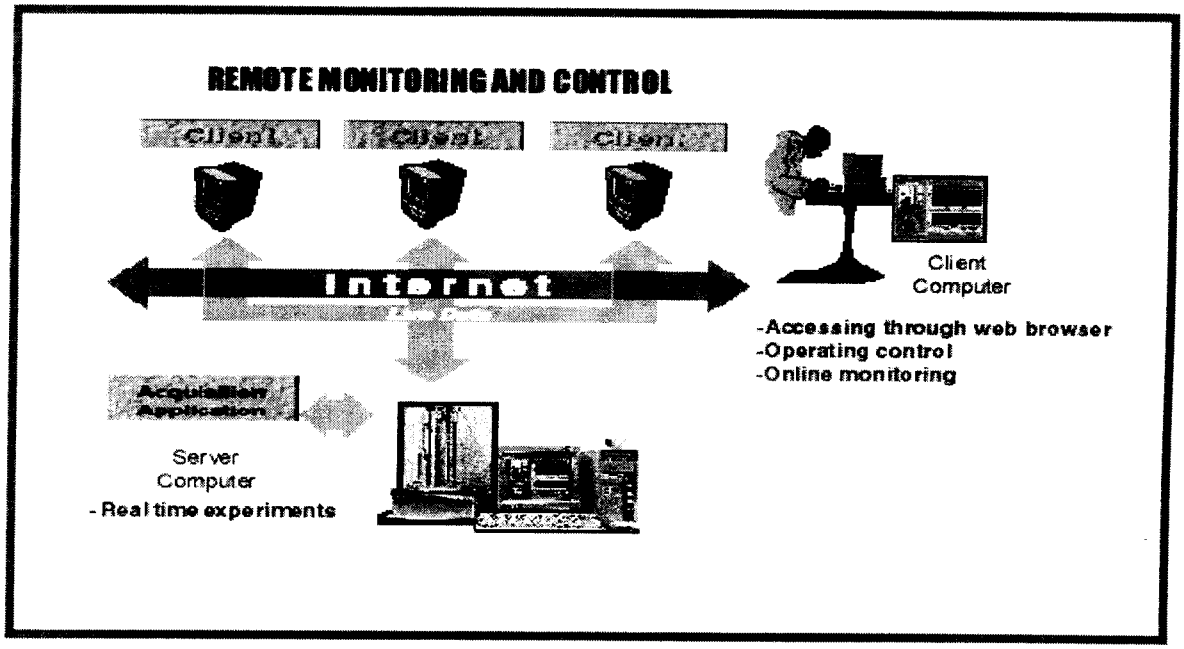

Fig.2. A set up showing how the virtual laboratory system can be accessed from any website through the WWW.

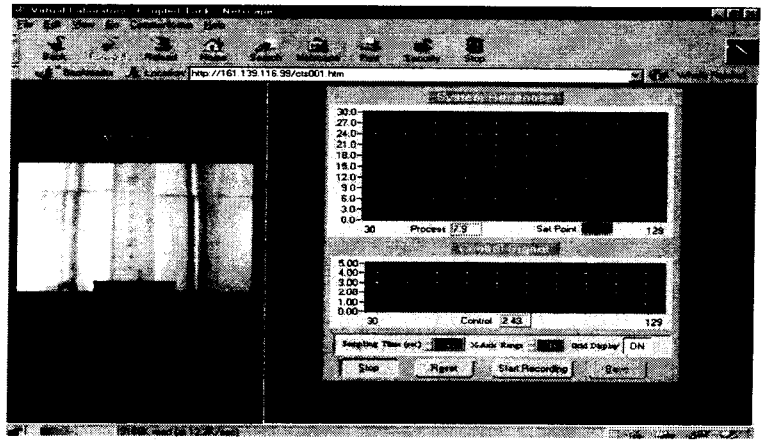

Fig.3. A GUI of the client side when performing an experiment on the Coupled tank system through the virtual laboratory concept. The illustration on the left shows a real-time image taken from the remote side.

6.0 Conclusions

The mode of e-learning will soon flourish in this first decade of the new millennium where students enrolling in distance learning programs can register for undergraduate and also masters courses such that the medium of the internet will be widely used. Such modes of learning are also beneficial even to full-time students where lack of staff, laboratory space and time can be somewhat overcome. In this paper we have discussed three categories of developments in e-learning which are currently being widely researched. An example of a virtual laboratory project on a coupled-tank liquid-level system has also been discussed.

References

Nakabayashi, Kiyoshi, et. al (1995). "A Distributed Intelligent-CAI System on the World-Wide-Web." Proc. of International Conference on Computers in Education. Singapore.

Pee Suat Hoon "Getting Web Enabled." Electrical Engineering Department, Singapore Polytechnic.

Burcin Akan, et. al. (1996). "Distance Learning Applied to Control Engineering Laboratories." *IEEE Transaction On Education*, **Vol 39, No. 3**.

Marcin A. Stegawski and Rolf Schaumann (1998). "A New Virtual Instrumentation-Based Experimenting Environment for Undergraduate Laboratories with Application in Research and Manufacturing" *IEEE Transactions On Instrumentation and Measurement*, **Vol. 47 No. 6.**

Anandapuram, Sudeep Hari, (1999)."Remote Laboratories for Distance Education"