

VIRTUAL LABORATORIES AT TECHNICAL UNIVERSITIES

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ABSTRACT

The paper discusses a problem of a usage of virtual laboratories in teaching process at technical universities. The analysis of advantages and disadvantages of simulated laboratories and laboratories with a distant access is presented. Also different ways of implementing simulated virtual laboratories are given. Moreover, the problem of the supporting virtual laboratories by multimedia lessons and a usage of e-platforms is raised. Several examples of virtual laboratories application at Wrocław Technical University are also given.

Keywords: e-learning, virtual laboratories, internet technologies

1 INTRODUCTION

Education in nowadays fast changing world is a very important aspect. The need of gaining more professional knowledge, shortening the time available for stationary methods of learning (esp. when somebody works) resulted in the development of distance learning methods.

E-learning is being more willingly and widely employed. Therefore, in an effort to diversify this form of sharing knowledge, it is common to use various available tools given by the available technology. We can safely say that Internet is at present the most interesting and dynamically expanding medium for providing educational contents in a truly distributed fashion for different actors.

E-learning becomes also very important for traditional universities. On one hand development of e-learning gives universities opportunity to reach potential wider audience. On the other there is a large need from students for supporting traditional way of teaching by a internet based one (so called blending learning). Traditional teaching uses different forms: lectures, exercise classes, laboratories and projects. However, within technical universities the laboratory is the lifeblood of teaching. During laboratory exercises students test their theoretical knowledge gained on lectures. Therefore, in case of e-learning we have to develop so called virtual laboratories which allow to work with real or simulated devices through Internet.

Virtual laboratory is an idea developed for many years by large number of researchers [1]. Currently large number of software packages, some of them are mentioned in chapter 4, allows creation of laboratory

environment with an access simulations and real equipment via a remote client web interface. Some exemplar application could be found in [2],[3]. The other popular approach is to design simulator of a device, mainly using Java languages [4],[5], we present such approach in chapter 3.

2 LABORATORIES WITH DISTANCE ACCESS

Generally, there are two approaches to virtual laboratories: real laboratory with distance access and simulated virtual laboratories, which are described in the next chapter. Assuming that we have an existing real device, to make an Internet access a full control of laboratories by a computer is required. In many cases it is already done, since many engineering laboratories use computer based equipment for controlling laboratory devices. Therefore, adding an internet access to the controlling computer and some camera for seeing results makes such laboratories Internet accessed ones. Of course, it requires a development of special software or a usage of existing software tools (for example Labview shortly described in 3.4). Such ideas of virtual laboratories are widely used, for example at our University [6].

However, it has many disadvantages. Firstly, there is a limited number of simultaneously working students. It strictly depends on the number of real devices. At a given moment only one user could access a device. Secondly, very often it requires a human attendance in the laboratory to control if everything is working properly. Therefore, the total cost of the system – real devices, webcams, software and technical staff - is expensive. And in case of blending learning, it's better and easier to perform traditional laboratories than virtual with distance access. However, there is a one important justification for using such approach. The situation when students are far away from real laboratories and costs of building laboratory near them is high (i.e. very specialized ones) or costs going of students to laboratories is too big or even impossible, for example due to security reason.

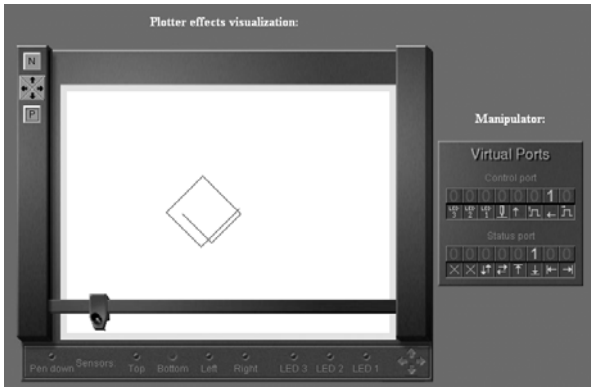


Fig 1. Example of NetVL device: plotter

3 SIMULATED VIRTUAL LABORATORIES

3.1 IDEA

The main big problem with real laboratories as well as with virtual ones with distance access is the fact that during exercises equipment is very often broken or even destroyed. Service and prices of used devices are usually high and reparation requires a qualified service man. The idea of replacement of real devices with simulator helps to overcome this problem. Devices available for students are fully simulated by computers. It is important to remember that simulator must behave in the same way like a real device. Generally, there are two ways of developing simulated virtual laboratories:

- develop a simulator in general purpose language,
- use a general purpose simulation software.

The first solution is usually based on Java technology, example of such approach developed by us is presented in 3.2. The second is shortly analyzed in 3.3 and 3.4.

We have to mention here, that in our opinion, the simulated laboratories in most cases are not able to fully replace the real one, but could be very effective in pre-training students with a usage of a given device resulting in shorter time spend by them in real laboratories.

3.2 NETWORK VIRTUAL LABORATORIES

Network Virtual Laboratory (NetVL) is a computer aided learning system developed at Wroclaw Univeristy of Technology [7][8] partly within MM-EDU [9] project sponsored by European Union. The aim of the NetVL is to support learning of programming such types of external devices as a plotter (Fig 1), milling table [10], LCD or an industrial robot. There is also a possibility of programming microprocessor devices such as PCs. The main purpose of the system is a distant access to those devices through the internet. The user is expected to have only a Java enabled internet browser and of course, the internet access. The devices themselves can be real

(e.g. a PC) or virtual (e.g. simulated plotter or heat meter).

In the NetVL environment, peripheral devices are programmed in C/C++. Communication with them is possible through a hypothetical interface which uses a set of I/O addresses in a virtual PC. Access to those I/O ports is available by the use of C/C++ functions which read/write words into/from desired I/O address.

The user can see the controlled device in a window of the browser. Usually, in the same window there is a module presenting the state of the device's registers which can be accessed from the user's program. There is also a possibility to manipulate individual bits, which can be useful in the beginning of the learning process.

Beside the ability to view the simulated device and its registers, the user can operate in the programming and running environment. He can write programs controlling devices, compile and run them without having any compiler installed on his machine. Access to the compiler and the computer, where the user's program actually is being run, is possible through the internet. Like in the case of inspecting the simulated device, only a Java enabled browser is required. A Java applet which provides communication with the compiler runs in the browser's window. NetVL provides authorized access to the system. The user has to login to the system by entering his name and password. Only after the successful login, can he access all devices and tutorials. The entire system was written using the Java language. This ensures that it will work on many hardware platforms. We have developed a detailed specifications [8], which allow the development of a large number of virtual devices which could co-operated.

Such simulated virtual laboratories are very efficient in learning. However development of them is not easy and requires a lot of work. Therefore, an interesting alternative to Java based virtual laboratories is a usage of general purpose simulation software package with an Internet access.

3.3 USAGE OF GENERAL PURPOSE SIMULATION TOOLS

There is a large number of commercial software witch support mathematical calculation and allows a simulation of complex system. The most important are:

- Matlab (www.matlab.com),
- Mathematica (www.wolfram.com),
- MathCAD (www.mathcad.com),
- Maple (www.maplesoft.com).

Most of them have a Web server extension which allows to deploy applications over the Web. It is mostly done in similar way like server side programming (i.e. PHP, JSP). The programmer has to develop a code which is a mixture of HTML tags and script language instruction which runs within a given software environment. An example of such solution is WebMathematica, which is based on Java Server

Technologies (JSP). Slightly different is an approach given in Web Server toolbox of Matlab. It resembles rather CGI-BIN programming or Java servlets. Designer has to develop a script in Matlab language which gets inputs from HTTP protocol (POST method), based on this data makes required calculation and then generates HTML output. To make it simpler, the output HTML file is based on a template in which the directives marked by \$ \$ are replaced by values from Matlab variables.

Usage of such tools for developing virtual laboratories is quite simple and very efficient. A huge number of functions in each of these software packages is very helpful. Moreover, these tools in standalone version are used for many years in the university education. Therefore, migration to internet environment is quite straightforward. For example, WebMathematica is successfully used in the field of mechanics at Wroclaw University of Technology [11].

However, such solutions has two main drawbacks. Firstly, they are commercial software and software licenses are quite expensive. Secondly, the interaction within a simulated model is very simple, due to the fact that it is based on HTML. Any changes in running simulation requires reloading of HTML page and fluent movement of any object controlled by a user is hardly achieved. Therefore, usually it is used in batch mode, i.e. the user is setting input data, then the simulation is run on the server, and results are send back. There is no interaction with a simulated model during simulation.

3.4 LABVIEW

The other solution to the virtual laboratory is a usage of Labview package (<http://www.ni.com/labview/>) by National Instrument. It is a very popular tool in signal analysis tasks. Labview has a very efficient web extension which allows creation of laboratory environment via a remote client web interface with a powerful graphical user interface.

Labview is used for many years at Faculty of Electronics at Wroclaw University of Technology in standalone version and there are ongoing works on developing a internet accessed exercises. Labview could be also used to gain an access to real devices – for creating laboratory with distance access (chapter 2). It requires the freeware VISA package. The Virtual Instrument Software Architecture (VISA) is a standard which provides the interface between the hardware and development environments such as Labview [12]. Therefore, any measurement devices with computer based interface could be accessed from Internet.

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Fig 2 Plotter lesson syllabus - WebCT course content[9]

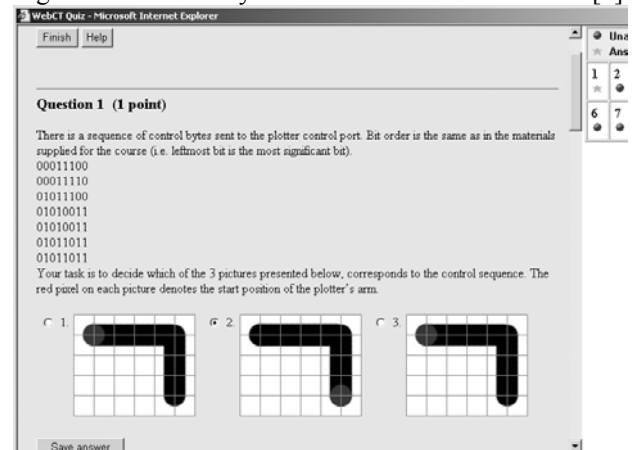


Fig. 3. Example of Plotter quiz within WebCT environment [9]

4 SUPPORTING TOOLS

4.1 E-LEARNING PLATFORMS

Using a virtual laboratory in a teaching process requires a development of the whole course, see an example of a course syllabus for the Plotter virtual laboratorie on Fig 2. If we assume that all materials are to be delivered by the internet, the virtual laboratories itself has to be included in a e-learning platform.

E-learning platforms are tools that are the virtual equivalent of universities (understood as institution,

facility) that have to meet four essential functions as: student's management, dissemination of knowledge, testing progress of its absorption and communication between e-learning process actors (students and teachers). There exist a large number (almost 200) of e-learning platforms, to mention only: Learning Environment Online (LEOTM), IBM Lotus Learning Management System, Blackboard Learning System, TopCalss e-Learning Suite, WebCT Campus Edition, R5, Lotus LearningSpace, Oracle i-Learning, Manhattan Virtual Classroom, Moodle. Most of e-learning platforms offer similar capabilities. One of the most popular is WebCT. It has almost 38% of the e-learning platform market. E-learning platforms can be deployed enterprise-wide to supplement the traditional classroom or for pure distance programs. Use of them allows the university to efficiently leverage campus resources to both extend their offerings and enhance the teaching and learning experience. One of the many benefits of using e-learning platforms includes the ability to offer an "always on" environment, providing more time for the student to interact with professors and classmates as well as with the course material in an efficient, engaging and effective manner. Moreover, their functionality allows to perform self test and quizzes allowing to check the level of the student knowledge gained during exercises with virtual laboratory (Fig. 3).

4.2 MULTIMEDIA LESSONS

Application of the virtual laboratories on didactic process requires additional learning materials for student like multimedia presentation with laboratory description and lessons on different aspects of devices used during the exercises (Fig. 4). One of the most popular tool for multimedia lessons is Macromedia Authorware. It is designed for putting multi-media together in one structured, interactive program. It is not, however, the best tool for creating images, sounds or animations. The metaphor used is that of a procedural program's execution flow line. The developer adds graphics, animation or sounds to the flow line in the order he wants them to appear.

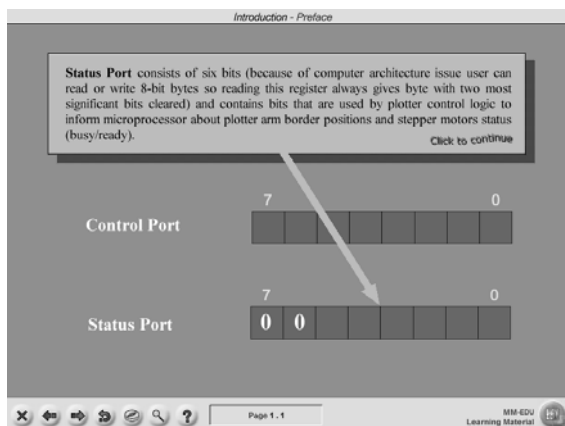


Fig. 4. Example of multimedia lesson – Authorware module [9]

Multimedia lesson supporting virtual laboratories (example on Fig. 4) should consisted of few pages containing text, graphics, animations and interactive material. Most of interaction should simulate some parts of presented device activity (e.g. clicking corresponding register bits resulted in changing plotter's behavior Fig 1,4). Authorware modules could also include a quiz, usually at the end of the presentation. Questions should be rather simple and their goal is to indicate student the places of potential problems. Such multimedia presentation can be easily launched from inside the e-learning platforms.

5 CONCLUSION

The paper presented different aspects of a usage of virtual laboratories from the point of view of technical universities. Laboratories in science and engineering are the lifeblood of teaching. And in e-learning environments virtual laboratories are becoming more and more popular. It's important to remember that a virtual laboratory is only a part of the course, and therefore should be included in the e-learning platform with it's student communication, cooperation and quizzes tools. Moreover, efficient usage of virtual laboratories requires a development of multimedia lessons allowing students to gain a knowledge required for performing laboratory exercises. We think that a good designed usage of multimedia lessons, e-platforms possibilities and virtual laboratories is very important for the success in distance learning deployment.

Our further work will focus on developing Digital Signal Processing virtual laboratories. We are planning to use Matlab with its Web Server toolbox and investigate a possibility of usage it's freeware clone Scilab.

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