The role of virtual laboratories in education

Authors:
Oleg Cernian
University of Craiova, Computer Science Department, Romania
e-mail: Oleg.Cernian@comp-craiova.ro
Ileana Hamburg
Institut Arbeit und Technik, Wissenschaftszentrum Nordrhein-Westfalen
Gelsenkirchen, Germany, e-mail: hamburg@iatge.de
Dan Mancas
University of Craiova, Computer Science Department, Romania
e-mail: Oleg.Cernian@comp-craiova.ro
Gabriel Vladut
IPA CIFATT, Institut Automation Engineering Craiova, Romania,
e-mail: office@ipacv.ro

Abstract: Virtual classrooms and virtual laboratories are used for individual learning as well for collective ones and distributed learning environments that support such learning places enable learners to access a wide range of resources rapidly and economically and allow their active participation in social communities.
In this paper after a short presentation of virtual learning places particularly virtual laboratories we describe the developments in the European-Minerva project ViReC.

1. Introduction

In the last decade the needs for life long learning coupled with opportunities offered by new media like the Internet have driven educators or developers of learning materials to seek alternatives that meet diverse requirements of increasingly heterogeneous populations of learners and make use of the Internet. As a result, they began to expand higher education and continuous training standard repertoire of classroom lectures, tutorials, labour exercises towards distance learning methodologies and projects.

So, virtual classrooms and virtual laboratories are used for individual learning as well for collective ones. These new learning places integrate many technologies and didactic methods and enhance their usability by net-based communication between learning students, tutors (on- and off-line) and connected real devices. For example computer animation and visualisation can help to illustrate complex relationships during classroom teaching as well as in individual learning at home.

Distributed learning environments that support such learning places enable learners to access a wide range of resources rapidly and economically and allow their active participation in social communities. Till now only a few didactic experiments have been made with students access to laboratory equipment though Internet communication.

In this context the involvement of staff from many European universities and research institutes in the project "ViReC e-Initiative" focussed on the development of distance learning modules including textbooks, tutorials and virtual laboratories as well as of supported distributed learning environment.
In this paper after a short presentation of virtual learning places (part 2) particularly virtual laboratories we describe the developments in the project ViReC (part 3 and 4).

2. Virtual learning places – virtual laboratories

It is know that traditional seminars and books do not fulfil staff qualification requirements determined by changing nature of the companies they work. Virtual learning places independent from location and time have to be developed to complement traditional ones. Some functions of these places can be the followings:

- to connect learners (from universities, companies) to form groups,
- to get individual tutorial help,
- to download latest learning materials,
- to access special experimental devices within virtual laboratories.

It is known that laboratory exercises are part of any university education and are also used in continuous vocational training. In distance education this part has been offered till now in special courses where students have to meet in real laboratories. In the last years virtual laboratories have been developed where students get access both to simulated equipment as well as to real laboratory devices.

It is intended to build virtual laboratories where students from anywhere can form a learning group to work together on a given exercise using laboratory equipment which can be installed at different places. One of the problems to be solved in this case is the development of secure and safety functions to form a virtual laboratory by individual configurations of real laboratory equipment, which can be used cooperatively and remotely.

3. Project ViReC

The project "ViReC e-Initiative" – University Virtual Resource Centre based on a distributed learning environment– represents an attempt with a European dimension to change learning environment in higher education institutions (http://cs.ucv.ro/ViReC).

A qualitative collaborative distributed learning environment in a network of European universities and research institutions will be set up ensuring an open access to improved training methods and educational resources, as well as the best practice applied at the partners in the Consortium (four universities and two research institutions) by outlining an innovative development of IT-based educational products. This project is clearly oriented toward the development of innovative practices and services, having in view seting up a virtual resource centre composed of a learning environment and use of ICT tools, as well as to arise awareness of the impact of blended learning in education.

Several remarkable results are foreseen, among them the most challenging achievement will certainly be the creation of a number of virtual laboratories interleaved with some real devices/equipment.

The project outputs try to use blended learning and distributed learning environments even in cases where classrooms or real labs are the main forms of training, e.g. including a learning program that provides seeking resources over the Internet and the Web about a topic, a product, a process or a device.

During the last months, partners developed distance learning modules consisting of tutorials and practical exercises in the fields of Data Bases and Network Security.

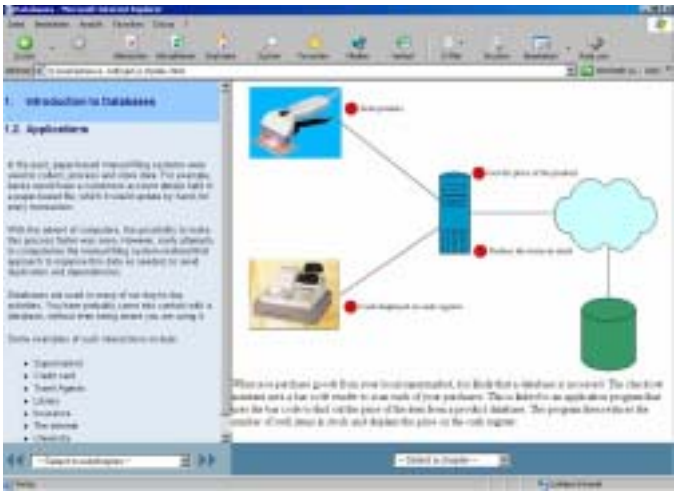

Figure 1: A chapter of the tutorial about Data Bases

The development phase started with some visits of online resources created by other instructors in these fields to explore how to support or extend the existing partner strategies and to identify the resources that will most effectively and efficiently enhance the distance learning modules. Some considered aspects are the following:

- the resources should provide alternative explanations or examples that will be valuable for the students,
- they should include simulations that facilitate the students to be able to perform procedures or apply principles,
- the content should be robust e.g. looking for indicators of currency and relevancy,
- the resource should be engaging and interactive and should meet high standards of access.

Within the tutorials long, linear sequences of screens have been avoided: the text is organized into short, easy-to-read parts. Menus, buttons and other controls could be used continuously through the program.

Students from the University of Craiova have tested the developed tutorials and exercises. But tests and evaluation process will continue during 2003/2004 academic year both with user groups and with expert groups.

4. Virtual laboratories within ViReC

In the following we describe a virtual laboratory which provides remote access to robots infrastructure and programming.

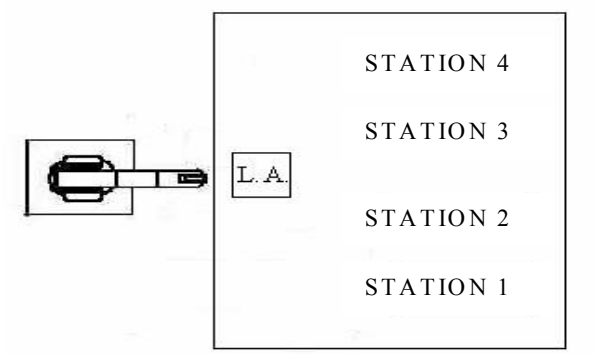

Figure 2: Remote access to robots infrastructure and programming

The following figure shows a manipulator to attendance the IRB 1400 robot for different possible operations. It has the role of extracting from the buffers parallelepiped and cylinder pieces (pins).

Once the pieces are extracted, the robot grabs them, in order to effectuate different operations: palletizing (pins or parallelepipeds), assembling or welding simulation (line or point welding). The set of operations should be diversified on user's wish. The scheme of this manipulator is the following:

Stations 1 and 2 are extracting parallelepiped pieces, station 3 thick pins, and station 4 thin pins. The piece holders capacity corresponding to stations 1, 2 and 3 is of eight elements, the fourth having a double capacity. "L.A." represents the place where the robot can execute the assembling operations.

The site is organized in many sections and presents the following functions:

Figure 3: Site Virtual Robot Centre

A. The section Home:

- Registration, necessary to access the whole information area,
- Consulting which facilitates to send questions to the administrator, Forum for exchanging information between users,
- Site map containing a map with menu links,
- Picture gallery with laboratory pictures and applications,
- RAPID Summary which describes briefly all instructions, functions and data types grouped in accordance with the instruction pick-lists using when programming. It also includes a summary of

Some laboratory exercises like Cylindrical piece palletizing, paralellipipedical piece palletizing, Assembling pieces and Wedding operation can be carried up.

B. The section How to programming a robots

This chapter describes how to programming a robots using Teach Pendant and offered possibility to test a Virtual Teach Pendant, "Virtual Robot Laboratory".

Virtual laboratories are an important educational tool that bring together geographically distant research groups, allowing them to share data, documents, video, while integrating their computational and laboratory resources.

Among the many benefits of virtual laboratories, the following are particularly important.

- Resource sharing becomes a reality, improving the utilization of costly equipment.
- Easier access to educational and research material is provided to students and professionals.
- Scientific investigation standard can be established in areas where practical experimentation is a required part of research.
- Reduction in travel time leads to productivity enhancement.

C. Section "Programming" "RAPID Summary"

This chapter briefly describes all instructions, functions and data types grouped in accordance with the instruction pick-lists using when programming. It also includes a summary of the syntax, which is particularly useful when programming off-line.

RAPID Summary "Communication Interface"

This chapter describes equipment, which the robots can communicate with computer, or other equipment via RS232/RS422 serial channels or via Ethernet.

-"Communication protocol"

This chapter shows the protocols use in the S4 Controller. All protocols except the Robot Application Protocol (RAP) are standard protocols: SLIP, Ethernet, IP, ICMP, TCP, UDP, RPC/XDR, TFTP, Bootp, RAP, NFS, FTP.

-"Program Maker description"

-"Instruction Set"

Present instruction details for programming ABB robots

-"Operator interface"

This chapter describes how to programming a robots using Teach Pendant and offered possibility to test a Virtual Teach Pendant.

- "Sample"

This chapter describes sample with robots programming including useful instruction for a better understanding of working laboratories. This chapter contend sample at Motion application, cylindrical pieces palletizing, Paralelipedicall pieces palletizing, assembling pieces, Welding operation. This textbox content program source and simulated and interactivity application for a better understanding.

D. Section "Tutorials" content:

"Motion application"

Purpose of work laboratory

Programming for the robot to do a simple motion application to write its own name. (ABB IRB 1400).

User can see a simulated application and sample code.

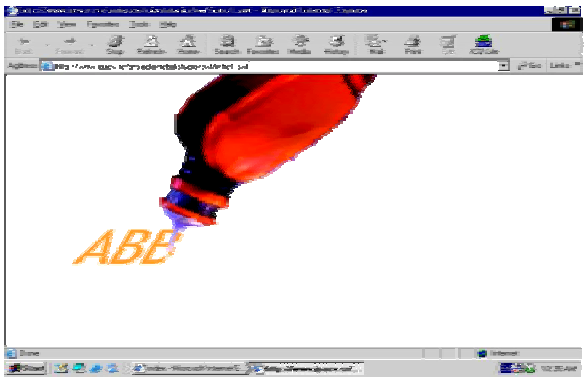

Figure 4: ABB IRB 1400 Robot; simulation

Cylindrical piece palletizing

Purpose of work laboratory

Realizing of program for pin palletizing operation with ABB Robot IRB 1400. We have pin pieces of two types: a pin pieces have big holes pierced and other small holes pierced. Flowing of the cylindrical pieces is supplied by the workstation number three and workstation number four. All the pieces must be placed in a matrcial storehouse with eight locations. User can see a simulated and interactivity application and sample code.

Paralelipipedical pieces palletizing

Purpose of working laboratory

Realizing of program for paralelipipedical pieces palletizing operation with ABB Robot IRB1400.

We have paralelipipedical pieces of two types: one of these types has three holes pierced and the other type of these pieces has three holes pierced. All the pieces must be placed in a matrcial storehouse with four locations.

User can see a simulated and interactivity application and sample code.

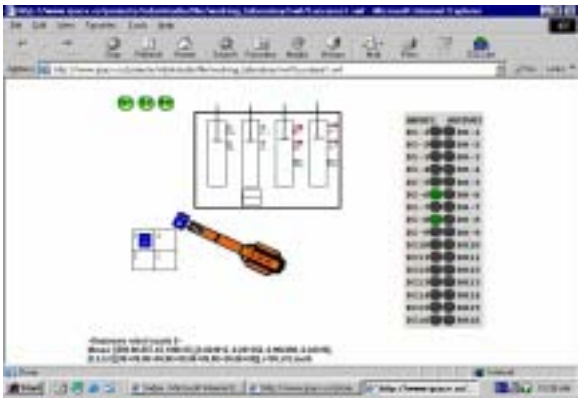

Fig. 5: Simulation, interactivity application, sample code

Assembling pieces

Purpose of work laboratory

Realizing of program for assembling operation with ABB Robot IRB1400. Inputs and outputs used for this operation: We have paralelipipedical pieces of two types: one of these types has three holes pierced and the other type of these pieces has three holes pierced. Assembling of these two types of pieces we will obtain a new product.

Flowing of the paralelipipedical pieces is supplied by the first two workstations and flowing of the cylindrical pieces from the last two workstation. All the pieces must be placed in specifically position known by the robot.

These two types of pieces are taken one by one by the robot and placed into the assembling place. Because of position's errors it's necessary for the robot to do two movements to arrange all the pieces in assembling place.

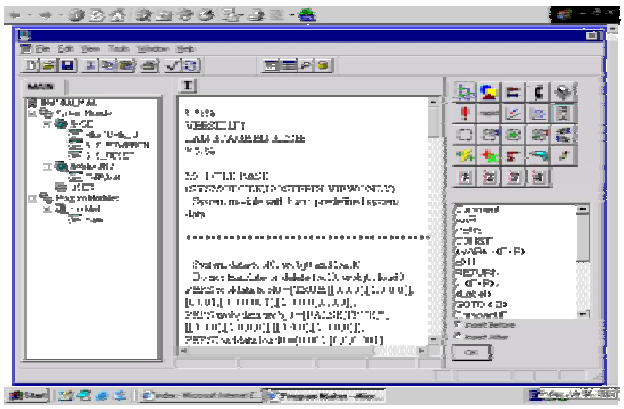

Figure 6: Realizing of program for assembling operation with ABB Robot IRB1400

After that, the robot puts the new product in a matrcial storehouse with four locations. User can see a simulated application and sample code.

Welding operation

Purpose of work laboratory

Programming for the robot to do welding-line and welding-point simulation.

To done this operation we use storehouses 1 and 2 who are supplied with paralelipipedical pieces. The robot take this pieces one by one and puts together in the assembling place (AP). After that, with a welding device that is taken from AS (support for the welding device) robot simulate welding-line and welding-point operations hen the operation is finished the robot puts in support (AS) the welding device and the piece in the matricial storehouse with four locations User can see a simulated application and sample code.

E. Section "Exercise":

"Virtual Program Maker"

This guide will familiarize you with Program Maker and provide the information you need to develop RAPID programs for the ABB S4 robot controller.

Program Maker, an ABB DeskWareTM application, is a development environment for creating, editing, and debugging RAPID programs for the S4 robot controller.

Virtual Console

This chapter describes how to programming a robots using Teach Pendant and offered possibility to test a Virtual Teach Pendant. Using Virtual Console it's possibly to edit a program and testing with Virtual Robot Center and simulated application.

Figure 7: Virtual Console

References

Hamburg, Ileana, 2003: **Verteilt und doch gemeinsam lernen**. In: Wissenschaftszentrum Nordrhein-Westfalen: Das Magazin 14, H. 1, S. 34

Hamburg, Ileana / Cernian, Oleg / Thij, Herbert ten, 2003: **Blended learning and distributed learning environments**. In: 5th International Conference on New Educational Environments: Lucerne, Switzerland - may 26-28, 2003; the know-how hub for blended learning. Berne: net4net, p. 197-202

Hamburg, Ileana / Cernian, Oleg / Thij, Herbert ten, 2003: **Lernen und Kooperieren in verteilten Umgebungen: die Chance für die betriebliche Weiterbildung!** In: Engert, Steffi / Hamburg, Ileana (Hrsg.): IT-basierte Lernformen für die betriebliche Weiterbildung. Gelsenkirchen: Inst. Arbeit und Technik, S. 45-55

JC Waller, N Foster: **Training via the web: a virtual instrument**, Computers and Education, 35, March 2000, 161-167

news.bbc.co.uk 2001: BBC **News Article – Virtual Lab brings Science To Life**, http://news.bbc.co.uk/1/hi/sci/tech/1111654.stm

physicsweb.org: **Virtual Interaktive Experiments**, http://physicsweb.org/resources/Education/Interactive_experiments/

www.sci.brooklyn.cuny.edu/-marciano **Virtual Multi-Media Internet Laboratories**, Access to web pages through a 3D, VRML enviroment

www.ipacv.ro ; http://www.ipacv.ro/proiecte/robotstudio/index.htm **Virtual Robot Centre**