Virtual and Remote Laboratories as an Important Educative Instrument in e-Learning

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Outline

- Review of e-Learning
  - Definition and properties
  - Facts, trends and statistics
- Virtual laboratories
  - Specification
  - Examples
  - Easy Java Simulation (Ejs)
- Remote laboratories
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  - Client application
  - Mobile client interface
  - Administration of remote laboratories
- Conclusions
e-Learning definition and properties

- One of the e-Learning definitions says:

  *E-learning means using new multimedia technologies and the Internet to improve the quality of learning by facilitating access to facilities and services as well as remote exchanges and collaboration*

  Source: [http://www.elearningeuropa.info/](http://www.elearningeuropa.info/)

- e-Learning brings flexibility related to:
  - time, pace and place of study,
  - content,
  - entry requirements
  - instructional approaches and resources,
  - delivery and logistics.
e-Learning facts and trends

- e-Learning is a progressive learning method dependant on ICT
- e-Learning courses are characterized not only by electronic study materials but also by support tools for doing tasks and performing desired activities
- Maximum interactivity of e-learning is reached by means of electronic communication
- E-learning courses are built from learning objects where it is necessary to keep standards
- Management of e-learning is covered by LMS
- The roles of teachers and tutors are changing
- The culture of education is changing
- Learning integrates into every aspect of our lives. In the future learning and living will merge.
Growth of e-learning

- Today, about 500 European institutions provide short courses and entire degree programmes at a distance – with continuous success: last year student enrolment increased 15-20% while the offer grew with 40%.
- In the last decade, the US has heavily invested in online education and it is projected that US online education will outgrow traditional education by 2015.
- Today, also renowned institutes like Stanford and MIT offer massive online courses for free – followed by up to 100,000 students worldwide (MOOCs).
- In Germany, nowadays, the largest and the most rapidly growing university with 80,000 students (in contrast to less than 45,000 in 2007) is the distance teaching FernUniversität in Hagen, established just in 1974.
- A new portal funded by the European Union and developed by the European study choice platform Studyportals and EADTU has been launched.
- To date, already 180 institutes participate in this European initiative (88 in UK) listing a total of more than 1,200 Bachelors, Masters, PhDs and Short Courses.
Statistics of increasing e-learning tools and technologies

### AREAS WITH INCREASING INTEREST

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Survey by New Media Consortium NMC in cooperation with the Spanish Distance University UNED
Virtual and remote laboratories
Virtual laboratories

- Virtual and remote laboratories can be accessed at any time from any place where the Internet connection is available.
- In the case of virtual laboratories the behavior of real systems is modeled in the computer.
- Models can be visualized in 3D form and together with interactive user interface they can be virtually manipulated by student in the desired way.
- Together with the simulation tools they form the base of virtual laboratories.
- There are several technologies that can present behavior of dynamical systems, such as Java, Flash, VRML, HTML5 and Ajax.
Virtual Laboratories – Ex. #1

Java client for the two-tank system
Virtual Laboratories – Ex. #2

Java client for the helicopter rack
Creation of virtual laboratories

- To build a virtual laboratory is not so complicated task
- The simplest way is to program Java applet that can be placed on the Web server
- A remote client downloads the applet and runs it within his/her browser
- Java offers good possibilities for programming numerical calculations and creating visualization suitable for simulations
Easy Java Simulations (Ejs)

http://www.um.es/fem/Ejs/

- Ejs is useful for no programmers
- It enables to create Java simulation
- User interface is as easy as possible
- User must know the mathematical model of the system that should be simulated
- The mathematical model consists of equations or differential equations
- User must know the initial values of variables and parameters
- Ejs enables simple visualization of the simulated process
- Ejs produces Java Applets
Easy Java Simulations (Ejs) - View

Creating jar file C:\Ejs\Simulations\InvPendCart.jar ... OK!
Congratulations! The simulation was generated successfully.
Trying to run simulation C:\Ejs\Simulations\InvPendCart.bat ... OK!
Congratulations! The simulation seems to run alright.
You can also run the simulation from the generated html page.
Easy Java Simulations (Ejs)
Ex. of Pendulum on the Cart
Easy Java Simulations (Ejs) - GUI for other Java Clients

- Client applications for helicopter model and two level hydraulic model created in Ejs
Remote laboratories

- In contrast to virtual laboratories, *remote laboratories* allow users to manipulate real equipment.
- They are very interesting for students as they can provide them with real signals measured on remote hardware.
- In this way students can experience how to cope with noisy signals, non-modeled dynamics, oscillating variables, etc.
- Thus students can authentically practice the influence of different controllers and they can do it comfortably from their homes using Internet connection.
- Usually remote laboratories are realized in the form of client-server applications using Java or .NET platform and commercial products LabView or Matlab/Simulink, or open products like Scilab/Scicos or OpenModelica.
- Examples of the client interface show, that data may be offered to students in various formats (text, numbers, graphs, animations or even video).
Client Server Application

- Both server and client parts are based on platform independent Java programming language.
Server application

- Client (Java applet within Web browser)
- Java Server (Web Server, MS SDK for Java)
- Matlab/Simulink
- AD/DA converter
- Real system

Connections:
- Internet TCP/IP
- COM
- (PCI)
- A/D Interface RS232, USB
Java Server Application

- It waits for the TCP/IP connection on the specific port.
- After client has established connection it ensures the Matlab Automation Server capabilities and waits for the commands that immediately transfers to the Matlab.
- It transmits Matlab responses from the Matlab environment to the client interface. For this it uses the functions of the Matlab Automation Server and the TCP/IP connection.
Client Application

- The client is an application that connects to a specific port on the server and exchanges data.
- Its task is to create user friendly environment for the remote experiment.
- It is usually realized as Java applet that enables:
  - to connect and disconnect to the server
  - to modify controller or experiment parameters
  - to start and stop the experiment
  - to gather and visualize measured data in the user friendly environment
- After establishing connection with the server the client sends Matlab commands written by the user and waits for responses.
- The response can be displayed in the form of text, numerical data, graphs, animations or video clips.
Client

- Java Client is created within the Easy Java Simulations Environment (Ejs)
- This enables easy to modify remote user interface in the future
- The extension of Ejs consists of the Java code for communication part that has been written on the Custom card.
Examples of Client Applications

- Thermo-Optical system
- Rotational pendulum
- Three-tank hydraulic system
Magnetic levitation client
Mobile client interface

- In the last years mobile learning became very popular as the number of smartphones and tablets increased rapidly.
- Young generation likes such devices because they are modern, funny, interactive and always with them, as they are used in common life.
- In comparison with desktop computer they are cheaper, lower weight and smaller size but still enough to read e-books, browse Internet, play (educational) games and videos or even access a remote laboratory.
Remote laboratories administration

- The administration of remote laboratories should ensure the access to the specific experiment only for defined group of users who have
  - access rights and
  - time scheduling
  - both specified in the SQL database
- Thus sharing of real plants by several users is synchronized
- Administrator of the system can create new accounts and specify time intervals when the user can access the real plant

WebLab application for the approach and administration of virtual laboratories
http://www.kar.elf.stuba.sk/~pbistak/applet/klient.html
Moodle Administration Module
Activity Creation

- After successful installation the WebLab module is available in the „Add an Activity...“ list.
Moodle Administration Module
Activity Creation

- In this window it is possible to set time constraints for the device
- By clicking Continue button the activity creation is completed
Moodle Administration Module

Device Booking

- If the device is available - word “Free” appears
- After booking the device (by clicking the “Free”), the cell changes to “Reserved” (number)
- After the device is booked, a new table will be displayed
- WebLab allows users to upload custom files (Simulink control schemes or m-files) - “Upload files” button
- When the actual time coincides with the booking time, the “Show device” button appears on the web page
Moodle Administration Module

Running the experiment

- Clicking the “Show device” button will activate a JAVA applet, which allows to communicate with the device and perform live experiments.

- Before it all necessary files must be properly uploaded to the server.
Remote laboratories - advantages and disadvantages

- Experimentation may easily be combined with learning approaches known as learning by playing, learning by doing, or learning by discovering.

- As already mentioned large-scale experimenting has shown us several weak points of the traditional approaches and enables us to proceed from education to research work.

- Of course, these approaches do not bring just advantages: e.g. in comparison with virtual laboratories the maintenance of remote laboratories is more time and costs demanding.

- Furthermore, they require an administration system because at the given time only one user can control the real system.

- Also the safety of remote laboratories should be better assured by authorized access.
Summary and conclusions

- e-Learning will gain a bigger deal in the field of education
- Virtual laboratories can higher interests of students to experiment with computer models of real systems.
- Using Ejs virtual laboratories can be build very fast.
- Remote laboratories enable to manipulate real systems
- It is recommended
  - Usage of platform independent programming language (Java)
  - Simple modification of remote user interface using Easy Java Simulations also for non-programmers
- The future will show importance of remote laboratories in engineering education
  - From the pedagogical point of view remote laboratories reasonably increase the student motivation (sometimes they serve as students toys)
  - We plan to replace the commercial product (Matlab) by open source solutions (Scilab/Scicos)
  - Administration system should be incorporated in existing LMS system (e.g. Moodle)