Experiment@Portugal

M.T. Restivo[1,2], J.C. Alves[2,3], and A. Cardoso[4]

[1] IDMEC-PóloFEUP, Porto, Portugal, [2] University of Porto, Porto, Portugal
[3]INESC-Porto, Portugal, [4] University of Coimbra, Coimbra, Portugal

Abstract—The main goal of the Project Experiment@Portugal is to produce a complete survey of Portuguese developments in remote and virtual labs. This knowledge will provide the conditions for joining forces in order to organize a well structured national website integrating a database of available remote and virtual experiments, categorized for sharing purposes, and looking for delivering valuable contents for high schools and for higher education. It is expected that the final result will bring up a solid team able to offer in this domain a Portuguese partner at international level.

Index Terms—Computer simulation, engineering education, haptic interfaces, remote sensing.

I. INTRODUCTION

Remote and virtual labs are presently unquestionable resources for learning/training activities all over the world. As a result many large scale initiatives exist nowadays [1], [2], [3].

At the University of Porto and in its Faculty of Engineering (FEUP) this subject has received special attention. Different projects have been internally [4], [5] and externally [6], [8] funded and produced many results during the past decade. At FEUP in particular, the first remote lab has been working since the nineties. It is a meteorological station, a remote laboratory of sensitive type. That lab has been collecting data in a database during the past decade and many works were produced based on those recorded data. Among them, an MSc thesis was finished in 1999, entitled "Influence of external climate in the humidity content of building materials" and an interesting prototype came out from studies related with the influence of solar radiation on the thermal behavior of intelligent windows.

For a couple of years it has been deactivated when in 2000 the Faculty moved to the new Campus. Later the meteorological station was available again on-line at FEUP campus and other MSc and PhD theses came out as well as different works both in the Civil and in the Mechanical Engineering Departments. As a consequence of an International cooperation project this has been the most international lab at FEUP, with information in 3 languages: Portuguese, English and Hungarian, [9].

Other interesting developments have been carried out at the two organizing institutions. At FEUP, the Chemical and Mechanical department labs host various remote experiments that can be accessed from [6] and [7].

New remote and virtual experiments incorporating haptic devices are now new goals at FEUP. Examples of recently developed work are: i) a workshop on haptic technology and virtual reality for training activities in mechanical assembly tasks and in the medical area, where haptic devices simulate the sense of touch [10]; ii) an user interface with a haptic device for actuating a remote experiment of a bending bar, transmitting the feeling of the force applied by the user [11], iii) a prototype framework for developing virtual lab experiments developed in a MSc thesis [12].

At the Faculty of Sciences and Technology of the University of Coimbra (FCTUC) distinct activities are also organized in this context. LABVIRTUAL – Virtual Laboratories for Chemical Processes (http://labvirtual.eq.uc.pt) aims to offer tools for the teaching/learning of Chemical Processes, looking either at high school or higher education levels. It also aims at the dissemination of Chemical Engineering. Many on-line simulators are available among many other contents. It has been supported by the POS_C National Program. The site has been receiving over 25.000 visits per month, mostly from Portuguese speaking countries. Recently, the work "LABVIRTUAL-A virtual platform to teach chemical processes", has been included in the Top 10 Most Cited Articles published in the last three years in the Chemical Engineering Education Journal (http://cee.che.ufl.edu/), [13], [14] and [15]. This result is directly related with the LABVIRTUAL success.

The LRV@DEI-FCTUC is another example of a remote and virtual lab at FCTUC, which constitutes a platform based on a client-server topology focusing on distant learning and testing of control methodologies in either batch or online operation modes [16]. The user has the possibility of using remote controllers to control different real or virtual dynamic systems. In addition, it inherently enables assessing networked fault tolerant control methodologies along with fault detection algorithms in shared data communication networks. The platform considers different possibilities to interface the real processes, using plug-in or USB data acquisition boards or wired or wireless local networks. The lab is intended to offer tools for the teaching and learning of Supervision and Control of Systems in a context of either higher education or of specialized technical training.

Many other initiatives [17] are running since 2000, but in a small country as Portugal it is urgent to link all of these activities in order to get a structured set of available materials easily found by any appropriate web searching tool. This is the aim of the present project Experiment@Portugal.

II. THE PROJECT EXPERIMENT@PORTUGAL

Experiment@Portugal is a one-year project started in November 2010 under Calouste Gulbenkian Foundation support. The project is hosted by the Faculty of Engineering of the University of Porto (FEUP) and has as partner the Faculty of Sciences and Technology of the University of Coimbra (FCTUC). It has been conceived in a singular

way - it is an inclusive project with an open team and a distributed leadership: one leader and two co-leaders.

The present project aims to realize and promote:

- a complete survey of all developments in Remote and Virtual labs available in Portugal;
- a unified platform for accessing all the contents, integrating a database for searching material by adequate subject keywords;
- the sharing perspective, increasing the collaborative work, among students and teachers even from different schools and areas of knowledge;
- a basic homogeneous structure for providing materials in order to make them available in any context – in lingua franca;
- the involvement of industry for development or adjustment of contents to lifelong learning;
- a Portuguese organized partner for future international networks.

For these purposes the project has an "open team" in order to include all the collaborations presently known and others that may be found during the project activities along the next 10 months. More than a leader, the project has also two co-leaders in order to get a distributed leadership for guaranteeing a flexible and efficient approach, not focused in a particular leader institution or area. And reinforcing this characteristic at the leadership level, the project team members are from mechanical, electrical and informatics engineering areas.

The project has two full time collaborators with MSc degrees. One is based at FEUP and other at FCTUC working in close interaction with the distributed leadership.

The project has two main public associated events. One took place in January 7, 2011 within the project third month, The Experiment@Portugal Workshop, limited to 50 invited participants, including presently identified collaborators from Portuguese Universities and Polytechnic Institutes with work on remote and virtual labs and people from Public Institutions, Industry and Companies. The second will be the Experiment@Portugal Conference which will happen in 17-18th November 2011. This is planned to host 150 participants, including two international expert invited speakers. Both events run at the funding institution, the Calouste Gulbenkian Foundation in Lisbon.

After this initial approach, and after identifying near all the possible participants, the two collaborators will visit and contact with all the remote and virtual lab developments in Portugal, getting complete information from all of them. In parallel, they will create a Portuguese version of the Lab2go platform [2] that will host the contents to develop in the scope of the project.

III. PROJECT ACTIVITIES

The first main event of the Experiment@Portugal project took place at Calouste Gulbenkian Foundation on January 7, 2011. The Workshop was attended by about 50 participants representing 8 Portuguese Universities, 3 Polytechnic Institutes, 1 Secondary School and 10 public institutions, industries and companies. The opening session, including a general project overview, was followed by 17 presentations about different initiatives of remote and virtual labs in academic environments, representing the majority of the labs with remote experiments in Portugal. This event included also a roundtable where the participants had the opportunity to discuss the project relevance and the next steps to develop a national platform to organize the labs in a uniform and collaborative mode.

A recent contact with the Global Online Laboratory Consortium (GOLC) [18], offered to the project the opportunity to use the software of the Web portal Lab2go [2], based on Ontowiki [19], to build the repository of the national laboratories and to create a Portuguese version of the platform. Considering this platform, the classification of each laboratory and experiment will follow the taxonomy considered by the GOLC consortium [20].

IV. EXAMPLES OF REMOTE AND VIRTUAL LABORATORIES

The workshop was an excellent opportunity for bringing together the most important initiatives on remote and virtual laboratories that have been identified so far in Portugal. Representatives from higher education schools did present several installations at their sites, some of them actively used in their curricula.

From the various presentations, a few will be presented briefly as paradigmatic examples of different RVL categories: observation remote laboratories, interactive remote experiments, virtual laboratories and virtual laboratories with sensitive feedback, also known as haptic devices.

A. Observation remote laboratories

One successful installation in this category is a meteorological station located at the campus of the University of Porto, Faculty of Engineering (FEUP), already referred in section I. Although this type of installation does not provide any means of interaction or actuation, in this installation the remote user interface provides real-time video of the sensing devices and the local environment, that helps transmit the feeling of the actual weather at the site. It also is possible to get data from the station database where new values are registered every ten minutes. This was the first remote laboratory at FEUP (in the nineties) and data gathered from this installation was the basis for one PhD thesis, two master thesis and several other works on civil and mechanical engineering at FEUP, and also on the architecture school of the University of Porto.

B. Interactive remote experiments

This category refers to the installations where a physical plant can be remotely actuated and observed in real time. Typically a video camera is used for feedback of real-time video to the user interface, in addition to the data that is collected during the realization of the experiment. One interesting example is an electronic remote laboratory located at the Polytechnic Institute of Porto. The hardware infrastructure at the lab is a bank of remotely controlled relays, signal generators and acquisition boards. The electronic circuit under experiment is pre-assembled on a conventional breadboard, connecting selected circuit nodes and branches to the relays contacts. The remote user can thus remotely re-configure the real circuit by inserting or removing components, create faults like shorts or opens, and apply signals to capture voltages and currents at selected points. This laboratory is intended for simple analog electronic circuits, thus it does not need the real-time video feedback.

In the digital electronics area, a remote laboratory at the University of Coimbra uses a prototyping board based on

a digital programmable chip (FPGA-Field-Programmable Gate Array) for implementing basic digital circuits, designed by the students at the schematic level. The board has a set of switches and push buttons that are normally used to provide the digital stimuli to the circuit under test. Because it would be very difficult (in mechanical terms) to build manipulators that actuate the real switches on the board, they are emulated by the remote web interface. The digital outputs are normally connected to a set of LEDs, 7 segment and LCD displays that can be watched through real-time video.

Remote experiments where the user activity results on the movement of parts of a mechanical setup or switching on/off of lights are among the most popular remote laboratories. Two good examples in the domain of mechanical engineering are a bar bending experiment for verifying Hooke's law and measure experimentally the Young modulus of a material, located at FEUP, and an automation experiment based on industrial controllers with ethernet interface, pneumatic pistons and electric valves that is hosted at Instituto Superior Técnico, Lisbon.

C.   Virtual Laboratories

Virtual laboratories are interactive simulation tools that provide a user interaction as close as possible to a real experiment. There is no physical setup, which reduces drastically the implementation costs. This approach eliminates the competition for access by many to real hardware and their utilization is naturally safe and maintenance free (contrarily to real remote experiments that cannot survive without regular maintenance). One paradigmatic example presented at the workshop is a virtual Michelson interferometer installed in the Physics Department at FEUP that mimics a real Michelson interferometer remotely available at the same institution. In this example, the decision for building the virtual experiment was due to the limited interactivity offered by the real remote interferometer, mainly because of the high sensitivity to the alignment of the optical components. The virtual experiment (or simulator) even allows the user to select the wave length of the laser light, which would be impossible to implement in a real interferometer with a single laser beam. Many other components are also available for interaction (e.g. beam splitter rotation tuning, selection of beam source type or simulated smoke to enhance the visibility of the laser beam). The user has a 3D view over the experiment in three different angles and can also control the position and the angle of the mirrors, Figure 1 shows a screenshot of the simulator and a short video demonstrating the usage of the application can be found at [21].

This virtual experiment is freely available as a software application and can be downloaded from [23] where a clip and its tutorial explains how to use it in an expeditious way.

Chemical engineering is another area that profits from the use of virtual laboratories due to the constraints in implementing actuators that perform the basic tasks in a chemical laboratory without resorting to expensive manipulators. The materials used usually have a limited servicel life and some experiments consume relatively long laboratory times. Although some existing installations implement interactive remote experiments with a chemical plant (e.g. a pH control experiment in an agitated tank and the monitoring of the formation of concentration fronts in bed adsorption, both in the Department of Chemical Engi-

Figure 1.   The Michelson interferometer virtual experiment

neering at FEUP), virtual laboratories can be particularly interesting in this application area. A joint collaboration between the University of Coimbra and the University of Porto has resulted in the virtual laboratory of chemical processes, a web portal with access to 20 simulators and 5 virtual experiments on different chemical engineering topics.

D.   Adding sensorial information

In remote and virtual labs any additional sensorial information is welcome for enriching their remote or even virtual condition. More than image and sound information, the use of haptic devices will permit to add sensorial information of force feedback type. Haptic devices may improve the realism and offer interactions similar to those in real systems.

At FEUP some applications were developed, some of virtual type and other of hybrid type and some more work will be developed in the near future. A demonstration of a simple application example developed at FEUP can be seen at [22]. An user bursts the balloons by pushing into them a (virtual) sharp pin. A force feedback is felt according the characteristics of each group of balloons (different groups have different colours).

V.   FINAL COMMENTS

The project is a huge opportunity for collecting all the work done on those emerging technologies in Portugal. As a global national consortium this also represents the opportunity to organize them in order to improve the offer of available material. It also will foster the collaboration between all the national teams involved in these activities in order to improve the technological solutions adopted by the various institutions.

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AUTHORS

M. T. Restivo is with the Faculty of Engineering of University of Porto and with Institute of Mechanical Engineering, IDMEC-Pole FEUP, Porto, Portugal (e-mail: trestivo@igip.org).

J. C. Alves is with the Faculty of Engineering of University of Porto and with INESC-Porto, Portugal (e-mail: jca@fe.up.pt).

A. Cardoso is with CISUC - Centre for Informatics and Systems of the University of Coimbra; Coimbra, Portugal (e-mail: alberto@dei.uc.pt).