Real remote physics experiments across Internet - inherent part of Integrated E-Learning

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Real remote physics experiments across Internet
- inherent part of Integrated E-Learning

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Abstract:

Implementation of the real remote experiments across the Internet into teaching process, up till now not available, enables introduction of Integrated e-Learning, composed of three components: the real remote experiments across the Internet, the simulation applets and the electronic interactive textbooks. We present here the prospective remote laboratory system with data transfer using Intelligent School Experimental System (ISES) as hardware and ISES WEB Control kit as software. This approach enables the simple construction of remote experiments without building any hardware and virtually no programming, only with paste and copy approach of pre built typical blocks as camera view, controls, graphs, displays etc. In conclusion we summarize the achieved experience with remote experiments.

1   Introduction

Many students perceive physics as a difficult subject, dealing with the abstract laws and models not describing the real world and so without much of help for their future carriers in both engineering and natural sciences. The physics teaching strategy of education based on the classical stereotype, i.e. lecture – seminary – laboratory exercise based on the accumulation of basic models, laws, cumulatively speaking „the rules" of the branch undergoes a crisis [1]. The other, more compatible strategy to the present state of the society is that used in the scientific method of cognition of real world [2] or the method of e-LTR (e-Learning, e-Teaching and e-Research) [3]. The main features of these methods are observations, search for proper information, its processing and storing, organization and planning of work, data and results presentation etc. In this method of education the experiment and experimentation plays a decisive role [4]. Traditional laboratory work courses do not comply with these trends; therefore it is necessary to redefine the learning targets and to reconsider the learning methods. The project work based on the theory of constructivism [5] and blended learning [6] will play a decisive role in laboratories and the idea that project laboratories will be the typical learning environment for physics and engineering students for the next generation is very probable [7]. In experimental laboratories a silent revolution has taken place due to the massive invasion of personal computers and information communication technologies (ICT). Experimental working places for the teaching purposes provide real experiments using nowadays omnipotent computer for data collection, processing and evaluation. The second, fast developing area of the physics experimentation in teaching are remote e-laboratories with remote experiments (RE). Many real remote e-laboratories across the Internet have been published that provide experiments on real world objects, supplying the client with the view of the experiment, interactive environment for the experiment control and resulting data for evaluation. Recently, two European activities arose

interest in Remote physics laboratories. The project Pearl " Practical Experimentation by Accessible Remote Learning " [8] and the project "Remotely Controlled Laboratory" [9]. The gathered experience, the inventory of the state of the art and corresponding references in Europe and United States are to be found there.

In the presented paper we want to add to those activities in a constructive way. We know, from our own long lasting experience, once the University or the Department and/or their teachers decide to build the RE, the main obstacle is often not the financial requirements of the RE, but the technical and know how of the ICT and the corresponding knowledge with the client-server communication and its establishing.

With the following paper we intend to offer the remedy to this situation and provide help both with prospective and available hardware and software solutions enabling easy building of both computer based real experiments and their straightforward transformation to the real RE across the Internet. It is based on the available scalable building set for the construction of natural science experiments, including physics, - ISES (Intelligent School Experimental System) [10] and ready for use software for easy and simple creation of remote experiments - ISES WEB Control [11]. Further we bring the overview of the two decades lasting activities in real physics experiments with computer and the present state of the e-laboratory of remote experiments with the data transfer using only the web services with common web browser and active Java support on the side of the remote experimentator. The potential and future possibilities of the ISES systems in connection to the RE are also discussed.

Implementation of the real experiments into teaching process, up till now not available, enables introduction of Integrated e-Learning, composed of three components: the real remote experiments across the Internet, the simulation applets and the electronic interactive textbooks. This strategy of education is actually copied from the method, sciences use in their cognitive work with the processing and interpretation of ensuing data and their presentation, search for relevant information, its classification and storing [12].

2   Remote experiments

The present state of the ICT in the area of measurements, data collection and transfer using web services is rather complicated and not clearly arranged for the physics teacher to think about building the remote real physics experiment. Missing standards lead to many individual solutions, and therefore to unnecessary hurdles for hosts and users [9].

To build the remote real physics experiments requires as the first step to set up the computer controlled experiment. This is at the present state of technology relatively easy. Computers have found their way into experimental students laboratories and on the market computer oriented building systems for the construction of natural science experiments, including physics, are abundant. Without the claim to be exhaustive, we mention systems like IP COUCH, LEGO, HEWLET PACKARD and Lab WIEW. The systems were devised for different purposes, with different proportion of hardware, software and simulations, and also price. The mentioned systems include modules and sensors, inputs and outputs for both analog and logical data and the software for the communication with the experiment and data visualisation and their processing.

2.1 ISES

In our laboratory, the friendly in use hardware and software for easy building of physics experiments - Intelligent School Experimental System (ISES) - has been constructed in the

long period of development starting in 1984 and constantly improving its performance. It forms the basis of our approach to the simple and prospective building of the remote experiments. Its detailed description and philosophy will be reported elsewhere [13]. Here we will mention only few simple facts important in relation to the RE building. ISES is an open system working under Windows operating system with all its advantages (OLE and multitasking). The system is composed of an interface card, a set of variable modules and sensing elements, and a service graphical and evaluation software (see figure 1).
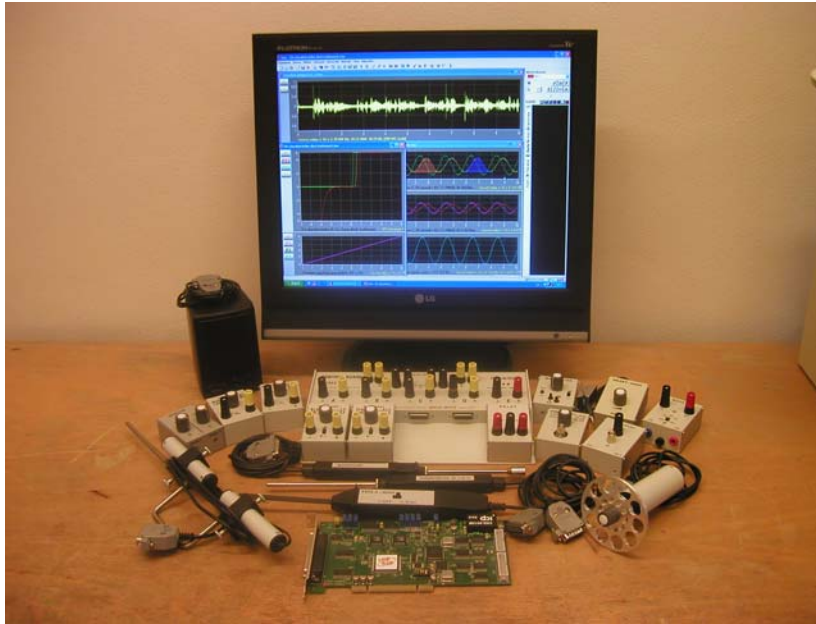

Figure1. ISES-Intelligent School Experimental System

The computer interface card, with the inputs and outputs and plug-in slots for modules, provides an easy way of interfacing to virtually any PC compatible computer. The card is the 12-bit analog-digital digital-analog, sample and hold with a maximum sampling frequency of 100 kHz. The ISES modules are easily interchangeable, their presence and adjusted range is automatically sensed by the computer, with the automatic calibration. The system is equipped with modules as e.g.: voltage ($\pm$ 5 mV$\div$ 10 V), current ($\pm$ 0.5 mA$\div$ 1 A), resistance, capacitance, temperature (-20 ^{o}C $\div$ +120 ^{o}C), microphone, deviation sensing unit, adjustable preamplifier, light stop, current booster, relay switch, pressure meter and many others. The service program enables the simultaneous measurement of 10 different channels (8 analog and 2 binary) and to use 4 output channels. All these modules are fully programmable, using the programming panel. The data are depicted both in analog or digital form on variable number of panels, with depicted quantities either those measured by modules or their combinations (addition, subtraction, product, quotient etc.). The software provides data processing (integration, differentiation, fitting, approximation etc.). The data export for another graphical processor is straightforward.

2.2 ISES WEB Control kit

Once the computer oriented experiment using ISES system is built, the second step in the building of the real RE across the Internet is needed. For the establishing of the classical system server-client connection with the data transfer from the server to the client and in the reversed direction for the control of the experiment by the client (experimentator) is necessary. For example, in [9] the controlling interface is built using the microchip controller interfacing the necessary peripheries with the server. National Instruments, using the products Lab View (6.1 and higher) introduced for the device of the automation and measuring applications for industry the unit for the remote experiments Run Time Engine [14]. This ready for application commercial system is used in majority remote experiments [15]. The disadvantage of the system is the necessity of the installation on the client computer the extensive software and also the limited applicability for physics.

In 2000 we decided to built the software kit for the easy transformation of the computer oriented experiment based on the ISES system to the RE (with server-client approach) using only the web services, web pages and Java support on the client side. The schematical representation of the RE "Photovoltaic cell " using ISES hardware is in figure. 2.
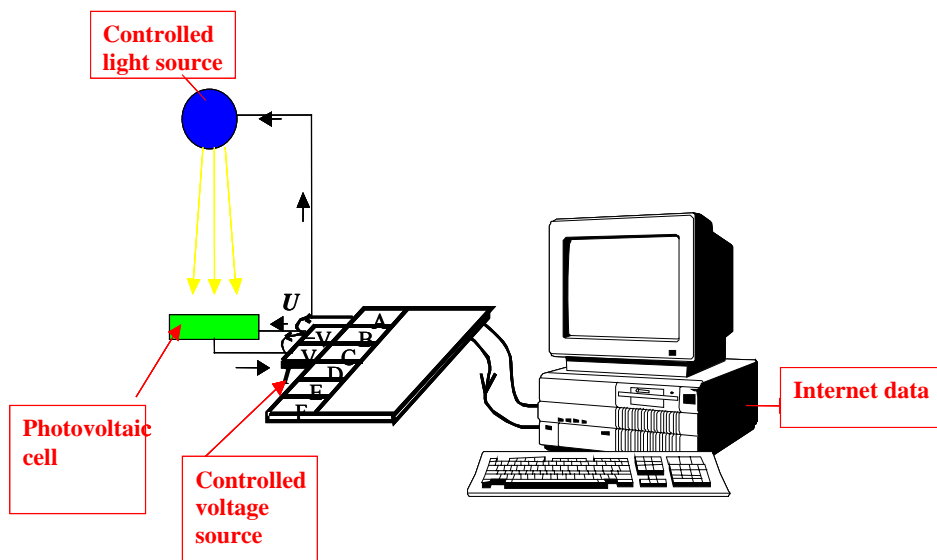
Figure 2 The schematic representation of the server of the remote experiment "Photovoltaic cell " using the system ISES http://kdt-4.karlov.mff.cuni.cz/vacharakteristika_2_en.html

The main requirement was the compiling of the control program by the arbitrary user on the copy-paste principle of the prefabricated building blocks with only very limited knowledge of the rules of web pages creation using suitable editor at hand. This software kit, transforming the computer controlling the experiment to the web server, is ISES WEB Control [16] consisting of

- ready made packages for automatic creation of the sub servers (Image Server, Measure Server, HTTP Relay Server),

- the prefabricated programs segments for the client web pages creation (view of the experiment, experiment controls, graphs, data digital displays and others),

- the prefabricated Java applets for the transfer of image and data.

The working principles of the RE are then based on the server computer with the ISES measuring system, with built in Image Server, Measure Server and HTTP Relay Server. Server generates web pages with built in Java applets controlling the experiment and data transfer and sends them to the client computer. On the client computer the web pages are then created comprising

- control keys and bars for the control of outputs,

- applets for measuring and digital displaying of input values,

- applets for graphic displaying of input values,

- applets for the transmission of measured values into the client computer,

- applets for the image transmission from a WEB camera, etc.

In figure 3 there are the examples of the typical prefabricated controls for the set up of client web page and in figure 4 is the example of the control web page for the RE "Electromagnetic induction " (with life web camera view, frequency controls, and the graph of the measured data and the measured data itself) available at http://kdt-20.karlov.mff.cuni.cz/ovladani_2_en.html) .The present ISES WEB Control kit consists of 15 typical Java applets with great flexibility and adjustable parameters enabling to build web pages for controlling the majority of physics experiments on the client side. The client computer needs only a web browser as Explorer, NetScape, Mozilla or similar and Java language support.
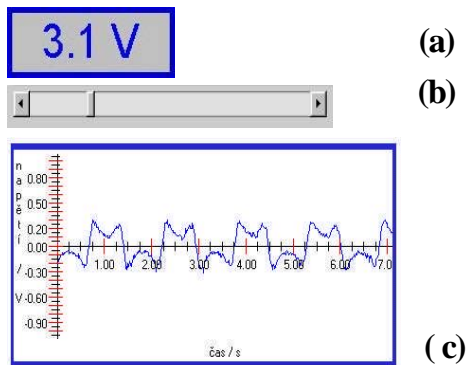
Figure 3. Examples of modular Java applets from ISES WEB Control kit [23] as building tools and blocks for remote experiments web control pages (a) display, (b) control slide, (c) graph for data presentation.
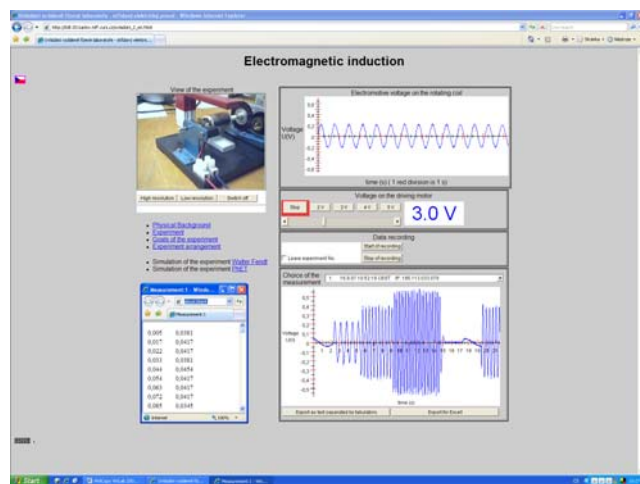
Figure 4. The web page on the client computer of the real remote experiment Electromagnetic induction with life web camera view, frequency controls, and graph of the measured data and data in tabular form itself for transfer to the client computer

The present state of the remote experiments in our e-laboratory is (see also http://www.ises.info/experiments.html) is:

- " Controlling of the liquid level " - http://kdt-14.karlov.mff.cuni.cz
- " Monitoring the environment in Prague "-http://kdt-16.karlov.mff.cuni.cz
- " Electromagnetic induction "-http://kdt-20.karlov.mff.cuni.cz
- " Driven oscillator" http://kdt-17.karlov.mff.cuni.cz
- " Photovoltaic cell".- http://kdt-20.karlov.mff.cuni.cz/ovladani_2_en.html
- " Diffraction of microobjects" http://kdt-13.karlov.mff.cuni.cz/sterbina.html
- " Heisenberg principle of uncertainty"-
- http://kdt-13.karlov.mff.cuni.cz/sterbina_nodirect.html

We have recorded till now (August 2007) over 7 000 trials with RE. Tendency is rising, what confirm the numbers of users (visitors) during monitoring period in Table.

Table Number of connections to remote experiments

Total Number of online connections to RE from start of monitoring till 17. 8. 2007						
Liquid level IV /2004	Meteorology in Prague XII /2005	Electromag. Induction X/2006	Driven oscillator X /2006	Photovoltaic Cell X /2006	Diffraction microobj. VI /2007	Σ
2 896	1 824	998	570	675	72	7 035

3 Conclusions

We may draw the following conclusions.

- The remote real experiments - interactive, real time, with data outputs - bring the possibility to make the study of many engineering and science subjects more interesting and idea generating, ushering the students to the involved elucidation of the real world phenomena+;

- With the real remote experiments we intend to step in favour of the real experiments against the idea of the virtual world and virtual measurements, the indistinguishable of the real and virtual "measurements" [8], stripped of the possibilities of the hypothesis formulations and their proving or disapproving;

- We hope to attract young people, used to exploit the Internet for the casual playing, chatting and communication purposes, for real work with the planned goals and aimed and involved output and to persuade them about the information strength of the remote experiments and the Internet;

- Finally, we hope to bring the practical experimental work by remote real experiments to those, hitherto not participating on the laboratory work for different reasons – distant students, disabled, handicapped, and those from underdeveloped countries, who can not afford to enter the real laboratories.

For all these reasons we suggest to build the network of e-laboratories of European universities, accessible without any preconditions.

4 Acknowledgments

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