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Nesimi Ertugrul 355 Guest Editorial

Gerard T. McKee 356–362 An Online Robot System for Projects in Robot Intelligence

Online robot systems can significantly increase the number of students that can participate in practical robotics and artificial intelligence projects and improve the quality of the learning environment provided by educators for these topics. We present an online educational environment based on employing toys as simple robotic devices and using vision-based sensing as the basis for guiding simple object manipulation operations. The paper describes the hardware and software environment that was developed to create the online system and reports on the use of the environment to support a task requiring students to implement a simple stop-look-act control cycle. The use of the environment by the students was monitored throughout the period of the project and is described in this paper. The student evaluation of the project is also described. In both cases the results are analysed and the main conclusions are presented. In general, the experience of the students was positive and lessons learned are being integrated into future systems and projects.

Francisco A. Candelas, Santiago T. Puente, Fernando Torres, Francisco G. Ortiz, Pablo Gil, and **Jorge Pomares** 363–370 A Virtual Laboratory for Teaching Robotics

Technical teaching often requires the use of expensive laboratory materials which are frequently beyond the reach of many students. Students are also required to go to laboratories, which offer the appropriate facilities, according to a strict timetable. For these reasons, the need for alternative methods arises for teaching such as virtual laboratories via the Internet. In this article we present a virtual laboratory that is being applied to robotics teaching which allows the simulation and tele-operation of a robotic arm.

L. Petropoulakis and **B. Stephen** 371–378 Resource Sharing Software for Distance Learning in Engineering Education

This paper presents the work being carried out in Strathclyde University to utilize generic methods for making computer-aided design (CAD) and simulation packages available on the Internet for distance learning and distance collaboration purposes. The system was developed over a 3-year period and has now evolved into a generic resource sharing structure with several features designed for use predominantly in education but also in other environments. This paper provides an overview of the development, illustrates the functionality and use of the system in sharing different applications and for various user-modes, analyses the significance of such systems in educational establishments, indicates the difficulties experienced thus far in implementation and gives a brief overview of the latest version of this development.

Lawrence E. Carlson, René F. Reitsma, Michael J. Brandemuehl, Jean R. Hertzberg, Jacquelyn F. Sullivan and **Stephen G. Gabbard** 379–388 Exploiting an Engineering *Building as a Unique Distance-Learning Tool*

At the University of Colorado at Boulder, the custom design and construction of a 34,500 square foot laboratory and classroom facility from the ground up provided a unique opportunity for engineering educators to use the building itself as an educational tool. This curricular concept and accompanying building data system at the ITL laboratory is called 'Building-as-a-Learning-Tool,' or BLT. The web-based BLT software system continuously monitors more than 300 building systems sensors, enabling engineering faculty and students to use the BLT system as a distance-learning tool to take the 'pulse' of the building from anywhere in the world (see http://blt.colorado.edu).

D. Gillet, F. Geoffroy, K. Zeramdini, A. V. Nguyen, Y. Rekik and **Y. Piguet** 389–397 The Cockpit: An Effective Metaphor for Web-based Experimentation in Engineering Education

Web-based experimentation is a key feature in the deployment of eLearning solutions for engineering education. At the Swiss Federal Institute of Technology in Lausanne (EPFL), Web-based experimentation is deployed thanks to a comprehensive environment called the Cockpit. This environment integrates all the components necessary to carry out hands-on practice in a flexible learning context. The Cockpit metaphor has shown to be an effective way to compensate for remoteness and to sustain active learning, interaction, collaboration and knowledge appropriation. Preliminary evaluations have shown both the effectiveness of the chosen solutions and the challenge of deploying a flexible learning approach in a traditional academic institution.

Srinivas Palanki and **Soumitri Kolavennu** 398–402 Simulation of Control of a CSTR Process

In this paper, the development of a software module to run a simulation via the Internet is described. The software module is developed in MATLAB/SIMULINK and simulates a regulation problem in a continuous stirred tank reactor (CSTR) in which a series reaction is occurring. The user has the option to input a wide variety of system parameters, initial conditions, final time, and controller parameters. The effect of changing these values on the overall system dynamics can be studied easily. The development of such modules eliminates space, time, and cost constraints and serves as a useful teaching aid.

Jim Henry and **Charles Knight** 403–408 Modern Engineering Laboratories at a Distance

This paper describes the technical aspects of conducting laboratory experiments from remote locations. Sixteen laboratory systems are available at UTC for students to operate remotely via the Internet. Collected data can be shared with other students via the Web. The laboratory systems described in the paper could be used by engineering and engineering technology programs in lieu of or to supplement existing laboratory curriculum content.

Ingvar Gustavsson 409–419 A Remote Access Laboratory for Electrical Circuit Experiments

Many laboratory experiments in electrical engineering courses can be performed remotely using real equipment in a laboratory. Traditional circuit theory experiments have been conducted over the Internet at Blekinge Institute of Technology (BTH) in Sweden using the same experimental set-up from different locations simultaneously. The circuits are formed using remotely controlled switch matrices. The instruments and switch matrices used are computer-based PXI (PCI extensions for instrumentation) devices which have

virtual front panels that can be displayed on a remote PC. This approach is neither a simulation nor a SCADA (Supervisory Control and Data Acquisition) application. The students control the instruments in the same way as they would in a local laboratory. The only difference is that they do not form the circuits and connect the test probes manually. These laboratory experiments have been used successfully in undergraduate engineering education at BTH and at Luleå University of Technology, Sweden using a lab server at BTH. Two transducer laboratory exercises are also available for more experienced students, who mostly welcome the chance of doing the experiments from home at any convenient time. These exercises contain comparatively slow mechanical movements allowing only one user to be logged on and controlling the experiments at once. Video transmission is provided so other users can follow what is happening and which also performs part of the experiments.

Antonino Serri 420–426 A Novel Website of Mechatronics for Remote Learning

This paper describes the development and use of a novel website to improve the learning of mechatronics concepts. The website has been designed for a twofold connection: Internet and intranet. First, it is a quite standard Internet information server for students that are evaluating their interest in mechatronics. In addition, the same server is used for remote laboratory experience improving the efficiency of the lessons using intranet connection. Examples of remote programming of 'LEGO mindstorms' autonomous robot are presented. Moreover, other Italian web-based remote learning realisations are described to represent different solutions.

F. Naghdy, P. Vial and **N. Taylor** 427–432 Embedded Internet Laboratory

A laboratory is developed in this work to teach embedded Internet systems to Bachelor of Internet Science and Technology students. The design and development of the system have been carried out based on the pedagogical outcomes expected from the laboratory and the subject. Accordingly, the laboratory designed for this subject does not only support all the objectives of the subject, but provides a platform to demonstrate all the principles associated with the concepts in a tangible manner. For example, the laboratory itself is designed as an embedded Internet system and access to the experimental device takes place remotely through the Internet from a client. The design and development of the laboratory is described and progress made is highlighted.

Charles J. Lemckert 433–440 Incorporation of a Demonstrator into Internet-Mediated Laboratory Experiments

A new form of interactive Internet-mediated science/engineering practical class that can be conducted by students from any campus within a hosting multi-campus university has been developed using readily affordable technologies. Unlike existing computer-aided learning packages and Internet-mediated practical classes, this new teaching/learning tool incorporated direct two-way voice demonstrator–student interactions. This combination of computer-aided learning and the more conventional real-time demonstrator-guided learning drew benefits from both modes of teaching and learning to produce an enhanced alternative to practical class delivery.

Peter J. Vial and **Parviz Doulai** 441–444 Using Embedded Internet Devices in an Internet Engineering Laboratory Set-up

In the autumn session 2001, a new Technology strand was initiated at the University of Wollongong. As part of this added degree structure, a subject called 'World Wide Web Engineering' was introduced, which has a laboratory component focused on remote embedded Internet devices. In this laboratory, students are exposed to devices capable of monitoring digital systems remotely via the Internet. Students also learn to program these devices using special libraries available from the vendors and are given practical experience in how to compile and use this software. Survey results show that students on this new course learnt a lot about devices that can be remotely accessed and controlled via the Internet. This paper covers relevant aspects of the course development, such as setting the course objectives and creating its supporting materials. Course development costs and future improvements will also be discussed. It is shown that, in teaching this subject, a strong commitment to the use of real Internet-embedded devices enhances students' learning, instils the concept of self-learning and promotes the idea of logical deduction and team effort.

R. Pastor, J. Sánchez, and **S. Dormido** 445–454 A XML-based Framework for the Development of Web-based Laboratories Focused on Control Systems Education

In this paper, a novel framework, termed RELATED, is described that allows Web-based labs focused on the teaching/learning of control systems to be published. With this approach, XML files are used to connect the laboratory elements (plant, simulations, controllers, experiments), conduct the remote system access, and define different experiments. Teachers can thus create and publish new Internet-based control labs using legacy code and control elements regardless of their locations on the Internet. A Java-enabled browser is the only tool needed by students to operate the remote experiments.

J. Trevor Jones and **Matthew Joordens** 455–459 Distance Learning for Laboratory Practical Work in Microcontrollers

This paper presents a simple and relatively straightforward solution to the problems of equity in laboratory practical exposure between distance-education students and their traditional, on-campus, fellow cohort. This system has been implemented for the past five years in a university that is amongst the leaders in distance education delivery and has proved to be extremely successful and very well accepted by all students. While the intention was to allow distance education students easy access to the required laboratory practical content of the course, the solution found has proved to have many advantages for the on-campus students. Although this specific implementation is based upon microcontroller technology units in an engineering degree course, the methodology is easily transferable to other disciplines and courses.

Bill Diong, Miguel Perez, Connie Kubo Della-Piana and **Ryan Wicker** 460–467 Remote Experimentation with a Wind Tunnel System for Controls Education

In this paper, we describe the initial phase of our attempt at identification and development of commonly available hardware and software components to fully exploit the idea of tele-operation or remote access to control systems over the Internet. We also present the results of a student evaluation of the system and its concept, as well as the results of a locally-organized faculty workshop and discussion on remote experimentation.

J. R. Porter and **J. A. Morgan** 468–477 Wireless Mobile Platform: A Tool to Implement a Distance Learning Laboratory for Teaching Computer-based Instrumentation and Control

Offering courses through the World Wide Web is becoming the modality of choice for distance education. While using tools such as WebCT has made the creation of lecture courses straightforward, laboratory intensive courses are more difficult to implement. Currently, the Electronics and Telecommunications Engineering Technology programs at Texas A&M have an ongoing effort to develop a distance learning laboratory for a computer-based instrumentation and control course. The goal is to create an instrumentation platform that allows students to design experiments remotely and then upload and test their work in real time over the Internet. This paper describes the progress to date, lessons learned, and presents the new distance learning curriculum currently being implemented.

James B. Dabney, Joshua McCune and **Fathi H. Ghorbel** 478–486 Web-based control of the Rice SPENDULAP

The Rice Spherical PENDULum Laboratory APparatus (SPENDULAP) is a laboratory educational system well-suited for illustrating a variety of important topics in kinematics, dynamics, and control. The SPENDULAP has been used successfully for several years in the classroom so as to enhance students' understanding of three-dimensional kinematics and dynamics including

Newtonian and Lagrangian dynamics. The device has also proven useful to illustrate key topics in nonlinear systems analysis such as linearization and the state portrait. Additionally, the SPENDULAP presents an excellent example for illustrating key concepts in nonlinear control and dynamic simulation. This paper describes the adaptation of the SPENDULAP to produce an autonomous web-based laboratory apparatus. The paper presents both the mechanical modifications required to permit unattended operation and the layered, distributed software architecture.

Dushyanthi Hoole and **M. Sithambaresan** 487–494 Chemical Engineering Home-Practicals: Towards Making Distance Education Truly Distant

This paper describes how some important experiments, which typically rely on expensive equipment and large quantities of chemicals that are a load on the environment, may be redesigned for safe demonstration at home. Practicals from Reaction Engineering and Pollution Control Equipment, two final-year chemical engineering courses at Peradeniya's Engineering Faculty, Sri Lanka, are given as examples. The paper also describes how a digital camera and CDs may be used in conjunction with Web pages to guide students in performing these at-home experiments and how certain practicals may also be given as computer simulations to be done away from the educational centre.

Dwight Krehbiel, Richard Zerger and **Jon K. Piper** 495–502 A Remote-Access LabVIEW-based Laboratory for Environmental and Ecological Science

Distance learning in laboratory science and engineering has been enhanced in recent years by making instruments accessible and remotely controllable on the Web. User-friendly technologies such as those of LabVIEW software have greatly facilitated this process. This paper reports the use of these technologies for online experiments in environmental and ecological science. Remote monitoring and control is provided through LabVIEW, AppletVIEW and live streaming video. Experiments are a collaborative effort of undergraduate and high school students and of college and high school faculty. Reduction of the technical demands of these experiments allows us to focus more attention on pedagogical issues.

K. K. Tan, K. N. Wang and **K. Z. Tang** 503–511 Mechatronic Experiment on Remote Vibration Monitoring and Fault Diagnosis via the Internet

This paper presents the development of a 'mechatronic' experiment on the development of an intelligent vibration monitoring system for remote vibration signature analysis via the Internet. It will highlight the operational principles of the system, and the hardware and software requirements for the implementation of the system on the Internet to enable remote monitoring and fault diagnosis. Specific outcomes and screen snapshots at key stages of the experiment will also be provided.