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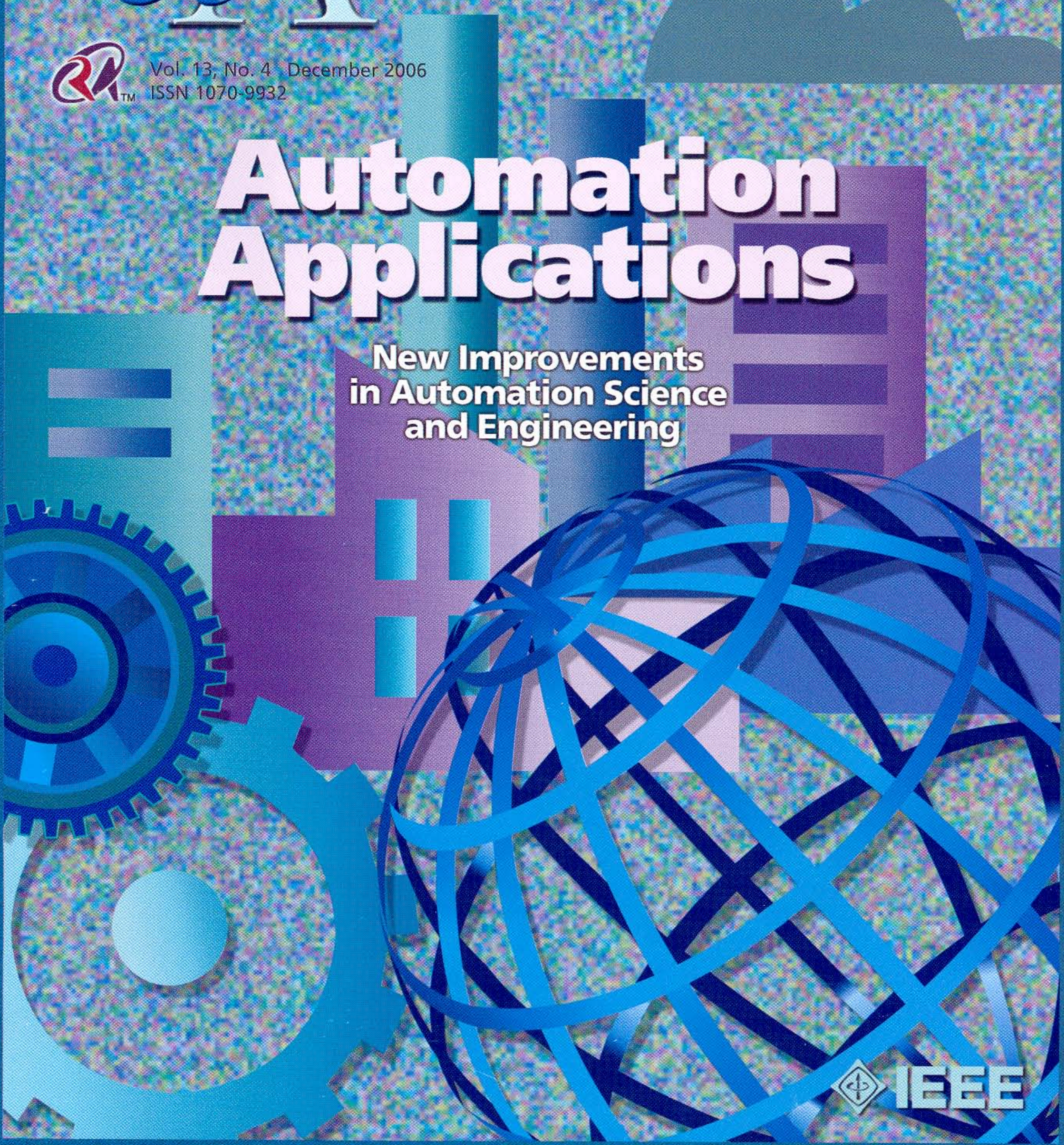
Automation Applications

New Improvements in Automation Science and Engineering



IEEE

Online Automation and Control

An Experiment in Distance Engineering Education

BY SAROSH H. PATEL AND TAREK SOBH

What began as an internal exercise at universities to share information and discuss ideas has evolved into a major trend in the education industry. Today, online education is a major part of the current education system. Over 1,600 online degree programs, over 2,300 career training programs, and over 2,500 online courses are being offered online in the United States.

Academic emphasis is shifting from course-completion to competency. In many cases, certification or accreditation is becoming more preferable than studying a theory-based set of courses towards a degree [1]. Diplomas are less meaningful to employers; knowledge, performance, and skills are what count for most [2]. Furthermore, there is a growing need for part-time accredited programs at the graduate level.

The majority of accredited programs offered through online education are mainly nontechnical programs. There are practically no universities offering accredited degrees requiring laboratory-based coursework in the classical engineering fields at the undergraduate or graduate level. This is because, unlike nontechnical degrees, engineering programs require comprehensive laboratory work.

This article investigates the advantages and the means of providing classical engineering programs online, by providing laboratory-based coursework in automation and robotics.

Online Education

The literature is replete with evidence of the growing demand for distance education. The annual market for distance learning in the United States was US$4.5 billion in 2003, and it is "expected to grow to US$11 billion by the end of 2005" [4], [5].

The major factors for the success of online education are the ever-growing need for part-time education and the need to keep oneself updated. Lifelong learning is becoming a competitive necessity [14]. More courses, degrees, and universities are becoming available through distance-education programs.

More and more learners are requiring flexibility in program structure to accommodate their other responsibilities, such as full-time jobs, family needs, or geographical separation [6]. With these constraints, students shop for courses that best accommodate their schedules and learning styles [7].

Another major factor in the growth of online education is the huge growth in Internet usage. Not only is technology becoming more ubiquitous, it is being used more competently by more people from all nationalities, age groups, and socioeconomic levels [8].

As universities digitally enhance more courses, the distinction between distance and local education is becoming blurred and vague as most universities offer online courses as a part of their curriculum [9]. Digitally enhanced courses provide students in traditional classrooms with more opportunities for independent study.

Universities are traditionally independent, free-standing, and competitive [10]. Interestingly, Rubin [11] has noted that "traditional universities are becoming more like distance learning universities and not the opposite." With this shift, more institutions are creating partnerships with other colleges, universities, companies, and other kinds of institutions to share technology and to produce and deliver courses [9],]12], [13].

There is a great demand for online accredited degrees in the field of engineering, which traditionally requires laboratory experiences. As Bates [3] suggests, "perhaps the biggest challenge [in distance education] is the lack of vision and the failure to use technology strategically." This addresses experiments to facilitate offering robotics and automation curricula via distance education.

Some Examples of Online Lab-Based Courses of Instruction

This section describes three innovative online laboratory-based programs in robotics and automation offered as a part of the graduate programs in computer science and engineering, electrical engineering, and mechanical engineering at the University of Bridgeport.

Teleoperation of Mitsubishi Movemaster Robot

Software developed at the Robotics, Intelligent Sensing, and Control (RISC) Lab, University of Bridgeport, Connecticut, enables users from around the world to access and operate a Mitsubishi Movemaster robot. The Mitsubishi Movemaster is a six-degree of freedom (6-DOF) manipulator. This tool is very helpful in learning the forward and inverse kinematics and dynamics of a manipulator.

This software tool is being effectively used in the instruction of the following courses at the University of Bridgeport: Introduction to Robotics (CS 460), Advanced Robotics (CS 570), and Control System Engineering (ME 217).

The software can be utilized in three ways. First, it can be used as a virtual simulation tool, where the student can verify his or her computation by entering the link joint angles and verifying the coordinates and orientation of the end effector and vice versa. The software visual interface is shown in Figure 1.

Second, and the most interesting, is that this tool can be used as a learning guide to operate the robot. In this mode, only the instructor is directly connected to the manipulator, all other students or users are connected to the manipulator but cannot command it. The instructor can operate the robot either through a serial port of his computer or via the Internet. Every operation that the instructor makes is reflected in the students' three dimensional (3-D) views of the robot. This is a very realistic means for teaching and also monitoring the system while students are operating the manipulator. Remote-controlled teleoperation also helps in reducing the wear and tear on the mechanical parts, which is otherwise common with all equipment.

Finally, when the student has gained enough experience in handling the robot, he/she can control the robot and solve kinematic, dynamic, and control problems in real time from any location in the world through the Internet.

RISCBOT: An Autonomous Telerobotic system

This section describes RISCBOT, an experimental 802.11b-enabled mobile autonomous robot built at the RISC Lab of the University of Bridgeport. RISCBOT

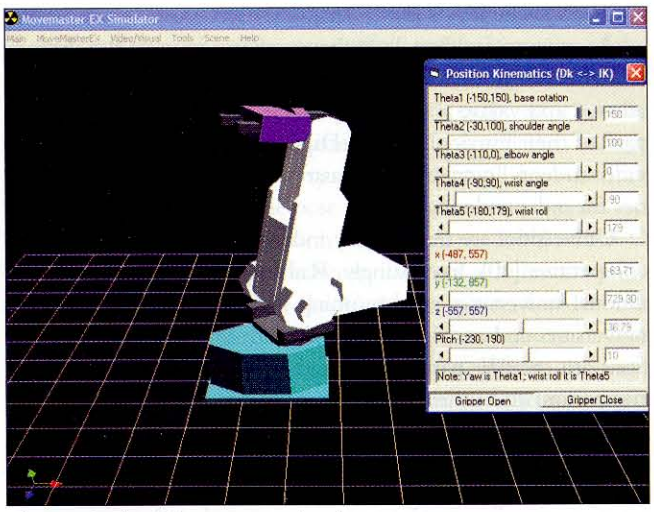


Figure 1. *The Movemaster simulator.*

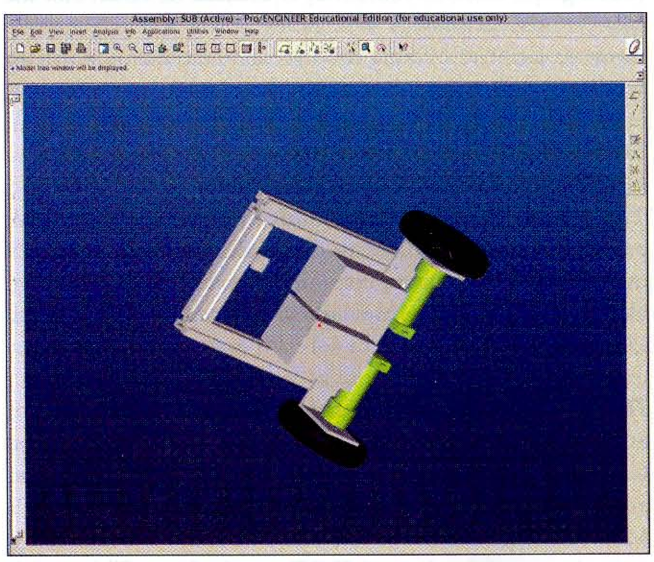


Figure 2. *RISCBOT Top view (front).*

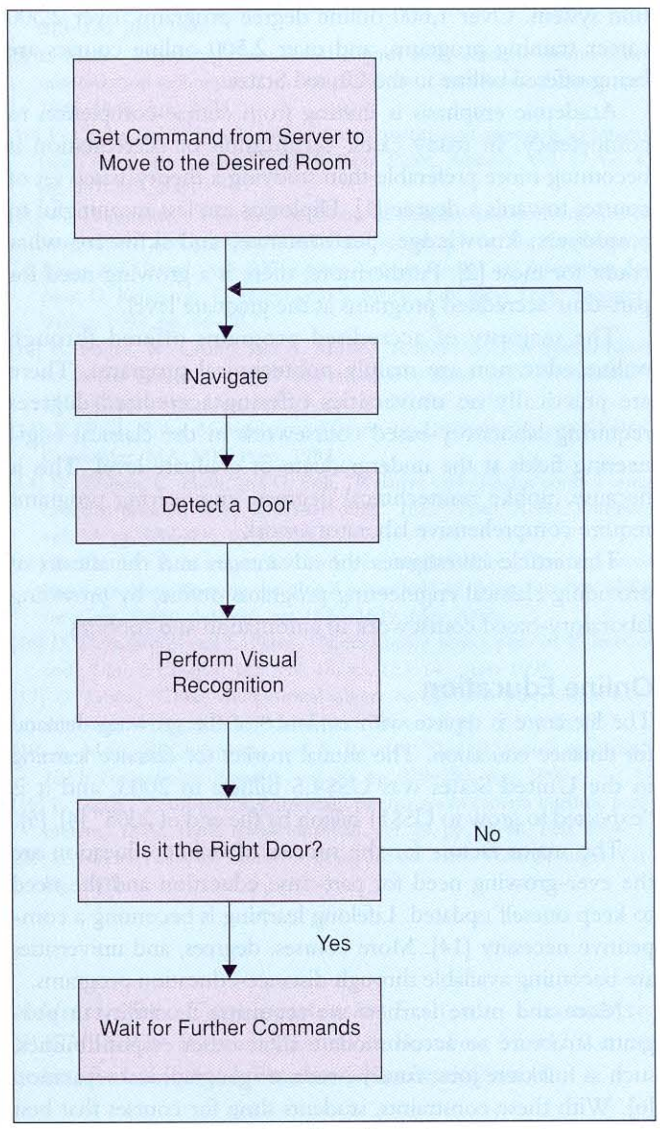


Figure 3. *RISCBOT top view (back).*

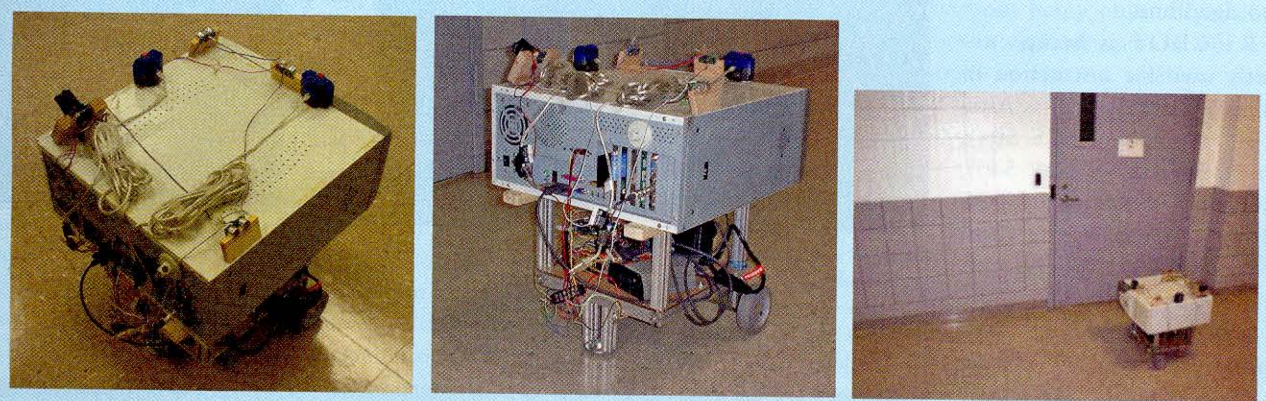
localizes itself and successfully fulfills Internet-enabled online user requests and navigates to various rooms, employing a visual recognition algorithm.

The experimental online robot we built, RISCBOT, utilizes visual room identification for localization. RISCBOT was built with the purpose of operating in a commercial office environment. RISCBOT is equipped with an onboard PC (personal computer), WLAN (wireless local area network) card, NM6403-based DSP (digital signal processing) board, batteries, cameras, and ultrasonic sensors. Online users receive real-time video feedback from the robot and can also view the robot position. Navigation is performed with the help of the cameras and ultrasonic sensors.

The robot processes images from the camera to differentiate between doors, walls, and obstacles. The robot can navigate the University of Bridgeport (UB) Engineering Technology building and successfully fulfills online user requests from the Internet. It can run uninterrupted for about an hour, but must be recharged hourly. Figures 2–4 shows different views of RISCBOT.

The Web interface is an integral part of the mobile navigation and identification process. The mobile robot is connected to the Internet through an onboard WLAN 802.11b card. The robot can be controlled and viewed from the internet, through its Web site: http://www.bridgeport.edu/sed/risc/html/proj/RISCBOT/index.htm.

The complete architecture of RISCBOT is shown in Figure 5. Updates on the Web services and server availability information are posted on the Web site. Users can also download videos and pictures of sample navigation and recognition tasks performed by the robot. The Web



(a) (b) (c)

Figure 4. *RISCBOT accomplishes its task.*

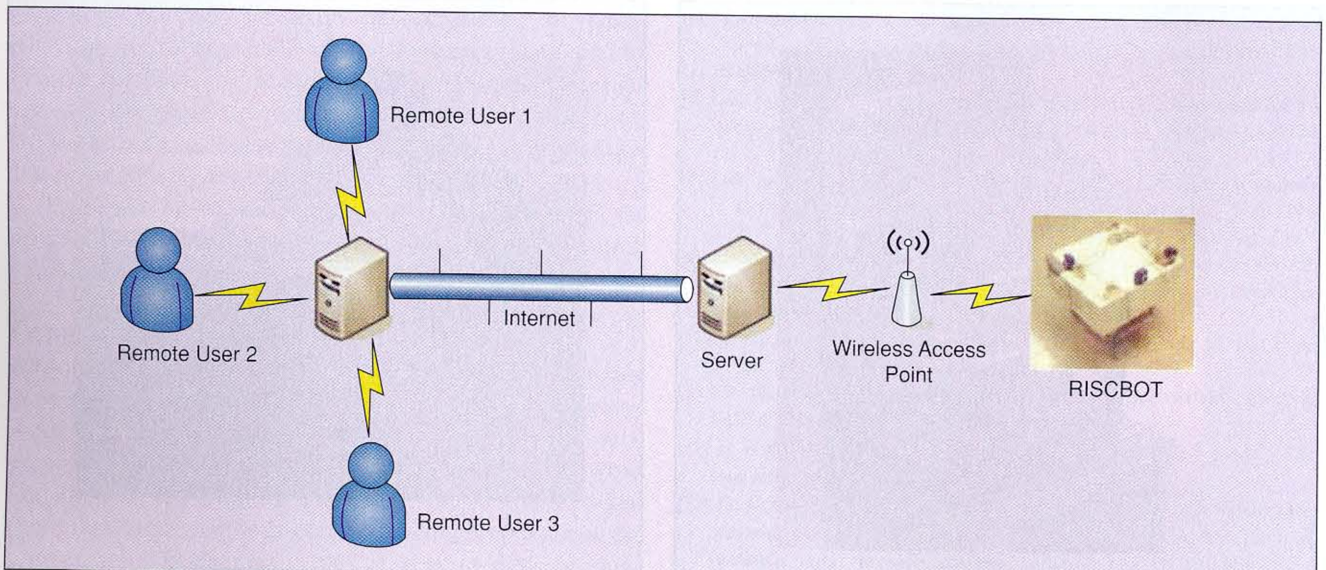


Figure 5. *RISCBOT network architecture.*

interface for the robot is simple, consisting of three windows: the control window, top view window, and the camera view window.

Figure 6 shows a view of the Web interface while the robot is navigating. Once logged on, any user can send a request to move the robot to a particular door by selecting the appropriate door ID on the control window. A real-time video feedback is provided as the robot broadcasts video while moving. The feedback is implemented using Microsoft Media Encoder [17]. This video can be seen on the top view window and the camera view window.

RISCBOT offers a stable telerobotic platform to remotely test new image-processing, computer vision, and navigation algorithms.

RISCBOT is being currently used for instruction in graduate courses such as Artificial Intelligence (CS 504), Image Processing (CpE 540), Machine Perception (CS 584), Computer Vision (CpE 585), and Control Systems Engineering (ME 417). Students can program and configure different application layers over RISCBOT's basic telerobotic architecture and test them.

Figure 6. RISCBOT Web site.

Online Process Control

Our current efforts at the RISC Lab are directed towards developing a remotely operable process control machine. The main aim of this exercise is to provide a tool to remotely operate and monitor a FESTO process controller (Figure 7). Remote users will be able to direct a Mitsubishi Movemaster (Figure 8) robot to perform different experimental setups for the FESTO machine.

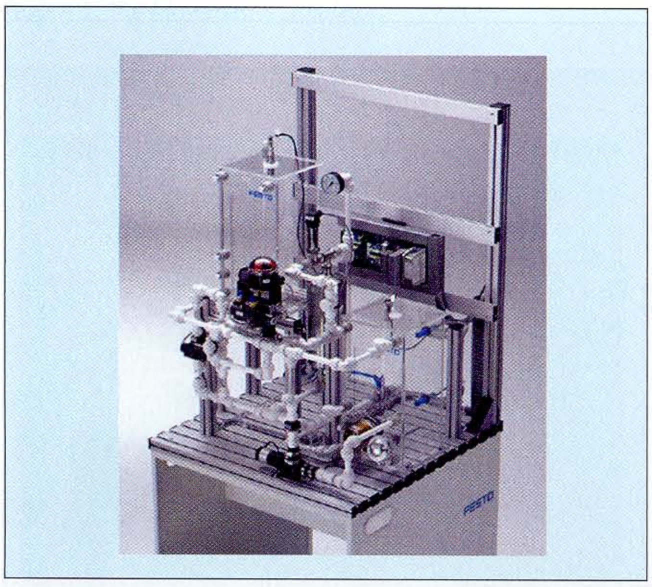


Figure 7. FESTO Process Controller.

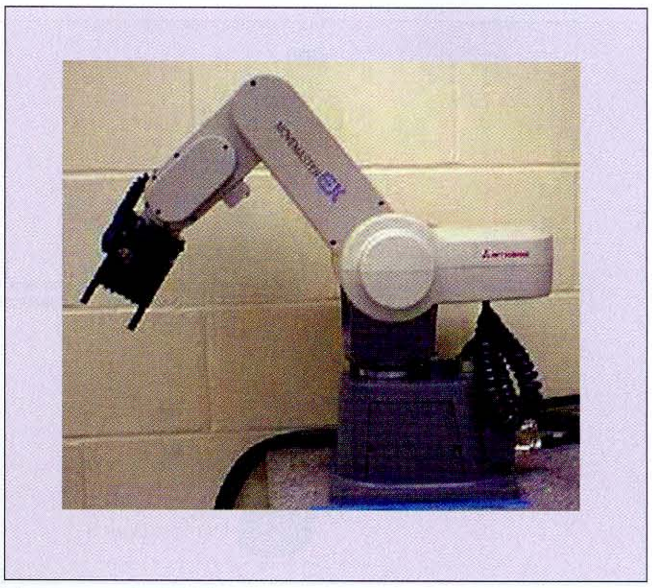


Figure 8. Mitsubishi Movemaster.

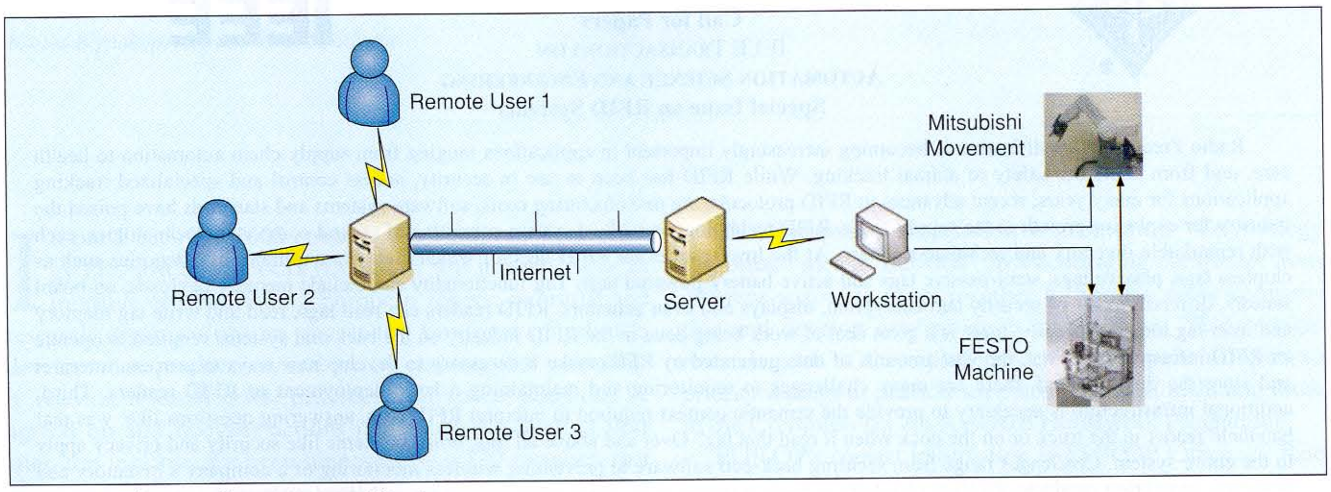


Figure 9. *Teleoperation system architecture.*

This Internet-enabled setup will enable online users to access and telerobotically operate and study different adiabatic and isothermal processes. Furthermore, the cameras mounted on the robot will provide real-time video feedback and visual monitoring of the control parameters.

A visual depiction of the system architecture developed for the teleoperation of the FESTO machine is shown in Figure 9. All remote users who are logged on the distance-learning Web site are connected to the server. The users are queued on a first in, first out (FIFO) basis to control the machine. Irrespective of whether they are controlling the machine or not, every user connected to the server receives real-time video feedback from the laboratory.

All the commands received from the remote users are directly forwarded to the workstation, which issues appropriate commands to the Movemaster robot, camera, and FESTO machine. The Movemaster robot as well as the FESTO machine are connected to the workstation via the serial port (RS 232). The main functions of the Movemaster robot are to physically set up the experiments on the FESTO machine, for example opening/closing appropriate valves on the process controller and to provide proper visual feedback by maintaining the necessary camera position and orientation as desired by the remote user.

This remotely interactive system is being employed in the instruction of courses in the controls area, like the Controls Lab. (EE 461)

Conclusions

Although most distance learning programs offered today are nontechnical, through the proper and strategic deployment of technology, it is possible to offer technical programs and degrees with comprehensive laboratory work via distance learning. As examples, the article detailed three innovative methods currently being employed at the University of Bridgeport in the delivery of distance engineering laboratory-based courses. Using these innovative techniques, students can remotely interact and perform experiments in real-time without being physically present in the laboratory. Telerobotics and automation not only makes distance learning more interactive and interesting but also provide the means for offering technical programs and degrees via distance learning.

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