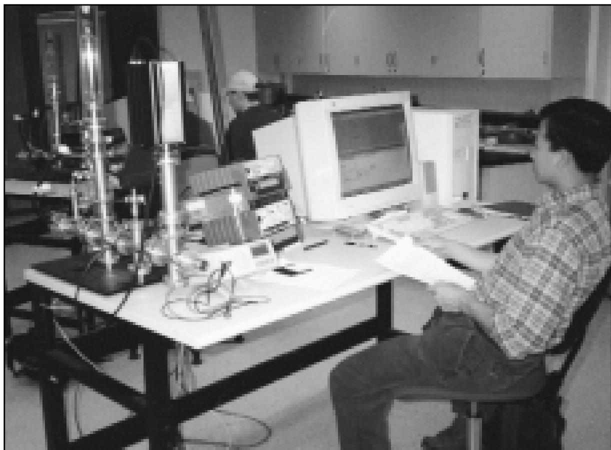
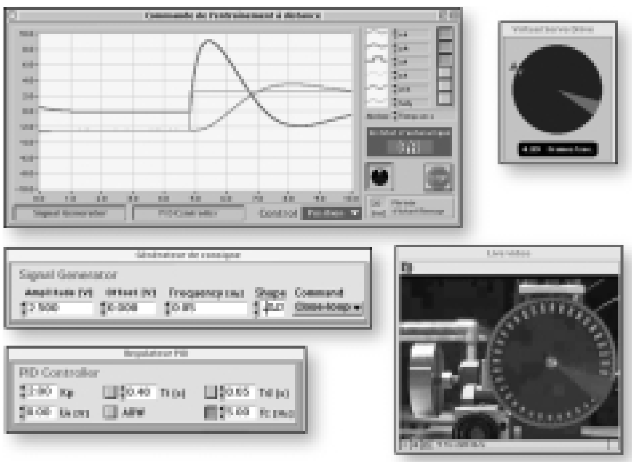
Distance Learning Solutions Guide



Contents

Overview

Customer Solutions



Using LabVIEW for Remote Virtual Instrumentation Via the Internet: An Overview

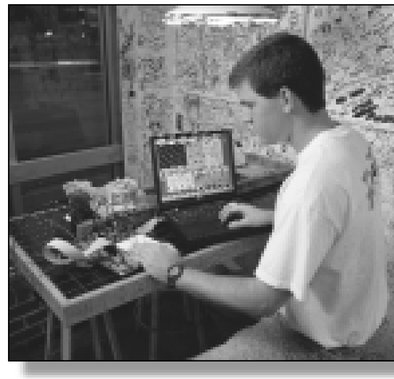
by Jeffrey Travis

Virtual Instrumentation, LabVIEW, and the Internet

The concept of virtual instrumentation is to create more powerful, flexible, and cost-effective instrumentation systems built around a PC using software as the engine and interface. A virtual instrument can easily export and share its data and information with other software applications because they often reside on the same computer.

When National Instruments introduced LabVIEW over a decade ago, it established a unique software tool for creating virtual instruments. The appeal of LabVIEW is largely tied to its graphical programming nature, because it is very easy to prototype and develop an application in a fraction of the time it would take to produce the same in a language such as C++. There is an interesting parallel between the success and popularity of LabVIEW and the popularity of the Web. In both cases, it was not so much the underlying technology that was so innovative, but rather the well designed graphical interface that made it accessible. After all, almost everything you could do in LabVIEW could be done in C or assembly code years before LabVIEW was popular. The Internet's use goes back to the '60s. Most of what it took to create these revolutionary tools, though, was the development of an intuitive, human-friendly interface. For LabVIEW, that meant programming by wiring graphical objects together, like building a breadboard circuit. For the Web, it meant a "Web browser" application that involves little more than just pointing and clicking on images or words that are of interest, and are hyperlinked to other places on the Web.

So you might say that using LabVIEW to create Internet-enabled applications brings some of the best user interface designs together. The possibilities are exciting for creating easy-to-use and intuitive networked applications that take virtual instrumentation to a new level.



Why Networked Instrumentation?

Consider these real-world scenarios:

On one early morning at a university campus, a student gets ready to do her homework experiments as part of the mechanical engineering lab course. She realizes the assignment is due this morning and the lab won't be open for another couple of hours. Besides, the dorm room is cozy. Drinking her coffee, she opens her Web browser and uses a Java applet interface to remotely connect to the lab equipment running LabVIEW. Running the experiment in real-time from the Web browser, she inputs several parameters until she is satisfied with the voltage-load graphs. She saves the graphs and e-mails the results to her professor, turning in her assignment a few minutes before it was due.

A unique high-power electron microscope has just been purchased by an internationally-funded research agency. Although the electron microscope is located in California, it is available to researchers in Russia. The Russian scientists do not need to travel to this facility, because they can control the settings, run experiments, and retrieve images remotely from specimens thanks to an Internet-enabled system. Because it is night-time in the U.S. during business hours in Moscow, both American and Russian scientists have the microscope available to them over the Net throughout the day.

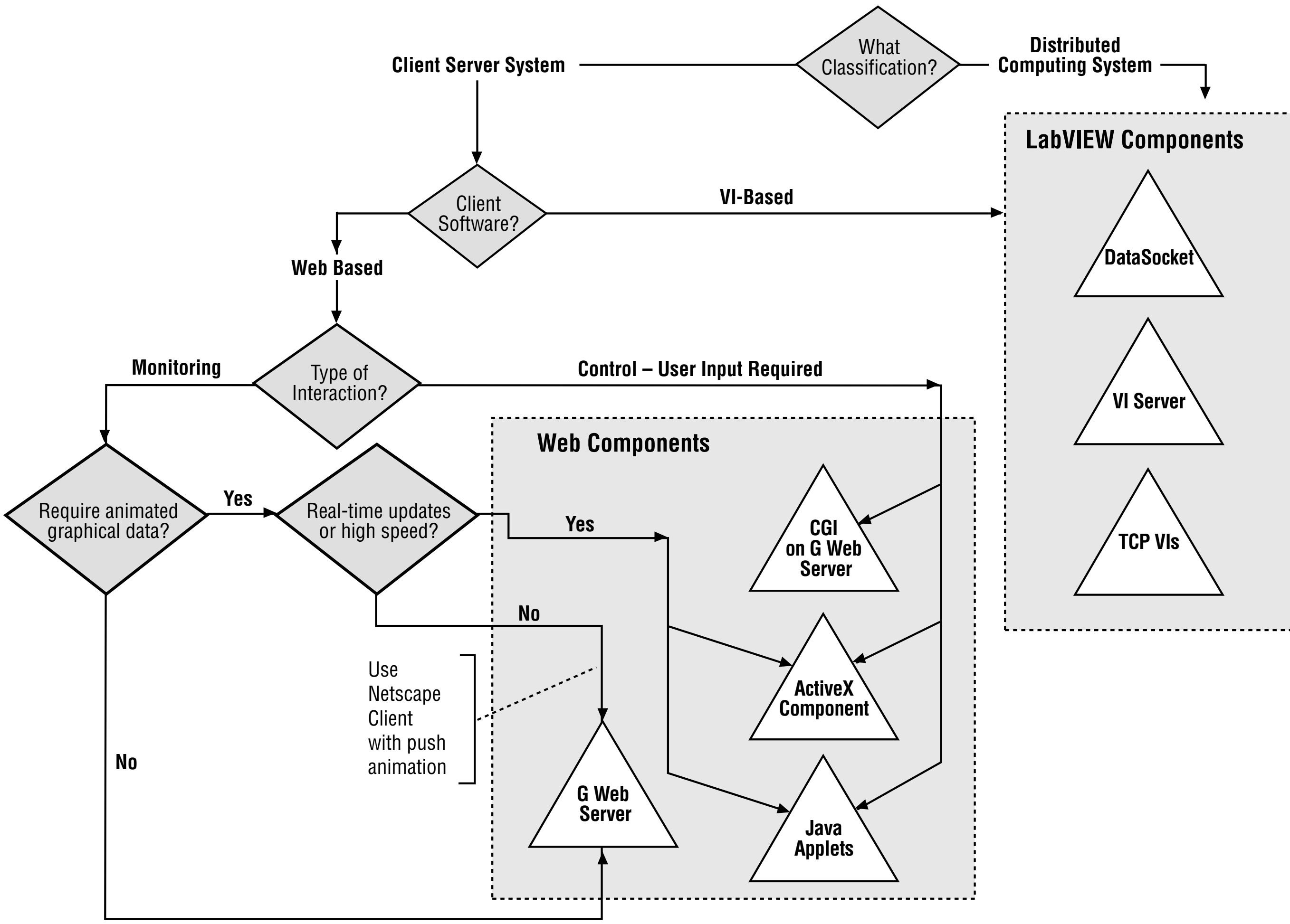
Classifying an Internet-Enabled Instrumentation System

The previous stories illustrate the possibilities of combining virtual instrumentation and the Internet. What kinds of applications are possible when your systems use network and Internet technology? What advantages are there to Internet-enabling your test lab or manufacturing process? The answer usually falls into one or more of the following functional categories of Internet-enabled instrumentation:

Remote monitoring – is when a process is observed from another location on the network. You observe through a client while the process runs on a server. In a pure remote monitoring scenario, the client cannot give feedback or provide inputs to the server process.

Remote control – usually includes the same capabilities as a remote monitoring system, but the remote user (the client) can send some data, messages, or inputs back to the server process that in turn affects the output.

Collaboration – several users from remote sites use a client program to not only communicate and share information with the server process, but be aware of and share information with each other as part of the communication.



Flowchart to Choose LabVIEW Internet Technologies

Choosing a Technical Solution with LabVIEW

When designing an Internet-enabled instrumentation system with LabVIEW, you have a wide array of choices and tools at your disposal. LabVIEW has a number of built-in capabilities for Internet connectivity, including:

- TCP/IP and UDP functions
- Built-in Web server that can create front panel images on-the-fly
- VI Server – a powerful framework for VIs or ActiveX applications to communicate over a network
- DataSocket support for using National Instruments DataSocket protocol

You can use LabVIEW with additional technologies and software packages such as:

- Java applets to remotely control or monitor a VI
- ActiveX controls
- CGI support in the G Web server
- E-mail, ftp, and telnet

A very common question people have when designing an Internet-enabled system is "which technologies should I use for my application?" The flowchart above shows you a general decision process for deciding what technologies to use. The decision process assumes that you are using LabVIEW as a data server in some capacity and does not take into account interfacing with other software systems (excluding the Web).

DataSocket vs. VI Server

Here is the general rule to decide when to use DataSocket and when to use VI server:

*Use **VI Server** when you need to share **processes and interfaces**; for example, if you need to call a VI's functionality remotely, or display its front panel.*

*Use **DataSocket** when you want to share **live data**, independently of how you are displaying, storing, or obtaining it. Also you should use DataSocket if you want data to be available to different type clients (VIs and the Web).*

Web vs. VI Clients

A major consideration in any Internet-enabled system is whether the remote users need to have a custom VI to access your system, or whether they can accomplish their tasks by using a Web browser. Table 1 on the following page compares these two choices.

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	Web-Based Clients	VI-Based Clients
Pros	• No special software to install; remote users only need a browser • Lower maintenance and upgrade costs, because all code resides on server • Easier for clients to use • Security – no source code ever is on the client machines • Wide platform support	• Remote control and interactivity much easier to program, because it is all in LabVIEW • More flexibility in choice of user interface, behavior • Security – only users with access to the client VIs can use the system
Cons	• Remote control is far more complex to implement; requires CGI, Java or ActiveX programming • Security – anyone with a browser could potentially access the system	• Requires that remote user have the current version of LabVIEW installed or distribute large executables • Security – remote users may have access to source code • More costly and complex maintenance – changes may require all users to download a new client program

Table 1. Web vs. VI Clients

Control on the Web – A Comparison of CGI, ActiveX, and Java

As you know, displaying data on the Web from LabVIEW is easy thanks to the built-in Web server. You can even display animated front panels on Netscape browsers using the special monitor. However, if you need to control or have users interact with your LabVIEW system over the Web, then you must choose between CGI, ActiveX, and Java applets for your solution. Table 2 contrasts the differences between these three.

Conclusion

The world of Internet-enabled instrumentation is just beginning to explode, especially in applications for distance-based education and remote labs. Using LabVIEW as the platform of choice is one of the easiest, fastest ways to get your instrumentation system on the Internet. A variety of technologies, using the Web as a primary interface medium, are currently compatible with LabVIEW.

To take a course on using LabVIEW for remote virtual instrumentation please visit **ni.com/custed**

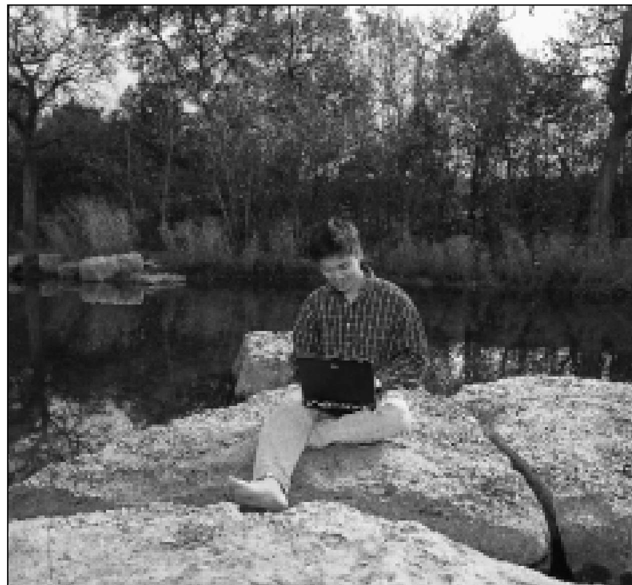
	CGI	Java	ActiveX
Ability to interact with controls (knobs, switches)	Possible with imagemaps, but very limited; requires reloading of page.	Yes	Yes
Ability for user to type in text or form data	Very easy with HTML forms; main purpose of CGI.	Yes, but more complex than CGI.	Yes, but more complex than CGI.
Ability to display live, animated data (e.g., stripcharts, gauges)	No	Yes	Yes
Multiplatform support	Yes. All browsers work with CGI.	Yes. Most browsers work with Java.	No. Only Internet Explorer on Windows can use ActiveX controls.
Tools recommended for development	Internet Toolkit for G (National Instruments).	Virtual Instrumentation Beans (ErgoTech) plus a Java IDE; or AppletVIEW (JeffreyTravis.com)	National Instruments Measurement Studio plus Visual Basic.
Security considerations	Possible security threats to server if CGI program is not designed right; none to client.	Very little security concerns to client or server, because sandboxing limits what Java applets can do.	Security threats to client from unstable or malicious ActiveX controls.

Table 2. A Comparison of CGI, ActiveX, and Java

National Instruments Web Site for Academia

ni.com/academic

National Instruments has an established measurement and automation Website that gives users easy access to an enormous amount of information for assistance in developing, configuring, and maintaining computer-based measurement and automation systems. The Web site is designed to be a complete resource for your instructional or research needs. You can access the information by selecting your discipline and your application (instructional or research). If you are familiar with National Instruments products, you will find direct links to desired information. Students link to a special page where they can find information about job listings, internship and co-op opportunities, and LabVIEW-based projects.



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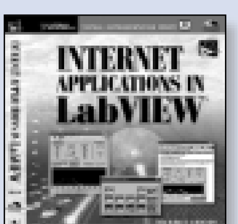
About the Author

Jeffrey Travis is the author of the Internet Applications in LabVIEW *(2000, Prentice-Hall) textbook and co-author with Lisa Wells of* LabVIEW For Everyone *(1997, Prentice-Hall). For more information contact jeffrey@JeffreyTravis.com, or visit his web page at* ***JeffreyTravis.com***



Internet Applications in LabVIEW is a tutorial and reference volume for LabVIEW programmers who want to learn to apply the latest Internet technologies to their LabVIEW solutions. The book covers in-depth topics such as TCP/IP, VI Server, DataSocket, ActiveX, Java, Web servers, network security, e-mail, and more.

The author's approach provides the necessary background information on Internet technologies, and then demonstrates how to apply them to LabVIEW. From client-server motion programs (VIs) to remote control over the Web, the text guides readers through hands-on activities and examples, with the source code on the enclosed CD.

For more information on this book and the associated LabVIEW-Internet connectivity course, visit **JeffreyTravis.com/books**

CUSTOMER SOLUTIONS

Education
- *Application Builder*
- *DAQ*
- *LabVIEW*
- *Picture Control Toolkit*

Remote Manipulation with LabVIEW for Educational Purposes

by Denis Gillet, Christophe Salzmann, and Eduardo Gorrochategui, Swiss Federal Institute of Technology – Lausanne (EPFL)

The Challenge: Manipulating a physical setup located in a remote laboratory, so that teachers can instruct from the classroom and students can learn from home. Providing distance access from campus as well as worldwide.

The Solution: Taking advantage of LabVIEW capabilities, such as Distributed Computing Tools, to build a link over the Internet between client computers and the physical setup. Designing a user interface that reproduces the look and feel of the local environment on the client side by combining virtual representations and live video feedback of the distant setup.

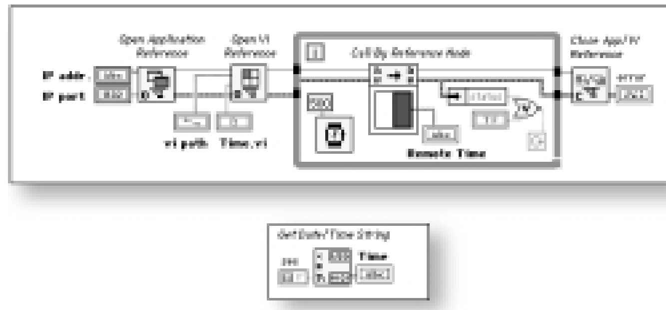
The high-level networking capabilities of LabVIEW empower instructors to implement virtual instruments for remote manipulation in a highly efficient manner, both from a time and resource point of view.

Introduction

Instructors need to have a distance learning opportunity readily available for classroom teaching. To avoid moving the experimental setup to the classroom or to overcome the difficulties of accessing laboratory facilities at any time, it is useful to provide interactive and remote access to such facilities. We designed a multiplatform client-server solution based on personal computers, which share information through the Internet, to serve this paradigm. LabVIEW is clearly the ideal candidate to provide the high level of interactivity and interoperability required for educational purposes.

The Laboratory Environment

One of the physical setups available for studying motion control at the Swiss Federal Institute of Technology in Lausanne (EPFL) is composed of the real process – a servo drive – connected to a Power Macintosh via a data acquisition (DAQ) board (National Instruments PCI-1200). The control software piloting the real process locally is a virtual instrument (VI) built using LabVIEW. An in-house real-time kernel extends LabVIEW capability and guarantees high-speed and accurate pace. The VI provides a complete interface between the user and the real process. It is used to generate excitation signals and observe corresponding responses. The main concept of such an interface is to provide a general view of the real process evolutions and facilitate full control of the operations.



A Simple "Call-By-Reference" Example

The Communication Architecture

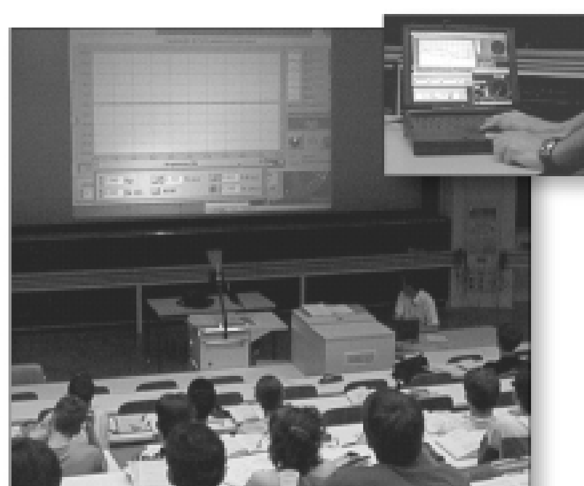
Given its fully computer-based implementation, we can easily expand the laboratory environment for remote manipulation. The main concept in turning the locally controlled setup into a remotely controlled one consists of moving the user interface away from the experiment. Two distinctive parts result – the remote client and the local server.

- The remote client is a computer equipped with the user interface functions. The client software with which the users can observe and act on the remote experiment is an executable application compiled for the target platforms using the Application Builder.
- The local server is the computer located in the laboratory and equipped with the hardware interface to the sensors and actuators. The server software receives the client commands and transmits them to the real process. It also returns the state of the real process to the client.

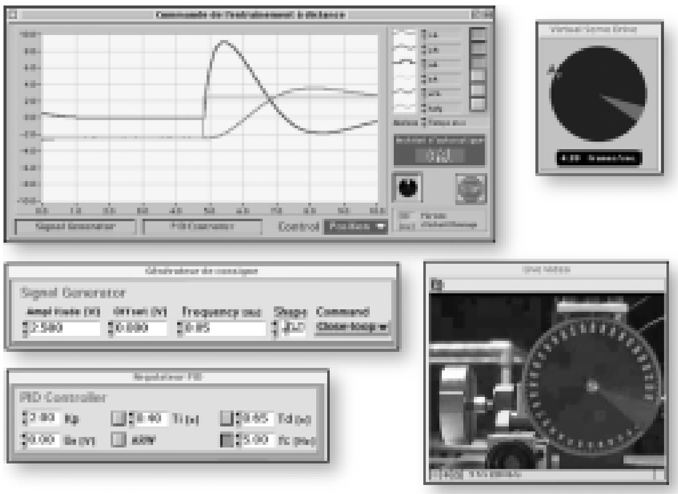
These two parts are linked through a communication layer built on LabVIEW Distributed Computing Tools.

Distributed Computing Tools

National Instruments has introduced an approach to call a subVI in LabVIEW, referred to as a call-by-reference. This principle is similar to Remote Procedure Call (RPC) under Unix. This approach is implemented with LabVIEW, which means simplicity and ease of use. Using this new mechanism, we can call a subVI on a local or a remote machine using TCP/IP transparently. The only difference between these two types of calls is the need to define the IP address and IP port of the remote machine. The remote machine, acting as a server, needs to be correctly configured. Prior to calling the subVI, the user needs to establish a connection with the server.



The Teacher and the Remote Setup in Action



Client's View

PowerBook G3) equipped with a built-in Ethernet interface and is manipulated by the teacher. The students can watch a copy of the computer screen projected onto the wall.

We perform remote manipulation of the servo drive during the lecture to enlighten the presentation of the subject matter. According to the topic studied, instructors can select different configurations – position or speed control, P, PI or PID controllers with different sets of parameters.

The user interface of the control software is presented in the figure at left. It consists of an oscilloscope signal visualization, a signal generator providing the reference, and parameter settings for the controller. An additional window provides a reconstructed virtual representation of the dynamic evolution (actual position of the rotating disk) driven by the transmitted measurements. We use the LabVIEW Picture Toolkit for this purpose.

The image and the sound of the physical setup are transmitted to the user with video conferencing software. The audio/video server runs in parallel and independently of LabVIEW on the computer connected to the real process (server).

On termination, the connection needs to be closed. A simple example of a remote machine transmitting its local time is shown in the figure at the top of this page. On the server side, the user can specify access by allowing or denying given addresses or domains. The user can also restrict access to the VIs called. To implement the remote manipulation of the setup, we used four call-by-reference VIs. The first one transmits the controller parameters from the client to the server, the second sends the measured values from the server to the client, and the last two implement watchdogs to detect if the client or the server are still available.

Application of Remote Laboratory

We apply the remote manipulation paradigm regularly within the basic automatic control course taught at the Swiss Federal Institute of Technology in Lausanne. Students from electrical engineering, mechatronics, mechanical engineering, and computer science attend this course simultaneously (about 160 students) in a large auditorium. The client software is installed on a portable computer (Apple

Conclusions

The LabVIEW Distributed Computing Tools give us the ability to perform highly interactive remote manipulation inside an institution equipped with an Intranet. This requires only minor changes when a local solution already exists. Therefore, it is well-suited for live demonstrations conducted by the instructor in the classroom or for experimentation carried out by students from a computer room. In this way, practice time is unrestricted. You can apply the same approaches for teaching and learning using remote facilities from home or even overseas connections. This requires the integration of lower level LabVIEW tools (IP) to use the available bandwidth wisely.

The LabVIEW Distributed Computing Tools give us the ability to perform highly interactive remote manipulation inside an institution equipped with an Intranet.

Compared with experimentation in virtual reality, remote manipulation on real processes is easier to implement and more versatile. In fact, adding or selecting another physical setup does not involve the elaboration of complex mathematical models and graphical representations.

Finally, remote experimentation is not limited to education. In research and industry, remote accesses also represent an interesting opportunity to meet the growing need of scientists who wish to share unique or expensive equipment and to give support engineers the ability to operate immediately at customer facilities. The high-level networking capabilities of LabVIEW empower instructors to implement virtual instruments for remote manipulation in a highly efficient manner, both from a time and resource point of view.

For more information, please contact Denis Gillet and Christophe Salzmann, Swiss Federal Institute of Technology – Lausanne, IA – DGM – Ecublens, CH – 1015 Lausanne, Switzerland, denis.gillet@epfl.ch and christophe.salzmann@epfl.ch

Conducting Experiments Over the Internet using LabVIEW and ComponentWorks

by Pee Suat Hoon, Department of Electrical Engineering, Singapore Polytechnic

The Challenge: Developing interactive experiments for students over the Internet.

The Solution: Using technologies such as ActiveX, ComponentWorks, LabVIEW, and the Internet Developers Toolkit to conduct and transmit experiments over the Internet.

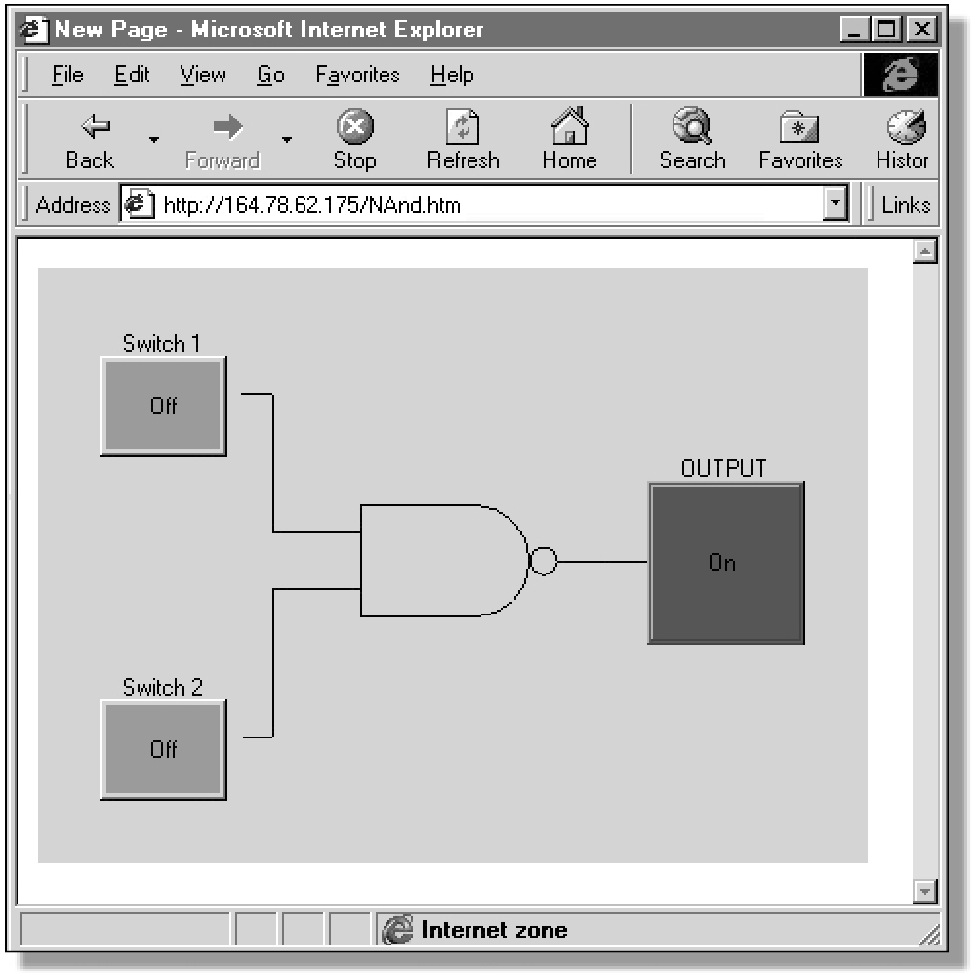
Introduction

Education for engineers requires a combination of theoretical knowledge and practical experience. Theories are discussed during lectures while students gain practical experience in the laboratory through experiments. With laboratory work, students can find their own meaning through self-directed activity and further understand the concepts covered during lecture.

Several tools have eased development of the above interactive laboratory experiments. These include Ispy, ActiveX control pad, Visual Basic Control Creation Edition, Internet control components, and National Instruments ComponentWorks.

Traditionally, educational software systems have been tied to a particular type of computer and operating system. However, with advanced technology such as ActiveX, users can now prepare the software systems and make them available worldwide on the web. The benefits of Web-based training materials include the independence of location, ease of use, accessibility, and reduced cost. Students are not required to purchase additional software using the web browser.

The impact of combining emerging technologies, educational animation systems, and hypertext delivery mechanisms for standard instruction as well as remote learning from a virtual laboratory is profound. There is great potential for Web-based training. In fact, Web-based training may grow from $1.7 to $3 billion by the year 2000 (Control Engineering, December 1997).



Web-Enabled Experiment

Web-Enabled Experiments

User-interactive animations over the Internet conducting an experiment in a remote laboratory in real-time are two variations of experiments that were developed. Engineering subjects such as digital electronics, programmable logic controllers, and control engineering are all suitable subjects for Web experiments. The figure illustrates a digital electronics experiment designed and coordinated over the Internet, in which students can interact with Switches 1 and 2 to observe output.

Besides simulations, it is useful for students to explore and conduct real-time experiments over the Internet. The figure on the next page depicts the setup required for such an experiment. In this situation, students use Internet Explorer or Netscape Communicator as the user interface and interact with the input settings. Students send the input settings over the Internet to the experiment, housed in a remote laboratory. The experimental rig produces outputs that National Instruments LabVIEW monitors. Students can publish results with the click of a button using the Internet Developers Toolkit. After applying the necessary input conditions, students then wait to see results from the same Web browser.

A digital image of the experimental rig is also available. After students are satisfied with the results, they can either print them out or e-mail the lecturer a laboratory report with the necessary plots obtained from the Web browser.

Several tools have simplified the development of such interactive laboratory experiments. These include Ispy, ActiveX control pad, Visual Basic Control Creation Edition, Internet control components, and National Instruments ComponentWorks.

Preparing Experiments for Use over the Internet

It is possible to develop the experiments described in this article by building the ActiveX component using Visual Basic Control Creation Edition software and Preparing the OCX for Internet download.

Building ActiveX Component for Download

Visual Basic Control Creation Edition provides the platform for creating the necessary ActiveX OCX. Preparing this component is now simplified by using ComponentWorks by National Instruments. User interface components, such as switches and sliders, are provided. Thus, the only task required is to prepare Visual Basic scripts. Once the OCX is compiled, we are ready to distribute experiments over the worldwide web. Additional Internet and data acquisition controls will be required for preparing the experiment for remote control. Specifically, Winsock and analog output controls will be required.

Preparing the OCX for Internet Download

The application setup wizard from Visual Basic Control Creation Edition is used for this purpose. This wizard provides point-and-click forms where settings are entered. To use the forms, the "Create Internet Download Setup" option must be chosen. Several files are created when the Setup Wizard manages to collect the essential information. The most important files are the cabinet (.cab) and html files. The .cab file contains all the information necessary to download, install, and register the components required to run the controls on an HTML page. The benefits of this architecture include file compression for faster download, a single file to describe necessary files, and automatic installation information when the control component downloads.

Conclusion

We successfully conducted interactive experiments over the Internet using enabling technology such as ActiveX, National Instruments ComponentWorks, LabVIEW, and the Internet Developers Toolkit.

Ms. Pee Suat Hoon is a lecturer with the Department of Electrical Engineering, Singapore Polytechnic. She can be contacted by email at PeeSH@sp.ac.sg

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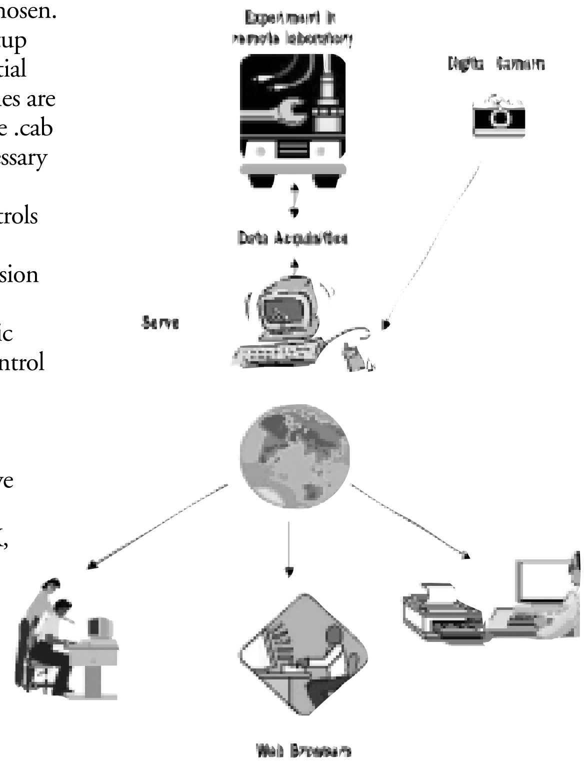

Conducting an Experiment over the Internet

CyberLab, A New Paradigm in Distance Learning

by Lambertus Hesselink, Ph.D, Professor,
Dharmarus Rizal, Research Associate,
Eric Bjornson, Ph.D, Post-Doctoral Fellow,
Stanford University

The Challenge: Providing students with an Internet-controllable laboratory to assist in learning complex physical processes through distance learning.

The Solution: Creating Cyberlab, a Web-based laboratory, which incorporates National Instruments LabVIEW, IMAQ, and GPIB boards.

Introduction

Distance learning is an exploding field, driven by the Internet revolution. However, a key component of current distance learning implementations in science and engineering is missing – distance laboratory experimentation. Classical laboratory teaching programs are costly, therefore we developed this new laboratory environment as a means of lowering staffing and training costs, keeping up with technology, and maintaining laboratory usage.

CyberLab provides a novel, cost effective paradigm for distance learning with National Instruments tools.

CyberLab addresses these issues, and provides an innovative solution for sharing of resources among institutions. It provides students access to the laboratory from anywhere, at anytime at a substantially reduced cost. We have created a full-scale implementation of a physical laboratory using National Instruments software and hardware tools. Although we have chosen an optical experiment in this pilot program, the concept of CyberLab lends itself for experimentation in almost any field, including but not limited to engineering, physics, biology, chemistry, medicine, and material and earth sciences.

An Optics Experiment Viewed and Controlled Using a Web Browser

The CyberLab interface provides a lab scheduler, reference library, course material, computer-based analysis tools, testing facilities, and a lab notebook – the key concept of the laboratory. It provides the classical functions of data recording and note taking and acts as a central repository of data describing the student's progress in the laboratory, the results of tests, data obtained during the course of the experiment, correspondence with the teachers and assistants, as well as a complete history of all steps taken by the student. Teachers can also use the notebook to efficiently evaluate the students' performance and as a tool for organizing and managing laboratory information. However, without the hardware and software from National Instruments we would not have been able to integrate this complex set of functions into a seamless CyberLab program, and complete this phase of the project in the allotted nine months.

System Hardware

The system is implemented using a standard 300 MHz Pentium II PC. We use a PCI-GPIB board to control and monitor a 635 nm diode laser. To display live pictures from the lab, we used the IMAQ PCI-1408 board to digitize the analog video signal from a standard camera. Our existing motion control system, based on National Instruments LabVIEW, automatically controls camera motion.

System Software

We first developed software libraries for instrument control, data acquisition, and analysis using LabVIEW. We also used IMAQ Vision for G to provide image-processing libraries such as a Fast Fourier Transform (FFT) routine to speed-up development of live data analysis software.

After we tested the experiment on site, we developed Web-based access that provided users access to remotely monitor and control the lab set-up in real time. We used National Instruments Internet Toolkit, with HTTP Server software, to process the user requests from Web browsers. The Server also provides a configuration utility to implement secured access to the experiment. Live image acquisitions as well as instrument front panels transmit continuously to the user browser at a rate of one frame per second, and users can monitor experiments in real-time over the Internet.

CyberLab provides a novel, cost-effective paradigm for distance learning. Students expressed that they increased their understanding of errors, and they reacted positively to the usage of the remote laboratory environment. They agreed that the remote laboratory experiment helped to illustrate concepts learned in class. Students found the remote laboratory an effective tool for enhancing their knowledge of optics and their understanding of the course material and the physical world.

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Electronic Instrumentation Laboratories on the Net

by Andrea Bagnasco, Marco Chirico, Walter De Michelis, Alan Rossi, and Anna Marina Scapolla, Department of Biophysical and Electronic Engineering, University of Genoa, Academic and Industrial Training

The Challenge: Supporting the increasing demand of distance and continuous education on electronics through the remote access to an electronic instrumentation laboratory on the net.

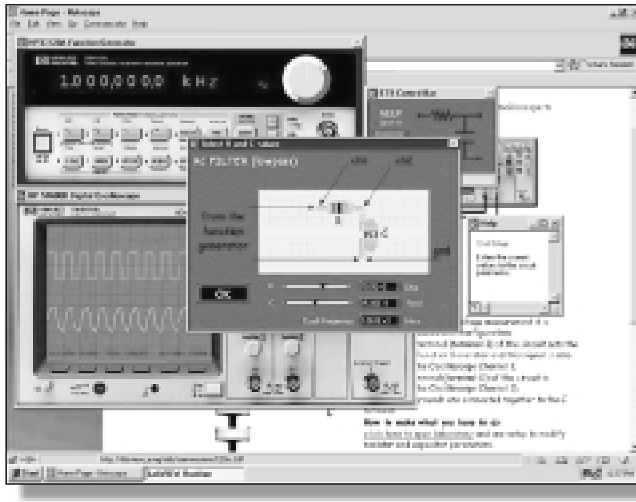
The Solution: Designing and implementing an interactive Web-based environment, the Electronic Test Bench (ETB), consisting of virtual instruments and guided experiments on basic circuits to create a virtual laboratory.

Abstract
Telematics and new programming technologies support the increasing demand of education and training leading to the delivery of computer-based learning systems open to distance and continuing education.

Using LabVIEW and Internet Developers Toolkit, we designed and implemented an interactive learning environment for practice on electronic measurement methodologies. The environment provides remote access to real and simulated instrumentation and guided experiments on basic circuits.

The environment is applied to the education on electronics during engineering graduation curricula.

Introduction
The exponential development and diffusion of information technologies of the last few years have produced a considerable amount of research and activity in the field of computer-based education aimed at:
- The enhancement of effectiveness of the learning process
- Multimedia educational material for high-quality training programs
- The improvement of methods and techniques for the "open" distribution of training material and the interoperability of resources.



An ETB Session

More recently, computer networks have become a driving force addressing client-server dynamics and network services. The traditional way to support learning and training activities and to produce, and distribute learning materials changed, and the concept of "virtual classroom" was introduced. Teachers make available didactical material on the network and guide the learning process using electronic communication tools. The virtual approach is suitable for distance learning, continuing education, and professional training and can encompass the entire learning process.

The term "virtual laboratory" refers to a representation of the laboratory, that is distributed on the network and provides access to and control of the real laboratory instrumentation and experiences, via student software simulation.

Our work extends the virtual approach beyond the distribution of didactical material to provide practice opportunities remotely. A virtual laboratory, to practice instruments and to conduct experiments addressed to the knowledge of measurement methods, plays a significant role in the learning process of electronic measurement and test.

The term "virtual laboratory" refers to a representation of the laboratory that is distributed on the network and provides access to and control of real laboratory instrumentation and software simulation.

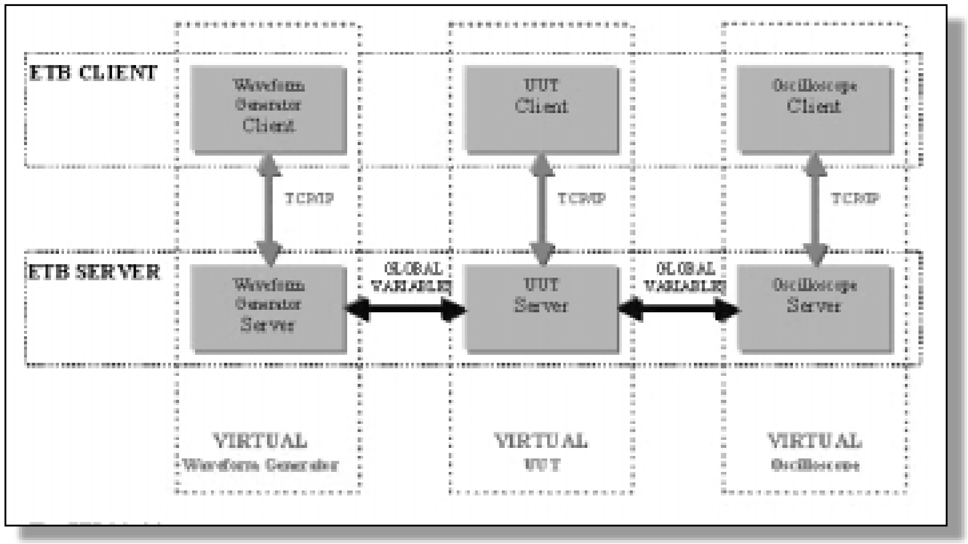
Virtual instrumentation helps to meet the challenge in a timely and cost-effective manner. Moreover virtual instrumentation systems dramatically reduce the time required to develop complex test programs and unify the separate worlds of test and measurement and industrial automation.

The proposed approach provides the following advantages:
- Students (users) can remotely operate laboratories
- Laboratory instruments are used by more than one person at a time
- Students "design" their own experiment
- High-cost instruments are shared by many researchers
- Incomplete use of resources is avoided both in academic and industrial sites
- Virtual laboratories become part of distance learning curricula, with all the related advantages
- Standardization of course/laboratories format can ease authoring and enlarge the availability of teaching/training material.

The Electronic Test Bench
With the ETB students practice with instruments and execute measurement experiments on electronic circuits through the Web. Students receive an introduction to the virtual laboratory, a set of on-line instrument manuals, and a set of experiments/lessons leading to gaining knowledge of instruments and measurement procedures.

Each lesson has a didactical target and offers a collection of exercises using virtual instruments. Hypertext guides the student to connect test circuits to the instruments and stimulate them with known signals in order to analyze the answers.

So far, a waveform generator and an oscilloscope were developed. The student starts the instruments panels, presses buttons, rotates knobs, and sees the results of these actions on the screen as if he/she was acting on real instruments. Using the control panel of the waveform generator students can view different kinds of waveforms and the variation of waveform parameters like amplitude, frequency, offset, and duty-cycle. Similarly, with the oscilloscope interface, students visualize one or both channels, and set various parameters such as the time scale, amplitude, vertical and horizontal shift, trigger setting, and screen brightness.



The ETB Model

A Look Inside the ETB

The ETB consists of three macro-blocks:

- The Web site
- The ETB server
- The ETB clients

The Web site delivers hypertexts and virtual instrument panels. We installed a G Web server, which is an HTTP server supplied with Internet Developers Toolkit. The Web also provides tips for the client's configuration.

The ETB takes advantage of the new features of LabVIEW and Internet Developers Toolkit, optimizing the distribution on the network of the instruments' interfaces and creating a successful virtual laboratory that can be an asset to almost any electronics distant and continuous education program.

The ETB server consists of the instruments' drivers and simulators of the circuits under test (Unit Under Test – UUT). The instruments' drivers and simulators are independent software modules and communicate by means of global variables. Each instrument driver receives input commands from the clients and then simulates the real instrument behavior. These commands are formulated according to the IEEE 488 Standard; in this way, we can reuse the same software modules both for real instruments control and for simulation.

The ETB clients are distributed on the net. They run the instruments and UUT interfaces; the instruments' front panels are characterized by a strong realism and obtained by a heavy customization of LabVIEW basic elements. The communication between the students and the server has been realized using the "VI server" features, and in particular using the "call by reference node" function, with which we set the communication through TCP/IP in an easy and functional way.

Conclusions

The ETB takes advantage of the new features of LabVIEW and Internet Developers Toolkit, optimizing the distribution on the network of the instruments' interfaces and creating a successful virtual laboratory that is an asset to almost any electronics distant and continuous education program.

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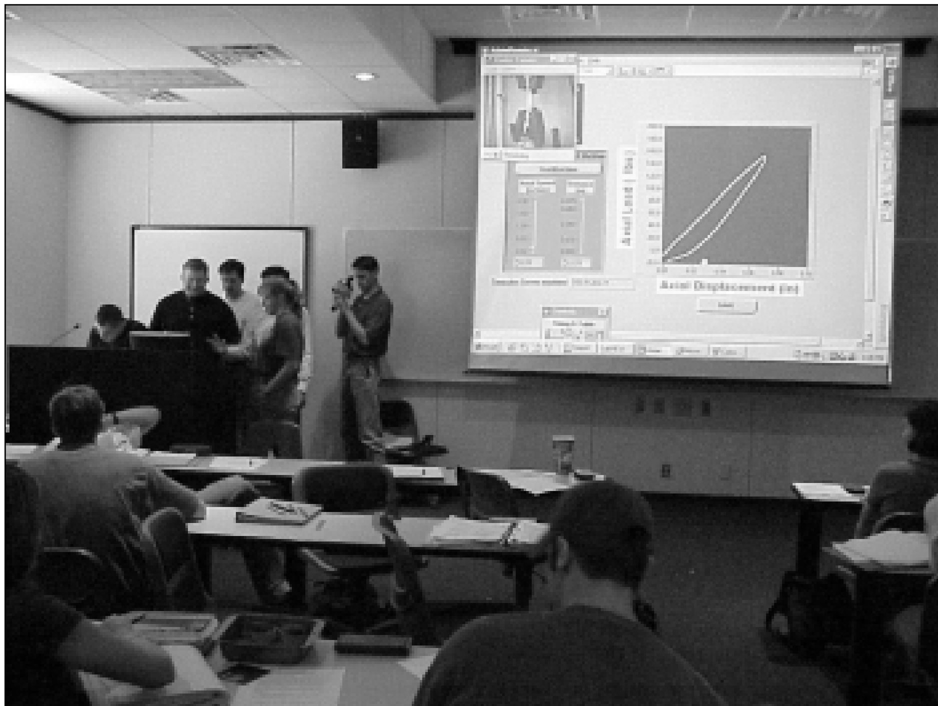
Mechanics of Materials Experiments Via the Internet

by Carlos L. Yapura, Richard Griffin, Dimitris C. Lagoudas, Research Associate, Professor, Texas A&M University

The Challenge: Developing remote experiments via the Internet that demonstrate the mechanics of materials taught to students who do not have access to a laboratory facility.

The Solution: Using LabVIEW with DataSocket to create virtual instruments (VIs) that access a tension/compression/torsion test frame via the Internet.



A Team of Students Performing a Remote Tension Test

Introduction

We developed experiments pilot-tested to sophomore-level engineering students at Texas A&M University as part of the NSF Foundation Coalition effort to restructure engineering courses. The courses, taught to a large number of the engineering students, have significant time constraints, therefore the timely execution of these labs is of primary importance. Using LabVIEW, students remotely ran tension tests and obtained data in a time-efficient manner.

Controlling the Testing Machine

We developed experiments using an adelaide testing machine (ATM), equipped with computer controlled loading and data acquisition. The ATM is capable of pulling specimens in tension, torsion, and compression and is controlled by a personal computer through two XT-type cards. We used LabVIEW to customize a test according to an experiment and created a VI that specified a deformation history by sending the corresponding commands to the servomotors of the ATM. The VI could easily be modified to specify any deformation history composed of axial and rotational motions.

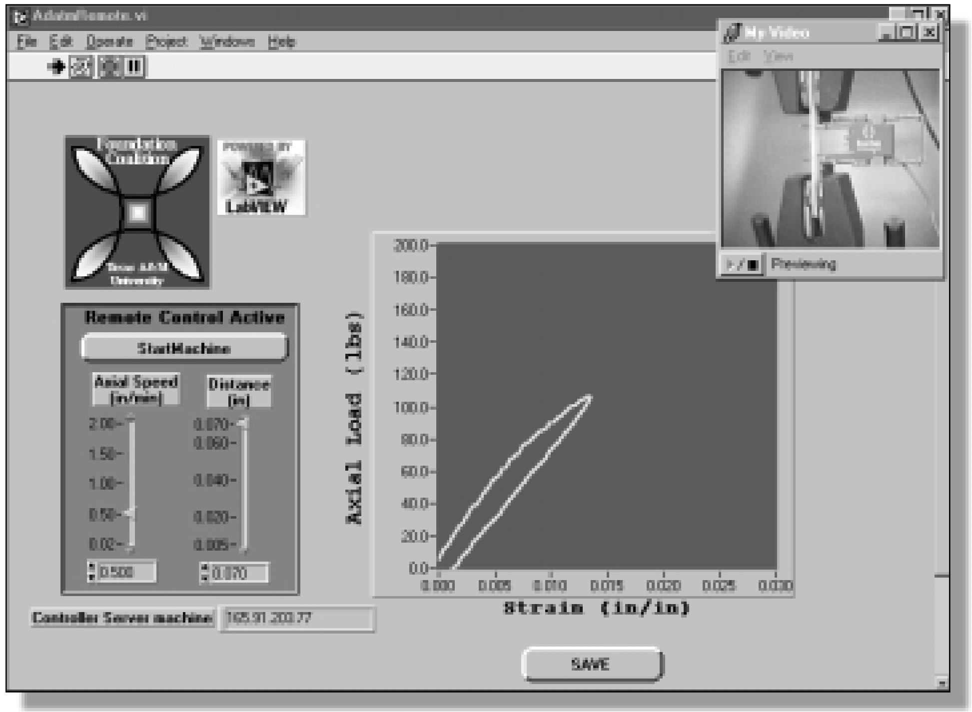
We used LabVIEW to customize a test according to an experiment and create a virtual instrument (VI) that specified a deformation history by sending the corresponding commands to the servomotors of the ATM.

Designing a Remote Mechanics of Materials Experiment

We used an ATM controlled by LabVIEW and DataSocket to conduct a remote experiment. During the first pilot test, students ran tests in succession using a single client computer. We designed a VI example that would repeat immediately after a test run by specifying a single cycle loading history. We attached the specimen once by an operator and loaded the specimen cyclically as many times as needed. The operator selected the maximum displacement of the cross-head and also the cross-head speed for a tension test. After setting these two parameters, the students executed the experiment from the client computer in the classroom. The students plotted the data points on the screen concurrently with the motion

ATM Test Frame Used for Tension, Compression, and Torsion Tests of the servomotors. They viewed a video stream of the current experimental setup to obtain a feedback of what was physically happening in the lab.

Using LabVIEW, students remotely ran tension tests and obtained data in a time-efficient manner.



Control Panel in LabVIEW Used for the Remote Tension Tests

Results

The class completed testing in less than half the time required for traditional experimentation. In the future, we can increase efficiency by using the various client/server features of DataSocket in classrooms. The technical support received from National Instruments for the implementation of DataSocket was extremely helpful during the development of this test. We successfully delivered the first pilot test as a result of the combined efforts from the Foundation Coalition Team at Texas A&M University and National Instruments.

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