

Virtual Labs for Distance Education Classes

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Abstract

In this paper, the concept of virtual labs in Engineering and Engineering Technology curriculum is introduced. LabVIEW's Internet features make it possible to implement virtual labs over the Internet. A demonstration of LabVIEW in developing PID control of a second-order plant is shown. Virtual labs provide an opportunity for non-traditional students to perform Engineering and Science experiments online. LabVIEW's Internet Toolkit along with its powerful graphical tools makes it one of the most attractive software packages in all disciplines in science and engineering.

Introduction

Life long learning in industry and educational institutions require the development of learning environments for computer-aided instruction, online instruction, and blended distance education. Educators must be prepared to provide students with electronic learning environments using new and emerging technologies. Lecture style courses are now a common offering via distance education. However, most of science and engineering laboratory courses are limited to traditional classroom presentation due to the *hands-on* nature of the curriculum content and the need to utilize laboratory equipment in order to demonstrate concepts and complete lab exercises and tests. The need is strong to develop virtual labs that can be offered using distance education.

Virtual labs have the following advantages:

1. **Cost effectiveness** -- the ability to simulate high cost experiments, which are often complicated and complex. Virtual labs can greatly reduce the cost of initial purchase of equipment and materials.
2. **Safety** -- the elimination of risk associated with running high-powered equipment in electrical labs.
3. **Flexibility** -- the provision of a constant lab environment allows students to work on projects and experiments on demand. For courses at a distance, this means that the lab work required for an online engineering course is not only available to the

students anywhere, but also anytime as part of the asynchronous tools that students access for their courses.

4. **Feasibility** -- virtual labs support the growing emphasis on distance education by making activities available that were previously found only in traditional courses.

Virtual labs are currently implemented in disciplines of Engineering and Technology for either complementing existing classroom labs or for demonstrating science topics. Institutions that have developed online labs include:

1. The University of Tennessee at Chattanooga, has used LabVIEW to set up virtual experiments on six different engineering systems. Their work can be viewed at:
<http://chem.engr.utc.edu>
2. The University of Oregon, Department of Physics, has a virtual lab website that simulates topics in astrophysics, environmental science, energy, and thermodynamics. Their website address is
<http://jersey.uoregon.edu/vlab/>
3. Northwestern University, Department of Physics, includes other relevant available links:
<http://www.physics.nwu.edu/ugrad/vpl/index.html>
4. Telemark University College, has developed SYSLAB that consists of a set of virtual experiments using LabVIEW. These can be downloaded free of charge at
http://techteach.no/syslab/index_eng.htm

Introduction to LabVIEW's Internet Features

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a powerful and flexible instrumentation and analysis software system that was introduced by National Instrument. LabVIEW departs from the sequential nature of traditional programming languages and features an easy-to-use graphical programming environment, including all of the tools necessary for data acquisition, analysis, and presentation¹. With this graphical programming language, called "G", you can program using a block diagram method that compiles into machine code. With LabVIEW, your software becomes your instrument, since you define the functionality you need².

LabVIEW allows computers to communicate with web by using a program called a *web server*. It provides either a static ("snapshot") image of a VI's front panel or a dynamic animated image ("monitor") of the VI's front panel². *Web server* can also be used to publish your web document with LabVIEW. LabVIEW is equipped with the standard TCP/IP protocols for network communication.

There are major communication mechanisms in LabVIEW: the VI server and DataSocket³. We will briefly describe each mechanism. Details of LabVIEW's Internet applications and implementation can be obtained in Travis' *Internet Applications in LabVIEW*².

VI Server: this feature provides a way to build a networked LabVIEW application over TCP/IP. This feature generates LabVIEW *network transparency*². It means you can perform data acquisition and analysis from a remote area via Internet the same way as you could do on your computer.

DataSocket: is a protocol-independent, language independent, and OS-independent communication mechanism. It allows the user to send and receive data from various software platforms.

Common Gateway Interface (CGI), Java, and ActiveX technologies are methods of web-based control and monitoring of VIs. These three technologies are widely used for interactive tools to communicate via the web. LabVIEW supports all three technologies in its Internet Toolkit.

Data Socket versus VI Server: Regardless of which system you use, you will use *DataSocket*, *VI server*, or *TCP VIs* or a combination. VI server is used when you need to share a process and interface such as when displaying a front panel².

DataSocket is used when you need to share live data, regardless of how you are displaying, obtaining or storing them. DataSocket is also useful when you want data to be available to different type of clients.

LabVIEW Internet Applications

There are various Internet technologies and tools. Choosing the right one for your applications depends on several parameters. There are two issues to consider before selecting LabVIEW for intended applications:

A Client-Server System: In this case, the system is continuously available for the user. In client server systems, it is recommended to use a web-based solution. Advantages of web-based solution for client-server are that no special software is required to install and it has the lowest maintenance requirements. Disadvantages of the web-based solution are that it requires CGI, Java and ActiveX and that anyone could access the system².

Distributed Computing System: Here, a set of two or more machines work on the same task and they also share information in a distributed computing system. It is recommended to use a VI-based solution. Advantages of VI based solution is that it is easier for the remote user to control because it has a LabVIEW or better security. It's

disadvantages include the requirement that the user have the current version of LabVIEW. Remote users may have access to the source code².

The interface between the remote user and LabVIEW can be achieved in two ways:

Web Server: the web server receives requests from web browsers to perform an operation. In this mode, a sub VI can be used to perform data acquisition and control of connected equipment.

Direct Communication Interface: In this mode the remote user has direct access to LabVIEW's front panel -- the control panels and knobs. Implementation of a direct interface of PID control in LabVIEW will be presented in the next section.

Implementing a PID control of a second order system using LabVIEW

LabVIEW's Internet Toolkit along with its powerful graphical tools makes it one of the most attractive software packages for disciplines in science and engineering. LabVIEW can either be used to simulate processes or can be used for data acquisitions and analysis of real systems. Next, we present one such application for virtual labs in control systems.

Figure 1 shows a closed loop block diagram of a general second-order plant. The controller is a simple parallel combination of PID controllers. One of the advantages of this structure is the user's ability to test other combinations such as PI, PD, and P controller.

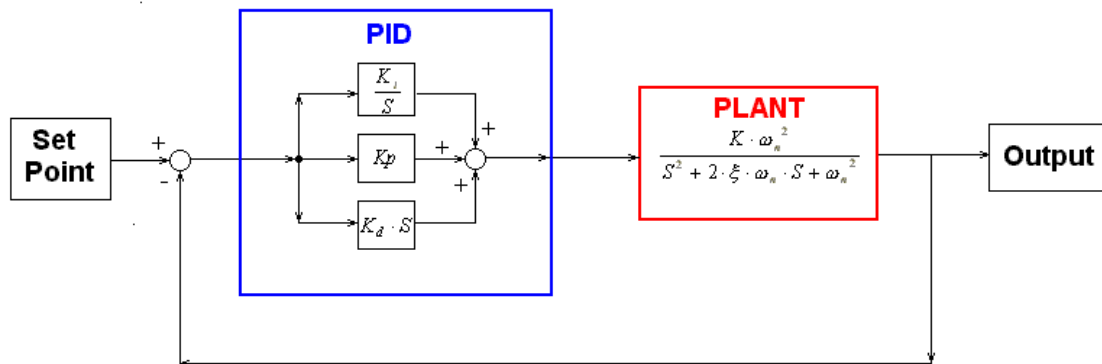


Figure1. Block Diagram of a PID Control of a Second-Order Plant.

Figure 2 demonstrates a front panel in LabVIEW, which is the implementation of a closed loop block diagram (as shown in Figure 1). The first set of radio buttons are designed to change sampling time, damping ratio, natural frequency, and constant gain. These parameters can be used to select a second order model. The second set of radio buttons are designed for set-point, proportional, integral, and derivative gains, as shown in Figure 2. This structure allows the student to perform various tests on the effect of changing sampling time, damping ratio, and natural frequency on the response of the

plant under control. These experiments can be done in a matter of minutes to verify control systems theory learned in a course lecture. The proposed program incorporates both the opportunity to change parameters in the controlled plant as well as tuning the PID gains.

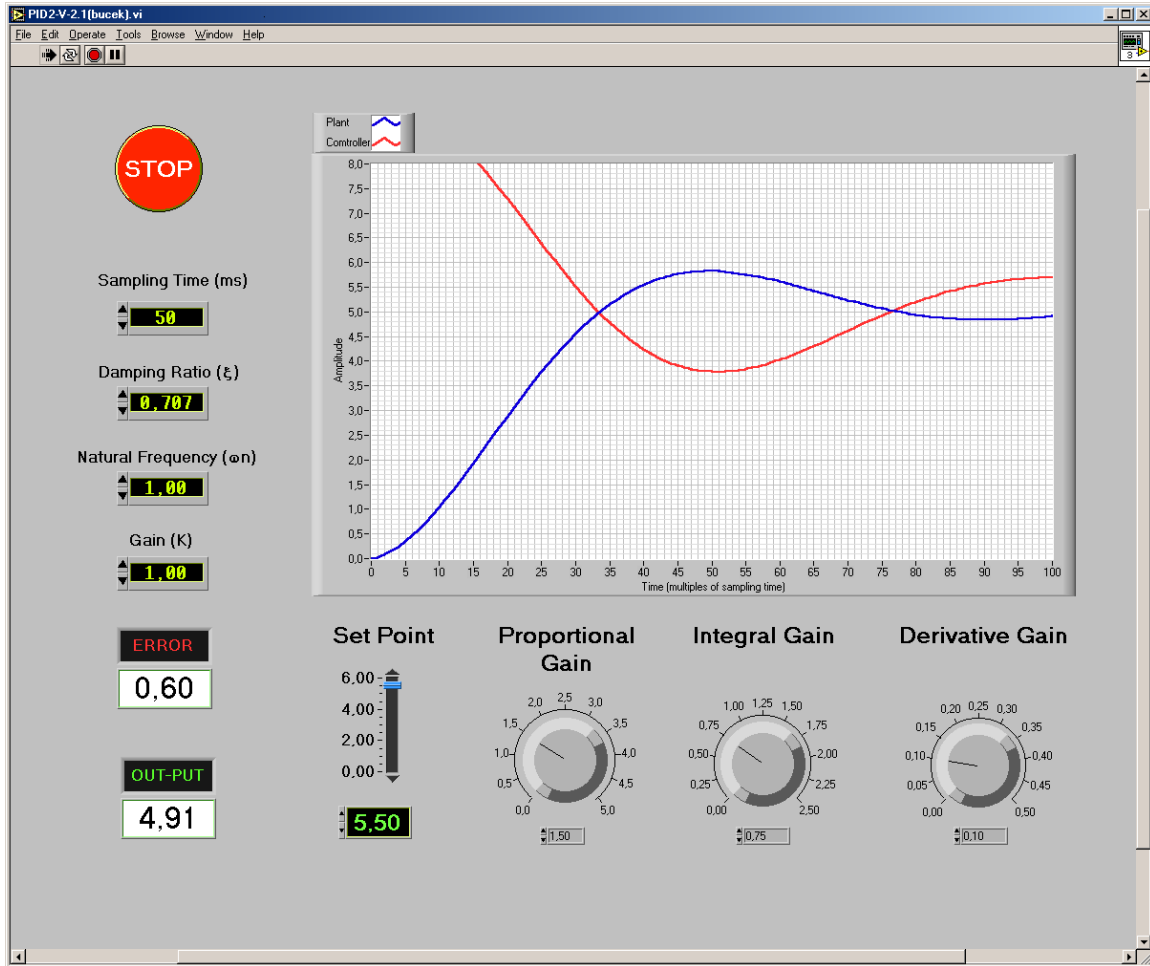


Figure 2. Front Panel of PID Control of a Second-Order Plant Using LabVIEW.

Conclusions

LabVIEW is an attractive choice for developing virtual labs for online environments because it provides a set of rich tools for high levels of interactivity and networked communications. Virtual labs can be used to complement traditional face-to-face labs or can simply be used for students who cannot attend the labs during regular hours. Virtual labs can reduce cost, maintenance, and completion time significantly. Virtual labs need to be fully explored in selecting technologies, software packages. Further work is needed to determine the effectiveness of virtual labs for distance education.

References

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