TECHNOLOGY FOR THE IMPLEMENTATION OF REMOTE LABORATORIES

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Abstract. Online virtual laboratories are a requirement for a modern and efficient education that provides students and pupils with educational tools appropriate to the development of any future profile engaged in the national or international economy. The present paper presents the current state of remote controlled laboratories and the technology of their implementation.

Key words: virtual lab; servomotor; Labview; Arduino; browser.

1. Introduction

It is known that the transition from the industrial society to the information society is taking place worldwide. Today's students, who will be tomorrow's specialists, need professional training to meet the new requirements imposed by the information society. In this sense, it is necessary to introduce and impose a fundamental change in the education process even from the undergraduate cycle.

We need to take into account that when starting work, students will need to have a certain amount of knowledge and skills in the field of information and communication technology and automated data processing. Computer use must become commonplace and indispensable for all students,

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similar to traditional means (books, notebooks, etc.). The rhythm of the new society is conditioned by the large amount of information that needs to be processed in real time.

The use of didactic software as a support in the student's teaching process is becoming increasingly acute. The multimedia, computer-aided learning opportunities (images, sounds, animations, etc.) are greatly increased in line with the new requirements imposed by modern education.

In the pre-university and university education institutions of the Republic of Moldova, the equipment of the laboratories is precarious and the laboratory activities are carried out in inappropriate conditions. Virtual Instrumentation is a solution when the laboratory in which there is a traditionally morally and functionally obsolete device must provide training standards at the standards level. The virtual lab can also be used when laboratory equipment is too expensive, unavailable or when the experimental procedure is unsafe.

One of the most important features of the virtual lab is the non-destructive nature of an experiment; for example, a student can learn from his failure without damaging the instrument involved. According to ABET, learning from failure is one of nine important aspects of engineering education. The virtual lab involves different programs such as LabVIEW, MATLAB/ Simulink, ANSYS, Java Applet and Flash, which allow simulation of laboratory environments.

The remote lab can be defined as the experimental procedure in which laboratory instruments are controlled from a remote location. The remote lab can be suitable for cases where the number of students enrolled in a course is too high, and there is also a limitation on the availability of certain laboratory equipment.

In a comparative study (Ma & Nickerson, 2006), virtual laboratories were defined as "duplications of real experiments", where the experimental structure is not real but simulated by computer software. They defined remote labs as "reality mediation", which is similar to the physical lab, as it also requires physical laboratory equipment and space.

The main difference between the remote laboratory and the physical laboratory lies in the distance between the laboratory equipment and the person conducting the experiment. In physical or classical laboratories, the equipment can also be controlled by a computer but, however, in the remote laboratory the experimenter is geographically located some distance from the experimental installation.

2. Bibliographic Analysis

In technical education, the use of remote laboratories depends on the flexibility, cost and efficiency of the system. The idea of remote laboratories came for the first time that Internet technology began in the 1970s. Since the

1970s, different online learning programs have been developed by educational institutions such as PROLEARN, MIT OpenCourseWare (Gomes & Zubía, 2008; Gustavsson *et al.*, 2009) Examples of widely used technologies of virtual laboratories adopted by engineering educational institutions are presented below.

a) Flash: There is no need for browser compatibility issues for this platform. With the plug-in only, Flash files can be viewed over the internet. It has been widely used by many different engineering schools around the world. For example, the University of Delaware has developed a virtual microscope using Flash (Barrett *et al.*, 2009).

b) Java: Java was used by (Chen *et al.*, 2009) to create a virtual lab system for learning the resistor color code. Customers can use the combo box to select different combinations of color strips in this model. The result is then calculated by the Java applet. Java has been adopted in many other remote and virtual laboratories.

c) Matlab / Simulink: This software is used in most today's engineering universities to perform simulation and modeling of various engineering issues. This is also widely used for research purposes. For example, (Schmid, 2001) presented a virtual laboratory using Matlab/Simulink using virtual reality. (Casini *et al.*, 2001) developed a Telelab automated control (ACT) using Java servlet and Matlab / Simulink.

d) LabVIEW: This commercial software is developed by National Instruments.

National Instruments – NI, has provided a revolutionary graphical programming environment-LabVIEW, which supports the above. LabVIEW offers everything you need to build measurement and test systems, process control and monitoring systems, scientific research, or complex data acquisition. LabVIEW is a programming environment for the present, but it will be a scientific tool absolutely necessary for future generations.

With LabVIEW, data acquisition, complex analyzes, and sophisticated data presentations can all be done in one programming environment, so making a specific application on a particular platform becomes an easy task.

LabVIEW enables quick and easy connection with measurement and control hardware so that a wide range of equipment can be easily configured and used, from stand-alone instruments to data acquisition boards, motion controllers, acquisition systems of images, etc. LabVIEW includes specialized functions for data acquisition, instrument control, measured data analysis as well as display and presentation of results. LabVIEW offers the flexibility of a powerful programming environment without the need for cumbersome programming in traditional languages.

Unlike general-purpose programming languages, LabVIEW provides users with specific functions for measurement, control and automation applications, thus speeding up application development. Using the Internet, applications created under this environment get the most powerful uses: a computer can control and command real processes in almost any domain and

remotely.

Recent developments in the field of remote laboratories include LabVIEW, which is based on all three different lab types: remote, virtual and hands-on (Abdulwahed, 2013). LabVIEW is designed to allow users access to the experiment.

3. On-line Control of LabVIEW Applications through HTM Pages

In the latest versions of the LabVIEW graphics programming environment, the Web server in the base package features a new communications technology, the Remote Panels feature, which allows the user to take control of an application by calling it inside an HTML page. Pages that allow you to take control of a Virtual Instrument can be done in an easy way by calling the Web Publishing Tool (Fig. 1).
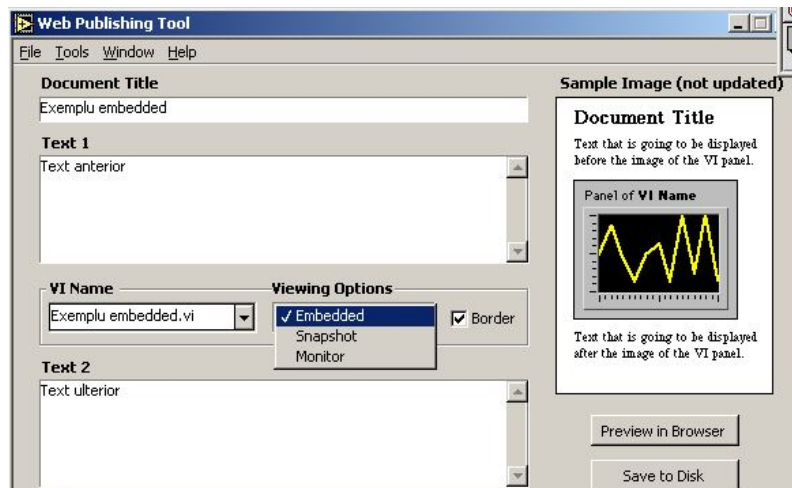
Fig. 1 – Web Publishing Tool.

Similar to Java applications, the Remote Panels feature requires at least the LabVIEW Run-Time Engine application on the client computer. When such an HTML page is displayed in an Internet browser, the Virtual Instrument interface initially appears as an animated image that reflects the evolution of the application running on the server (Fig. 2).

The user can take control of the application (Fig. 3), which is then transferred to the client computer, and the application running on the server will only perform a monitoring of the transferred and controlled user (Fig. 4).

The client waives the applications control (Fig. 5) or disconnects it from the server application that plays the role of connection manager, returning the situation to the initial state in which the client views how the application is running on the server (Fig. 6).
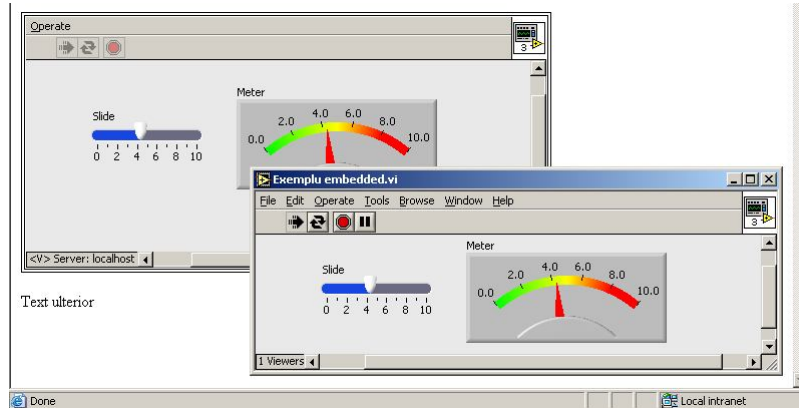
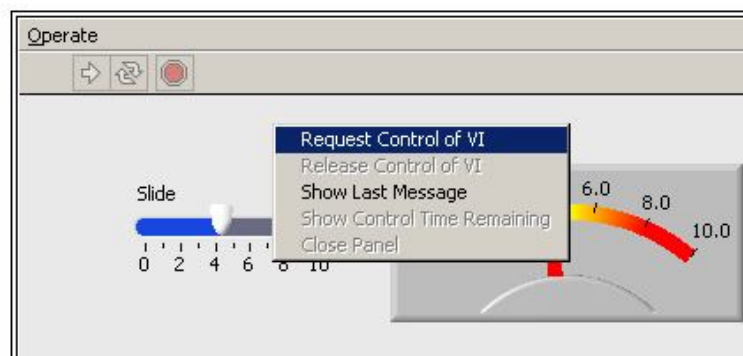Fig. 2 – The application running on the server.

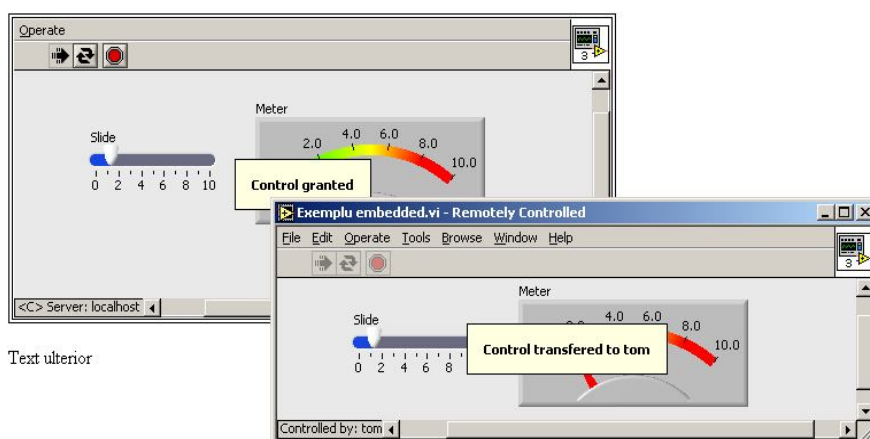Fig. 3 – Take control of the application.
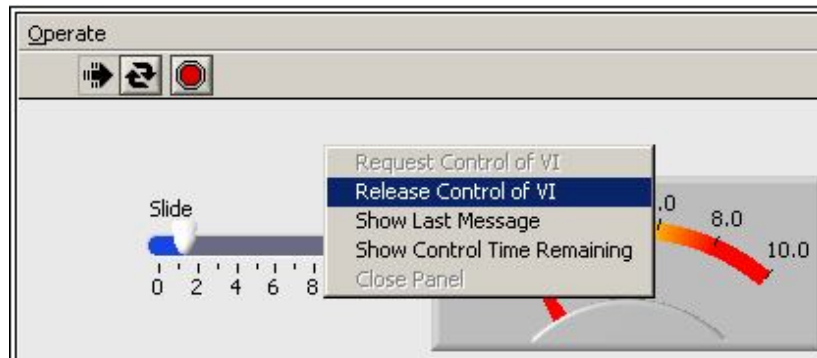

Fig. 4 – Monitoring the transferred application.

Fig. 5 – Client abandonment of application control.

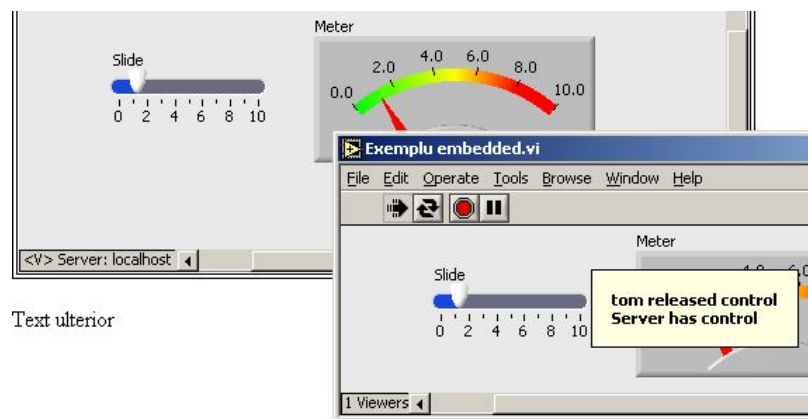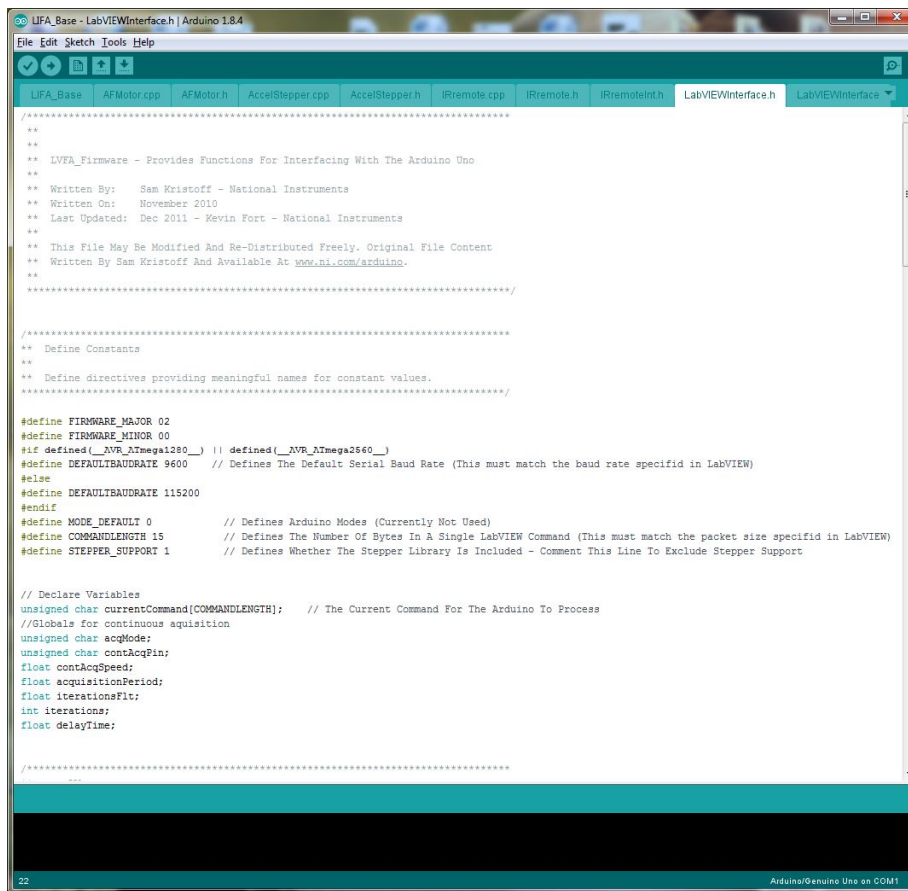Fig. 6 – Application on the server.

4. Application: Remote Control System of the Servomotor

Based on the above concept, a set of laboratory works was developed for the students from the Electromechanical Studies, an undergraduate program: experimental testing of a servomotor, the standard tests of a single-phase transformer, the use of PWM to control an LED, the creation of an automation with DC motor. Servomotor testing, for example, includes; start-up, lifting the mechanical feature, measuring engine parameters online, creating automation logic, and so on. The LabView application provides remote control of the actuator. In this case, the following steps are taken:

Step 1. We link the LabView application to the Arduino board. First, we download the "arduino-1.8.4-windows" exe file from the "https://www.arduino.cc/en/Main/Software" site. Then install it on your

computer. At the same time, download and install the "VI Package Manager" software from the "http://www.ni.com/tutorial/ 12397/en/", which contains the program file that provides the LabView interface with arduino (Fig. 7).

Step 2. Load the program in Fig. 7, in the memory of the Arduino UNO board. This ensures communication between Arduino and LabView.

Fig. 7 – LabView interface with Arduino.

Step   3. The front panel (Fig. 8), which contains the control and acquisition part of the laboratory and is visible to the student, is also elaborated, as well as the block diagram (Fig. 9), which is intended for the creation of control logic of the actuator, it is not visible to the student.

In the front panel for servomotor control, the student can change: the direction of rotation of the actuator, the number of steps, the angle of rotation, etc. LabView also allows real physical parameters of the servomotor to be viewed, such as voltage, current, and so on. In order to pay attention to the laboratory work, each student receives an individual task on the study of the

servomotor and the results he/she includes in the report and sends them to the teacher on the electronic educational platform (*e.g.* Moodle). The platform provides online communication between teacher and student. So the student can ask any questions at any time. This possibility gives the student the maximum speed to elaborate and present the report of the laboratory work.
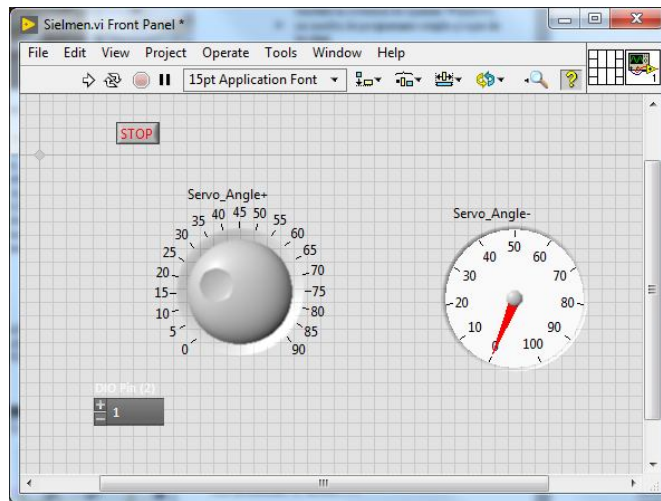

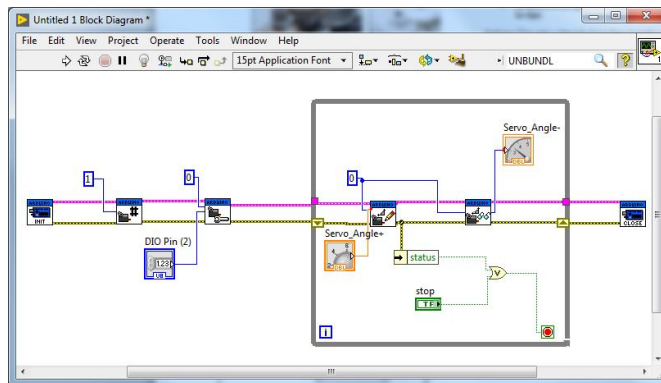Fig. 8 − Front panel for servomotor control.

Fig. 9 − Bloc Diagram for servomotor control.

5. Conclusions

The various facilities that LabVIEW's graphical programming environment provides for the transfer of information allow for the development of applications for virtual labs with varying degrees of complexity and various levels of user access:

1. Assuming that a server application is running on a data acquisition board computer that performs measurements in a real process, the most simple access level of a user connected to the Internet is one that can be viewed through a browser , front panel (interface with user) of the server application, in order to monitor the process monitored or controlled.

2. If the user has the LabVIEW graphics programming environment or at least the LabVIEW Run-Time Engine and has the appropriate access rights, he or she can take control of an application with the Remote Panels facility and be able to handle the commands at the as if they were working directly on the server computer.

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TEHNOLOGIE PENTRU IMPLEMENTAREA LABORATOARELOR VIRTUALE

(Rezumat)

Laboratoarele virtuale online sunt o cerinţă pentru o educaţie modernă şi eficientă care oferă elevilor şi studenţilor instrumentele educaţionale adecvate dezvoltării oricărui profil de activitate în economia naţională sau internaţională. Prezentul articol prezintă starea actuală a laboratoarelor virtuale şi a tehnologiei de implementare a acestora.