Innovative Remote Experiments using Virtual Instruments for Effective Engineering Education

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Abstract

Computer-based learning in presence of accessibility to World Wide Web plays an important role in education systems nowadays. It provides great facilities such as animation and interactive processes that are not possible with textbooks. Web/Internet-enabled applications that can be fully controlled and monitored from remote locations are extensively used by a number of Universities, national laboratories and companies for different kinds of applications all over the world. Continuous advances in computers and electronics coupled with falling prices in these industries have made Web/Internet-based technologies less costly than before, particularly for educational organizations. Thus, it is more affordable to invest in these technologies that are essential for both expanding education over Web and further improving and advancing such technologies [1].

Introduction

Current technology enables remote access to laboratory equipment and instruments via Internet. This can have a significant part in engineering education; a part-time student and remote student are able to conduct laboratory experiment remotely. Thus, expensive laboratory equipment becomes readily available to be used by students not having such equipment. Based on this general method, other applications and remote experiments can be developed; we only need to develop the program using LabVIEW for controlling different instruments locally and then design the procedure and content for the new experiment quickly and smoothly [2].

The sophisticated and expensive lab equipment which can be used for testing and diagnosing is located at a centrally-administered site. These resources can be accessed via the virtual lab framework through the Internet using a generic web browser, e.g., Internet Explorer. The students' access to the equipment will be completely transparent. It will appear that the equipment is local to the student, giving the student real-time access to the equipment [3].

A very general laboratory structure must include:

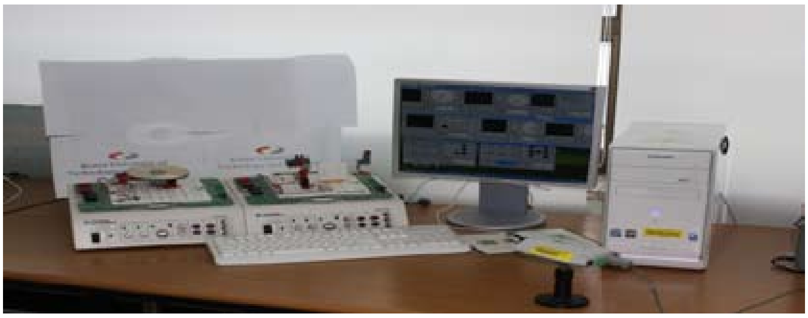
- The equipment (the regulated object, in the case of automatic control laboratory) associated with a server computer and a data acquisition card;
- An interface program, running on the server computer, that drives the signals to and from the data acquisition card and manages the information about the students' work;
- server software that deals with the communication between the laboratory and the remote students;
- an informative environment (usually Intranet or Internet);
- Client software running on the remote (student's) computer that provides the Graphic User Interface and communicates with the server [4].

The remote laboratory experimentation represents an extension to the ways in which people utilize Internet. A remote laboratory for engineering education should realize an integrated environment for user controlling the real device through the remote site and conducting the actual experiments in the remote laboratory through a computer network. The core of the remote laboratory is a cluster of general-purpose and/or specialized instruments interfaced to a set of personal computer systems connected to the Internet. With the ability to configure instruments and data analysis remotely via software, the laboratory will facilitate the sharing of expensive instruments and equipment, and may well be the next important step in remote distance learning [5].

A student laboratory approach that is established on Internet-based - remotely accessible experimental set-ups- is

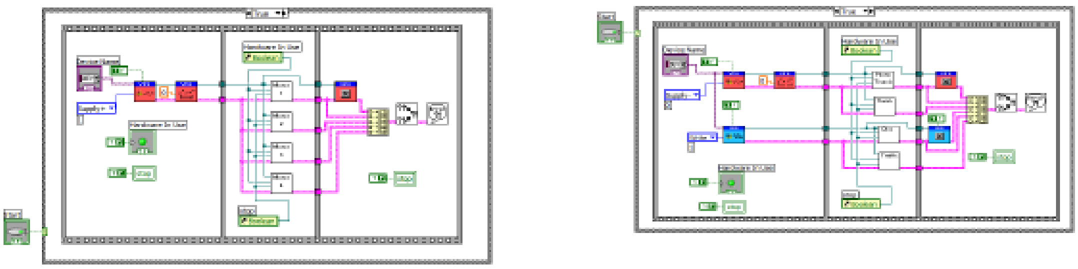
proposed in this paper.
Our designed virtual lab shown below:

Fig. 1. Remote Lab Illustration



The remote lab system comprises two NILVIS devices (to the left) connected to a PC which functions as the host for LabVIEW application software as well as the main server for remotely accessing to the experiment. All hardware components are placed and connected to breadboards on the top of NIELVIS. Thus, this enables us to control the system via LabVIEW software application. In addition, a web camera is placed on high position so that the system is available to see. The application software “LabVIEW program.vi” run on the main server controls the system mentioned above as well as gives a user an opportunity to access the system remotely and start desired experiments.
The main program diagram code is presented below. It is composed of two independent loops; each of them controls one NIELVIS device that has some experimental components on it. The structure of both loops is quite similar except the sub-Vis used within each loop.

Fig.2 Diagram code



The remote lab system is accessed from Internet through a web browsers (user interface) containing different experiments designated as workshops. Normally, every experiment wanted to be conducted by a remote user can be accessed with the following steps:

1. Choose the desired workshop (Experiment).
2. Request control of the VI (software interface)
3. Start experiment (Initializing the hardware to work) by clicking start.
4. Finalize the experiment (clicking stop button).
5. The control returns to the server (main PC) after finishing the experiment.

Next, these steps will be show more clearly by real examples.
Our remote lab includes 5 experiments. They are as follow:

- Measuring DC-motor parameters by different types of sensors
- PID control of DC-motor
- Temperature Measurements

- Light source and phototransistor
- Traffic light

Measuring DC-motor rotation parameters

The system consists of a DC-motor and four types of sensors. These sensors are as follows; Hall sensor, photo coupler and accelerometer sensor. These components are placed and connected together on the breadboard of NIELVIS so that all signals can be acquired, processed and presented through LabVIEW software operated by the main PC, at the same time this PC acts as a server so that a remote user can access and run the experiment. The front panels (user interfaces) for this experiment are shown below.

FIG.3 DC-MOTOR SPEED MEASUREMENT BY HALL SENSOR

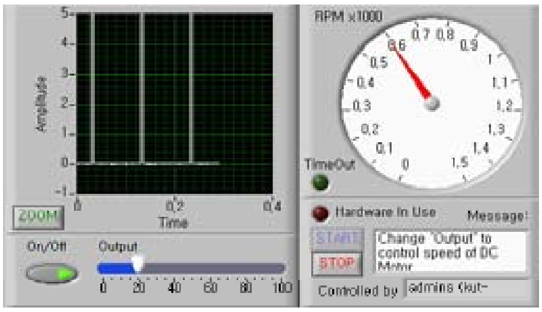


Fig.4 DC-motor speed measurement by coil

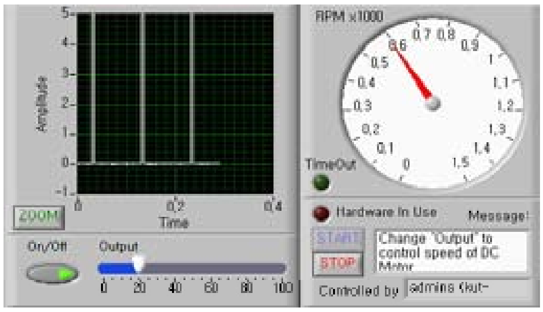
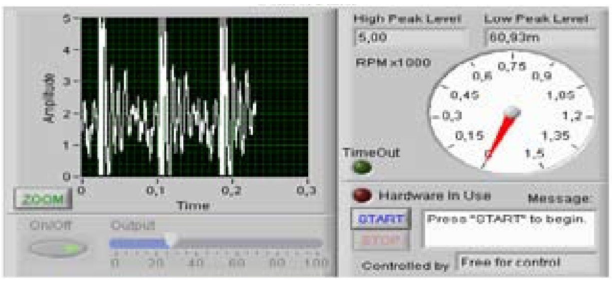


Fig.6 DC-motor speed and vibration measurement by accelerometer

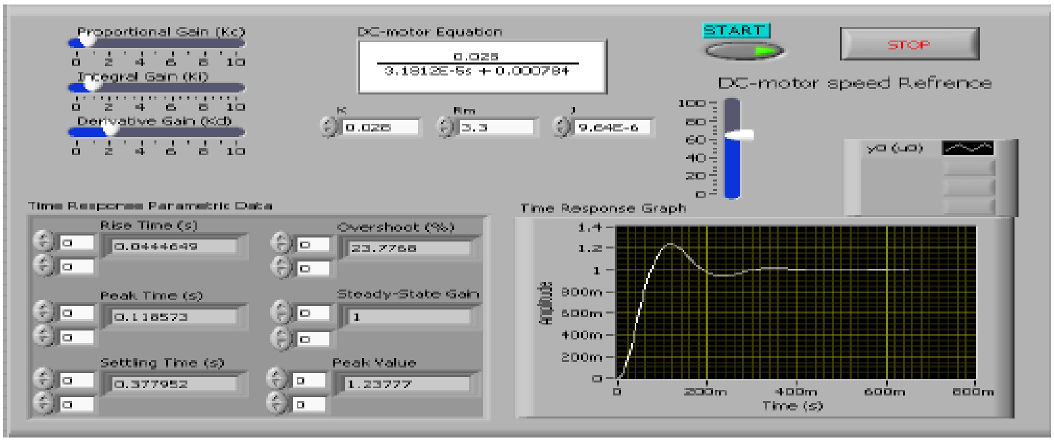


As indicated above, all the three front panels are almost the same appearance except the data presented on the charts. The data represented by each VI looks different as each VI receives data from a different sensor. The remote user, who can be a student or another researcher, can start running the experiment by taking the control of VI, just right clicking on the appeared panel and choosing "Request control of VI" from the menu appeared. Then, a message will be displayed "Control granted "if the server is not busy or anybody else doesn't access the same workshop (Experiment). After that the remote user can press the start button at the lower part of the panel to launch the hardware. In this experiment the remote user can vary the voltage from 0 – 100 which corresponding to 0 – 10 V voltage interval. The remote user will notice the data acquired is displaying on the waveform charts in form low and high peaks and the rotational speed (frequency) is indicated on a dedicated gauge as seen above. By analyzing the time intervals of these peaks, the user can calculate the motor speed from the apparent data displayed. The user also can verify the identity of the speed indicated by both chart and gauge by analyzing the data as mention previously. Such experiment can be given as a task to students to remotely access the experiment and to investigate the relation between the supplied voltage to the motor and the speed indicated and plotting a graph relating applied voltage to indicated speed.

PID control of DC-motor

The remote user can test PID algorithms and parameters, change reference velocity values and register the motor output velocity profile to optimize the values of PID coefficient according to requirements. The front panel (workshop front panel VI) is shown below.

Fig.7 PID control VI remote experiment

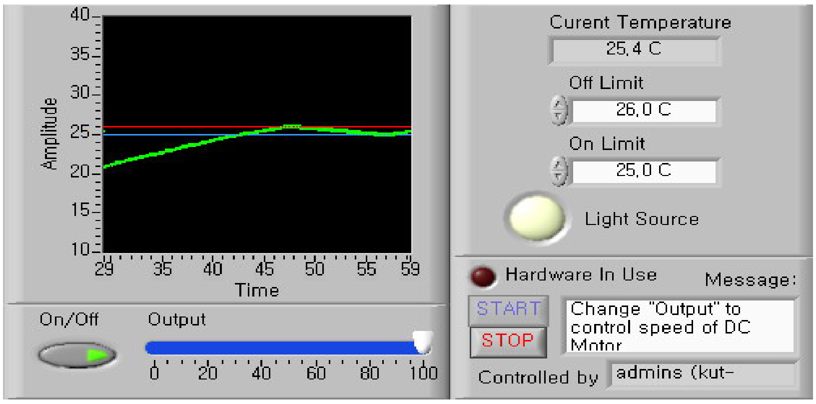


The access to the experiment is the same way as before. This experiment includes the DC-Motor used in the previous experiment. The feed back signal can be received from any available sensors (such as Hall Effect sensor or by coil) where the signal acquired through NIELVIS and hence sent to the PC containing application software “LabVIEW”. At then, LabVIEW contains PID control sub VI so that the received signal is processed and the control signal is sent back again to the system. At starting, user first sets the reference speed (set point) and then manipulates PID parameters noticing the time response graph indicated on the chart on front panel. The values at then can be optimized if the remote user notices a good response from the system.
Such experiment can be an effective tool during a lecture about the control of DC-motor.

Temperature Measurements

In this remote experiment, temperature sensor is placed just near the light source (bulb). By varying the light intensity of the light source, we can observe the temperature rise. The users are able to adjust upper and lower limits of temperature and watch the system working automatically.

Fig. 3.Temperature measurement



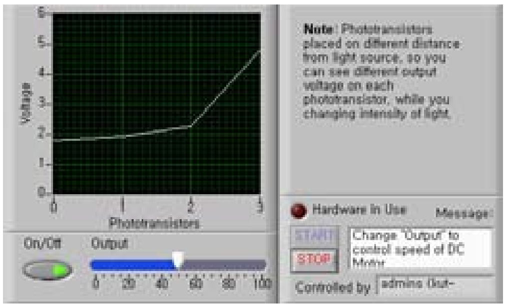
The system works in the following way. At first, when the temperature (thick green line on figure above) is lower than upper limit (upper horizontal line) set by user, the light source turns on and hence, heating the temperature sensor nearby. After the temperature around the latter reaches the upper boundary, the light source is being automatically switched off, and the temperature around the sensor starts decreasing. When it reaches the lower limit (lower horizontal line), the light source is being switched on again, thus, increasing the temperature, etc. As we mentioned above, the light intensity can be controlled by user through a special slider placed under the temperature history chart.

Moreover, user can manually switch the light source on and off.

Light source and phototransistor

Another virtual instrument related to light intensity is a workshop dedicated to phototransistors. During this experiment, students may examine the exponential relation between the distance from light source and phototransistors and intensity of illumination.

Fig. 4. Light source and phototransistors remote experiment.



Totally, there are four identical phototransistors placed in a different distance from the light source. As a result of switching the light source and changing the intensity of it, a student will see 4 different values of transistors output currents. The levels of these currents have an exponential nature, and the user can easily estimate the distances between every phototransistor and the light source. This experiment is very important to understand and examine the basics of optics and physics and can be a part of an educational basis in this field.

Traffic light

Another simple demonstration of remote laboratory capabilities is traffic lights application:

Fig.10. traffic light remote experiment

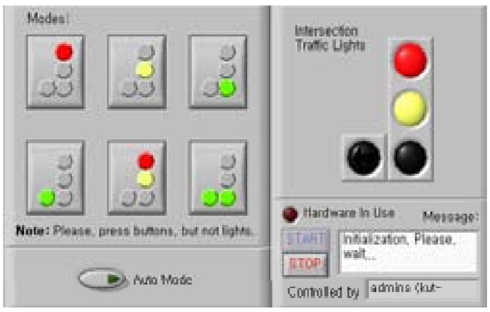
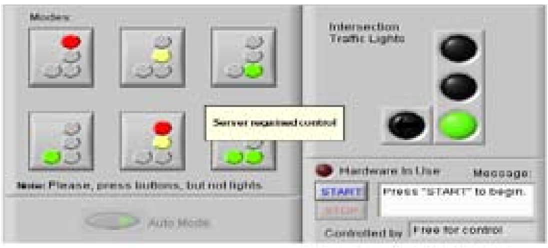


Fig. picture from a web-cam

As you can see from figures above, students can choose different modes of traffic light from the front panel of virtual instrument and observe it working by means of web-camera (the traffic lights itself on is in the upper-right corner of **Error! Reference source not found.**). During this experiment, we can also measure the time delay imposed between front panel and hardware indication. This delay is mainly caused by network latency and will tend to increase with the distance from hardware.

The overall application is designed in a way that if user remains idle the experiment is considered to be finished or more useful to other users, and the server regains control of this VI (see figure below) to transmit is to other users if necessary.

Fig.5. Regaining of control by server



Conclusion

We can summarize that remote laboratory experiment can be used in following fields:

- Distance learning for part time and remote students without time and distance limitation.
- Pre-experiment for undergraduates before they go to the actual laboratory,
- Enable students to use expensive laboratory experiments which they actually have no access.
- Share expensive laboratory equipment with other universities.

In the conceptualization and implementation of this technology, a strong emphasis was then placed on the following technical characteristics:

- Modularity and expandability.
- Scalability.
- Usage of, and compatibility with, existing communication standards;
- Computer platform independence.

Acceptance of remote laboratories by the academic community is expected to hinge on the following attributes:

- Correlation with curricular needs;
- Compliance with ABET requirements;
- Pedagogical soundness;
- Affordability;
- Ease of use;
- Reliability.

References

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