원격 가상 계측장치와 DC 모터를 이용한 효과적인 공학실험

Effective Engineering Experiments Using Remote Virtual Instruments and DC-Motor

최 성 주*, 갈 리**

Seong-Joo, Choi*, G. R. Mikhail**

요 약

Web을 이용한 컴퓨터기반의 학습은 교육을 위한 유용한 적용방법이다. 이런 방법은 애니메이션과 상호작용을 통해 제공되어 지고 복잡한 설비들은 교본을 통해 쉽게 학습할 수 없다. 웹/인터넷이 가능한 응용문제들은 원격지에서 제어되고 모니터링 될 수 있으므로 전 세계 원격지 대학, 연구소 또는 회사에서 다양한 방법으로 충분히 사용된다. 컴퓨터와 전자기술의 결합을 통한 저가의 하드웨어 개발은 이전에 비해 웹/인터넷 기반기술의 발전을 통해 특별히 교육기관을 위해 만들어졌다. 따라서 이런 분야에 적합한 기술개발은 광범위한 웹기반 교육의 확장과 이를 위한 기술개발 적절한 투자가 필수적이다. 원격 가상계측기의 응용은 실험을 통해 검증되어져야 하며 공학도를 위해 실험이 가능할 수 있도록 적용되어야 한다.

Key Words : Virtual Instrument, Remote laboratory, LabVIEW

ABSTRACT

Computer-based learning with the access to World Wide Web has become a fundamental base for adopting beneficial education. It provides significant facilities such as animation and interactive processes that are not possible with textbooks. Web/Internet-enabled applications which is 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 drooping prices of hardware 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].the application of remote virtual instruments will be demonstrated in this context along with experiments that can be adopted to be educational experimental lab for Engineering Education students.

* 한국기술교육대학교대학 기계정보공학부 (sjchoi@kut.ac.kr)
** 한국기술교육대학교 기계공학과 (ghaly@kut.ac.kr)
제1저자 (First Author) : 최성주
교신저자 : 최성주
접수일자 : 2009년 11월 24일
수정일자 : 2009년 12월 21일

Ⅰ. Introduction

A virtual instrument is a software program that implements a functionality as hardware instrument by computer, sensors and actuators. moreover, this virtual Instrument (VI) can remotely be operated as long as the virtual instrument (VI) program like LabVIEW is hosted in a computer connected to a local network or the internet.

Any physical system under test can be experimented on so long as there are appropriate sensors, actuators and VIs (Virtual Instruments) that handle the inputs and outputs of the system in interest. in addition to , a VI through the acquisition of data can analyze, present and act as controller. accordingly, any lab experiment can be conducted conveniently as long as the user is familiar with virtual instrument software. as a VI is run by a computer, the experiment can be achieved remotely.

The user is able to conduct laboratory experiment remotely. Thus, expensive laboratory equipment becomes available to be used by users who don't have such equipment. Based on this general method, other applications and 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.

In the following context, a general description of a remote laboratory along with lab experiments will be demonstrated in more details.

Ⅱ. Remote laboratory usually includes the following

Experiments components (hardware) with a platform that enables the connection to a server computer

Data acquisition device, such as NIELVIS with interface card PnP or USB data acquisition part (DAQ -USB6008)

Operating system running the server computer, which manages the work of communications for the data acquisition system and arranges the access of remote users.

Application software(LabVIEW) to handle signals acquisition.

An informative environment (usually Intranet or Internet);

Client software running on the remote (User's) computer that provides the Graphic User Interface and communicates with the server computer [4].

The figure below show the layout of remoter lab.

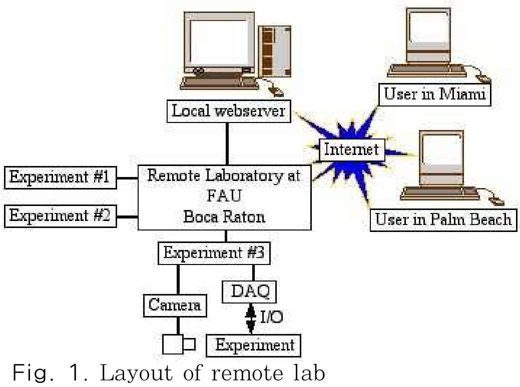

Fig. 1. Layout of remote lab

The remote laboratory experimentation represents an extension to the ways in which people use Internet. A remote laboratory for engineering education should realize an integrated environment for a 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 remotly via software,the laboratory will facilitate the sharing of expensive instruments and equipment, and it may 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.

Our designed virtual lab shown below:

Fig. 2. Remote lab illustration

The remote lab system comprises NILEVIS and NI-USB6009 DAQ device 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. 3).

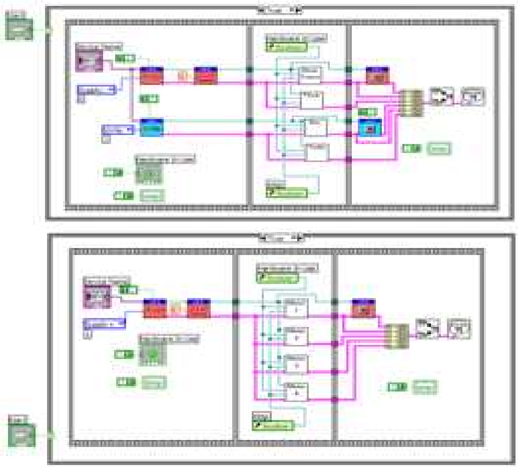

Fig. 3. Diagram code

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 different experiments. They are for instance:

Measuring DC-motor parameters by different types of sensors PID rotational speed control of DC-motor Temperature Measurement in the following context we are going to present previously mentioned experiment in details

Ⅲ. 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.

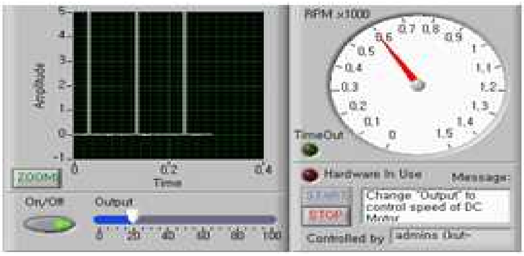

Fig. 4. DC-motor speed measurement by Hall sensor

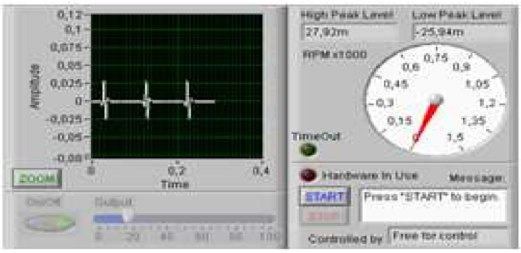

Fig. 5. DC-motor speed measurement by coil

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.

Ⅳ. PID control of a 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.

This experiment setup is conducted using USB-6009. In this, we use analog output to supply voltage to DC motor meanwhile we check speed signal through analogue input. PID algorithm is developed using LabVIEW code (PID.vi) that regulate DC motor speed by receiving feedback through analog input signal (acquired from photo transistor sensor) and controlling the output voltage applied to the DC-motor (Fig. 6).

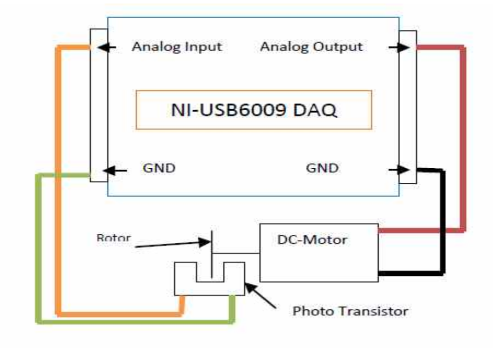

Fig 6. PID speed control of DC- Motor

The front panel (workshop front panel VI) is shown below.

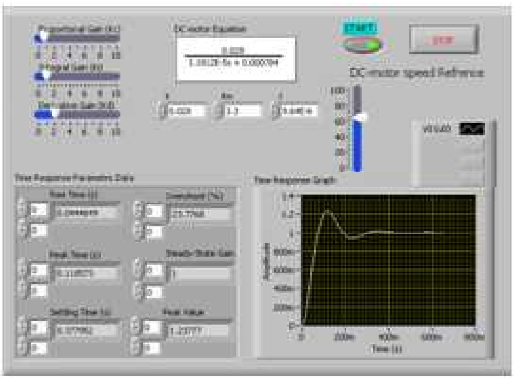

Fig. 7. PID control VI

The access to the experiment is the same way as before. This experiment includes the DC-Motor used in the previous experiment. The feedback signal can be received from any available sensors (such as Photo transisitor sensor) where the signal is acquired through DAQ USB 6008 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. in the beginning,ent bafirst sets the rerst setsspeed (set point) and then manipulates PID he beginni noticing the time response g bph indicated on the ,enrt on front panel. The t setsspt then can be ni noticd if the reis sent banotictssp gooed (sponse from the system. Such experiment can be an effective tool during a lecture about the control of DC-motor.

The figure below shows the code of PID speed control of DC motor

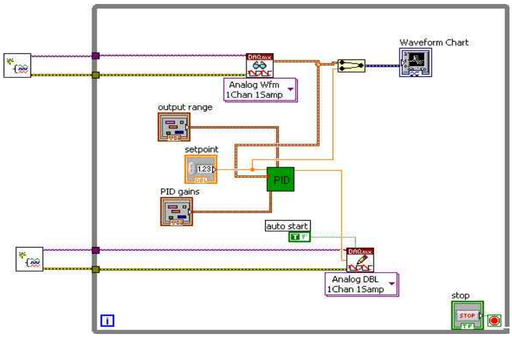

Fig. 8. PID block Diagram Code

V. 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.

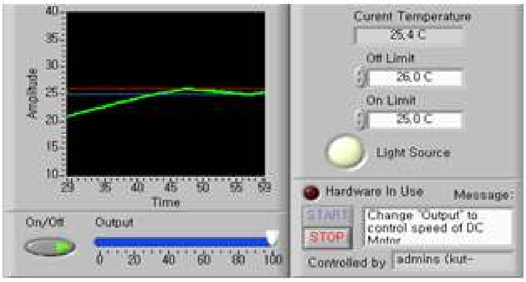

Fig 9. Temperature measurement

The system works in the following way. At first, when the temperature (thick green line on figure above)(fig.9) 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 dunreasing. 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.

Ⅵ. 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.

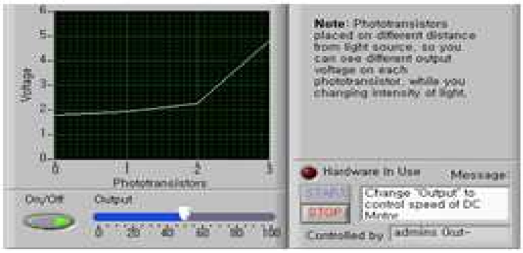

Fig. 10. Light bulb phot transistor

Totally, there are four identical phototransistor 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.

Ⅶ. Conclusion

virtual instrumentation is powerful tool to demonstrate concepts and applications in Engineering field which in turn consolidate quality of engineering education. throughout this context , examples have been illustrated to indicate a paradigm that can be applied to education field.

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

1. Distance learning for part time and remote students without time and distance limitation.
Pre-experiment for undergraduates before they go to the actual laboratory,

2. Enable students to use expensive laboratory experiments which they actually have no access.
3. Share expensive laboratory equipment with other universities.
4. In the conceptualization and implementation of this technology, a strong emphasis was then placed on the following technical characteristics:
5. Modularity and expandability.
6. Scalability.
7. Usage of, and compatibility with, existing
8. Communication standards;
9. Computer platform independence.
10. Acceptance of remote laboratories by the academic community is expected to hinge on the following attributes:
11. Correlation with curricular needs;
12. Compliance with ABET requirements;
13. Pedagogical soundness;
14. Affordability and reliability

References

〔1〕 M. Naghedolfeizi, S. Arora, and S. Garcia, "Survey of LabVIEW Technologies for Building Web/Internet-Enabled Experimental Setups", *Proceeding softhe 2002 American Society for Engineering Education Annual Conference&Exposition*,2002, pp. 2248-2257.

〔2〕 S. C. Brofferio, "A University Distance Lesson System: Experiments, Services, and Future Developments", *IEEE Transactionson Education*,Vol.41,No.1, February 1998.

〔3〕 Ji Hua, Aura Ganz, "Web Enabled Remote Laboratory (R-Lab) Framework", *33rd ASEE/IEEE Frontiersin Education Conference*,SessionT2C, November 2003.

〔4〕 C. Chiculita, L. Frangu, "Remote Laboratory Allowing Full-Range Student-Designed Control Algorithm", *Proceedings for 9th International Conferenceon Electronics*,Circuits and Systems,Vol.3,2002,pp.1235-1238.

〔5〕 S. H. Chen, R. Chen, V. Ramakrishnan, S. Y. Hu, Y. Zhuang, C. C. Ko, and B. M. Chen, "Development of remote laboratory experimentation through internet," *inProc.1999.IEEE HongKong Symp.Robot.Contr.*, Hong Kong, July 1999, pp. 756 - 760.

최 성 주 (Seong-Joo Choi)

1981년 : 한양대학교 기계공학과 공학석사
1987년 : 한양대학교 기계공학과 공학박사
1991년~현재 : 한국기술교육대학교 기계 정보공학부 교수
관심분야 : 고속정밀가공, CAD/CAM, Graphical Programming.

갈 리 (G. R. Mikhail)

2005년 : Alexanderia University in Egypt, MechanicalEngineering, Naval Architecture and Marine Engineering
2009~현재 : 한국기술교육대학교, 기계공학과 대학원 석사과정.
관심분야 : 고속정밀가공, CAD/CAM, Graphical Programming.