VIRTUAL INSTRUMENTS –
A CHANCE TO TEACH ENGINEERING AT A DISTANCE

Nermina Zaimoviæ-Uzunoviæ[1], Samir Lemeš[2] and Darko Petkoviæ[3]

Abstract ¾Most modern mechanical engineering courses follow the life cycle of future product. Product life cycle consists of well-known phases: design, analysis, manufacturing, quality control. Not all of these phases are easy to implement through distance learning courses; expensive laboratory equipment is usually unavailable to distance learning students. Virtual instruments developed with National Instruments' software "LabVIEW" give opportunity to students to have powerfull instrumentation within the software, while measurement is performed in a laboratory. Virtual instruments even enable students to build their own instruments, using software-simulated signals. This paper shows how virtual instruments can be implemented in distance engineering education.

Index Terms ¾ Virtual instruments, Distance learning, Metrology, Engineering

INTRODUCTION

Engineering education is faced with lack of new students throughout the world. Unlike other disciplines (social studies, economics, law, etc.), engineering study requires full-time engagement, because of its complexity. Engineering study consists of lectures, laboratory exercises, earning skills among with fundamental knowledge. All these aspects make engineering study more complex than studying economy, law or foreign languages, which in turn decreases interrest for these studying areas.

A need for new engineers is likely to be increased in the near future because of disproportion between lack of interest and rapid growth in technology development. Distance learning could be a good tool to fill this gap.

The term "Distance learning" is often used to denote both education where student and teacher are physically separated, and all forms of flexible education supported by information-communication technology (ICT). ICT is widely used to provide flexibility in terms of time and place.

Traditional way of engineering education, focused on detailed theoretical background, as it is practiced in Bosnia and Herzegovina, is not effective enough since it is not focused enough on practical aspects. A good way to improve it is to follow a product life cycle throughout the educational process. Virtual instruments could be used to improve engineering distance learning courses in that sense.

DISTANCE LEARNING IN BOSNIA AND HERZEGOVINA

Distance learning is not widely used in higher education in Bosnia and Herzegovina. A couple of international projects started recently with intention to spread distance learning awareness and to give boost to education system reconstruction. One of these projects finished by the end of 2000 was international project "Establishment of Phare Open Distance Learning Centers in Bosnia and Herzegovina". The project itself represented the final phase of a multi-country project for distance education, with 13 Phare countries involved.

University of Sarajevo took part in this project; Regional ODL Center was established and pilot course "3D modeling of mechanical parts and assemblies" was developed and delivered. The topic for the pilot course was not selected randomly, but as a part of mid-term plans for reconstruction and improvement of our courses. The plan is to simulate and explain in details complete product development cycle, developing simultaneously distance learning courses for each particular phase of this process.

One of the courses being prepared is "Metrology", and we decided to use National Instruments' software "LabVIEW" for that course.

MODERN PRODUCT DEVELOPMENT PROCESS

Some phases of the modern, technology-supported process of creating the new product are:

- Conceptual analysis, sketching
- 3D modeling
- Engineering analysis
- Optimization
- Drafting, creating technical documentation
- Manufacturing
- Testing

Some of these phases can easily be implemented as distance learning courses, because there are lot of commercial CAD/CAM software tools developed for these phases. Modern CAD/CAM software products have modules for particular phases of product development cycle, such as modeling, static analysis, vibration analysis, NC code generation, mold-flow simulation, etc. There are also

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[1] Nermina Zaimoviæ-Uzunoviæ, University of Sarajevo, Faculty of Mechanical Engineering in Zenica, Fakultetska 1, Zenica, BA 72000 zaimovic@yahoo.com
[2] Samir Lemeš, University of Sarajevo, Faculty of Mechanical Engineering in Zenica, Fakultetska 1, Zenica, BA 72000 slemes@mf-ze.unsa.ba
[3] Darko Petkoviæ, University of Sarajevo, Faculty of Mechanical Engineering in Zenica, Fakultetska 1, Zenica, BA 72000 dpetkovic@mf-ze.unsa.ba

measurement modules, but they require expensive measurement hardware or laboratory equipment. To avoid use of this equipment in educational process, virtual instruments can be affordable solution.

Recent development in software industry, such as Java, Microsoft .Net, Transmeta Crusoe, etc. show that there is a trend to move the boundary between hardware and software towards software. Wherever possible, trend is to use software solutions instead of hardware. That trend reflects also the design of measuring and laboratory equipment. Virtual instruments simulate real measuring equipment, with lower price and better flexibility.

VIRTUAL INSTRUMENTS

Virtual instrument (VI) is a program in graphical programming language G. It models the appearance and function of a physical instrument. The distinction between traditional and virtual instrument is illustrated in fig.1.
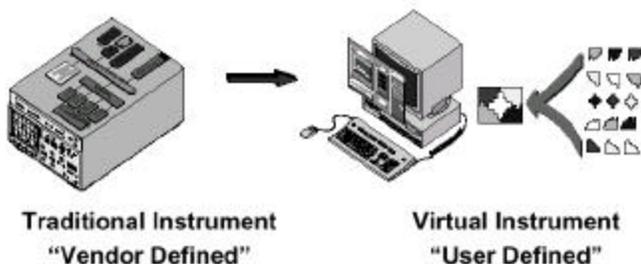

FIGURE. 1
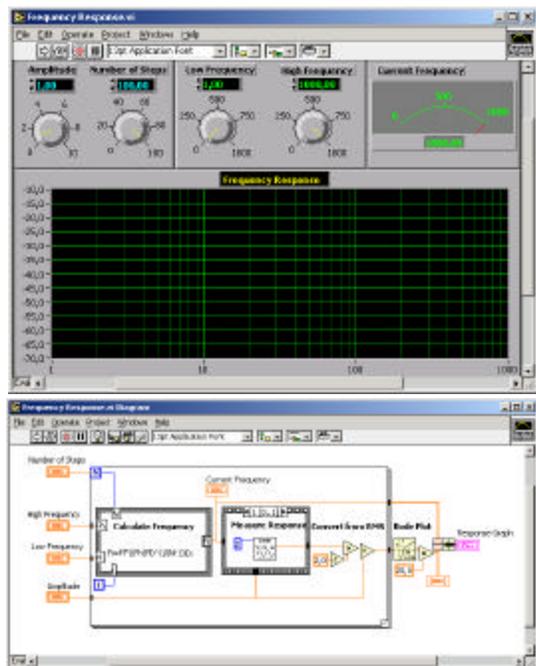TRADITIONAL VS. VIRTUAL INSTRUMENT [2].

FIGURE. 2
FRONT PANEL AND BLOCK DIAGRAM

Fig. 2 shows two LabVIEW windows: front panel (containing controls and indicators) and block diagram (containing terminals, connections and graphical code). The front panel is the user interface of the virtual instrument. It consists of controls and indicators, which are the interactive input and output terminals of the VI, respectively. Controls are knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays.

Controls simulate instrument input devices and supply data to the block diagram of the VI. Indicators simulate instrument output devices and display data the block diagram acquires or generates.

The code is built using graphical representations of functions to control the front panel objects. The block diagram contains this graphical source code. Front panel objects appear as terminals on the block diagram. Additionally, the block diagram contains functions and structures from built-in LabVIEW VI libraries. Wires connect each of the nodes on the block diagram, including control and indicator terminals, functions, and structures.

From the aspect of distance learning, the most important issue of virtual instruments is the fact that they can be used to simulate physical phenomena – to generate signal that appears as it would appear if it had been acquired by real transducers. The same software is being used for real and virtual phenomena. That way virtual instrument becomes the part of virtual laboratory (fig. 3).
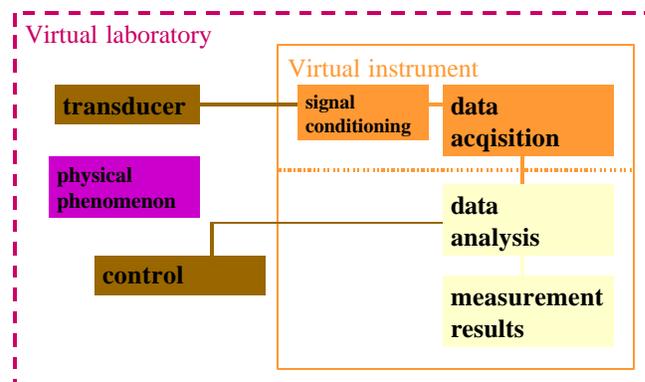

FIGURE. 3
VIRTUAL LABORATORY .

ADVANTAGES OF VIRTUAL INSTRUMENTS

One of the main advantages of virtual instruments is the fact that students are able to define instruments inside the software. Other characteristics of virtual instruments are:

- lower costs of instrumentation
- portability between various computer platforms
- easy-to-use graphical user interface
- graphical representation of program structures
- code can be compiled to standalone.EXE or .DLL file
- TCP/IP connectivity (Web server integrated into virtual instrument)

EXAMPLES OF APPLICATIONS

There are many examples where LabVIEW is effectively used in engineering education.

The College of Engineering and Applied Science at the University of Colorado at Boulder created interdisciplinary program combining computer and instrumentation technology with the fundamental knowledge gained from project-based learning [1].

Swiss Federal Institute of Technology in Lausanne developed distance learning system for studying motion control using LabVIEW [4]. Remote client (student) uses laboratory setup to control the motion process.

"CyberLab" developed at the Stanford University [5] is yet another example of distance learning facility – virtual laboratory with pilot course for image acquisition.

Department of Electrical Engineering at Singapore Polytechnic developed distance learning courses for engineering subjects, such as Programmable logic controlers, Digital electronics and Digital control. Experiments can be conducted over the Internet using LabVIEW and ComponentWorks [6].

Texas A&M University developed remote experiments via the Internet that demonstrate the mechanics of materials taught to students who do not have access to a laboratory facility [7]. LabVIEW was used to create virtual instruments that access a tension/compression/torsion test frame via the Internet.
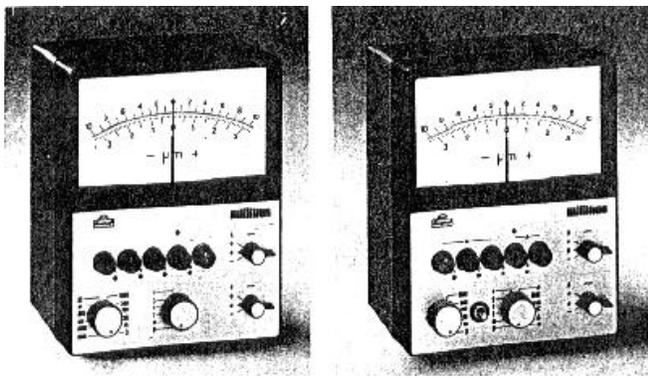

FIGURE. 4
TRADITIONAL INSTRUMENT USED AS THE BASIS FOR DEVELOPMENT OF VIRTUAL INSTRUMENT - ANALOG MILLITRON SYSTEM (MAHR-FEINPRÜF).

Our Distance learning course "Metrology" should be delivered at the autumn 2001, and figures 4 and 5 show one of virtual instruments prepared for the course. Example shown is developed by one student as part of his graduate work and it represents motion control system. The student created virtual instrument which is equivalent to Analog Millitron system (Mahr-Feinprüf). That way, we substituted expensive instrument with its software represent. Students are then able to identify the key parameters of the instrument, in -site or at the distance.
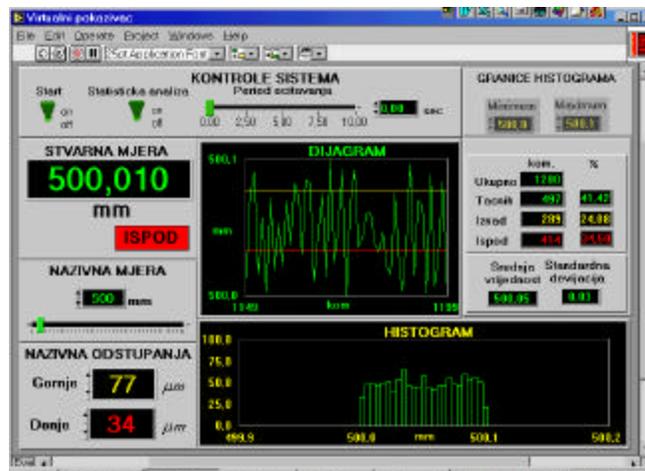

FIGURE. 5
FRONT PANEL OF VIRTUAL INSTRUMENT BUILT BY OUR STUDENT.

CONCLUSION

Distance learning is an excellent tool to improve engineering education by providing flexibilty to students and teachers. That flexibility can be used to overcome the complexity of engineering study contrary to other fields of education. Not all disciplines are easy to be learned at the distance, since some require expensive laboratory equipment. Development of distance learning courses is costly, therefore it is a must to decrease costs to provide flexibilty in education process.

Virtual instruments are excellent solution, since they significantly decrease costs for laboratory equipment. They provide access to expensive laboratories over the LAN or even Internet.

ACKNOWLEDGMENT

REFERENCES

[1] Carlson, L, "Using LabVIEW to Reform Engineering Education", National Instruments Corporation, 1996.

[2] "Computer-Based Measurement and Automation", National Instruments Corporation, 1998.

[3] Williams, M, Paprock, K, Covington, B, "Distance Learning – The Essential Guide", Sage Publications, 1999.

[4] Gillet, D, Salzmann, C, Gorrochategui, E, "Remote Manipulation with LabVIEW for Educational Purposes" Swiss Federal Institute of Technology - Lausanne (EPFL), Switzerland, 2000

[5] Hesselink, L, Rizal, D, Bjornson, E, " CyberLab, A New Paradigm in Distance Learning", Stanford University, 2000

[6] Hoon, P, S, "Conducting Experiments Over the Internet using LabVIEW and ComponentWorks", Department of Electrical Engineering, Singapore Polytechnic, 2000

[7] Yapura, C, L, Griffin, R, Lagoudas, D, C, "Mechanics of Materials Experiments Via the Internet", Texas A&M University