

HOW TO USE NI ELVIS/LABVIEW IN MECHATRONICS ENGINEERING EDUCATION?

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Abstract— Mechatronics engineering is one of the trendiest branches of engineering discipline nowadays, which combines mechanical and electrical engineering knowledge with information technology. So in the education of engineering students, to become mechatronics engineers, we have to introduce interdisciplinary techniques too. There were several programs developed in the last three decades, but the most useful programs should provide platform for system design and present a suitable environment for development. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is such a programming language and its graphical nature and visual clarity makes it a good candidate to become a teaching tool in several different subjects.

Keywords— *LabVIEW, mechatronics, modelling, simulation, instrumentation, control theory.*

I. INTRODUCTION

Mechatronics engineering combines mechanical and electrical engineering knowledge with information technology and it is the most popular engineering degree program among candidates. In the renaissance era of the Middle Ages engineers were polyhistor (Renaissance man), with great expertise in many areas, the most famous representative of them was Leonardo da Vinci. Later sciences and specially engineering disciplines were starkly separated and distinguished from each other. Recent time again interdisciplinary studies has come to the fore, most prominent representative member is mechatronics, moreover mechatronics itself can be associated with other disciplines and turning out like bio-mechatronics, building-mechatronics etc. (<http://www.mcgs.ch/web-content/Robotics.pdf>) So in the education of engineering students, to become mechatronics engineers, better to introduce interdisciplinary techniques too. There were several programs developed in the last three decades, but the most useful programs should provide platform for system design and present a suitable environment

for development. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is such a programming language and its graphical nature and visual clarity makes it a good candidate to become a teaching tool in several different subjects.

Didactical alternatives in LabVIEW programming education are teaching it as a standalone programming course, or as part of an engineering subject? To learn LabVIEW programming is not an end, but a means. Most probably it is better to teach LabVIEW as an appropriate tool to solve problems of a particular subject, especially when the students have some basic programming knowledge.

This article is a study about experiences of mechatronics education at University of Debrecen and Budapest University of Technology and Economics.

II. IMPORTANCE OF LABVIEW IN MECHATRONICS EDUCATION

When somebody talks about mechatronics, most of us think about embedded systems. What exactly is an embedded mechatronics system? A particular mechanical system, robot, plant etc. might be the focal point of a mechatronics system, which by the help of some extent intelligent auxiliary system is able to perform some desired action, see **Ошибка!** **Источник ссылки не найден..** [1].

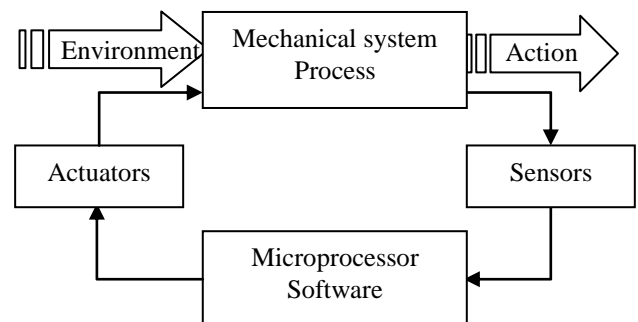


Figure 1, Embedded mechatronics system.

Sensors can pick up the signals from the mechanical system and the environment. The processing unit (e.g. microprocessor/FPGA/PLC) calculates the necessary control signal for the mechanical system from these amplified and processed signals. The produced output signal can stimulate the system through actuators.

There are two striking representative of this software, Matlab and LabVIEW, they are of different kinds, but increasingly converging to each other. Matlab is matrix based script language, but besides its numerical computing ability, its graphical Simulink package can be used for symbolic computation in embedded systems [2] [3]. http://www.mcgs.ch/mechatronics_definition.html

III. MECHATRONICS COURSES USING LABVIEW PROGRAMMING

3.1. LabVIEW in Teaching Instrumentation Technology Subject

Instrumentation Technology is the first technical subject taught in mechatronics curriculum. They get to know the measurement chain (Figure 2), its components, measurement techniques, sampling and quantizing data, statistical processing of measurement results.

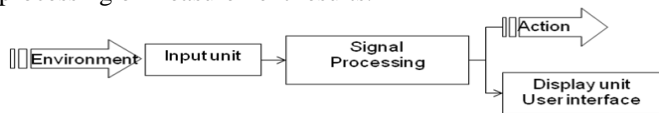


Figure 2, Measurement chain.

This is an excellent opportunity to familiarize themselves with these theories at their fingertips immediately in practice. National Instrument provides portable, low-cost multifunction data acquisition (DAQ) devices for this purpose.



Figure 3, NI USB-6009 USB Student Data Acquisition Kit

NI USB-6009 Student Kit for USB (Figure 3) is a perfect cost effective true multifunction DAQ capability device, provides 48 kS/s at a resolution of 14 bits, eight single-ended (four differential) analogue inputs; also provide two true analog outputs and 12 digital I/O lines (5 V TTL/CMOS).



Figure 4, NI myDAQ data acquisition (DAQ) device

NI myDAQ (Figure 4) is also a low-cost DAQ device, students can measure and analyze live signals and it is compact and portable so students are able to extend their understanding how to use industry-standard tools and methods. NI myDAQ is a compact USB device, provides two analog inputs (AI) for ± 10 V signals 200 kS/s per channel, two analog outputs (AO), eight digital input and output (DIO), audio, power supplies, and digital multimeter (DMM) functions. Anyone can start to use these devices even without any previous expertise in LabVIEW programming. First approach using Measurement and Automation Explorer (MAX) is the easiest way. Beginners can experience how to communicate with a device, how to send and acquire measurement data.



Figure 5, NI Measurement and Automation explorer

These DAQ devices can be addressed by NI ELVISmx Instrument Launcher too, see Figure 6, not all, but most of its features are functional, for example digital multimeter, scope, Bode diagram etc. (Also they can use NI ELVISmx instruments in NI Multisim to simulate a circuit, measure the real signals with NI myDAQ, and compare simulated and acquired data.)



Figure 6, NI ELVISmx Instrument Launcher

And last they can build their first real Virtual Instrument (VI) by the help of LabVIEW programming. For example they can generate output signal on one of the device's analogue outputs and measure Voltage on one of the device's analogue inputs. They can learn to create a basic graphical user interface, a Front Panel and the consequent Block Diagram. This basic application helps getting to know Controls and Indicators, DAQ assistant, data acquisition and basic file management even without a thorough LabVIEW programming knowledge.

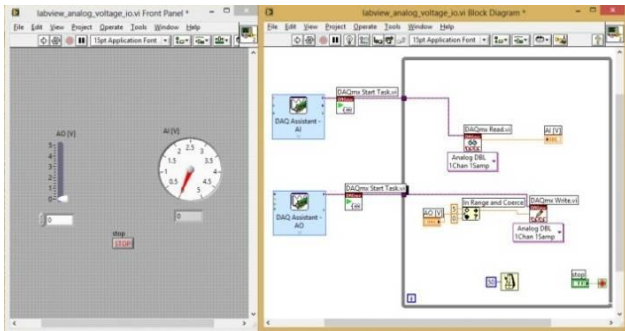


Figure 7, Basic data acquisition Virtual Instrument (VI)

3.2. LabVIEW programming in Simulation and Identification subject

Modeling and simulation of a dynamical system subject requires from the students deeper familiarity with LabVIEW programming. Furthermore also because most of the problems involved need to solve differential equations to visualize the results [4] [5].

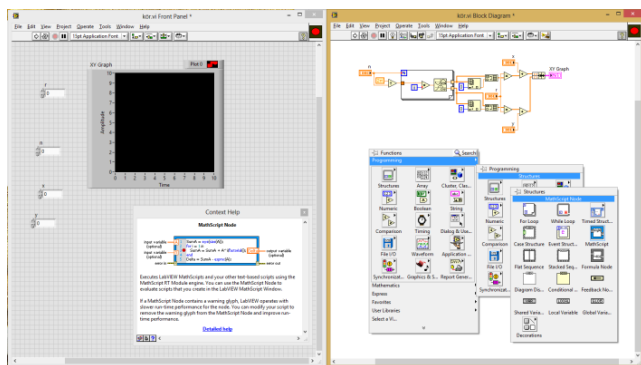


Figure 8, LabVIEW structures.

During practical training students learn to configure Front Panel and Block Diagram elements, how to use different programming structures available in LabVIEW (For loop, While loop, Case structure, Sequences, Formula node, Math node, e.t.c.). Among others they become skilled how to set up

subVIs create a new project and LabVIEW library (lib.).

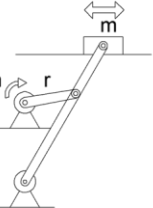
Problem statement	Figure	
Prepare the model of a planing machine's splitter mechanism shown on the figure. Perform experiments using different cutting force, mass, speed and radius depending on the size of the planing machine, what will be the torque and power requirement of the engine.		
Code	Title	Consultant
	Planing machine splitter (coulisse) mechanism	Piros Sándor

Figure 9, Student homework example from Simulation and Identification subject.

At the end of the semester as a conclusion of this course each and every student has to prepare an individual homework. Figure 9 shows an example homework task, this student has got a problem statement and he had to prepare a model for it and perform simulations using this model.

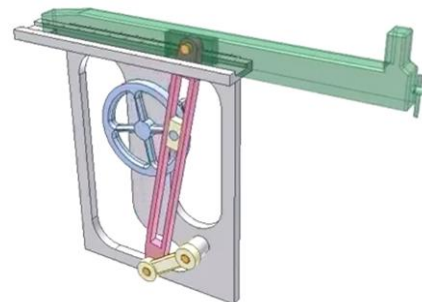


Figure 10, student work: realized 3D model of the system described on the previous figure.

First task was to set up practical dimensions then to prepare a realistically looking 3D model example with using any CAD program to visualize the problem to be solved, see Figure 10. Second part of the homework was the theoretical consideration to find the solution, for example by generating differential equations describing a physical process. LabVIEW programming environment provides several possibilities to solve any task. There are several readymade VI-s available by the manufacturer or from the internet by other developers or one can build it from elementary building blocks. When somebody is more familiar with C or Matlab programming languages, he has the option to use Formula Node or MathScript Node respectively (Figure 11).

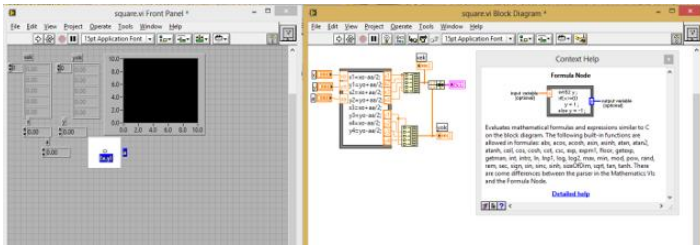


Figure 11, There is the option in LabVIEW to use C programming or Matlab by using Formula Node or MathScript Node

The third part of the student project is to run simulations and analyze the results. The best tool for this purpose is the visualization of the problem solution by a properly designed Front panel, like the one shown on Figure 12.

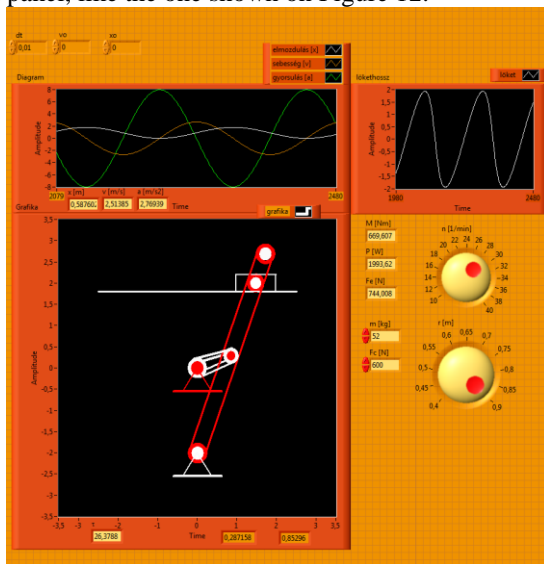


Figure 12, Frontpanel of the Simulation and Identification homework exercise.

3.3. LabVIEW programming in Control Theory subject

Example problem statement:

DC motor control by full state feedback (pole placement)

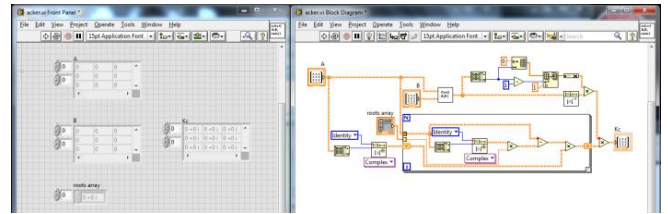
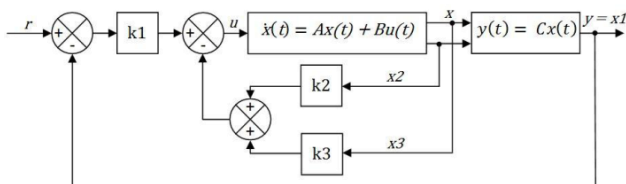


Figure 13 Solution by Ackermann formula

$$\dot{x}(t) = Ax(t) + Bu(t)$$

$$y(t) = Cx(t) + Du(t)$$

$$u(t) = -Kx(t) + u_r(t)$$

$$\dot{x}(t) = (A - BK)x(t) + Bu_r(t)$$

Solution by Ackermann formula:

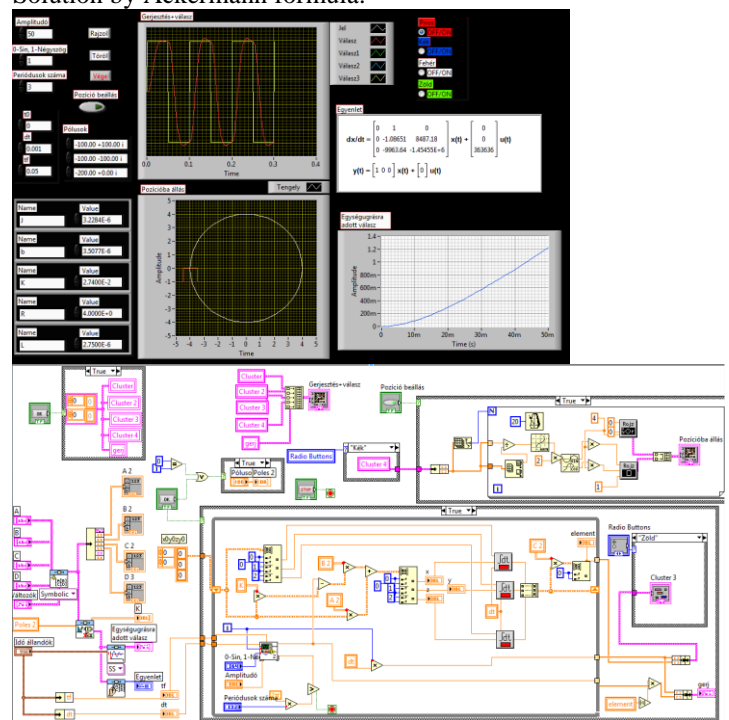


Figure 14 Frontpanel and Block diagram panel

3.4. Using LabVIEW and NI ELVIS in Mechatronics project subject:



Figure 15 NI ELVIS II Teaching Laboratory Virtual Instrumentation Suite

In the laboratory founded by National Instruments Magyarország kft. 20 students can measure at 10 working places with NI ELVIS I II and II+ tools, see Figure 15. The product package named NI ELVIS (Teaching Laboratory Virtual Instrumentation Suite) developed and manufactured by National Instruments is individual on the market and is expressly a computerized working station planning and preparing prototypes planned expressly for practical teaching of physics and technical subjects. The product developed expressly for teaching unifies all measuring technical functions in one tool, which are really necessary in a measuring technical laboratory. They make possible the efficient and spectacular testing of simple NI ELVIS circuits. The apparatus can be used in any field, where circuits composed on a test panel shall be measured, but it eases especially tests, in which more different types of instruments shall be used.



Figure 16

The Rotary Inverted Pendulum Trainer offers students the opportunity to balance a vertical rod at the tip of a rotating arm using a DC motor.

The DC Motor Control Trainer illustrates the fundamentals of DC motor control using the NI ELVIS platform and LabVIEW™ software.

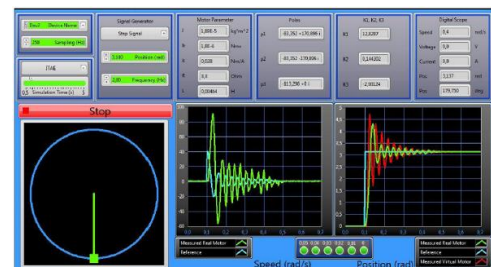


Figure 17 Emona Sustainable energy trainer kit

QNET Mechatronic Sensors Trainer, Hands-On Learning for Controls and Mechatronics

Example problem statement:

DC motor control by full state feedback (pole placement)



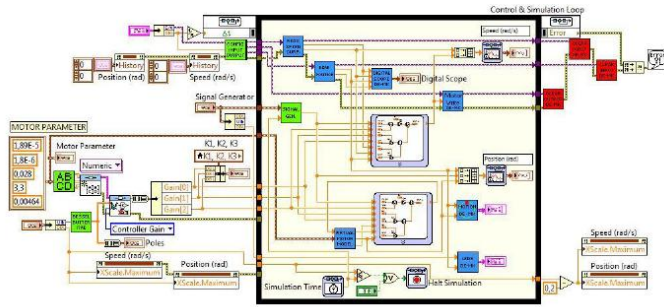


Figure 18 DC motor control by full state feedback using NI ELVIS II platform

Vernier Biosensors: Students will learn basic concepts of acquiring and analyzing an electrocardiogram (ECG or ECG) by working and becoming familiar with Vernier's ECG sensor, shown on Figure 19. This lab also introduces the Biosignal Logger and ECG Feature Extractor of the NI Biomedical Startup Kit. Also we can use Vernier bloodpressure sensor and Vernier Air Flow and Lung Volume for NI ELVIS II.

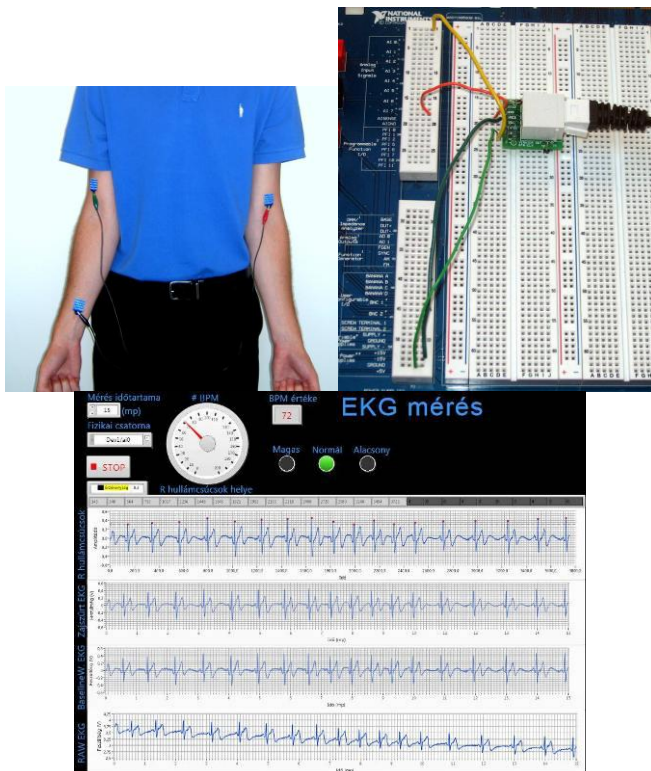


Figure 19 Using ECG sensor

IV. CONCLUSIONS

Labview is one of the most powerful and universal programming language both in education and also in controlling real-life applications. Teaching LabVIEW programming is more challenging and interesting for student as part of any technical subject, than a separate "l'art pour l'art" (Art for art's sake) programming class. The generally achieved knowledge and LabVIEW development experience is sufficient to pass an entry-level certification exam. This is called NI Certified LabVIEW Associate Developer (CLAD), the first step in a three-part NI LabVIEW certification process.



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References

- [1] Y. Han, R. Tzoneva and S. Behardien, "MATLAB, LabVIEW and FPGA linear control of an inverted pendulum," AFRICON, vol. 1, no. 7, pp. 26-28, Sept. 2007.
- [2] R. Tekin, "MATLAB and LabVIEW in modeling, analysis and real time control of a motion control system,," 2010.
- [3] P. D. G. Schweitzer, "Mechatronics Consulting," [Online]. Available: http://www.mcgs.ch/mechatronics_definition.html.
- [4] G. Lipovszki, "Discrete event simulation program in LabVIEW environment," in "Gépészet 2002 " 3-rd Conference on Mechanical Engineering, Budapest. Hungary, May 30- May 31, 2002.
- [5] G. Lipovszki and P. Aradi, "Simulating Complex Systems and Processes in LabVIEW," Journal of Mathematical Sciences, , vol. 132, no. 5, p. pp. 629 – 636, February 2006.