Type practical application in spectral analysis, combining Labview and open source software

C P Chioncel and C V Anghel Drugarín

"Eftimie Murgu" University of Resita, Electrical Engineering and Informatics Department, Traian Vuia Square, no. 1-4, 320085 Resita, Romania

E-mail: c.anghel@uem.ro

Abstract. The paper presents the interconnection possibility of LabVIEW with his different opportunities and Scilab, one of the successful free Matlab clones. The interconnection between those was made possible through the LabVIEW to Scilab gateway. This tool can be applied in virtual as well as in real laboratories, representing a true assistance for self-learning, too.

1. Introduction

The development of computers technology, with high processing speed and increasing available memory, equipped with dedicated software, have turned the way in which engineers design and work. Virtual Instruments (VI) gained a well-defined place in the world of measurements and system analysis, permitting flexible customization and easy integration. In these days, virtual instruments are used as educational tools in various domains, too, [1]. On one side, those are utilized to develop and design measurement system and on the other side, are used as simulation tools in a closed virtual world in which the user can observe the behaviour of complex systems in different contexts, being of great help in understanding various phenomena or complex mathematical expression, implemented and simulated at subsystem level, [2]. This way of approaching the problems is well accepted by students in the technical field, stimulating innovation in the process of designing proper virtual instruments, mostly in the field of process control and signal processing.

The virtual instrumentation leads to discover interrelations, between mechanic and electric interconnections, and the phenomena can be better understood, theory clearly learned. Those tools can be used in the industry, in laboratories as well as home, in virtual laboratories, constituting a support for self-learning, [3].

The present paper aims to illustrate how Virtual Instruments can be used in engineering education, combining the LabVIEW environment with open source software - Scilab, with practical application in spectral analysis from the Signal Processing Laboratory of the "Eftimie Murgu" University of Resita, together with a quantitative research regarding the perception of students to this issue.

2. Virtual instruments in the learning process

Virtual Instrumentation (VI) is used as well for designing applications which simulate real-world devices and instruments, as well as for modelling and simulation of the real mechanical processes, being capable to use both, computer generated time data and/or real recorded experimental data.

Those facilities represent an important and significant characteristic of VI, which can be used to create adapted tools in the teaching process, LabVIEW software, registered trademark of National
Instrument Inc. (NI), represents a programming environment that include specific tools necessary for instrument control, data acquiring, storage, analysis, presentation and integrating of those features in a single system, [4]. It uses graphical programming and a special graphical language.

The main goal of LabVIEW represents the creation of virtual instruments. Scilab represents free and open source software for numerical computation, providing a powerful computing environment for engineering and scientific applications, ensuring multiple interoperability and interconnection through gateways in the case of LabVIEW, [5].

3. Spectral analysis - Fourier Transform Tool
In the frequency domain, signals can be analysed, synthesized, filtered or passed through different windows. This processing is performed using Fourier series and the Fourier, Laplace and Z transform, [6]. The method was, initially, based for the linear physical systems, on their remarkable properties of sinusoidal fidelity, i.e., the fact that response of a linear system to a sinusoidal signal is also a sine wave with the same frequency but different amplitude and phase, [7], [8].

The Fourier transform (FT), the transformation from the time domain to the frequency domain, and vice versa, represents one of the most important practical transforms met in the field of electrical and computer engineering, [6]. Periodic signals with period $T_0$, can be expressed as a sum of sinusoids using Fourier series:

$$x(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} (a_k \cos k\omega_0 t + b_k \sin k\omega_0 t)$$

(1)

where

$$a_0 = \frac{2}{T_0} \int_{t_0}^{t_0+T_0} x(t) dt$$

(2)

Also,

$$a_k = \frac{2}{T_0} \int_{t_0}^{T_0+t_0} x(t) \cos (k\omega_0 t) dt$$

(3)

$$b_k = \frac{2}{T_0} \int_{t_0}^{T_0+t_0} x(t) \sin (k\omega_0 t) dt$$

(4)

Using Euler’s relation, we obtain the Fourier as a complex expression, like in relation:

$$x(t) = \sum_{k=-\infty}^{\infty} X_k e^{j\omega_0 t}$$

(5)

If the repetition period $T_0$ increases to infinity, the sum from relation (5) turns into an integral and we obtain the Fourier transform, in terms of angular frequency $\omega = 2\pi f$, determinate by the following relations:

$$X(j\omega) = F[x(t)] = \int_{-\infty}^{\infty} x(t) \cdot e^{-j\omega t} dt$$

(6)

$$X(t) = F^{-1}[X(j\omega)] = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(j\omega) \cdot e^{j\omega t} d\omega$$

(7)

where $x(t)$ is the time signal and $X(j\omega)$ the frequency signal.
The LabVIEW to Scilab Gateway acts like a ‘script node’, a text editor area, which can be moved in the LabVIEW block diagram [Sevgi]. The access to and out of the Scilab “script node” is done based on defining the input / output variables on the side of the node [9].

![Figure 1. Inserting the Scilab script in the Block Diagram](image1)

Figure 2 presents the Block diagram window of the virtual instrument, which contains the graphical source code, designed using graphical programming, user friendly and accessible even for inexperienced users, where the analysed signals, three in number, are generated and added, the signals are viewed, the ‘spectral measurements’ block returns the FFT and the ‘Power Spectrum’ displays the signals spectrum.

In ‘Scilab Script’ an Scilab code sequence will compute the FFT, facilitating the use of different operations on the signal, offered by the Scilab predefined functions and / or programming language, Figure 2.

![Figure 2. The complete application scheme](image2)

In Figure 3, the upper side of left hand, represents the time signal and on the upper right hand, the FFT obtained by the predefined LabVIEW block, [10] and on the bottom of the right hand, the FFT after running the Scilab application, [11-13], highlighting the three components the time represented signal, of different frequency and amplitude.
4. Quantitative research regarding the perception of students to use VI / Open Source software in educational process

We put the questions and the answers in the Table 1.

| Statement                                                                 | Answers           |
|---------------------------------------------------------------------------|-------------------|
| Hardware and software resources to use VIs are available                  | Strong reject    |
|                                                                           | Reject            |
|                                                                           | Neutral           |
|                                                                           | Accept            |
|                                                                           | Strong accept     |
| It’s easy to use VI’s                                                    | 16                |
| VI’s have been used mainly for measurements                               | 19                |
|                                                                           | 23                |
|                                                                           | 4                 |
| Can VI’s substitute seminars and problem solving in the field of signal processing | 35                |
| Phenomena’s became understandable with VI’s                               | 13                |
| Self-learning, through VI and open source software, is easy               | 29                |
|                                                                           | 2                 |
|                                                                           | 2                 |
|                                                                           | 3                 |
|                                                                           | -                 |
|                                                                           | -                 |
|                                                                           | -                 |
|                                                                           | -                 |
|                                                                           | -                 |

As shown in Figure 4, the availability of resources - hardware and software - in the university laboratories are appreciate among the students, so that the use of those facilities does not create an administrative issue in the educational process, [14], [15].
Also, handling VI’s and graphical editors to design models, simulate process and signal analysing became usual for the students, what turns out from the answers highlighted in Figure 5.

The following two questions aimed to find out the mean of using VI’s. The answer, Figure 6, shows that the VI’s and the related open source applications are not only used for measurements or process control, but strongly integrated in the education process, but being not able to replace problem solving and seminars, Figure 7, [15].

---

**Figure 4.** Availability of resources

**Figure 5.** Easy handling

**Figure 6.** Uses of VI’s
Figure 7. Substitution of seminar

Even so, virtual instruments are excellent tools to improve engineering education by providing flexibility to students and teachers too, in order to overcome the complexity of engineering study, making the understanding of the real world more clearly, [16].

This is reflected in the perception of how useful the VI together with open sources programs are among the students in assimilating information, Figure 8 and also, in Figure 9, highlighting the opportunity for individual teaching, [17].

Figure 8. Uses of VI’s

Figure 9. Substitution of seminar

Supplementary, our experience shows that virtual instruments, supported by open source application, brings more interest in engineering studies, making it more attractive and, in the same time, stimulating innovation and creativity during all involved factors.
5. Conclusion
The use of virtual instruments and open source software in experiments development and in regular lessons in the field of engineering studies makes the teaching and studying process more exciting. Especially the domain of signal processing, with one of his basic applications – the Fourier transform, in different technical directions - makes the use of virtual instruments attractive for the entire students, bringing more dynamic and improving the quality of education in the teaching process of a classroom.

References
[1] Gillich G R, Frunzaverde D, Gillich N and Amariei D 2010 The use of Virtual Instruments in engineering education, Procedia-Social and Behavioral Sciences 2(2) 3806-3810
[2] Ugurlu Y 2010 Measuring the Impact of Virtual Instrumentation for Teaching and Research, IEEE Global Engineering Education Conference (EDUCON), pp 152-158
[3] Sevgi L and Uluisik C 2006 A Labview – Based Virtual Instrument for Engineering Education: A Numerical Fourier Transform Tool, Turk J Elek Engin 14(1) 129-152
[4] Draghi S, Prostean O, Raduca E, Anghel Drugarin C V, Chioncel C P and Rudolf C 2015 The Relations Between the Mathematic Ideal, the Generating Polynome and the Matrixes, G, H Used in Encodings, Procedia-Social and Behavioural Sciences Journal 197 2032-2039
[5] Drăghici S and Anghel Drăghărian C V 2015 The Design of The Moebius Mod-6 Counter Using Electronic Workbench Software, Procedia-Social and Behavioural Sciences Journal 191 2316-2324
[6] Anghel C V 2004 Studiu comparatîv al funcțiilor ortogonale Haar si Fourier la transmisia semnalelor prin cablu, cu aplicatie in Matlab, Analele Universității "Eftimie Murgu" Reșița, Fascicula de Inginerie XI(1) 1453-7397
[7] Gillich G R and Praisach Z I 2013 Damage-patterns based method to locate discontinuities in beams, Proceedings of SPIE, Volume: 8695, Article Number: UNSP 869532
[8] Gillich G R and Praisach Z I 2013 Detection and Quantitative Assessment of Damages in Beam Structures using Frequency and Stiffness Changes, Key Engineering Materials 569-570 1013-1020
[9] Janik Z and Zakova K 2011 Online design of Matlab/Simulink and SciLab/Xcos block schemes, 14th International Conference on Interactive Collaborative Learning (ICL2011), IEEE Conference Publications, pp 241-247
[10] Anghel Drugărîn C V 2012 The Dichotomy Method Programmable in LabView, Editura Politehnica Timisoara
[11] Chioncel C P, Gillich N and Tirian G O 2011 Wigner Ville Distribution in Signal Processing, using Scilab Environment, Annals of Eftimie Murgu Universiv XVIII(2) 101-106
[12] Chioncel C P, Spunei E, Anghel Drugări C V and Piroi I 2015 Direct Self Control Structure for the Asynchronous Machine, Implemented in Scilab /Xcos, Acta Electrotechnica 56(3)
[13] Magyar Z and Zakova K 2010 Using Scilab for building of virtual lab, 9th International Conference on Information Technology Based Higher Education and Training (ITHET), IEEE Conference Publications, pp 280-283
[14] Anghel C V 2008 E-Learning a new method for Environments of 21th Century, The 14th International Scientific Conference THE KNOWLEDGE – BASED ORGANIZATION, Academia Fortelor Terestre “Nicolaie Balcescu”, Sibiu, 27-29 November
[15] Anghel C V, Drobot L I, Constantin A, et. al. 2009 Aspects about information technology education in university environment, 5th Balkan Region Conference of Engineering and Business Education, October 15-17, Sibiu, România
[16] Beirao P and Valero D 2012 Creation of Virtual Graphic Interface Applied to a Process Control System, Procedia Social and Behavioural Science 46(1) 565-569
[17] Olteanu R L, Dumitrescu C, Ghoghiu G and Gorgiu L M 2009 Related aspects to the impact of virtual instruments implementation in the teaching process, Procedia-Social and Behavioural Science 1 780-784