

INTEGRATION OF REMOTE DSP EXPERIMENTS INTO MOODLE LEARNING ENVIRONMENT

RADOJKA KRNETA, MIRJANA BRKOVIĆ, DJORDJE DAMNJANOVIĆ, MARJAN MILOŠEVIĆ, DANIJELA MILOŠEVIĆ

Faculty of Technical Sciences Čačak, University of Kragujevac
radojka.krnet@ftn.kg.ac.rs, mirjana.brkovic@ftn.kg.ac.rs, djordje.damnjanovic@ftn.kg.ac.rs,
marjan.milosevic@ftn.kg.ac.rs, danijela.milosevic@ftn.kg.ac.rs,

Abstract: Development of the blended learning module integrating remote laboratory experiments into Moodle learning environment for an engineering master course in DSP, is described in this paper. New Moodle block called Remote Lab View (RLV) is created allowing remote experiments time scheduling as well as synchronous chat session available for teacher present in the laboratory and for students who access to laboratory remotely.

Keywords: DSP course, On-site experiments, Remote experiments, Blended learning module

1. INTRODUCTION

Learning theoretical concepts of digital signal processing (DSP) theory is usually difficult for the engineering students. This difficulty is a result of the gap between understanding mathematical formalisms of these concepts and student's abilities to connect these theoretical concepts with practical engineering applications. In order to solve this problem many "recipes" suggested for "visualization" of DSP theory. Many of them suggest conducting experiments from remote engineering laboratories [1] - [8].

The integration of remote and hands-on laboratory exercises in addition on learning of theoretical DSP concepts creates the perfect match for improving student practical skills. On the basis of mixture of on-site and remote exercises and web-based teaching materials, blended delivery mode of DSP course is provided at Faculty of Technical Science Čačak, University of Kragujevac.

Blended learning environment integrating online and hands-on laboratory practices together with theoretical DSP concepts have been created to enhance the teaching process for our engineering students [9]. We intend to foster the class and web discussions to enhance collaborative work during student's activities on on-site and remote laboratory exercises and solving their homework. In this way the simulation of real work engineering environment is done. Also, in doing experimental online learning, a learner creates her own learning path as a 'walk through' modularized learning activities by designing exploratory research questions, conducting remote experiments, finding answers, making interpretations and discussing results in the community as emphasized [10]. This approach of combining of on-site and remote experiments also compensates the disadvantages of one type of experiments with the advantages of other one [11].

Within the master study course in Advanced Digital Signal Processing we use on-site MATLAB/SIMULINK® and LabVIEW virtual interactive DSP experiments and hardware DSP laboratory experiments on the NI-ELVIS II + development platform as well as remote DSP experiments on the NI CompactRIO platform in our DSP lab for "visualization" of some course topics.

The course comprises theoretical lectures placed on the Moodle LMS system, lab and computer sessions. Beside lectures, additional teaching materials, like different tutorials, are hosted on the laboratory Moodle system and delivered through the web. On-site lab exercises with appropriate computational examples and short theoretical test before the lab exercise are organized on the weekends for each of the main course topics.

In order to help our students who are employed to exercise on hardware experiments we enable them to exercise remote DSP experiments via the web in addition to on-site lab sessions. We aimed to develop our DSP laboratory towards the usage of the remote experiments in a blended learning scenario based on common learning platforms such as Moodle [12], [13].

2. COMBINING ON-SITE AND REMOTE HARDWARE EXPERIMENTS IN DSP LABORATORY

The laboratory environment for hardware experiments concerning LMS adaptive algorithm "visualization" is shown in the Fig. 1. The hardware experiment regarding noise cancellation carried out in the NI LabVIEW FPGA programming environment by using adaptive LMS algorithm.

The experiment carried out by using sine wave input signals that was compromised by noise. The input signals were set as follows: a sine wave with 0.4V amplitude and

30Hz frequency and the noise signal with 100Hz frequency.



Fig. 1 The laboratory environment for LMS adaptive algorithm hardware experiments

The input noisy signal in comparison with the smooth one is shown in the Fig. 2.

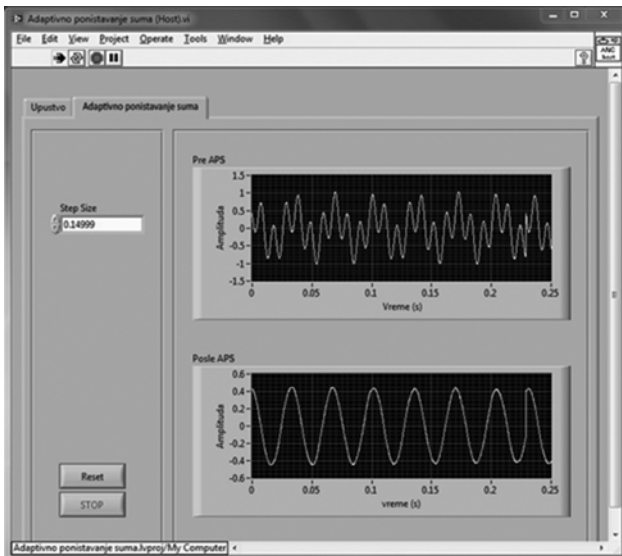


Fig. 2 The input noisy signal in comparison with the smooth one

A system is said to be adaptive if it tries to adjust its parameters in order to meet a well-defined goal or target that depends upon the state of the system and its surroundings. So the system adjusts itself so as to respond to some phenomenon that is taking place in its surroundings [14]. In this case we can say that “surroundings” is noise (first graph in the Fig. 2) and when the process of adaption is done, smooth sine wave signal will be appear on the output of adaptive system (second graph in the Fig. 2).

This is one of good examples for learning how adaptive LMS algorithm can be used in practice that is how the theoretical DSP concepts learned in the classroom are ultimately implemented in a real time embedded DSP system. Similar implementation of the LMS adaptive algorithm on the NI cRIO-9104 FPGA chassis by using of 20 bit fixed-point arithmetic, have presented by Szopos

and Hedesiu [15]. The tracking performance of the LMS derivatives in adaptive noise cancellation for a speech signal corrupted by white noise analyzed by Szopos et al. [16] by using the same NI cRIO-9012 module.

Web-based remote experimentation assists remote users to develop skills, which deal with real systems and instrumentation with the added advantage of providing broader access to expensive specialized equipment at any time and from any location [2]. When students interact remotely with the laboratory plants they have the opportunity to verify what happens when they alter and manipulate the experiment. Besides, the student can run the same experiment more than once. The combined use of connected FPGA/PC hardware and appropriate software may open a way to develop a remote multi-user time-sharing system for hardware experiments, where students at remote terminals can perform actual experiments using real hardware equipment and tools remotely from home or students residence.

The remote laboratory, accessible from anywhere through the Internet connection, has been built according to the general methodology to control instruments through Internet [2], [6], [17] - [19]. Basic structure of the laboratory is shown in Fig. 3. The workplace in the Fig. 3 in case of our DSP laboratory provides hardware platform for the experiment of noise cancellation that carried out in the National Instrument LabVIEW FPGA programming environment. This experiment we realized previously as on-site hardware experiment (Fig. 1).

Lab View has its internal web-server supporting web publishing of the created models and algorithms. This option allows us to control remotely cRIO platform [20] as well LMS adaptive algorithm implemented on the platform. In order to allow students to run the algorithm remotely, we configured the network as it follows: the computer running LabVIEW and the cRIO platform are connected to the same LAN network, using Wi-Fi router, which is further connected to the Internet and got a public IP address. The LabVIEW’s web-server listens on port 8000, and this port is forwarded on the router, thus the remote user might get to the PC in the LAN and access its web-page.

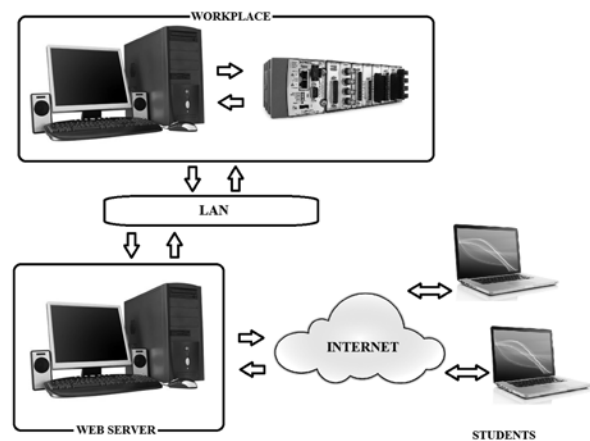


Fig. 3 Basic structure of remote laboratory

By using web publishing tool option we assign the URL address to our application. Actually, this is the router's public IP, and using this address the remote user access the hardware or software, which is connected to the PC running LabVIEW. The result of remote hardware experiment on the remote user side is shown in the Fig. 4. It is evident that this result is the same as the one carried out as on-site hardware experiment.

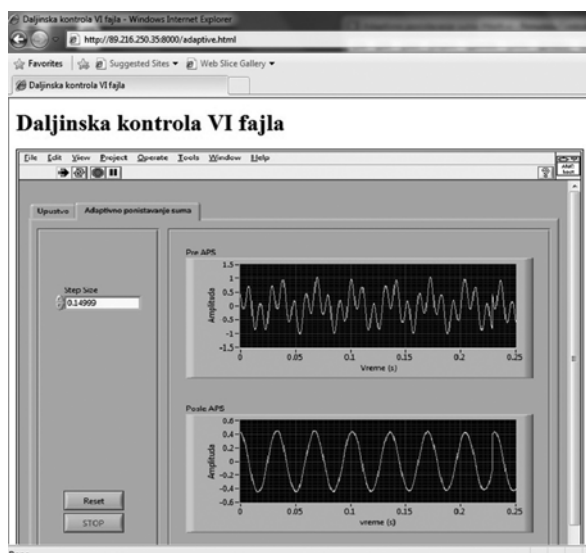


Fig. 4 The result of remote hardware experiment on the remote user side

There is a drawback to this remote-experiment scenario: only one user may access the remote experiment at the same time. However, this is natural, having one physical device on-site. Therefore, the usage should be well planned and scheduled.

3. INTEGRATION OF REMOTE LABORATORY EXPERIMENTS INTO MOODLE LEARNING ENVIRONMENT

Integration of remote laboratory experiments into Moodle learning management system is carried out with the aim of time scheduling and supervision of students' experiments sessions [21]. A new Moodle block - Remote LabVIEW (RLV) is created, which allows time scheduling when students are supposed to access remote experiment. Technically, it is a new Moodle block that is available to teachers and students within the learning environment. Fig. 5 shows student view when he/she is logged to Moodle learning environment.

RLV block displays all sessions that are already scheduled or being currently active. Students must schedule the time at which they want to take the experiment. Set-up is being done by using the link for creating session inside RLV block

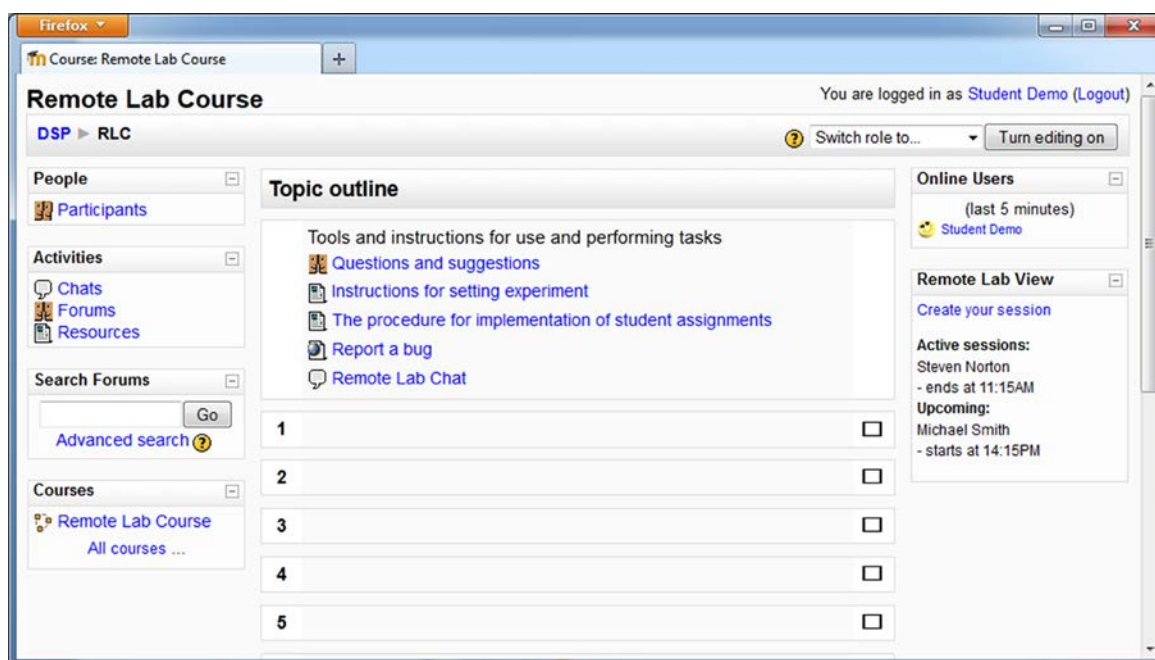


Fig. 5 Moodle learning environment from remote student side

Student is supposed to choose appropriate time for his experiment - 20 minutes long session. Student may choose time from available session's timetable – the first available session time is offered. Time between two sessions is 10 minutes, so two experiment sessions could not overlap and there is some time to adjust experiments if it is needed.

The teacher/tutor on the course should be available for students during experiment. Teacher is able to join the active experiments any time.

When the session for a student is ready to start, Remote LabVIEW block contains the link to virtual experiment. Link is visible to specific students only, according to scheduling data, and no other user can access to specific

experiment at the same time. This access control is done with Moodle block programming. For some experiments it is possible to perform user access control by using LabVIEW web services. That is possible when the user doesn't want to perform remote control experiment, and experiment is being used for some calculations – when experiment is used just for returning value from some LabVIEW functions based on user entry.

Fig. 6 shows control panel used by an individual student who performs remote control of experiment running in the

remote laboratory. This control frame for remote experiment control appears when user starts his session.

At same time when experiment link is activated, new chat session is being started. Initially, teacher and the student that started the experiment are added to chat room, and chat room link is visible to other users and they can join the discussion.

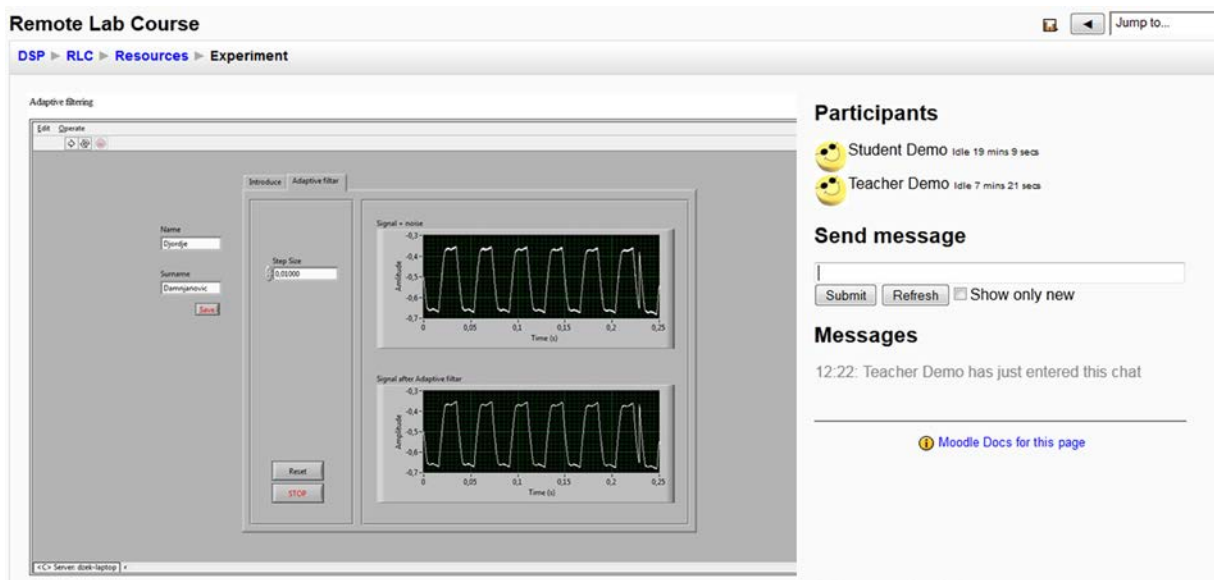


Fig. 6 Control panel from remote student side

4. CONCLUSION

It is obvious that a significant number of authors deal with remote lab exercises in recent years. That is from the reasons of the importance and potential of remote labs for the enhancement of the learning process in engineering education in the classroom or in an e-learning and blended learning environment.

Blended learning of DSP course on the basis of mixture of on-site and remote hardware experiments as well as web-based teaching materials have been considered by authors with the aim of overcoming the gap between understanding mathematical formalisms in engineering courses and practical application deployment. The usage of remote DSP laboratory in an e-learning scenario based on Moodle platform has been described here as one of the ways of enhancement of engineering education.

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LITERATURE

[1] R. Marcelino, J.B. Silva, V. Gruber, M.S. Bilessimo, "Immersive learning environment using 3d virtual worlds and integrated remote experimentation",

International Journal of Online Engineering, vol. 9, pp. 31-34, 2013

[2] X. Yue, E. M. Drakakis, J. Harkin, M. J. Callaghan, T. M. McGinnity, L. P. Maguire, "Modular Hardware Design for Distant-Internet Embedded Systems Engineering Laboratory", Computer Applications in Engineering Education, Vol. 17, Issue 4, pp. 389-397, December 2009.

[3] C. H. Chen, H. C. Lin, "A Distance e-Learning Platform for Signal Analysis and Measurement Using FFT", Computer Applications in Engineering Education, Vol. 19, Issue 1, pp. 71-80, March 2011.

[4] R.C. Maher, "Crossing the bridge: taking audio DSP from the textbook to the DSP design engineer's bench", Proc. IEEE Signal Processing Society 4th Digital Signal Processing Education Workshop, Jackson Lake, WY, pp. 476-481, September, 2006

[5] M. Drutarovský, J. Šaliga, I. Hroncová, "Hardware infrastructure of remote laboratory for experimental testing of FPGA based complex reconfigurable systems", Acta Electrotechnica et Informatica, Vol. 9, No. 1, pp. 44-50, 2009.

[6] D. Hercog, "Hands-on Teleoperation", Faculty of Electrical Engineering and Computer Science, University of Maribor, February 2007.

[7] Krneta, Đ. Dammjanović, Danijela Milošević, "Integration of virtual and hands-on-laboratory experience in learning of filtering

- concepts”, SCIENTIFIC BULLETIN of "Politehnica" University of Timisoara, Romania, Transactions on AUTOMATIC CONTROL and COMPUTER SCIENCE, Vol. 56 (70), No. 3, pp. 121-126, September 2011.
- [8] International Journal of Online Engineering (iJOE), vol. 9 (2013), Special Issue: "REV2012 Exhibition" [Online]. Available at: <http://online-journals.org/i-joe/issue/view/155>
- [9] Z. Dvir, "Web-Based Remote Digital Signal Processing (DSP) Laboratory Using The Integrated Learning Methodology (ILM)", Information Technology: Research and Education, 2006. ITRE
- [12] on PErvasive Technologies Related to Assistive Environments, Athens, Greece, Article no. 63., 2008
- [13] P. Buschiazzo, D. Leoncini, R. Zunino and A.M. Scapolla, "A Web-Based Laboratory for Digital Signal Processing", International Journal of Online Engineering (iJOE), Vol. 6, pp. 6-11, 2010.
- [14] B. Daku, "Individualized Laboratory Using Moodle", 39th ASEE/IEEE Frontiers in Education Conference, San Antonio, TX, pp. M1E1- M1E5, October 18 – 21, 2009.
- [15] D. G. Manolakis, V. K. Ingle, S. M. Kogon, "Statistical and adaptive signal processing", McGraw-Hill book, ISBN 13: 978-1-580053-610-3, 2005
- [16] E. Szopos, H. Hedesiu, LabVIEW FPGA based noise cancelling using the LMS adaptive algorithm, ACTA TECHNICA NAPOCENSIS Electronics and Telecommunications, Vol. 50, No. 4, pp. 5-8, 2009
- [17] E. Szopos, H. Hedesiu, V. Popescu, L. Festila, "Comparison of LMS algorithm derivatives using LabVIEW", ACTA TECHNICA NAPOCENSIS Electronics and Telecommunications, Vol. 50, No. 4, pp. 43-46, 2009
- '06, E-ISBN: 1-4244-0859-8, Tel-Aviv, pp. 211-216, July 2007.
- [10] I. Jahnke, C. Terkowsky, C. Pleul, A. E. Tekkaya, "Online Learning with Remote-Configured Experiments", DeLFI 2010 - 8. Tagung der Fachgruppe E-Learning der Gesellschaft für Informatik e.V, ISBN 978-3-88579-263-5, pp. 265-277, September 2010.
- [11] A. Bagnasco, P. Buschiazzo, D. Ponta, A. M. Scapolla, "A learning resources centre for simulation and remote experimentation in electronics", PETRA 2008 Proceedings of the 1st international conference
- [18] O. Peñaloza-Mejía, L. A. Márquez-Martínez, J. Alvarez-Gallegos, H. J. Estrada-García, "DSP-based real-time platform for remote control of internet-connected systems", Computer Applications in Engineering Education, vol. 21, Issue 2, pp. 203-213, June 2013
- [19] M. Stefanovic, V. Cvijetkovic, M. Matijevic, V. Simic, "A LabVIEW-Based Remote Laboratory Experiments for Control Engineering Education", Computer Applications in Engineering Education, Vol. 19, Issue 3, , pp. 538-549 September 2011.
- [20] H. Çimen, Đ. Yabanova, M. Nartkaya, and S. M. Çinar, "Web Based Remote Access Microcontroller Laboratory", Proceedings of World Academy of Science: Engineering & Technolog, vol. 46, pp. 192-195, October 2008.
- [21] National Instruments. CompactRIO cRIO-9072/3/4. USA. [PDF Manual] Available at: <http://www.ni.com/pdf/manuals/374639e.pdf>
- [22] C. A. Jara, F. A. Candelas, F. Torres, S. Dormido, F. Esquembre, "Synchronous collaboration of virtual and remote laboratories", Computer Applications in Engineering Education, Vol. 20, Issue 1, pp. 124–136, March 2012.