DEV1.2

Joined report on remote laboratories at Serbian partner institutions

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1 Introduction

This report is a final report for WP- State of the Art; DEV1.2 Report on Serbian partner institutions remote laboratories network in Tempus project NeReLa 543667 (Building Network of Remote Labs for strengthening university-secondary vocational schools collaboration).
The aim of this WP is to establish a good reviewing and analyzing remote laboratories/networks already established at Serbian partner Universities.
This report presents final report on this topic and hereby-final report for DEV1.2 Report on Serbian Universities remote laboratories network.

2 DEV1.2 report

The document comprehends a short overview and summary of reports on existing remote laboratories/networks as well as on ICT-enhanced laboratories of four Serbian partners.

Complete reports of Serbian partners are available in four attachments as follows:

- NeReLa DEV1.2; University of Kragujevac
- NeReLa DEV1.2; University of Nis
- NeReLa DEV1.2; University of Novi Sad
- NeReLa DEV1.2; University of Belgrade

3 Summary of DEV1.2 partners’ reports

3.1 Remote laboratories/ ICT-enhanced laboratories

Remote laboratories have been developed and implemented in education process at University of Kragujevac, University of Nis, University of Novi Sad, and University of Belgrade.
All four institutions have an experience in remote experimentations and have intention to improve and enhance remote experimentation within their laboratories.

3.2 Realization of remote laboratories/ ICT-enhanced laboratories

University of Kragujevac comprises 13 faculties. The Faculty of Technical Sciences in Čačak, provides facilities and resources for students to develop their own practical skills in the degrees. The Faculty of Technical Sciences has study programs in Electrical, Mechatronic and Computer engineering as well as 2 modern master studies programs, M.Sc. in E-learning delivered online and Master in Remote Control delivered in blended mode. Hypermedia laboratory E-lab and Laboratory for Electrical Machines and Drives are established at the Faculty with remote experiments as a parts of laboratory exercises. Since 2010 the Faculty of Technical Sciences in Čačak provides some remote experiments for engineering curricula. Some of remote experiments are integrated with
Moodle online learning environment. Students are able to access the laboratory experiment remotely through Moodle block called Remote Lab View (RLV), which is created to do experiment time scheduling and to enable communication between teachers and students during the experiments.

University of Niš comprises of faculties. Only two faculties – the Faculty of Electronic Engineering (FEE) and the Faculty of Mechanical Engineering (FME) have remote control laboratories. The first one, Remote Virtual Instruments Lab, is at the Department of Measurements, FEE, and the second one, Remote CNC Milling Machine Lab, is at the Department of Mechatronics and Control, FME. These laboratories are developed separately, as a part of different projects, and that is why they are not interconnected. There's been no integration to LMS as well as no automated booking system, up to now. There are many ICT-enhanced laboratories at FEE and FME, which are recently improved by introducing new experiments using rapid prototyping design software environments such as Matlab/Simulink and LabVIEW. One of ICT-enhanced laboratories is Mechatronics ICT-enhanced Labs. All experiments can be easily adapted to be internet enabled. According to the project application, it is expected to design the remote laboratories in electrical, mechatronics and computer engineering.

University of Novi Sad: The Faculty of Technical Sciences in Novi Sad, provides various facilities and resources for students since it is organized as a unique complex institution comprising of smaller organizational units such as departments, chairs, research centers, etc. for appropriate scientific fields and laboratories. Since 2008, the Faculty of Technical Sciences in Novi Sad provides some remote experiments for engineering curricula. The remote experiments are integrated in the current teaching curricula. For example: Subject Design Of Industrial Devices at Master study programme in Electrical Engineering and Subject Laboratory for electrical measurement at Professional Studies in Power Engineering – Renewable Energy Resources has part of exercises realized as remote experiments.

University of Belgrade: Development of the remote laboratory for students begins in 2004, when the project was launched by UNESCO – Hewlett Packard Partnership, under the name of Piloting Solutions for Alleviating Brain Drain in South East Europe. The main goal of this project, titled ‘E-Lab Piloting Distance Lab Experiment’, was to explore further the aforementioned approach through establishing a pilot distance lab experiment linking the control labs at the University of Belgrade and other universities and education institutions. The project objective was to develop one pilot distance real-time experiment. The experiment performed through the cooperation between the Institut d'Automatique, EPFL and Control lab, Faculty of Electrical Engineering at the Belgrade university. Students can control eLab laboratory equipment from home computer through the Internet or from the classroom through the LAN network. These exercises, which are performed within the courses Real time control and Industrial process control, significantly help students gain a broader knowledge in the field of control systems. Within laboratory exercises held in the courses of the Signals and systems department, control systems orientation, at the moment there is no automated booking system, but rather a schedule system which is formed offline.

### 3.3 Remote experiments

A number of experiments (remote and virtual) are already available within remote laboratories of Serbian partner universities.
At **University of Kragujevac** the following remote experiments already established:

- Remote control of electromagnetic load emulator for electric motors
- The DSP remote experiment integrated with Moodle online learning environment
- Remote - acquisition system
- Ni ELVIS based remote workstations
- Ni wireless remote workstations
- Remote LabVIEW application for learning filtering concepts and creating reports

At **University of Niš** the following remote experiments already established:

- Remote Virtual Instruments
- Remote CNC Milling Machine

At **University of Novi Sad** the following remote experiments already established:

- Virtual function generator
- Electrical measurements:
  - Exercise 1: Simulated sine wave signal
  - Exercise 2: Temperature measurements in real-time
  - Exercise 3: Chronological temperature measurement (Data Logger)
  - Exercise 4: Measuring air pressure
  - Exercise 5: The measurement of relative humidity
  - Exercise 6: Measurement of CO2 in the air
  - Exercise 7: Measurement with Wheatstone bridge
  - Exercise 8: Measuring the energy of solar radiation
- Teaching Frequency Estimation Techniques in remote mode

At **University of Belgrade** the following remote experiments already established:

- Experiment 1: Demonstration of the PI/PID control algorithm
- Experiment 2: Demonstration of the predictive control algorithms

### 3.4 Remote laboratories/ ICT-enhanced laboratory in education process

At the Faculty of Technical Sciences in Čačak Hypermedia laboratory E-lab and Laboratory for Electrical Machines and Drives are established with remote experiments as a part of laboratory exercises. Some of remote experiments and virtual experiments are integrated with Moodle online learning environment within blended learning delivery mode of some engineering courses.

At the Faculty of Technical Sciences in Novi Sad the remote experiments are integrated in the current teaching curricula. For example: Subject *Design Of Industrial Devices* at Master study programme in Electrical Engineering and Subject *Laboratory for electrical measurement* at Professional Studies in Power Engineering – Renewable Energy Resources has part of exercises realized as remote experiments.
At the School of electrical engineering, University of Belgrade, the application of eLab laboratory significantly reduces the workload of the teacher, increases laboratory capabilities, enhances students’ productivity by allowing them to access the laboratory from their home, and increases the interest, not only of college and high school students, but also of former students who wish to supplement their knowledge with new experiences. The remote experimentation is introduced within teaching process of the following courses: Real time control, Industrial process control. As a part of this exercise students learn about practical aspects of classical control laws and are thus trained to adjust the given control structures in their future engineering practice. In this way students can, in a fast, efficient and interesting way, gain practical knowledge.

### 3.5 Improving/Introducing remote experimentation at partner universities

At the Faculty of Technical Sciences in Čačak there is series of on-site experiments, which are planned to be carried out as remote experiments. The following experiments could be established as remote experiments:

- Drawing characteristic of resistive thermometers
- Solving electrical circuits with capacitors only
- Solving electrical circuits
- Operational amplifiers
- Experimental System for Abdominal Aortic Aneurysm Mechanical Properties Research Using “Bubble Inflated” Method
- Positioning system with variable frequency drive in open loop
- Stepper motor control
- Regulation of water level in tanks
- Visualization of rotating magnetic field

At the University of Niš ICT-enhanced experiments are mostly in the field of mechatronics. These are: tower crane, 3Dcrane, anti-lock braking systems (ABS), modular servo system, rotor system, 3 tank system, inverted pendulum, ball&plate and fly wheel pendulum. It is possible to redesign these experiments to run remotely very easily, as all these experiments have already existed. Several remote lab exercises would be also designed in the field of electrical, measurements and computer engineering. One of them would be “Remote control of mechatronic redesigned slider crank mechanism”.

At the University of Novi Sad, Faculty of Technical Sciences the demo complex robotic cell is going to be realized for the purpose of the investigation of various topics of advanced automated manufacturing technologies like: robot trajectory optimization, proportional pneumatic control synthesis, robotic contact tasks, energy efficiency etc. as well as for teaching students about robot programming, PLC programming, pneumatic and electropneumatic simple and advanced control. Demo complex robotic cell consists of three separate sub systems that can be operated autonomously but, it can operate as an integrated system as well. The following group of experiments will be realized:

- Standard robotic tasks
- Pneumatic manipulator
• Pneumatic two axes robot for contact tasks
• Integrated operation of the demo cell

At the School of electrical engineering, University of Belgrade, the capacity of the eLab is not sufficient, so it is necessary to significantly expand it. The number of experimental exercises, which can be done remotely, should be increased, in order to better present the experimental part of the class to the students. Also, by upgrading the existing laboratory in terms of increase of interest and the number of tasks will lead to improvement of practical part of the course. In the future, it is necessary to expand not only the capacity and the number of eLab exercises, but also the number of courses, which implement the remote laboratory in their teaching process. This will increase the efficiency and reduce the burden on the employees, but also increase the interest of students. In any case, the plans exist to interconnect remote laboratories not only between partner university organizations, but between other universities as well. In that way, by exchanging different exercises the variety of equipment would increase, as well as the ability of the laboratory to increase the level of education.