E-training for Adult Education in Mechatronics

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Abstract. This paper describes e-training in mechatronics developed for the education of adults. The training was developed as one of Leonardo da Vinci life long learning programs within the MeRLab project (Innovative Remote Laboratory in the E-training of Mechatronics). The primary target group for the training are employed and unemployed engineers and the technicians who have already completed their formal education in some of the engineering fields, but are not acquainted with mechatronics. For the training special E-learning system was built in the user friendly environment based on eCampus and Moodle platforms. The complete materials with animations, graphical presentations, online tests and the utilities like discussion forums are offered. In addition to e-learning materials with the theory also remote laboratory experiments are available. Those experiments enable the user to acquire some practical knowledge and obtain some skills. The training comprehends four major topics: Introduction to Mechatronics, Servomotor in Mechatronics, Electrical Circuits and Mechatronic Devices. Pilot testing of the training was executed February-March 2009. From 70 registered participants 62 have successfully finished the training.

Keywords. Mechatronics, adult education, distance learning, remote laboratory.

1. Introduction

An adult education is very important part of modern educational chain, since it enables the specialists to keep the touch with the latest development in their profession. Also, it offers possibility for gaining the knowledge and skills in new fields. This is especially important for the people who are with their current education unable to find a job or when the demands of their job are growing. However, the development of such learning programs is very demanding, especially for the education of engineers. The participants in such programs are mostly employed persons with full time schedule and are sometimes also widely geographically distributed. Therefore, the education process must be designed in the way to meet the constraints of time and distance so that the learners can fit it in their everyday life. A distance learning based educational approach can meet those requirements.

In the education in technical fields it is necessary to give the participants a possibility to gain some practical experience by operating the real devices and by performing some measurements. In the distance learning this can be achieved only by implementing remote laboratories where the user operates real devices trough the Web [1], [2], [3], [4], [5]. Only the distance courses, which include the remote experiments with high quality study materials and sufficient online support of the teacher, can provide complete learning experience that can be compared to the conventional in-the-classroom education with the laboratory exercises.

This paper presents the e-training which offers such complete experience. Additionally the training covers the field of mechatronics, where there is a significant lack of specialist all over the Europe. The training is developed in the way that is also suitable for engineers and technicians from the related technical fields and for the teachers of the secondary schools. As well it can be used for the education of regular students of mechatronics and automation in their first year. From the participants only the basics preliminary knowledge is required that can be obtained in the secondary schools.

Paper is organised as follows. Second section presents MeRLab E-learning Web portal and the portal of the remote laboratory. Third section describes the organization of the training and in the training adopted educational approach.
Fourth section describes the training topics, respectively all four modules of the training. Fifth section presents experimental part of the training and some experimental setups used in remote experiments. In the conclusion the future work plans and the summary is given.

2. Web portal

The theoretical part of training is performed within MeRLab e-learning portal based on eCampus system. This is a system which is used in commercial adult education by a company B2, [10]. eCampus system offers all functionalities that are required for the execution of distance training, both to the learner and to the teacher. According to the usability testing of eCampus it is in some aspects even better then open source Moodle system [6], especially when it comes to the visual design of e-learning content. The home page of the MeRLab learning portal is presented in Fig 1, [9]. User account is necessary in order to log in to the portal.

Practical part of the training is executed in the innovative Remote laboratory which is established at the Faculty of Electrical Engineering and Computer Science, University of Maribor, [7]. Remote laboratory is built in the Moodle environment and includes also the booking system for remote experiments as well as another copy of the complete learning materials, however not in SCORM format, [8].

The users are, after finishing the study of theoretical part in eCampus portal, forwarded to the Moodle based Remote laboratory page. The connection between the eCampus e-learning portal and Remote laboratory is automatic and requires no additional registration or actions from the learner. The learners mostly don’t even notice the change of platforms since they are redirected directly from eCampus to the booking table in the Remote laboratory where they can book and run remote experiments.

3. The training

The training is divided in three parts as shown in Fig 2. First part is Introduction to the training which is organized as three hours long live meeting between the teaching mentor and the participants. The purpose of the live meeting is to introduce the participants with the organization of the training as well as with the e-learning portal and the Remote laboratory. At the meeting, the participants also create their user account. Then, each of the four modules in the training is briefly describes and few live experiments are shown.

Second part of the training is Distance training. Here the participants study materials for each of the modules, execute exercises, perform tests and also execute remote experiments, everything under supervision of the mentor. Fig 3 shows the learning unit where the operation principle of the direct current motor is explained by using the animation. The discussion forums are introduced after each important learning unit. Participants also have to solve one or more tasks and send the results to the mentor, who provides feedback.

Third part of the training is Evaluation of the training success. Learners are asked to write the comments and to fill anonymous questionnaire concerning the training, e-learning portal with documentation and remote experiments. Based on those results the educational approach, materials and/or remote experiments are updated.

4. Contents of the training

The training is composed from four modules. The modules should be studied in the predetermined order. However, the participants with sufficient preliminary knowledge can also study only separate module(s). Each of the modules introduces one major topic in mechatronics. Theoretical part always includes a case study and remote experiment. The training requires approximately 50 hours of the intensive work.

Modules are:
- Introduction to Mechatronics,
- Servomotor in Mechatronics,
- Electrical Circuits,
- Mechatronic Devices.
In the module *Introduction to Mechatronics*, the meaning of the term mechatronics and its origin is explained. Then, the historical development leading from the pure mechanical systems to the state-of-the-art mechatronic devices is described. The structure of mechatronic systems and the role of each element of such a system are also discussed.

In the module *Servomotor in Mechatronics* the types of actuators as well as the role of actuators in the mechatronic devices are described. Basic operational principles of direct current motor are explained with the help of simulations and animations. The construction of direct current motor is also discussed. Basics of the control theory are presented next. Only simple controllers as Bang-bang controller, P, PI and PID controllers are discussed. Servomotor is first presented by theory. After that, the learners can operate real servomotor by execution of the remote experiments. Two possibilities are offered in the remote experiment. First is the open-loop control of motor, where the learner can observe the motion of the motor for different amplitudes and periods of square input voltage signal. Second, the user can tune parameters of the position and velocity controller of servomotor.

In the third module *Electrical Circuits*, first the fundamental elements of electrical circuits are presented. This includes resistor, capacitor and inductance as well as a new fundamental element memristor. This is followed by a detailed presentation of operational amplifier. A frequency characteristics and its graphical presentation in form of Bode plot is also described. Mathematically more demanding parts of the theory are included as additions and the learners can decide whether they want to study it or not. Then, the main topic of the module which is filter analysis and design follows. Passive and active low-pass, high-pass and band-pass filters are described in the analogue realization. Additionally, the switched capacitor filters and digital filters are described. Basic operating principles and the frequency characteristics of the filters are studied through the remote experiments. In the remote experiment the user can choose from first order passive low-pass filter and second order band-pass active switched capacitor filter. In both cases it is possible to change the frequency of input signal and observe the filter’s output. In this way the user is able to measure the frequency characteristics of both filters. For the band-pass filter the learner can also set the corner frequency by changing the switching frequency of the switched capacitors circuit.

In the last module *Mechatronic Devices*, the structure and operation principles of complex mechatronic devices are treated. First, the mechanical elements, such as gears, belts and joints, are considered. As a simple mechatronic device and building block for more complex devices, a design of a joint drive system is presented. Next, it is described how joint drives are used to build a robot. The operation principles of the robots are explained in the case study. Finally, the real world problems in the control of complex mechatronic devices are demonstrated by executing the remote experiments with the SCARA robot.
5. Experimental part of the training

The remote experiments are accessible at the remote laboratory described in [7]. Remote laboratory experiments are built with different experimental devices. Figure 4 shows two degree of freedom SCARA robot, which is implemented in the module Mechatronic Devices.

Very important feature of Remote laboratory is the booking system. By using booking system learner can book in advance time when he or she wants to execute remote experiments. In the booked time period nobody else can access remote experiment and therefore learner can perform experiments as he or she had planned. At the booked time, control window appears in the Web browser on learner’s computer, and he can overtake the control of experiment. During execution of experiments learner can change number of different system parameters and observe system response in textual and graphical format. Further video transfer can be applied in order see experimental device and effects of remotely given commands on the operating or motion of the device.

As an example, the remote experiment performed with SCARA robot will be described. User interface for operating the robot is shown in Fig 5. In remote experiment following three controllers are implemented:

• PD controller with the position and velocity feedback loop. The controller is built for each robot joint separately.

• Computed torque controller. For realization of this controller, the derived dynamic model of SCARA robot is implemented. This is centralized controller, which means that there is only one controller for both joints.

• Cascade controller. This a linear controller implemented in many commercially available controllers. It is composed from P position, PI velocity and PI current controller. The controller is built for each joint separately.

For all controllers the user can change some of the controllers’ parameters and observe position error and the motor current for both robot joints. Also it is possible to choose simultaneous motion of both joints, or just the motion of one joint. In the case, when motion of only one joint is chosen, the second joint is held in the zero position by the controller in order to compensate the influences of the moving joint. In this way the user can see the effect of dynamic coupling between the robot joints.
6. Summary

In this paper a distance engineering education of adults in mechatronics is presented. For the training, the web environment which combines two different learning platforms was developed. Within first, commercially available platform eCampus, e-learning materials are available. Second platform is Moodle based and serves for the implementation of Remote laboratory with experiments that supplement the theory. In this way the advantages of both systems are combined in order to obtain very efficient and user friendly learning environment and also to solve some of the technical problems that appear at the establishing of remote laboratory.

The training includes four modules, Introduction to Mechatronics, Servomotor in Mechatronics, Electrical Circuits and Mechatronic Devices. Each module is given with theory, exercises, tests and suitable remote experiments. The modules are supplementing each other.

Some parts of the training were already tested by the local students and improved/updated according to their comments. For the complete test, a pilot training was executed in February-March 2009. From 70 participants, mostly electrical and mechanical engineers and technicians employed in industry, 62 have successfully finished the course. The feedback obtained from the participants shows that they think that the training meets its goals and judge the whole training as excellent. All of them would also like to take part in the advanced training.

After some additional updates, the training will be further offered to the potential users from industry and to the educational institutions in Slovenia as well as in Austria.

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8. References


