Chapter 8
The Role of Internet-Accessible Laboratory Plants in the Teaching of Automatic Control

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ABSTRACT

This chapter presents a sequential approach to the introduction of e-learning in the field of automatic control as realized at the Faculty of Electrical Engineering, University of Ljubljana, Slovenia. However, the proposed methodology can easily be extended to other scientific fields. First, the organization of the lectures and the main activities are described. Then the motivational aspects for the reorganization are presented, where the design projects introduced during the exercises play an important role. As a result of the positive response to this approach, one of the projects was further extended and realized as a combination of exercises and exams, incorporating parts of a computer game and competition using virtual and remote experiments with a chosen multivariable pilot plant. The students' responses and staff experiences are evaluated and analyzed, from which the potential advantages of the proposed approach become clear.

INTRODUCTION

Automatic control, also referred to as control technology, control engineering, industrial informatics, etc., is associated with informatics, cybernetics and process automation. A modern understanding of the domain is based on the connection of control techniques with areas like system theory, modeling and simulation, industrial informatics, computer sciences and specific knowledge from the application domains. The feedback-loop paradigm represents the essential idea in automatic control, ensuring the functionality of devices, systems

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and processes. Control technology represents a "hidden" infrastructural and convergent technology with a strong potential and influence on the economy. It is well known that the introduction of automatic control substantially contributes to an increase in economic competitiveness since it results in an expansion of the quantity and flexibility of production, in improving product quality, in reducing the consumption of energy and raw materials, in decreasing environmental pollution, in the humanization of work places and the safety of workers, etc. At the same time the investments in this area have been shown to be highly profitable, which is the reason for the high level of automation in developed countries.

Automatic control has a 50-year-long tradition in Slovenia. The country's undergraduate as well as postgraduate studies were among the earliest to be introduced in Europe. The Department of Automatics on the Faculty of Electrical Engineering, University of Ljubljana is involved in research and education in the area, with support coming from some other strong research teams.

In the past few years intensive efforts have been focused on the introduction of the so-called Bologna study program, which is now common in the EU, where, of course, aspects of e-learning are becoming very important.

Regarding some earlier papers, attention was mainly focused on simulations and on so-called virtual experiments (Schmid, 1999; Narayanan et al., 1999; Alfonseca et al., 2000; Waller and Foster, 2000; Shin et al., 2000; Shin et al., 2002; Bertoni et al., 2003; Guggisberg et al., 2003), while some papers reported on experiences in the field of automatic control (Copinga et al., 2000). As indicated, for example, in Dormido (2004), the time has arrived for remote laboratories, as proposed in Chiculita et al. (2002).

At the moment it is practically impossible to find new solutions with respect to web-based simulation approaches, web-based teleoperation, visualization or work organization. The differences are frequently the consequence of the area where they are used: chemical engineering (Cristea et. al., 2005; Rafael et al., 2007; Dalgarno et al., 2009), control engineering (Sánchez et al., 2004; Gillet et al., 2005; Nguyen, et al., 2007; Uran and Jezernik, 2008), biomedicine (Michaelides et al., 2005; Čorović et al., 2009), and mechatronics/robotics (Potkonjak et al., 2010). They differ with regard to the hardware and software used: virtual labs (Grimaldi and Rapuano, 2009; Dalgarno et al., 2009; Domingues et al., 2010), remote labs (Dormido et al., 2008); combinations of virtual and remote labs (Jara et al., 2008), and organizational aspects (exams, for example, can be included in the presented frame of e-learning) as described in Judex et al. (2008).

This work deals with the use of virtual and remote laboratory functionalities in the pedagogical process of the undergraduate study of automatic control at the Faculty of Electrical Engineering, University of Ljubljana. The step-by-step introduction of e-learning is described, giving some ideas that can easily be used in any e-learning process. The mentioned ideas are illustrated with an example of introducing e-learning in lectures about Multivariable Systems in the 9th (also the final) semester of the undergraduate university study program.

EDUCATIONAL SCHEME DEVELOPMENT

The ideas leading to the proposed step-by-step introduction of the education scheme for internet-accessible laboratory plants in automatic control are as follows.

The usual organization of the education process at faculties in Slovenia consists of lectures and exercises, finishing with written and/or oral exams at the end of the semester (Matko et al., 2001; Atanasijević-Kunc and Karba, 2006). This approach was also adopted by the Faculty of Electrical Engineering and, as such, represents a frame that was later gradually improved.