

# Remote Laboratories for Education and Research Purposes in Automatic Control Systems

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**Abstract**—This paper describes the experiences using remote laboratories for education and research in the field of Control Engineering. The use of remote laboratories for education in subjects of control is increasingly becoming a resorted method by the universities in order to offer a flexible service in schedules with greater and better operation of available resources. Nevertheless, for research activities, remote laboratories are not widely used. The aim of this contribution is thereby to apply the experience of remote laboratories in research applications in order to share complex equipments among different researchers. Some experiments are carried out to demonstrate the effectiveness of using remote laboratories in research experiments related to robotic system. The results of the implementation of remote experimentations to control a 3-DOF parallel robot by using Distance Laboratory System (SLD) are exposed. The performance of the system is evaluated by the possibilities and functionality of the proposed remote laboratory platform.

**Index Terms**—Remote experiment, remote laboratories, parallel robot, control systems research.

## I. INTRODUCTION

EXPERIMENTAL validation represents a fundamental component of education and research methodology in engineering. However, their practical implementations present numerous restrictions due to the cost of equipment, limitations in spatial capacities, security problems, time and maintenance. The use of information technology offers new opportunities in order to reduce these constraints. Remote laboratories can provide remote access to experiments and can allow learners to have access to experiments with less restrictions on time and location, providing the necessary guidance and assuring a safe and secure operation for both the equipment and staff in charge [1].

For engineering distance education courses, remote facilities constitute as the only realistic method of performing many experiments. It must allow remote access to students, no longer constrained by time or geographical considerations, complete laboratory assignments. Thus, it is fair to conclude that remote experimentation facilities enhance the development of skills in the use of real systems and instrumentation [2]. A model for

evaluating the effectiveness of remote engineering laboratories and for simulations in education are provided in [3]. The authors concluded that students have learned laboratory content information equally well from both types of laboratories, hands-on and remote labs, and that they have a realistic understanding and appreciation of the practical advantages of remote laboratories.

This paper is focused on the use of remote laboratories for education and research purpose ensuring the security of real equipment. Considering the remote access to real equipment, "Sistema de Laboratorios a Distancia" (SLD) created by the Department of Automatic and Computational Systems of Universidad Central "Marta Abreu" de Las Villas (UCLV) in collaboration with the Universidad Politécnica de Madrid (UPM) has been used. The SLD is a distance laboratory system that allows learning and adjusting predefined controllers, designing new controllers, testing and analyzing the performance of the predefined/designed controllers over a set of physical devices through the Internet [4].

This paper is organized as follows. Section II shows the most relevant works developed for remote laboratories in Control Engineering. Section III describes the characteristics of SLD Web application. The characteristics of remote laboratories for research purpose are shown. Section IV shows the general operation of SLD. Section V describes how access to remote equipment for experimentation. Some topics where SLD could be used are presented. Section VI is focused on the description of the parallel robot used for the research. Section VII presents the results obtained using SLD on research. Section VIII explains the experience and opinions using SLD. Finally, Section IX summarizes the main results of this study.

## II. RELATED WORKS

There are numerous virtual laboratories and remote experiments available in the literature [5]–[12]. The iLab [13] at Massachusetts Institute of Technology, Cambridge, MA, the LabShare [14] at Curtin University, Australia, and the WebLab-DEUSTO [15] at the University of Deusto, Spain, are important remote laboratories. In [16], the authors provide a literature review of modern remote laboratories. In [17], after a brief overview of state-of-the-art technologies in the development of remote laboratories and presentation of recent and interesting examples of remote laboratories in several areas related to industrial electronics education, some current trends and challenges are also identified and discussed. In addition, in [18], the authors identify possible evolutions for the next generation of remote laboratories that are under a strong current of evolution. Such labs would no longer be restricted to a single topic, where Automatics and Robotics are among the most frequently used tools.

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