

A VIRTUAL REALITY BASED TELELABORATORY FOR THE REMOTE LEARNING OF ROBOTICS

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Abstract: In the present work, a virtual reality system, used in the framework of a web-based educational tool, is presented. Such tool, called *VRL*, can be used as a support for active learning of robotics in a web-learning environment. *VRL* guarantees forms of flexible learning, and couples virtual reality experiments, obtained through the integration of Matlab and Shockwave technology, and remote lab experiments, in order to allow a preliminary verification of theoretical concepts without the risks of damaging the remote experimental device. *Copyright © 2006 IFAC*

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1. INTRODUCTION

A consequence of the continuous advances in information technologies is that educational models emphasizing collaborative and active learning have been more and more claimed for in university courses. University curricula for control engineering courses have been substantially modified during the last years, to include modern techniques for analysis and design as well as novel learning tools based on the Web (Pointdexter *et al.*, 1999). In face of continuously evolving programs, yet the recognized need for laboratory experience in the curricula is a constant issue: "More and more educators recognize the importance of a complete educational experience involving theory and practice" (Yorkovich and Passino, 1996).

In educational terms this corresponds to the need of learning skills. In the Control Engineering domain, an important category of skills is the ability of capturing the experimental richness of the real physical processes, and to abstract from it the approximate models suitable for an effective control. This would imply the availability of large laboratory resources, which is instead limited due to economic factors. The need of integrating traditional classroom

lectures with some kind of "experimental practice" is often addressed using simulation tools, but the richness of physical realities is inevitably omitted. Distance learning has been more and more effectively used to overcome these problems (Corradini *et al.*, 2000).

Nevertheless, remote access to technological laboratory resources cannot be allowed indiscriminately, particularly when a sophisticated device (such as a robotic system) is accessed for learning purposes, f.i. with the aim of testing a student's own control algorithm. A preliminary phase of testing on a virtual device, which mimics most of the real device features but relieves the user from worrying about a number of physical constraints, can greatly help in limiting damaging risks and improving safety (R. Carloni *et al.*, 2003), (L. Villani, 2003).

This paper describes a prototype of Virtual Remote Lab (VRL) designed and implemented at the University of Lecce (Italy) in the framework of the national FIRB project "TIGER" (Telepresence Groupware For Higher Education in Robotic). VRL can be defined a learning tool containing also a tele-laboratory of robotics aimed at coupling experimental training and active learning in the field

of Control Engineering. Beyond the usual facilities typical of remote laboratories, VRL is also a virtual lab allowing the preliminary testing of user supplied control algorithms through virtual reality animations (M. Cefalo *et al.*, 2004), (L.Villani, 2003), (Chung and Chen, 2001), (Rodriguez *et al.*, 2002), (Muzak and Cavrak, 2000).

A further novelty of VRL consists also in the definition of a flexible and user-tailored learning path, containing also some experiments on a virtual reality set-up, which the user has to follow before being allowed to access the remote physical devices available. This latter choice stems from the fact that obvious safety reasons usually hinder, de facto, the effective use by students of classical remote labs. In VRL active learning is achieved by the use of learning "elements" (tests, exercises, design) which can be executed according to a totally flexible, user defined order, still maintaining complete interactivity with the system (Bagnasco and Scapolla, 2003), (Bagnasco and Scapolla, 2004).

A further remarkable issue of VRL is the definition of a dynamically updated "learning coefficient", associated to each user, which formalizes the degree of successfulness in learning of the user according to his/her individual learning pathway. Therefore, not only the sequence of the learning elements varies with the user, but also their number and type, according to the learning "performances" of the user itself.

The availability of virtual reality experiments in VRL, obtained through the integration of Matlab and Shockwave technology, allows the user to integrate theoretical concepts with a preliminary practical verification, without the risks of damaging the experimental device. The user can check his/her controller again and again on a virtual version of the selected device and, when the virtual control experiment is successful, he/she gains access to the physical device. It is worth noting that the virtual device can be accessed simultaneously by more students, while the experimental device can be accessed only by a user at a time.

2. VRL ARCHITECTURE

Design of VRL has been carried out according to the following issues.

1. Simplicity of use. The goal was the creation of a structured and integrated environment allowing an easy interaction with the remote device.
2. Allowing distance and/or long-life learning.
3. Integration between practice and theory. The user can be registered as a "learning user" or "privileged user". In the former case, access to the physical device is regulated according to his/her learning path, while in the latter case users have no constraints in performing experiments.
4. Interactivity and Multimediality.
5. Lightness. The system has been designed as an internet application.
6. Allowing learning monitoring. VRL allows real-time monitoring of the learning performances of users by a properly designed database.

7. Allowing self evaluation. The learning path of VRL is indeed a self evaluation tool.
8. Allowing collaborative learning. Being a web based tool, VRL allows the definition of multi-user environments (i.e. communities) where opinions, results and experiences can be exchanged among lab students.

From the theoretical viewpoint, VRL has been modelled using the so-called VRL Meta-Object, i.e. "any digital entity that can be used for learning, education or training" (see Fig.1).

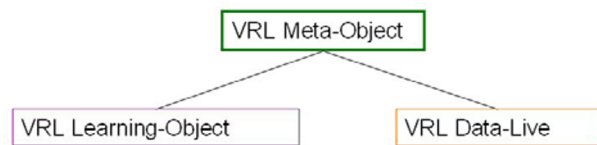


Fig.1. VRL Meta-Object

A VRL Meta-object includes:

- A *VRL Learning-Object*. This object is of "learning element" type (Fig.2), i.e. the basic element containing all attributes need to represent, manage and store all relevant information.

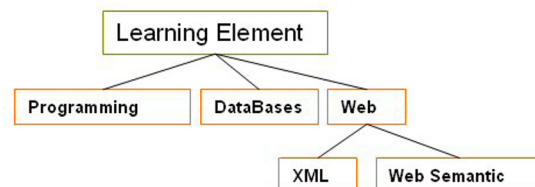


Fig.2. Learning element

- *VRL Data-Live*. It is the advanced learning element formalizing the web-based collaboration.

The element representing the virtual application in VRL is contained in the VRL Learning-Object, as shown below.

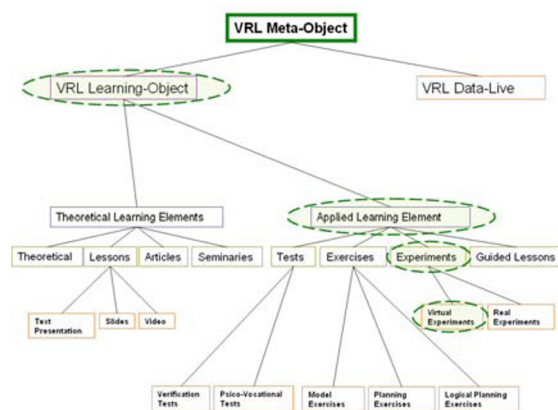


Fig.3. VRL Learning-Object

Figure 3 shows how the virtual experiment is classified as an "applied learning element" improving interactivity and multimediality in the VRL environment.

VRL architecture is composed of a Knowledge Base, representing the scope (knowledge domain) and an Inferential "Motor" designed in order to create a self evaluation tool for the users.

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