

# A Novel Website of Mechatronics for Remote Learning\*

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*This paper describes the development and use of a novel website to improve the learning of mechatronics concepts. The website has been designed for a twofold connection: Internet and intranet. First, it is a quite standard Internet information server for students that are evaluating their interest in mechatronics. In addition, the same server is used for remote laboratory experience improving the efficiency of the lessons using intranet connection. Examples of remote programming of 'LEGO mindstorms' autonomous robot are presented. Moreover, other Italian web-based remote learning realisations are described to represent different solutions.*

## INTRODUCTION

NOWADAYS the information revolution due to the diffusion of information and telecommunication technologies has changed also the education system both in requirements and in strategies. Looking at university education, particular effort is devoted to shorten the time for completing students' curricula. For example, in Italy a new didactical structure has been implemented and the university engineering degree (Laurea) should be completed within three years. Thus a dramatic reduction in time without a major cut in curricula topics should be obtained by improving teaching efficiency.

Moreover, the expected large number of students will pose many logistic problems, e.g. transportation and accommodation, with relevant social impact. In particular, in the island of Sardinia transportation is a cumbersome problem due to the low population density and lack of efficient road and railways connections. Despite these problems, the island condition allows easy testing and monitoring of new teaching techniques. From the students point of view, Internet connections are widely used and difficulties due to inefficient transportation system will be minimised.

Recently, there is a lot of initiatives about remote or distance learning with special emphasis to control experiment [1, 2] and new terms like 'remote laboratory' or 'virtual laboratory' are frequently used to describe new learning tools.

Remote learning can be realised in two completely different configurations: off-line and on-line. The off-line remote learning is similar to the old-style mail between students and institute and allows very poor interaction. It is important to state that off-line learning material is extremely useful for subsequent refresh of concepts. The new

techniques of hypertext writing are very useful to design reference material helping students to grasp the key points of the subject.

The on-line remote learning requires high technical equipments and infrastructures to realise good interaction between teacher and students.

From the pedagogical point of view, on-line interaction is extremely important to pace learning. Similarly to the reduction of efficiency in teaching to wider attendance, on-line remote learning will be inefficient if students are not stimulated to interact. The 'on-air' remote display of lectures is much more effective when students are required to complete final test or, even better solution, can ask questions directly to the teacher.

It is truly important to observe that both on-line and off-line remote learning approaches are important to obtain effective and efficient learning results. Very different actions must be adopted depending on the topic and on the audience.

In the following, discussion is focused on the developing of remote learning facilities to support teaching of mechatronics within industrial engineering university curricula. Referring to the development of a novel website for mechatronics at the Department of Electrical and Electronics Engineering (DIEE) in the University of Cagliari, a detailed description of remote learning strategies is reported.

## MECHATRONICS UNIVERSITY COURSE IN CAGLIARI

Mechatronics is a recent word, first coined by Yaskawa in 1969, that merges mechanics and electronics in the same topic. The word has taken a wider meaning and an actual definition should be: 'the synergistic integration of mechanical engineering with electronics and intelligent computer control in the design and manufacture of products

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Table 1. Proposed contents of mechatronics lectures

#	Argument	h
1	<b>Mechanics:</b> motors and gears. Kinematics and Dynamics	5
2	<b>Sensors and actuators:</b> solid state sensors, piezoelectric and ultrasonic. Signal processing.	5
3	<b>Movement Control:</b> electric motors, power electronics, electrical drives, smart drives.	5
4	<b>Circuit Design:</b> analog and digital circuits, microcontrollers and DSP, communications and control.	10
5	<b>Mechatronics system design:</b> system integration, human interfaces, robotic manipulators.	5

and processes' [3]. Avoiding further confusion with machine learning or artificial intelligence, here the term 'mechatronics' addresses basic design of autonomous robots. Thus, relevant concepts of mechanics, sensors, microcontrollers and control algorithms are presented in the lectures.

Referring to the new basic university degree, the three-year laureate, the proposed mechatronics course is limited to 60 hours (6 credits for ECTS) including 30 hours devoted to laboratory activities. Considering engineering education objectives, laboratory is critical and the equipment management is very difficult. To realise a good trade-off between ease of use and flexibility, LEGO Mindstorms are chosen for laboratory experiments [4].

Table 1 lists the proposed contents of lectures, while a short description of laboratory activities is given in Table 2.

### THE MECHATRONICS WEBSITE (ROBOWEB)

The challenge is to design both lectures and experiments to be offered to the widest audience.

Both traditional classroom and laboratory lessons can be digitally recorded in order to allow remote playing, while the interactive part of lessons (questions and exercises) can be reported in compact form so to use the website facilities.

This way, the university may offer the mechatronics module to a wider attendance without increasing classrooms and laboratories, but high-tech equipment should be used. More difficult is arranging didactic material to capture student interest and manage learning without tutoring. Unfortunately, this approach is not appropriate for engineering students that must also experience a real contact with gears and physical devices. This need should be partially satisfied with scientific laboratories, but this will conflict with the main scientific research work.

A possible solution to this challenge is the realisation of a novel website with multiple and structured access. Figure 1 sketch the relationships of this website with other entities. The website has two different objectives: informative and formative.

Table 2. Description of laboratory activities

#	Argument	h
1	Getting started: lego components and examples of using motors and sensors	3
2	Mechanics: motors and gears. Realization of robot arm with fingers	3
3	Mechanics: design and realisation of two and six-legged robots	3
4	Mechanics: design and realisation of 'pathfinder' robot	3
5	Mechanics: design and realisation 'basket player' robot	3
6	Controls: coding the control algorithm for 'pathfinder' obstacle skipping	3
7	Controls: coding the control algorithm for 'pathfinder' traced road following	3
8	Controls: coding the control algorithm manipulating objects	3
9	Controls: coding the control algorithm for 'basket player' robot	3
10	Controls: Vision Command simple applications for autonomous walking	3

The information issue aims to stimulate students interest in the proposed mechatronic course. This is truly important to collect highly motivated students for the class-room activities. To attain this goal is important to describe cultural requisites for efficient attendance of lessons and test preliminarily the actual knowledge of candidate students. All these functions can be realised with 'off-line' remote learning through Internet access to the website.

The formative issue is more critical and must be obtained interacting with laboratory experiments. This is possible realising a remote access to the LEGO programmable robots. This way students exercise their control algorithms with remote access and checking on-line for correct operation. These functions configure 'on-line' remote learning and are better restricted to intranet connection within the university campus.

### INTERNET INTERACTION

The informative mission of the web server is fully accomplished with standard HTML pages that are continuously maintained from experienced students that are working in the DIEE laboratories. In Fig. 2 an introductory page of the 'RoboWEB' server is reported.

Through these pages, information about didactical and scientific (i.e. research) activities are available for electrical and electronics engineering students. Material about lessons and projects may be downloaded. Students will also use CD-ROMs with videos of traditional lessons that will be played using their own computers. Web interactions are concentrated to preliminary questions and laboratory exercises (control algorithm coding). Information about programmable robots and links to other websites complete the use of this Internet server. Figure 3 shows a slide of the video

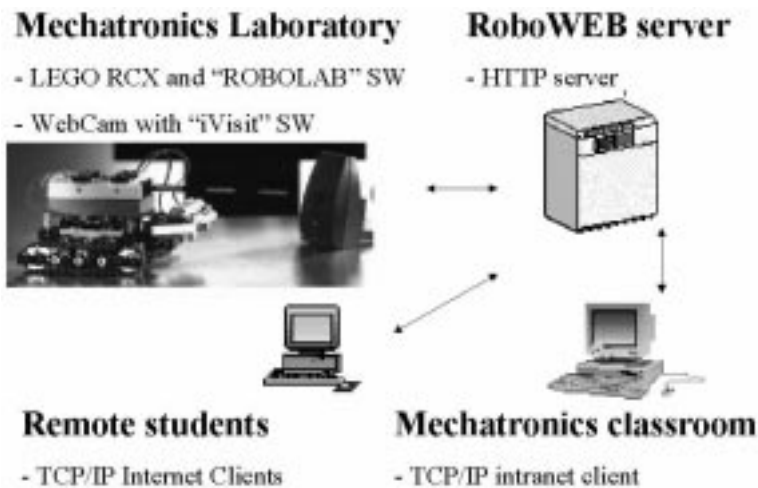


Fig. 1. Entity-relationship diagram for RoboWEB.

training for first assembly of 'LEGO MindStorm' robot.

Due to this particular topic, some laboratory experience (building mobile robots and programming them for autonomous operation) should be developed directly by students to enhance learning, but the proposed remote training can greatly reduce the time absolutely required for subsequent classroom attendance. Indeed, only students that are already informed about course topic and LEGO mindstorms operation could easily enrol the course.

### INTRANET INTERACTION

Using the same hardware of the traditional web server, more interactive tasks can be realised. As previously stated, laboratory experience is absolutely required for effective training of engineering students, but physical constraints (i.e. laboratory dimensions and equipments) represent a hard limit. On-line remote learning represents a smart solution for this problem. Both during mechanical-oriented and control-oriented laboratory lessons,

students work efficiently without direct manipulation of hardware, but using standard PCs of a general-purpose multimedia classroom. To obtain pedagogical effectiveness at least one teacher must be present in the classroom to assist and help students. Workgroup must be stimulated through co-operation within each group of about three students for each PC. At the same time, to increase student applications, competition among groups in the classroom to reach the goal of that laboratory lesson must be stimulated.

For example, during mechanical oriented laboratory lessons each group has to present their design by completing the part list and the assembly instructions to realise a specific task-oriented robot. Thus, best designs will be built in the real laboratory only by their authors while the teacher can illustrate a general comparison of different design proposal to the other students.

Similarly, for control-oriented lessons each group has to draw their own control algorithm for a given robot. Each code can be downloaded to the single specified robot located in the laboratory and the resulting behaviour is displayed to the general audience using low-cost webcam and

## WELCOME at "RoboWEB"

### DIEE robotics home page



Fig. 2. Home page of the 'RoboWEB' server.

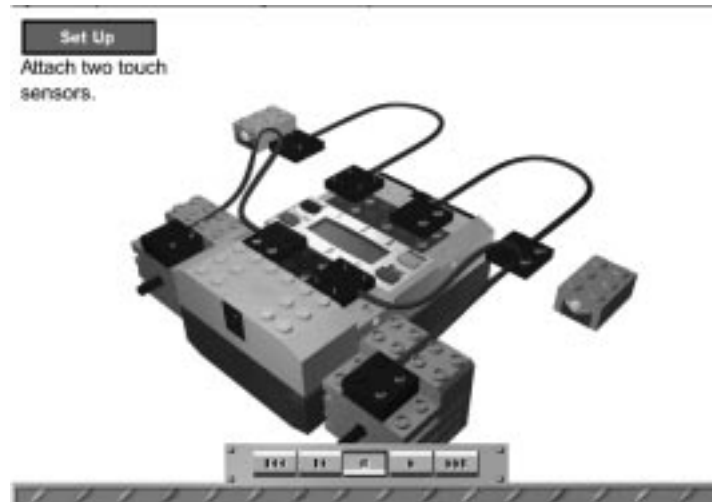


Fig. 3. Sample slide of the video training for first assembly of LEGO robot.

Internet videoconference software. Figure 4 shows examples of mobile robots used for testing control algorithms.

It is worth noting that the commercial version of RoboLAB 2.5 include the 'Internet server

connection' allowing easy remote downloading of code from the client to the server with IR connection to the RCX. Moreover, the RoboLAB programming environment is quite similar to LabVIEW and allows for easy understanding of the control algorithm. In Fig. 5 the screen dump of the editing of a RoboLAB virtual instrument from library is given.

Of course, during laboratory lessons, code downloading and robot operation must be regulated by the teacher and accomplished from technicians in the remote laboratory. Moreover, site licence restrictions of software limit such type of web interaction to classroom only in intranet connections.

In summary, this part of the website allows for registered students to interact (download and upload) following a didactical path equivalent to traditional attendance of classroom lessons, but permits important savings of resources both in equipment and operators.

In the near future, it will be possible to manage a competition for a fast labyrinth escape with 24-hours availability by using a set of four IR towers to be able to communicate with the RCX in every position within the competition area. Thus, no human operator will be required to reset the robot and to place it near the IR transmitter for a new start.

#### OTHER WEB RESOURCES FOR REMOTE LEARNING IN ITALY

Also in other parts of Italy there are many universities involved in distance learning projects. Web-based teaching, distance learning, electronic books and interactive learning environments will play increasingly significant roles in teaching and learning processes over the next years. A special attention is devoted to the automatic control laboratories accessible through the Web. One can divide telelaboratories in two classes: 'virtual lab'

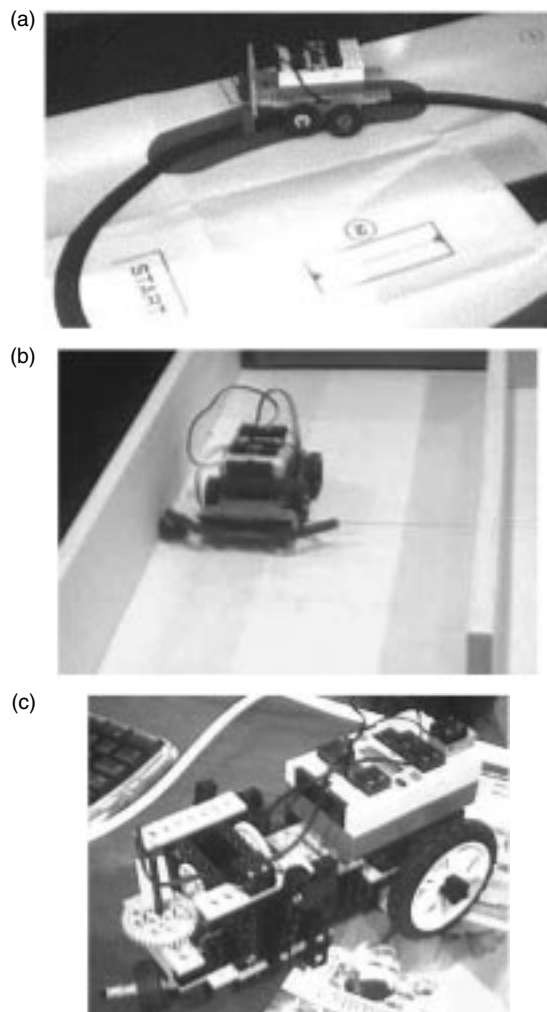


Fig. 4. Examples of mobile robot used for testing control algorithms: (a) 'line follower'; (b) 'labyrinth escape'; (c) 'landscape exploration'.



Fig. 5. Screen dump of a running RoboLAB virtual instrument.

and 'remote lab'. The first ones are systems which allow remotely run simulations with possible animations of the controlled system. The student typically connects from a remote client to the virtual lab server, chooses the experiment, changes some parameter and runs the simulation; then he looks at the simulation results through some graphical interface or downloads data stored in a given format. 'Remote labs' are laboratories where students can interact with actual experiments via the Internet. Usually, remote operators through a Web interface can change several control parameters, run the experiment, see the results and download data. Among others, it is remarkable the site realised by the Automatic Control Group at Siena University (<http://www.dii.unisi.it/~control/act/index.html>).

At the University of Siena, a remote laboratory of automatic control has been developed [5, 6]. The main target of this laboratory is to allow students to easily interact with a set of physical processes

through the Internet. It will be possible to run experiments, change control parameters and analyse the results remotely. The Automatic Control Telelab (ACT) allows the user to design his own controller by means of a user-friendly interface based on the Matlab/Simulink environment. Another interesting feature of ACT is its architecture easily allows the integration of new processes for control experiments. Some of the experiments available at the remote laboratory of the Siena University are reported in Fig. 6. Work is in progress to add Lego processes at the Automatic Control Telelab structure.

## CONCLUSIONS

There is a remarkable effort to develop novel strategies for distance learning and remote laboratories all over the world mainly resorting to Internet connections. Description of a novel website

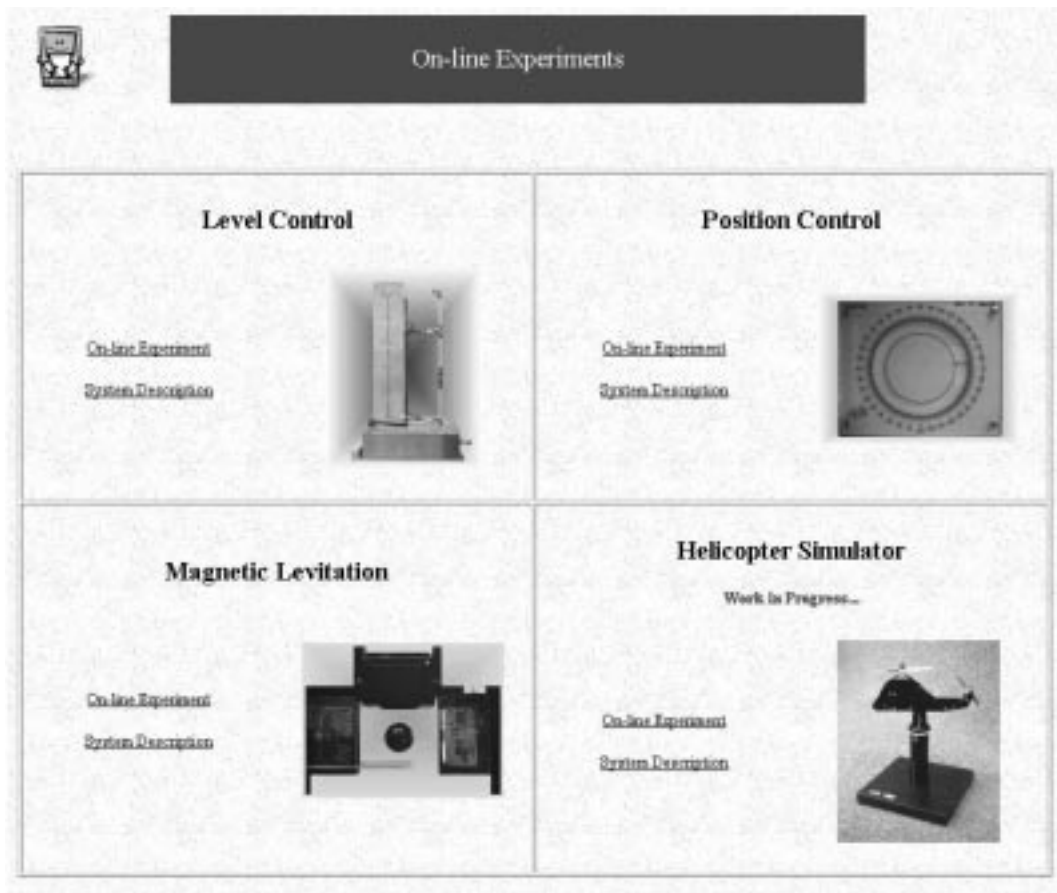


Fig. 6. Web page of experiments available at the remote laboratory of the Siena University.

suitable for supporting the teaching of mechatronics at the University of Cagliari is presented.

This particular website interacts with any http client (browser) to offer information about teaching and research activity. Moreover, it allows intranet access to simple LEGO robots in the laboratory using Internet server features of RoboLAB software.

It is the author's opinion that beyond the offer of information and culture to a potentially global audience, the university website must focus its contents for recruiting motivated students and to allow them for efficient attendance of lectures. Indeed, real laboratory experience and the human relationship between teacher and students cannot be replaced by any virtual system, but a properly designed Internet server may help to

really improve the teaching efficiency. Moreover, a virtual laboratory in conjunction with remote experiments may improve the design capabilities of engineering students with an efficient managing of equipment and laboratory structures.

It is important to use Internet facilities to sustain the increase in the number of students attending to much more intensive lectures in university, rather than try to empty the real classrooms by creating virtual ones. Changes in engineering curricula will be monitored to evaluate the impact of the proposed strategy.

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