STUDY AND BUILDING OF A COMPUTER BASED CONTROL LABORATORY

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ABSTRACT

Laboratory practices in a Distance University involve greater problems than those one has to usually deal with in a conventional University. These problems are mainly related to the students' possibilities of access to the laboratory. Within this framework, we thought if would be useful to design a laboratory that was as close as possible to the student, so we built a Computer Based Control Laboratory with an environment with a hypertext structure that allowed the students to do all laboratory practices both simulated and on real systems, with the same user interface. In this way, the students can do the practices at home by simulation, and when they go to the laboratory, they are better acquainted with the real process and the instrumentation; therefore the time in the actual laboratory is spent fruitfully.

1. Introduction

Laboratory practices are essential in control teaching. One of the most difficult lessons to teach is the connection between theory and practice. This problem is stressed in the case of Automatic Control, where there is normally a high abstraction level. In this way, all control students would have practical experience with the real behaviour of the control systems.

Laboratory practices in a Distance University involve greater problems than those one has usually is deal with a conventional University. These problems are mainly related to the students' possibilities of access to the laboratory. The typical student of UNED (the Spanish Distance University) is an adult with a job or a person with little free time, and furthermore they usually have some trouble in getting to a real laboratory. Within this framework, we thought it would be useful to design a laboratory that was as close as possible to the student.

With this idea in mind and with the possibilities that are offered by the new technologies and the cost reduction of hardware for multimedia systems, we are researching into Computer Aided Learning Systems, having implemented a courseware in Control Teaching (HyperAutomatica [1]) to be used by the students of UNED.

HyperAutomatica hasn't any practices; it has only some interactive examples and a link with HyperLab [2]. HyperLab was a simulation environment for control systems; it was developed as a toolbox of MatLab [4] with a interface made in HyperCard [5].

But even if the students made previous use of this tool, when they went to the laboratory they spent most of their time trying to understand the physical system, the instrumentation and the software, and only a short time was dedicated to the practice itself.

With the aim of solving this problem, we designed and implemented the Computer Based Control Laboratory (CBCL) for control teaching with multimedia techniques and with hypertext structure. CBCL must prepare the student as adequately as the real laboratory, so that a student using CBCL must be able to do real laboratory practices without any problems.

CBCL has three main parts: a simulation laboratory for control, simulation of practical sessions and an interface for connection with real systems. Furthermore, it has a hyper handbook of laboratory instrumentation, control kit and software; helps and explanations with video and audio and scripts for practical sessions.

In section 2 we suggest some practices chosen for the laboratory and the objectives intended. In section 3 we show the structure and features of CBCL. In section 4 we integrate CBCL in a hypertext system for control teaching. Finally, in section 5 we give the main conclusions obtained in this paper.

2. Laboratory Practices

In the practice selection we considered the requirements that all good experiments in a control laboratory must observe according to Balchen et al. [3] :

- Demonstrate important ideas.
- Reflect on relevant problems of a practical kind.
- Possess tight time scales.
- Give visual sensations and acoustics.
- Not to be hazardous.
- Be inexpensive and of an easy execution.

With these requirements in mind we have designed five practical experiments for the students to do:

- Design of classical control.
- Study of the dynamic characteristics for a fluid tank and level control design.
- Study in open and close loop of a first order system.
- Study of a second order system.
- Study of the characteristics for a DC motor, rate PI control and position PI control.

The aim of the first practice is the application of the computer in the analysis, simulation and classical design of lineal control systems, described by transfer function. This practice is done with a simulation program in MatLab.

In the second practice the dynamic characteristics of a fluid tank are studied and a level control is designed. There is a didactic equipment of TecQuipment CE5 [6] and a specific control program for this equipment. In this practice the student must do four experiments: a simulation with the program CE5, a test of input and output signal, a study of process characteristics and level control.

The aim of the third and fourth practices is the study of first and second order systems (in closed and open loop) in time and frequency domain. For this purpose analog modules have been built in the laboratory with amplifiers, resistance and condensers.

Finally, the objectives of the fifth practice are the study of the characteristics of an induced DC motor controlled and of two typical control systems for the motor, rate PI control and position PI control. There is a didactic equipment of TecQuipment CE9 [7] and a specific control program for this equipment. The student must do four experiments: a test of input and output signals, a study of the process characteristics, a rate control and a position control.

The first of these five practices is about computer simulation and the student could do it at home without any problems. For the other four practices, the student must use the real systems to scale and the laboratory instrumentation, so the student must go to the laboratory.

We have designed a multimedia framework with a hypertext structure so that the students can also prepare these practices at home, and obtain a knowledge equivalent that obtained in the real laboratory.

3. CBCL

There are three basic types of practices: computer simulation, analog electronic systems and real system to scale. Practice 1 is of the first type, practices 3 and 4 are of the second type and practices 2 and 5 are of the third type.

CBCL gives an environment with a hypertext structure that allows the students to do all laboratory practices, both simulated and on real systems, with the same user interface. Figure 1 is a simplified general plan of CBCL. Each practice has a link to its script and to the HyperHandBook section having the instrumentation, software and kit control information for such practice.

Practice 1. is about computer simulation and it is done in the simulation laboratory. The simulation laboratory is developed as an extension from HyperLab [2]. It has new features and a new design, and it is more "friendly" with students. There are new user interfaces and MatLab functions (there are nearly 100 .m files).

Practices 3 and 4 correspond to analog systems. In the real laboratory these analog systems are electronic systems based on operational amplifiers. They are first and second order systems. The computer is not needed in these practices, so in CBCL these practices are only simulated. The diagram and connections are the same as for the real analog systems.

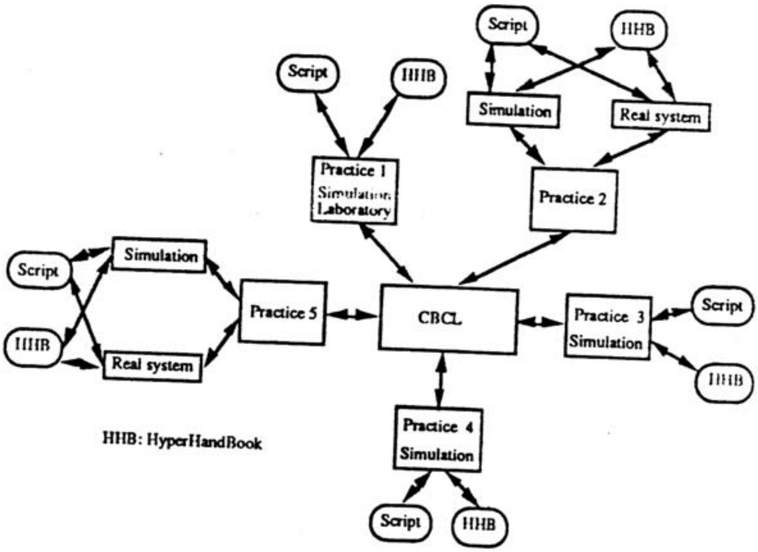

Figure 1

Practices 2 and 5 are based on real systems to scale. They correspond to the plan showed in figure 2. The computer works as a controller, implementing algorithms of PI control, and serves as user interface.

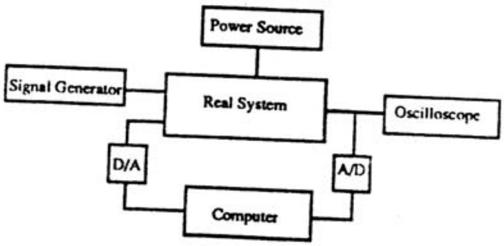

Figure 2

With CBCL, the student has the same computer-user interface both in the implementation of the plan in figure 2 in the real laboratory and in the real system simulation in the computer, as indicated in figure 3. Therefore, the student can do those practices outside the real laboratory; when the student goes to the actual laboratory, he/she knows the process and the instrumentation for those practices, and the time spent there is shorter and more fruitful.

Development of CBCL

CBCL is developed by using HyperCard to generate the hypertext structure and greater user interface. MatLab is used to generate functions for the analysis, design and simulation of the systems of control. The interface with real systems is made from programs CE5 and CE9.

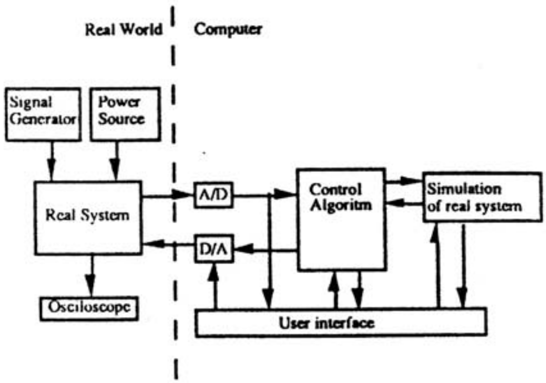

Figure 3

The computers used for systems control in the real laboratory are PC's. This is due to the greater availability of data acquisition card and of A/D and D/A converters with respect to Macintosh, their cost is also much smaller.

CBCL is used in PC's too by translating of HyperCard stacks to ToolBook.

4. Hypertext system for control teaching

If a laboratory is not integrated in teaching, it has a poor use; that is why CBCL is integrated in a complete courseware in control.

We think that a complete hypertext system for control teaching, and, as a rule any discipline with a high practical content, must include:

1- A HyperBook with examples and simulations. This HyperBook contains all course topics.

2- A set of problems with their solutions. This set is included within the HyperBook or distributed separately.

3- Tools to generate in an easy and quick way short tutorials and seminars to complement dark or difficult HyperBook parts. The tutorials and seminars maintain the hypertext structure. These tools are HyperCard functions incorporated to the HyperBook and run from button or menu bar when the seminar generating mode is selected.

4- Student evaluation by test and problems. The student can compare his/her solutions to the problems with proposed solutions.

5- Laboratory practices. They are essential for the assimilation of theory.

With those points in mind, we have integrated a new version of HyperAutomatica with CBCL. In CBCL we have designed a button with direct link to HyperBook whenever the practices require any theoretical information.

5. Conclusions

Laboratory practices are essential in control teaching, their main purpose being to help the students' assimilation of theoretical knowledge. The problem with students of UNED is that they have little free time to go to laboratory, so, we thought of designing a laboratory to which they could have an easy access.

We selected five practices with the requirements given by Balchen et al. [3]. The students can do those practices both by simulation with CBCL and in the real laboratory. In this way, the students can first do the practice by simulation at home, and when they go to the laboratory, they know the real process and the instrumentation better; then the time in the real laboratory is well spent.

A test about CBCL was performed with some of our students. Whose answer was satisfactory. The results of this test are given in a UNED report [8].

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