

A Prototype Internet Experiment System for Control Engineering

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Abstract

This paper describes an Internet experiment system for control engineering that is comprised of an experiment system and a computer-aided teaching system. The experiment system was set up in a laboratory and connected to the Internet so that students could do experiments on their own personal computers anywhere anytime. The computer-aided teaching system was implemented by building a database on a server to which students had free access, and which they could then use to store and share information on their experiments.

1 Introduction

Experiments are one of the best ways to gain a deeper understanding of control theory. They are also a very important aspect of instruction in control engineering in that they make students aware of the difference between simulations and experiments. The problem is that it is not easy to build an experiment system for a single individual because of the cost and know-how required. On the other hand, repeating the same experiment can help students get a better understanding of the topic being taught; but under the present circumstances, it is not possible for students to carry out experiments in the laboratory whenever they want. One possible way to solve this problem is to build an experiment system in the laboratory [1, 2] and connect it to the Internet so that students can do experiments on their own personal computers anywhere anytime. Furthermore, by exploiting the Internet, a computer-aided teaching system for control engineering could also be established. This would enable students using the system to communicate with each other about experiments, sharing whatever knowledge or experience they

had acquired. The system could be implemented by building a database on a server to which students had free access, and which they could then use to store and share information.

The experiment system together with the computer-aided teaching system is called *the Internet Experiment System for Control Engineering*; and the purpose of this study was to build a prototype of the system. This paper is organized as follows: Section 2 shows the structure of the experiment system and explains how experiments are carried out over the Internet. Section 3 explains the structure, operation and functions of the computer-aided teaching system. Section 4 gives some concluding remarks and lists some improvements needed to make the system more functional.

2 The experiment system

The experiment system was built in a laboratory, and is connected to the Internet. A student can run an experiment anywhere just by accessing the web page of the experiment system from his own computer.

2.1 Contents of the experiment

There were two main considerations in the selection of the plant: simplicity and safety. Since the course is for undergraduates, the plant should be easy to understand and its model should also be easy to identify. On the other hand, there is no one in the laboratory to supervise experiments, and a physical failure could occur during an experiment. So, the experiment system should allow a wide range of errors and should be safe even if an error occurs. So, a one-link manipulator [3] was selected as the plant for the control experiment was chosen to be.

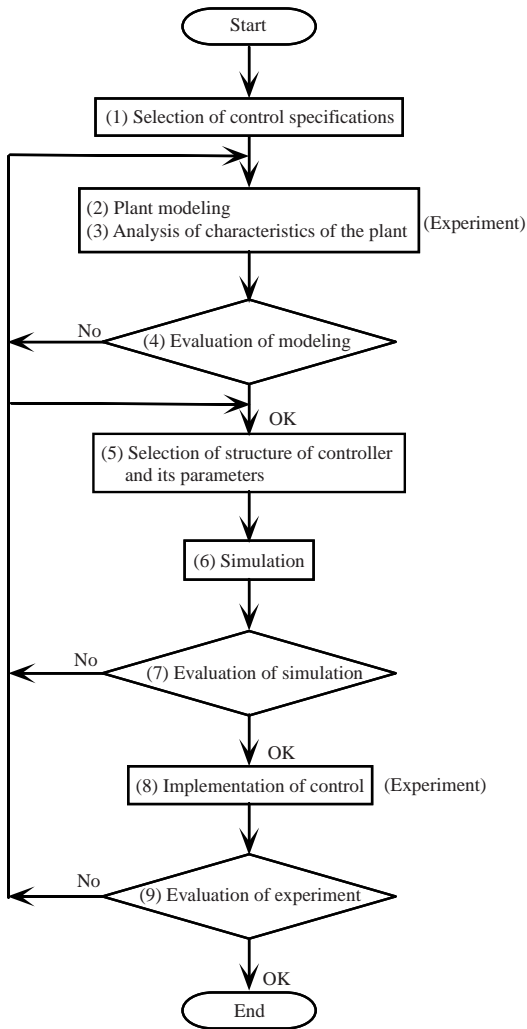


Figure 1: Procedure for running experiment.

A student has to do the procedure shown in Figure 1 to run an the experiment. At present, only Steps (5) - (9) are available.

2.2 Structure of the experiment system

As shown in Figure 2, the experiment system is comprised of four parts: the plant, a control machine, a server machine and a client machine. The client is connected to the server over the Internet. The server processes commands from the client and sends instructions to the control machine to prepare the experiment. The control machine runs the experiment under the supervision of the server. The following programs are executed in these machines:

- Client program: stored on the server machine. The client uses a WWW browser to execute it to run an experiment.
- Server program: stored and executed on the server

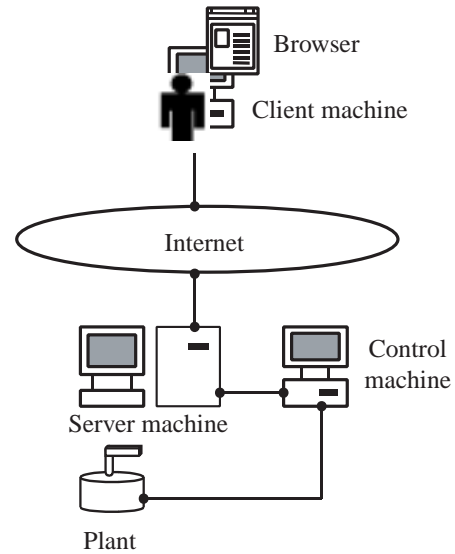


Figure 2: Structure of the experiment system.

machine. It is used to monitor client connections, process commands from clients, supervise the control machine and send experimental results back to clients.

- Control program: stored and executed on the control machine according to instructions from the server. It runs the plant.

The client program was written in Java (Java Applet), and the server and control programs were written in C language. The experiment system is presented to the client as a web page.

Regarding communications, a LAN is used between the client and the server; an RS232C connection is used between the server and the control machine; and mouse and printer ports are used between the control machine and the plant.

2.3 Operation of the experiment system

When a student uses a WWW browser to access the web page of the experiment system, the client program starts and a window is displayed on the client machine (Figure 3 shows the screen for PI control). The student can then uses the prepared environment to set the control system up as follows.

- Selection of control event: selection of a control method (state feedback /PI) and a reference input (step signal/sine wave).
- Amplitude of the reference input.

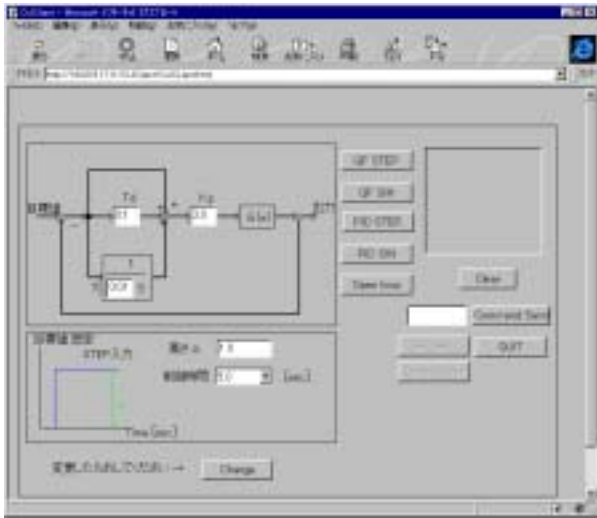


Figure 3: Client window of the experiment system (PI control).

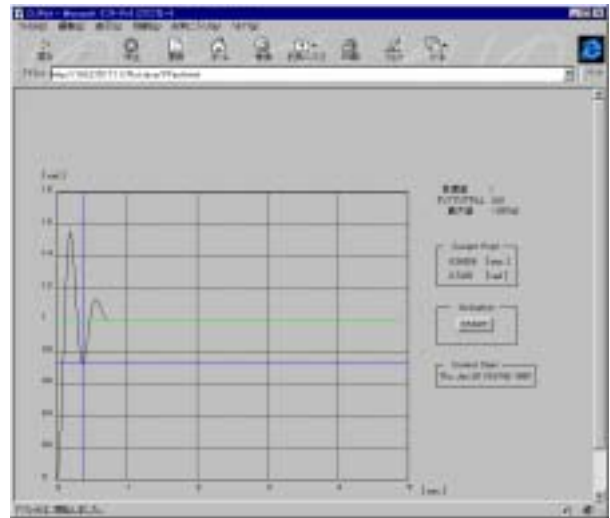


Figure 4: Window displaying experimental results.

- Frequency of the sine wave input (if the reference input is a sine wave).
- Parameters of the controller.
- Control time.
- Number of data logged as experimental results.

These values can easily be changed before the student sends a signal to start the experiment. When a start command is sent out from the client, the server sends all of the selected parameters to the control machine. The control program starts the experiment when it receives the start command. When the experiment ends, the control results (logged data) are stored in a file and sent back to the server. The server converts the data file into a HTML data file and informs the client that the experiment is finished. The client then accesses the HTML data file, displays the results on the browser and evaluates the results. These are the main steps needed to run one experiment.

The system can also store start commands from clients temporarily (cache function), and execute them in the order in which they are received. This function allows a plant to be shared by several clients.

3 The computer-aided teaching system

The computer-aided teaching system was constructed to help students learn control theory. For example, as shown in Figure 5, assume that students *A* and *B* carried out their experiments under almost the same conditions using the experiment system in Section 2. The

experimental results should be quite similar. *A* explains them as “.....”, and *B* explains them from a different standpoint as “*****”. If they can communicate with each other, they may gain a deeper understanding of the theory. Based on this consideration, the computer-aided teaching system should have the following basic functions:

- A student can tie the experimental conditions, results, comments, etc. up in a bundle (called an *InfoBundle*), and register it in the system.
- A student can search all the *InfoBundles* in the system by keyword and/or experimental conditions and view them.

3.1 Structure and operation of the system

The computer-aided teaching system is shown in Figure 6. It is on the computer-aided teaching server machine. Students can access it over the Internet using their own computers. Just as for the experiment system, this system is presented as a web page. When a student accesses this page, the computer-aided teaching program starts and displays an introductory message. The database was constructed using MS Access, and the database system was constructed using Java (Java Applet).

The experiment system and the computer-aided teaching system are implemented on two separate computers.

The basic operations of the database system are as follows.

- Students input data, comments, etc., and push check buttons.

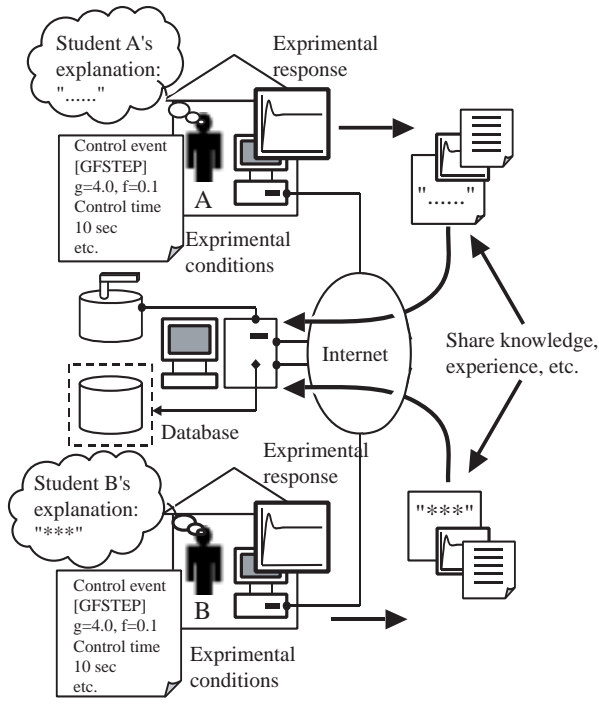


Figure 5: The basic idea of the computer-aided teaching system.

- An SQL (Structured Query Language) file is generated automatically according to the input information.
- The database program sends the SQL file to the database on the server.
- The information is displayed on the client's screen, broken down into appropriate categories.

3.2 Functions of the system

The computer-aided teaching system has two main functions: registration and search. Registration is performed using two information registration windows (Figure 7).

The registration content consists mainly of experimental conditions, experimental results (logged data file), comments on the experiment, etc. A subject for the *InfoBundle* and graphs of the results must also be specified.

Information search is divided into two levels. Figure 8 shows the search window for Level 1. At this level, a student inputs experimental conditions and/or keywords to check if there are any *InfoBundles* available. The search results are shown in the result window (Figure 9). That window displays ID numbers, subjects and experimental conditions. At Level 2, the student chooses what he wants to see from the search results

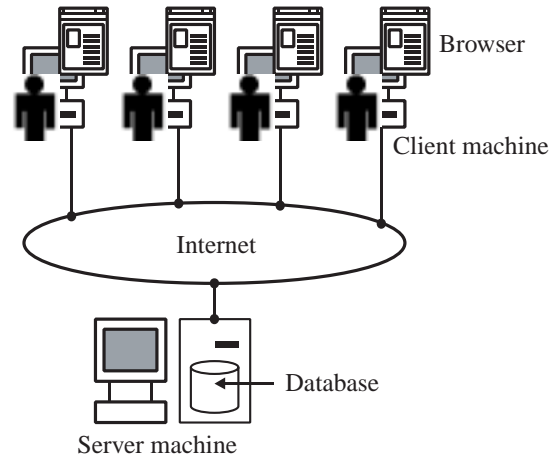


Figure 6: Structure of the computer-aided teaching system.

of Level 1 and inputs the ID number of the *InfoBundle*. Then the information is displayed on the client's computer (Figure 10).

A registered student can use this system to look at *InfoBundles* built by other students, and can update or delete his own registered *InfoBundles*. A User Name and a User ID are required to perform these functions.

4 Conclusion

This paper describes a prototype Internet experiment system for control engineering. It is very important for control engineering students to learn control theory through experiments. This system is useful for students who do not have an experiment system on hand and/or who want to share knowledge and experience with other students. At present, the system has only one plant, and the experiment system and the computer-aided teaching system are completely independent. The whole system needs to be improved by building more plants, building a connection between the experiment system and the computer-aided teaching system so that they can share information, and writing a manual for the system.

References

- [1] C. Bohus, L. A. Crowl, B. Aktan and M. H. Shor, "Running control engineering experiments over the Internet," *13th IFAC World Congress*, **G**, 1996, pp. 25-33.
- [2] C. J. Munaro and M. F. S. Meto, "A network environment for computer control of dynamic process," *4th Symp. on Advances in Control Education*, 1997, pp. 75-78.

[3] Y. Ohyama and J. Ikebe, "Exercise in control technique using simple handmade equipment," *3rd Symp. on Advances in Control Education*, 1994, pp. 215-218.



Figure 7: Registration windows.



Figure 8: Search window of Level 1.



Figure 9: Search results for Level 1.

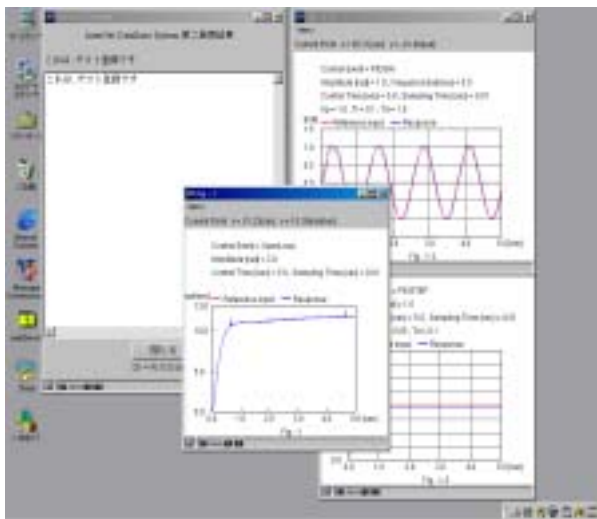


Figure 10: Search results of Level 2.