Chapter 1

Introduction

1.1 Motivation

The Internet has been playing more important role in everyday human's life. The development of quality and quantity of the Internet accessibility all around the world has raised its utilization for far wider fields, compare with its first intention aim. The Internet is not only used by commercial, government and entertainment business but also employed for educational purposes.

We recognize that the Internet has been widely used by many institutions of education to present the education material to the learners using an application, namely e-learning. E-learning has been considered as a very good solution to deal with geographical and time problems that exist between the providers and the learners. Furthermore, it gives people who have less chance to come to classroom or to meet physically, the opportunity to grab the same amount knowledge with other who come more frequently.

In control systems, e-learning also being regarded as an important element of its education media. As an extension of classroom learning, the Internet can be employed for the purpose of control system virtual education or even conducting laboratory experiment. Certainly the requirements of the Internet-based experiment are much more complex than common e-learning for classrooms or non- laboratory class. The problems may vary from how to construct, combine and integrate between plants, computers and applications until how to present it to the learner in a fine form so that the material can be easily studied. The Internet-based experiments is demanded to have some features as well as facilities which can represent real experiment inside the laboratory. In that condition anything that learners could sense and understand from remote computer is attempted to be as near as the condition when one could get from conducts real experiments.

Because of these reasons, we are interested in doing research in development of a remote conducted control experiment via the internet. We expect this application can be used as computer-aided control systems analysis and design as well.

1.2 Literature Review

Education must be both conceptual and experiential. Abstract concepts are elegant and powerful, but learning is always enhanced by direct experience, concrete examples, and real-world relevance [1]. That is the reason why in control education, we also need to provide information as a complement of the roles served by textbooks and lectures. The intention is to develop education aids to illustrate control system and analysis and enable students to quickly use their knowledge. Moreover, as an engineer, the development of full range of skills is necessary. The suggestion that computer simulations and laboratory experiments can be used to deliver those skills which are needed by engineer is addressed in [2].

Using web technology, students with access to the Internet will be able to have their experiment without presence at laboratory. They only need to open the appropriate pages which are related to the plant they want to study. The pages will be used as experiments interface, will provide assistances, manuals and theories. Web-based laboratories offer more flexibility in preparing assignments for students who require experiment with virtual or real phenomena. In addition, an Internet laboratory allows better use of equipment since students can access laboratory from anywhere and anytime with just an Internet connection. This sharing of resources not only brings down the experiment cost per student, but equipment is also available to more students. These results is agree with an existing study of Sebastian [3].

Given those impetus, there are many research which concern about development of integrated set of remote control experiments, which are accessible over the Internet. In this research, we will call the experiment as E-laboratory. E- laboratory is a Web-based application that allows user to easily conduct real apparatus on-line, using only Web browser. This method is designed to be an alternative method of conducting and testing experiment. It provides an easy access to actual hardware equipments in a virtual environment as if the learner were physically conduct the experiment, as addressed in [4].

There are several virtual and remote laboratories on the web, mainly developed in university research laboratories. One of the pioneers in control education was developed in Carnegie Mellon University which broadcasted MATLAB Help based tutorial via the Internet [5]. That program, namely Controls Tutorials and Web-assistants, provide students with useful information from diverse sources whenever and wherever they need it. After that, they develop the virtual laboratory by enabling a connection from students to engineering test equipment, like oscilloscope and function generators. When students enter the system, they are able to control both the computer and the equipment to test different electronic circuits.

Later, the employment of real plants as part of experiments via the Internet were pre-

sented by [4], [2]. The experiments in [2] consist of a direct drive robot, inverted pendulum and a motor control which are simultaneously used to support a related subject of college level at the University of Illinois at Urbana Champagne. Meanwhile, the remote laboratory development which is try to emphasize special concept of reusability, like concept of object oriented programming was conducted by [4] at Nanyang Technological University. They use the same interfaces to be applied to different plants. Their plants are a couple-tank and an inverted pendulum.

Another realization of a remote lab, the Automatic Control Telelab (ACT) developed at the University of Siena, Italia, is presented by [6]. ACT allows students to choose a control law, change the control parameter on-line, and design their own controller simply through MATLAB/SIMULINK environment. The main feature of this system is that a remote user can synthesize his/her own controller without learning any special language other than MATLAB.

Regarding the development system, a remote laboratory can be designed using a well-known software environment such as LabVIEW or MATLAB/SIMULINK or it can be implemented through a new and on purpose designed software. Several remote laboratory based their experiment with MATLAB which combined with Wincon [7], [8]. One of the key features of the Automatic Control Telelab (ACT) is that students can design their own controllers through the MATLAB/SIMULINK environment. This feature allows a remote user to synthesize his/her own controller without learning any special language other than the MATLAB/SIMULINK software. According to [9] using standard tools like MATLAB/SIMULINK will dramatically encourage the practice of control theory through remote labs. Other use their own developed software like proposed in [10] .

The existence of two different options that can be found for setting up laboratories, those are virtual laboratories and remote laboratories, was addressed in [11], they are as follows.

1. Virtual Laboratories

   Virtual laboratories are laboratories that provide access to a simulation process in networked computer. Virtual laboratories base the laboratories with simulation model. They share or publish their laboratory experiments using the Internet and let the clients access them. Learners from client upload their input, for example controllers or parameters, and the server will run those file. No real time interactions are needed. We can call this type as store and forward model [12]. In this model, experiments run after all the information needed by the server is provided completely. The experiment will not start unless all required basic inputs have been transferred from client to server or host computer. Collected data is stored as a file and sent asynchronously to the remote site afterward.

2. Remote Laboratories

   Remote laboratories offer real experiments to remote users. Different from virtual laboratories, remote laboratories base the laboratories with real time experiments. Real time means occurred in actual time or live. Real time experiments try to prototype and test real-time systems. In control engineering environment this experiment can be done by using a single computer as a host and target, not a simulation. We call this type of experiment as a real time mode. A Real time mode is a mode of remote control experiments which run the data acquisition, send the command and get the response from the controlled system instantly. Collected data in the experiment is streamed to the remote site.

In other literatures, references [2] and [4] state that a remote experiment has to be equipped with sufficient plants, representative graphical interface, good response and feed-back or even streaming video to provide learners comfortable media and enough choices in learning. There are some features which are needed to be considered. Features of a remote experiment which are suggested by [2] can be stated as follows:

- In-house developed plants.

  In-house means those physical experiments are located in laboratory. The host computer runs the experiments and acts as the hardware host while users can access the physical experiment by graphical user interface software remotely through the Internet.

- Common control interface and architecture that can be run in browser.

  Common browser means that the client computers already support the interface sent by the host and therefore do not need to download or install new addition software locally. Usually, systems that require the local installation of special software often encounter compatibility problems and discourage the students from making the effort necessary to get the experiments working.

- Assistance.

  Basic theories and materials which could help students, need to be attached on the interface. Most of them could be taken from MATLAB Help and Documentation. Picture and animation can also be added so that students can get the sense of experiment.

In [5], the authors stress out the importance of web based education availability for students across country. This paper also motivates the web- based education providers to equip their application with features that make the learner more self reliant in their study. The philosophy has been to provide information to complement the roles served by text books, simulation software and lectures.

1.3 Objective

The primary objective of this research is to develop remote conducted control experiments via the Internet.

1.4 Scope of Thesis

This research will be performed in some certain following conditions :

1. Three experiment platforms will be employed in the E-laboratory system, they are flexible link, rotary inverted pendulum and belt conveyor system.
2. The expected experiments that could be conducted are system analysis, identification, and controller design.

1.5 Methodology

The steps that will be taken to accomplish this thesis are described as follows:

1. Create an intranet.
   The first step of the development of e-laboratory system is started inside the laboratory itself. As we want the computers in the laboratory to be connected each other, we need to create a network. Intranet is a system of connected computers which works like the the Internet and enables people within the network to communicate each other and share information. Completeness of this step is marked by the ability of each computer to communicate each other, to share information (file, printing) and to recognize the existence between them. The intranet is controlled by a server which also has a function as the gateway to other networks (the Internet).
2. Set up the host PC.
   Setting up host PC is to configure the computer which is directly connected to the experiment plant so that experiment can be run. This activity includes installing software, writing the needed program if necessary and setting up the plant to be ready to be used. Set up host PC results in the ability of host PCs to conduct the experiments.
3. Set up the server.
   Once we have created the intranet where every computer which hold experiment connected, we need to make them available to be accessed from server. Server can read not only the data in each computer but also drive the plant. Beside that, server also provides the Internet connection and web server domain. Web servers are computers

in the Internet that host websites, serving pages to viewers upon request. This service is referred to as web hosting. We will be able to put our index of the website (main page) on this computer once we have finished this activity.

4. Develop the website.
   Website development processes in chronological order can be divided into

   - Design process.
     Flow order of website and graphical interface is the main part of design process.
   - Database process.
     Database is needed to store the help, manual or educational documents and user data. Good management of database is compulsory in order to have a good application.
   - Interface development process.
     The main problem of this process is to have good, and user friendly interaction tools between the user and the experiment, including tool to access the database. At the end of this activity we should be able to browse the index page of E-laboratory, access the database of user, read the manual (document), and pick data of experiment result.

5. Demonstrate the application.
   The demonstration of the application program aims to show the experiment results. By this demonstration, developer could share the idea of the program and get suggestions from participants as well.

6. Write the thesis
   The output is a complete, finalized thesis including all supporting documents in organized condition.

1.6 Contributions

The expected contributions from this thesis are:

1. A remote laboratory application to control Flexible Link System and to present the simulation of Rotary Inverted Pendulum and Belt Conveyor System.

2. Additional facilities which support the application such as manual and help.