CONTROLS LABORATORY TEACHING VIA THE WORLD WIDE WEB

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The engineering controls systems laboratory at UTC has been made available for students to use via the World Wide Web. Students can conduct controls lab experiments from remote sites. This paper describes the hardware and software that is used for this facility, describes the way the course was managed and discusses strengths and "opportunities for improvement" that have been observed in this offering.

The web address for the lab is
http://chem.engr.utc.edu.
This paper in expanded form is at
http://chem.engr.utc.edu/Henry-Pub

HARDWARE AND SOFTWARE

The controls laboratory for several years has been using desktop computers for data acquisition and control of engineering equipment. The students conduct experiments to accomplish system identification and design feedback controllers for the systems. The data acquisition and control software is written with LabVIEW software. Controller design involved tuning two feedback controllers, a proportional controller and a proportional-integral controller.

The computers are all networked with ethernet and have internet (IP) addresses. A web-server program was developed which allowed students to conduct experiments using widely available web browsers. The students conducted the experiments either from

Hardware Stations

Six different stations for controls systems experiments are available. They consist of

1 Pressure control by varying the speed of a blower

2 Level control in a water tank by varying the speed of a water pump

3 Temperature control in a heat exchanger by varying the flow rate of a hot water supply

4 Speed control of a motor-generator set by varying the signal to a motor power supply

5 Position control in a cart-on-a-rail by varying the torque in a motor

6 Flow control in a closed flow loop by varying the speed of a pump.

Each of these is a single-input, single output system. All are inherently stable systems when run in open-loop configuration. that is, if you specify a fixed input value, the system will reach a constant steady-state condition.

computer labs on campus or from home computers via internet providers.

More details are given in Henry (1996).

More complete descriptions of these have been given before (Henry, 1993, and Henry, 1995).

Software

The systems are operated by (student) operators using the LabVIEW software on desktop computers at each control station. The software operates the equipment under the conditions of parameters as chosen by the (student) operators.

Experiments available. System identification (1-5) and controller design (6 & 7)

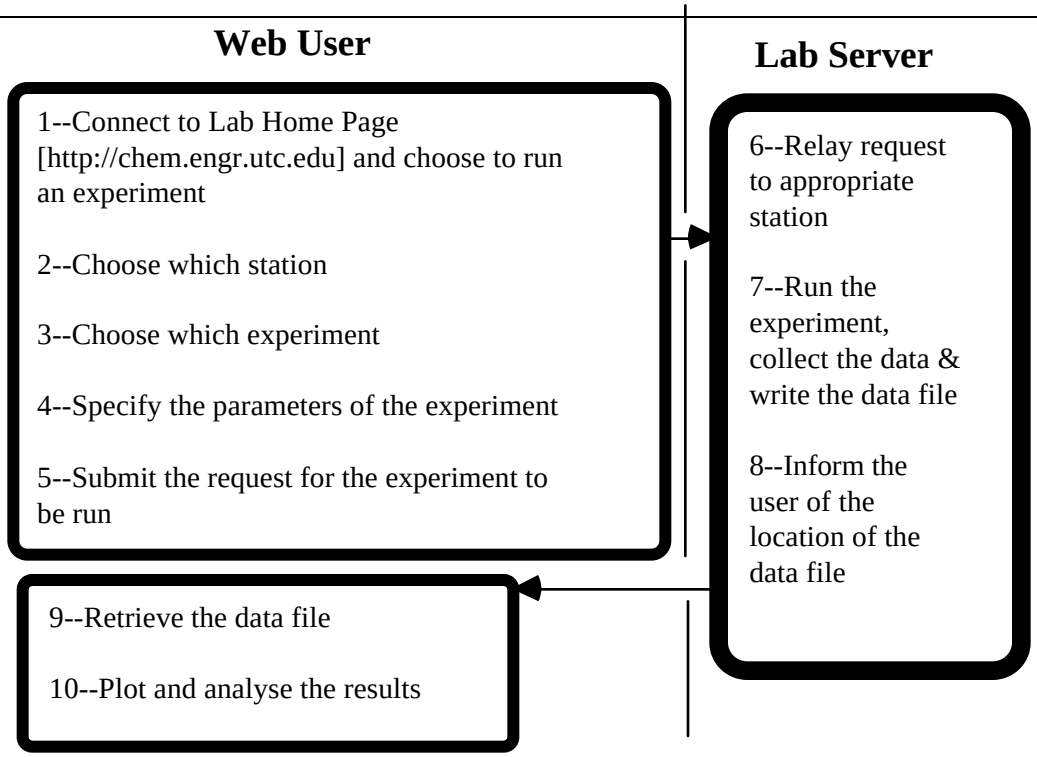
	Name	Application
1	Constant input	Developing the steady-state operating curve for the system
2	Step input	Finding the first-order plus dead-time (FOPDT) parameters
3	Sine input	Finding the Bode plot
4	Pulse input	Refining the FOPDT parameters
5	Custom input	Design your own input function. Ramp, sawtooth, triangle, for examples.
6	Proportional feedback	Verifying controller design. Determining region of stability, quarter decay, offset, etc.
7	Proportional-integral feedback	Verifying controller design. Determining region of stability, quarter decay, offset, etc.

EXPERIMENTS

Seven different experiments can be run on each of the laboratory stations. The software runs an experiment, collects the data and writes the data on a computer hard disk at the end of the experiment. The file of results data is available to the web user. The various experiments consist of the seven listed in the table above.

NETWORK ENVIRONMENT

All stations are available for experimentation via the World Wide Web. Experiments run via the Web are run in "batch" mode. The steps of running an experiment via the Web are diagrammed in the figure below.



COURSE MANAGEMENT

In the Spring, 1996, semester, we offered a "Web"-based class. The equipment was available via the Web for 24 hours a day, 7 days a week. This class was managed by-in-large without "face-to-face" meetings. Laboratory information and assignments are provided on the Web server. The experiments, the analysis of the data, the controller design and the reporting were done at times chosen by the students. Discussion among students was available via a listserv. Students' reports were submitted via e-mail.

FACULTY WORKLOAD EQUIVALENT

The amount of work that went into putting this (existing) laboratory on the web was about half the amount of work of developing the lab originally from scratch. The previously prepared lab manual had to be significantly revised for applicability to the Web user. The communication software & equipment was continually presenting new learning opportunities. The Web "pages" took significant preparation time, largely due to the newness of the UTC is committed to continuing to develop and expand this Web-available laboratory. Extending the experiments to include unit operations labs is a possibility.

ACKNOWLEDGMENTS

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REFERENCES

Henry, Jim, (1993), "Engineering Controls Systems with LabVIEW," Scientific and Engineering Applications for Macintosh, Woburn, MA, August, 1993. Available via Web at http://chem.engr.utc.edu/Henry-Pub

medium for the developer.

STRENGTHS AND OTHER ASPECTS

Sharing resources is one strong point of this ability to teach controls laboratory via the internet. The investment in equipment at UTC can be shared by other engineering schools. Previously, we have actively used the equipment for about 6 hours a week for about 20 weeks per year. This is a very small utilization fraction of the available hours in a year.

Providing learning opportunities for students with scheduling conflicts is another strong point of this ability to teach controls laboratory via the Web.

The main weaknesses experienced were equipment or communications bugs.

FUTURE

In keeping with the nature of the Web, the output provided to the Web user needs to be modified to provide graphical results, not just tabular data.

Henry, Jim, (1995), "LabVIEW Applications in Teaching Controls Systems Laboratories," ASEE Annual Meeting, Anaheim, CA, June, 1995. Available via Web at http://chem.engr.utc.edu/Henry-Pub

Henry, Jim, (1996) "Details of Web-based Controls Laboratory Hardware and Software," available via Web at http://chem.engr.utc.edu/Henry-Pub

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