

Web-casting of Nuclear Reactor Experiments

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INTRODUCTION

The Internet has become an indispensable part of the modern day education system. Burgeoning as a versatile communication medium, it allows further technological developments that may spread the reach of the existing experimental training infrastructure essential for nuclear engineering. Moreover, due to dwindling nuclear research reactor facilities, there exists a need to develop such web-based systems that can virtually access the reactor under operation. These systems should be inexpensive, easily installable, allow interactive audio/video communication as well as remote access (or sharing) of data in real-time. In an effort to make this a reality, the University of Massachusetts at Lowell (UML) [1] and the University of Illinois at Urbana-Champaign (UIUC) [2-4] are working towards developing and testing a distance reactor operations laboratory. Though the efforts started independently, the teams are now working together to ensure the best possible model for efficient outreach as part of the distance educational mission of the UML research reactor. Similar efforts are also underway at other universities [4].

METHODOLOGY

As a part of the Department of Energy Reactor Sharing Program, the University of Massachusetts Lowell Research Reactor (UMLRR) has developed a system for making real-time and archived research reactor data available to educational users via a standard web browser. Those with access to the web are not only able to access archived UMLRR experimental data, but also observe most of the UMLRR control room instrument readings, in real-time, in a graphical interface for use in classroom lectures, demonstrations, and experiments. In the UMLRR control room, a series of personal computers with touch-screen displays connect to the Control and Data Acquisition System (CDAS) controllers via an

ethernet switch to provide human machine interfaces (HMI). Various programmed configurations provide graphical displays for operational data from the CDAS controller and for the transfer of operator commands. The display configurations are programmed to meet the individual needs of each application. The operator can view instrument readings, plot trends using real-time or historical data, and can view and acknowledge alarms. Almost all the process variables (74 total) within the UMLRR (power level indicators, various temperatures, flow rates, pressures, and conductivity measurements, control blade position indicators, on/off status of various motors, valves, fans, etc.) are available for real-time display, data trending, and archival storage. Overall, with the new digital control and data acquisition systems in place, a tremendous amount of information can be accessed from the reactor and may be used in a variety of educational settings in real-time beyond the physical boundaries of UMass-Lowell.

As part of this unique reactor-sharing project, a website devoted to providing a variety of Nuclear Engineering (NE) educational resources has been initiated. Besides archived data, direct access to real-time operating data from the UMLRR is also provided, which allows a user to view reactor operational data, in real time, as an experiment is being performed.

A prototype system has been developed to provide the UMLRR Online link [5] described above. This was accomplished using a standard personal computer to act as a web server along with the acquisition of a dedicated software package that receives data from the control room computers and then distributes it in a web-based format. In particular, this real-time web-broadcasting capability is made possible by InduSoft Web Studio 6.0 [6], a supervisory control and data acquisition (SCADA) package donated to UMass-Lowell by InduSoft Ltd. IWS 6.0 creates a series of HMI screens that allow a user to observe most of the same information that is accessible to the reactor operators within the UMLRR control room.

This includes a variety of real-time operational indicators (power level, pool and reactor outlet temperatures, primary coolant flow rate, secondary flows and temperatures, etc.) as well as historical data for many of these variables [1].

On the receiving end, UIUC has developed a computer lab equipped with two large screen monitors and several computers. It is also equipped with a web-network-camera that has remotely controllable zoom/pan/tilt capability. Figure 1 shows a picture of large screen monitors mounted on a wall. Web browser windows showing different shots of the laboratory and windows displaying the data being measured can be displayed on these screens for a large number of students/visitors to view. Several modalities for an audio link between the remote computer lab and the experiment site, including conference calling and an audio transmission feature built into the webcam, are available. However, for real-time access, Centra web-based meeting software [7] is recommended to be installed at both the locations. Use of this specific package enables bi-directional audio and video communication to/from the user and the UMLRR control room operators.

This virtual control room facility and visual access to different reactor parts as well as audio link will provide the students at UIUC (or for that matter, any other place with an internet connection and permission from UML) to “participate” in reactor operation labs conducted by UML students on site. Obviously, the virtual console can also be used by on site students to enhance their reactor lab experience.



Fig. 1. A picture of part of the remote client facility at UIUC showing live broadcast of UMLRR “approach to criticality” experiment

TEST EXPERIMENTS

Two experiments have been web-casted so far: a reactor pool heating experiment, and an “approach to criticality” experiment, which is described here in detail. The “approach to criticality” experiment at UMLRR on May 5, 2006 was webcasted and students at UIUC were able to successfully “perform” the experiment in real-time. The purpose of this experiment is to use the definition of the subcritical multiplication factor to predict the critical height of a control blade in the UMLRR. The regulating blade and 3 out of 4 control blades are kept in fixed positions to yield a subcritical configuration and then, the blade of interest is pulled out by some amount. From an estimate of the count rate for the current configuration, one can determine the relative subcritical multiplication factor and make a rough estimate, using a 1/M plot, of the critical height of the blade. With a new estimated critical height, a new blade position is requested (about ½ of the predicted change needed for criticality), and the process is repeated. After several steps, a very good estimate of the critical location of the blade is predicted.

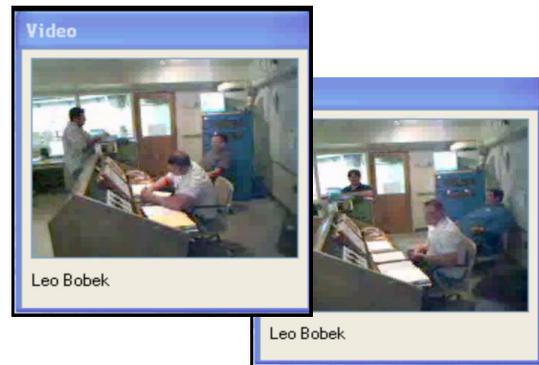


Fig. 2. UMLRR control room as viewed by UIUC students

During the lab only the UMLRR staff was present in the control room (see Fig. 2). The participants included two separate groups of UMass-Lowell students and a group of observers at the UIUC, each at separate remote computer sites. The UMLRR online link allowed all groups to independently view the real-time data from the reactor, as illustrated in Figs. 3 and 4 (the control blade position and count rate on the startup detector were the primary readings of interest in this experiment). Using these data, students generated 1/M plots, estimated the critical blade height in real-time, and made suggestions to the lab facilitators for the next location for the control blade. After a quick check and brief online discussion to draw a consensus from all the participants, the reactor staff would move Blade#2 as requested, eventually reaching a critical height of about 19.4 inches withdrawn

relative to the predicted location of 19.5 inches out. Overall the lab ran very smoothly and, upon completion, verbal feedback from all the groups was very positive.

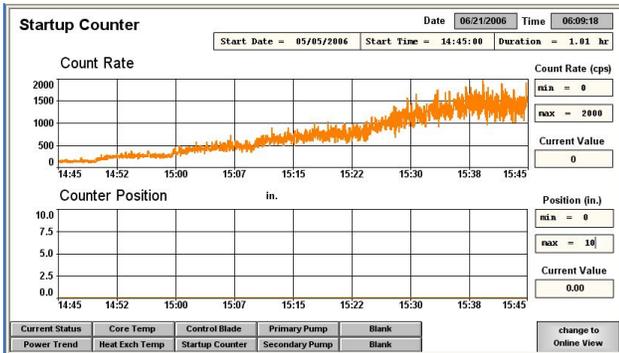


Fig. 3. Selected experimental data as observed by UIUC students

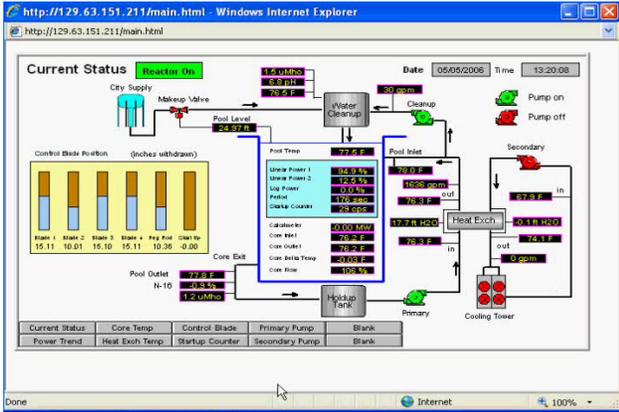


Fig. 4. Reactor status panel displayed in a browser window at UIUC

CONCLUSIONS AND FUTURE WORK

The lab was quite successful in achieving its primary goal of educating the students, and in its secondary focus of testing the new communications features of the distance education facilities. Although emphasis is given on observation, data retrieval, and analysis of particular experimental sequences that illustrate or reinforce some basic physics or engineering concept, future developments, after sufficient safety features have been installed to satisfy regulatory requirements, may also allow some limited control actions from a remote site. This would allow a single research reactor to maximize its educational benefit via actual remote ‘hands-on’ control of certain aspects of some experimental sequences, such as initiation of a pump coast-down test, or regular movement of the low-worth regulating blade to develop the differential and integral blade worth curves for a real operating reactor.

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