

## A WEB-BASED TUTORIAL AND TELE-OPERATION SYSTEM FOR EARTHQUAKE ENGINEERING EDUCATION

Scott R. Smith, Charles W. Husted, Sidney Smith, Brad Cross<sup>1</sup>

**Abstract** - We describe a system for the demonstration, explanation, and control of a laboratory setup comprising a scale-model of a building affixed to a "shaker-table" that simulates earthquakes. Senior design class students are creating a system to control the shaker-table. The signal generator controlling the table's translation is interfaced to a Web page, allowing the user to easily select different ground motion patterns. The building's reactions exhibit various modes of vibration. A 3D graphics model of the building is also shown on the Web page using VRML. This model is animated using Java programs so that it also exhibits the vibration modes of the real building. A set of associated Web pages provide a tutorial for the structural and earthquake engineering concepts that can be demonstrated with the shaker-table scale building in creative combination with the computer graphics models.

In an FIE'99 presentation, we described the educational aspects of producing and using Web-based 3D graphical simulations of scientific and engineering concepts. This paper describes a senior design group project that extends this animated simulation work we have done by interfacing to real laboratory equipment.

We have developed a system to demonstrate a building's responses to ground motion. A simple, scale model of a 5-story building is affixed to a moveable platform (the shaker table). The shaker table can be translated in one-dimension under control of an electrical signal (provided by a signal generator controlled through a computer's serial port). In our application, we program the signal generator to produce sinusoids of various frequencies and amplitudes, or to produce arbitrary waveforms corresponding to ground movement data collected during earthquakes. The sinusoidal signals allow observing the building's natural modes of vibration. This information allows structural engineers to determine a building's response to a complex motion waveform like an earthquake.

We developed the Web-based tutorial and tele-operation system to explain the engineering concepts that can be demonstrated with the model/shaker table combination. This project is one example of our investigations into the use of Web-based 3D graphics and simulation to convey scientific and engineering concepts. The project provides opportunities to teach Java, 3D modeling, Web

multimedia production, network programming, Web security issues, distributed processing, remote sensing, and tele-operation.

We have developed a set of Web pages that show a 3D graphics depiction of the building using the Virtual Reality Modeling Language (VRML). Web browsers display VRML models with a high degree of user interactivity to allow zooming in on or walking around the model. Coupling this ability with animation provided by VRML and a Java applet allows the user to observe building motion on the Web page as well as in the real model. The Java applet's user interface includes buttons which put the 3D graphic into various vibration modes and also send commands over the internet to control the signal generator driving the shaker table. The user can select a guided tour, or a narrated tutorial to explain each mode of vibration.

The need to interface a Web page to a piece of laboratory equipment required a distributed processing environment. We wrote Java and C programs that ran on the Web user's computer and a computer connected to the shaker table setup, respectively. Network programming was used so these programs could communicate over the internet. This communication had to operate within the Web's security protection mechanisms. We are exploring the use of this connectivity to allow feedback concerning the scale model's actual motion back to the Web-site. Students could design a microcontroller-based system which senses and relays information from position sensors and accelerometers. Similarly, students will learn valuable data communications concepts and trade-offs when trying to provide a video link from the model back to the Web pages. This feedback will allow superimposing predicted and actual responses while highlighting any differences.

The Web pages we have created allow students and interested engineers to remotely access our Web-site and learn by watching the 3D graphics model. Also, when using the shaker table and model to demonstrate earthquake engineering concepts, running the Web pages locally allows self-guided explanation and discovery.

This interdisciplinary project has given our electrical and computer engineering students an opportunity to work with, and provide applications for, civil engineers. We thank Jim Taylor of EQE International for his contributions to the project.

<sup>1</sup> Department of Electrical and Computer Engineering, Department of Civil Engineering, Southern Illinois University, Edwardsville, IL 62026