Project HaptEK16

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ABSTRACT

Haptic Environments for K-16 (HaptEK16) is a multimodal haptic simulator designed to assist students in understanding difficult concepts related to hydraulics. The simulator includes three different components: pressure measurements, hydraulic machines simulation, and hydraulic car lifting. Multimodal interfaces combining 3D graphics and haptics have the potential to advance understanding of concepts and phenomena as well as promote new methods for teaching and training. This project explores such interfaces, called haptic interfaces that include a 3D representation of a hydraulic system designed to simulate various forces and pressures.

BACKGROUND

Haptics is the science of applying tactile sensation to computer applications, enabling users to receive tactile feedback in addition to auditory and visual cues. Such feedback is achieved through the use of haptic devices. A haptic device, such as the SensAble Technologies PHANTOM® Omni™ device (Fig. 1), typically has a robotic arm that tracks the position and orientation of a user-manipulated stylus. The tip of this stylus is the physical reference point of the device. Within a haptic application, there is a corresponding virtual reference point. As the user moves the stylus, the virtual reference point moves as well. When this virtual reference point (the yellow dot in Fig. 1) comes into contact with a virtual object, a force is felt by the user through the stylus. In this manner, the user can "feel" the features of the virtual object, including its mass, elasticity, and even surface texture. Through the rendering of these tactile sensations, haptic devices provide means to extend the capabilities of a computer simulation.

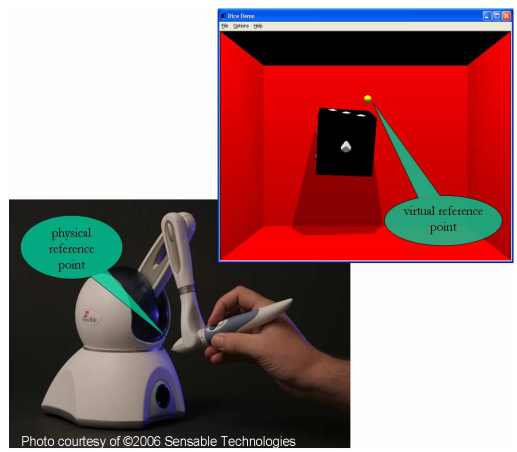

Fig. 1 Phantom Omni Haptic Device

HAPTEK16

In our simulator, the student is presented with a 3D scene of connected cylinders, rendered by instructions from an XML file, following the X3D and H3D specifications. By manipulating the haptic device the student can apply different forces on the small cylinder as he witnesses the resultant force on the second, larger cylinder. The H3D software API is used to tracks the position of the haptic device, and to provide force feedback from the interaction with the pistons. A module of the software component we developed (using the Python scripting language) performs calculations on

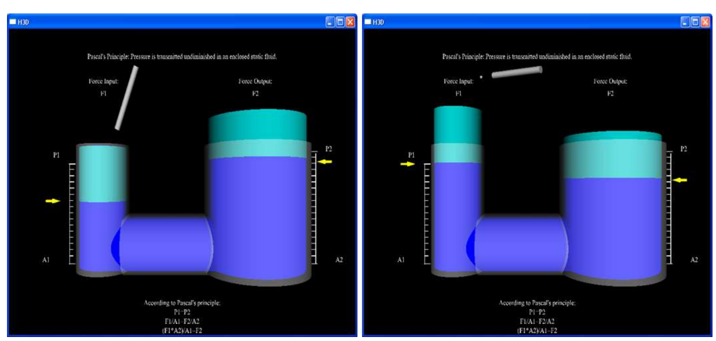
Fig. 2 HaptEK16 Screen Shot

the result of the interaction to provide the user with tactile feedback. As the student "presses" down on the left cylinder with the haptic device, the larger cylinder on the right moves up, as seen in Fig. 2. During this interaction the values of all the forces within the system are continuously displayed on screen to aid the student in understanding the principle (i.e. Pascal's Principle) at work.

SOFTWARE COMPONENTS

The simulator was developed using the Python scripting language, SenseGraphics's H3D API, and the Web3D Consortium's X3D standard. X3D, the XML-based successor to Virtual Reality Modeling Language (VRML), is an open standard file format and run-time architecture used to represent 3D scenes. The H3D API is a General Public License (Open Source) software development platform used to create multi-sensory applications. It was developed on top of X3D, leveraging OpenGL® and SensAble's OpenHaptics© Toolkit. With its haptic extensions to X3D and easy extensibility via the Python scripting language, the H3D API is an efficient tool for rapid development of multimodal applications that combine the senses of touch and 3D graphics.

ASSESSMENT

As a preliminary assessment, we have designed and executed a preliminary pilot study to collect feedback from students and teachers in order to assess the project's impact on learning. The pilot study was conducted at the Richmond Hill high school in southeast Georgia. The teachers provided us with information on how the topic had been covered in the curriculum and worked with us closely to develop the user requirements for the application. The software and haptic interfaces were delivered and installed during the spring 2007 semester. The students were selected from the 11th and 12th grade Earth Science classes. Students were divided in two groups: the students who did not receive the HaptEK16 instruction "**Group A**" and those students who received the HaptEK16 instruction will be called "**Group B**". Fig. 3 provides a brief glance at the preliminary results on a set of five fundamental questions on hydraulics. There is an obvious improvement in tests scores.

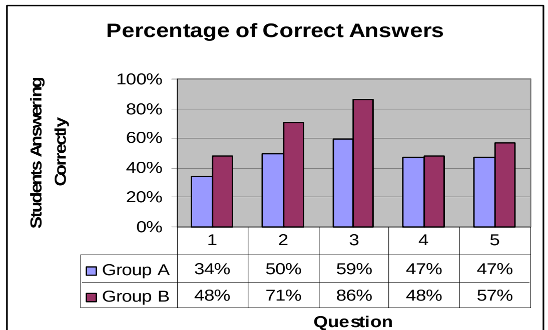

Fig. 3: Percentage of Correct Answers for Groups A and B

FUTURE DIRECTIONS

In the future we plan to add additional hydraulic scenarios for students to explore, as well as investigate additional principles that will help in the teaching and learning process, such as spring resistance or friction. We plan to explore available haptic APIs and technologies and fully deploy the simulations in a web-based environment as an addition to existing e-Learning systems.

REFERENCES

- Felix Hamza-Lup, Michele Adams (2007) "*Understanding Hydraulics Using Haptics*", 14th Georgia Conference on College and University Teaching, Kennesaw, GA, Feb. 23-24. (available at http://www.felixlup.info/)
- HaptEK16 Web site: http://projects.felixlup.info/haptek16/