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Graphical and Haptic Manipulation of 3D Objects

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1. Research Interests

We are interested in identifying new ways of human - machine interaction via haptic and graphical devices. In particular we have been working toward developing a cooperative graphic and haptic interface that allows us to manipulate and sculpture 3D objects more effectively. That includes compact and efficient representation of the object as well the ability to "feel" the 3D object - different textures, friction, etc. - and sculpt and model it through the Phantom. We are assuming that the combined graphical and haptic interface to 3D objects will allow us much richer and powerful interaction as well as t he ability to perform tasks that are not possible with the current technology.

2. Joint Haptics project with Stanford University.

During the past year we started by building an interface based on the UNC haptics library [1] that includes on one side the Phantom and a PC server to it and on the other side an SGI for graphical visualization and manipulation of virtual objects. The communication between the PC and the SGI is done over the Internet. That setup allowed for effective use and experiments with simultaneous haptic and graphical interface with virtual 3D objects. It also allowed us to study better the problems of latency over the Internet, transfer of complicated 3D objects, as well as graphic visualization.

As part of this effort we built a joint research project between Interval Research Corp. and the research group of Prof. Oussama Khatib from the Robotics lab at Stanford University. This project explores the possibility of interactions between remote sites with the Phantom arms that include:

human (using a Phantom) -to- human (using a Phantom);

human (using a Phantom) -to- dynamic, realistic, 3D simulation;

human (using a Phantom) -to- Puma robot (master-slave teleoperation).

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3. Student projects in Advance Robotics at Stanford University

We initiated and organized joint projects with the students in the Experimental Robotics class at Stanford in 1995 and 1996 taught by Prof. Oussama Khatib. That included equipping a Pentium PC and a Phantom with the right software and hardware for the project, organizing, directing and supervising the student's efforts. The project was successful in that in a few weeks, the students produced interesting and ambitious demos illustrating the advantages of combined use of haptic feedback and graphics. It also provided a good basis for extending the existing system to more complicated 3D objects and meshes. I will describe the projects that the students did, some of which were successfully demonstrated at the Experimental Robotics conference at Stanford in July 1995.

3.1 The Virtual Xylophone.

The first project built a virtual xylophone. The graphics were done on SGI Inventor and included the color xylophone and a mallet that was controlled by the Phantom (see Figure 1). The sound changed depending on the acceleration with which one plays the xylophone. For sound experiments there was a provision for changing from xylophone to an organ sound as well. A number of interesting issues relating to the interaction of haptic, visual and sound feedback were raised.

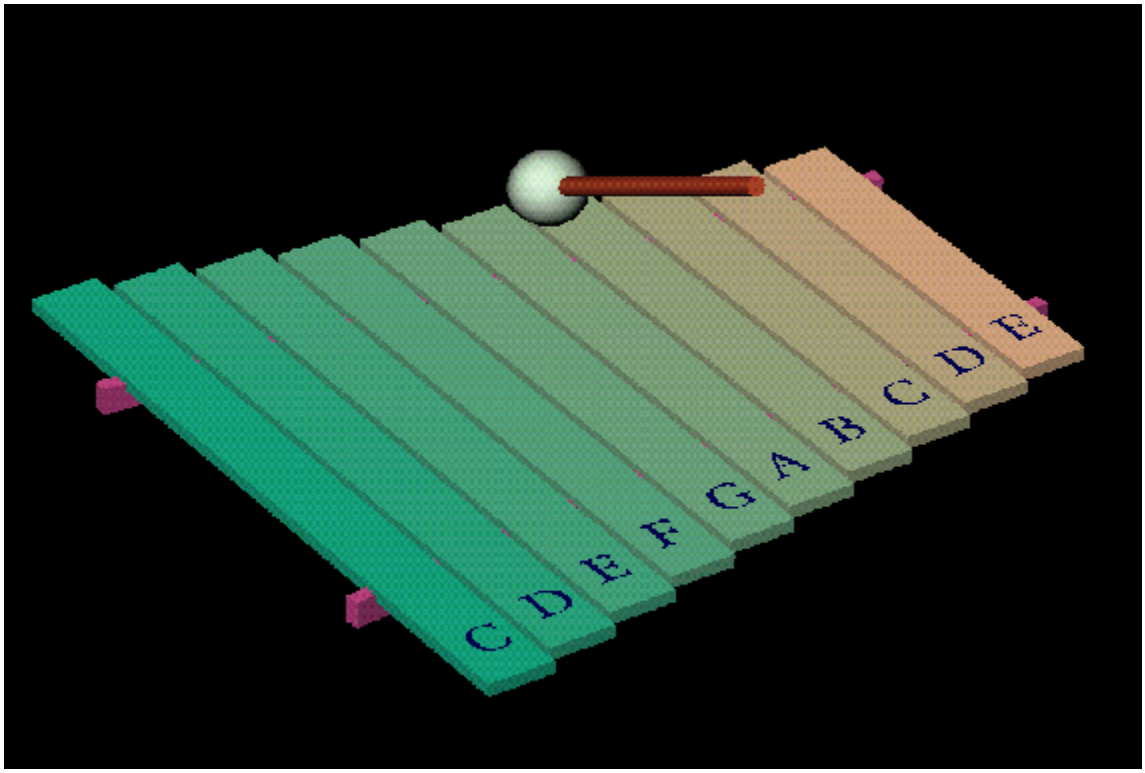

Figure 1. Graphical view of the Virtual Xylophone.

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3.2 Haptic Roaches.

The second project described involves a "Roaches" game. The graphical environment (done on the SGI with Inventor) includes a large playpen with cylindrical obstacles, a number of roaches and a small sphere representing the users' finger (controlled by the Phantom) - see Figure 3. The goal is for the user to kill the roaches by pinning them down from above. The roaches have certain amount of intelligence and try to hide underneath the obstacles which the user needs to put aside in order to reach the roaches. All graphical objects are inherently 3 dimensional and the game is enhanced via sound and visual effects. The criteria for the user's performance in the game is time, which adds another dimension to the project.

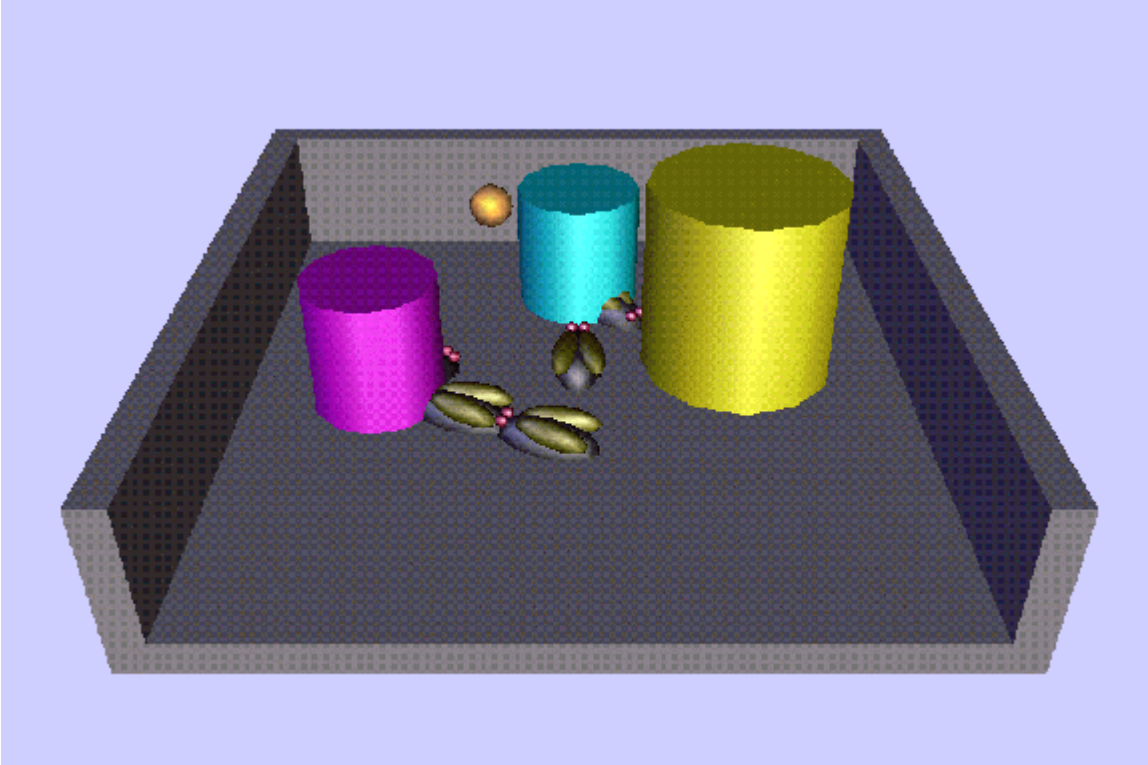

Figure 2. The game of Haptic Roaches.

3.3 Haptic Exploration of rigid 3D objects.

The third project describes our first joint efforts with Diego Ruspini from Stanford on graphic and haptic exploration of rigid 3D objects with surfaces described as polygonal meshes. Examples include a virtual 3D staircase, 3D bunny and space shuttle. The newest results and the theoretical foundation of this work are further explained in a separate paper for this Workshop [2]. Our overall goal is to extend the capabilities of our haptics library to support a more powerful and general set of modeling primitives (for manipulating arbitrary complex rigid objects), and to allow the haptic server to operate with a greater

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amount of autonomy from the host computer and simulate a wide range of virtual environments. On the next stage the support libraries provides a means of allowing the developer to specify constraints between the objects in the environment and for controlling the motion of objects in the virtual world. The last part of the effort will involve modeling the contact forces caused by contact and collisions between the objects in the virtual environment. This work will build on research being done in the areas of fast distance/collision calculation and dynamic simulation at Stanford [3].

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