Scribe Notes for 4/4/2011
Topic: Haptics Demos
Notes by: Chris Mangus

The Demo Device:

The haptic device that was shown is similar to the device shown above. It has 3 degrees of freedom, and the stylus has 2 buttons. The device connects to a computer via a Firewire cable which transmits 6 values approximately 1000 times a second. The 6 values are 3 for the position of the stylus, and 3 for the Euler angles of the robotic arm. The amount of force that the device can emit is about one to two Newtons, and the device can be about as stiff as one newton per millimeter which is twenty times softer than a real wall. This device, since it is a 3 degrees of freedom device (3DOF), can only emit forces in the x, y, and z directions. More expensive devices that are 6DOF have torques that can be actuated on the stylus. The hole that the stylus sits in is called the well, and it is used in the calibration phases of using the device.

Programming on the Device:

It is a low level API which uses two threads to execute code. One thread is for all of the display functions of a simulation. OpenGL and any other graphics calculations are done on this thread, and its goal is to run at 60Hz. The other thread is where all the haptic related calculations are done. This thread needs the 6 numbers from the device as input and outputs the force. This thread needs to be executed very fast, at about 1 millisecond of computation time or 1000Hz. The speed requirement is so that the high update rate of the haptic device can be satisfied at all times. If the code runs over the 1ms barrier, the device will go unstable and will not be able to update as often as it needs. The driver for the device will then shut it down. So one challenge is to write the haptics code to run very quickly.

Peg into Hole Demo:

In this demo, the stylus represents a rectangular cube that needs to be placed into a similarly sized hole in a box on the ground surface. The peg into hole case is a difficult collision detection case due to the large contact areas that exist in it. The stylus doesn't exactly represent the cube, it represents a wire frame that guides the cube. This is the "god object" that was talked about in the previous lecture, in which the solid rectangular cube follows the wire frame but is subject to any collisions that occur in between. The gap that occurs between the solid cube and the wire frame cube is how the force that the user feels is calculated. The larger the discrepancy, the larger the force. This force that holds the wire frame and the solid together is called the coupling force. This value can be adjusted in the simulation. The weaker the force, the larger the penetration. The larger the force, the more the stability of the device and the

simulation is threatened. When the force is put up very high, the device "chatters" in the hand of the user because the force is too stiff for the device. In the demo, there is various information displayed to the user. Temperature of the motors in the device, the time to execute the haptic calculations, the tree traversal count for collision detection, the torques that could be actuated by a device, and the forces actuated are some of the information that is provided by the simulations.

Dinosaur with Bridge Demo:
        Here a rigid body dinosaur is controlled by the stylus and it is interacting with a deformable bridge model. This simulation is important to show that you need more than just fantastic haptic code to show off the hard work that is done. The collocation of graphics and haptics is very important when showing demos. Even though the dinosaur is a complex object, since it is rigid, all of the forces on the dinosaur can be summed together to form the force for the stylus. There would be a much bigger number of collision calculations, but this number is reduced due to "graceful degradation". Graceful degradation, like model reduction, allows the calculations to be done in a much simpler space speeding up the haptics core greatly.
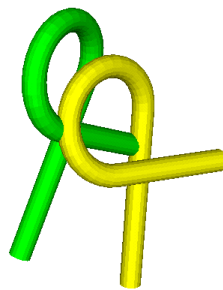
Alpha Alpha Demo:
        The puzzle(seen above) proposed by this demo is to connect the two rings together, and use of the clutch button is very important here to line up the rings. The clutch button is set to one of the buttons on the stylus. It is used to pause the movement of the object that represents the stylus on the screen, allowing the user to reposition the stylus in reality. The clutch allows the user to obtain much more control over the simulated object, yet it subtracts from the immersion somewhat. The use of the clutch is one way to expand the workspace of a simulation. Instead of being confined to only the area by the range of the haptic device, the clutch enables the device to move an object an infinite amount of distance in any direction.

Dragon and Horse Demo:
        In the last demo, there is a deformable horse that is moored to the ground, and the stylus represents a rigid body dragon. Here, collision detection is discussed a bit. The horse is covered in points that are sampling the object. The dragon has a distance field. So the distance field around the dragon is queried by the points covering the horse. For any points that are in contact, the force is computed. The "compliance value" in the simulation is how much the horse is obeying the deformations that would arise from the dragon coming into contact with it. The more and more compliant the horse is, the more deformations occur and the more unstable the model can become.