

How SPRING works with 3-D haptic devices

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In SPRING, a *sensor* is an object that connects a visual object, such as a tool, to an input/output device such as a mouse, a haptic device, a 3-D digitizer, or another physical device. SPRING communicates with most of the sensors by means of TCP/IP connections, expecting a 3-D orientation matrix and a 3-D translation offset that defines the position of the tool. In addition, one or more *activation* values may be sent that indicate the state of buttons, dials, levers, or switches in the interface. These may be digital (on/off) or analog values.

Setting up a sensor

A sensor is connected to SPRING in one of two ways:

1. The DESC file defines the visual object, and then indicates the type and address of the computer on which a sensor's server is running (only for those that are run as separate servers, such as haptic_v1).
2. Manually, with the user first selecting a tool from the Tool menu, then creating a sensor of the desired type from the menu. If the sensor type is implemented by a server, the user must type in the IP address of the computer on which the server is running.

When the server is selected, the connection is initialized, and, if successful, the sensor is added to an array of sensors that is maintained by SPRING.

In the case of the Sensable Phantom, a haptic_v1 type of sensor is used. This uses a very simple protocol to make the connection using the string "haptic_v1.0", expecting the string "ACK" to be returned.

Using the sensor

When the SPRING simulation is running, which is controlled by the space bar, the array of sensors is queried in each cycle of the simulation.

SPRING calls the `handle_sensor()` function for each sensor that is active. Within that function, the sensor's continually reads the 3-D orientation information from the sensor's interface. For a 3-D input device, these consist of a 3-D position, and usually, a rotation matrix, which encodes the 3-D angular orientation, so that points and edges in the drawable object are transformed properly as the 3-D interface is manipulated.

When the tool interacts with an object, a force is computed between the tip of the virtual tool and the point of intersection with the deformable object. This force is sent to the

sensor object, which transmits the values to the device. Usually the force has X, Y, and Z components (twist and grasping are included for some devices.)

SPRING sends force values as a 3-D vector, 3 floating numbers encoded as a string. Twisting and gripping forces are also sent, for those interfaces that can implement such forces.

The force values are encoded as a string, with the following formatting:

```
numbytes = sprintf(buf,"%f %f %f %f %f"  
                  hforce.x, hforce.y, hforce.z, twist_force, grip_force);
```

The twist and grip force are not currently set, and are not used by a Phantom.