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A Haptic Interface for Fishing Training

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Abstract— **One important application of haptic devices is to build a haptic interface in simulation so users can interact with virtual objects in virtual environments. This paper implements a haptic interface for fishing training using a 3D haptics device, Novint Falcon. The interface simulates the force sensation during fishing. In the interface, the user is able to move the rod in 3D space. The virtual objects are modeled as dynamic objects which have attributes of mass and stiffness. The pose of the virtual object can be updated by computing forces applied to the contact point on the object. The program was implemented using CHAI 3D, an open source C++ API for computer haptics, visualization and interactive real-time simulation.**

I. INTRODUCTION

Haptic feedback provides us a sense of force feedback so that we can interact with virtual objects in virtual environment. Providing force sensation requires special hardware that serves as haptic interface. Haptic interface has been widely used in various applications, such as medicine, teleoperation, military, CAD systems and gaming [1]. One main application is virtual training. For example, doctors can get training in a virtual surgical environment with force sensation, so it reduces the risk in real surgery. Drivers get training in drive simulators, they feel a force feedback in steering as if they are driving a real car, which improves their performance in driving. Ball players practice using a ball hitting simulator. It is easier to record their performance in virtual world so they would improve their skills in virtual training. The haptic interface simulates the real haptic feel so it gives a quick practice for beginners before turning to real system. An advantage of virtual training is that the cost of a virtual system is much lower than a real training system. Also, it saves time for system setup and maintenance.

Haptic device can also be be designed for fishing training. Fish usually taps the bait before biting the hook. So there would be some small vibrations on the fishing rod. Sometimes the fish half bites the hook. In this situation even if one feels a gravity change (s)he would fail to catch the fish. It is tricky because it is hard to judge a real bite due to different weights of fish. Moreover, it also needs a large patience for beginners to wait for a bite - usually more than 10 minutes. It would frustrate the beginners if they fail to catch the fish after waiting so long a time for a bite.

This project is to simulate the force sensation during fishing using an interface of Novint Falcon. The environment would mimic a force changing when there is a bite on the hook. In the interface, the user is able to move the rod in 3D space. The virtual objects are modeled as dynamic objects which have attributes of mass and stiffness. The pose of the virtual object can be updated by computing forces applied to the contact point on the object. The program was implemented using CHAI 3D, an open source C++ API for computer haptics, visualization and interactive real-time simulation. The haptic interface helps beginners get more practice before they turn to real fishing.

II. SYSTEM SETUP

The haptic device used in this project is Novint Falcon, shown in Figure 1. It is a high resolution, 3-d commercial (3-d translation) haptic force feedback device. The workspace of Novint Falcon is about 4 inches cubed and the force capability is 10 N. It has a low price of $200 and is therefore a reasonable device used in training systems. Novint Falcon is a impedance device: the input to the device is position, while the output is force. There is the another type of haptic device, admittance device. The input to a admittance device is force, but the out put is position. The impedance control is easier than the admittance control, because it does not have a force feedback. In impedance control, the force needs to be controlled even if the desired force is zero.

Fig. 1. The 3D haptic Device, Novint Falcon

The virtual environment is built using CHAI 3D [3], an open source C++ API for computer haptics, visualization and interactive real-time simulation. CHAI 3D supports several commercially-available three-, six- and seven-degree-of-freedom haptic devices, and makes it simple to support new custom force feedback devices. CHAI 3D takes an important step toward developer-friendly creation of multimodal virtual worlds, by tightly integrating the haptic and visual representations of objects and by abstracting away the complexities of individual haptic devices.

III. INTERFACE DESIGN

In the interface, some 3D objects need to be created to interact with users, such as fish, fishing rod, hook and fishing line. All the objects have physical attributes of mass and stiffness. The 3D graphic display was implemented by OpenGL, an 3D graphics API that is integrated in CHAI 3D. One end of the fishing rod was attached to the Haptic

Interaction Point (HIP). Since the Novint Falcon has 3 degree of freedom, the user can move the fishing rod in the virtual space but cannot rotate the rod. Force can be rendered to the HIP so that the user can feel a force change on the point contact with the virtual environment.

The fish and hook need to be modeled as dynamic objects. A dynamic object has an attribute of mass so a gravity can be rendered to it. It also has a stiffness, so that forces can be generated to the contact point using some collision detection algorithms. The object also has attributes of velocity, acceleration and momentum. The pose of the object can therefore be updated in haptic updating loops by computing its dynamics.

In real world, the fishing line is not a rigid object. The rotation and deformation are approximated by a linear combination of 3D basis rigid shapes. Since it is much more complicated to model a non-rigid object than a rigid object. I simplified it as a straight line. The class `cShapeLine` defines a line by the positions of the two ends.The line indicates the connection between the HIP and the hook. The grasp force between the HIP and the object was modeled by a virtual spring. The function `getGlobalPos()` retrieves latest position, which is a 3 by 1 vector in world coordinate; the function `getGlobalRot()` returns the orientation of the hook center in world coordinates, which is a 3 by 3 matrix. They are denoted as $\hat{P_g^{h_c}}$ and $R_g^{h_c}$ respectively. The grasp point $\hat{P_g^h}$on the hook in global coordinates is computed by (1), which is transformed from the local position by the global position and rotation of the center.

$$\hat{P_g^h} = \hat{P_g^{h_c}} + R_g^{h_c}\hat{P_{h_c}^h} \quad (1)$$

where $\hat{P_{h_c}^h}$ is the local position vector of the grasped point on hook. The interaction grasped force vector $\hat{F}$ is computed by (2).

$$\hat{F} = K(\hat{P_g^t} - \hat{P_g^h})(1 - \frac{l}{\|\hat{P_g^t} - \hat{P_g^h}\|}) \quad (2)$$

where K = 6 is the spring coefficient; $\hat{P_g^t}$ is the HIP position vector in the world coordinate; $l = 0.4$ units is the length of the line. The two ends of the line are determined by $\hat{P_g^h}$ and $\hat{P_g^t}$.

Once the hook immerses into water, an attraction force is applied to the fish mouth. The attraction force is modeled as a spring as well, where the coefficient is 1. Similar to (1), the global position of fish mouth is transformed from the local position by the global position and rotation of fish center. When the fish reaches the hook, a vibration is applied to the rod to mimic a hit or a nibble on the bait. After a short vibration, the fish's weight is loaded to the rod. the vibration is modeled as a sinuous function, with a frequency of 50 Hz.

In order to increase the difficulty, some random factors were introduced to the system. In the program, two sizes of fish is randomly selected, and the weight is proportional to the size. Besides, two vibration time and the period of biting is randomized, so the user is not able to anticipate the real bite. This makes the system more like the complicated reality.

In the program, two threads are used to deal with graphics display and haptic computation. The graphics has a lower priority, which updates thread updates the pose display of each object in the virtual world. The haptics thread has a higher priority, which handles the main calculation of interaction. The haptics thread updates the force applied to each objects and compute the dynamics. The algorithm in the haptic thread is described as a flow chart in Figure 2.

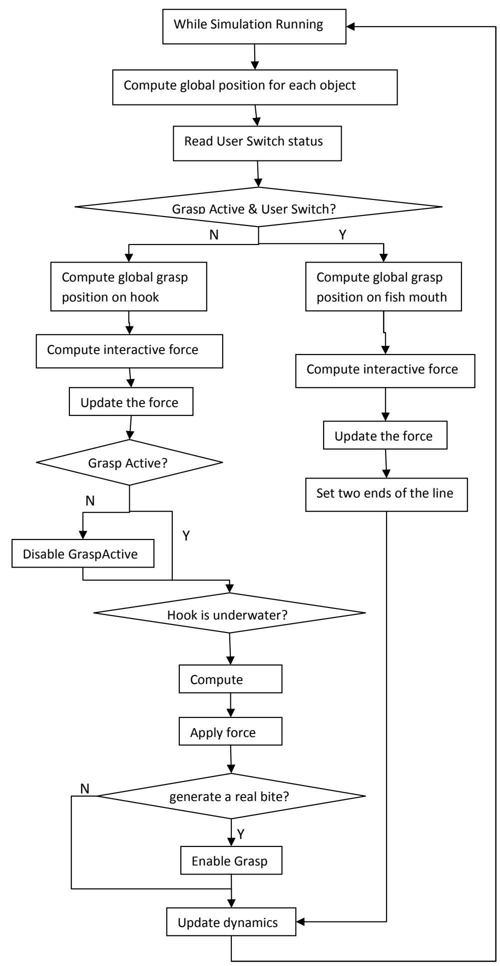

Fig. 2. Flow chart of the haptics update

IV. Results

Figure (3) is the fishing training interface. The interface makes you feel force changes on the rod like a real fishing. The user controls the Novint Falcon gripper to move the rod. The fish was hided underwater. The hook attracts the fishwhen it is underwater. The fish would tap the hook, and then bite. When the user feels a weight on the rod, (s)he should press the user button on the gripper to catch the fish at a suitable time.

I studied the force feeling in real fishing from a fishing lover. People who tried it in the demonstration found it very interesting. Two of them who fished before thought the force

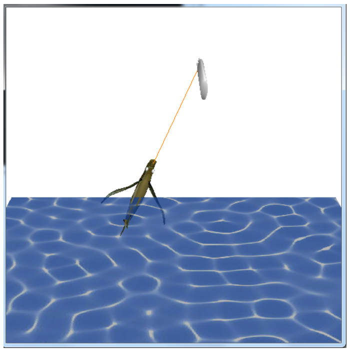

Fig. 3. The graphic interface of the fishing training.

feeling similar to real fishing. Some caught the fish quickly, while some felt difficult to caught the fish. They got lost the fish because of unsuitable timing. All users enjoyed playing with the interface. They thought it to be a good training system for beginners because people do not need to wait.

V. Conclusions

This paper implements a haptic interface that simulates the force sensation during fishing using a haptic interface, Novint Falcon. The program uses CHAI 3D library to simulate the virtual dynamic objects, such as fishing rod, hook and fish. The 3D graphics API, OpenGL, is used to display the 3D virtual world. The environment mimics a vibration and a weight change when there is a bite on the hook. The interface helps beginners get more practice before they turn to real fishing. Good feedback was received from the demonstration. Three fishing lovers agreed that it successfully mimic a real fishing. Other users found it to be interesting. They thought they both haptic feedback and visual feedback are beneficial to users.

Future work would be improve the complexity of the force feeling, for fishing needs a complex interaction with the environment. For example, different types of fish have different habits; different fishing rods, baits and hooks all matters the force changes. To better simulate the complex interaction with the environment during fishing, more research is needed to study the force sensation in real fishing.

References

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