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Haptic Feedback in Large-Scale VEs: Evaluation of SPIDAR-G

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Abstract

This paper deals with haptic feedback in large-scale Virtual Environments (VEs). After a short survey and comparison of haptic devices, we present an original integration of SPIDAR-G. The device position measuring capacity is given. A VE where the user can select and manipulate virtual objects while feeling their weight and resistance offered by a static obstacle was developed. A preliminary evaluation of the system is presented. Results from questionnaire revealed a very good acceptance and feeling from the users.

1. Introduction

To increase the user's immersion in Virtual Environments (VEs) and to impart them with realistic experience, several sensory modalities like 3D vision and sound have been added with success. The use of these modalities along with high quality interactive scenes resulted in VEs that allow more comprehensive understanding of problems.

However to fully understand VEs, to make them more realistic and to increase human performance, the haptic feeling of their physical characteristics (inertia, weight and hardness) is required. Thus the inclusion of haptic modalities becomes more compulsory.

In this paper, we present an original integration and a human performance evaluation of SPIDAR-G in a large-scale VEs. The user can select and manipulate virtual objects while feeling their weight and resistance offered by a static obstacle.

The paper is organized in the following manner. In section 2 we present a short survey of existing haptic interfaces and we make a comparison between SPIDAR [1, 2] and other force feedback devices. Section 3 describes the SPIDAR-GL

(Large-scale SPIDAR G). Section 4 describes the VE developed for experimentation with the SPIDAR-GL. Section 5 presents a preliminary user study.

2. Related work

In order to provide force feedback in VEs, a number of technological solutions have been proposed and utilized. For example the PHANTOMTM desktop has a (160 x 120 x 120) mm³ workspace and returns force on a single finger [3]. Some other models of PHANTOMTM and their characteristics are present in table 1 [4].

Table 1. Characteristics of PHANTOMTM devices.

Model	DOF (output)	Workspace (in)	Maximum Force (N)
PHANTOM 1.5	3/6	381x267x191	8.5
PHANTOM 3.0	3/6	838x584x406	22
PHANTOM Premium	3	381x267x191	8.5

Such devices normally suffer from small workspace and integration problems with immersive displays. Alternative solutions provide finger force feedback to the user. For example, the CyberGraspTM can exert a force of 12N on each finger of the user's hand. It has a workspace of 1m-radius hemisphere and the user has to bear its weight of 450g.

The CyberForceTM that provides external force feedback [5] is very precise in measuring position and orientation of the user's hand and can prevent penetration into a simulated wall. However, it offers a small workspace of 12"x 12".

Sato proposed a more interesting and less intrusive approach, based on the use of strings. The resulting devices are called SPIDAR (Space Interface Devices for Artificial Reality). In [6] two

SPIDAR-G systems were used for object manipulation in a small-size desktop VE. Task completion time was analyzed under different conditions including haptic feedback. In [7] a SPIDAR-H was used in a human scale VE for product design and maintenance tasks. In this study, the SPIDAR was only used to provide position tracking and the feeling of objects weight.

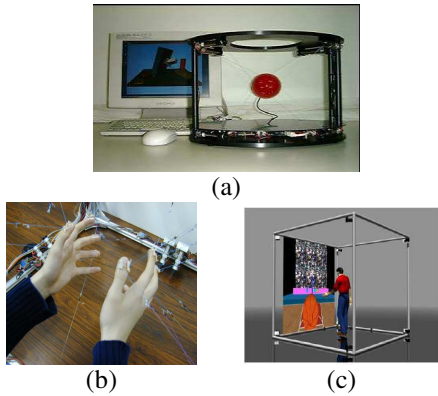


Figure 1. Illustration of different SPIDAR: (a) SPIDAR-G, (b) SPIDAR-8, (c) SPIDAR-H

3. System description

3.1 SPIDAR-GL

We have mounted the 8 motors of SPIDAR-GL on the corners of a large size (1.8 x 1.2 x 1.2) m³ iron frame. All these motors are connected to the HDHC (High Definition Haptic Controller) that communicate with PC via USB 2.0. We placed this frame in front of a (1.2m x.9m) screen. The system provides 6DOF, with translation and Orientation force and is capable to measure a distance of .80m, .50m and .50m in X, Y and Z directions respectively from the origin (center of frame). An illustration of the system configuration and a picture of the system is given in the figure 2 and figure 3 respectively.

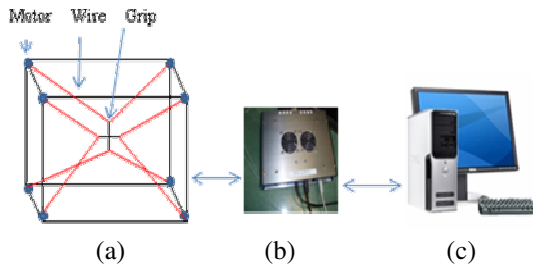


Figure 2. System configuration: (a) frame and strings, (b) HDHC controller, (c) Computer.

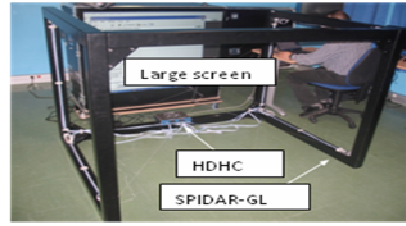


Figure 3. SPIDAR-GL of IBISC lab.

3.2 System calibration

In order to calibrate the SPIDAR we took the centre of the frame as home position (i.e. origin) and calculated the coordinates for both ends (i.e. one end attached to the grip and the other attached to the pulley) of each string.

The coordinates of strings were stored in a text file (called device information file). Similarly the phase sequence of each motor was set on hit and trial bases and was also stored in this file.

Our program developed in C++, which communicates with HDHC controller, makes use of the calibration routine that comes as a part of the SPIDAR API. The calibration routine takes the device information file as input and gives the initial position and orientation of the grip as output. Before the execution of the calibration routine the user is required to hold the grip at the middle of the frame. Figure 4 presents an illustration of the calibration process, where P represents position and O represents orientation of the grip.

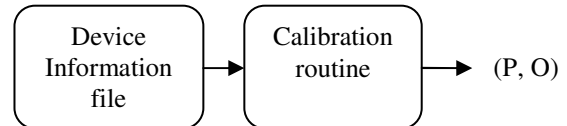


Figure 4. Illustration of the calibration method.

4. Virtual Environment

In order to carried out a usability study with our system we developed the VE that is given in figure 5.



Figure 5. Experimental virtual environment

The VE is a virtual square room that contains a total of eight cubes. Three walls (left, right and back) and a screen act as static obstacles. A wood-textured floor represents the limit of the room in the downward direction. A small black sphere is used as a pointer and follows the movements of the SPIDAR-G grip.

The virtual cubes are made from the same material but have different size. Each cube is associated with a mass ranging from 200g (smaller cube) to 1kg (bigger cube). The user can select any cube using the pointer. For selection, collision detection between a cube and the pointer is used as a metaphor. When selected, the corresponding cube is attached to the pointer and follows its movements. Thus any cube can be moved and placed on any of the red or green zone. As the SPIDAR has no binary input for selection/release confirmation, we have used a metaphor for the placement of the cubes on the two zones. This metaphor is based on the collision detection between a zone and a cube.

As the user selects a cube using the pointer, he feels the its weight. For each cube the weight is calculated using the following the formula:

$$W_t = m_o g + W_c$$

Where W_t represents the total weight of a cube. m_o is the mass associated to a cube and g represents the gravitational force. W_c is the weight of the grip which is added to the weight of each object.

5. Software architecture

Our software that enabled us to use the SPIDAR in the VE has client-server architecture as illustrated in the figure 6.

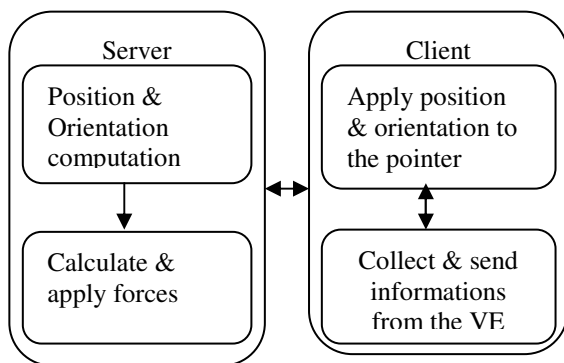


Figure 6. Illustration of software architecture.

We developed the server part of this software using C++ language. This part of the software performs the following tasks:

1. Establish PC and HDHC controller communication
2. Take the calculated position and orientation from the HDHC controller.
3. Establish connection with Virtools client.
4. Calculate and apply the force or weight based on the information received from the client.

The client part of this software was developed using Virtools Dev4.0 environment. This part is responsible for the presentation of virtual environment and supports the interactivity of the virtual objects. The position and orientation send by the SPIDAR server are applied to the pointer. Based on the collision detection mechanism, object selection is checked. The selected object is attached to the pointer and its ID is send to the server for force calculation. Similarly the collision is checked for object placement in a particular zone. In addition the client detects collision between the selected cube and the static obstacles (walls or screen) and the corresponding information is sent to the SPIDAR server for creating a resistive force in a particular direction.

By default the Virtools Dev. software has no support for communication with SPIDAR. In order to establish this communication and to enable the integration of the SPIDAR device in Virtools Dev. environment, we developed three building blocks (BB). These building blocks are presented in figure 7.

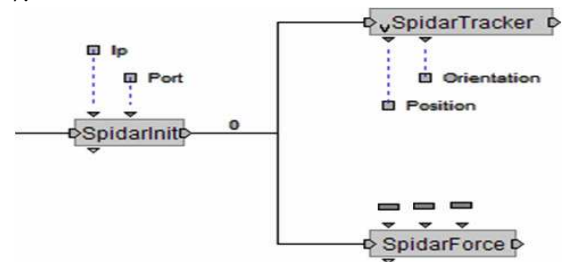


Figure 7. Building Blocks developed for SPIDAR to be used in Virtools.

The BB **SpidarInit** is used for communication and data exchange between client and server. **SpidarTracker** BB takes the position and orientation and forwards it to another BB for application to the pointer. The BB **SpidarForce** takes the data from the rest of the program about object selection, releasing and collision with obstacles.

We tested this software on two different system configurations: (1) firstly, we installed both SpidarServer and Virtools client on the same machine and then each on a different machine.

6. System evaluation

In order to evaluate our system, we carried out a usability study. A total of 13 young volunteer students including 11 males and 2 females participated in the experiment. All participants performed without any knowledge of the system. The objective of this experiment was twofold: evaluate (1) the overall usability of the SPIDAR-G in tasks involving manipulation of virtual objects with force feedback, and (2) the subjective effect of haptic cues on user performance. Therefore, each user performed the experiment with and without force feedback. In first case the system (SPIDAR-GL) was used while its haptic rendering was active then it was made inactive and users depended only on the visual feedback to manipulate objects in virtual environment. While the haptic rendering was active the users not only experienced the weight for all objects but also the resistive force the static obstacles (walls). In order to avoid any training transfer, these conditions were counterbalanced.

Initially all cubes were present in the middle of the two zones and near to the screen. The users were asked to randomly select a cube and place it all on a zone of their choice. Once all cubes were placed on the given zone, the participants were asked to place all the cubes on the other zone and finally again on the first one. To record the user's opinion about the system, they were asked to fill a questionnaire. The questions were the following: "the device used in the application is simple", "it is light, natural", "objection selection & positioning is easy, precise, and comfortable", "the system don't give tiredness", "the wires don't disturb visualization", "the task is easier with force feedback", "Each object has a weight" and "it is differentiable for two objects closed in mass (200g & 300g)". Each question has three options for response such as: agreed, neutral, not agreed. The following graph in the figure 8 represents the results of the questionnaire.

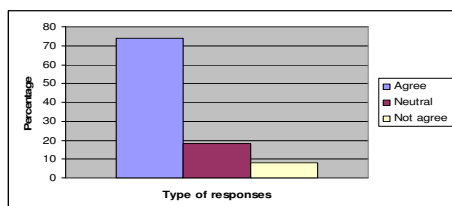


Figure 8. Results of the questionnaire.

5. Conclusion and future work

We presented an original integration of the SPIDAR-G (a string-based haptic device) in Virtools Dev 4.0 software environment. The overall system allows the users to interact with virtual objects or obstacles (walls) in a large-scale set-up. An experimental virtual environment was developed in order to carry out a usability study of this VR platform. Participants were asked to repetitively pick and place a total of nine cubes on the floor of a virtual room, using the SPIDAR-G haptic device. Results from questionnaire revealed a very good acceptance and feeling from the users. (73% of responses are positive, 18% of responses are neutral and only 8% of responses are negative). This shows that the SPIDAR in virtual environment has many advantages over other grounded force feedback devices in terms of usability and transparency. Such a device is therefore more likely to contribute to the field of enactive interfaces.

In order to investigate some other interesting characteristics of SPIDAR like speed, force and accuracy etc, we are going to carry out more precise experimentations in the near future. Similarly we are planning to deploy the SPIDAR for virtual/augmented reality supported teleoperations and collaborative teleoperations.

References

- [1] Makoto Sato "Development of String-based Force Display: SPIDAR", IEEE VR 2002 Conference.
- [2] N.Tarrin, S.Coquillart; S.Hasegawa L.Bouguila and M.Sato "The string haptic workbench: a New Haptic Workbench Solution". Computer Graphics Forum, Volume 22 Issue 3 Page 83 Issue 3 - 589 - September 2003.
- [3] Grigore C. Burdea "Haptic Feedback for Virtual Reality" Innovation Research, Vol. 2, No. 1, pp. 17-29, July 2000.
- [4] <http://www.sensable.com>
- [5] <http://www.immersion.com>
- [6] Luo yanlin, Jun Murayama, Katsuhito Akahane, Shoichi Hasegawa, Makoto Sato" Development of new force feedback interface for two handed 6DOF Manipulation- SPIDAR-G&G System". ICAT 2003 December 4-5, Tokyo Japan.
- [7] Paul Richard et al. "Human-Scale Virtual Environment for Product Design: Effect of Sensory Substitution", the international journal of virtual Reality, 2006, 5(2):37-44.