Guidance Services for a Haptic Museum in Distributed Virtual Environments

Toshio ASANO
NTT Service Integration Laboratories
NTT Corporation
1-11, Midori-cho 3-chome, Musashino-shi,
Tokyo 180-8585, Japan
Tel: +81-422-59-7116
asano.toshio@lab.ntt.co.jp

Yutaka ISHIBASHI
Department of Computer Science and Engineering,
Nagoya Institute of Technology
Gokiso-cho, Showa-ku,
Nagoya 466-8555, Japan
Tel: +81-52-735-5440
ishibasi@nitech.ac.jp

Abstract

This paper proposes guidance services in a haptic museum, which is a distributed virtual museum with touchable exhibits, as an application using haptic media as well as audio and visual media. The services enable users to receive detailed information by audio and video when they touch a specific and interesting portion of each exhibited object. Moreover, we collect users' operation logs related to exhibited objects, and we utilize the logs in order to modify the explanatory part of the guidance services.

Keywords

Distributed virtual environments, Virtual museums, Haptic media, Guidance Services, Operation logs.

1. Introduction

Cyber worlds based on virtual reality (VR) such as 3D game, tele-medicine, and e-commerce have actively been researched. As one possible breakthrough application of VR in virtual prototyping and entertainment areas, the authors proposed a distributed haptic museum, which is a distributed virtual museum with touchable exhibits through QoS non-guaranteed networks like the Internet [1]. The distributed haptic museum lets multiple users such as visitors, presenters, researchers, and curators access touchable exhibits; that is, the users can touch the interesting or desired portion of exhibited objects by using haptic interface devices and watch/listen to presentations made by an avatar acting as a presenter or by using actual realtime voice and video of a specialist. Since haptic interface devices let us feel the weight, form, and surface smoothness of each exhibited object, they can greatly improve visitors' understandings and impressions of the exhibited object. They also enable researchers and curators located at different places to build a realistic virtual space which improves the efficiency of collaborative work. Furthermore, users located at different places can appreciate the exhibited objects by the game style or play the collaborative work in a virtual space.

This paper proposes two types of audio visual-based guidance services activated by touching a specific and interesting portion of an exhibited object: the on-demand service and the guided tour service. We also discuss how to collect user operation logs related to exhibited objects and how to utilize them.

After a review of the distributed haptic museum in Section 2, Section 3 proposes the guidance services. Section 4 describes methods for collecting user operation logs related to exhibited objects and reflecting the logs in the services.

2. Distributed Haptic Museum

This section explains the components of the distributed haptic museum, the exhibited objects, and the information files.

2.1 Components

Figure 1 shows the configuration of the distributed haptic museum. In this study, as a haptic interface device, we employ the PHANToM DESKTOP (SensAble Technologies, Inc.) [2], which is a "position input, force output" type of device. Exhibited objects, which have information about the reaction force to be calculated, are displayed in exhibition rooms. A software development kit (SDK) called Ghost (General Haptic Open Software Toolkit) [3] for PHANToM is used to calculate the reaction force.

Two modes of observing exhibited objects are available to users: the weight perception mode and touch mode. The former lets us perceive the weight of an object and move the object. In the latter, we can feel the object's form and surface smoothness by touching it. It is possible to change the operating mode. Viewpoint movements (left rotation, right rotation, forward, backward, left, right, upward, and downward) and zooming in/out are also possible for each object at each client. Avatars acting as presenters can move freely in the virtual spaces (i.e., the exhibition rooms). They explain each exhibited object that is touched by users not only with audio, video, and computer data (a pointer, drawing, text, etc.), but also interactively with gestures [4].

The information files for each exhibited object are stored in a database connected to the server. The files are transferred to a client when necessary.

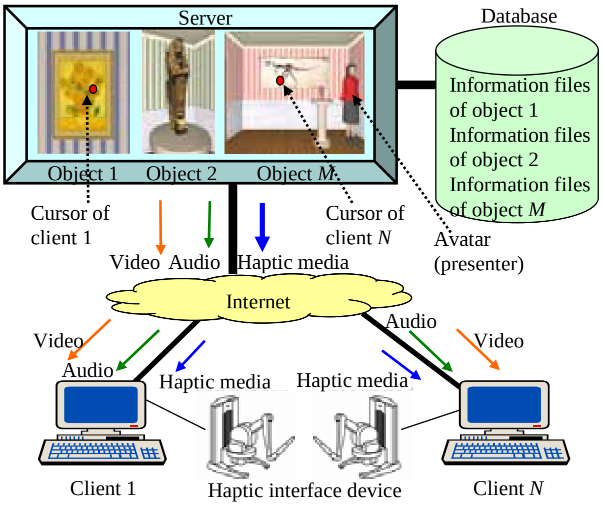

Figure 1: Configuration of the distributed haptic museum.

2.2 Exhibited objects

The exhibits created to date are described below:

(a) Sunflowers by Van Gogh

(b) Mummy sculpture

(c) Dinosaur skeleton

(d) Dinosaur fang

Figure 2: Examples of exhibited objects.

i) A painting of sunflowers by Vincent Van Gogh ((a) in Fig. 2): Visitors go and see this famous painting to appreciate the feeling of the thick paints and brushstrokes. We chose it in order to investigate how effective a flat immovable painting is in the distributed haptic museum.

ii) An Egyptian mummy sculpture ((b) in Fig. 2): We employ the sculpture as a touchable and movable object that has the same size and weight as the real thing.

iii) A dinosaur skeleton and one of its fangs ((c), (d) in Fig. 2): The skeleton was chosen as a huge object to test the size limits of the virtual museum. The skeleton is half buried in the ground in order to reduce the required number of polygons. The fang is handled as a touchable and movable exhibit with realistic size and weight.

2.3 Information files

The information about each exhibited object consists of the explanatory information, the haptic information defining the weight and form of the object, and visual information such as color and texture. Thus, each exhibited object has three types of information file.

The explanatory information file explains the whole of the object as well as specific portion of the object. For example, the meaning of hieroglyphs carved on the mummy image can be called up by touching them using the PHANToM. Audio and video files are transferred by a streaming technique and text files are simply downloaded.

The haptic information file defines the three-dimensional (3D) form of the object in a virtual space by VRML (Virtual Reality Modeling Language) [5]. The weight and form that a user feels through the PHANToM at the client are given by the spring-damper model. They are calculated from the penetration depth between the exhibited object and the cursor, the relative velocity between the cursor and the exhibited object, the spring coefficient [kN/m], the damper coefficient [Ns/m], and the dynamic friction coefficient of the exhibited object.

Although the VRML file gives haptic information, to improve the reality of the object, we need to provide color and texture information about the object. This visual information is expressed in the 3DS format [6] in our system. The 3DS format is read by modeling software for designing 3D figures (3DstudioMAX is used here), and positional information is preserved by exporting to the corresponding VRML file. In our system, the VRML file is not displayed using an API [7] which is offered by the Ghost SDK. As a result, the 3DS file and the VRML file are allocated to the same position in the virtual space, and the 3DS file is displayed while the VRML file is not displayed. We can feel as if we were touching the object which is displayed in the color and texture offered by the

3DS file in the virtual space. This implementation is explained in more detail in [8].

3. Guidance services

We propose two types of guidance service: the on-demand service, which responds to a request from a user made via a haptic interface device, and the guided tour service, which uses an avatar acting as a presenter.

3.1 On-demand service

For this service, an explanation start ring (or sphere) is set up in one or more portions of each exhibited object. For example, in Fig. 3 there are three explanation start rings. An explanation of a touched portion is started when a user's PHANToM cursor enters an explanation start ring. To decrease the response time experienced by the user, the explanatory information file is read proactively. A streaming start ring is set at a certain distance from the related explanation start ring. The data transferred from the moment the user's PHANToM cursor enters the streaming start ring to the instant the cursor enters the explanation start ring is stored in the buffer of the client terminal. The distance between the explanation and streaming start rings is varied according to the network load and the CPU processing load of each terminal, etc. It is also effective to determine the streaming start ring by predicting how the user's PHANToM cursor will move based on user operation log information, as described in the following section, in the case where some streaming start rings overlap.

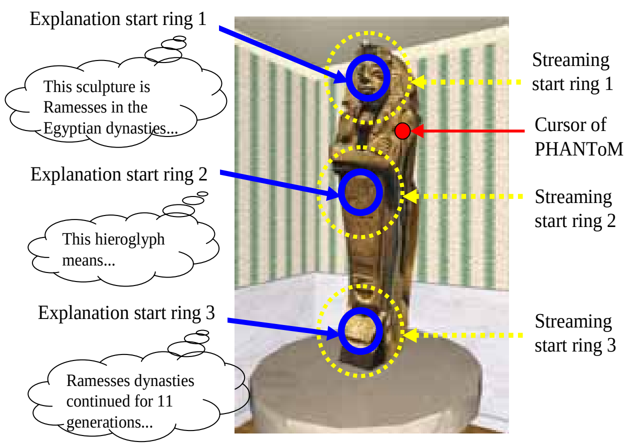

Figure 3: Proactive reading of explanatory information files.

3.2 Guided tour service (Fig. 4)

In this service, an avatar guides users and explains important or characteristic portions of each exhibited object. The avatar can deliver recorded presentations, but greater realism is achieved by using actual realtime voice and video of a curator delivered using live media transmission techniques. We adapt the traffic amount of voice and video according to the network and terminal loads. For example, the video may be shown with a lower time resolution (frame rate) or space resolution (number of pixels) or be replaced by CG output, or the explanatory information may be changed from voice to text or other low-bandwidth formats such as simple images.

We have implemented guidance services in the weight perception mode as well as in the touch mode. A user can hear the explanation about the weight when he/she lifts the Egyptian mummy sculpture. Also, the avatar guides him/her to a frame position of the dinosaur skeleton when he/she lifts the fang.

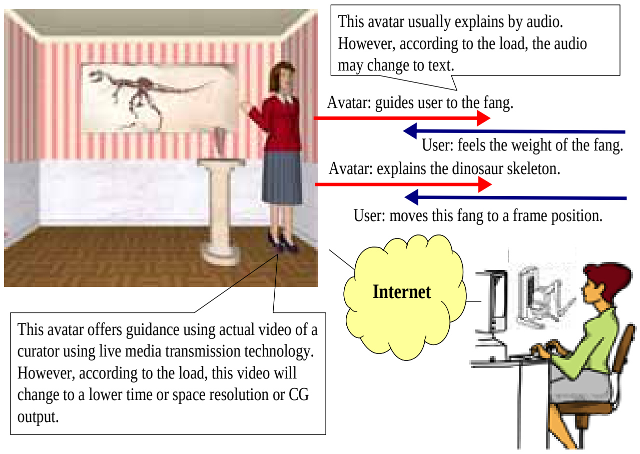

Figure 4: Guided tour service.

4. Collection of operation logs

The positional information about the PHANToM cursor and the exhibited objects in the virtual space is included in the haptic media unit (MU), which is an information unit for media synchronization (Fig. 5). A haptic MU is generated every millisecond by each client and transmitted to the server.

For collection of operation logs, the positional information in the haptic MU transmitted from the client to the server is used, and the information is accumulated at the server for later analysis. Based on the collected logs, data such as the operation trajectory within the exhibited object and period of stay in every explanation portion are visualized on a 3D graph. Also, based on these data of the visualized 3D graph, explanation portions are added or changed, and the explanation time and contents are modified. For example, explanation portions in which users stay for a long period can be extended to provide more details, or those in which users stay for only a short time can be deleted.

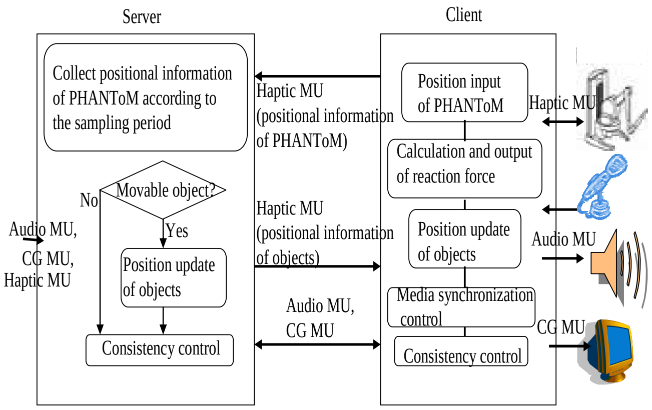

Figure 5: Collection of operation logs.

5. Conclusions

We proposed guidance services in a haptic museum, which is a distributed virtual museum with touchable exhibits. So far, we have implemented two types of guidance service: the on-demand service and guided tour service. We introduced the explanation start ring and the streaming start ring to decrease the response time for the on-demand service. We also discussed the collection of user operation logs related to exhibited objects and reflecting the results in the guidance services.

As the next step in our research, we plan to verify the effectiveness of the guidance services quantitatively by experiment. We will also study the system configuration for a large-scale haptic museum with many touchable exhibits and many visitors.

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