A Remote Interactive Exhibition Method

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Abstract:
This paper presents a remote interactive exhibition method, which provides users with a way to visit remote high-resolution exhibitions of real artefacts. During the visit, users can control exposure, rotation and zooming parameters of a camera to adjust display conditions. Our method avoids complex modelling or scanning tasks and has no limitation on view angles. The method has been applied in the "University Digital Museum - IPv6 upgrade Project" which funded by the MOE (Ministry of Education) of China.

Keywords: *Remote Exhibition, Digital Museum, Interactive Exhibition*

Introduction

Characteristics (e.g. shapes, surface materials) of artefacts contain a great deal of valuable information for archaeology and art research. But real artefacts cannot be imitated or moved easily, which is inconvenient to archaeologists and artists. Therefore, it is useful to set up a remote exhibition for them. How to present artefacts remotely and interactively becomes an important issue. Nowadays, a variety of effective methods can be used to make remote exhibitions.

A 3D model-based method renders the virtual artefacts based on a 3D model, which requires 3D scanning and 3D modelling. The method can be divided into 2 types that are local rendering and remote rendering. Using the local rendering method, we download models from the server, and then render them locally. To reduce the requirements on the computing capability of the local machine, we should usually downsample models to a lower precision, which is inadequate for high precision applications. Using the remote rendering method, our client reports the information to the server; the server renders and then returns the results. In order to provide an efficient service to exhibitions, such a method typically requires powerful rendering servers. Abate et al. (2011) present the whole pipeline from the creation of a high resolution 3D model of an "Acquasantiera" to its remote rendering on the World Wide Web. The project consists of 4 high performance workstations which are very expensive. Koller et al. (2004) introduces a remote rendering system in the Digital Michelangelo Project, which have been installed by 4000 users in several months. The project was accomplished by more than 30 faculty, staff, and students in 2 years since the modelling is so complex. Such methods cannot easily be adopted in most museums due to the high price of hardware and the lack of professional IT staff.

A 2D image-based method is based on a set of images, which are used to make a panorama or

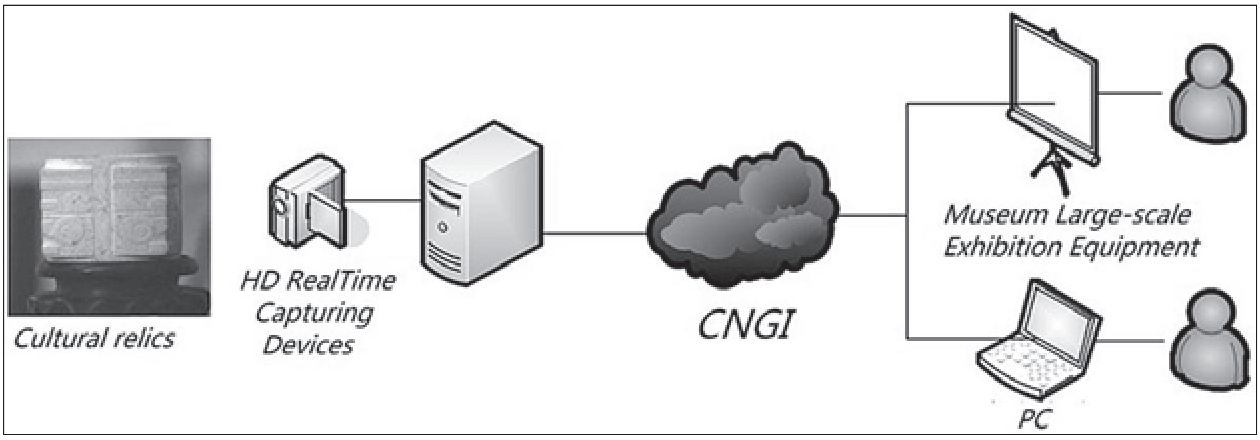

Figure 1. System deployment diagram.

semi-panorama. Soares et al. (2009) develop a 3D virtual museum in an embedded system based on 2D photos. The main disadvantage of these systems is the absence of some real-time characteristics, such as zoom, and viewing objects from any angle. Gabellone et al. (2005) introduce an interactive RealTime3D navigation environment using digital photo modelling and digital photogrammetry. This application can only offer a few fixed viewpoints to users and this limitation significantly affects the user's experience. Since the 2D image-based method avoids scanning and complex modelling, it is less dependent on hardware performances. Unfortunately, the method can only provide a finite number of view angles for displays and causes more distortions than the 3D model based-method.

Compared with the 3D model-based and the 2D image-based method, our method requires no professional pre-exhibition modelling or photographing, which is a welcome advantage for most museums. We capture the artefacts directly with a high-resolution camera, and then transfer and exhibit them on the Internet in real-time. On the other hand, visitors can also adjust the exposure, rotation and zooming parameters online. The geometric distortions in our system are caused by the lens, which can be ignored. In addition, our method allows visitors to experience the artefacts as if they were "watching" them.

In the following sections, we will begin by introducing the entire system architecture of our remote exhibition. Secondly, we present the entire visualization process and the implementation detail for a practical application. Finally, we discuss the future work and some applications based on our method.

System Architecture

By adopting a C/S architecture, our system offers a visualization service for remote artefacts. It exploits high resolution, high speed capturing devices (e.g. GigE industrial camera). The server program continuously captures the real-time frames of artefacts, encodes the image into packets, and then transmits the packets to clients immediately. The deployment diagram of our system is shown in figure 1.

Our system is similar to the one described in Ishida et al. (2008), but is designed for two kinds of users: home PC visitors and remote museums. Home PC visitors can enjoy the exhibition using their own browsers. Due to the limitations (e.g. planar, single channel, etc) of their monitors PC users are advised against visiting the stereoscopic exhibition. Museums usually do not lack large-scale exhibition equipment (e.g. LED screen, projector screen, etc) and therefore they can use both kinds of visualization systems; stereoscopic displays can be presented on a metallic screen; while wide-

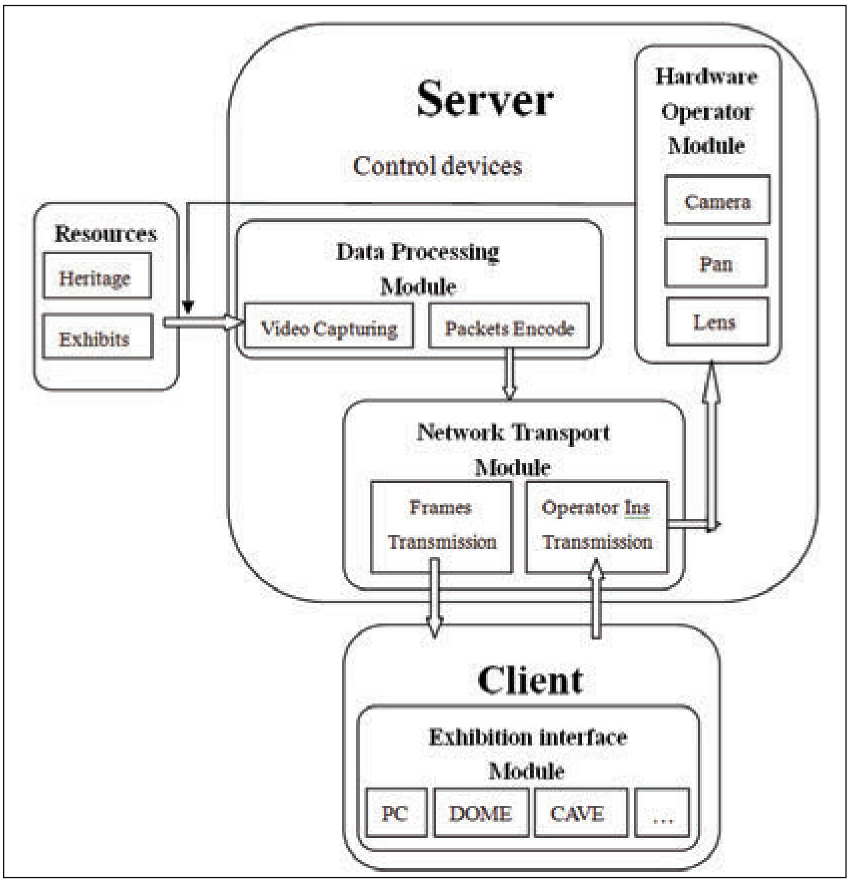

Figure 2. Software module diagram.

angle or fish-eye displays can be presented in an immersive environment (e.g. circular screen, Dome, CAVE).

As figure 2 illustrates, our software can be divided into 4 modules: hardware operator module, data process module, network transport module and display interface module. The first three modules are integrated into a server program, and the exhibition interface module is encapsulated in a client program.

The hardware operator module is responsible for controlling all devices (e.g. capturing device, lighting equipment, rotating platform, etc). These devices are handled indirectly through a digital decoder. The data process module is responsible for real-time image capturing and packets encoding. The network traffic module contains two components respectively in charge of the operator instructions transmission and the packets transmission. The display interface module decodes the real-time receiving packets and display it for users on multiple platforms.

Technical Details

So far, we have constructed a normal remote exhibition site, which was implemented on the website of the University Digital Museum (http://digitalmuseum.zju6.edu.cn).

Hardware configuration

Since the scene of our method is similar to the video and security systems, we adopt the PELCO's default PTZ (Pan Tilt and Zoom lens) solution and choose a controllable camera lens rather than a normal lens. As figure 3 shows, camera, camera lens, exhibit pan, and other hardware are controlled by the digital decoder, which is compatible with both the D and P protocol of PELCO (http://www.secumaster.com.tw/driver/Pelco-P.pdf). The P protocol of PELCO is used in our system. Each instruction is formatted into 8 bytes data without parity. Bytes 3-6 determine different pan and tilt commands which are described in Table 1.

After the decoder receives the operator instruction sent by the computer serial port, the decoder sends the signal to the corresponding device, and the device takes the appropriate action, e.g. message "ROT" means rotating pan. Users can easily control the lens by sending a zoom instruction, as well as control the pan by a rotation or elevation instruction. To further

	Bit number							
	7	6	5	4	3	2	1	0
Data 1	0	Camera On	Auto scan On	Camera on / off	Iris Close	Iris Open	Focus Near	Focus Far
Data 2	0	Zoom Wide	Zoom Tele	Tilt Down	Tilt Up	Pan Left	Pan Right	0(for pan/ tilt)
Data 3	Pan Speed $00 to $3F and $40 for Turbo							
Data 4	Tilt Speed $00 to $3F							

Table 1. PELCO P protocol.

improve the quality of display, it is necessary to permit users to regulate the ambient brightness by controlling the exposure parameters and the luminance of light. We select an incandescent lamp for lighting instead of a fluorescent lamp since the frequency of the fluorescent lamp will cause twinkle. Gigabit network adapters are essential for capturing and forwarding high resolution frame information. On the client side, we use mouse and keyboard to control the operation. White et al. (2007) use the space mouse and a gamepad to handle this work. We will utilize these devices in our system in the next steps.

Data processing

High resolution frame quality depends on the bandwidth and encoding algorithm. By taking the relative static properties of the frames into account, motion estimation is a practical technique that reduces network traffic. Thus, H.264 and other video-coding standards can be applied in frame data compression. To simplify the solution, we compress frames into JPEG format since the JPEG images can reach extreme high compression ratios. 15 fps frame rate is enough for preserving the quality of display. As shown in Table 2, the network traffic of our application is obviously well below the bandwidth.

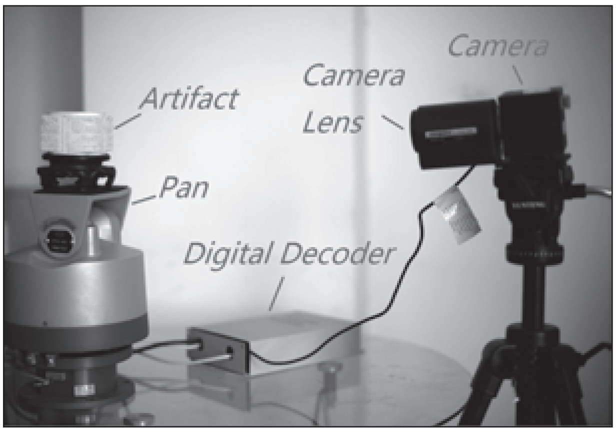

Figure 3. Hardware configuration.

Network transport

The high-resolution exhibition site is developed with the IPv6 protocol on the CNGI (China Next Generation Internet). Due to the network latency, interactive operators cannot respond immediately. In addition, network instability will cause the loss of packets. Therefore, we create buffers to ensure that stream frames can be displayed smoothly, and design exception operations to enhance the robustness of network transport. As shown in figure 4, we store the received frames queue in a frames buffer of a client program, and we store the received instruction queue in an instruction buffer of a server program. Both of the queues are processed according to the FCFS (first come first served) policy. Experience shows that the response delay time of the device's operation is less than 0.6s, which is acceptable for users.

If network exception (e.g. connection timed out) occurs, our system will disconnect the connection between client and server, and suggest refreshing the connection.

Resolution	Average data size/ Frame	Frame rate	Network traffic	IPv6 network bandwidth
1024×768	60KB	15/s	900KB/s	10Mb/s

Table 2. Network traffic analysis.

Demonstrating the application

We adopt the applet technique to the client program since the Java application can be conveniently developed on the webpage with a tag in HTML. Using any terminal machine with JRE installed, users can visit the exhibition page through browsers. Logon our homepage of the digital museum; click "Characteristic Service Interactive Presentation" in order, then users can enjoy the exhibition.

As can be seen in figure 5, a precious artefact named "Jade Cong" is exhibited on our webpage. Visitors can rotate the artefact, enlarged surface detail and take pictures of it. They can also click the "auto rotate" button to rotate the artefact automatically. In addition, we have developed executable client program for professional users, which involves more parameter setting such as exposure and white balance.

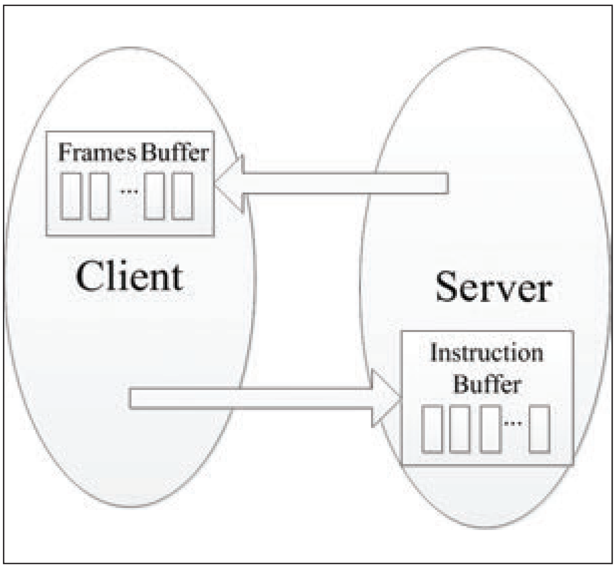

Figure 4. Buffers in system.

Future Work

We have discussed a remote interactive exhibition method and developed a practical application. The application is integrated in the IPv6 webpage of the University Digital Museum funded by the MOE of china.

Figure 5. Artefact exhibition page.

With regard to artefact display, we are now planning to introduce the stereoscopic display technique to our method. Unlike the normal exhibition, stereoscopic frames will be captured by a dual camera set or depth TOF (time of flight) cameras. On the client's side, we will modify our remote exhibition program for PC monitors with a red-blue form and for museum screens we will introduce polarized stereo projection.

For sites exhibitions we are planning to adopt a wide-range display. The wide-range frames will be captured by cameras with short throw lenses. Using the immersive and semi-immersive screen our system will put users in the scene and give them a realistic experience.

The method can also be used for archaeological excavations, which is a so-called destructive process. It is meaningful to record the original appearance of ruins and give a real-time representation for archaeologists all over the world. For example, in some cases the artefacts in tombs will quickly oxidize after we open the tomb, and lose their original colour. It is a good idea to design special equipment similar to gastroscopy to monitor the whole process of archaeological excavation. Using such equipment we can observe how the tomb looked like before destroying it. During the process users can also adjust the view angle and light brightness as described above.

We hope we are able to provide a convenient service for remote exhibitions in most museums. In the future, users can browse the real object real-time on the virtual museum webpage; when they visit a museum they could also enjoy the real-time artefacts in other remote museums. The abundant sharable resources will provide a good way for intercultural communication.

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