Digital Display Case Using Non-contact Head Tracking

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Abstract. In our research, we aim to construct the Digital Display Case system, which enables a museum exhibition using virtual exhibits using computer graphics technology, to convey background information about exhibits effectively. In this paper, we consider more practical use in museum, and constructed the system using head tracking, which doesn't need to load any special devices on users. We use camera and range camera to detect and track user's face, and calculate images on displays to enable users to appreciate virtual exhibits as if they were really in the virtual case.

Keywords: Digital Display Case, Digital Museum, Computer Graphics ,Virtual Reality.

1 Introduction

In our research, we aim to construct the Digital Display Case system, which enables museums to hold an exhibition with virtual exhibits using computer graphics technology, to convey background information about the exhibits effectively[1].

Recently museums are very interested in the introduction of digital technologies into their exhibitions, to tell more about background information about their exhibits. Every exhibit has many background information, for example when or where it was made, what kind of culture it belongs to and so on. However, museums have some problem in conveying these information, because they cannot modify the exhibit itself to preserve them. They conventionally used panel to convey them (Fig. 1), but it is not so effective way to help visitors to connect the exhibit itself and its information on the panel, because they often placed detached. Thus digital exhibition system is needed to tell the background information in a manner more closely to the exhibit, without suffering their exhibits.

Therefore in our research, we aim to construct an interactive exhibition system to tell the background information about exhibits more effectively, which is designed based on the contexts of conventional exhibitions in museums. In this paper, we consider more practical use in museum, and constructed the system using head tracking, which doesn't need to load any special devices on users. We use camera and

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Fig. 1. Conventional Exhibition in Museum

range camera to detect and track user's face, and calculate images on displays to enable users to appreciate virtual exhibits as if they were really in the virtual case.

2 Related Works

2.1 Digital Devices for Museums

Although some digital devices like Information Kiosk or video about exhibits are already introduced into museums, most of them are placed out of the exhibition rooms. This is because curators in museums, who design exhibitions, do not know how to use it effectively, while they know much about conventional exhibition devices. We have to consider this know-how to introduce mixed reality technologies into museums.

The most popular digital system is a theater system, which some museums already introduced. Several studies have been conducted on the gallery talk in the theater[2]. These systems can present the highly realistic images about the theme of the exhibition. However it is difficult to introduce the system into exhibition rooms, and it is a big problem which looses the connection between the contents in the theater and the exhibits in the room.

There are also some researches to use digital technologies at the gallery talk in exhibition rooms. Gallery talk is a conventional way for museums to convey the background information about exhibits to their visitors, which means oral explanation about exhibits by

However, it is difficult to have frequently or individually because of the problem of manpower shortage. Some digital devices are made to solve this problem. Gallery talk robot[3][4] is one solution for the problem, which realize the gallery talk from a remote person. This reduces the geographic restriction of commentators, and makes it easy to do the gallery talk. However it has the problem how the robot moves in the exhibition rooms where people are also walks. We have to consider the robot not to knock against the person nor disturb person's movement.

Mobile devices are also used to convey the information about exhibits. Hiyama et al[5] present this type of museums guiding system. They use mobile device with position tracking using infra-red signals, and show visitors the information based on this position data. This enables museums to have a structural explanation of the entire exhibition room. However, it is difficult to install the devices for positioning into all exhibition rooms, and this is a high threshold for introduction.

In addition, there are some works about digital exhibition devices for museum. Some researches about the exhibition system with HMD have been conducted[6]. However wearable systems like HMD system have a big problem when we introduce them into permanent exhibition, because it is difficult for museums to manage them. On the other hand, there are also some installed devices for museums presented. We can cite Virtual Showcase[7] as an example, which overlays images on the exhibit with half mirror and allows multiple users to observe and interact with augmented contents in the display. It can explain the background information using real exhibit, but at the same time has some constrain in its exhibition because it cannot move the exhibit.

2.2 Display Device of 3D Model Data

There are also some other related works especially about the display device of 3D model data and the interaction with it.

Many studies have been conducted for the 3D display, and today we can easily get the 3D display system with glasses and a display in the shape of conventional one.
Here we focuses on the volumetric displays considering the shape of current display cases of free-standing type. Seelinder[8] is a 3D display with the rotation of cylindrical parallax barrier and light source array of LED. This system allows multiple viewers to see the appropriate images corresponds to there position from any position, but it can show appropriate image only correspond to horizontal motion, and does not support vertical motion. On the other hand, there are some displays[9][10] which can show the appropriate images for vertical motion with the two-axis rotation of mirror. However, they can only display small images in low resolution and low contrast.

On the other hand, there are also some studies about the system consisted of 3D display system and a kind of interaction devices. We can take MEDIA^3 [11] or gCubik[12] as examples. However when we use it in the story-telling in museums, We need more complex interaction than ones they realize.

3 Digital Display Case

In the previous paper[1], we constructed a prototype of Digital Display Case(Fig. 2), which realizes an exhibition using computer graphics(Fig. 3). With this prototype we considered how to tell background information about exhibits, categorized to synchronicity and diachronicity (Fig. 4), and make some exhibition to tell them.

Fig. 2. Prototype of Digital Display Case

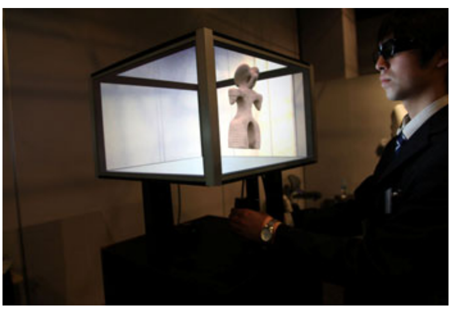

Fig. 3. Exhibition of virtual exhibits

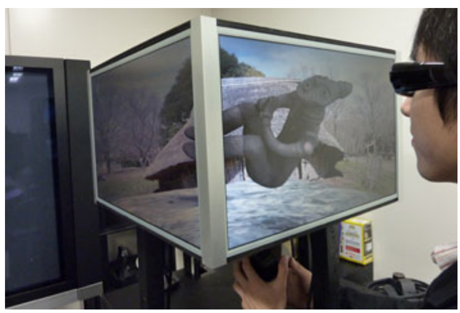

Fig. 4. Exhibition to Convey Diachronicity

That prototype was enough to indicate the effectiveness of Digital Display Case in museums. However, it has relatively law compatibility with conventional display cases, which is not suitable when we place the system in an exhibition room, It has also necessity to load polhemus sensor on a user, which will be the problem when we enable many visitors in museum to experience the system.

Therefore In this paper, we aim to construct the display system of virtual exhibits using CG, which is more compatible with conventional display cases, and which visitors in museum can appreciate virtual exhibits more easily.

3.1 Implementation of the System

We constructed the system shown in Fig. 5. In this system, we use 40 inch 3D televisions as display, and constructed three displays into box shape like conventional display cases. In previous prototype, we use polhemus sensor to measure user's position of view. Then in this system, we use camera and range camera attached, and measure the position of view without loading any special devices on users.

This system composed of two subsystems, one for detect and track user's head and the other for render the images on the display. Fig. 6 shows the dataflow of the whole system.

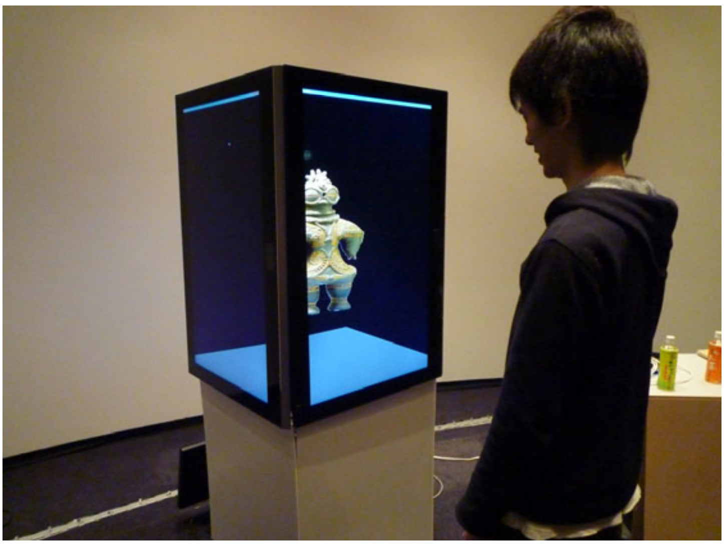

Fig. 5. Digital Display Case more compatible with conventional display cases

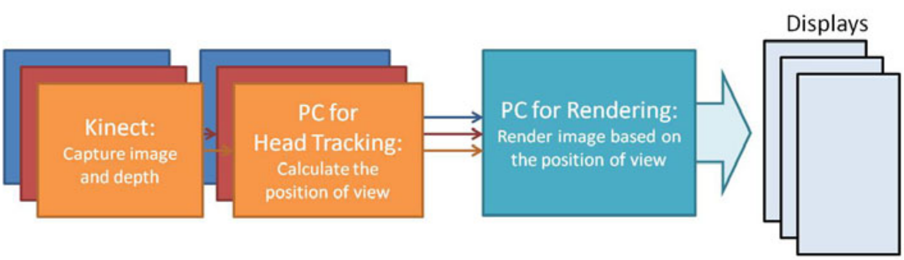

Fig. 6. Dataflow of the system

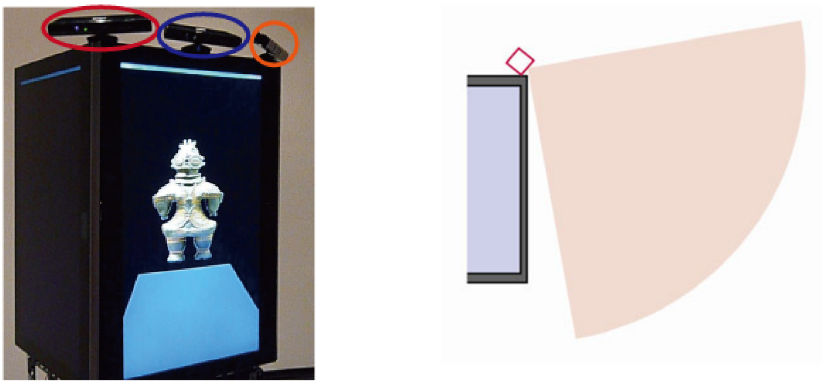

Fig. 7. Kinects placed at the top

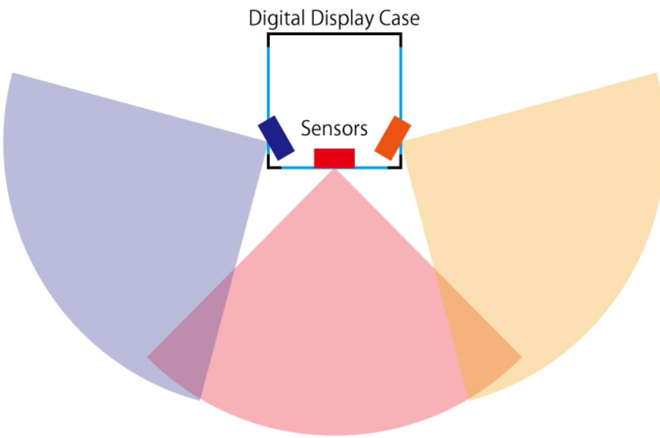

Fig. 8. Capture image and depth around the system

3.2 Motion Parallax with Non-contact Tracking of User's Head

For tracking user's head, we use Kinect [13], which has camera and range camera as sensor. We place three Kinects at the top of the system (Fig. 7), and capture image and measure depth around the system (Fig. 8). We measure the position of view based on these data.

Fig. 9 shows how to measure user's position of view. First, we use depth image to detect user around the system, and extract the area of user from captured image. From this area, we detect a user's face and calculate its position in the image. Then we get an average of depth around the position and calculate the position of view.

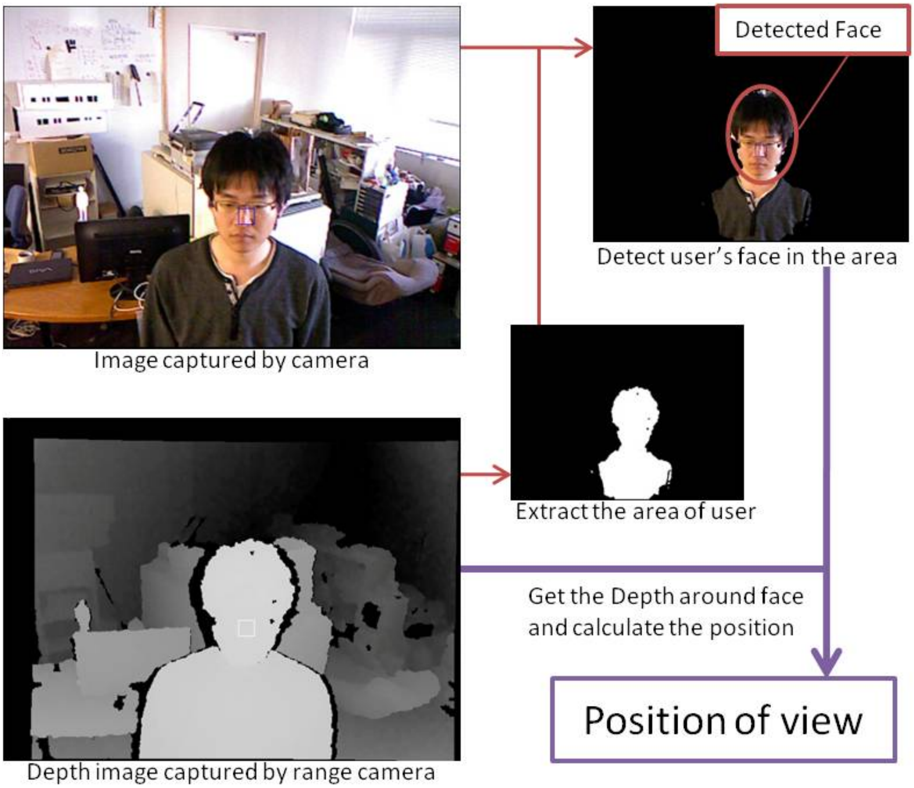

Fig. 9. Dataflow to get the position of view

Then the system gathers the data from three Kinects and select the user most near to the system. To avoid the confusion when two or more person are in the same distance, we set priority on the one most near to the position detected in the precious detection.

3.3 Discussion

Fig. 10 shows how the system works. It shows that the head tracking process works effectively, and realizes a motion parallax about the virtual display case in the system, without any sensors on a user. This is more suitable for museum exhibition, because visitors can appreciate virtual exhibits in the same way we appreciate real exhibits, without putting any sensor on them.

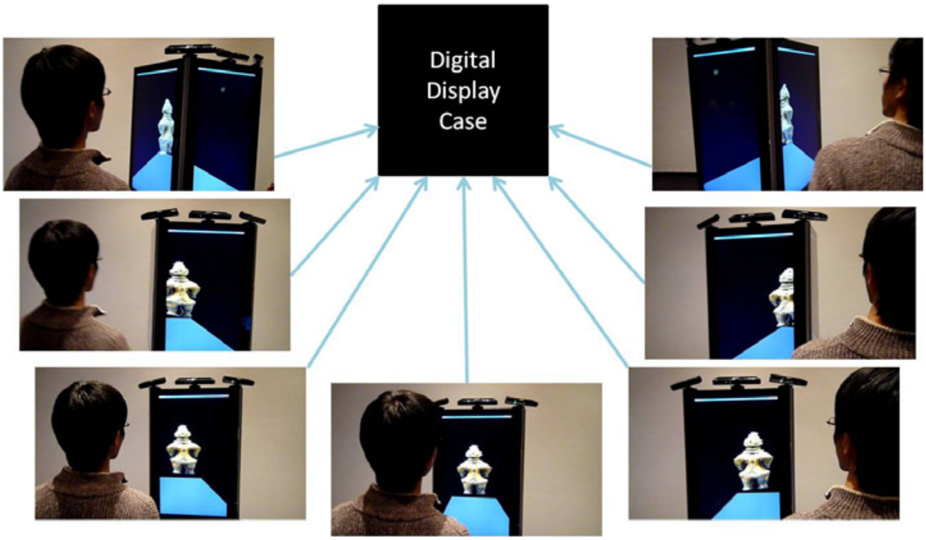

Fig. 10. Motion parallax without any sensor on a user

This system measures the position of view in 15 fps and enable users to move almost 180 degree around the system and appreciate the virtual exhibit in it. It also can select the appropriate user when some users are detected, and he can keep his appreciation.

The speed of the head tracking is enough when user go around the system. However, when user moves so fast, the big gap between frames reduces the smoothness of motion parallax. Failure in the detection also reduces this smoothness. So we have to improve the speed of processing in head tracking and complement the movement between frames in detection. To do this, we have a plan to introduce the object tracking using computer vision, and use hybrid algorithm composed of detection and tracking, to realize more effective head tracking processing.

Although this system can track user's head in enough range to enable him to move around and appreciate the virtual exhibit, he cannot appreciate the virtual exhibits from very near or under, because there face goes out of the range Kinects can capture. To avoid this, we have to consider more about the number or placement of Kinects base on user's behavior in his appreciation.

Selection of the appropriate user usually works well even if some faces or users are captured. However, the system is confused when many people stand in the same distance from the system. To solve this problem, we have to use more intelligent user detection using depth data captured by range camera. We are also planning to introduce some system to indicate who has the priority in the appreciation, for example spot light on the user, to avoid users from confusing on the position of the priority in head tracking.

4 Conclusion

In this paper, we constructed the Digital Display Case system to realize museum exhibition using virtual exhibits using computer graphics, designed more compatible with conventional display cases. We constructed vertically long system composed of large display. We also constructed head tracking system using Kinect, and realizes the appreciation of virtual exhibits from any point around the system, without loading any special devices or sensors on users, which we can use more easily than previous prototype.

As our future work, we have to improve the process of head tracking as described in the chapter 3.3 to realize more natural motion parallax. In addition to this, we are now planning to introduce some interaction to our system using the detection of users' gesture using Kinect, which we now use only for the measurement of their position of view.

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