Archives and Exhibits of Buddhist Ceremonial Processions for Museum
Asako Soga*1, Masahito Shibata1, Yusuke Niwa*1, and Yoshihiro Okada*1

Abstract — We have been archiving Buddhist ceremonial processions called Nerikuyo. Nerikuyo has special features in its objects and actions. It is difficult to display these features using traditional panels in a museum. Our purpose is to create videos and interactive content that vividly portray this ceremony. We have archived two Nerikuyo ceremonies with super-high-detail videos and then created video contents for a special exhibition on Nerikuyo. We have also proposed a virtual fitting system that recognizes gestures of users and then displays the corresponding images and sounds over the captured images of the users. All of the gestures are related to the poses or motions of Nerikuyo, and they are assigned to masks and tools. The created videos were shown at a special exhibition of the Ryukoku Museum, and the proposed system was demonstrated for three days as one of the events related to the special exhibition.

Keywords: digital archive, museum, interactive system, 4K, Nerikuyo

1 Introduction

Many cultural properties have been archived with digital technologies, and they are being effectively used in museums. For example, 3D scanning techniques and successive model reconstruction have been applied to obtain a virtual model cataloging system at the Doccia Museum [1]. In addition, systems have been developed to visualize digital content in order to support exhibits, and some of these can be interactively manipulated by visitors. The Natural History Museum in London [2] uses augmented reality to take visitors on a virtual journey back through their evolutionary past, and interactive stereoscopic content has been used in Nagoya City Science Museum [3]. Recently, many museums have prepared space to support visitors in understanding their certain exhibits.

Our research group has been archiving performances of Buddhist ceremonial processions called Nerikuyo. In this ceremony, many actors make a procession and act out the story with masks and costumes. Nerikuyo has special features in its objects and actions, and it is difficult to display these features using ordinary museum panels. The purpose of this research is to support exhibits at museums. We have archived two Nerikuyo ceremonies with super-high-detail videos of 4K resolution and then created video contents. In addition, we have developed a virtual hands-on exhibit system for Nerikuyo that helps visitors to understand the actions and paraphernalia of the ceremonies. This paper describes the process of archiving Nerikuyo and creating super-high-detail videos, and then describes the system for virtual fitting and the resulting exhibits at a museum.

2 Archiving and Exhibiting Nerikuyo

Nerikuyo is one of the Buddhist ceremonies depicting the life of Chujo-hime, who produced a Mandala-style hanging scroll. Nerikuyo ceremonies have been performed in Japanese temples since the Heian period (794-1185). Many actors make a procession and act out the story with masks and costumes to represent the life story of Chujo-hime. Stories in novels and comics are often represented by real actors these days. Similarly, stories in picture scrolls seem to have been represented by real actors with masks and statues in the past.

Nerikuyo has the following special features.

- Large area performance of outdoor
- Traditional human motions in ceremonies
- Masks and statues worn by actors

At first, Nerikuyo is held in a large area. A special stage with an actual bridge is built for the cer-
emory, and many actors act on this stage. In some ceremonies, stairs and public roads are also used along the path. In addition, the motions of actors in the processions are important. Just as in many other religious ceremonies, there are special motions in Nerikuyo. It is difficult to display these features using traditional panels in a museum. For effectively representing the large area and traditional human motions, it is necessary to record the procession as videos from multiple positions.

Another feature is that Nerikuyo uses many objects such as masks and statues. There are many actors who play roles such as Bodhisattvas and monks, and they act using various objects. In some ceremonies, the actor wears the statue of Buddha. Moreover, some of the masks and statues used in Nerikuyo are important cultural properties, and so touching them cannot be allowed. Although they can be displayed in show cases in museums, visitors cannot see their inner structures.

For effectively representing these features, we created super-high-detail videos of 4K and an interactive system that vividly display the ceremony. The video represents procedure and motions that are difficult to describe using ordinary museum panels. The interactive system enables the user to virtually try on the masks and objects used in Nerikuyo. Although some museums use big screens to show movies [4], 4K contents are not yet widely used. On the other hand, there has been some research on using computer graphics to archive intangible cultural properties such as dances and traditional festivals [5], most of these approaches are not applicable to actual exhibits at museums. Our approach is to support visitors to understand the exhibits of museums, and we use certain actions and motions as the input method of our proposed system.

One of our contributions is to archive two Nerikuyo ceremonies with super-high-detail videos of 4K resolution. We recorded the Nerikuyo ceremony of Kobo-ji temple in Okayama prefecture and Taimadera temple in Nara prefecture with 4K-resolution cameras and created 4K-resolution videos. There are some difficulties to record Nerikuyo. The camera positions are often constrained by the actors and visitors as well as the landscape, and it is difficult to record many times since the event is not held often. In addition, the recorded videos may include unfocused frames since it is difficult to focus on all actors of the moving procession. We refocused frames of the video of Nerikuyo by using a system that applies image filters to frames of a video using multiple PCs. These videos were shown at a special exhibition of Nerikuyo at the Ryukoku Museum [6].

Furthermore, we have developed a virtual hands-on exhibit system for Nerikuyo that helps visitors to understand the actions and paraphernalia of this ceremony using a Kinect device. Since it is easy to capture human body motion with a Kinect device, many studies have developed adopting it in natural user interfaces. Although applications using Kinect devices are recently used for rehabilitation [7] as well as entertainment, our purpose is to support exhibits at museums with Kinect devices. This system detects poses and motions of Nerikuyo with a Kinect device and displays a video of the user with the images of Nerikuyo-themed objects superimposed on him or her in real time. The system enables the user to virtually try on the masks and objects used in Nerikuyo without touching a real one. The poses and motions used in this system are related to those of Nerikuyo. The system provides an interactive experience and helps visitors to easily understand the actions of the ceremony. The proposed system was demonstrated at an event related to the special exhibition.

3 Making 4K Videos

3.1 Archiving Nerikuyo at Kobo-ji

We recorded the Nerikuyo of Kobo-ji in Okayama prefecture on May 5, 2013. In this ceremony, two main buildings, called Henmyo-in and Toju-in, have the roles of start or goal positions. These roles are interchanged every year. This year, the procession started from Henmyo-in and ended at Toju-in. The path is about 300 meters long, and it takes about one hour for all actors to finish walking in procession. Stairs, a special stage with a bridge, and the slope of a public road are used along the path.

At the midway point, there is a small building called Shaba-do, and here the portrait of Chujo-hime is passed to the Bodhisattvas while special actions are performed by two Bodhisattvas. At the goal point, an actor who wears the statue of the principal Buddha, i.e. the standing Amida, is waiting for the procession. Figure 1 shows an actor wearing the standing Amida. He bows with two helpers to
the actors in the procession.

For capturing videos, two cameras with 4K resolution (3,840 x 2,160 pixels) were used. The route and the camera positions are illustrated in Figure 2. In order to record many video images with two cameras, we prepared a capture schedule and moved the camera position according to the position of the procession. The sound was recorded with a 5.1-channel microphone, and the recording engineer moved with the procession. In addition, we captured photos of the Bodhisattvas' family and videos of the scene showing the actor wearing the standing Amida.

### 3.2 Archiving Nerikuyo at Taima-dera

We recorded the Nerikuyo of Taima-dera in Nara prefecture on May 14, 2013. In this ceremony, the procession starts from Hondo with the portrait of Chuo-hime being passed to the Bodhisattvas at Kodo, and then the entire party returns to Hondo. A long straight bridge of 120 meters is built from Hondo to Kodo. The procession lasts about one hour on the bridge. When the procession returns to Hondo, the sun is going down. The two main Bodhisattvas with masks act their roles dynamically on the bridge.

Figure 3 shows the actions of the Bodhisattvas.

For recording the procession, two 4K-resolution cameras and a microphone were used just as at Kobo-ji. The route and the camera positions are illustrated in Figure 4. The event had many visitors and the area was crowded, so we set the cameras on the second floor of a building between Hondo and Kodo. Each camera was controlled from a remote place. A microphone was fixed on Hondo.

#### 3.3 Creation of 4K-resolution Videos

We created 12 minutes of 4K-resolution videos of Nerikuyo at Kobo-ji and Taima-dera with narration and pictures of Mandalas. In some cases, the video needs to be treated with filters, which correct color or brightness, for inclusion as contents in digital archives. The video of Taima-dera included some unfocused or blurred scenes, since the procession was long and we could not set up the cameras effectively from the remote place. We refocused images of unfocused or blurred frames of the video. The size of these images is large, and it takes about 12 seconds to process one image. For example, it takes about 2.5 days to process a 10-minute video.

We developed a system that applies image filters to frames of a video, since correcting 4K resolution video need much processing power. We used the environment shown in Figure 5 to process two or more images at the same time. Some PCs were con-
and the workers repeat steps 2 through 4 to process images. Each worker works independently, and the PCs that the workers use can have different processing power. Even if the processing power of some PCs is comparatively low, the performance of the entire system is not degraded.

The workers run an image filter that inputs an image and outputs a refocused image. The image filter is “Refocus,” which works on GIMP as a plug-in. This plug-in refocuses images using a technique called FIR Wiener filtering. Each worker has GIMP running without the user interface and gives a script that instructs the GIMP instance to refocus the image. Each GIMP instance reads the source file, refocuses it, and writes the results to the destination file without any user interaction. Figure 7 shows an example of refocusing: (a) is an original image and (b) is the refocused image of (a).

If a system is implemented using libraries for parallel computing, such as MPI, it can refocus images efficiently. However, this would involve considerable costs and be difficult to use for normal users. Our system drives an existing application, so it is friendly to normal users. The users can easily try various parameter sets of their filters before the parallel pro-
cessing. In addition, the system can be used to apply filters other than refocusing.

4 Virtual Fitting System

4.1 System Overview
We have created a virtual fitting system which supports visitors in understanding the traditional methods of Nerikuyo by using augmented reality and interactive techniques at museums [8]. This system detects the specific poses and motions of Nerikuyo and interactively displays Nerikuyo-themed objects such as the masks and statues. For example, when a user makes a pose of putting a backpack on his or her shoulders, the system recognizes this as wearing the standing Amida as shown in Figure 1 and displays the image of the standing Amida over the user’s real image. In another case, when a user traces the Bodhisattva’s action seen at Taimadera as shown in Figure 3, the system displays the image of the portrait of Chujo-hime. This system is helpful to users in understanding the traditional actions as well as the way to wear statues.

Figure 8 illustrates the structure of the system. This system consists of a PC, a Kinect device, a display, and a speaker. By using the Kinect device, the system captures the skeletal frame of up to two users and then recognizes their poses or motions. After that, the system displays the corresponding images and sounds over the captured images of the users.

4.2 Gesture Recognition
The system obtains joint positions from the skeleton tracking of Kinect at 30 frames per second, and then it recognizes gestures by using the joint positions of head, hands, right elbow, and pelvis in each frame.

By using the local positions of two joints, the system distinguishes the actor’s poses by calculating the distance and relations of the joints. For example, the arrangements of hands, right elbow, and pelvis are used to recognize a person holding a stick as shown in Figure 9(a). If the right hand is higher than the right elbow and the left hand is lower than the pelvis, the system recognizes this as holding the stick with the right hand. Figure 9(b) shows another example of a pose, where the user wears the standing Amida on his or her shoulders. If the distance between the hand and the shoulder is close enough, the system recognizes this as wearing the standing Amida.

By recognizing some poses in a predefined order, the system can be extended to motion recognition. Figure 10 shows three poses of the Bodhisattva’s action seen at Taimadera. In this case, the hands and head positions are used to recognize motions. If the distance between the two hands and the heights of them are under a threshold, and the center positions of both hands are located at (a) right-upper area around the head, (b) in front of the bust, and (c) left-upper area around the head, the gesture is rec-
4.3 Virtual Fitting

The system selects an image and displays over the user’s real image according to the recognition results. Figure 11 shows results of the virtual fitting.

In the case of the masks, one of them is always displayed. The corresponding image will be shown at the center of the head position if the head position is correctly captured. The corresponding image can be freely changed with a keyboard according to the age bracket or interest of the visitor. For example, if the system recognizes the pose of holding a stick, the mask is changed to the monk, and a stick is displayed from the right hand to the floor. Figure 11(a) shows a result of the monk mask with the stick.

Figure 11(b) shows a result of the Bodhisattva mask with the portrait of Chujo-hime. When the Bodhisattvas’s action seen at Taima-dera is recognized, the image of the portrait of Chujo-hime is displayed between the hands, and this image remains displayed as long as the distance between the hands is under a particular threshold.

Figure 11(c) shows a result of the standing Amida. In this case, the image of the standing Amida is layered over the user’s real image. The position of the image is based on the center of the shoulders, and the image has transparency in order to express the size of the standing Amida. In addition, two virtual Bodhisattvas are also displayed at the side of the image of the standing Amida. This method is helpful for users to understand how to wear the statue and to appreciate its size.

In some cases, the corresponding sound is outputted. The sound is not outputted if the user continues to maintain the same pose. After this recognition is disrupted but then the system again recognizes the pose, the sound is once again outputted.

5 Exhibition at Museum

The created 4K-resolution videos were shown at a special exhibition of the Ryukoku Museum, “Art and Ceremony of the Pure Land Buddhism.” During the special exhibition, from September 7 to October 20, 2013, the videos of the Nerikuyo ceremonies were shown on a 200-inch screen using a 4K projector in the museum’s theater. One screen contains approximately 8.85 megapixels (4,096 x 2,160 pixels). Each video was scheduled to be shown four times a day.

The virtual fitting system was demonstrated at the Ryukoku Museum for three days as one of the events related to the special exhibition. Figure 12 shows the floor plan of the demonstration. Two PCs, a Kinect device, a projector, and a printer were used for the demonstration. A background poster of the descent of the 25 Bodhisattvas was prepared to guide...
the standing position for the visitors. Panels to explain the poses and motions of Nerikuyo were put on the wall. The Kinect device and the projector were connected to one of the PCs to execute the system. The result of the virtual fitting was displayed on the screen by the projector. In addition, the result of the virtual fitting was saved as an image every 10 seconds. The PCs were connected via a network, and the saved images were sent to the other PC for printing. The images were printed out as a postcard, which were given to each visitor as a gift. Figure 13 is a photo of the demonstration at the museum. In all, 128 visitors tried the system during the three days.

6 Evaluation

In the demonstration of the virtual fitting system, we asked the 128 visitors about the usefulness of the system for understanding Nerikuyo. Among these visitors, 70% were over 40 years old and 67% were female. After a brief instruction session, each visitor group tried the system’s interaction for about 8 minutes and then answered a questionnaire. The evaluation items were (1) the variety and size of masks, (2) the size and structure of the standing Amida, (3) the way of wearing the standing Amida, (4) the instructions for action, (5) the actions of the Bodhisattvas, and (6) the overall system. Each subject was evaluated on four levels: “4: understandable,” “3: somewhat understandable,” “2: less understandable,” and “1: not understandable.”

The results are presented in Figure 14, where (a) shows the answers of 105 visitors who had already seen the museum exhibits and (b) shows the answers of 20 visitors who had not seen the museum exhibits. The remaining three visitors did not respond.

Table 1 shows the average rating for each item. Although the ratings are on a statistically ordinal scale, we regarded them as being on an interval scale and calculated their averages according to the conventional social scientific method. All items were marked between 3 and 4. Therefore, the results indicate that users understood the specific features of Nerikuyo by using the system. In particular, the results of items (4) and (5) were better than that of item (6) for the overall system. These items are related to the actions of the ceremony, and thus we verified that the system allows visitors to understand the actions that are difficult to describe using ordinary museum panels. In focusing on the relationship between museum exhibits and the system, the rating of “4: understandable” of visitors who had already seen the museum exhibits was higher than that of visitors who had not seen them.

We verified the difference between (a) and (b) by a chi-squared test at 5% significance level. The significance was examined for (3) but not for the other items. Because there was an exhibit of the actual statue of the standing Amida at the museum, visitors who had already seen the exhibit could easily understand the demonstration. On the other hand,
visitors who had not seen the statue seemed to have difficulty in imagining how to wear the statue, which naturally is not commonly known. The virtual fitting system was more effective in combination with the museum exhibits because it was designed to support exhibits in the museum.

From the feedback, we received many favorable comments about the system: how to move the arms was easy to understand, it was more understandable than the original museum panels because of the actual experience, and it was expected to provide new media at museums for any age group, from children to seniors. We also received the some comments on desired improvements: the fitting result should be shown as not only the front view but also the side view, the fitting with videos as well as images would make the results more interesting, and giving weight to the standing Amida would make it more realistic.

Consequently, by actually performing poses and motions with the system and comparing the visitor’s body with objects in the virtual space, users could intuitively understand the size of the objects and the actions. Since it is impossible to wear the actual statue of the standing Amida, this system can supplement the weak points of the original exhibits in the museum. Furthermore, tracing the Bodhisattvas’s motions provides interactive exhibits, and thus the proposed system can help visitors to understand the traditional actions.

7 Conclusion

This paper has described a process for archiving Buddhist ceremonial processions called Nerikuyo in high resolution video as well as a system for virtual fitting of masks and objects to users. We recorded Nerikuyo with 4K-resolution cameras and created videos to represent the actions of Nerikuyo. We also created the virtual fitting system to help visitors to understand the objects used in Nerikuyo. These videos and this system support exhibitions on Nerikuyo held at museums.

In future work, we will archive the 3D shapes of the masks and statues used for Nerikuyo and extend the virtual fitting system to 3D content. We also plan to create content that effectively uses timing and spacing information.

References


(2014年3月17日受付)

著者紹介

曾我麻佐子
（正会員）
名古屋大学大学院人間情報学研究科博士後期課程修了。2007年龍谷大学理工学部助手。2011年より同大学講師。主として人体アニメーションに関する研究に従事。博士（学術）。

芝公仁
2002年立命館大学大学院理工学研究科博士課程後期課程修了。同年龍谷大学理工学部助手。2007年同大学助教。主としてシステムソフトウェアに関する研究に従事。博士（工学）。

丹羽勇介
2014年龍谷大学理工学部卒業。在学中、インタラクティブ技術を用いた博物館展示支援に関する研究に従事。

岡田至弘
1977年立命館大学理工学部卒。京都大学工学博士。1988年龍谷大学理工学研究科を経て現在、龍谷大学理工学部教授。2001年より古典籍デジタルアーカイブ研究センターにおいて、大規模デジタルアーカイブ管理・運用方式の研究に従事。専門はパターン情報処理・画像理解。

— 412 —