Augmented Reality Tour System for Immersive Experience of Cultural Heritage

Kangsoo Kim* Byung-Kuk Seo† Jae-Hyek Han‡ Jong-Il Park§

Department of Electronics and Computer Engineering
Hanyang University, Seoul, Korea

Abstract

Cultural heritage sites, such as traditional palaces, have a wide range of services to help tourists understand them easily and to provide more attractive experience. However, these services are not easy to provide intuitive information about cultural relics to tourists because they typically use guide books or audio equipments. In this paper, we propose an augmented reality system for tourists' immersive experience at cultural heritage sites. The proposed augmented reality tour system provides an opportunity for tourists to have more realistic experience by showing virtual characters, which reproduce the past life at heritage sites. Its usefulness and effectiveness are verified by applying to a tour system at Sajeongjeon and Gangnyeongjeon of Gyeongbokgung, which is the representative of the cultural heritages in Korea.

CR Categories: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systmes—Artificial, augmented, and virtual realities I.4.8 [Image Processing and Computer Vision]: Scene Analysis—Tracking; I.4.9 [Image Processing and Computer Vision]: Applications

Keywords: augmented reality, virtual tours, cultural heritage tour system

1 Introduction

Cultural heritage sites have been encouraging tourists to have more interests and historical information through many different types of services, such as local guides or reproduction events. For example, Gyeongbokgung which is one of the representative traditional palaces in Korea offers not only a variety of historical information through international language guide books or portable audio guide devices, but also an opportunity to experience the past life through reproduction events such as the ceremony of opening and closing the palace gate or the ceremony of gate guard change. However, most of tour guide services are difficult to provide realistic and immersive experience to tourists because they typically use guide books or audio guide equipments that explain and describe historical information.

Augmented reality (AR) has been applied to a variety of tour systems for enhancing user experience at cultural heritage sites. ARCHEOGUIDE reconstructed a 3D virtual Greek temple on ruins at Olympia [Vlahakis et al. 2002]. [Papagiannakis et al. 2005] restored 3D virtual characters by showing them to tourists via HMD and enabled to provide information intuitively. [Zoellner et al. 2008] proposed the system which augments additional information about cultural heritages by tracking frescos or pictures. These systems induced interests of tourists and enabled attractive experience. In this paper, we propose an AR tour system, which can provide realistic and immersive experience about the cultural relics. The proposed system helps understanding of tourists and improves their experience by overlying 3D virtual characters, which reproduce the past life, on the cultural heritage site. The usefulness and effectiveness of the AR tour system is verified through demonstrations at Gangnyeongjeon and Sajeongjeon in Gyeongbokgung.

2 System Implementation

In order to augment 3D virtual objects on the real world, camera pose (position and orientation) against the target scene is required. In general, the camera pose can be obtained by measuring from position and rotation sensors or estimating from feature points extracted from images. The proposed system uses visual information of a target scene without any additional devices such as sensors and obtains the camera pose by tracking a rectangular structure where its corners are more robust features. Here, we assume that the target scene has rectangular structures.

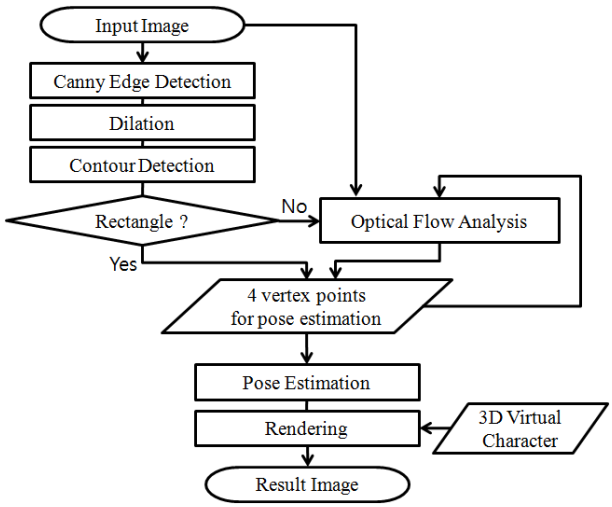

Figure 1: *Workflow.*

The workflow of our tracking method is shown in Figure 1. First, an edge image of a target scene is obtained by using the Canny edge operator. As a post-processing, we make the edges linked lines without discontinuity because our method uses the contour information of the target scene to detect rectangular structures and thus, the edges should be mostly linked to find contours reliably. Next, contours of the target scene are found, and a possible rectangle, which is used to estimate a camera pose, is determined with some constraints: convexity, four corners, and the area of the rectangles. If the rectangle detection is failed, the four corners on the current image can be approximated from the previous ones if the camera motion is not fast. Thus, we find the correspondences of the

*e-mail: vistavision@mr.hanyang.ac.kr
†e-mail: nwseoweb@mr.hanyang.ac.kr
‡e-mail: turbostar@mr.hanyang.ac.kr
§e-mail: jipark@hanyang.ac.kr

VRCAI 2009, Yokohama, Japan, December 14 – 15, 2009.
© 2009 ACM 978-1-60558-912-1/09/0012 $10.00

pre-obtained corners from the previous image by using the optical flow analysis [Bouguet 2000]. Assuming that these obtained four corners are coplanar, planar-based pose estimation methods can be used. In this paper, we use the robust planar pose estimation method to estimate the camera pose [Schweighofer and Pinz 2006]. Finally, 3D virtual objects are rendered on the image of the target scene in real time according to the camera pose.

3 Experimental Results

The proposed AR tour system consisted of a laptop (LG X-NOTE C1, Intel Core2 1.20GHz, RAM 2.00GB) and a USB camera (MS LifeCam NX-6000, resolution 640 by 480, 15fps) and was tested at Gangnyeongjeon and Sajeongjeon in Gyeongbokgung. As shown in Table 1, there were not sufficient robust features inside Gangnyeongjeon and Sajeongjeon because of their illumination condition and complicated patterns. These made detecting edges and tracking objects difficult, and thus model-based tracking method was also not easy to be applied. Nevertheless, the door of the room inside Gangnyeongjeon could be used as a target object for proposed rectangle tracking algorithm because its edge was relatively distinctive, and its position and shape were not changeable. In the case of Sajeongjeon, its door could not be used because it was generally not in the camera view. Instead of the door, rectangular painting, which is hanging above king's chair, was utilized to the proposed system because it had relatively clear and distinctive corners.

Table 1: *Object tracking environment.*

Location	Object tracking environment
Gangnyeongjeon	(Interior) [-]Complicated background [-]Changeable objects' location and shape [-]Lack of robust features (Exterior) [+]Entrance of room: rectangle, distinctive and unchangeable
Sajeongjeon	(Interior) [-]Complicated background [-]Changeable objects' location and shape [-]Lack of robust features [+]Painting: rectangle, distinctive and unchangeable (Exterior) [-]Entrance of building: invariant location and shape, out of view

Figure 2 shows the result of our tracking algorithm at Gangnyeongjeon and Sajeongjeon. Rectangular structures could be found easily in both cases. The camera pose was accurately estimated from the detected four corners, and 3D virtual characters that reproduce king's life of the past were rendered on each site as shown in Figure 3. In this paper, the proposed system achieved AR using the rectangle tracking algorithm even if the environment was not suitable for extracting robust features, or additional sensors were not allowed to be used. This system was, therefore, able to provide more intuitive and immersive experience at cultural heritages.

4 Conclusion

In this paper, AR tour system was proposed to offer realistic and immersive experience to tourists at cultural heritage sites. The proposed system used visual information of the target scene, i.e. rectangular structures, without any sensors and estimated the camera pose. We demonstrated the proposed system at Gangnyeongjeon and Sajeongjeon of Gyeongbokgung to verify its usefulness and effectiveness. Currently, we are preparing for trial services using our AR tour system and trying to apply this method to mobile phone-based AR system to support more personalized tours.

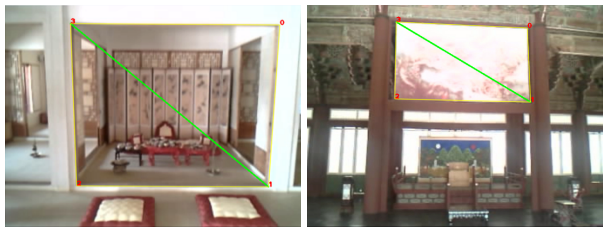

Figure 2: *Results of the rectangle tracking algorithm. (left) Gangnyeongjeon, (right) Sajeongjeon.*

Figure 3: *3D virtual character rendered in the target scenes. (left) Gangnyeongjeon, (right) Sajeongjeon.*

Acknowledgements

This research was supported by Ministry of Culture, Sports and Tourism (MCST) and Korea Creative Content Agency (KOCCA) in the Culture Technology (CT) Research & Development Program 2009.

References

BOUGUET, J.-Y., 2000. Pyramidal implementation of the Lucas Kanade feature tracker description of the algorithm. OpenCV Documentation.

PAPAGIANNAKIS, G., SCHERTENLEIB, S., O'KENNEDY, B., AREVALO-POIZAT, M., MAGNENAT-THALMANN, N., STODDART, A., AND THALMANN, D. 2005. Mixing virtual and real scenes in the site of ancient Pompeii. *Computer Animation and Virtual Worlds 16*, 1, 11–24.

SCHWEIGHOFER, G., AND PINZ, A. 2006. Robust pose estimation from a planar target. *IEEE Transaction on Pattern Analysis and Machine Intelligence 28*, 12, 2024–2030.

VLAHAKIS, V., IOANNIDIS, N., KARIGIANNIS, J., TSOTROS, M., GOUNARIS, M., STRICKER, D., GLEUE, T., DAEHNE, P., AND ALMEIDA, L. 2002. Archeoguide: An augmented reality guide for archaeological sites. *IEEE Computer Graphics and Applications 22*, 5, 52–60.

ZOELLNER, M., PAGANI, A., PASTARMOV, Y., WUEST, H., AND STRICKER, D. 2008. Reality filtering: A visual time machine in augmented reality. In *Proceedings of International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST)*.