Authoring System Using Panoramas of Real World

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Abstract. A panorama is a wide-angle view of a real world. Panoramas provide users real world information as the component of map services. Recently researchers try to augment additional information on panoramas to extend the usefulness of panoramas. However, the existing researches and applications provide users inconsistent experience by augmenting information on a single panorama. To solve this inconsistency, we present an authoring system helping users create contents on panoramas. Users create contents by augmenting virtual information on panoramas using the authoring system that propagates virtual information augmented on one panorama to neighboring panoramas. The resulting contents provide users consistent viewing experiences. Users can experience the contents on their desktop or they can view the contents on a smartphone display at the locations near to the locations panoramas were captured.

Keywords: Panoramas, Authoring, Augmenting, Consistent Experience.

1 Introduction

A panorama is a wide-angle view of a real world (Fig. 1). Panoramas have been used as the component of a map service such as Google Street View [1] and Microsoft Bing Maps Streetside [2] from the end of 2000 (Fig. 2). Panoramas provide users 360 degree views of a real world so users can understand the real environment of locations selected on a map. The coverage of panoramas extends to the world, even for off-roads and inside stores. Recently researchers try to augment additional information on panoramas to extend the usefulness of these panoramas. The Streetside photos of Microsoft [3] augments photos from Flicker on the Streetside view (Fig. 3). The photos are viewed as the part of the Streetdise view and provide users new experience. However, the existing researches and applications only augment additional information on a single panorama. The additional information is not presented on neighboring panoramas. This problem causes inconsistency in users' viewing experiences.

In this paper, we present an authoring system helping users create consistent contents on panoramas and share them with other users. Users create contents by augmenting virtual information on panoramas using the authoring system that propagates virtual information augmented on one panorama to neighboring panoramas. The resulting contents provide users consistent viewing experiences. Users can experience the contents on their desktop or they can view the contents on a smartphone display at the locations near to the locations panoramas were captured.

R. Shumaker (Ed.): VAMR/HCII 2013, Part I, LNCS 8021, pp. 65–72, 2013.

Fig. 1. The panorama of the old palace, Kyongbok Gung, in Korea

Fig. 2. Map services with panoramas (Left) Google Street View [1] (Right) Microsoft Bing Maps Streetside [2]

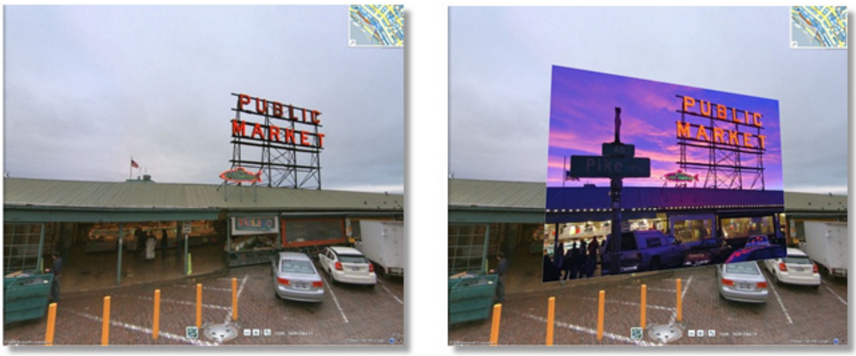

Fig. 3. Microsoft Streetside photos [3] (Left) Streetside view (Right) Streetside view with an augmented photo

2 Proposed System

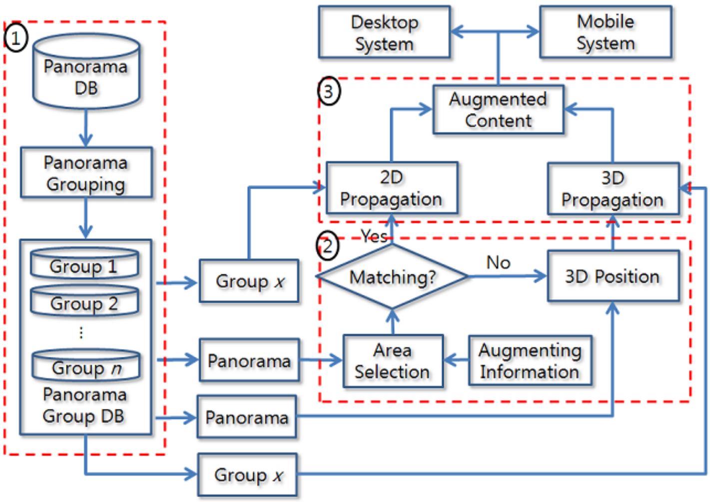

Fig. 4. System overview (1) a grouping procedure (2) an area selection procedure (3) a propagation procedure

2.1 System Overview

The proposed system is divided into three procedures, a grouping procedure, an area selection procedure and a propagation procedure (Fig. 4). Panoramas are captured at indoor or outdoor environments and stored in a database (DB) then categorized into groups. A user selects panoramas and areas on the panoramas to augment additional information such as an image, a text, and a 3D object using the proposed system. The proposed system augments the additional information on the selected areas of the selected panoramas then propagates that information to other panoramas captured at locations near to the captured locations of the selected panoramas. Using this propagation procedure, the proposed system can help a user to create contents that provide consistent viewing experiences to users.

2.2 Grouping Procedure

After panoramas are stored in a DB, the grouping procedure groups panoramas in the DB into several groups and creates a panorama group DB. A user selects a key panorama from the DB. Panoramas in the DB captured at close locations to the key panorama's location are grouped together and called a position-group. Panoramas in the position-group share scenes with the key panorama are grouped and called a sharing-group (Fig. 5). The matching algorithm SURF [4] is used to compare panoramas in the position-group with a key panorama. The performance of matching between panoramas is lower than the performance of matching between perspective images because of the deformation on panoramas. Panoramas are transformed into four perspective images before applying the matching algorithm. These position-groups and sharing-groups are input to the area selection and the propagation procedures. The grouping procedure runs once so it does not cause any delay to the authoring systems.

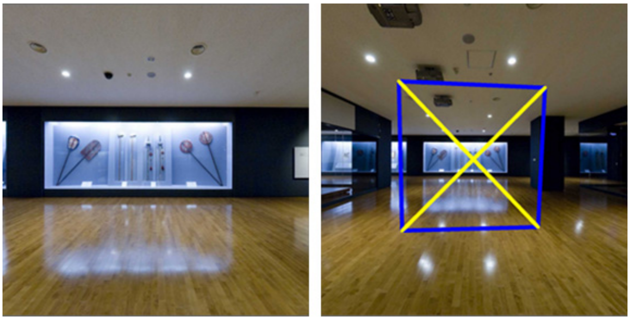

Fig. 5. Creating a sharing-group (Left) one of four perspective images of the key panorama (Right) one of four perspective images of the matched panorama with the rectangle indicating the view of the left image

2.3 Area Selection Procedure

A user selects an area on a panorama (called PA) to augment virtual information in the area selection procedure. The user selects the target area by browsing the panorama PA with the panorama viewing system, which displays the perspective view of the panorama. If the panorama PA is found in the sharing-groups, the target area is called 2D augmenting area and the area selection procedure is ended. If the panorama PA is found in the position-groups only, the procedure asks the user to select the same target area on another panorama (called PB). The 3D positions of the target area are computed by finding intersections of two pair of lines.

Panoramas were captured with their positions and orientations. The azimuths and altitudes of panoramas are used to align all panoramas to the predefined direction using the equation 1. The 3D positions are computed using two angles (A_{pc}, a_{pc}) and locations of two panoramas. The area defined by the estimated 3D positions is called a 3D augmenting area (indicated as two circles in the top and the middle images in Fig. 6).

$$\begin{cases} A_p + I_h \dfrac{360}{h} = A_{pc} \\ a_p + \dfrac{180}{v}\left(I_v - \dfrac{v}{2}\right) = a_{pc} \end{cases} \quad (1)$$

h and v indicate the size of a panorama in pixels along the horizontal and vertical direction respectively, (I_h, I_v) indicates the location of a target pixel, A_p and a_p are azimuth and altitude of the camera, and A_{pc} and a_{pc} are compensated azimuth and altitude of the target pixel.

Fig. 6. An image augmented on a 3D target area (Top) a panorama PA and one perspective view of PA with two selected points (blue circles) (Middle) a panorama PB and one perspective view of PB with two selected points (blue circles) (Bottom) The 3D target area (a red rectangle) on another panorama and one perspective view showing an augmented content

2.4 Propagation Procedure

Augmenting areas and corresponding contents are propagated to other panoramas in the group DB using the propagation procedure. It is divided into 2D propagation and 3D propagation procedures. In the 2D propagation procedure, 2D augmented area is searched on panoramas in the sharing-group using the matching algorithm. If the corresponding area is found, the content is augmented on the detected area. In the 3D propagation procedure, the image location of the 3D augmenting area is estimated using the azimuth, altitude and the position of each panorama and positions of the 3D augmenting area. The azimuth and altitude of the panorama is used to align the panorama to the same predefined direction.

2.5 Viewing Contents

The augmented contents on panoramas can be viewed on the desktop environment and the mobile environment. In the desktop environment, a user will browser each panorama one by one and the user can view the content on consecutive panorama not like the exiting system providing a user a single view of the augmented content. One example view is shown in Fig. 6. In the mobile environment, a user views the augmented content on the real camera view of the mobile phone (Fig. 7). The content is augmented based on the position and the azimuth and the altitude of the mobile phone and the positions of 3D augmenting area.

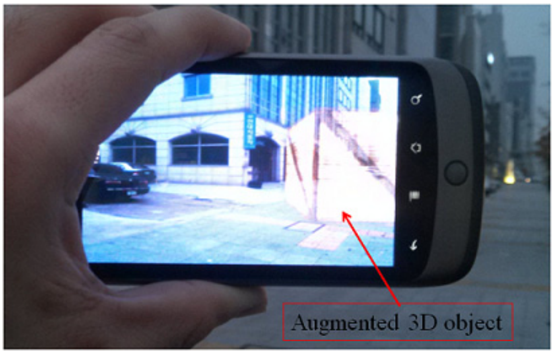

Fig. 7. Viewing an augmented 3D object on a mobile phone

3 Experiments

We applied the proposed system in three locations, one indoor and outdoor locations. First the proposed system was used to propagate a target area to panorama in the sharing group. Since the matching between images did not work well for images captured at outdoor environment, we used panoramas captured at the museum to text the 2D propagation procedure. The distances between two consecutive panoramas captured at the museum were about three meters. A user selected a part of an image as the target area, which was used to augment a virtual object. The user also selected the first target panorama and confirmed the correct augmentation on the selected panorama. The augmentation result on the selected panorama is shown in Fig. 8. If the augmentation was not correct, the user could modify the location of the augmented object using a mouse. Using the 2D propagation procedure, the 2D augmenting areas on other panoramas were detected and the virtual object was augmented on the 2D augmenting areas (Fig. 9). This result demonstrated that the proposed system could easily propagate augmented contents to other panoramas using the 2D propagation procedure of the proposed system.

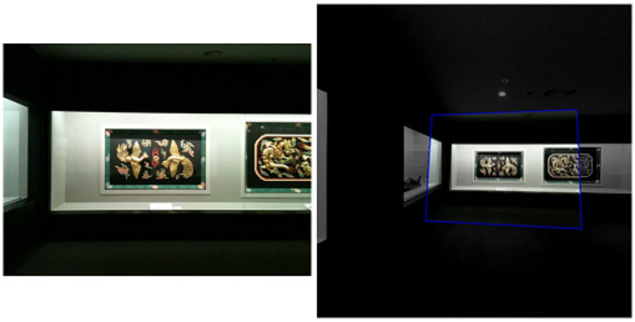

Fig. 8. An experiment at the museum (Left) a target area (Right) augmenting a quadrilateral on the 2D augmenting area found on the target panorama

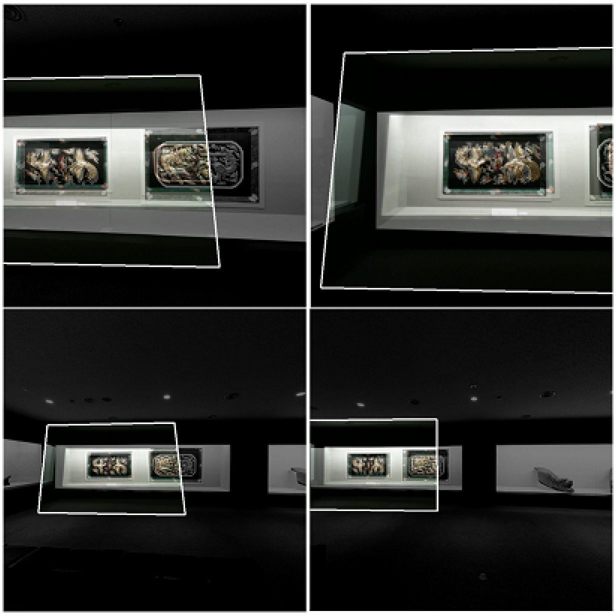

Fig. 9. The results of 2D propagation with white quadrilateral, which are augmented virtual information

The proposed system was applied to panoramas captured at open space in an old palace. The distances between two consecutive panoramas captured at the old palace were about five meters and the result is shown in Fig. 6. A user selected the same target area on two panoramas and augmented the virtual object on the target areas (Fig. 6). The augmented object was propagated to other panoramas using the 3D propagation procedure of the proposed system (Fig. 6). One example view on a mobile device is shown in Fig. 7. This experiment demonstrated the proposed system could be used to augment virtual objects on panoramas easily and so provide the user consecutive viewing experience.

4 Conclusion

The proposed system was tested with panoramas captured in indoor and outdoor environments. The 2D propagation was used to augment contents on panoramas captured inside the museum because the matching between panoramas was quite successful. Since the matching between panoramas captured in the outdoor environment was poor, the 3D propagation was used to augment contents on panoramas captured at an old palace. The augmented content was viewed on a PC and a smartphone with GPS and the rotation sensor for outdoor experiment.

The proposed system helped users create useful contents on panoramas and provided consistent viewing experience. The proposed system also had few limitations. The first limitation is the accuracy of GPS. GPS was used to estimate positions of panoramas that are used to estimate positions of 3D augmenting areas. Because of the poor estimation of the positions of 3D augmenting area, the augmented results are sometimes not realistic. We need to overcome this limitation using other information on the images since the accuracy of GPS is not going to improve soon. Another limitation is the accuracy of the matching algorithm. Currently the matching algorithm is not applicable for outdoor environment and some indoor environment. If the accuracy of the matching algorithm is improved, we can use the matching algorithm more frequently in the proposed system to crate contents.

Acknowledgements. This work (Grants No. C0016661) was supported by Business for Academic-industrial Cooperative establishments funded Korea Small and Medium Business Administration in 2012. This work was also supported by the Industrial Strategic technology development program, 10041772, (The Development of an Adaptive Mixed-Reality Space based on Interactive Architecture) funded by the Ministry of Knowledge Economy (MKE, Korea).

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