Augmented Reality Guide System Using Mobile Projectors in Large Indoor Environment

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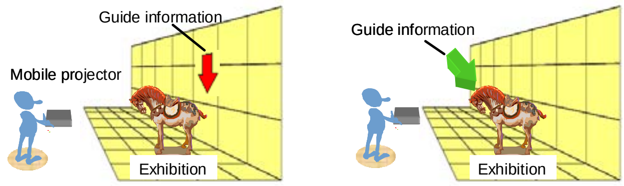
ABSTRACT

This pager proposes a projection-based Augmented Reality (AR) guide system which guides users with mobile projectors in large indoor environment. The projection-based AR guide system projects guidance of exhibits onto walls or floors in the real world. In order to realize this system in a wide area, it is necessary to measure a position and an orientation of the projector precisely. In the proposed guide system, the projector's position is estimated from images capturing invisible markers which are set up on ceilings with an infrared camera attached to the projector. In addition, to indicate the guide information intuitively for users, the proposed system also displays information at 3D position by a stereoscopic view using two mobile projectors and polarized glasses.

1. INTRODUCTION

By using an augmented reality (AR) technique [1, 2] which can overlay information over the user's view and a wearable computer [3] which user can use always, location-based information can be intuitively provided to user at any place anytime. Such system is called wearable AR system and has applied for user navigation or guide system of sightseeing [4, 5].

In the wearable AR system, head mounted display (HMD) [6, 7] or head-up display (HUD) are usually used for a display device of augmented information. The AR system with HMD or HUD can provide the user with personal information which is suited for each user. However, the users cannot communicate smoothly each other because it is difficult to do eye contact, and the users cannot share information. AR guide systems with a hand-held display such as PDA have been also proposed already[8, 9]. These systems using the device are not suitable for situation in which some users would like to share same information since users cannot see the small display at same time. Especially in case of sightseeing, users often desire to share information about sightseeing location.



(a) projection onto a wall(2D) (b) 3D pointing

Figure 1: Guide information on projection plane and in 3-D space.

On the other hand, a projection-based AR system which projects information onto wall or floor can usually provide some users with information at same time [13, 10]. In this system, since information is generally projected onto plane such as wall etc. by a projector installed at fixed position[14], location where information is displayed is limited. By using mobile projector which has been downsized and improved drastically, user can get information anyplace anytime. However, in order to realize AR guide system, which needs to register between the real and virtual worlds, with mobile projector in large indoor environment, a position and an orientation of the mobile projector should be acquired continuously in real time. In this paper, a localization method [11] which estimates position and orientation of user's viewpoint by using an infrared camera attached to user and an invisible marker installed on the ceiling is used. By accurately estimating the position and orientation of a mobile projector with the localization method, proposed system can project information onto wall or floor anyplace.

When a projector is used as a display device, the system can generally provide user with only 2D information because the information is projected onto a plane as shown in Fig. 1(a). To provide user with 3D information which indicates 3D point in the real world as shown in Fig. 1(b), images for left and right eye must be given to user. Especially a mobile projector whose position and orientation can be change in real time, it is difficult to show user 3D information with a stereoscopic view. In this study, we develop AR system with but only one mobile projector not also two mobile projectors for giving stereoscopic view to user.

2. AR GUIDE SYSTEM USING MOBILE PROJECTOR

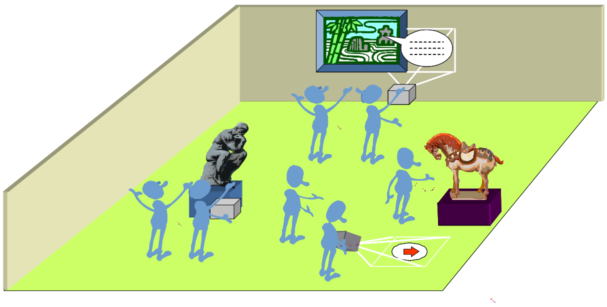


Figure 2: Environment for the usage of guide system.

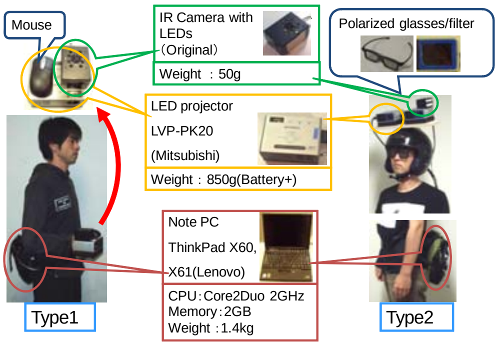


Figure 3: Hardware configuration of AR guide systems.

In this study, we assume that AR guide system is used in a place where there are some exhibits in a room such as a museum as shown in Fig. 2. One of members has a mobile projector and the projector shows all members guide information by projecting the information onto a wall or a floor. All members can share the guide information by looking the image projected onto a wall or floor.

2.1 Hardware Configuration

Fig. 3 shows appearance and hardware configuration of two types of AR guide system. These systems equip an infrared camera with infrared LED to estimate a position and an orientation of the projector in real time. By analyzing invisible markers observed by the IR camera, 3D position and orientation of camera can be estimated. The invisible markers are printed on wallpaper and the wallpaper is installed on the ceiling as shown in Fig. 4. The invisible marker consists of a retro-reflective material which reflects light back to its source with minimum scattering of light and its color is similar to color of the wallpaper. User cannot see markers because the color of marker is same as color of the wallpaper. However, IR camera can observe the markers by receiving reflection of IR light emitted from IR LED attached to the camera.

In type 1 system which provides user with 2D information on the plane, a user equips a wearable PC and holds a mobile projector by a hand as shown in Fig. 3. Buttons are attached on the projector so as to select a menu by the user. Type 2 system can give user 3D information by stereoscopic view with two mobile projectors mounted on the user head.

(a)Invisible marker (without flash) | (b) Invisible marker (with flash)

Figure 4: Invisible marker wallpaper on a ceiling.

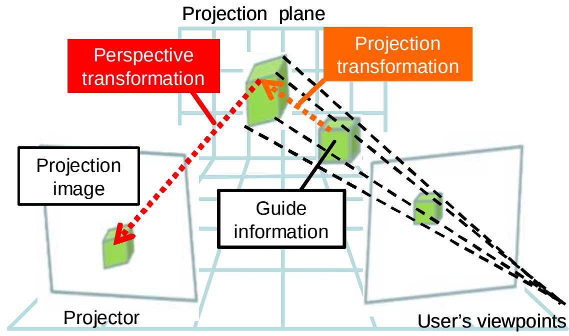


Figure 5: Geometric transformation of stereoscopic images.

In ideal case, user should hold two small projectors by hand also in type 2 system. However, in order to give precise 3D information by stereoscopic view, it is necessary to acquire position of not only the projector and also user's viewpoint. In this study, to simplify hardware configuration, 3D geometric relationship between user's viewpoint and projectors is constant by attaching the projectors to user's head. In addition, to separate right and left images, user takes a polarized glasses and a polarized filter is attached to each projector. A silver screen which keeps reflection of light polarized should be also used.

2.2 Projection Image Generation

In type 1 system, a projection image is generated with a position and an orientation of a mobile projector and 3D shape of real scene. The projected image which can be seen correctly without distortion on the real wall (projection plane) is transformed by using a geometric relationship between the wall and the mobile projector. In type 2 system, in order to correctly look 3D information with stereoscopic view in 3D space, the projected image should be generated for each eye as shown in Fig. 5.

In type 2 system, only user which has projectors can see 3D information at correctly 3D position. Other members of group see distorted 3D image or information at wrong position because of displacement of their viewpoints. In this study, we investigate relationship between a position error of 3D information and distance of viewpoints. By considering the results, the guidance contents of an AR system can be made without effects of position error of 3D information.

Fig. 6 illustrates relationship among users' viewpoints, pro-

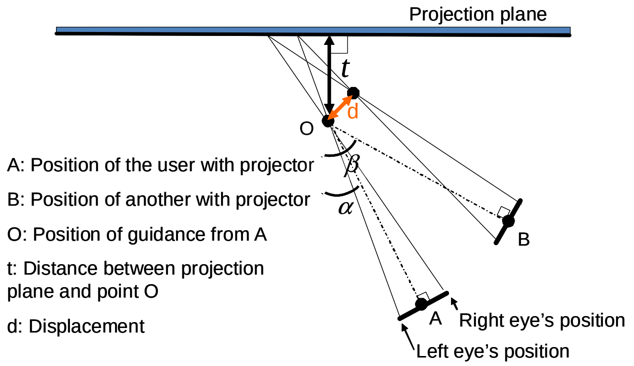


Figure 6: Environment for the usage of presentation function of stereoscopic information(Type2).

jection plane and an exhibit from top view. Note that a position of guidance of exhibit is O. A and B are positions of user with and -out projectors, respectively. Distance between projection plane and exhibit is t, and error distance between correct position and projected position is d. Angles α and β mean angles to position A and B, respectively. Here, we assume that a distance between the user's viewpoint and information position O is 1 m and a baseline of user's eyes is 6.5 cm.

Fig. 7 shows position error of projected guidance when $t = 0.2\ m$, $\alpha = 0, 15$, and $30°$, and angle $<$AOB is changing. We can find error when $\alpha = 0$ is smaller than errors when $\alpha = 15$ and 30. If an allowed error sets $0.05m$, an angle $<$AOB should be 15 ° or less. If an allowed error sets $0.1m$, an angle $<$AOB should be 35 ° or less. Fig. 8 shows position error d of projected guidance when $\alpha = 0$, $\beta = 30$ and a distance t is changing. If an allowed error d sets $0.1m$, a distance should be 0.25 m or less. If an allowed error d sets $0.2m$, a distance should be 0.26 m or less. As the results, the error d becomes small when distance between the position of the guidance and the projection plane is small.

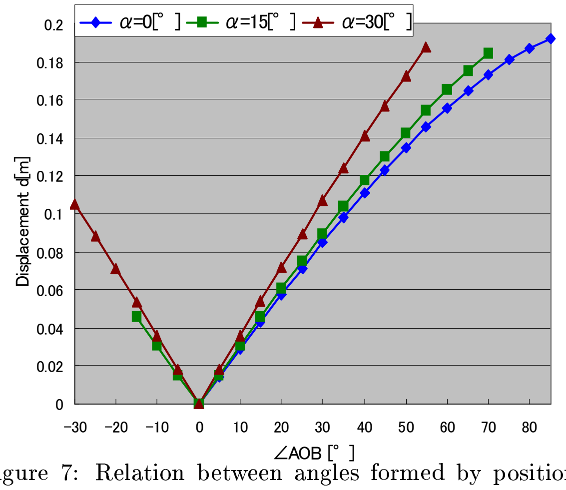


Figure 7: Relation between angles formed by positions A and positions B for O and displacement of stereoscopic information.

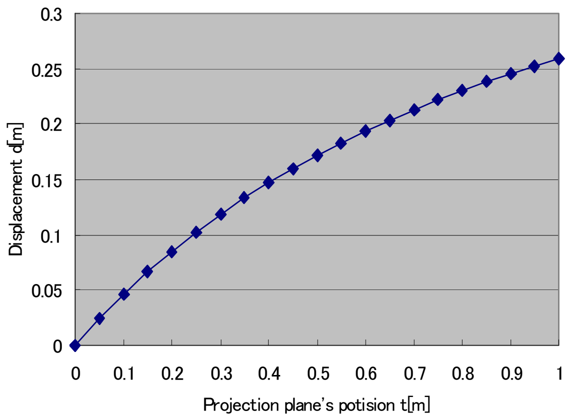


Figure 8: Relation between position of a projection plane and displacement of stereoscopic information.

3. EXPERIMENTS

We developed a prototype of AR navigation system as shown in Fig. 3 and carried out an experiment in indoor environment. We assume that the system guides user in place where there are some exhibits such as a museum. In order to estimate the position and orientation of mobile projectors in real time, invisible markers are installed on a ceiling of the environment as shown in Fig. 4

Figs. 9 and 10 show appearances of guidance with type 1 system. Since guidance information can be projected onto the correct position, user can intuitively recognize information of the real exhibits. We can confirm that the information is projected at appropriate position even if mobile project is moving.

Fig. 11 illustrates projection image and the result of user's view with type 2 system. The user could see stereoscopic view with polarized glasses by seeing images for each eye, which are projected two mobile projectors. User can recognize information pointing at 3D position intuitively with stereoscopic view.

4. CONCLUSION

This pager has proposed a projection-based AR guide system which guides users using mobile projectors in large indoor environment. The proposed system can provide not only 2D information but also 3D information for user by realizing stereoscopic view with two mobile projectors. In experiments, we developed a prototype AR guide system and we could confirm that user see 3D information by using the system. In future work, we should construct the system which can provide user with stereoscopic view by using handheld projectors.

5. REFERENCES

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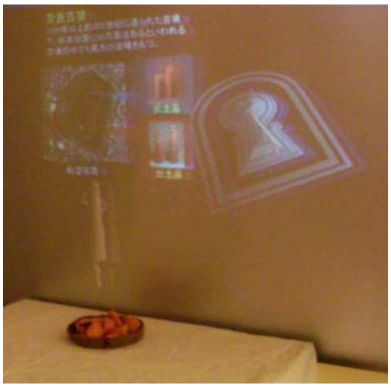
(a) Projected image for left eye



(b) View from right eye

(c) View from left eye

Figure 11: Presentation of stereoscopic information for exhibit.

(a)

(b)

Figure 9: Appearance of guidance for exhibition.

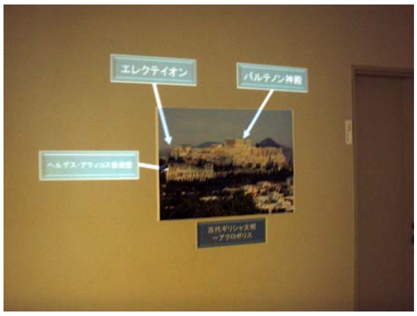


Figure 10: Appearance of presentation of guidance.

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