# Representation of Three-dimensional Information Using Portable Augmented Reality Projection System

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***Abstract*— Recently, though a lot of information is generated in various fields, it is difficult for the users to access necessary information easily. In this study, a portable AR projection system that projects the information directly on the object using the portable projector based on the location information and the AR marker was developed. Particularly, this system can represent the three-dimensional information based on the effect of motion parallax when the user moves the portable projector along with his or her view position. This paper discusses the system construction of the prototype system, accuracy of the location information, three-dimensional representation of the projected image, and the application to the conference room information system.**

***Keywords*— portable projector, augmented reality, motion parallax, three-dimensional information, AR Toolkit**

## I. Introduction

In recent years, a lot of information has been generated and accumulated in various fields according to the development of the information society. However, it is generally difficult for the users to access the necessary information quickly when and where they need it, because they must use the information terminals such as the PCs and the smart phones to retrieve it. For example, in order to confirm the reservation status of the conference room, we must access the reservation system using the information terminal even when we are in the conference room. Or in order to know the arrival time of the train on which we are boarding, we must access the information of the timetable through the Internet from the moving train. These inconveniences are caused by the problem that the information is managed separately from the objects in the real world. Therefore, the establishment of information access method in which the user can retrieve the necessary information easily from the object when and where it is required is an important research topic in the current information communication society.

In order to solve such a problem, this study aims at developing the information access interface technology in which the necessary information can be retrieved directly from the object by using the portable projector. Particularly, the portable AR (augmented reality) projection system that can superimpose the three-dimensional information on the real object by utilizing the effect of motion parallax was developed [1]. Figure 1 shows the concept of the information access interface that is proposed in this study. In this method, the user can retrieve the necessary information directly from the real object. In this paper, we discuss the system architecture of the constructed portable AR projection system, the ability of the information representation of the proposed system, and several applications.

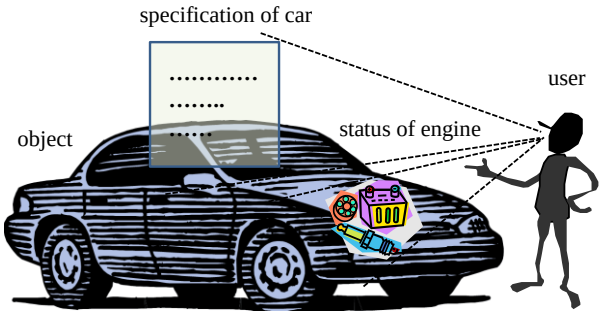


Fig. 1 Concept of proposed information access interface in which the necessary information is displayed directly on the object.

## II. Concept of Portable AR Projection System

The purpose of this study is developing an information access mechanism in which the object itself presents the necessary information directly so that the users can easily obtain the information when and where they need it. Moreover, it is required that the AR based information projection technology that can present the three-dimensional information on the scene of the real object is constructed. In order to realize this mechanism, the implementation of not only the three-dimensional display function but also the pointing and position measurement functions that indicate the object of interest is necessary. Therefore, in this study, the portable AR projection system that utilizes the portable projector was developed.

Figure 2 shows the prototype of the portable AR projection system that was constructed in this study. As a portable projector, ADTEC AD-MP15A is used. In addition, Logicool QCAM-200V USB camera and the holding grip are attached to the portable projector, and it is connected to the note PC. Wi-Fi position sensing service PlaceEngine is installed in the note PC, and the position can be measured based on the strength of the radio field in the wireless LAN environment [2]. Moreover, in this system, AR Toolkit is used to measure the position and posture of the portable projection system [3]. When the portable projector is faced to the AR Toolkit marker that is attached on the object, the marker image is captured by the USB camera and the position and the posture are detected based the image processing. In this system, the portable projector can effectively be used for the pointing function by using the projection light as well as for the display function.

Figure 3 shows the system construction of the information access interface that uses the portable AR projection system. When the location of the user and the object of interest are detected by using PlaceEngine and AR Toolkit marker respectively, the necessary data is retrieved from the database using the location and the object ID as data retrieval keys and it is projected onto the object by using the portable projector. In this case, the three-dimensional information can also be represented based on the effect of motion parallax by projecting the image seen from the user's view direction that is detected by AR Toolkit marker.

Fig. 2 Prototype of portable AR projection system that consists of portable projector, USB camera and note PC.

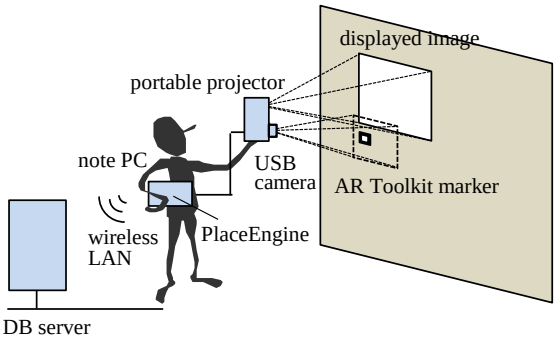


Fig. 3 Construction of information access interface that uses the portable AR projection system.

## III. Related works

In recent years, the portable projector has been used in various research fields. For example, it was used as a new interface device in MIT Media Lab's SixthSense Project [4], and it was used as an entertainment device in Twinkle of Keio University [5]. In Osaka University, it was used as hip mounted display by putting it on the user's body [6]. Moreover, the portable projector was applied to the information display in the museum by attaching the location sensor to it in Nara Institute of Science and Technology [7]. As AR application that projects the computer graphics image onto the real object, Shader Lams of MIT and Free Form Projection Display of Gifu University have been developed [8][9].

On the other hand, the feature of this study is realizing the AR based three-dimensional representation interface by utilizing the effect of motion parallax that is caused by the movement of the hand held projector.

## IV. Accuracy of location information

In this system, the location information measured by PlaceEngine is used to retrieve the necessary information. Therefore, in this study, the experiment on evaluating the accuracy of location information measured by PlaceEngine was conducted. In PlaceEngine, the users register the location data at various positions beforehand, and these data are used as standard positions to detect the location based on the strength of the radio field in the wireless LAN environment.

In this experiment, the building (Collaboration Complex Build.) in the university campus was used. After registering the location information at five points along the corridor in front of the conference rooms ten times, the locations at the same five points were measured ten times. Figure 4 shows the registered points displayed on the Google maps. In the result of this experiment, the average value and the standard deviation of the gap between the registered position and the measured position were 12.6m and 8.6m, respectively. Though the accuracy of the position measured by PlaceEngine depends on the stability of the wireless access point, we can understand that this system can be used effectively to identify the room where the user exists.

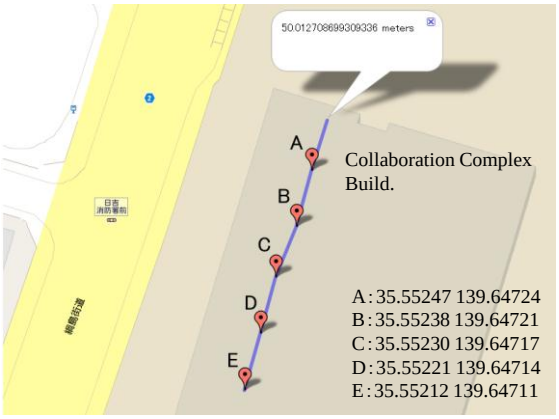


Fig. 4 Registerd and measurement points along the corridor in the building of the university.

## V. 3D Representation Using Portable Projector

In this system, though the projected image itself is a two-dimensional monaural image, it can be expected that the user can perceive the three-dimensional representation based on the effect of motion parallax that is caused by the movement of the portable projector. In order to measure the representation ability of the three-dimensional image, the psychophysical experiment was conducted.

In the experiment, the image of 5cm cube that was placed on the wall screen was projected onto it as shown in Figure 5. The subjects were asked to stand 1m away from the wall and to answer the three-dimensional sensation and distance sensation that were felt from the projected image using the magnitude estimation method. In this case, the subjects were allowed to move freely keeping the distance of 1m from the wall, and then they can look at the projected image from various directions. In addition, the same experiment was conducted by using the video see-through AR system to compare the results. In this method, the computer graphics cube image was superimposed on the video image that was captured by the USB camera and the superimposed image was displayed on the note PC.

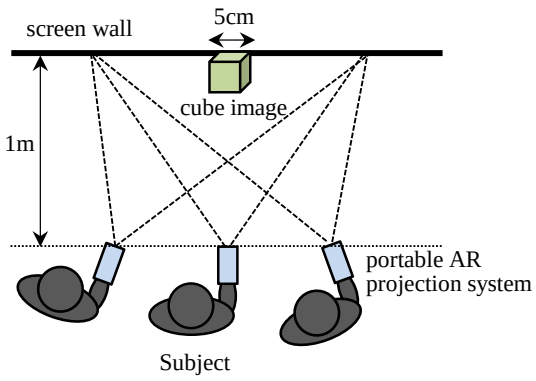


Fig. 5 Condition of experiment where computer graphics image of cube is projected onto the wall.

As for the three-dimensional sensation, the subjects were asked to evaluate the number of sensation felt from the displayed image, by assuming the standard stimulus of evaluation 1 for two-dimensional square plane and 10 for three-dimensional cube object. And as for the distance sensation, the subjects were asked to evaluate the number of sensation, assuming the standard stimulus of evaluation 10 for the distance to the screen wall. Figure 6 shows the experimental result for 11 subjects.

From the result, the average values of the three-dimensional sensation for the portable projection AR and the video see-through AR were 6.0 and 5.9 respectively, and there was no significant difference between them. However, the average values of the distance sensation for the portable projection AR and the video see-through AR were 9.6 and 3.7 respectively, and t-test reported the significant difference at 1% significant level. Namely, it was shown that the subjects felt nearly three-dimensional sensation and almost accurate distance sensation from the displayed image when the portable projection AR was used, though they felt the displayed image at shorter distance when the see-through AR was used.

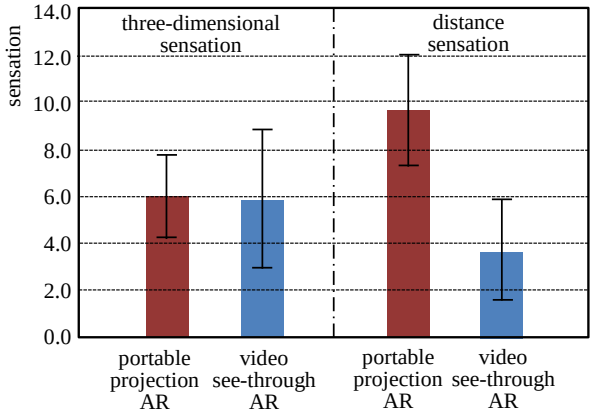


Fig. 6 Result of experiment on three-dimensional sensation and distance sensation using portable projection AR and video see-through AR.

## VI. Applications

In this study, as an example of the application system, the conference room information system in the university campus was developed. When we want to know the layout and the number of desks and chairs in the conference room, we usually look in the room. And when we want to know the reservation status of the conference room, we must access the reservation system through the Internet. In this application system, the user can see the information of the reservation status and the layout of desks and chairs easily, by illuminating the door of the conference room using the portable projector. The reservation data and the computer graphics model data of the conference room are stored in the database, and they are retrieved using the location information and the object ID that is detected from the AR Toolkit marker.

Figure 7 and Figure 8 show that the user is using this system to confirm the reservation and the layout of the conference room. When the user refers to the reservation status of the conference room, the location of the target room in front of which the user is standing can be identified using the PlaceEngine. And when the user refers to the layout of desks and chairs in the conference room, the position and posture of the portable projector can be measured using the AR Toolkit marker, and the user can recognize the three-dimensional model by moving the portable projector with his view position, as if he or she is looking in the room through the transparent door. Thus, by using the application of the conference room information system, the effectiveness of this method was evaluated.

In this study, though the simple application of the conference room information system was constructed, this technology can be applied to various application fields such as the action support system in disaster or the interactive electronic advertisement system, etc.

Fig. 7 The user can confirm the reservation status on the door by using the conference room information system.

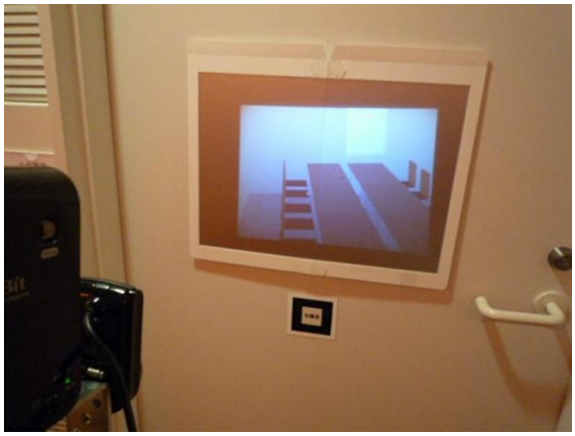

Fig. 8 The user can look in the room through the door by using the conference room information system.

## VII. Conclusions

In this study, the portable AR projection system using the portable projector was developed. Though this system cannot project the stereo image, the user can feel the three-dimensional sensation from the projected image by moving the projector. The three-dimensional sensation and the distance sensation that the user felt from the projected image were experimentally measured and this system was applied to the conference room information system. Future work will include using the marker-less position and posture measurement method and integrating the audio information with the visual information in the portable AR projection system.

## Acknowledgment

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## References

[1] Y. Kurita, Y. Tateyama, T. Ogi: Spatial AR Representation Using Portable Projector, Proc. of ASIAGRAPH 2010 in Tokyo, pp.107-108, Tokyo, 2010.

[2] J. Rekimoto, T. Miyaki, T. Ishizawa: LifeTag: WiFi-based Continuous Location Logging for Life Pattern Analysis, Proc. of 3rd International Symposium on Location- and Context-Awareness (LOCA2007), pp.35-49, 2007.

[3] H. Kato, M. Billinghurst: Marker Tracking and HMD Calibration for a Video-Based Augmented Reality Conferencing System, Proc. of 2nd IEEE and ACM International Workshop on Augmented Reality (IWAR 99), pp.85-94, 1999.

[4] P. Mistry, P. Maes: SixthSense - A Wearable Gestural Interface, Proc. of SIGGRAPH Asia 2009, Sketch, Yokohama, 2009.

[5] T. Yoshida, H. Nii, N. Kawakami, S. Tachi: Twinkle: Interacting with Physical Surfaces Using Handheld Projector, Proc. of IEEE Virtual Reality 2010, pp.87-90, Waltham, 2010.

[6] K. Tajimi, K. Uemura, N. Sakata, S. Nishida: Stabilization Method for Floor Projection with a Hip-Mounted Projector, Proc. of ICAT2010, pp.77-83, Aadelade, 2010.

[7] M. Kanbara, A. Nagamatsu, N. Yokoya: Augmented Reality Guide System Using Mobile Projectors in Large Indoor Environment, Workshop on Personal Projection via Mobile and Wearable Pico Projection (Ubiprojection 2010), pp.16-19, 2010.

[8] R. Raskar, G. Welch, K.L. Low, D. Bandyopadhyay: Shader Lamps: Animating Real Objects with Image-Based Illumination, Proc. of Eurographics Rendering Workshop, pp.89-102, 2001.

[9] D. Kondo, R. Kijima, Y. Takahashi: Dynamic Anatomical Model for Medical Education using Free Form Projection Display, Proc. of 13 International Conference on Virtual Systems and Multimedia (VSMM 2007), pp.142-149, 2007.