Portable Ambient Projection System: Build your room projectable space

Yoonsik Yang
yoonsikyang@msl.yonsei.ac.kr
Yonsei University

Yoonjung Park
yoonjung.park@msl.yonsei.ac.kr
Yonsei University

Seungho Chae
seungho.chae@msl.yonsei.ac.kr
Yonsei University

Tack-don Han
hantack@msl.yonsei.ac.kr
Yonsei University

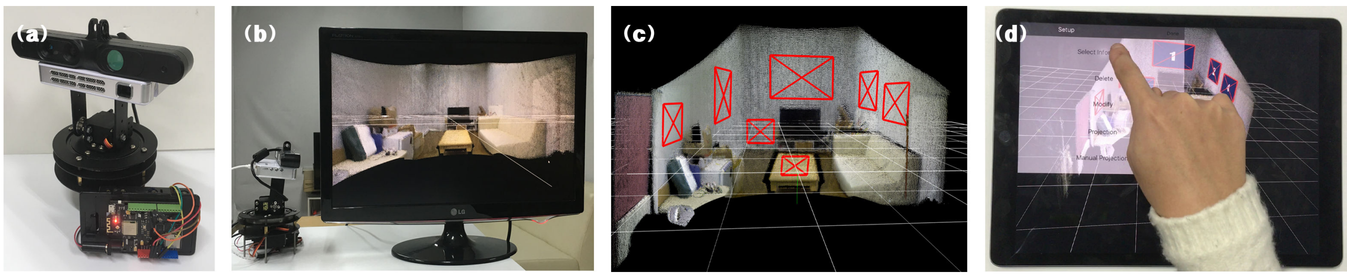

Figure 1: (a) Hardware configuration of portable ambient projection system. (b) 3D map construction with portable ambient projection system. (c) Plane detection for recommendations. (d) Mobile interaction for user to enable projectable spaces easily.

ABSTRACT

With the development of digital technology, many researchers increasingly study projection-based augmented reality (AR) that recognizes surrounding space, considers users' situation and provides space-oriented information rather than merely providing simple, fragmentary information. However, complicated installation issues persist, such as projection system installation and space setup to provide projection under various environments. In this study, we propose a portable, ambient projection system to address such complex installation issues. We defined pervasive projection AR system that enables projection in various spaces. The system consists of a pico-projector, a depth-sensing camera, and a pan/tilting platform that supports the projector-camera system. The portable ambient projection system can be positioned at an unknown space and can extract plane information by scanning its surrounding environment as it rotates 360-degrees in a clockwise manner. Users are provided with a pervasive projection AR environment as with a simple tablet user interface to control it.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**;
• **Computing methodologies** → *Reconstruction*;

SIGGRAPH '17 Poster, July 30 - August 03, 2017, Los Angeles, CA, USA

ACM ISBN 978-1-4503-5015-0/17/07…$15.00
https://doi.org/10.1145/3102163.3102211

KEYWORDS

Augmented Reality, Projection Augmented Reality, Spatial Augmented Reality, Plane detection, 3D Map Reconstruction

ACM Reference format:
Yoonsik Yang, Yoonjung Park, Seungho Chae, and Tack-don Han. 2017. Portable Ambient Projection System: Build your room projectable space. In *Proceedings of SIGGRAPH '17 Poster, Los Angeles, CA, USA, July 30 - August 03, 2017,* 3 pages.
https://doi.org/10.1145/3102163.3102211

1 INTRODUCTION

Many studies have been carried out on projection-based AR technology as it could provide additional information to the actual environment using camera images and projector screen. The studies on the projection-based AR were divided into a fixed type [Wilson et al. 2012] [Pinhanez 2001] and wearable type [Raskar et al. 2006], which is portable. Most studies on the fixed type provided information, with their system fixed on a ceiling or wall most of the time [Wilson et al. 2012]. The fixed type was only operable in a pre-established environment and was limited by space. Under this system, one projection system considered only one direction instead of the entire environment. This implied that a system with multiple projector-camera system should be established to consider the overall surroundings. To address the space limit, a wearable projection system was developed[Raskar et al. 2006]. However, it resulted in poor usability because it was inconvenient for users to hold it or continuously carry it with them for use. This paper proposed a portable ambient projection system to overcome the poor usability facing the wearable type as well as the space limit of the fixed type. Accordingly, it established a small 360-degree controllable projector and camera-based pan-tilt system. It built a 3D point cloud map showing 360-degree of a new surrounding environment and used the point cloud map to automatically extract projectable planes. Users are allowed to select, modify and add the plane location and information they want with the extracted information and simple tablet user interface. By using this system, users are provided with pervasive projection AR environment.

2 PORTABLE AMBIENT PROJECTION SYSTEM DESIGN

The portable ambient projection system was designed to recommend the optimal place under all unknown environments unlike the fixed system that provided limited information at a limited position and provide information at the optimal place by enabling the users to select the place they want. Hardware of the portable ambient projection system consists of the 360-degree controllable projector and camera-based system (Fig 1.(a)). The 360-degree controllable projection system was made to have the pan-tilt system with two servo motors mounted on, projector and depth sensing camera. Arduino was mounted on the pan-tilt system to control the two servo motors. A tablet(iPad) is used as a mobile device. The implementation of the demonstration system is divided into two integrated parts: the projector system is responsible for 3D map reconstruction and projection control; the mobile device is for selecting the projection position from reconstructed 3D point cloud map and control pan-tilt rotation. The system process of the projection system is shown in Fig 1.(b,c,d).

2.1 3D map construction

To build the map, feature matching was used where feature points are extracted from the input images an compared with features of the previous frames to calculate pose. The pan-tilt rotates 5 degrees each in one direction and gather color and depth image. When images enters through the mobile device camera, the feature points were extracted with use of the feature point extraction algorithm. RANdom SAmple Consensus (RANSAC) [Fischler and Bolles 1981] algorithm is used to calculate the pose of the current frame through the 3D world coordinate point that matched the previous frame and the 2D point that matched the current frame. The point cloud information of the current frame is rotated and translated based on the 3D world coordinate.

2.2 Plane detection for recommendations

In the next step, areas with possible projection areas are recommended by the 3D point cloud map. Depth information of the 3D point cloud map is used to perform depth segmentation and the RANSAC algorithm was carried out based on the segmented area to extract a plane areas. Then, the maximum projection areas are extracted from the plane and the normal vector of the plane areas are used to reduce projection distortion and determine the final projection location. The projection area was determined using camera-projection calibration matrix information that is pre-calculated.

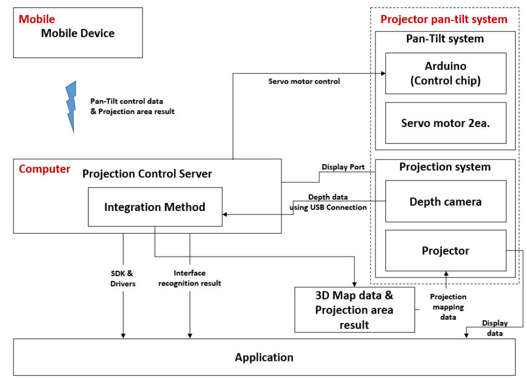

Figure 2: System Configuration

2.3 Mobile interaction

Mobile interaction is performed by a separate ios application developed. The mobile application allowed the users to browse the established 3D point cloud map and extracted planes on a mobile screen and also to select, modify and add the position of the extracted plane. Additionally, the application operated the pan-tilt system manually, enabling the camera of the current position to extract a new projection area. It allows users to easily create the pervasive AR spaces using mobile devices. The mobile application and projection system transmitted and received data by using Open Sound Control (OSC) [Wright 2005]. User can modify contents at any time using mobile devices.

3 CONCLUSION AND FUTURE WORK

The portable ambient projection system helped establish the 3D point cloud map showing the surrounding environment and extract the plane without special installations under many environments. With simple operation of this information by the users, the pervasive projection AR environment could be provided for the users. When this is put to use, lots of information could be provided adaptively for the users at any space.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. NRF-2015R1A2A1A10055673)

REFERENCES

Martin A Fischler and Robert C Bolles. 1981. Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography. *Commun. ACM* 24, 6 (1981), 381–395.

Claudio Pinhanez. 2001. The everywhere displays projector: A device to create ubiquitous graphical interfaces. In *International Conference on Ubiquitous Computing*. Springer, 315–331.

Ramesh Raskar, Jeroen Van Baar, Paul Beardsley, Thomas Willwacher, Srinivas Rao, and Clifton Forlines. 2006. iLamps: geometrically aware and self-configuring projectors. In *ACM SIGGRAPH 2006 Courses*. ACM, 7.

Andrew Wilson, Hrvoje Benko, Shahram Izadi, and Otmar Hilliges. 2012. Steerable augmented reality with the beamatron. In *Proceedings of the 25th annual ACM symposium on User interface software and technology*. ACM, 413–422.

Matthew Wright. 2005. Open Sound Control: an enabling technology for musical networking. *Organised Sound* 10, 03 (2005), 193–200.