A Tabletop System Using an Omnidirectional Projector-Camera

Kosuke Maeda
School of Computing
Tokyo Institute of Technology
maeda.k.ai@m.titech.ac.jp

Toshiki Sato
School of Computing
Tokyo Institute of Technology
toshiki@c.titech.ac.jp

Mitski Piekenbrock
RWTH Aachen University
mitski.piekenbrock@rwth-aachen.de

Hideki Koike
School of Computing
Tokyo Institute of Technology
koike@acm.org

ISS '18, November 25–28, 2018, Tokyo, Japan .
ACM 978-1-4503-5694-7/18/11.
https://doi.org/10.1145/3279778.3279911

Abstract
We propose an omnidirectional projection system embedding a projector with an ultra wide-angle lens in the table. AR markers are attached on the target surfaces so that the system can track them with an omnidirectional camera. Finally, we developed a prototype of the system and introduced some applications to show the effectiveness of our method.

Author Keywords
Meeting system; Projection Mapping; Tabletop systems; Omnidirectional camera; Omnidirectional projector;

CCS Concepts
•**Human-centered computing** → **Displays and imagers;**

Introduction
Even though projectors are widely used in many situations, we are often disturbed by projectors. For example, we pay attention to the projected screen instead of the speaker during a presentation. With a single projector, since only one user can show his own contents with it, we have to switch the user when another user wants to show his contents. Recently, there are some researches which enhance the collaborative task by using projector-camera system, however, these researches cannot solve the problem fundamentally, and they are high in cost because they need

multiple projectors.

Therefore, we introduce an omnidirectional projection system embedding a projector with an ultra wide-angle lens in the table. Figure 1 shows a conceptual sketch of this research. Any surface around the table can be turned into a display simply by attaching a marker to it when needed.

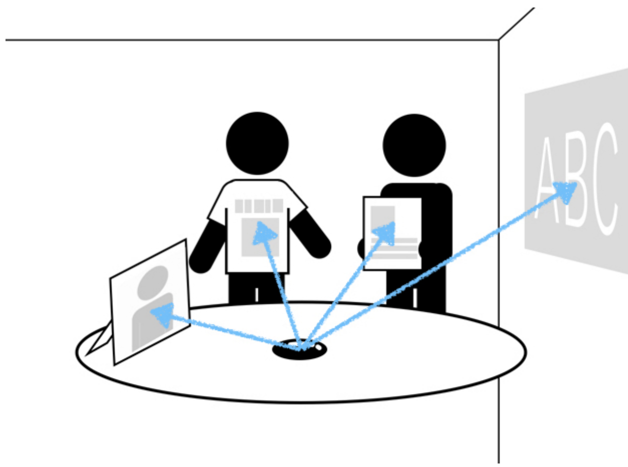

Figure 1: A conceptual sketch of our research.

Related work

The Everywhere Displays Projector[2] is a research using a rotating mirror to steer the light out of a projector onto any surface. In this method, it is possible to project onto any one surface within the moving range of the mirror but it is impossible to handle multiple surfaces spread around the table simultaneously.

MeetAlive[1] is a research to create a room-scale omnidirectional display surface using multiple depth cameras and projectors. This system is designed to allow any participants to control all displayed contents. In this method, it is possible to project onto multiple surfaces in the room simultaneously, but the cost to implement this system is high because it requires multiple cameras and projectors.

In this research, we propose a method that allows users surrounding a table to create and utilize any desired surface as a display, with the usage of one embedded pair of camera and projector.

Implementation

Hardware

We developed a prototype as shown in Figure 2. This prototype utilizes one Kodak PIXPRO SP360 4K omnidirectional camera and one Canon XJ-V1 projector. The resolution of the projector is set to 768×1024 pixels. An ultra wide-angle lens SHIBUYA OPTICAL Glomal350 is attached to the projector. The camera is connected to a computer by cable. The fisheye images captured by the camera, which have the resolution of 1440×1440 pixels, are transferred to the computer at 15 fps. On the table, the distance between the camera and the projector is set to 20 cm. Figure 3 shows the covered range of projecting and capturing.

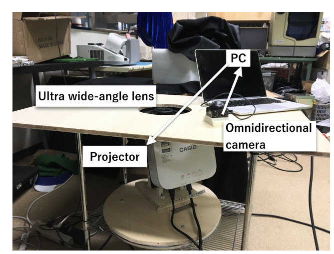

Figure 2: The prototype hardware of this research.

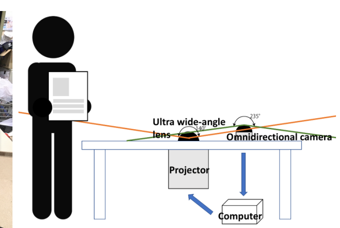

Figure 3: The range of omnidirectional projector-camera.

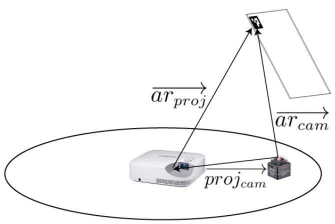

Figure 4: Calculation of the projection direction.

Software

Each projection target contains a unique AR marker in order to identify its properties such as size and projection content which are set beforehand. First, our software undistorts the fisheye image from the camera, then calculates the position and the distance from the camera to the target. In this prototype, the projector and the camera do not share the same vertical axis, so the direction from the camera to the target differs from the direction from the projector to the target. In order to obtain the correct projection angles as shown in Figure 4, the following equation has to be calculated.

$$\overrightarrow{ar_{proj}} = \overrightarrow{ar_{cam}} - \overrightarrow{proj_{cam}}$$

Applications

Projection to paper documents

In situations such as a discussion with multiple persons, it is necessary to switch the display to show their own contents. However, in this application, users can simply show their own contents just by raising their projection surface such as a paper document with an AR marker attached to it. Also, multiple projections is possible which was not the case in previous research. Figure 5 shows this application in use.

Instant video chat using a card board

Conventionally, video chats require either one display per absent participant or a split screen to show them all. In this application, it is sufficient to have boards with an AR marker attached for each absent participants and to lean these boards against the participants' seats. Figure 6 reveals a participant on a board by doing so.

Projection to T-shirts

It is often difficult to focus on content when meeting people for the first time as we try to memorize their names with their faces. In this application, users attach AR markers

Figure 5: Projection to paper documents.

Figure 6: Instant video chat using a card board.

to their clothes in order to have their personal information projected on their clothes. With this application, they can communicate naturally without focusing on remembering the information simply by moving their line of sight slightly. In Figure 7, names are projected on users' clothes.

Figure 7: Projection to T-shirts.

Discussion

Our method utilizes an ultra wide-angle lens to spread the light. Therefore, the further the target goes, the lower the resolution of projection image becomes. One of possible solutions is to use a high resolution projector.

In this prototype, we used a DLP projector, thus there is focus issue. To overcome the issue, we could utilize a laser projector which is focus-free.

Conclusion

We introduced an omnidirectional projection system embedding a projector with an ultra wide-angle lens in the table. We implemented the applications using our method and demonstrated the effectiveness of this system.

As a future work, we plan to get rid of AR markers or at least make them invisible. Also, tracking accuracy and speed are to be improved. HideOut[3] is a work related to invisible AR markers. This research uses infrared-absorbing ink to make markers invisible. Invisible markers can be integrated on the entire projection surface, thus, making the tracking process faster and more accurate.

REFERENCES

1. Andreas Rene Fender, Hrvoje Benko, and Andy Wilson. 2017. MeetAlive: Room-Scale Omni-Directional Display System for Multi-User Content and Control Sharing. *Proceedings of the Interactive Surfaces and Spaces on ZZZ - ISS '17* (2017), 106–115. DOI: http://dx.doi.org/10.1145/3132272.3134117

2. Claudio Pinhanez. 2001. The Everywhere Displays Projector: A device to create ubiquitous graphical interfaces. *Ubicomp 2001: Ubiquitous Computing* (2001), 315–331. DOI: http://dx.doi.org/10.1007/3-540-45427-6_27

3. Karl D D Willis, Takaaki Shiratori, and Moshe Mahler. 2013. HideOut: Mobile Projector Interaction with Tangible Objects and Surfaces. *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction - TEI '13* (2013), 331. DOI: http://dx.doi.org/10.1145/2460625.2460682