

# EgoSpace: Augmenting Egocentric Space by Wearable Projector

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## ABSTRACT

In this work, we propose a novel wearable device to augment the user's egocentric space to a wide range. To achieve this goal, the proposed device provides bidirectional projection using a head-mounted wearable projector and two dihedral mirrors. The included angle of the mirrors were set to reflect the projected image in front of and behind the user. A prototype system is developed to explore possible applications using the proposed device in different scenarios, such as riding a bike and map navigation.

## CCS CONCEPTS

• **Human-centered computing** → **Ubiquitous and mobile devices**; **Interaction devices**.

## KEYWORDS

Wearable device, interactive projection, personal space, navigation.

### ACM Reference Format:

Yuya Adachi, Haoran Xie, Takuma Torii, Haopeng Zhang, Ryo Sagisaka. 2020. EgoSpace: Augmenting Egocentric Space by Wearable Projector. In *AHs '20: Augmented Humans International Conference (AHs '20)*, March 16–17, 2020, Kaiserslautern, Germany. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3384657.3385328>

## 1 INTRODUCTION

In the human augmentation research field, many wearable devices have been proposed to amplify human abilities and human bodies, such as jumping [4] and adding body part [5]. In this work, we focus on the augmentation of egocentric space. In recent years, mobile devices have become a part of our lives. Representative products include smartphones and smartwatches, which are normally equipped with quite small displays. As users focus upon the smartphone display, their attention becomes limited to the display, and they usually ignore the surrounding environment. This type of user is well known as the "smartphone zombie". To address this issue, our research attempts to augment egocentric space during the use of smartphones.

We were inspired by automotive designs: modern cars have both front and back headlights that illuminate the way ahead and communicate the driving information to other users behind. Similarly, we proposed a bidirectional projection system that could not only transmits typical display information from the mobile device but

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*AHs '20, March 16–17, 2020, Kaiserslautern, Germany*

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ACM ISBN 978-1-4503-7603-7/20/03.

<https://doi.org/10.1145/3384657.3385328>

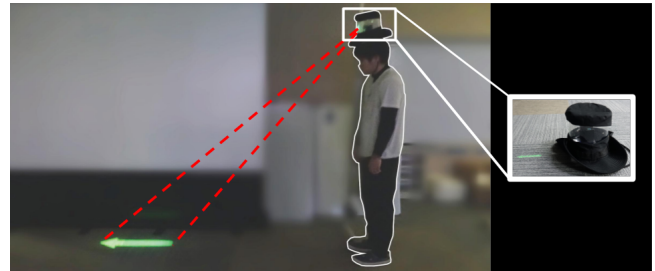


Figure 1: Space augmentation with the proposed device.

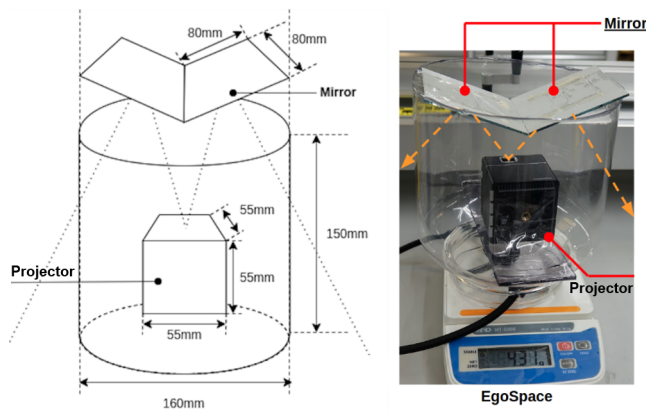
also provides information on the wearer's state to other users. Taking common route navigation as an example, the proposed device would project navigation information as turning arrows onto the ground, so that the user does not have to check the phone display as frequently. Meanwhile, the proposed device would also notice the activity of the wearer and alert relevant information that help the rear user to make a decision. In this sense, our proposed device is designed to augment egocentric space with interaction support.

To achieve these goals, we proposed EgoSpace, a bidirectional head-mounted projector to augment the wearer's personal space, as shown in Figure 1. There are several head-mounted devices proposed in the human-computer interaction field. The s-Helmet uses laser range finders mounted on the back of the head to detect skiers approaching for safety [2]. HearThere uses Ultra-WideBand radio tracking to help users navigate complex natural environments [3]. Unlike the previous works, we propose a head-mounted projector device with bidirectional projection. In the proposed device, it projects images onto the ground in front of and behind the wearer. The device is lightweight and designed to be mounted on the wearer's head. We believe that the use of EgoSpace can be extended to various applications and scenarios with sensors and wireless communication.

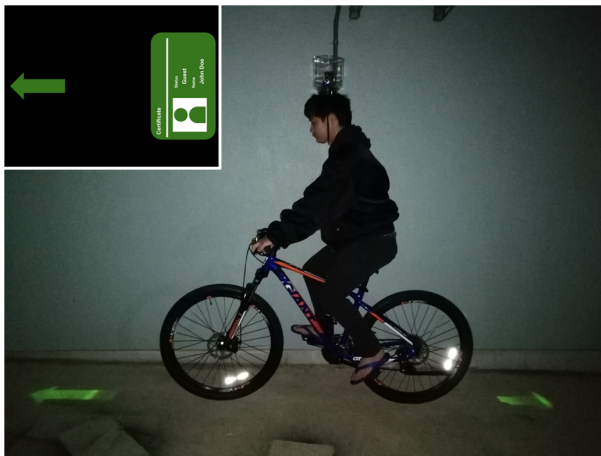
## 2 SYSTEM IMPLEMENTATION

Inspired by the communication design of autonomous vehicles [1], we adopted a projection-based interaction for the wearer and surrounding individuals to augment egocentric space. Similar to the function of front and back headlights in automotive communication, we aimed to project information in front of and behind the wearer.

To consider these issues, we proposed EgoSpace, a bidirectional head-mounted projection device (Figure 2), composed of a portable projector and dihedral mirrors. The projection image is divided into two zones by the mirrors. The mirrors were arranged to project an image on the ground in front of and behind the user. This mirror arrangement enabled bidirectional projection where light rays



**Figure 2: Design blueprint of the proposed device (left) and our developed prototype (right).**



**Figure 3: Potential application as riding a bicycle. The upper left figure represents the projected image as an example.**

from the projector were reflected and separated into two opposite directions.

Figure 2 shows our prototype design of EgoSpace. We used a portable optical projector, TENKER DLP mini projector (size 55mm × 55mm × 55mm; weight 168g; 100 lumens). We used two regular mirrors for the projection (size 80mm × 80mm; weight 20g). A cylindrical acrylic plate (size 160mm × 150mm; diameter 165mm; weight 219g) was used to place the projector and hold the two mirrors over the projector lens. The total weight of our prototype was 431g without the hat-like cover for decoration, and became 556g with the cover. A tablet computer (iPad 6; CPU 2.34GHz, RAM 2GB) was connected to the projector. We assumed that the proposed device would be used in low lighting due to the projection requirements. The projected images were in green color projected on the ground in front of and behind the user.

### 3 DISCUSSION

In our preliminary study, we asked the participants to wear the proposed device and confirmed their intentions based on the wearing experience in various usage scenarios, such as in the conditions of both hands occupied, poor visibility, outdoor and indoor attractions, and riding a bicycle. We found that the users want to actively use the proposed devices in these scenarios. Because many traffic accidents occur due to poor lighting conditions, our proposed device would be helpful in poor lighting conditions when riding motorbikes or bicycles (Figure 3).

Our current proposed device adopted bidirectional projection inspired by automotive design. However, it is an interesting future work to explore the omnidirectional projection with curved mirrors. The distorted projected image would be a difficult issue which could be solved by the preprocessed calibration.

### 4 CONCLUSION

In this work, we proposed a wearable device to augment user’s egocentric space. The proposed device provides a bidirectional projection system that enables interactions useful for various daily tasks. We believe that the proposed device can be useful in many daily situations, such as route navigation in outdoor and indoor areas. We think that smartphone information projected onto the ground will enable novel interactions among users.

### ACKNOWLEDGMENTS

We thank all the participants in our preliminary study. This work was supported by JAIST Research Fund and Hayao Nakayama Foundation for Science & Technology and Culture.

### REFERENCES

- [1] Trung Thanh Nguyen, Kai Holländer, Marius Hoggenmueller, Callum Parker, and Martin Tomitsch. 2019. Designing for Projection-Based Communication between Autonomous Vehicles and Pedestrians. In *Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI 19)*. Association for Computing Machinery, New York, NY, USA, 284–294. <https://doi.org/10.1145/3342197.3344543>
- [2] Evangelos Niforatos, Ivan Elhart, Anton Fedosov, and Marc Langheinrich. 2016. S-Helmet: A Ski Helmet for Augmenting Peripheral Perception. In *Proceedings of the 7th Augmented Human International Conference 2016 (AH 16)*. Association for Computing Machinery, New York, NY, USA, Article Article 45, 2 pages. <https://doi.org/10.1145/2875194.2875233>
- [3] Spencer Russell, Gershon Dublon, and Joseph A. Paradiso. 2016. HearThere: Networked Sensory Prosthetics Through Auditory Augmented Reality. In *Proceedings of the 7th Augmented Human International Conference 2016 (AH 16)*. Association for Computing Machinery, New York, NY, USA, Article Article 20, 8 pages. <https://doi.org/10.1145/2875194.2875247>
- [4] Takumi Takahashi, Keisuke Shiro, Akira Matsuda, Ryo Komiyama, Hayato Nishioka, Kazunori Hori, Yoshio Ishiguro, Takashi Miyaki, and Jun Rekimoto. 2018. Augmented Jump: A Backpack Multitrotor System for Jumping Ability Augmentation. In *Proceedings of the 2018 ACM International Symposium on Wearable Computers (ISWC 18)*. Association for Computing Machinery, New York, NY, USA, 230a–231. <https://doi.org/10.1145/3267242.3267270>
- [5] Haoran Xie, Kento Mitsuhashi, and Takuma Torii. 2019. Augmenting Human With a Tail. In *Proceedings of the 10th Augmented Human International Conference 2019 (AH2019)*. Association for Computing Machinery, New York, NY, USA, Article Article 35, 7 pages. <https://doi.org/10.1145/3311823.3311847>