Evaluation of active patterns on direction instruction for pedestrians

Yu Tamura[1], Hidehiko Shishido[2] and Yoshinari Kameda[2,*]

[1]*Master's program in Intelligent and Mechanical Interaction Systems, University of Tsukuba, 1-1-1 Tennoudai, Tsukuba, Ibaraki, 305-8573, Japan*
[2]*Center for Computational Sciences, University of Tsukuba, 1-1-1 Tennoudai, Tsukuba, Ibaraki, 305-8573, Japan*

Abstract
In this paper, we propose a direction instruction method using active patterns that is both easy to understand and safe in augmented reality fashion. An active pattern is a set of moving virtual objects dynamically arranged in a landscape. We discuss the factors that make active patterns easy to understand and safe. We have developed a preliminary system for presenting active patterns and included the gaze accumulation counter inside the system so that the gazing time of watching the active patterns could be counted.

Keywords
Pedestrian navigation, Optical See-Through HMD, Direction instruction, Active pattern

1. Introduction

Augmented Reality is useful for walking pedestrians on streets [1]. Navigation support on walking is a promising application of Augmented reality.

Direction instruction using an HMD may superimpose the route to go on the scenery. Because the instruction is presented directly in the user's field of view, the direction to go should be intuitive and easy to understand. The user can recognize the direction to go while always looking forward.

When using augmented reality technology to guide pedestrians to their destinations, the problem is how to superimpose the virtual objects that guide them to their destinations. AR-based direction presentation should fulfill the visibility on display. As the comprehensibility, it should have a good shape and/or motion to indicate the direction to go. In addition to visibility and comprehensibility, it is also important to keep the safety on a walking task. A user should have a clear field of view while walking. This implies that any inserted virtual objects in AR fashion should not interfere with safety.

In this paper, we propose a direction instruction method using active patterns that is both easy to understand and safe in augmented reality fashion. An active pattern is a set of moving virtual objects dynamically arranged in a landscape (Figure 1).

APMAR2022: Asia-Pacific Workshop on Mixed and Augmented Reality 2022, Dec. 02–03, 2022, Yokohama, Japan
*Corresponding author.
tamura.yu@image.iit.tsukuba.ac.jp (Y. Tamura); shishido@ccs.tsukuba.ac.jp (H. Shishido); kameda@ccs.tsukuba.ac.jp (Y. Kameda)
0000-0001-8575-0617 (H. Shishido); 0000-0001-6776-1267 (Y. Kameda)

Since the good balance of visibility, comprehensibility, and safety on the AR-based direction presentation is crucial, we investigate the performance of the active patterns by changing the shape, size, height, and transparency of the virtual objects. We have built a preliminary system for evaluation on gaze attraction for checking the safety. We also conduct subjective evaluation by questionnaires.

Figure 1: An active pattern of ball shape to instruct the direction in augmented reality. The balls are flowing down to indicate the way to go.

2. Related work

As for the challenges of direction display at high level visibility, four kinds of direction display methods have been investigated in [2]. Among them, the bird avatar is thought to be a kind of active pattern. It is designed to make a good balance between safety and comprehensibility, but they have not conducted the subjective evaluation of their approach.

A 3D shaped arrow in Augmented reality has been investigated for the purpose of direction presentation on streets[3]. It is good from the viewpoint of visibility and comprehensibility, but it may have the possibility of decreasing the safety since the size of the object is large and it might hide certain size of the field of view of the user.

Performance of AR-based direction display methods on off-road situation has been studied [4] but they do not conduct safety evaluation.

Safety is a critical issue to design the navigation and to analyze the performance on direction presentation in AR fashion. It is demanded to focus the safety evaluation on developing new AR-based navigation approaches [5].

3. Active pattern for direction display

Our active pattern to present direction on an HMD is composed by a set of virtual objects that are moving along the way to go. We adopt an optical see-through glass as to build the preliminary system for evaluation (Figure 1).

Since the purpose of presenting the direction is to let users understand the direction to go, active pattern should be visually simple and small not to interfere with the the field of view of the user. We have prepared three simple shapes as candidates for the virtual objects (Figure 2). On a see-through HMD, the objects are arranged to follow the planned path. Three snapshots of a user's view with the different virtual object shape at ground level are shown in Figure 3.

Some variation of ball-shape active pattern is shown in Figure 4. Transparency is controlled so that users can see the the regions behind the virtual objects.

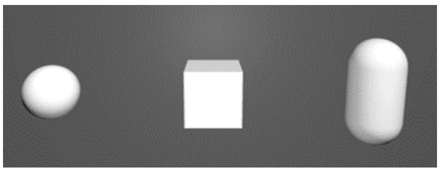

Figure 2: 3D shapes of virtual objects.

Figure 3: Active patterns with different shape of the virtual objects.

4. Evaluation

We have developed a preliminary AR system on a Magic Leap 1 (Figure 1). The experiment was conducted in a

Figure 4: Ball-shape active pattern at the size of 5 cm with 0% transparency, 10 cm with 50%, and 10 cm with 75%.

corridor where the planned path is set to turn right at 15 meters away (Figure 5).

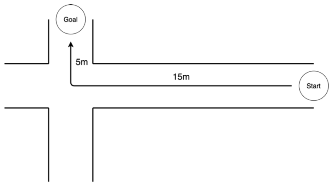

Figure 5: Map of the experiment environment.

All the subjects are familiar with the corridor and with AR experiences in their twenties.

4.1. Shape and height

We prepared eight subjects for shape and height evaluation of the virtual objects. Each subject had a calibration process and practice time before the experiment. The order of the variations is changed for subjects so as to eliminate the order effect in total.

There five kinds of trials on this experiment. The first one (static/ground) is the ball shape virtual object with static placement. The objects are at the ground level. For the second to the fourth, the virtual objects of moving along the planned path is rendered at the ground level with the shape of ball, cube and ellipsoid respectively. The last fifth is same as the third except for the height at knee level. The size of the virtual objects are set to 10 cm and transparency level is 0% for all the five trials.

The subjects mark scores with a seven-level Likert scale for four questions after each experience of trials. The average and the standard deviation are shown in Figure 6 - 9. A larger score indicates the affirmative evaluation.

Q1 (Figure 6) corresponds to the visibility and Q2 (Figure 7) corresponds to the comprehensibility. The scores are high with small standard deviation regardless of shape and height if only they are moving. Q3 (Figure 8) and Q4 (Figure 9) corresponds to the safety evaluation. We think if the score of Q3 is high, it means it looks natural, so it may indicate that the score of Q4 becomes low because they do not need to watch the virtual objects for a long time. This also implies the safety could be in good level. As the Q4 score are rather high around 5.0, we have conducted further investigation with gaze analysis in the next experiment.

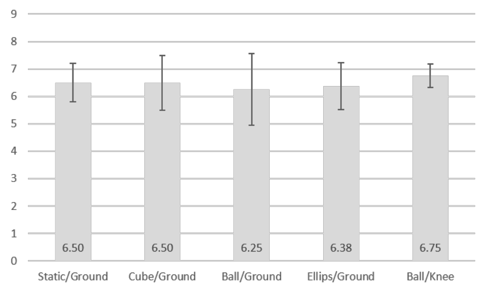

Figure 6: Exp1-Q1: Did you see the active pattern clearly?

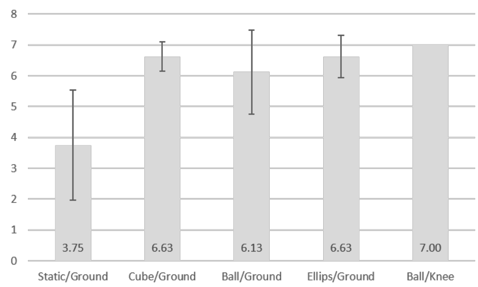

Figure 7: Exp1-Q2a: How did you know which way to turn?

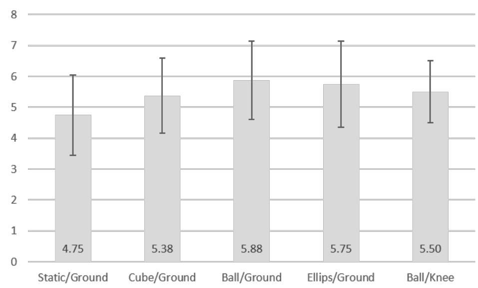

Figure 8: Exp1-Q3: Did you get the impression that the active pattern was blending into the real world?

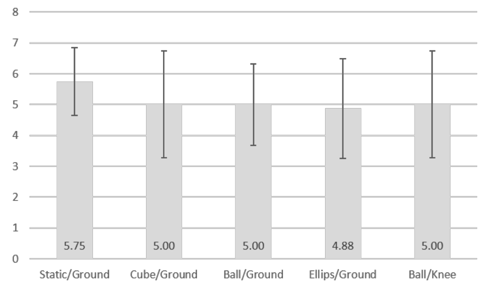

Figure 9: Exp1-Q4: Did you ever keep an eye on the active pattern while walking?

4.2. Size and transparency

On the second experiment, we have developed a gaze accumulation counter on our preliminary system. We have utilized the gaze tracking function of Magic Leap 1 and set nine by nine bins to cover the field of view of the user (Figure 10). The bin matrix is fixed to the head position of the user, and it is not moved against the head rotation. It is because the virtual objects are attached to the world and the bin matrix should be relatively fixed against the virtual object coordinate.

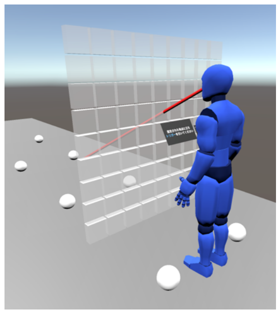

Figure 10: Gaze accumulation counter.

We prepared nine subjects for size and transparency evaluation of the virtual objects. The basic procedure is same as the first experiment.

There five kinds of trials on this experiment. For the all five trials, the shape is ball and the objects are placed at ground level and move to follow the planned path. The first three trials changes the size at 20cm, 10cm, and 5cm respectively. As for the fourth and the fifth trials, the transparency level is changed to 50% and 75%.

The subject evaluations are conducted by setting the four questions after each experience of trials. The average and the standard deviation are shown in Figure 11 - 14. A larger score indicates the affirmative evaluation.

From the results, Q1 (visibility) and Q2 (comprehensibility) becomes lower when the transparency level is up. We expected the trials with higher transparency may get higher score in Q3 and lower in Q4, but actually the subjects did not respond as we expected.

Note that we have not shown the results of T-test intentionally as the numbers of the subjects are less than ten and we think the application of T-test is not appropriate

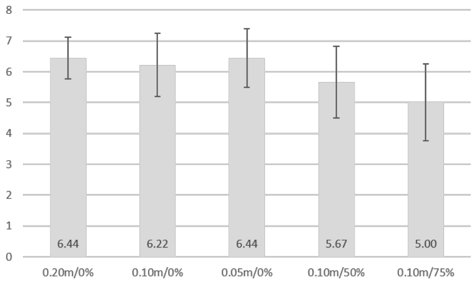

Figure 11: Exp2-Q1: Did you see the active pattern clearly?

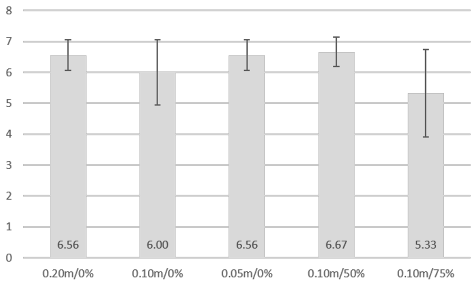

Figure 12: Exp2-Q2b: Do you think this active pattern is suitable as a method to indicate the direction to turn?

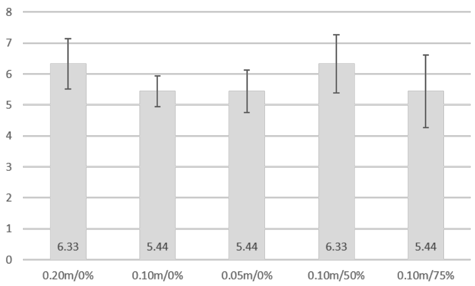

Figure 13: Exp2-Q3: Did you get the impression that the active pattern was blending into the real world?

for Figure 6 - 9 and Figure 11 - 14.

The results of the gaze accumulation counter during the second experiment are shown in Figure 15 and Figure 16. Figure 15 corresponds to the first three trials of the second experiment. Figure 16 corresponds to the second, the fourth, and the fifth trials of the second experiment. The darkest green color bin indicates the 0.0 time unit of gaze accumulation and the brightest color bin indicates the maximum amount of time unit through the second experiment in the average of all the nine subjects' trials. time length per time unit is determined to normalize the length difference between the five trials.

Since the virtual objects are placed on the ground level on the second experiment, the lower half of the bin matrix corresponds to the area of presenting the virtual objects.

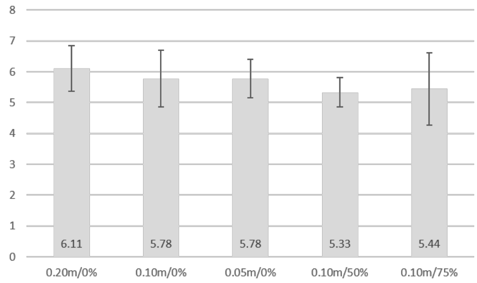

Figure 14: Exp2-Q4: Did you ever keep an eye on the active pattern while walking?

Even with the high scores of Q4 (Figure 14), we can say that actually the subjects spent little time on checking the virtual objects. This means the current implementation satisfies the safety property to some extent.

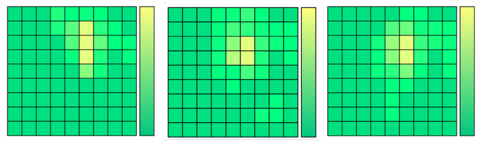

Figure 15: Gaze count results of 0.20m, 0.10m, and 0.05m size.

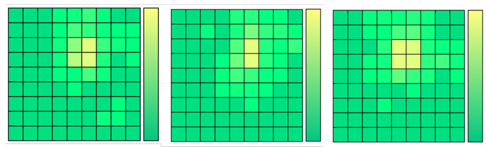

Figure 16: Gaze count results of 0%, 50%, and 75%.

5. Conclusion

In this paper, we proposed a direction instruction method using active patterns that is both easy to understand and safe in augmented reality fashion with a optical see-through HMD. We have developed a preliminary system for presenting active patterns and included the gaze accumulation counter inside the system so that the gazing time of watching the active patterns could be counted. We have conducted subjective evaluation experiments and discussed the factors that make active patterns easy to understand and safe.

Acknowledgments

A part of this work is supported by KAKENHI 21H03476.

References

[1] J. Joo-Nagata, F. Martinez Abad, J. García-Bermejo Giner, F. J. García-Peñalvo, Augmented reality and pedestrian navigation through its implementation in m-learning and e-learning: Evaluation of an educational program in chile, Computers & Education 111 (2017) 1–17. doi:https://doi.org/10.1016/j.compedu.2017.04.003.

[2] J. Cron, B. Jenny, Engell, R., Z. Lucarelli, Head-mounted augmented reality visualisation for outdoor pedestrian navigation, in: Adjunct Proceedings of the 15th International Conference on Location-Based Services, 2019. doi:10.34726/lbs2019.15.

[3] Y. Makimura, A. Shiraiwa, M. Nishiyama, Y. Iwai, Visual effects of turning point and travel direction for outdoor navigation using head-mounted display, in: J. Y. Chen, G. Fragomeni (Eds.), Virtual, Augmented and Mixed Reality. Multimodal Interaction, Springer International Publishing, Cham, 2019, pp. 235–246. doi:10.1007/978-3-030-21607-8_18.

[4] I. Aaltonen, J. Laarni, Field evaluation of a wearable multimodal soldier navigation system, Applied Ergonomics 63 (2017) 79–90. URL: https://www.sciencedirect.com/science/article/pii/S0003687017300911. doi:https://doi.org/10.1016/j.apergo.2017.04.005.

[5] T. Thi Minh Tran, C. Parker, Designing exocentric pedestrian navigation for ar head mounted displays, in: Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems, CHI EA '20, Association for Computing Machinery, New York, NY, USA, 2020, p. 1–8. URL: https://doi.org/10.1145/3334480.3382868. doi:10.1145/3334480.3382868.