# Evaluation of a Campus Navigation Application Using an AR Character Guide

Yamato Kuwahara[1(✉)], Hung-ya Tsai[2], Yuya Ieiri[1], and Reiko Hishiyama[1]

[1] Graduate School of Creative Science and Engineering, Waseda University, 3-4-1, Okubo, Shinjuku-ku, Tokyo 169-8555, Japan
kuwayama08@akane.waseda.jp, ieyuharu@ruri.waseda.jp, reiko@waseda.jp

[2] Osense Technology Co., Ltd., 8F., No. 325, Sec. 4, Zhongxiao E. Road, Da'an District, Taipei City, Taiwan
hungyatsai@osensetech.com

**Abstract.** In recent years, many studies have been conducted to realize easy route navigation for pedestrians using augmented reality (AR). Many of these studies use methods where the direction or sign is indicated using AR. However, only a few have focused on using AR for route navigation to follow. Our research aims to realize easy route navigation using an AR character agent. We develop a navigation application wherein the user follows an AR character agent. We evaluate it from the behavior of the user. For that purpose, we conduct an experiment at a university festival using the navigation application. We then analyze the experimental data and questionnaire responses. The results show that route navigation by the AR character agent makes route identification easy. However, problems involving many participants feeling uneasy or being lost are encountered. Problems in accuracy caused by errors in the positional information are also observed. In future, a method to indicate directions more accurately must be considered.

**Keywords:** A context-aware AR navigation system · Human–agent interaction · Human wayfinding performance · Interactive behavior

## 1 Introduction

In recent years, many studies have been conducted to realize easy route navigation for pedestrians using augmented reality (AR). Yokoi et al. [1] developed a system wherein a user can intuitively understand the direction of the destination by displaying the landmark using AR. However, many previous studies displayed direction and signs using AR, and only a few focused on the route navigation following using AR. Therefore, this study aimed to realize easy route navigation using an AR character agent. We focus herein on the efficiency of route navigation by an AR character agent. We then make a hypothesis that the route is


H. Nakanishi et al. (Eds.): CRIWG+CollabTech 2019, LNCS 11677, pp. 242–250, 2019.
https://doi.org/10.1007/978-3-030-28011-6_18

easily detected, which gives the user a sense of security. In addition, we establish a hypothesis that the navigation by AR character agent can accurately guide the user to the destination. We verify these hypotheses using the experimental results. The remainder of this paper is structured as follows: Sect. 2 discusses several previous studies; Sect. 3 provides the hypotheses; Sect. 4 presents the developed application and describes the experiment; Sect. 5 discusses the analysis of the results of the questionnaire and log data; and Sect. 6 provides the conclusions and the future works.

## 2 Related Work

Many studies using AR for pedestrian navigation were conducted. Hervas et al. [2] evaluated a useful system for people with cognitive impairment by combining AR and text. Chang et al. [3] proposed a system for guiding historic buildings. Chu et al. [4] indicated that navigation using AR was superior to that using a map in terms of time and accuracy. As mentioned earlier, using AR for pedestrian navigation is effective.

However, Dunser [5] showed that users encountered more problems with using the AR view alone for navigation compared to using the AR and the map in combination. In addition, Pankrats et al. [6] showed that AR navigation may lose accuracy because of an error in the positional information. Therefore, research on pedestrian navigation using AR must be conducted.

Some studies have also focused on the user experience of navigation using AR. Sekhavat et al. [7] showed that in location- and marker-based AR, the former user experience without the task of reading markers was better than the latter. Mulloni et al. [8] focused on where and how users use AR. They showed that they often use AR at corners of streets in navigation applications. Campbell et al. [9] showed that navigation by a character enabled faster navigation along a shorter route than that by an arrow. We focus herein on the human behavior of navigation, in which the user only follows the guide.

## 3 Hypotheses

The user was assumed to be able to easily understand the route by following the AR character agent. Moreover, the user was assumed to not feel uneasy or lost. We made the following two hypotheses from the factors mentioned earlier:

Hypothesis 1: The navigation by the AR character agent is easy for the user to understand.

Hypothesis 2: The navigation by the AR character agent provides a sense of security to the user.

Moreover, this guide seems to be able to correctly lead the user to the destination. The following are defined herein as correct navigation:

- Walking on the right route

– Not going right or left on a straight road
– Not turning back the way they came.

We judge the guide to be incorrect when an action does not meet the above-mentioned criteria. We then establish Hypothesis 3.

Hypothesis 3: The navigation by the AR character agent is accurate.

## 4 Method

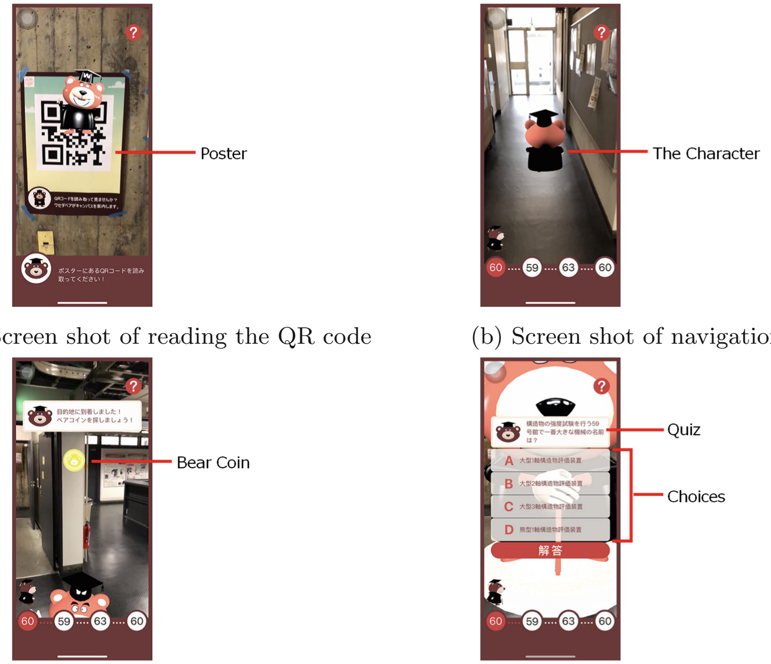
We developed a navigation application, called "BearNavi," to guide the user around the Waseda University campus. In this application, the university's bear mascot character guides the user. Using this application, we held an event called the "BearNavi Tour" at Waseda University on November 3 and 4, 2018, with 16 participants. Two of them were familiar with the campus, but the others didn't know the campus. Therefore, the application functioned as a navigation system. Furthermore, we followed them and observed their behavior. We then analyzed the experimental data and the questionnaire and evaluated the guide. Finally, we verified Hypothesis 1 and Hypothesis 2 from the results of the questionnaire and Hypothesis 3 from the log data results.

The user repeated the following actions in this application:

1. Reading the QR code of the poster
2. Moving to the destination following the guiding AR character
3. Finding the "Bear Coin," which can be tapped to reveal a quiz
4. Answering the quiz.

First, the user starts the tour by reading the QR codes of the posters on the wall. The character then appears on the screen and starts walking in front of the user. The character stops at a certain interval and waits for the user to catch up. When the user comes closer enough, the character starts walking again. The character repeats these actions until the user reaches the destination. A "Bear Coin" is displayed when the user reaches the destination. The user then attempts a quiz that appears when they tap the "Bear Coin." This application is for introducing the campus to people coming to the university for the first time, so the quizzes are about campus facilities and the university. The user can move to the next destination, regardless of the quiz correctness. The user repeats this flow thrice and finally reaches the goal point. Figure 1 shows a screen shot of each of these steps as example.

For this application, we used an indoor space computerization AI system [10] that obtains location information based on a video recorded with a smart terminal. Therefore, the user can be guided indoors and outdoors, and the user behavior in various places, such as the stairs and in narrow passages, can be evaluated. Figure 2 shows the route guided by the "BearNavi Tour." The segment in gray shows a buildings and in white shows a passage. We created a route on the Waseda University campus, where the user leaves the start point, passes two




(a) Screen shot of reading the QR code (b) Screen shot of navigation

(c) Screen shot of finding the "Bear Coin" (d) Screen shot of attempting the quiz

**Fig. 1.** Screen example of "BearNavi"

checkpoints, and reaches the goal point. We call the route from the start point to checkpoint A route 1, from checkpoint A to checkpoint B route 2, and from checkpoint B to the goal point route 3. The "Bear Coin" and a quiz were placed at each point. Posters were also set up.

The experimental flow is as follows:

1. Explanation
   First, the participants downloaded the application, and it was explained to them.
2. Main experiment
   The participants walked the route using the application.
3. Questionnaire
   Finally, the participants answered the questionnaire about this application.

# 5 Results and Discussion

## 5.1 Questionnaire

We asked the participants to answer the questionnaire on the route navigation of this application after the experiment. First, the participants answered the

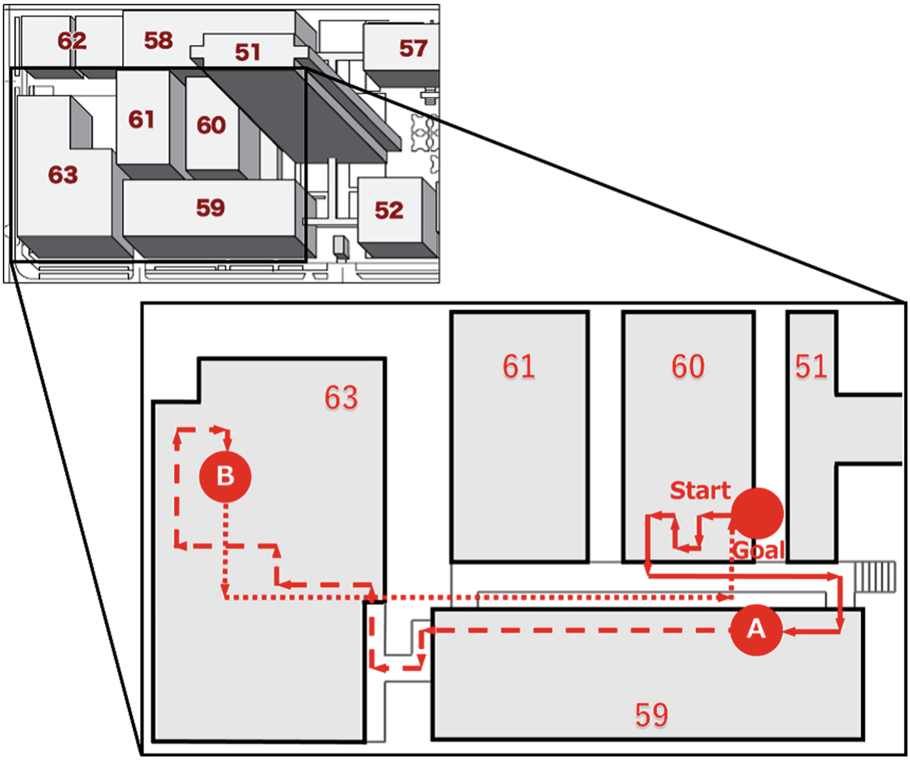



**Fig. 2.** Route guided by the "BearNavi Tour" [11]

following question in six levels: "Was navigation by the character easy to follow?" Table 1 shows the choices and the number of people who answered.

Approximately 70% of the participants (i.e., 11 of 16 participants) answered either "I think so," "I think so somewhat," or "I think so if anything." The most common reason was "I just follow the character" (i.e., 7 of 11 participants selected this reason). Therefore, the navigation method of following the character tended to easily assist users. In contrast, the participants who did not think it was easy to follow the route answered, "Because the direction was difficult to understand" or "the character sometimes went to a place that is not on the path."

Next, the participants answered in six levels to the following question: "Were you feeling uneasy if you were walking the right path?" Table 2 shows the choices and the number of people who answered. More than 80% of the participants answered either "I was," "I was somewhat," or "I was if anything" (i.e., 13 of 16 participants). This result implies that some situations made the user feel uneasy. The most common reason for this uneasiness was "since the character sometimes went to a position outside the path, there could be errors in the positional information." Ten out of 13 participants expressed this reason, which can

**Table 1.** Answer of the first question (N = 16)

| Choice | Number of people |
|---|---|
| I think so | 4 (25% of the total) |
| I think so somewhat | 5 (31.3% of the total) |
| I think so if anything | 2 (12.5% of the total) |
| I don't think so if anything | 2 (12.5% of the total) |
| I don't think so somewhat | 2 (12.5% of the total) |
| I don't think so | 1 (6.3% of the total) |

be attributed to the fact that the positional information cannot be correctly measured, and an error frequently occurs in the positional information. Particularly on route 2, the character passed through a non-aisle area, and the situation where the user stopped moving forward and started over again occurred many times. This problem seemed to have influenced the questionnaire results.

**Table 2.** Answer of the second question (N = 16)

| Choice | Number of people |
|---|---|
| I was | 4 (25% of the total) |
| I was somewhat | 7 (43..8% of the total) |
| I was if anything | 2 (12.5% of the total) |
| I wasn't if anything | 0 (0% of the total) |
| I wasn't somewhat | 2 (12.5% of the total) |
| I wasn't | 1 (6.3% of the total) |

Finally, the participants answered on six levels to the question "Did you lose your way?" Table 3 shows the choices and the number of people who answered. More than 80% of the participants answered either "I did," "I did somewhat," or "I did if anything" (i.e., 13 of 16 participants). This result indicates that a situation occurred, in which the user loses direction. This also seemed to be caused by the error of the positional information.

The questionnaire results indicated that navigation using this application tended to be considered easier; however, many participants felt uneasy or lost.

### 5.2 Human Behavior Analysis

We obtained as log data the coordinate data every 3 s from the point where the QR code was read. We made the movement locus of the participants from the coordinate data and clarified the user behavior while using the application. This movement locus showed three actions that did not meet the conditions of

**Table 3.** Answer of the third question (N = 16)

| Choice | Number of people |
|---|---|
| I did | 4 (25% of the total) |
| I did somewhat | 7 (43.8% of the total) |
| I did if anything | 2 (12.5% of the total) |
| I didn't if anything | 2 (12.5% of the total) |
| I didn't somewhat | 0 (0% of the total) |
| I didn't | 1 (6.3% of the total) |

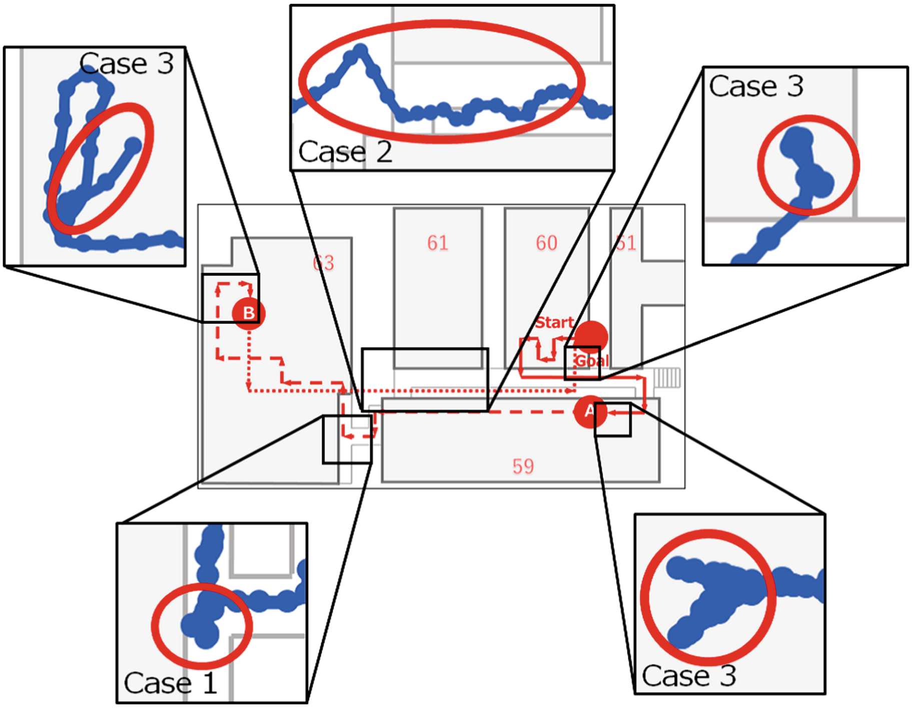



**Fig. 3.** Movement locus of subjects

the correct guide defined in Sect. 3 (i.e., "Going in the opposite direction to the real direction," "Going right or left on a straight road," and "Turning back the way"). "Going in the opposite direction to the real direction" and "Going right or left on a straight road" were counted as 1 for cases where the user acted for over 9 s. "Turning back the way" was counted as 1 for cases where the user acted twice or more in the same straight line. Figure 3 shows movement locus of subjects.

**Case 1.** Five of 16 participants exhibited the behavior of "Going in the opposite direction to the real direction" at the same point on Route 2. At the point encircled in the figure, the subject went to the left when it should go to the right. This behavior arose from the problem that the character moved in reverse because of an error in the positional information.

**Case 2.** Seven of 16 participants exhibited the behavior of "Going right or left on a straight road." Six participants exhibited this behavior at the point encircled. The cause of this behavior was thought to be the character going right or left on a straight road because of an error in the positional information. Many stores opened in this street on the day of the event, and many people were here. The user needed to go ahead by avoiding people. This seemed to also have influenced this behavior.

**Case 3.** The behavior of "Turning back the way" was the most common among the three, and 11 participants exhibited this behavior. As shown in the figure, this behavior was frequently observed near checkpoints A, B, and the goal point, and seemed to be an action wherein the participants searched for "Bear Coins" and quiz tips. "Bear Coins" and quiz tips are found as soon as the user follows the character. However, such behavior seemed to be observed because the participants were not correctly guided to the destination.

### 5.3 Discussion of Hypotheses

The questionnaire results showed that the navigation of this application tended to easily catch the route. Nevertheless, the user felt uneasy and lost direction. In addition, three actions of the user considered to be abnormal were seen. Therefore, the navigation of this application lacked accuracy. These results supported one of the three presented hypotheses. Each hypothesis is discussed below.

Hypothesis 1 (i.e., "The navigation by the AR character agent is easy for the user to understand.") was supported. The questionnaire results showed that the users tended to easily understand the routes. Hypothesis 2 (i.e., "The navigation by the AR character agent provides a sense of security to the user.") was not supported. The questionnaire results showed a situation in which the user felt uneasy. Hypothesis 3 (i.e., "The navigation by the AR character agent is accurate.") was not supported. The log data results indicated that the navigation of this application was not accurate.

## 6 Conclusion and Future Work

This study focused on the efficiency of route navigation following an AR character agent. We assumed that the navigation leads to an easy understanding of the route, provides a sense of security, and guides correctly. We evaluated the guide by conducting an experiment using the navigation application. Consequently, users thought that the navigation using the AR character agent easily helps finding and following the route. Therefore, this paper's contribution is the realization of an easy route navigation.

However, some situations made the user feel uneasy and lost. The navigation of this application also lacked accuracy. As mentioned earlier, some problems were encountered. The implementation of experiments with a larger number of participants, comparative experiments with other navigation systems, and analysis of the interaction between the user and AR in more detail will be future tasks. In particular, comparison with other navigation methods is necessary to clarify the effect of AR character.

## References

1. Yokoi, K., Yabuki, N., Fukuda, T., Michikawa, T., Motamedi, A.: Way-finding assistance system for underground facilities using augmented reality. In: Proceedings of Indoor–Outdoor Seamless Modelling, Mapping and Navigation, International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences, vol. 44, no. W5, pp. 37–41 (2015)
2. Hervas, R., Bravo, J., Fontecha, J.: An assistive navigation system based on augmented reality and context awareness for people with mild cognitive impairments. IEEE J. Biomed. Health Inform. **18**(1), 368–374 (2014)
3. Chang, Y.L., Hou, H.T., Pan, C.Y., Sung, Y.T., Chang, K.E.: Apply an augmented reality in a mobile guidance to increase sense of place for heritage places. Educ. Technol. Soc. **18**(2), 166–178 (2015)
4. Chu, C.H., Wang, S.L., Tseng, B.C.: Mobile navigation service with augmented reality. IEEJ Trans. Electr. Electron. Eng. **12**, S95–S103 (2017)
5. Dunser, A., Billinghurst, M., Wen, J., Lehtinen, V., Nurminen, A.: Exploring the use of handheld AR for outdoor navigation. Comput. Graph. UK **36**(8), 1084–1095 (2012)
6. Pankratz, F., Dippon, A., Coskun, T., Klinker, G.: User awareness of tracking uncertainties in AR navigation scenarios. In: Proceedings of 12th IEEE and ACM International Symposium on Mixed and Augmented Reality – Arts, Media, and Humanities, ISMAR-AMH 2013, pp. 285–286 (2013)
7. Sekhavat, Y.A., Parsons, J.: The effect of tracking technique on the quality of user experience for augmented reality mobile navigation. Multimed. Tools Appl. **77**(10), 11635–11668 (2018)
8. Mulloni, A., Seichter, D., Schmalstieg, D.: User experiences with augmented reality aided navigation on phones. In: Proceedings of 10th IEEE International Symposium on Mixed and Augmented Reality, Basel, 26–29 October 2011
9. Campbell, A.G., Stafford, J.W., Holz, T., O'Hare, G.M.P.: Why, when and how to use augmented reality agents (AuRAs). Virtual Reality **18**(2), 139–159 (2014)
10. Thai, T.H., Chang, C.H., Chen, S.W.: Vision based indoor positioning for intelligent buildings. In: Proceedings of 2nd International Conference on Intelligent Green Building and Smart Grid (IGBSG), pp. 50–53 (2016)
11. Faculty of Science and Engineering, Waseda University. https://www.waseda.jp/fsci/en/. Accessed 15 June 2019