Improving Information Acquisition in City Tours via Simplified Virtual Scenes with Location-Based POIs

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Abstract. Virtual city environments have been used widely in recent years as a substitute for physical travel in the form of mirrored worlds. This study aims to enhance user experience by providing better self-location and spatial knowledge acquisition during visits with simplified virtual city scenes and location-based floating information of points of interest (POIs). Our goal is to reduce redundant information disturbance by simplifying the overload of environmental information. Three experiments were conducted to explore the effect of simplifying overload redundant information and different information acquisition methods. We are hopeful that our study will assist users in better learning about specific areas in reality through their visits to virtual scenes and provide some reflection for further explorations of the demands of spatial knowledge and information acquisition during a city tour.

Keywords: Virtual reality · City exploration · Location-based service · Spatial learning

1 Introduction

Virtual city environments, which are generally considered a mirrored world, have been used widely in recent years. There are three main purposes for virtual city environment applications: arrangement purpose, social purpose, and travel purpose. For arrangement purposes [4, 8], a mirrored city in the virtual environment provides an ideal place for testing and modifying tasks having great impact. Communities, such as local government and researchers, could use such environments to collaborate on arrangement tasks such as city planning and threat assessment. For social purposes [2, 5], social information is combined into virtual city environments to build an immersive social media platform in 3D, where users pretend to visit specific points of interest (POIs) and gather comments or recommendations from their social acquaintances and friends without being there in person. For travel purposes [3], a virtual city environment provides convenience for users who are not able to physically visit and helps them explore the area with related information in an immersive city tour. This paper mainly focused on enhancing the user experience via virtual reality environment scenes for city travel.

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For the travel-oriented virtual city environment, the main research was devoted to mirrored scene reconstruction, the overlay of information of POIs based on actual locations and the design of engaging interaction to enhance the user experience. Spatial learning, which refers to the process through which users acquire a mental representation of the environment, plays an important role in navigating the scene, promoting the experience of exploration in an unfamiliar area. Studies [1, 7] have demonstrated the benefits of landmark cues that enhance spatial learning in a virtual environment; users can use landmarks as reference points in natural navigation of the environment [9]. However, sometimes a mirrored virtual world based on an actual location geographically displayed on a map may contain some redundant information; for example, similar buildings in blocks without regional characteristics would easily confuse users with their locations. Such extraneous information may lead the viewer to ignore it altogether; for example, unnecessary information may cause interference with navigation without leaving significant impressions of the are-as during the experience of the visit. Therefore, this study aimed to enhance user experience by providing better self-location and spatial knowledge acquisition during the visit. To reduce redundant information, help users enhance location awareness and acquire spatial knowledge from the surrounding major spots of the area, a simplified virtual city environment was proposed in this paper, where the majority of spots, such as landmarks, are kept as mirrored ones in reality, and unimportant in-formation without characteristics would be simplified as a few general models, while the area distribution would be kept for spatial learning. Users, like tourists who are not familiar with the city, and someone who is not able to visit in person can still experience and learn about the homologous destination area by visiting the simplified virtual city environment; with photo billboards and introductions provided in addition to models, users receive a general impression of the entire area without redundant in-formation disturbance. To help users better recognize their location in the area, we designed both an overview map with the corresponding user location viewer and location-based floating information of nearby POIs to help users acquire location-based information.

To study whether the simplified virtual city scenes and different methods of floating POI information can enhance user experience in specific city areas, two user study experiments were conducted. One is the comparison between the simplified virtual city environment and the mirrored virtual city environment of one specific area. In this case, Senso-ji, a typical tourism spot in Tokyo, was chosen as an example area. Another is the comparison between location-based floating information of POIs to show nearby spots and shops as an interest-based navigation guidance and an overview map viewer of navigation guidance. Through the user study experiments, we explored the effect of simplifying overload of redundant information and the demands of information acquisition methods during an immersive virtual city tour experience. A simplified environment and position-based information could contribute to an improvement in an interest-based virtual tour experience of users, while some limitations still exist. Furthermore, the provided information should be dynamic because the user navigation requests for POI recommendations may keep changing during the tour.

2 Related Work

2.1 Virtual City Environment and Mirrored Worlds

The development of virtual reality (VR) technology prompts the probability of build-ing mirrored worlds, which aim to provide an immersive experience for users leading them to pretend to be in an alternative reality. Various visual representations or textures are used to capture and visualize similar urban scenes as reality [10], such as getting textures from maps' street view [2] and using multiple cameras to build one model from different points of views. The key differentiator of our work is the provision of a simplified virtual city environment for users' exploration. We discuss challenges such as the choices of remaining mirrored areas and simplified areas in the virtual environment, the remaining area distribution and interactive capabilities during users' exploration.

2.2 Multiple Purposes for Virtual City Environment Applications

Generally, there are three main purposes for mirrored virtual city environment applications: a) arrangement purpose; b) social purpose; and c) travel purpose.

Urban design is a typical example for applying virtual city environments in arrangement purposes [4, 8], as it affects people's experience of real-world cities, which need to be considered carefully. Developing the potential impact of urban design is important for urban planners and local governments. The virtual environment, which is a mirrored world as the reality, is an ideal platform to apply, test and modify the current design plan. Online application in a virtual city environment provides a feasible approach for collaboration between several departments and organizations as well, which is a great promotion for processing complicated affairs.

For social purposes, the virtual environment, as a mirrored world, provides a platform for combining social information with locations. For example, Geollery [2], which is an immersive social media platform in 3D, combines the social information in mainstream social media platforms into a virtual mirrored world with imaging from Google Street View. Users can walk in the virtual streets as mirrored ones in reality and obtain information from social acquaintances and friends, such as comments or recommendations of surrounding spots or shops. The improvement in immersion and location-based social information provision make it possible to be an ideal place for virtual family gathering and parties, as well as travel planning.

For travel purposes [3], a virtual city environment provides users with a place to explore and learn about the area with related information, especially for users who are not able to visit the area in reality. With a virtual traveling system, users are able to visit various destinations online without considering the arrangements for transportation and accommodations. It is a great chance for culture propagation, as more people would know a remote spot by visiting it in an online virtual environment. In this paper, the main research is designed for travel purposes, and is devoted to the overlay of POIs based on real locations with interesting interactions to enhance the user experience.

2.3 Spatial Learning in Virtual City Environment

Spatial navigation plays an important role in the virtual environment, which allows the active exploration of an unknown area without being lost through the use of spatial information and ensures efficient movement across well-known areas. Commonly used navigation supportive systems, such as Google Maps and Apple Maps, have benefits in daily navigation with efficient automatic orientation and route guidance. However, the spread of these navigation supportive systems may result in the ignoring of surrounding environment information [9] and decrease spatial knowledge acquisition. Users who are accustomed to such supportive systems gradually lose their navigation ability. Spatial learning, which refers to the process through which users acquire a mental representation of the environment, promotes users' exploration experience in an unfamiliar area.

Studies [1, 7] have shown the benefits of landmark cues that enhance spatial learning in a virtual environment and that users could use landmarks as reference points as a natural navigation skill. The interactive landmarks with related information pro-vide a natural method for users to learn about the current area. However, virtual city environments as mirrored worlds overlay landmarks that are visible to the users with redundant information making it difficult for users to be aware of the location of landmarks. To avoid such a situation, highlighting landmarks is necessary for users' spatial learning in their virtual city exploration. For example, providing virtual global landmarks [9] as references is a proper solution to improve users' spatial learning in mirrored virtual environments because the virtual global landmarks would be seen from any places without being overlayed by redundant information.

In this paper, we conduct a simplified virtual city environment, which is different from the mirrored worlds, to highlight the landmarks during users' exploration, im-proving their spatial learning. Our qualitative evaluation of comparative studies further reveals the strengths and weaknesses of a simplified virtual city environment and a mirrored virtual city environment.

3 System Overview

In this section, we present an overview of the simplified virtual city environment. Unity is used as a 3D platform, and the models are prefabs from the Unity accessory store. Google Maps is used as a reference for area distribution during construction.

3.1 Distribution of Simplified Virtual City Environment

Senso-ji is chosen as an example area for a simplified virtual city environment, which is a famous templet in Tokyo. Typical spots, such as Senso-ji, Kaminari Mon, and Hozou Mon, are constructed as mirrored spots in reality, as shown in Fig. 1 (Left), while other regions are simplified, such as shopping areas, as shown in Fig. 1 (Right). Related information is attached in addition to the typical spots, as well as introductions to several specificities.

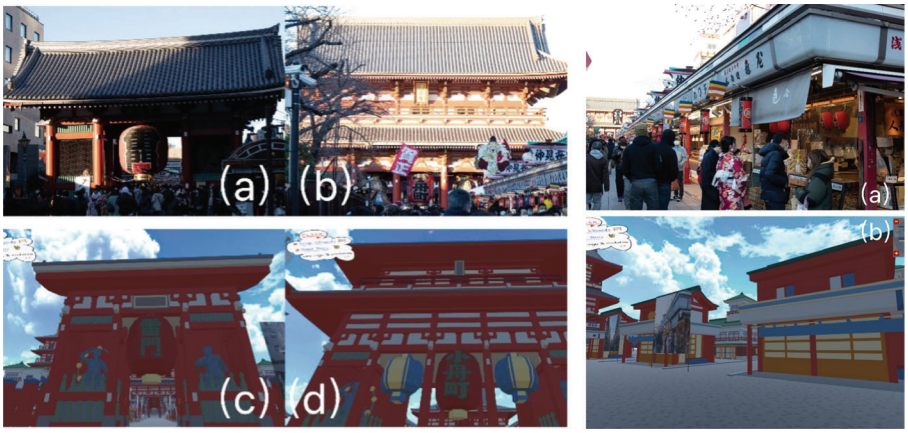

Fig. 1. (Left) Comparison between: (a) real photograph of Kaminari Mon, (b) real photograph of Hozou Mon, (c) mirrored model of Kaminari Mon, (d) mirrored model of Hozou Mon, and (Right) Comparison between: (a) real photograph of shopping street, (b) simplified model of shopping street.

3.2 Location-Based POI Guidance

Maps are provided for better exploration experience, with a mini map, an integral map, and a local map, as shown in Fig. 2 (Top). The integral map shows the distribution of the whole area, providing a general impression of this area to users. The sur-rounding POIs are shown on the mini map and the local map for users to design their own routes for exploration based on their interests, as shown in Fig. 2 (Bottom). Users are allowed to teleport to the position they want to visit by simply clicking the map.

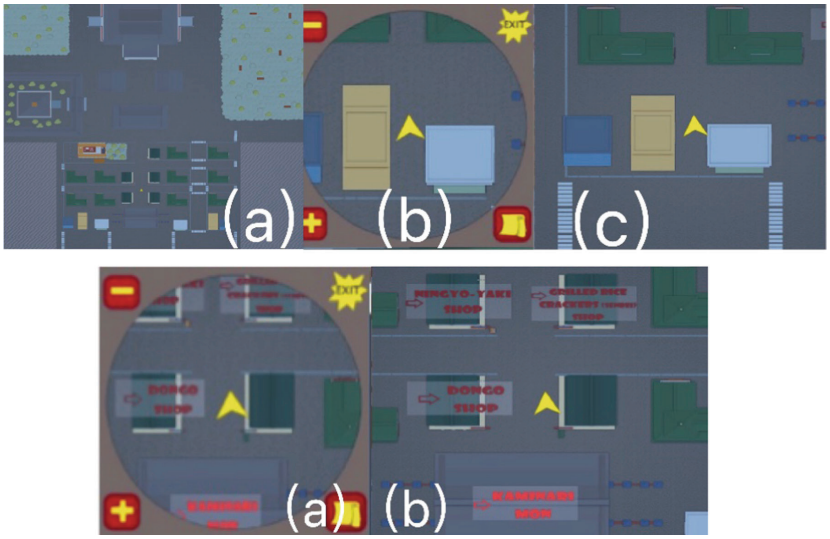

Fig. 2. (Top) Overview of maps: (a) integral map, (b) minimap, (c) local map, and (Bottom) Overview of POIs located on the maps: (a) POIs on the minimap, (b) POIs on the local map.

3.3 Virtual Representation of Reality

To help users gather information to learn about the same area in reality, we designed image billboards as a virtual representation of reality and separated them among the whole area to show users the reality information, as shown in Fig. 3. All photos are taken by the Canon camera in Senso-ji.

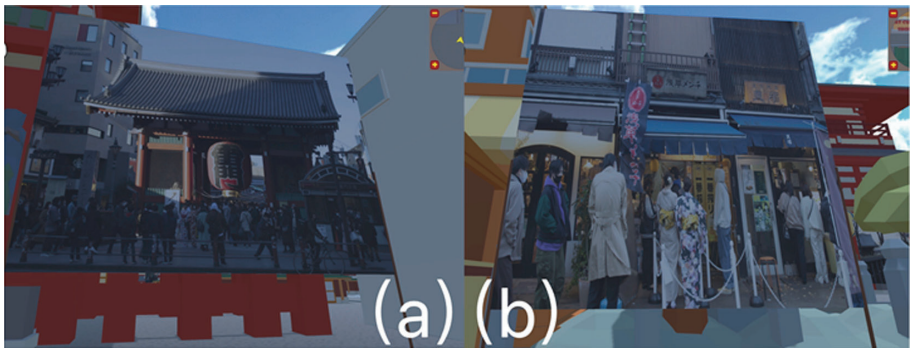

Fig. 3. Overview of image billboards located beside: (a) Kaminari Mon and (b) Meat cutlet shop.

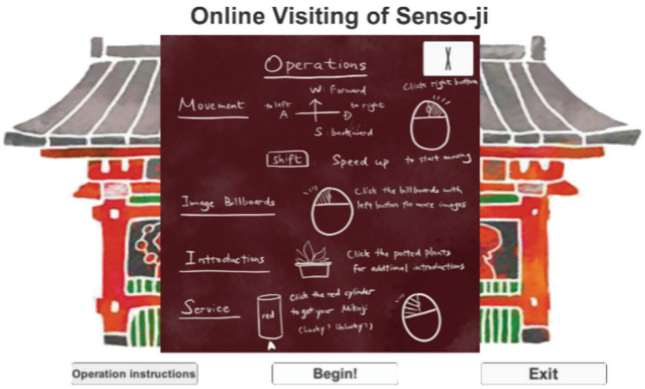

Fig. 4. Overview of operation instruction page.

3.4 Interactive Capabilities

Several interactive capabilities are available in this simplified virtual city environment.

Operation instruction. In the opening page of this system, an operation is provided for users to learn about the operation methods and interactive experiences inside the scene, as shown in Fig. 4.

Potted plants. Inside the scene, potted plants are placed beside the models, which could interact to show the related information of specificities, as shown in Fig. 5.

Online omikuji. At the omikuji corner, there is an interactive omikuji box, as shown in Fig. 6 (Left) for users to experience an online omikuji game, which is a typical event

in Senso-ji. Users could test their fortune with seven different results: a) best fortune; b) regular fortune; c) medium fortune; d) a little fortune; e) fortune but finally; e) a little fortune but finally; and f) bad fortune, as shown in Fig. 6 (Right). We conduct this service to help users connect virtual city exploration with reality exploration to improve the attractiveness of their exploration in simplified virtual city scenes.

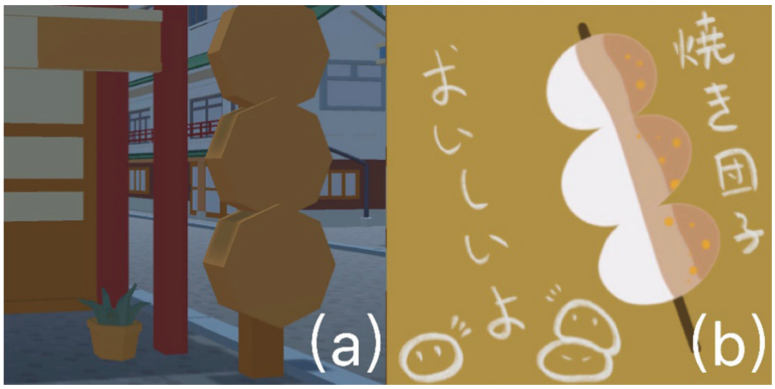

Fig. 5. Overview of (a) potted plants, (b) related information introduction.

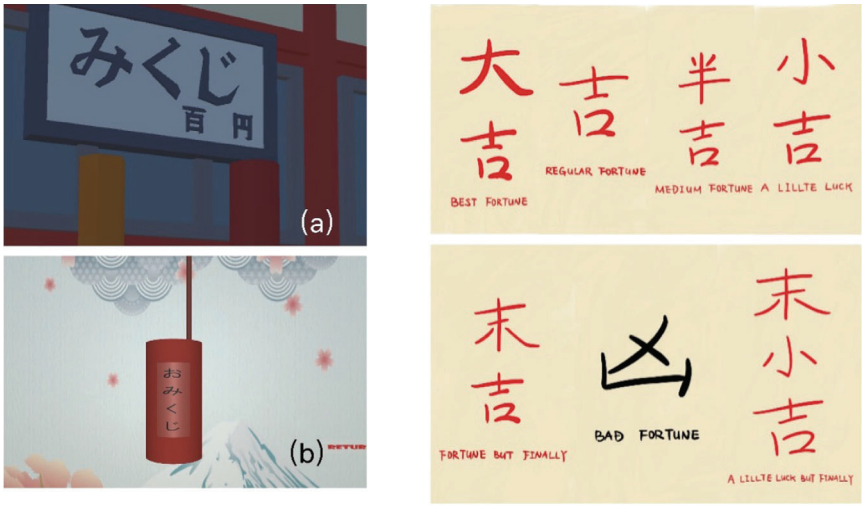

Fig. 6. (Left) Overview of (a) interactive item for omikuji, (b) online omikuji event, and (Right) Overview of various fortune results.

4 User Study

Two studies are conducted to investigate the environment and navigation influences during virtual city tours. In the first study, we wanted to directly compare the improvement in spatial learning using a simplified virtual environment instead of a mirrored virtual environment. We reasoned that the simplified virtual environment might be clearer and easier for users to learn about the area distribution and surrounding POIs. In the second study, two navigation approaches are compared, location-based POI guidance and simple guidance according to minimap information, to investigate a proper approach to provide information during virtual city tours in simplified virtual environments. We suspect that location-based POI guidance would help users design their touring routes based on interests, improving their virtual tour experience. These two comparison studies were performed online by watching demos since COVID-19 has spread recently. Furthermore, in a third study, the simplified virtual city tour system was implemented by participants for comments and advice. We believe these comments and advice will help us improve the simplified virtual city tour system in the future.

4.1 Study 1: Comparing the Virtual City Environment

Study Design. Our study has two environmental variables: the simplified virtual city environment and the mirrored virtual city environment. The simplified virtual city environment retains the main spots as mirrored regions and simplifies other regions to reduce redundant information and stress featured landmarks. The mirrored virtual city environment used in this comparison is google earth, which uses map information in reality to build a mirrored world, as shown in Fig. 7. A virtual tour demo is prepared for each virtual environment, with a questionnaire shown in Table 1 to investigate the exploration degree of the specific region in each virtual environment.

Fig. 7. Overview of mirrored virtual environment (Senso-ji).

Table 1. Questionnaire of exploration degree in virtual environment

Q1. Do you remember the name of the temple?
Q2. Do you remember what is been written in gate board?
Q3. Do you remember the mikuji corner?
Q4. What is your idea about getting your own mikuji online? (Be interested or not)
Q5. Please write down names of spots or specialties you remember

Depending on our concept and study design, we propose the following hypothesis:

H1: We expect that the simplified virtual city environment could help users focus on landmarks and have a better impression of area distribution.

H2: We expect that the simplified virtual city environment shows information more clearly, improving users' visiting experience.

Implementation. To implement the virtual city tour demo, senso-ji, a famous spot in Tokyo, is chosen as an example region for visiting. Image billboards and interactive icons are located near main spots in the simplified virtual city environment to help users learn more about this region and build connections between virtual and reality scenes. For better comparison, the same interactive icons are attached to Google Earth, the mirrored virtual city environment, as shown in Fig. 8, and two virtual tour demos are within similar time periods.

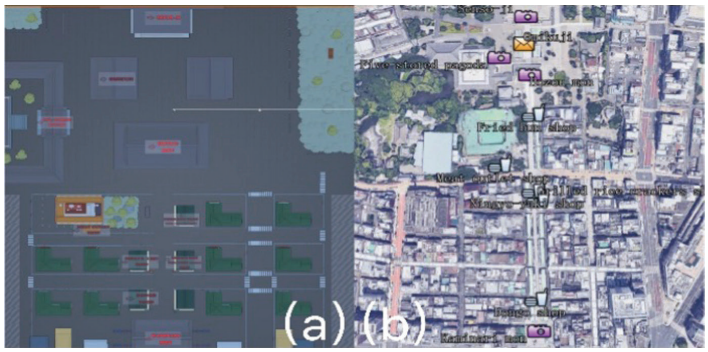

Fig. 8. Overview of POI locations in: (a) a simplified virtual environment and (b) a mirrored virtual environment.

Participants. We invited 15 volunteer participants for each environmental variable (30 in total). for the mirrored virtual city environment, 15 participants are invited (10 males and 5 females), aged between 20 and 30 years (average age = 24.3). We asked the participants to describe their experience in virtual tours and acquire POI Information during a tour, and 8 had virtual tour experience by using virtual maps or travel assistant apps. Recommendation systems (8 participants) and maps (6 participants) are their

major approaches for POI information acquisition. generally, 15 participants were not familiar with Senso-Ji, including 10 participants who had not visited Senso-Ji and 6 participants who visited once without leaving many memories. For the simplified virtual city environment, 15 participants were invited (9 males and 6 females), aged between 20 and 30 years (average age = 24.5). We asked the participants to describe their experience in virtual tours and acquire POI information during a tour, and 7 had virtual tour experience by using virtual maps or travel assistant apps. Recommendation systems (8 participants), specific searches (5 participants), and maps (6 participants) are their major approaches for POI information acquisition. Generally, 15 participants were not familiar with Senso-Ji, including 13 participants who had not visited Senso-Ji and 2 participants who visited once without leaving many memories.

Results. The questionnaires included several questions to test the exploration degree for each environmental variable. accuracy is calculated for each question, as shown in Table 2. For the mirrored virtual environment, the accuracy for Q1 is 26.7% (4/15), the accuracy for Q2 is 33.3% (5/15), and the accuracy for Q3 is 53.3% (8/15). The aver-age number of main spots and specialties remembered after virtual tour is 0.67 per person (10 in total). For the simplified virtual environment, the accuracy for Q1 is 33.3% (5/15), the accuracy for Q2 is 86.7% (13/15), and the accuracy for Q3 is 80.0% (12/15). The average number of main spots and specialties remembered after the virtual tour is 1.4 per person (21 in total). For the online Mikuji event, 26.7% (8/30) of the participants showed their interest in getting their own Omikuji online, while 26.7% (8/30) of the participants showed no interest in this event. A total of 46.7% of participants (14/30) showed no preference for this event.

Table 2. The results for exploration degree questions in the questionnaire

Accuracy	Q1	Q2	Q3	Average number of main spots and specialties remembered
Mirrored virtual environment	26.7%	33.3%	53.3%	0.67
Simplified virtual environment	33.3%	86.7%	80.0%	1.4

Discussion. Based on our study results, the simplified virtual city environment shows a better exploration degree for participants within a similar time period (19.8% higher accuracy in Q1, 61.6% higher accuracy in q2, and 33.4% higher accuracy in Q3). Therefore, we can accept Hypothesis *H1*.

Most participants in the simplified virtual environment could name or describe at least 1 or 2 main spots and specialties, while most participants in the mirrored virtual environment stated that they forgot the details of the main spots and specialties, as well as their names (52.1% higher on average, the number of main spots and specialities remembered after the virtual tour). Therefore, we can accept Hypothesis *H2*.

Participants stated that they would use a virtual tour system for traveling assistants, for example, checking for information correctness, searching for routes in advance or visiting places that are difficult to visit in reality. However, mainstream traveling assistant

applications and digital maps may contain redundant information, which confuses users remembering main spots in the region and prevents them from efficient spatial learning. Under such a situation, the simplified virtual tour system is more suitable for users who are not familiar with their destination region to learn about the general information of that region, such as distribution and surrounding POIs, and help their route planning efficiently during the tour.

An online omikuji event is a service that connects a virtual city environment and a reality city, which helps users become familiar with the reality event located inside the region. Since some participants showed their interest in this service, its gamification may improve users' experiences during visits.

4.2 Study 2: Comparing Navigation Approaches

Study Design. Our study has two navigation variables: location-based poi guidance and minimap information guidance. The simplified virtual city environment is used in this study. The location-based POI guidance approach provides floating information about surrounding POIs, which allows users to choose their next destination according to their interests. The click-to-teleport function is applied to the floating information map as a convenient and direct method for user movement in city tours. A virtual tour demo is prepared for each navigation approach, with a questionnaire shown in Table 3 to investigate the exploration experience of the specific region with each navigation approach.

Depending on our concept and study design, we propose the following hypothesis:

H3: We expect that location-based POI guidance provides clearer regional information during tours, which would be preferred by more users.

H4: We expect that location-based POI guidance provides more suitable route planning for users based on interests.

Table 3. User experience evaluation on different guidance approach

Q1. Which mode do you prefer for acquiring location-based Point-of-interests information?
Q2. Which one do you think is more interesting?
Q3. Which one do you think is more attractive?
Q4. Which one do you think is more helpful to learn about the surrounding POIs while visiting?
Q5. Which one do you think is clearer to show the general area distribution?

Implementation. To implement the navigation guidance demo, the simplified virtual city tour system is used as an example for virtual city tours. The location-based POI guidance approach allows users to click on the POIs they prefer to visit and teleport to their destination. The minimap information guidance provides the minimap and general map of this region, as shown in Fig. 9, so users can select their destination according to the area distribution. For better comparison, similar visiting routes are used for both navigation approaches.

Participants. We invited 19 participants (8 males, 11 females) aged between 20 and 56 years (average age = 27.4). We asked the participants to describe their experience in virtual tours and acquire POI information during a tour, and 7 had virtual tour experiences by using virtual maps. Recommendation systems (11 participants) and maps (11 participants) are their major approaches for POI information acquisition. Nine participants had not visited Senso-ji, while 10 participants had visited.

Fig. 9. Overview of minimap information guidance, includes: (a) minimap and (b) integral map

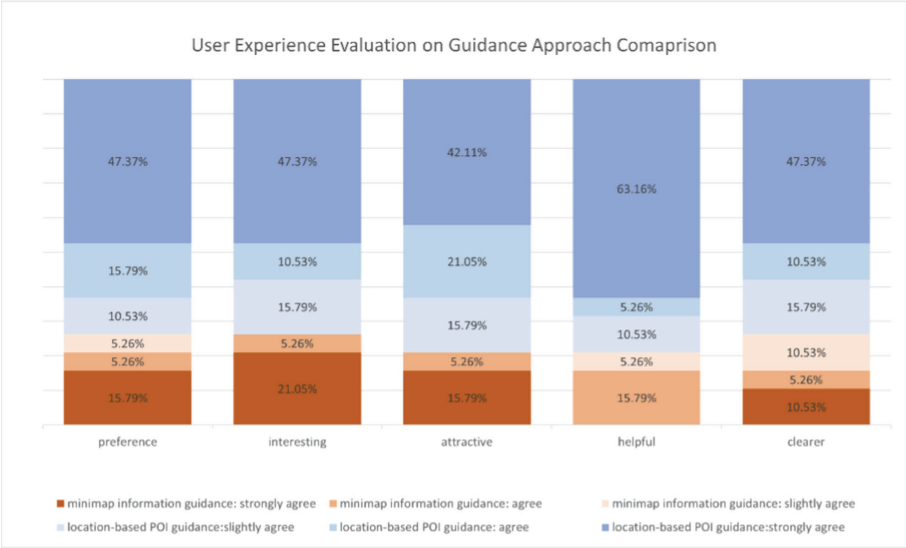

Fig. 10. Results of user experience evaluation on guidance approach comparison.

Results. The questionnaire included several questions, and investigated two users' preferences on different guidance approaches. As shown in Fig. 10, over 70% of participants (14/19) showed their preference for location-based POI guidance as a navigation approach during their virtual tour. None of the participants reported that they strongly agreed

that the minimap information guidance approach is more helpful, while an extremely large number of participants (12/19) strongly agreed that location-based POI guidance is more helpful during tour.

Discussion. Based on our study results, location-based POI guidance is ahead in all ratings, especially in helpful aspects, where over 60% of participants strongly agreed that location-based POI guidance is more helpful during their tour. The majority of the participants preferred to use location-based POI guidance during virtual tours and said that this guidance approach is interesting and attractive. Therefore, Hypothesis *H3* is accepted.

Over 70% of participants agreed that location-based POI guidance is clearer to show surrounding information, which is more helpful to plan their routes based on interests and learn about the region as well. Therefore, our Hypothesis *H4* is accepted.

Participants stated that they would use a virtual tour system for travel planning, for example, learning about the region in advance for major spots and route planning. Some participants preferred to use a virtual tour system to visit some regions to decrease their cost in money and time and to learn about the introduction to the region. Under such situations, the location-based POI guidance approach is more suitable for users to learn about the surrounding POIs according to their locations and design routes step by step. They may have the chance to visit famous spots without actually being there, which would reduce the cost of transportation and accommodations.

4.3 Study 3: User Experience of a Simplified Virtual City Environment System

Study Design. To investigate the performance of the simplified virtual city tour system, we conducted a study of users trying virtual city tours with a simplified system to evaluate their virtual tour experience. Participants are allowed to explore the simplified virtual city in freedom for approximately 10 minutes and respond to the questionnaire shown in Table 4 about the user experience of this simplified system. Comments and advice are expected from users for future improvement.

Participants. An executable file is exported from Unity and is uploaded to the cloud platform for remote use by participants. An operation instruction is attached on the opening page with an interactive button to explain the common functions and operation methods in this simplified virtual city system. A 10-min exploration in freedom is required before answering a questionnaire to show users' comments and advice in this simplified virtual city tour system.

Implementation. Five volunteer participants are invited (4 males), aged between 23 and 25 years (average years = 24.0), to experience the practical use of the simplified virtual tour system. We asked the participants to describe their experience in virtual tours and ac-quire POI information during a tour, and 2 had virtual tour experience by using virtu-al maps and wandering virtual games. Recommendation systems (3 participants) and specific searches (2 participants) are their primary approaches to POI information acquisition. One participant had not visited Senso-ji, while 3 participants had visited.

Table 4. User experience evaluation of the simplified virtual city tour system

Q1. Do you think this simplified virtual scene with location-based POIs is supportive?
Q2. Do you think this simplified virtual scene with location-based POIs is easy to use?
Q3. Do you think this simplified virtual scene with location-based POIs is efficient?
Q4. Do you think this simplified virtual scene with location-based POIs is clear
Q5. Do you feel exciting when exploring in simplified virtual scene with location-based POIs?
Q6. Do you feel interesting when exploring in simplified virtual scene with location-based POIs?
Q7. Do you think this simplified virtual scene with location-based POIs is inventive?
Q8. Do you think this simplified virtual scene with location-based POIs is leading edge?
Q9. Do you think this kind of virtual tour would be helpful when you visit the same area in the reality?
Q10. Do you think this simplified virtual scene with location-based POI guidance could help you to plan exploration route based on your interests preference and need?

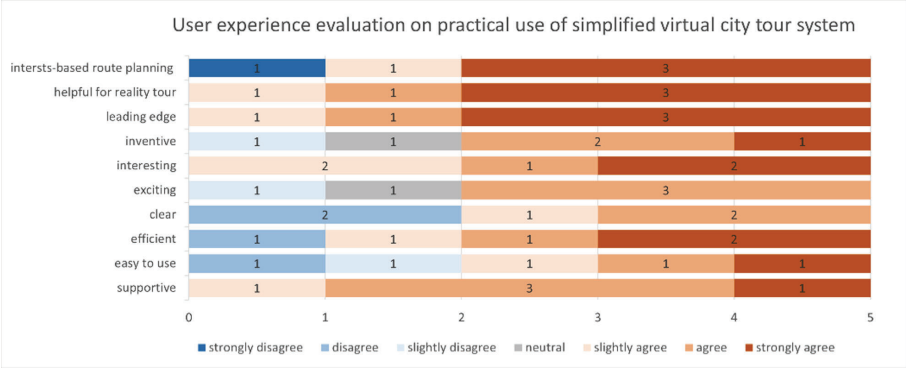

Fig. 11. Results of user experience evaluation of the simplified virtual city tour system.

Results. The questionnaire includes several questions to investigate user experience during their exploration in the simplified virtual city tour system. As shown in Fig. 11, all participants agreed that this simplified virtual tour system is supportive and is helpful for their reality tour. Leading edge and interesting aspects were also agreed upon by all participants. However, participants were shown to have some doubts about the ease of use and clarity of the tour system.

Discussion. Based on our study results, guidance clarity and ease of use are the main problems that affect the user experience of this simplified virtual tour system. Some comments from participants are as follows: *'The guidance to interactive items inside the system is not clear, and I need spend some time to find them…' (P3). 'Movement operations are quite different from other systems, which need to hold the right button*

to activate the movement functions. Users who skip the operation instructions on the opening page may not have chance to check for operations inside the system…' (P1). 'Information insides the scene is not enough for me to explore and design a route. I can only get introductions for specialties when exploring on the main shopping street. I hope more information would be attached for other parts of the scene…' (P4). According to those comments, attention guidance for interactive items inside the scene is a major problem that needs to be addressed to improve user experience. Since some simple approaches to guide users' attention, for example, arrow or sur-rounding highlights, are proven to decrease immersion during the tour, immersion preserving attention guidance [6] should be considered in this simplified system. Information on other parts of the region should be added to future work for a better exploration experience.

5 General Discussion

According to our studies, the simplified virtual city environment showed better spatial learning than the mirrored virtual city environment, especially in remembering main spots and typical specialties. The simplified area stresses the main spots and reduces redundant information disturbance; participants were able to pay more attention to the mirrored spots remaining inside the scene. Participants showed their interest in exploring simplified virtual city tour systems for travel assistance and route planning with location-based POI guidance. The floating POI information around their location could help them choose their next destination based on their interests. According to the comments by participants, they preferred to use such a simplified virtual city system for route planning and leaning about the region in advance. Some participants preferred to visit some spots to reduce their costs on transportation and accommodations and acquire relevant information about the spots if they had difficulties visiting in reality.

However, some limitations still exist. The number and gender of participants in Study 3 may have some influence on the final results. The attention guidance to interactive items inside the scene also needs to be improved. Attaching icons of interactive items to maps may be a great idea to show users the distribution of surrounding interactive items. The immersion-preserving attention guidance method is also needed to guide users' attention to interactive items when they are not referring to maps. The information inside the scene is mainly located on the main street inside the scene, which may affect users if they want to explore other parts of the region.

6 Conclusion

In this paper, we propose a simplified virtual city tour system with location-based POI guidance to improve user experience in virtual city tours. We found that a simplified virtual environment could improve users' spatial learning by stressing landmarks, and location-based POI guidance could help users plan their route based on interests. We expected that this simplified virtual city tour system can be improved in future work, for example, a more convenient operation instruction access while virtual tours and more attention guidance to interactive items. We hope to find more participants of different genders for user experience as well.

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