Open Experiments of Mobile Sightseeing Support Systems with Shared Virtual Worlds

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ABSTRACT

In this paper, we describe results from the experiments of a location-dependent shared virtual world system applied to sightseeing entertainment. This system can be used with GPS-phones on the current Japanese market. Users can enjoy interacting with virtual objects including virtual animals/agents. Subjects of the experiments were real tourists who had their own GPS-phones compatible with our system. We found that evaluations on the system varied depending on age, gender, and experiences of subjects. Results from the experiments gave suggestions on prospective users and service design.

Categories and Subject Descriptors

H5.m [**Information Interfaces and Presentation (e.g., HCI)**]: Miscellaneous. J.4 [**Computer Applications**]: Social and Behavioral Sciences

General Terms

Design, Experimentation, Human Factors.

Keywords

Shared Virtual Environment, Mobile Phones, User Study.

1. INTRODUCTION

In Japan, a mobile phone company (KDDI/au) employs GPS function based on Qualcomm's gpsOne system. More than 15 million GPS phones have already been shipped out in Japan. The company also provides some flat-rate packages for data packet communication. This means that many people can enjoy GPS-based applications without paying extra costs. Other two major mobile phone companies also provide some GPS-phones. The government plans to embed location-sensors on all phones shipped out in Japan from April 2007.

There are some research projects developing virtual world models for mobile users including entertainment applications for gaming or tourist guide [1-9]. However, they have adopted PDA (with an attached GPS antenna) or larger terminals that are not appropriate for real usage by consumers. We have considered that the mobile phone is the most prospective multimedia portable terminal from the viewpoint of popularity and business costs. However, shared virtual worlds for phones have not yet thoroughly been evaluated.

In particular, an important problem of other research projects was that *subjects recruited for the evaluation used an unfamiliar terminal.* In such cases, subjects tend to evaluate devices rather than services. Another problem was that *subjects were recruited for the evaluation itself and did not use the system for their real motivation*. For example, university students recruited for the experiment or guests of an IT-related event have different motivations, as they are not sightseeing visitors.

We have developed a virtual world service for popular mobile phones in Japan, so that users can enjoy virtual world services without buying extra devices or paying extra communication costs if they already have any GPS-phone. The system is based on our SpaceTag concept [10]. We developed some prototypes and evaluated them [11, 12]. Past evaluations were given by recruited subjects such as students. This time, in order to obtain more pragmatic evaluations from subjects of all ages, we conducted evaluation sessions at sightseeing destinations, asking *real* tourists on the spot to use our sightseeing guide system, with their *own* mobile GPS-phones.

Another challenge is to solve the problem of *balanced interest* to real and virtual worlds. In the past evaluation [12], it was pointed out that users should neither be absolutely absorbed into the virtual world nor neglect it, in order to realize successful mobile information service for sightseeing entertainment.

In this paper, after showing the system outline in section 2, we will describe the evaluation by real tourists at two popular sightseeing destinations in our local area in sections 3 and 4. Both of the two evaluation sessions were held in November 2005, after about half-year of development. The first destination, the

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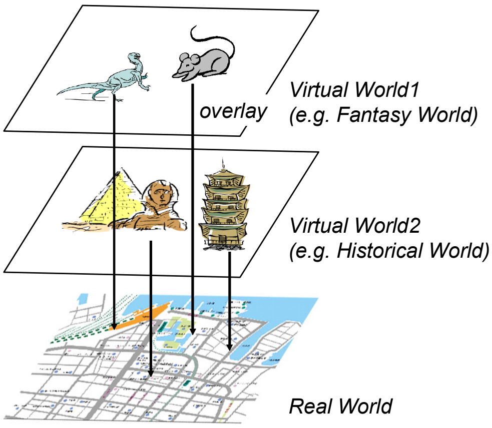

Figure 1. Overlaid Virtual Model

Kotohiragu Shrine, has a natural goal -- the main shrine building -- after a long and hard approaching way. The second destination, Ritsurin Park, is a garden, where visitors can freely walk about, without particular goals. The difference should be considered in the design of service:

- At Kotohiragu, visitors are always conscious of their relative location from the goal. GPS accuracy problem is easier to handle since the walking path is restricted.
- At Ritsurin Park, we should give a story-less navigation that can keep visitors' interest. For this purpose, designers from Tama Art University mainly participated in the service design. The GPS accuracy problem is not easy to handle at Ritsurin Park since the walking path is not so restricted.

Besides these differences, we have found many interesting facts through these experiments. They will be also mentioned in sections 3 and 4. Finally, we will conclude this paper in section 5.

2. OVERVIEW OF THE SYSTEM

With our system, users can experience virtual worlds using mobile phones. Each virtual world has the same geographical parameters with the real world. In other words, we can create various virtual worlds that have the same geographical structure, and they can be overlaid onto the real world. We call it the overlaid virtual model (Figure 1 [10]). A user can select and visit one (or even more) virtual world with his/her mobile terminal.

A virtual world consists of virtual architectural objects and virtual creatures. Virtual architectural objects are static objects like buildings, houses, and bridges. Virtual creatures are dynamic objects that can move or interact with other objects, or with users visiting the virtual world. In other words, a virtual creature is an active agent that can react to stimuli from the environment and dynamically execute methods like giving messages to the user. They can also exchange messages with other agents. Sometimes we call virtual creatures simply agents.

From a user with a mobile phone, a virtual world can be seen with a perspective view. A far object is drawn as a small image, whereas a closer object is shown as a larger image. If a face of a virtual creature can be seen from the north side of the virtual animal, its back can be seen from its south side. Location of a user can be detected by the GPS embedded on the mobile phone.

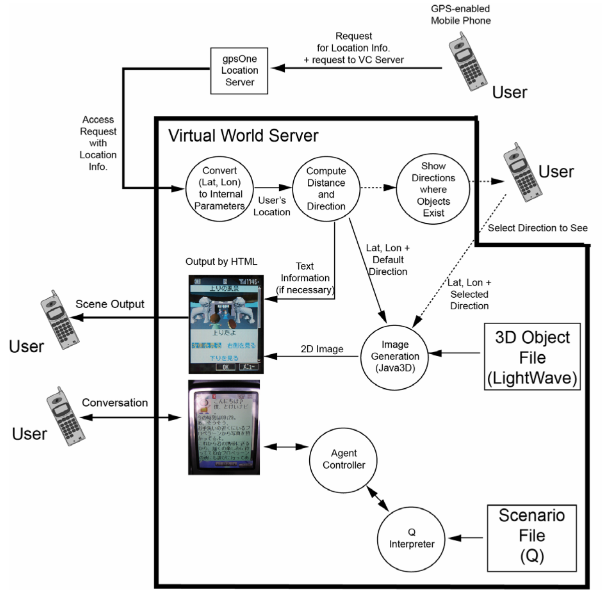

Figure 2. System Configuration (Browser-based Version)

Hence a user can walk in the virtual world while he/she walks in the real world. The correspondence between the two worlds is based on location.

We have two versions of the virtual world system: a *browser-based* version and a *Brew-based* version. The Brew-based version needs special software based on Brew[1], at the terminal side. With the Brew-based version, the graphics can be automatically redrawn [11]. However, since it needs a contract with pre-subscription of each terminal, we used the browser-based version for the open experiments.

The browser-based version does not need any special software on a mobile phone. Only a built-in browser is used. All the necessary processing for the virtual world system is performed at the server side. However, it is a *pull* information system, so a user should manually send a request to the server whenever he/she has moved to a new location, to download a new description or an image of the virtual world.

Figure 2 shows the configuration of our virtual city system prototype. It is basically a client-server system. Clients are mobile phones on the Japanese market with GPS function and internet accessibility. Because we do not have space to write more about Figure 2, please refer to our past paper [11] to understand it fully.

The system uses the Q interpreter to control the behaviors of agents. Q is a language developed by the Q consortium [13], which is a scenario-description language based on the Scheme language. A more detailed description of the agent control mechanism is given in [14].

[1] http://brew.qualcomm.com/brew/

3. KOTOHIRAGU EXPERIMENT

The first experiment was conducted at the Kotohiragu Shrine[2]. Details of this experiment are shown in [15]. In this paper, we show an outline of the experiment and its results.

3.1 Overview

3.1.1 *Provided Service*

The Kotohiragu Shrine is one of the most famous old shrines in Japan, well known for its long approaching way of stone steps. It has totally more than 1300 steps, but the main shrine building is at the 785th step. Many of the tourists stop climbing at the main shrine building and return.

At the 365th step, there is a big gate. The approaching way after the big gate is the official territory of the shrine, where many points of interest exist. We have designed a virtual world between the big gate and the main shrine building. It was a partial set of copies of the real buildings, monuments, and trees. Users can see virtual copies on the phone's display. We have totally 22 virtual copies; four of them can introduce themselves in the virtual world. They were all designed by students of Faculty of Engineering, Kagawa University (Figure 3).

A user is virtually accompanied by a *guide agent*. It is a virtual character, who gives a short message to the user whenever the user requests. The message is a description of the shrine, or sometimes just an encouraging comment to the user climbing the mountain. On the other hand, there are eleven location-dependent guide agents in the virtual world. They give tourists location-dependent comments on the shrine when they encounter them. With these agents and messages, we expected balanced interest of users in the real and virtual worlds.

Another challenge of ours was to encourage users to enjoy the shared virtual world among users. To accomplish this goal, we have designed a function to generate a new virtual creature by users themselves. A user can generate one special agent whenever he/she likes. A special agent can be given a message from the user and stays at the location where it is born. It will give the comment to other guests it encounters. Hence the comment is shared by tourists. Tourists can see how other people feel at the place by the shared comments given from a virtual creature.

3.1.2 *GPS Error Compensation*

The target mobile phones adopt the *gpsOne* location system, which has ten or more meters of inaccuracy depending on the local and temporal conditions. To avoid bad effects of the GPS inaccuracy, we have implemented a compensation method using a map of walking path, into the system shown in Figure 2. All location values measured by GPS are changed to a nearest location value that is on the map of walking path, which is given as a bitmapped data.

Fortunately, as the walking path of visitors to the Kotohiragu Shrine is limited to the stone steps, map-matching was finely implemented in this experiment. At the places where the path was straight, we were free from the location error in the orthogonal direction against the path, with this method. However, we still have an inaccuracy of five to ten meters in the direction of the path. In some places where the walking path is less restricted, for example in a square, the compensation effect was weak. Also, if the path had a corner, the compensation result was sometimes confusing. Despite the imperfectness of compensation, we can still say that the service quality had been much improved compared to the previous experiment [12].

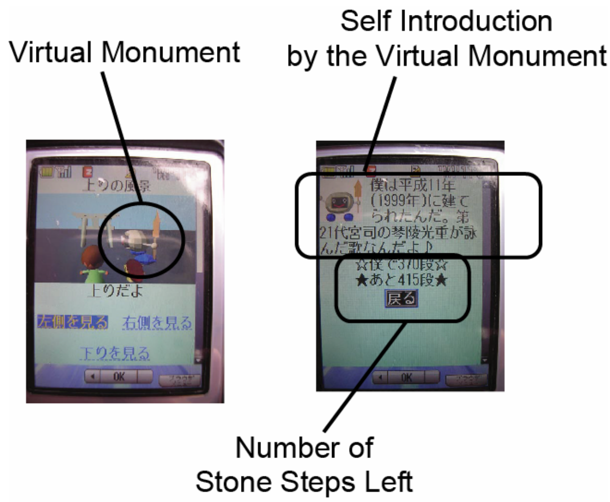

Figure 3. Sample Screenshots from the Kotohiragu experiment; a virtual world scene (left), texts (right)

Figure 4. Using the Service at Kotohiragu; the big gate (left), in front of the main shrine building: (right)

3.1.3 *Method of Experiment*

From November 9th to 15th, 2005, we stayed at the entrance of the approaching way. We caught tourists walking along the way and asked to join our experiment. We offered them a book coupon of 500 yen for their cooperation.

If a tourist accepted our offer, we gave him/her a card that only shows the URL for the service and some legal notices. We explained where the service area is and that the tourist could take an accompanying agent, and talk with it. Other detailed description of the system was given by the system itself. Receiving little information before using the system is a natural situation if the service is really intended for the public. We did not accompany the subject in order to obtain un-biased evaluation. Two pictures showing students using the service at the Kotohiragu Shrine is given in Figure 4, for readers to understand the user's situation and environment.

After 90 minutes or so, the tourists came back to us. We asked them to fill a survey form (two pages).

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[2] http://www.konpira.or.jp/ (in Japanese)

3.2 Results

During the seven days experiment, totally 29 tourists (21 men and 8 women) agreed to participate. They accessed the system 24.2 times in average, including 5.8 times of location acquisition. They talked with agents 7.7 times in average.

3.2.1 Analysis by Age

On the survey form, we asked their evaluation on the location-aware description of monuments. This evaluation of the system varies by generation. If we observe only young tourists under 30 years old (17 subjects), the score was 3.56 in average (1 is the worst, and 4 is the best). On the other hand, tourists over 30 years old gave average score of 2.67. Surprisingly, the difference between generations in this matter was much wider than other evaluations (e.g., understandability of usage). The difference was proved to be statistically significant by a t-test ($p<0.01$). Another question on the total evaluation on the service also showed different scores between generations (statistically significant, $p<0.01$). Other scores did not show any statistically significant difference.

With respect to the comment sharing function, the generation gap was much wider in the evaluation of "leaving comments" than that of "reading comments." Though they were not statistically significant, we can assume that younger people are more willing to actively communicate with others in a shared virtual world.

3.2.2 Analysis by Visitor's Experience

We had 13 subjects who visited Kotohiragu for the first time (*first-time visitors*). Other 16 people visited there for the second or more times (*repeaters*). We could not find any statistically significant differences between the two groups. However, there was an interesting suggestion.

First-time visitors supported location-aware description of monuments better than repeaters. On the other hand, repeaters supported the comment-sharing function better than first-time visitors. These tendencies can be naturally understood. We can consider that repeaters need another kind of entertainment other than just to know the shrine itself. Different service designs for first-time visitors and for repeaters should be considered.

3.2.3 GPS Accuracy

Subjective evaluation of GPS accuracy had not been improved from the previous experiment [12], although it became much better in our own evaluation. We consider that this is because the subjects did not know the former system and no comparative evaluation was made between the two experiments. Subjects always tend to require more accurate location-based system.

In order to understand the mental bad effects of GPS inaccuracy on the service, we calculated correlation coefficients of the evaluation data. All absolute values of coefficients were less than 0.4, between the evaluation of GPS inaccuracy and all other evaluations. This shows that subjects recognized the GPS inaccuracy as an independent problem from the value of service.

3.2.4 Communication between Subjects

The comments-sharing function was not used by all subjects because we did not have enough time for the introduction of this function to subjects. This function was only described in the text shown to the user at the beginning, and also in the help file. Only six subjects left their comment using this function. However, this function was fairly well evaluated among users who experienced it. Example comments they left were "I have been exhausted by climbing," and "You can find a stamp at the rest house." These types of messages are what we had expected.

3.2.5 Goal-Oriented Function

The most highly evaluated function was the indication of remaining steps to the main shrine building. It was supported by all categories of subjects. This is because there are no real signboards along the steps showing the number of remaining steps, although most climbers would like to know it. From this fact, we believe that a sightseeing destination with a goal was a successful selection for this kind of service.

3.2.6 Balanced Interest

As mentioned in section 3.1.1, agents give comments on the real world, in order to let users be aware of the real world.

Several subjects appreciated that this system gave some information that they did not know. One of the most appreciated comments from agents was that there is a water jar in which a coin floats on its water.

Some people pointed out that they felt it dangerous to use this system when they were on the stairways, especially when they were going down (though this system was just for the situation of climbing up). One of the subjects claimed that when he was using this system he was almost left alone from his friends. These facts show that they were still sometimes absorbed into the virtual world. However, the facts also suggest that the service was attractive enough.

3.2.7 Other Evaluations and Free Comments

In the free description on the survey sheet, they also gave negative comments. A popular comment was on the battery, as the GPS-related functions consumed energy.

Another popular comment was that they preferred a map on the display.

4. RITSURIN PARK EXPERIMENT

Another experiment was taken place from November 18th to 25th, 2005, at the Ritsurin Park[3], which is one of the most famous Japanese gardens. The area of experiment was approximately 300 meters x 400 meters. Note that the experiment started only three days after the end of the Kotohiragu experiment. It was not designed after some discussions on the Kotohiragu's result, but designed in parallel with the Kotohiragu system. Since November is the best season for sightseeing, we conducted both experiments in November to ask as many visitors as possible to try our system.

4.1 Overview

4.1.1 Differences from the Kotohiragu System

This system is basically similar to the Kotohiragu system, but has some differences:

(a) Artistic Design

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3 http://www.pref.kagawa.jp/ritsurin/sanukikikou/english/index2.htm

The Ritsurin Park system was fully designed by the authors from Tama Art University, while the Kotohiragu system was designed by students of faculty of engineering in Kagawa University. As an artist, the chief designer, Kayo Yokoo, defined an outlook of the virtual world.

According to her definition, there are twelve animals as virtual creatures to guide visitors. The experiment area was divided into twelve sub-areas, in each of which one of the virtual creatures lives (Figure 5). When a visitor enters one sub-area and accesses the system, a corresponding virtual creature appears in the phone's display (Figure 6(b)), gives self-introduction, and offers the user to guide around the park. When the visitor goes into another sub-area, another virtual creature will come and take its turn to guide (Figure 6(c)). This design was considered to fit the goal-less nature of the garden.

As well as these virtual creatures, some attractive trees, mountains, wooden bridges, garden houses, etc. were also designed as 3D virtual objects in the virtual world (Figure 6(d)). When a visitor accessed the system, a description of the closest point of interest was shown to the visitor. If there were no points of interest around the visitor, the accompanying virtual creature gave a location-independent description on the garden.

(b) Representation

All virtual animals have both 3D and 2D representations (Figure 5; Figure 6 (a, b)). Although 2D representations of characters were given in the Kotohiragu system, we gave more artistic (cute) 2D representations here and used them more frequently. 3D representations are shown in virtual scenes, but they are often too small in the scene. 2D representations are used with dialogs.

To change scenes, users use commands shown in Figure 6 (f). If a user moves to another location, location sensing is needed to start the GPS system. To look into another direction, four commands are prepared. Directions are shown as "Mountain," "Street," "North" and "South" according to the representations on the map given from the park office to visitors, which is different representations from the Kotohiragu's system.

We also used photographs to give explanation of several points of interest. This technique was not used at Kotohiragu. In Figure 6 (g), two targets for Japanese archery are graphically appended on a picture. This is because the garden was used for training of Japanese archery hundreds of years ago. In Figure 6 (h), a red arrow showing a direction to the next point of interest is drawn on

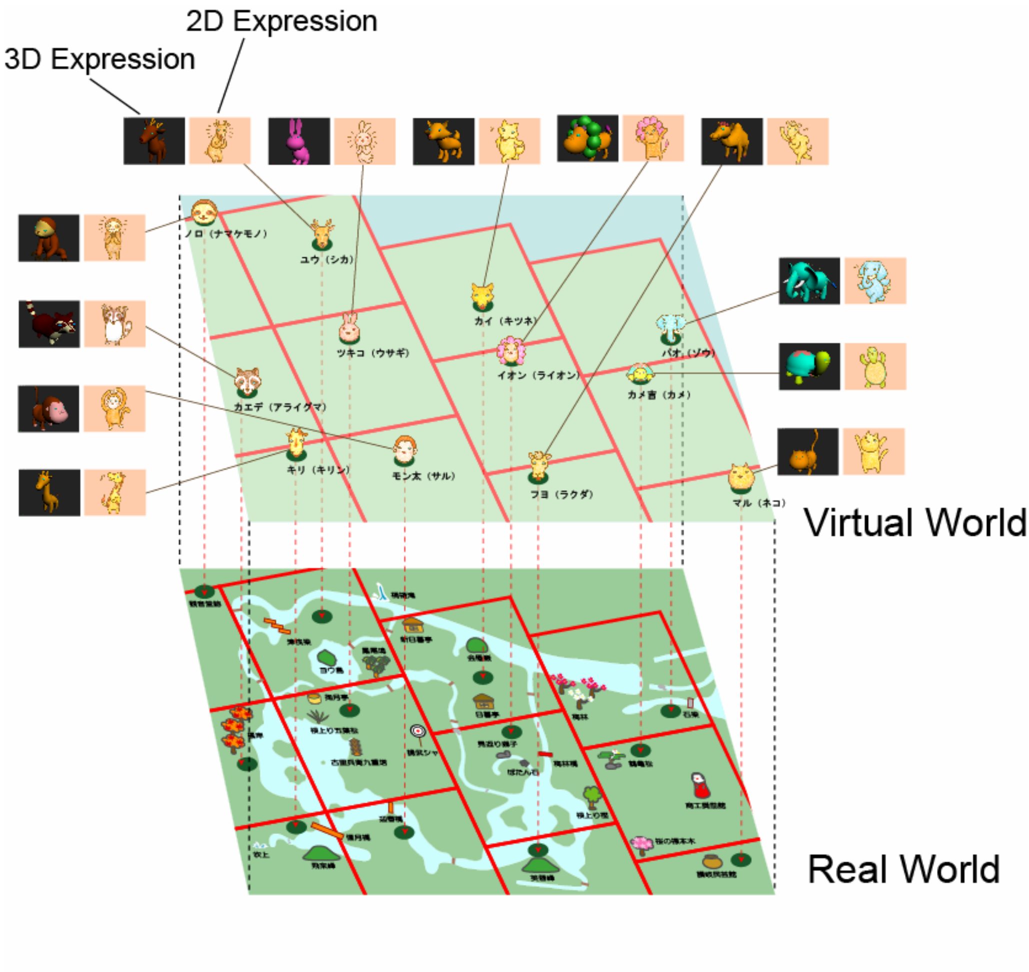

Figure 5. Outlook of the Real/Virtual Worlds at Ritsurin Park

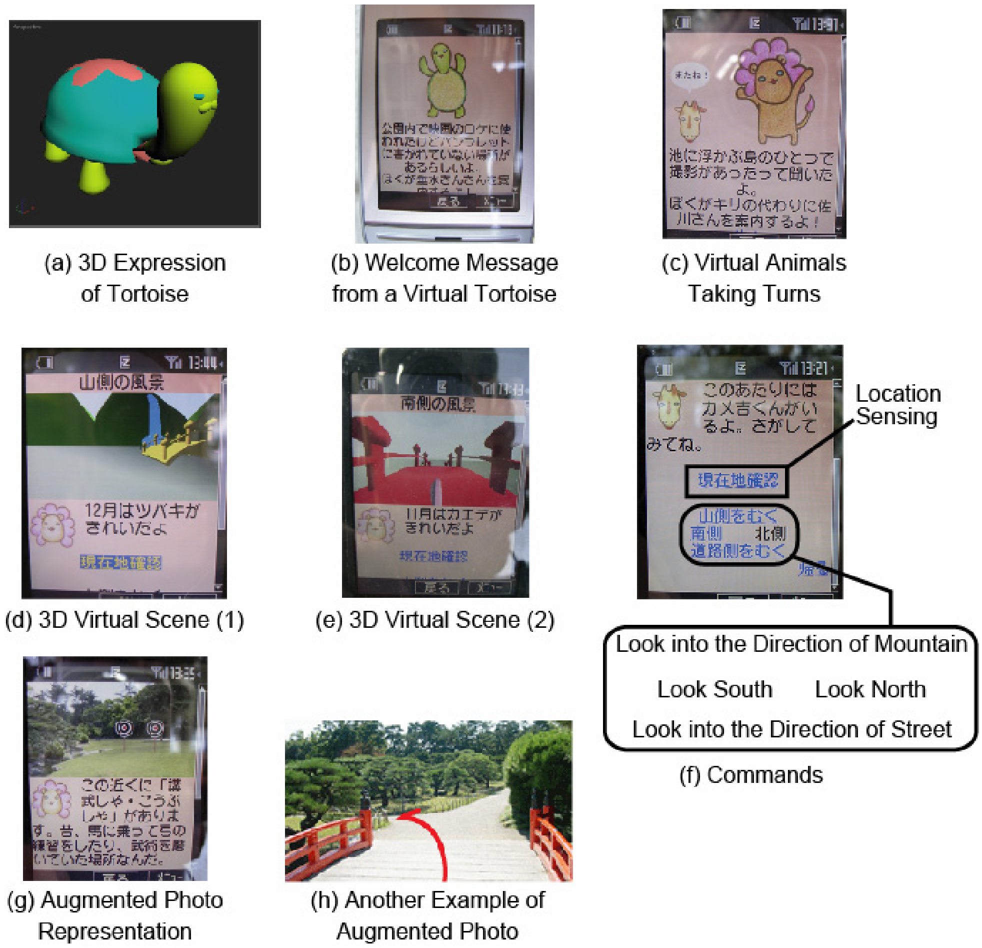

Figure 6. User Interface

a picture. These *augmented photos* were used in this system to help visitors understand the park easily. Non-augmented (pure) photos were also used.

(c) Communication between Users

Shared comments were held by virtual plants in this system. A visitor could sow a virtual seed with a comment at several places in the park. It would sprout up and a flower would come out in a few days. The comment could be read from personal computers on the Internet.

(d) Structure of User's Experience

At Kotohiragu, almost all visitors aim at climbing to the main shrine building. Hence user's experience started at the big gate and finished at the main shrine building. On the other hand, in Ritsurin Park, visitors have many options. The route of walking is not defined. Whenever a visitor likes to exit from the park, it is possible. Hence the service did not have any particular story. Visitors just encounter virtual animals that can guide them at each sub-area, one after another.

4.1.2 Method of Experiment

As with the case of the Kotohiragu experiment, we stayed near the entrance gate of the garden, and asked visitors to participate in the experiment with their own GPS-phones. Totally 35 visitors (17 men and 18 women) of all ages agreed during the seven days of experiment. To each subject, we gave a short instruction that the visitor should access GPS when he/she moved to another place. We did not accompany the subject. Figure 7 shows two volunteers (not subjects) using the system at Ritsurin Park. After 60 to 90 minutes of experience, the subject was asked to fill a survey form (two pages) and was given a book coupon of 1000 yen[4].

4.2 Results

4.2.1 Analysis by Gender

In this experiment, the numbers of men and women were balanced, and we found some results were strongly affected by gender. Female subjects gave higher evaluation to photographs better than males (statistically significant, $p<0.01$). They felt friendlier to virtual characters, liked the design of contents and descriptions better than men (statistically significant, $p<0.05$).

[4] Difference of the value from the Kotohiragu experiment is due to the higher estimation of communication cost that would be charged to subjects, if they had not made flat-rate contracts with the phone company.

Figure 7. Using the Service at Ritsurin Park

From their comments, we consider that beautiful photos and cutely designed 2D appearances of animals caused higher total evaluation by female subjects.

4.2.2 Analysis by Age

We could not find any difference between generations in the Ritsurin Park experiment, which is different from the Kotohiragu's result. We now have a hypothesis that user interfaces in this experiment was simpler than the Kotohiragu's experiment, which might cause a good effect on elder generation subjects.

4.2.3 GPS Accuracy

We installed a GPS compensation module as we did on the Kotohiragu's system. However, in Ritsurin Park, there are many squares where pedestrians can walk without restriction. At squares, of course, the GPS compensation did not work. Subjects' evaluation on GPS accuracy was not good (average =2.80, where 5 is the best and 1 is the worst score), and we cannot find any difference from the same evaluation at Kotohiragu with respect to this score.

However, at places where the walking path is restricted, GPS compensation worked well. Good examples are places near bridges. Figure 6 (e) is a 3D scene on the bridge. One subject commented it impressive.

Again, we have calculated correlation coefficients of the evaluation data. All absolute values of coefficients are less than 0.3, between the evaluation of GPS accuracy and all other evaluations. It again means that subjects recognized the GPS inaccuracy as an independent problem from the service's value.

4.2.4 Communication between Subjects

The comment-sharing function using seed was used only by a few subjects. Hence we could not evaluate this function. We regard the reason of few attempts due to the low-understanding of the concept of seeds, with the explanation we could do for them under the condition of experiment.

4.2.5 Balanced Interest

Total evaluation scores from the subjects were wide-spread. Some subjects liked this system very well, and others disliked it. Free comments from subjects gave us suggestions. Subjects who gave good evaluation commented that they found something new from the system. On the other hand, subjects who did not like the system tended to regard this system as giving same information as guidebooks or notice boards.

It makes us remember the evaluation on the number of stone steps at the Kotohiragu's experiment. The number of stone steps was necessary information for visitors, but it was not shown in the real world. The case of water jar (in section 3.2.6) is also an example. At Ritsurin Park, visitors who found or expected to find new information that cannot be obtained from the real world, gave good evaluation scores.

From these facts, we can consider what kind of information the virtual media should give to tourists, and how to share roles with real media (guidebooks or notice boards). It is important for the virtual media to provide information on the real world that is not given by the real media, so that it can provide satisfactory service and make users pay balanced attention to both of the worlds. It seems to be a paradox, because the virtual media would become of no value if such real information sources had been very rich. However, handy guidebooks cannot be too thick. Many signboards cannot be set up, because they would spoil the scenery. As a conclusion, we should design the service to well balance the real and virtual information sources.

Real media can intrinsically give only general information accepted by all visitors. Virtual media should give special information, for example such information that is personalized to each visitor's interest or language.

Another comment from some subjects who appreciated this service was that they could get information without being bothered with annoying human guide. There are actually some volunteer guides in Ritsurin Park who can serve visitors if requested. However, it seems that only few visitors really ask them. It would be better that human information resource mainly serves group tourists.

4.2.6 Goal-less Structure

It is not easy to evaluate the effect of the goal-less structure of service in this experiment. However, we can say that it is easier to design a mobile information service with a goal than without a goal. With a goal, we can keep the user's interest using goal-oriented information.

In this experiment, we adopted virtual animals that took turns of guiding at each sub-area. Some subjects did not understand why so many animals appeared. Many female subjects, as mentioned in 4.1.1, highly evaluated the cuteness of virtual animals. It made up for other imperfectness of the service and succeeded to keep the user's interest, but it had nothing to do with the sightseeing itself.

4.2.7 Other Evaluation and Free Comments

A map on the screen was again requested by several subjects, although a paper map was given by the park office at the entrance. In our case, including the case of the Kotohiragu system, we avoided using maps to let users focus on the virtual world model, and also due to the copyright problem and development cost. This problem should simply be solved by adopting map interfaces in the future system.

Other frequent complaints were on the battery problem, again.

5. CONCLUSIONS

From the experiments, we can conclude that GPS-based location-dependent shared virtual world system can be applied to a sightseeing guide system, if it is designed artistically in high-quality, properly advertised to make people believe it gives original information (and really so), and has clearly defined target

Figure 8. Sample Screenshot from the next Brew-based version (with output for testing)

users. Female users are more sensitive to artistic representation than males, according to the Ritsurin Park experiment. First-time visitors need descriptive information more than repeaters, according to the Kotohiragu experiment.

Communication features between users via the shared virtual world would be hopeful, if the system is well targeted to active group of users who are strongly interested in communication. Such groups are young users and repeaters, according to the experiment at Kotohiragu.

GPS inaccuracy is still a severe problem, but users are regarding it as an independent problem that is different from the value of service.

Finally, many subjects did not like *pull* information service, since they had to invoke the GPS function every time they moved. To solve this problem, the *brew-based* version is required. Figure 8 is a screen snapshot from the latest prototype of the brew-based version for Ritsurin Park.

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