Experiments of Entertainment Applications of a Virtual World System for Mobile Phones

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Abstract. Using a virtual world system for GPS-phones, we have developed a small RPG-like game to give information to tourists. Comparing with other virtual systems for mobile terminals, the cost of our system is much lower because only phones on the current market are required but no additional devices are needed. The game follows a Japanese famous tale and a player plays as the hero. We recruited twenty subjects and they played it 35 minutes in average. Through evaluation sessions of the system, we have found that the system is highly evaluated as an entertainment system.

1. Introduction

Virtual information systems are highly expected for entertainment applications. Especially, virtual information services to mobile terminals are actively developed and researched. Prototypes developed by such research projects adopted wearable terminals [1-4], larger terminals [5], or laptop computers and/or PDA [4, 6-8].

However, from a viewpoint of business, these kinds of terminals are not appropriate. Since they are relatively costly and heavy, it is difficult to let many consumers buy such terminals and walk with them. On the other hand, mobile phones have already been widespread to consumers. In Japan, more than ten million mobile phones with GPS have been shipped out, but the number of PDA users is very much smaller. People usually go out with their mobile phones even if they do not expect outdoor virtual information services.

With these reasons, we believe that mobile phones are the only one candidate as terminals to deploy outdoor virtual information services. We have developed a virtual information system for mobile phones with GPS [9-11]. The system is based on our concept of SpaceTag [12-14].

The difference between PDA and phones are not only in the hardware resources such as CPU or memory. There are more restrictions on user interfaces of phones, including the size of display. Application programming interfaces (API) and

peripheral devices for phones also give restrictions to programmers. For example, location values from GPS cannot be obtained as frequently as in the cases of PDA or laptop PCs. Hence we needed to develop and evaluate a system with mobile phones, though there have already been several evaluation results using PDA or laptop PCs by other researchers.

In this paper, we will describe an evaluation of our new application of the virtual information system. This application is more sophisticated than before. A user plays a scenario of RPG, where the user plays as a hero of a famous tale. Through the game, the user will be given information of a sightseeing spot in our city, which encourages the user to visit there.

Evaluation results of the system and application are also given in this paper. We can say that it is highly evaluated as an entertainment system and it is useful for sightseeing support.

2. A Virtual World System for Mobile Phones

Our goal is to develop and deploy a system with which people can experience virtual worlds using their mobile phones. Each virtual world has a same geographical structure (with respect to latitude and longitude) with the real world. In other words, we can create various virtual worlds that have same geographical structure, and they can be overlaid onto the real world. We call it the overlaid virtual model (Fig. 1 [12]). 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 uttering words to the user. They can also exchange messages with other

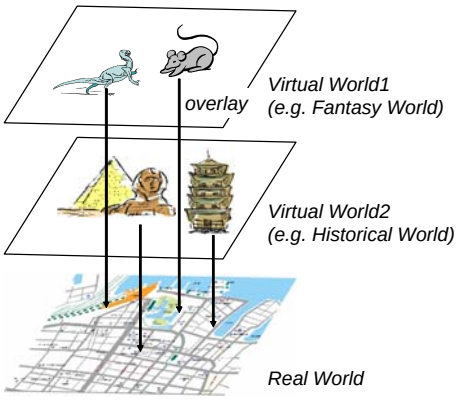

Fig. 1. Overlaid Virtual Model

agents. Sometimes we call virtual creatures just as 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 large 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. Hence a user can walk in the virtual world when 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 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 download a new image of the virtual world, whenever he/she has moved to a new location.

On the other hand, the Brew-based version needs special software based on Brew, at the terminal side. Brew (http://brew.qualcomm.com/brew/) is a software platform for mobile terminals designed by Quallcomm, Inc. With the Brew-based version, the graphics is dynamically redrawn [9-10]. It gives more satisfying user interfaces than the browser-based version. However, since we had not completed the development of a reliable version with Brew before this study, we used the browser-based version.

Fig. 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 a GPS function (Qualcomm's gpsOne) and internet accessibility. Terminals we used for this study were A5502K, W21S, and W21SA provided by KDDI with "au" brand (http://www.au.kddi.com/), but other types of terminals can be used if they support GPS.

In Fig. 2, the server is drawn as one block, but it consists of two computers. Because the graphics processing needs computer power, one machine is used only for drawing.

The server's main function is to generate a static image of virtual city for each user. When a user accesses to the server, location parameters are attached to the request message by the gpsOne location server. The virtual city server can then detect the location of user by latitude and longitude values ("Convert (Lat, Lon) to Internal Parameters" module). These location parameters are converted to the internal coordinates, and distance and direction of virtual objects are computed ("Compute Distance and Direction" module). They are shown on the user's display like "a house, 200m west" for reference.

The "Compute Distance and Direction" module gives a default direction to the "Image Generation" module. A default direction is defined as the direction in which the closest object exists. The user can look into another direction by selecting from a direction list (its flow is shown as broken arrows). In this case, a user is asked by the server about the direction he/she wants to see. The user should select one of the eight directions: N, NW, W, SW, S, SE, E, or NE.

Data of virtual objects are stored as LightWave 3D data files on the server. A LightWave file is loaded to an image generation module written by Java using Java3D package, and is converted to a 2D image (120 x 120 pixels). An image generation

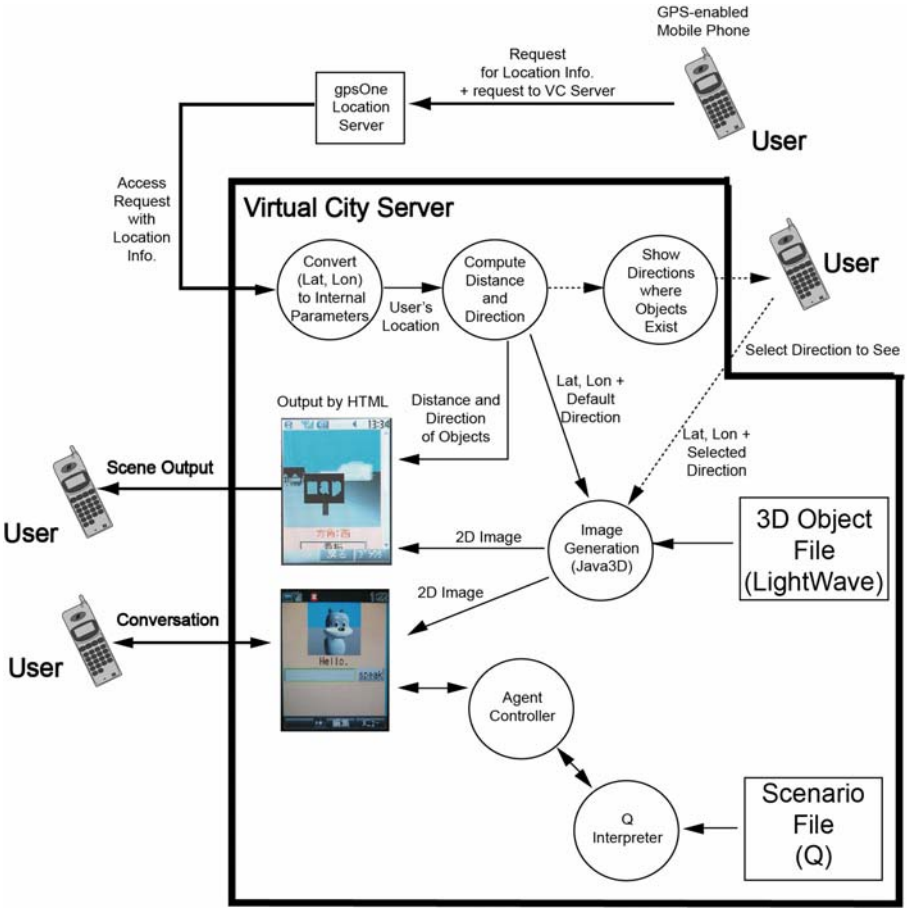

Fig. 2. System Configuration (Browser-based Version)

process is invoked by the servlet mechanism triggered from the user's request. By adopting a popular tool like LightWave, many people will have chances to take part in the activities of authoring virtual city objects. However, we cannot take full advantage of LightWave, because complex objects that have many polygons or fine textures could not be handled by Java3D and phone terminals.

In Fig. 2, two images are shown. The upper image is an example of the viewing mode. In this case, the generated page in HTML format containing an image of scenery is just sent to the user's terminal. Distance and direction parameters as texts are also attached as mentioned above.

The lower image in Fig. 2 is an example of the conversation mode. A user can enter this mode by selecting "conversation" button that is shown along with a virtual creature. Conversation of an agent is controlled by the "Agent Controller" module. This module uses the Q interpreter to control the conversation. Q is a language developed by the Q consortium [15], which is a scenario-description language based

on the Scheme language. With Q, we can easily define the behavior of agents. A more detailed description of the agent control mechanism is given in [11].

3. Entertainment Applications of the Virtual World System

The virtual world system can be used for various applications [13]. For example, providing local public information or advertisement is expected as applications. However, while GPS-phones have been shipped more than ten million in Japan, we still cannot say almost all people have them. These applications are effective when most of the people can access the information services. We consider that the market for these kinds of application is immature.

Entertainment applications, on the other hands, have a considerable market even if only some people have GPS-phones. RPG (Role Playing Game) is a typical example of such application we can consider. With our system, we can control agents based on a scenario. Agents are located and move around in a virtual world that is overlaid onto the real world. Game players walk about in the real world, encounter such agents, talk with them, and play the scenario seeking the goal.

Comparing with conventional RPG on game computers or personal computers, RPG on our virtual world system has some barriers to play. Players have to walk, rather than simply inputting a “move” command or manipulating a joy stick. When it is raining, hot, or cold, players would be reluctant to go out. On the other hand, there are merits of this style of game. Players have chances to meet other players in the real world. They also have chances to discover some real objects (e.g., historic objects, curious plants, etc.) while playing a game. Walking is better for health than playing in the room. We are expecting potentials of such kind of RPG.

Sightseeing is one of the practical applications that can be mixed with games. While playing a game, players will find interesting points in a sightseeing area. They might spend money in the area to take a rest or to buy memorial items or souvenirs. In other words, such RPG has some economical effects and is anticipated by the local government, shops, and the tourist industry.

Of course, the system can be used for just showing explanations of sightseeing spots to visitors. This kind of usage is also expected. However, from the viewpoint of entertainment, we have developed and evaluated an RPG-like sightseeing support application.

4. Evaluation Sessions

In this section, we introduce an application of the virtual world system with a scenario of RPG based on a famous Japanese tale, designed for sightseeing support. We also show results of evaluation of the application.

Fig. 3. Momotaro, Animals, and Oni designed with LightWave 3D

4.1 Background: Momotaro and Megijima

The tale of Momotaro is a very well known story in Japan. All Japanese people know it. The outline of the tale is as follows. Momotaro was a boy living in a village in ancient Japan. His village was very much damaged by Oni (ogres). Momotaro went to Onigashima, which means “the ogres’ island” in Japanese, with a dog, a monkey, and a pheasant, and exterminated Oni.

Today, it is believed that Megijima, which is an island located four kilometers north from Takamatsu port, is the Onigashima. In Megijima, there is an artificial cave where people believe Oni (ogres) lived. Oni are considered as pirates in ancient Japan. With this background, Megijima is one of the recommended sightseeing destinations in Takamatsu city. However, since Megijima itself is not as famous as the tale of Momotaro and people must take a boat to go to Megijima, the number of visitors is not so many. Promotion of Megijima is hence required.

4.2 Evaluation Settings

At the beginning of this project, we were planning to build a virtual world on Megijima. However, it is more important to encourage tourists to go to Megijima than to give virtual experiences in Megijima, since visitors would have nothing to do except for sightseeing in Megijima. Hence we have changed the plan to build a virtual world on Takamatsu port, where the boat departs and people can see Megijima well.

We designed Momotaro, a dog, a monkey, a pheasant, and Oni with LightWave 3D (Fig. 3). They were placed onto the area of Takamatsu Port as shown in Fig. 4. Megijima is at the left of the map. It can be well viewed from the seawall, where the Oni was placed virtually. We placed other virtual animals like a bear, a penguin, a rabbit, a giraffe, etc. within the experiment area. They could make conversation to players and give some information useful to play the game. Eight virtual buildings were also placed in the area.

A virtual Moai statue was also placed. There really is a Moai statue in Megijima, which is not well known. We placed the virtual one to give such information to players.

We recruited 21 subjects and asked them to play the game. The sessions were conducted from January 15th to 29th, 2005. Since a server trouble occurred for one

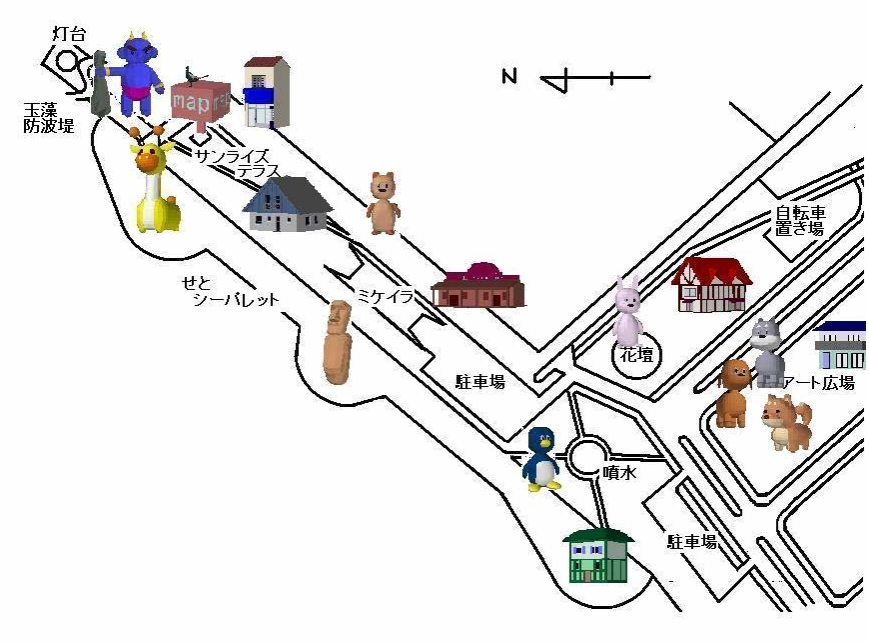

Fig. 4. Map of the Experiments Area (colored objects are virtual)

subject, totally 20 sessions were completed. Six of them were male, and fourteen were female. They were university students from various faculties.

Prior to each session, we gave each subject a GPS-phone and explained how to operate it. Also we explained each subject that he/she should play as Momotaro, find a dog, a monkey, and a pheasant, and defeat Oni in cooperation with the animals. We also gave a map to him/her. The map was different from Fig. 4; it does not show virtual objects except for a house, where the game started. We also gave each subject a compass to find a correct direction.

Fig. 5 shows examples of the screen. The player, Momotaro, was shown at the center, from his back. We had adopted this third person view rather than Momotaro's own view, since our previous evaluations had shown it better. A dog, a monkey, and a pheasant were displayed behind Momotaro, if they had been already found by the player. When the player scrolled down the screen, he/she could find names of virtual buildings and virtual creatures, look into arbitrary directions, or talk to virtual creatures.

During the game, we helped a subject only when he/she got lost in the virtual world and continued to proceed to an opposite direction from the final destination, the seawall. It took 35 minutes for a subject to play the game, in average. The shortest case was 25 minutes, but the longest case was 58 minutes. They walked 1.5km, approximately.

At the final stage of the game, a player should fight a battle with Oni. To win the battle, a player had to give right answers to all three quizzes about Megijima given by Oni. If the player had conversations with virtual creatures other than a dog, a monkey,

Fig. 5. Sample Displays (left: top of the screen, right: scroll-downed)

Fig. 6. Game (left, center) and Interview (right) Scenes

and a pheasant, the player had been given some hints by those virtual creatures. If the player won, Oni declared his defeat, and went back to Megijima. If the player gave wrong answers at least to one question, Oni won, made fun of the player, challenged the player another battle in Megijima, and returned there.

After the game, we gave each subject a questionnaire sheet and asked him/her to answer. We conducted an interview to get more information from each subject.

Game and interview scenes are shown in Fig. 6.

4.3 Results and Discussion

Table 1 lists excerpt results of questionnaire. For each question, score 5 is the highest, and 1 is the lowest. A subject could select 1, 2, 3, 4, or 5, for each.

4.3.1 Evaluation as an Entertainment System

As the result of first question shows and according to interviews with subjects, we can say that this system is highly evaluated as an entertainment system.

We observed and videotaped one subject who often looked back and watched his friend who was also playing the game. At the interview, he said that he enjoyed competing with his friend, although we did not say this was a race. This is a typical fact of evidence that subjects are entertained.

Table 1. Result of Questionnaire (N=20)

Question	Average Score (1:bad ... 5: good)
Did you enjoy the game?	4.60
Have you become interested in Megijima after this game?	4.10
Do you want to visit sightseeing spots introduced in the game?	4.15
Do you think that sightseeing guides using virtual and real worlds like this are effective?	4.40
Were you interested in the quiz battle with Oni?	3.90
Did you feel that you were walking in a virtual world?	3.95
Did you find some bad effects of GPS errors?	3.40

We also observed and videotaped that another subject naturally uttered “Kandou...” (in Japanese), which meant that she was much impressed, when she found that real Megijima was in front of her at the end of the game.

In the interview, we asked all subjects what aspect of the experience was enjoyable. Answers from all subjects included “gaming by walking.” We can say that it gave subjects a kind of new experience different from conventional role playing games. With all these facts, we can say that this system is successful as an entertainment system.

4.3.2 Evaluation as a Sightseeing Support System

Results of the second and third questions in Table 1 show that the subjects were well interested in Megijima after the game. From the fourth question we can find that subjects generally agreed that this system can be used as sightseeing guides.

However, we still need further long-time evaluations before concluding that this application has some good effects on the tourism industry. Being interested in an island and really visiting it are different things.

Besides the evaluation sessions, we also asked four tourism-promotion staffs of the local government to play the game and evaluate it. They very much agreed that this was an exciting experience and the application really entertained them. However, they expected us to provide more links to real objects from the game scenario. They were also afraid that players would be interested in the game itself, not in the sightseeing.

Providing links to real objects is not so easy because of GPS errors mentioned in the next subsection. We should find a well-balanced solution for it.

4.3.3 Technical Quality

(a) Reality of Experience

The result of the fifth question in Table 1 shows that subjects felt in a sense that they were walking in a virtual world. The score was not high enough, but it is better than our previous experiments [10]. We consider that introduction of the third person view

(Fig. 5) and other minor refinements contributed to the improvement. Also, an exciting scenario of Momotaro may have also contributed to this subjective evaluation, comparing with previous evaluation sessions without scenarios.

(b) GPS Errors

According to the result of the last question in Table 1, where 5 means that they did not feel bad effects and 1 means they felt it most, subjects felt GPS errors to some extent. This score is not good, but also better than previous experiments. One reason of improvement would be that there are no tall buildings, which make GPS precision worse, at Takamatsu Port. However, GPS error is still the most serious problem for our system. Techniques to avoid the bad effect of GPS error will be described in another paper in very near future.

(c) User Interface

Since all of our subjects were young people, they quickly became accustomed to the operation of the game. However, tourists include elder people. Mobile phones are not always appropriate for them. It is a difficult problem because adopting other kinds of terminal needs additional costs and our goal of the project is to adopt popular terminals with GPS.

The browser-based system architecture was not well evaluated. Subjects needed to reload new data from the server, whenever he/she had moved to another location, or looked into another direction. Adopting the Brew-based version with a mobile-phone with electronic compass will be able to solve this problem.

(d) System Response

We received no complaints about the system response from the subjects. It took about ten seconds to detect the position using gpsOne. About five additional seconds are needed before finishing receiving contents from the server.

5. Conclusions and Future Work

In this paper, we have introduced a virtual world system for mobile phones with GPS, an RPG-based sightseeing application, and its evaluation.

According to the formal evaluation by young subjects and informal evaluation by local government staffs, we can say that this virtual world system for mobile phones with an RPG-like scenario can provide good quality of entertainment. As we designed it to minimize the additional costs paid by consumers, this system is much more realistic solution than other virtual systems using wearable computers, laptop PCs, or PDAs.

Subjects said that they became interested in Megijima, which is the theme of the game and a sightseeing spot to promote. We can expect that it can promote tourism to some extent, but more refinement of the system is needed. For example, taking real objects into the scenario is expected. This problem should be considered taking GPS errors into account.

The evaluation sessions were conducted with a browser-based version of the system. A Brew-based version will be more user-friendly, because users do not need to reload data by themselves, and they can find right directions of objects without a reference to a compass. To finish the development of a Brew-based version is our future work, but good evaluation for the browser-based version suggests that a Brew-based version be more successful.

We are planning to another future work, evaluation sessions involving many users who have mobile phones compatible to our system. As we have stated, some current mobile phones can be used to enjoy our system without any additional devices. We will announce our evaluation project to the public so that many users participate in the evaluation without our attendance.

One of the interesting characteristics of our system is the virtual creature. There are some games using GPS phones (for example, http://www.mogimogi.com/), but shared autonomous virtual creatures are not supported. We are also developing an authoring tool for virtual world, including a script editor to define behaviors of virtual creatures.

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