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A Real World Role-Playing Game as an Application of the Guide System in a Museum

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Abstract

Our research group is studying the educational applications of virtual reality and mobile computing technology. In this paper, we describe system and our development in the mobile computing field where children can learn about an exhibition interacting all over an exhibition site just as though they were playing a game. We developed a mobile device, portable enough to carry during application, and a positioning system which can track paths walk by visitors. We are also working on the system contents. The developed system has been used this summer as a next-generation museum guide at National Science Museum in Japan, where more than 15,000 children have experienced this system.

Key words: Mobile Computing, Indoor Positioning, Digital Museum, Entertainment Computing

1. Introduction

As ubiquitous computing is becoming a reality today, much research concerning the linking of the real environment with information stored in computers is proceeding in the fields of ubiquitous or mobile computing. Particularly, facilities such as museums, which motivate study, are trying to apply the outcome of this research without delay.

A developed system will be applied at the National Science Museum in Tokyo, Japan. The exhibition about "video games" is going be held at the National Science Museum from July until November 2004.

2. A Real World Role-playing Game

In a real world role-playing game a designer of the game can set up a real environment as the game location. Participants of a real world role-playing game can enjoy the game narrative by walking around the game location and obtain information about the real environment, for example, as in a museum.

While a conventional video game is designed for its contents to be enjoyed in front of the computer display, participants of a real world role playing game can enter the game environment by moving freely around a real environment.

This effort is not only exploring the amusement of ubiquitous computing technology as a game, but also introducing the latest computer technology itself to general public. In particular, we intend to force participants to realize the characteristic of ubiquitous computing system that can allow user to obtain information whenever or wherever they want.

In our real world role-playing game, participants of the game interact with a virtual world, which overlaps with real environment, through a small asteroid-type-device "Wall-Stone". In designing the interface of "Wall-Stone", we omitted any usual computer input method such as a joystick or a button. Instead of these traditional interfaces, we adopted a shaking or tilting motion as the input, just like handling a real object. Such interactions that inspire our usual treatment of a real object have the effect of easily presenting contents to participants. The shaking or tilting operation is easily observed by bystanders, so that the participants themselves can enrich the real environment and excite interest of the observers. A museum utilizing this real world role-playing is quite different from a normal static exhibition which just presents a set of exhibits to museum visitors.

For the world-view of contents of our real world role-playing game, we took advantage of a cartoon, popular with Japanese children. Participants walk around the exhibition location with "Wall-Stone". The "Wall-Stone" encourages the participant to solve several problems in a virtual world when they enter specific areas in the exhibition.

3. System Requirements

The system requirements for real world role-playing game can be divided into two sub systems.

(1) An indoor positioning system, which is accurate enough and have capacity of locating all the people inside the exhibition location at the same time.

(2) A mobile system, which induces participants to make interact with the device and return those interactions to game scenario. The mobile device must be small and light enough to carry while participants are enjoying the game.

We have installed an infrared positioning system on the ceiling of the exhibition area. The width of the exhibition area is about 400㎡. For mobile sub-system, we developed a mobile device, including sensors and output components. This mobile device can estimate its current position in real time by receiving positional data from the infrared transmitters on the ceiling (Figure 1).

Figure 1. Installed Transmitters

In following section, we describe details of these two sub-systems and illustrate the original script language, which renders it easy to implement the game scenario for a real world role-playing game.

4. Positioning System

The width of the exhibition hall is about 400㎡, so that if we put infra-red transmitters at 1m intervals, about 400 LEDs will be required. In order to achieve as high a time resolution of positioning as possible, taking into account to the catering for increasing the number of infrared transmitters, we set the position data length to 12 bits (6 bits for each x and y coordinate). Positional data is transmission is bounded by start and stop bits.

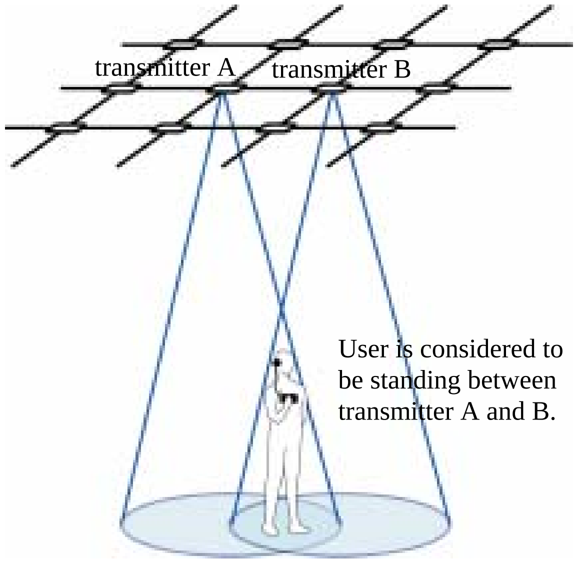

Figure 3. Use of Overlapped Area

In our positioning system, we intentionally overlapped the area covered by infra-red spotlights. For example, if a user is receiving position data from both transmitter A and transmitter B, the iGuide will take it that the user is standing between transmitter A and transmitter B. In this way, we are able to calculate user's position with higher precision than the transmitter layout density would imply (Figure 3).

However, uncontrolled operation of these infra-red transmitters will give rise to interference problems in infra-red spot overlap region. Therefore, during transmission of position data, adjacent transmitters time multiplexed. To make this time-sharing transmission method work effectively, we have to discuss the number of transmitter to be set up in a time-sharing relay loop (Figure 3). The overall system configuration is shown in [1].

For infra-red transmitters, we are using Toshiba TLN110 infra-red LEDs. The half-value angle of TLN110 is ±8°. This transmitter will be installed in the ceiling of the National Science Museum. The height of ceiling is about 7m. For the transmission of the infra-red light further than 7m, a modulation of 38kHz is added to the original infra-red signal

4.1 Design

Fig. 3 shows an example of the overlap region of the boundary areas when utilizing three transmitters. Three is the minimum number of the transmitters for the positioning using signals received separately in time. To prevent interference created by receiving more than two signals at the same time, sets of four transmitters are selected sequentially to identify the location of a visitor. Therefore, the correct locations of the transmitters are essential in order to improve the efficiency of the positioning of the visitors using the proposed scheme. In this study, five different arrays of the transmitter

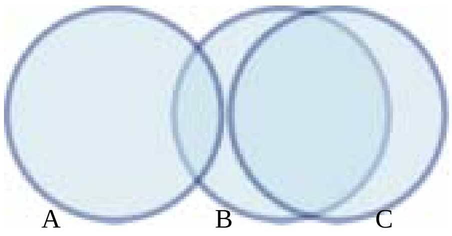

Figure 3. Example of covered areas by three transmitters

locations have been investigated as follows: three grid shaped locations, an isosceles triangle shape, and an equilateral triangle shape.

A moving average based method has been proposed for the identification of the current position of a visitor. Namely, the visitor can easily recognize where he/she is following the received signals sent from the transmitters separately in time. The target area should be divided into a certain number of regions with the same size for the efficient usage of the transmitted signals in identifying the locations of a visitor or visitors. In the case of Fig. 8, the covered area contains three divided areas. However, the transmitted signals do not enable the transmitters to achieve the maximum efficiency because of the uneven distribution of the boundaries, i.e., the uneven distribution of the transmitters.

The positioning signals from the transmitters are assumed to be the Markov source. Therefore, the location of the transmitters should be determined to maximize the entropy of the information given by the transmitters. Namely, the locations should be determined to maximize the amount of information sent from the transmitters in each area separated by the boundaries. The average amount of information is given by

$$\bar{I} = -\sum p_i \log_2 p_i$$

In the above equation, the term p_i denotes the area separated by the boundaries.

Fig. 4 illustrates five different layouts for the transmitter locations investigated in the experimental studies.

In the experiments, the interval between neighboring transmitters is set to 1.5 meter, except in the grid shape of case c. Monte Carlo simulations have been performed for the five different layouts of transmitter locations. Table 1 indicates the averaged amount of information for the five different layouts shown in Fig. 4. When considering the averaged amount of information in each spot, the type b grid location is the best of the five layouts. However, the maximum amount of information is achieved from the averaged information per transmitter when applying the equilateral triangular layout. Thus, the equilateral triangular layout is the most efficient of the five candidates for transmitter locations. Further studies are ongoing with the equilateral triangular layout of transmitter locations.

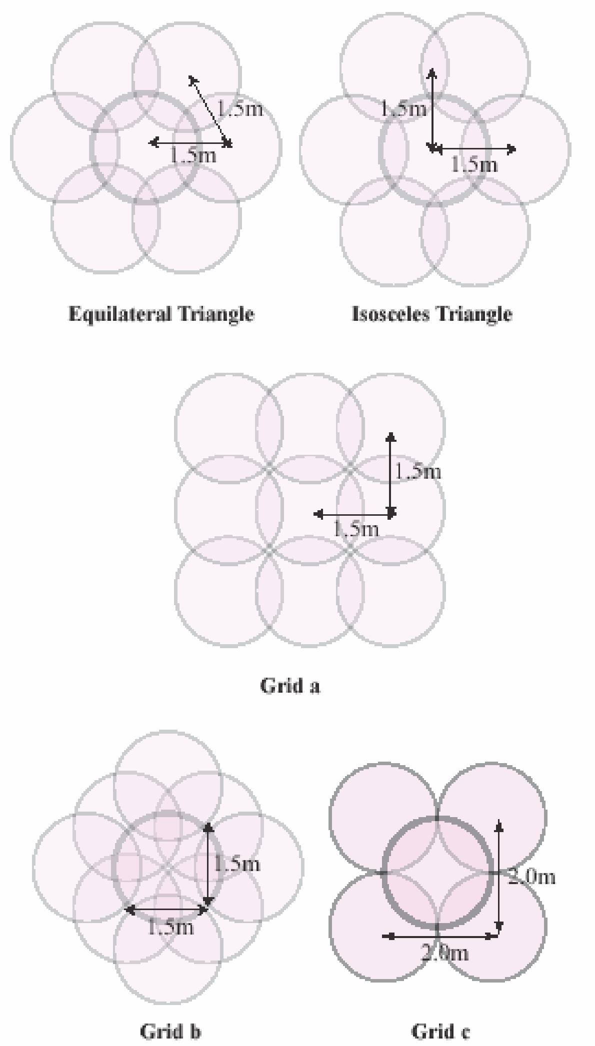

Figure 4. Transmitter Layouts

Table 1 Average Amount of Information Depending on Shapes of Locations

Shape of Location	**Averaged Information per Spot (bit)**	**Average Information per Transmitter (bit)**
Equilateral Triangle	**3.24**	**2.81**
Isosceles Triangle	**2.62**	**2.62**
Grid a	**2.14**	**2.14**
Grid b	**4.25**	**2.13**
Grid c	**2.3**	**2.04**

4.2 Evaluation

We evaluated the accuracy of position in the exhibition site. An Infra-red receiver is fixed on top of a 1.5m high tripod. A plumb line is dropped from the center of tripod as a pointer to the actual position. Positions are measured at 60cm grid intervals. Figure 5 illustrates the results of the measurement. The red points are locations above which infra-red transmitters are laid out. The rectangular shape at the center of figure is an exhibit.

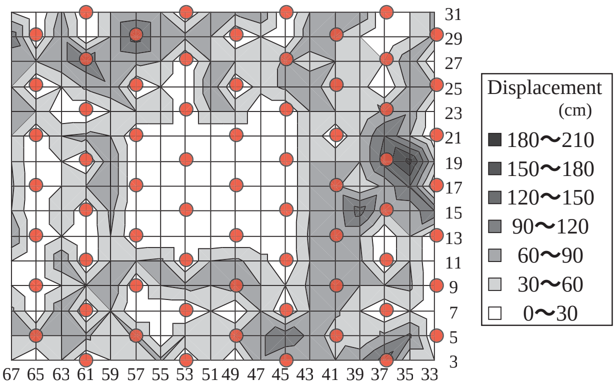

Figure 5. Positioning Error

Figure 5 visualizes the positional deviation from the actual position. Positioning accuracy between measurement points are interpolated. The dark region indicates that the point has a relatively large positioning error. Numbers at right hand end and at the bottom are coordinate values of the real environment.

From figure 5, the developed positioning system has an accuracy of 60-90cm. Top-left and right-middle regions show a relatively large positioning error. This error was due to damaged transmitters.

4.2 iGuide

As the receiving unit for the infra-red signal, we use a SHARP GP1UD281XK. The GP1UD281XK is embedded into the monaural headphone connected to the museum guide device. Fig. 6 shows the developed museum guide device called iGuide (Inpulse Soft inc.). The iGuide is developed for the exhibition of "video games". Besides the infra-red receiver, the iGuide includes a biaxial accelerometer, a digital compass, a jog shuttle switch and a button switch as input interfaces. As an output interface, the iGuide has a 16x16 tricolored LED matrix, five RGB LEDs, a pager motor and an mp3 decorder for. The iGuide is also equipped with bluetooth SPP service. The memory size for programming is 2MB and iGuide includes a 32MB flash memory for MP3 data storage. Total weight of the iGuide is 210g. Figure 7. illustrates the hardware configuration of the iGuide.

When participants enter a certain region, the iGuide device requests the answer to some questions or plays some simple games with participant. Participant reacts to these requests by shaking or tilting the device. The actions, shaking or tilting, are sufficiently simple that the participant can interact with iGuide, even if he/she is holding the device for the first time. Moreover, paticipants do not need to operate iGuide with their fingertips so that they can pay attention to exhibits more easily than when using a button type of interface. Therefore, the new interfaces are acceptable to the user in conditions of both walking or paying attention to exhibits.

Figure 6. iGuide

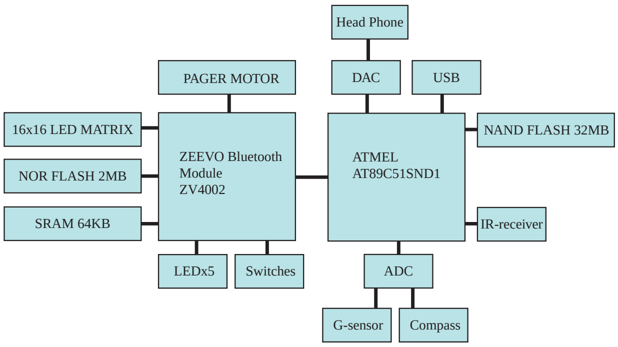

Figure 7. iGuide Hardware Configuration

Figure 8 illustrates an input operation with iGuide. A participant is selecting the answer to a question by tilting the device. There are five types of iGuide device, each having different guidance character. Usually a hint to next destination is displayed on 16x16 led matrix. When participant reaches an event area, a simple animation for guidance or selection of an answer will be displayed on the matrix. Each of the five devices guides participants in differently.

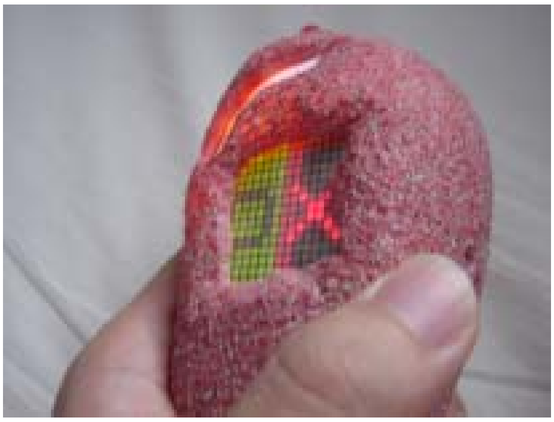

Figure 8. Tilting as Input Operation.

4.3 Position Driven Script Language

To produce a game scenario, we have developed a simple scripting language to reduce the burden of the programming process. In the process of downloading an application binary file to the iGuide device, the script language interpreter is also transferred to the device. This interpreter enables the hardware to read the application scenario described in script language.

The main feature of the script language comprises event driven style programming according to the participants position and the event areas. In the script language, the application programmer defines event areas (regions) in gaming field and a corresponding set of device reactions (scenes). If participant enters an area in the gaming site, a particular action is ordered to be processed in iGuide system by defining those regions and scenes (Figure 9).

Additionally, the application of this scripting language advances the efficiency of content production. Generally, software development environments for embedded systems are specific and expensive. In our strategy, the programmer has only to develop the interpreter in the native development environment and the content itself can be described in a script language by the content producer. Therefore, we can reduce the cost of development and separate out the content program. This strategy has also made it easy to develop multiple content scenarios at the same time.

5 From the Museum Site

The opening of the exhibition coincided with the school's summer vacation, providing a large number of participants from the beginning. Tenth percent of museum visitors enjoyed our real world role-playing game during the holidays, while on weekdays, 30% of visitors, at most, have had the experience. Most of the participants come to experience the real world role-playing game between 11:30 to 13:30. Nearly 60 people per hour have participated over this period. We did not measure strictly but calculated from the circulation of the device over a certain period of time. The average time of the experience is about 30 to 40 minutes.

```
SCENE SCN_ID_ZONE1_ENTER
CONDITION ((S[CNT_ID_ZONE1_FLAG] & Z1_FLAG_ENTER) == 0 &&
  in_region(RGN_ID_ZONE1_ENTER))

/* if user enters RGN_ID_ZONE1, following action will executed */

BEGIN /* descripting the device action */
 call(SCN_ID_COMMON_ENTER);
 mp3_play(MP3_ID_Z1_ENTER);

 $[CNT_ID_ZONE1_FLAG] =$[CNT_ID_ZONE1_FLAG] | Z1_FLAG_ENTER;

 data_save();

 call(SCN_ID_COMMON_EXIT);
END
```

Figure 9. Example of Description of Scene

Figure 10. Participants in the Museum

6 Related Work

Although in outdoor environments, we had worked with handheld GPS receivers to monitor positioning in past experiments[2]. Using a handheld GPS receiver, we were forced to spread the exhibition contents quite sparsely in outdoor settings. Thus, there was a large "amount of information gap" between the real environment, which has abundant information, and the information that could be presented through the wearable computers, and participants became bored while they were walking between event areas. For this reason, we felt that we needed to develop a high-time-frequency-resolution positioning system, superior to a handheld GPS.

In contrast to the outdoor positioning system, indoor positioning systems are typically based on an ultrasonic sensors or infra-red sensors [3][4]. Ultrasonic and infrared sensors both have great accuracy for positioning. However, the use of these systems in a museum still has a problem that they could not handle large numbers of users and position estimation is not handled by a local mobile device.

Some other positioning systems have been evaluated [5]. There are several examples of adopting RFID as an interaction trigger to present exhibition contents to museum visitors, such as the digital museum at the University of Tokyo [6] or the Exploratorium in San

Francisco [7]. Exhibition systems such as these work as follows. When the museum visitors, who are carrying an RFID tag, make a specified action such as holding up the RFID tag to RFID readers placed in the exhibition halls, the exhibition system displays personalized information to the visitors, according to data retrieved from the RFID tag. However, the problem with this system is that it is designed only for one fixed exhibition, and its design becomes more complex as the number of exhibits increases. On the other hand, in our recent study the user is equipped with an RFID reader and the experimental field is covered with RFID tags. Visitors can retrieve their position continuously from fixed tags that are embedded below them. Digital exhibition contents are governed by positional data. Therefore, it is possible to overlap multiple exhibition themes in a single field. Moreover, we do not need to reconstruct the system configuration even if the number of exhibits changes [8]. However, RFID reader is still not small enough to carry and it is not reasonable to embed RFID tags on the floor. Thus we need to develop another positioning system that is portable, reasonable, and also has the same advantages as our RFID positioning system. Therefore we examined the use of infra-red beacons just like the RFID system.

7 Conclusion and Future Work

In this paper, we have described our application of a mobile device to a real word role-playing game in an exhibition item, "video games", at the National Science Museum in Ueno, Tokyo.

This exhibition has presently been opened for two months. We have gained a variety of information and important indications for future work through the actual use of our system.

From the experience of designing and making use of ubiquitous computer technology for a real world role-playing game, we believe that the main focus of our future work will address how to make participants recognize the event from iGuide in a natural way.

So-called 'ubiquitous technology' is making computers unnoticeable in our daily life. Meanwhile, ubiquitous computing is a technology that can provide inputs at anytime and anywhere. Therefore, it may force itself upon the user at an unexpected time and in an unexpected place.

Currently, at the exhibition, we set up a surprise event to take interaction with display and iGuide, in order to make participant to feel the world is connected between iGuide and outer space (Figure 11). However, this attempt seems not to be working very well. Most of the participants did not recognize this event during the game experience.

Perhaps this problem can be solved by modifying the game scenario or some new system may be required. The solution is uncertain at this moment, but the means of making a moving user recognize the information in static display will be studied from now on.

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