A real-space navigation system based on ubiquitous technology

Sooyeon Oh[1], Yutaka Kidawara[2]
[1]Universal city group
National institute of information and communications technology,
[2]Strategic planning division
National institute of information and communications technology
http://nict.go.jp/intex.html

In next-generation networking environments, ubiquitous networks will be available both indoors and outdoors. Various devices will be ubiquitously embedded in the surrounding environment, such as buildings and urban spaces. We will be able to browse digital contents on ubiquitous networks anywhere and at anytime. In our research, we have proposed several content-processing mechanisms for use in environment-enabled collaborative acquisition of embedded digital content in real world situations. We have developed a network management device that makes it possible to acquire embedded content using coordinated ubiquitous devices. We have also developed two prototype systems using these devices. In this paper, we describe the implementation of a prototype system that can share 3D objects in a virtual 3D space based on a real-space environment. This system can be used not only as a virtual 3D browser in a private area, but also as an interactive digital poster in a public area. We tested our system in real situation, and explore the feasibility of applying our system in a ubiquitous environment.

Keywords: *Ubiquitous technology; Navigation; Collaborative service; Embedded digital content; Real space.*

Introduction

Information, communication, and entertainment services are increasing being used indoors and out because various network-accessible devices now provide wide-ranging coverage in real spaces. Such devices are the result of recent advances in ubiquitous computing technologies. Further advances in communication and device technologies will soon enable the development of a next-generation communication tool that will make the Internet ubiquitous.

While many researchers have investigated the technologies required for ubiquitous and pervasive computing, the focus has been on the development of an infrastructure and framework for handling various types of devices. Far less attention has been paid to how content should be browsed and how information can be obtained from physical objects in a real world. Ubiquitous and pervasive computing technologies enable information about physical objects to be distributed using the information directories on a network. These physical objects may have RFID tags or small microprocessors attached or embedded; they can be annotated and browsed to obtain information about the object's characteristics. We may also be able to use various cooperative devices to browse and manipulate the characteristics of various types of information.

In this paper, we describe the concept of a content navigation as a form of device-cooperative content and an operating mechanism that enables the extraction of information from common public content and the monitoring of information of interest. We also describe a browsing system that can be used cooperatively by various types of devices, both indoors and out. Section 2 explains our objectives and assumptions regarding embedded digital content and access through ubiquitous devices. In section 3 we describe the implementation of a prototype system that can share 3D objects in a virtual 3D space based on a real-space environment, and in section 4 we also describe its testing. Section 5 discusses related work, and section 6 summarizes our finding and future plans.

Assumption and objectives

The seamless exchange of information among people necessitates modes of operation that are more suitable to human behavior and living than is the case with today's computing equipment and operating systems. "Ubiquitous computing" means that the computer is simply part of the environment and daily life.

Locally ubiquitous computing technologies are widely used in the distribution of information about physical objects using information directories on a network. The introduction of RFID tags and optical ID codes has changed how such real-space information is accessed. Attaching tags and codes to physical objects enables us to bind digital information (e.g., Web contents, pictures, and movies) to actual objects. Digital content will eventually be ubiquitously embedded throughout real spaces using these technologies.

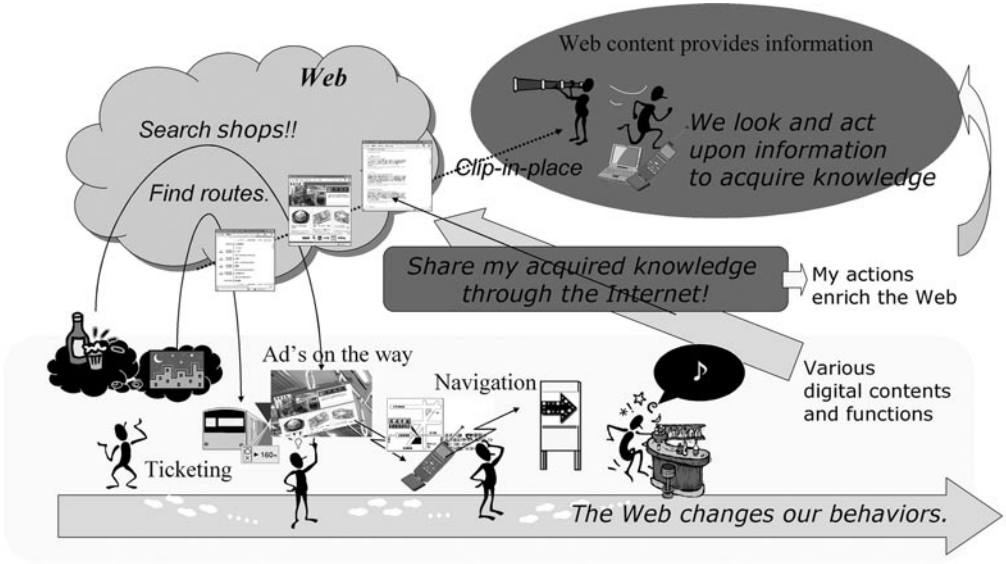

Figure 1
Digital content processing in real world.

However, such technologies are being developed with a focus on an infrastructure and a framework for handling several types of devices. Far less attention has been paid to what content should be available for browsing and what information from physical objects should be accessible in a real space.

Even if ubiquitous computing enables us to acquire digital information about physical objects anywhere at any time, we might not be satisfied with the content-access procedure. In practice, when we try to access information about physical objects, we often want to compare related information obtained from many sources. In many cases, we cannot obtain enough information for comparison because of the limited capabilities of a mobile device at the location of the physical objects. As a result, information-rich digital content cannot be easily understood through the limited capabilities of mobile devices. Simple content is most suitable for display on mobile devices, but users generally find it difficult to acquire the information they need from the display of simple content. We believe that two kinds of content functions are necessary to enable effective access to embedded digital content through a ubiquitous network. First, we need a content acquisition function. Second, we need a data browsing and comparison function. Moreover, each function must be support by various types of devices. This concept of digital content processing is illustrated in Figure 1.

Mechanisms required

Two mechanisms are thus needed to make content available on a ubiquitous network. First, we need a mechanism to acquire embedded content. We think that users will probably acquire embedded digital content in a real space and then move the content to various destinations. Second, we needed a mechanism to browse, store, and move content about with personal devices. This will enable users to move embedded content to other areas and to manipulate the content on the basis of their interest. A user can browse, touch, and operate the content freely. Moreover, the user can compare and apply the content by using various types of devices.

- Acquisition of embedded digital content. Ubiquitous computing technology enables various types of devices and small computers to be embedded in a real space and to be connected

Figure 2
Example devices embedding digital content.

through a ubiquitous network. Such devices (Figure 2) provide digital content in the form of digital data. This "embedded digital content" is local content that we might not be able to obtain from the Internet but that can be provided to other devices as information about physical objects and that has both regional and temporal specifications.

- Distribution of embedded digital content. Users can acquire embedded digital content through personal devices connected with embedded devices through local networks. Local networks may not necessarily be connected to the Internet and might only connect to a content server in the immediate area. That is, users have to be within the server area to obtain the content. This type of digital content might come with special features depending on which users are within the area at a given time. The content server might be able to provide different levels of information to users depending on the digital content embedded in their devices. The content could thus function as an access key for location-dependent services as well as a digital document. For example, the content could serve as a ticket for a particular content service or a key to an actual entrance gate. The embedded content could be shared between various devices and applied to a variety of purposes in line with the user's context, which may include not only the users' profile but also information about the devices being used. For example, users could list their favorite items and browsing styles on content servers in their local area, enabling content to be processed more effectively.

Objective

We will be able to browse digital contents on the ubiquitous network anywhere and at anytime. Various types of personal devices will display/play the contents. Devices will display/play contents along with an overlay of the real-space view. The objective of our research is to develop a means of providing digital content through embedded devices using ubiquitous computing technology. That is, we want to develop a practical method for disseminating embedded digital content. So far we have developed two prototype systems.

- Our virtual insect catching system acquires and processes information from embedded digital content in a real space
- Our real-space navigation system uses virtual 3D characters that support the browsing and navigation needed to obtain real-space information

The virtual insect catching system has already been developed and tested (Oh, 2006). The real-space navigation system is described in the next section. It enables virtual 3D content to be shared among PCs. This content consists of virtual 3D spaces and 3D objects with their behaviors. The system can change the characters' behaviors in real time. If we prepare a suitable interface for the system, various behaviors can be attached to the virtual 3D characters by using the interface. A navigation system with virtual 3D characters provides functions by dynamically generating a character script on the basis of user operations. This system can be used not only as a virtual 3D browser in a private area, but also as an interactive digital poster in a public area.

Implementation

Prototype system

We used our prototype real-space navigation system with virtual 3D characters to investigate its effectiveness. It displays information on a large public viewing screen using an interactive visual menu that can communicate with any type of PC. The system provides various types of information from various areas of the real space, such as geometrical information. Displaying this information in a virtual space corresponding to the real space enables a user to easily receive the surrounding information. We applied our system to navigation in a real space. The system consists of six computers with monitor screens; the computers are connected by a network. The navigation

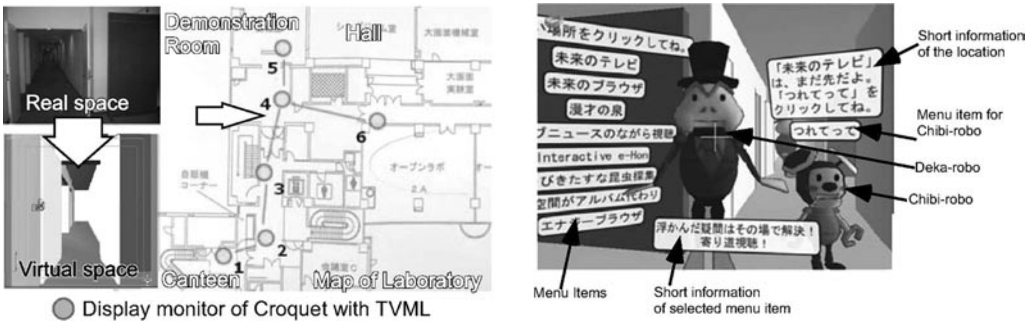

Figure 3
Virtual 3D space for real space navigation (left); example virtual 3D content (right).

system distributes 3D object information using an original peer-to-peer protocol that shares all object information in real time. We also developed a protocol for sharing the virtual 3D positions and behaviors of the characters. The protocol is currently optimized for less than ten PC connections.

Modeled space

The developed navigation system is for our laboratory. We prepared a virtual 3D space of our laboratory using 3ds Max modeling software. The virtual space has a lunchroom, demonstration room, and hall. All the rooms are connected by a corridor. Doors, stairs, tables, chairs, and various pieces of equipment were modeled in detail. The left panel in Figure 3 shows our virtual 3D space, and the right panel shows example content.

Virtual 3D Content

The real space was rendered into the virtual 3D space using computer graphics (CG). Six monitors were set up in our laboratory, and the virtual space has six viewpoints corresponding to the location of each monitor. The actual view and the virtual space view are almost the same. A user can find various types of information about the real space and the objects therein the virtual world view. A trackball attached to the monitor enables the user to change the view's direction; the user rolls the trackball to point to and select menu items. The virtual 3D space content is presented by 3D characters acting as hosts, as shown in the right panel in Figure 3.

Each host manages the local information as character content. The content is presented when the character arrives at the place where each host is set. The characters act out behaviors that are defined as character content. Figure 4 shows two screen shots of characters acting as hosts. The menu items shown on the left are destinations for navigation. The character in the middle is "Deka-Robo." It stands at the center of the image as if it were in front of the actual monitor in the real space.

Deka-Robo shows the information with a "surprise" behavior. It displays a short piece of information about an item on the left menu when it is clicked. The character on the right is "Chibi-Robo." Chibi-Robo presents a short piece of information when it arrives at a location. If the location is not the destination or the halfway point, it shows another menu item to take the user to the goal. The status of Chibi-Robo is managed on the basis of the status parameter in each host.

Real-space Navigation

The navigation system plays real-space navigation content in our experimental system. It works as follows.

1. Calling Chibi-Robo to Departure Position: Users check the monitor of the host PC. If Chibi-Robo is not there, a menu item to call it is shown on the right (see Figure 4a). Chibi-Robo comes to the departure location after the user clicks on the

call button (see Figure 4(b)). Chibi-Robo, which was at another host, starts walking to the user's host PC. The information and the character's behaviors are written as character scripts. The navigation system loads each script, which controls the character's behaviors and a brief information display.

2. Selection of Destination Position: User selects a demonstration room from the location menu. Deka-Robo displays a short description of the location with a behavior. Chibi-Robo introduces the menu item selection operation in order to guide users to the target room (see Figure 4b). Chibi-Robo walks to the room after the user clicks on the "Take me there" button.
3. Arrival at Halfway Position: If Chibi-Robo goes to a host located far away, the user may lose sight of it. There can be several hosts between the departure host and the destination host. Chibi-Robo stops at the host at the halfway point to the destination (see Figure 4d).
4. Arrival at Destination Point: Chibi-Robo stops and shows the information about the destination when it arrives at the target host (Figure 4c)

Testing

We tested our prototype real-space navigation system at the NICT open house in July 2005. We modeled the 2nd floor of the research center as a virtual 3D space. Six computers were positioned in particular places. The system comprised a virtual 3D space, six Deka-Robos and one Chibi-Robo. Each Deka-Robo took the place of the monitor screen. Chibi-Robo guided users to their requested destinations. The system was developed with children in mind. Chibi-Robo moved to the target destination in the virtual space when a user requested to go to there. Each Deka-Robo provided its character script when it met Chibi-Robo. Chibi-Robo changed its behavior on the basis of the character script. The users interacted with the virtual 3D content and were guided

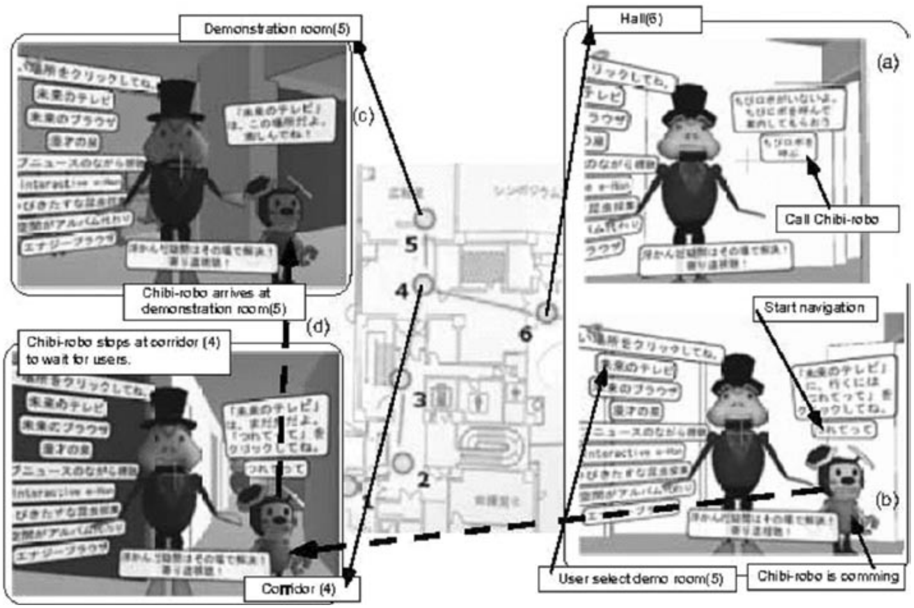

Figure 4
Example of navigation using characters.

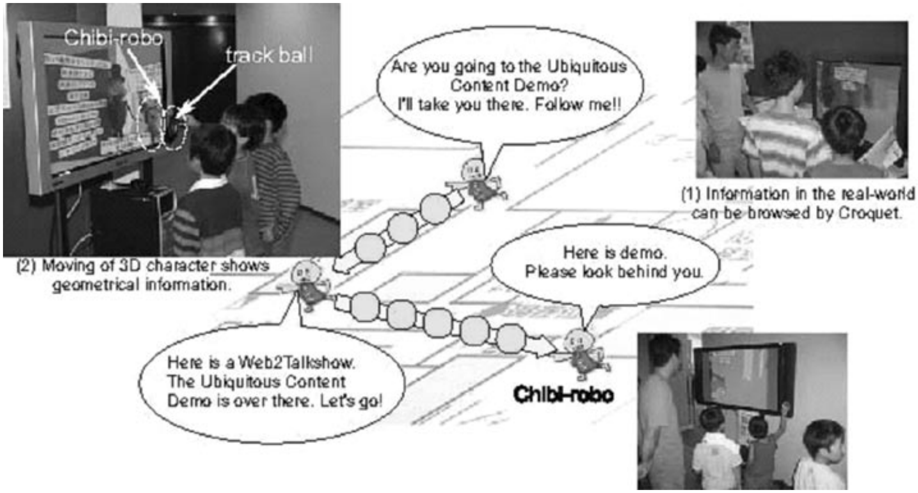

Figure 5
Testing of navigation system during an open house at NICT.

to their target destination by Chibi-Robo. An example guided tour is shown in Figure 5. In this experiment, the children were able to understand Chibi-Robo's guidance and follow it. Chibi-Robo acted as a perfect virtual guide. This testing demonstrated that our real-space navigation system can be applied to indoor digital content accessed and demonstrated its usefulness as a virtual 3D browser.

Related Work

Several methods have been proposed for content browsing and management of a real world. The hypermedia research has focused on a combination of real and virtual objects. Physical hypermedia (Gronbak, et al., 2003) uses three kinds of tags that combine physical objects with digital objects. Simple object tags and collectional tags are linked to digital objects. Tool tags are linked to operations in a digital space. The HyperReal model (Romero & Correia, 2003) provides a hypermedia framework for constructing context-aware and mixed realities. It specifies the relation between real and virtual space. The Ambient Wood Journal Project (Weal et al., 2003) aims at facilitating learning experiments in outdoor environments. Detailed logs of children's activities are recorded on portable devices, and the logs are displayed as journals on the Web. The virtual 3D content browser for outdoor spaces we described in this paper can be used to combine virtual and real objects.

Conclusion

We are researching the acquisition and processing of embedded digital content in a ubiquitous computing environment and have developing various methods that can serve as a basis for constructing and implementing ubiquitous environmental spaces. Our first step was to develop various practical prototype systems. Testing demonstrated the practicality of these systems.

In this paper, we described our latest prototype system, a real-space navigation system with virtual 3D characters. We evaluated the performance of the character scripts processing in the shared virtual 3D space and found that the character scripts were useful in controlling the characters. We also found that the communications mechanism of a conventional system is not suitable for moving characters shared among more than four PCs. We developed an original communications protocol and resource management method for the prototype system. Testing of the prototype system demonstrated the usefulness of the character scripts in generating virtual 3D content in the shared virtual 3D space. The prototype system can share a virtual 3D world and objects among six PCs, all of which can manage and control the character movements. Testing of our prototype system at NICT's open house demonstrated that it can effectively guide children as well as adults. They intuitively understood that the Chibi-Robo character can guide visitors to other locations in the place.

The current scripting capability is very simple. The system needs to support more character event scripts so that more behaviors can be added to the virtual 3D characters. The functions offered by our prototype system will enable us to develop applications in various areas; ubiquitous environmental space planning, collaborative design, education, entertainment, etc. We plan to enhance the character scripting language.

Our next step is to complete the development of the guidelines for designing structures and urban spaces best suited for a ubiquitous environment based on various experiments. To do this, we need techniques for processing ambient intelligence found in embedded digital contents. For example, we need a way to transform digital content into various functions using ubiquitous devices. Ambient knowledge and intelligence are processed by user activities. Although ubiquitous computing will open a new era in information access, what it bestows upon structures and the urban environment is primarily associated with the interface. The question of how to use ubiquitous computing for structures warrants some thought. Moreover, if structures are to actively construct the information society, various types of information must be stored and shared, which will open up a wide range of possibilities in many fields.

Acknowledgements

We are sincerely grateful to Professor Katsumi Tanaka for his constructive comments on this article. We are also grateful to the other members of the Interactive Communication Media and Content Group at NICT for their useful comments and suggestions during the course of this work.

References

Oh S., Kidawara Y., Tanaka K. & Nagafune T.: 2006. A Prototype System for Use in Designing Ubiquitous Environmental Space, The 11th CAADRIA, pp. 355–361

Gronbak K., Kristensen J.F., Orbak P. & Eriksen M.A.: 2003, Physical Hypermedia: Organizing Collections of Mixed Physical and Digital Material, ACM HyperText '03, pp. 10–19.

Romero L. & Correia N.: 2003, HyperReal: A Hypermedia Model for Mixed Reality, ACM HyperText '03, pp. 2–9.

Weal M.J., Michaelides D.T., Thompson M.K. & Deroure D.C.: 2003, The Ambient Wood Journals-Replaying the Experience, ACM HyperText '03, pp. 20–27.

TVML: http://www.nhk.or.jp/strl/tvml/english/player2/index.html.

Jeng T.: 2005, Advanced Ubiquitous Media for Interactive Space, CAAD Future2005, Springer, pp. 341–350

Chang Y.: 2003, Spatial Cognition in Digital Cities, The International Journal of Architectural Computing, Issue 04, Vol. 01, pp. 472–488.

Kidawara Y., Zettsu K. & Katsumoto M.: 2003, A distribution Mechanism for an Active User Profile in a Ubiquitous Network Environment, IEEE Pacific Rim Conference on Communications, Computers and Signal Processing, pp.181–184.

Coles A., Deliot E., Melamed T. & Lansard K.: 2003, A framework for coordinated multi-modal browsing with multiple clients, The 12th International World Wide Web Conference 2003, ACM, pp. 718–726.

Want R., Pering T., Danneels G., Kumar M., Sundar M. & Lignt J.: 2002, The personal server: Changing the way we think about ubiquitous computing, UBICOMP2002, pp.194–209

Gregory D.A., Elizabeth D.M. & Tom R.: 2002, The Human Experience, IEEE Pervasive Computing, pp. 48–57.