A Compact Battery-less Information Terminal For Interactive Information Support

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ABSTRACT

One target of a ubiquitous computing environment is to aid users to get necessary information and services in a situation-dependent form. We have proposed a location- and orientation-based information support system using the Compact Battery-less Information Terminal (CoBIT). The CoBIT is a small, low cost communication terminal that works using only energy from the information carrier and the user. We realized one example of CoBIT, which downloads sound information and uploads position and orientation of the user along with signs from the user. However, previous work realized only earphone-type CoBITs and no detailed characteristics of communication between CoBIT and the interface system were discussed. We have investigated detailed characteristics of the CoBIT system download and upload processes. We also developed two types of CoBIT and used them in demonstration services that have been used by more than 200,000 people. Furthermore we will introduce a liquid crystal shutter, which emit the ID of the CoBIT realizing personalized information support. And the user can also use high spec personal computer on a desk or cellular phone in the hand seamlessly cooperated with the CoBIT.

Keywords

User-dependent, information support, information terminal, location-based, battery-less, compact.

1. INTRODUCTION

More and more people will come to enjoy information services while moving around in the real world. In the fields of " pervasive" , "ubiquitous" [1] and "context-aware" [2] computing, the most important point is realization of a context-aware information service system which supplies proper information "here, now, for me."[3] In this paper, we focus on use of location as a salient clue to the context. Examples of location independent information include electronic books, e-mail or movies that are intended to be delivered "any time, any where, and to every person." On the other hand, a user sometimes needs information which is strongly dependent on the user location and orientation. This paper presents discussion of the latter information service system with walking and browsing users as the primary target rather than quickly-moving users riding vehicles. In addition, we aim to create a mobile terminal that would be easy for anyone to use.

Two widespread media which connect mobile terminals and interface systems are radio waves and light beams. Radio waves spread omni-directionally and can broadcast over a wide area by use of strong radio wave sources. In contrast, light beams offer directivity and can be controlled; thus, we can set a service area more easily even though light is occluded by objects. Next, we compare the two types of media from the perspective of use as a location-aware information service for pedestrians.

Cellular phones, personal headphone systems (PHS), and wireless LANs use wide range radio waves which travel more than 10 m. When they are used for locating the device, the accuracy is usually within a cell range unless other methods are combined. A positioning device, such as GPS or terminal orientation sensor such as terrestrial magnetism sensor, must be installed in the mobile terminal to make such mobile terminals location-aware for pedestrians [4]. Such users usually require accuracy of 1 m or less for use in guided mobility.

Alternatively, positioning accuracy is achieved by use of many interface terminals using weak radio wave. For example, weak FM radio wave systems can support a user who has an FM radio. If a user approaches a base station, she receives location-dependent information. Very promising ubiquitous items, RF-tags and IC-tags, use very weak radio waves which travel less than 1 m. They will be implanted to various objects holding each characteristic or history [5].

Generally, beam light travels shorter distances than radio waves and can be occluded easily. Notwithstanding, we believe that a salient characteristic of light, its straight path, is important because we can control the service area and a mobile terminal's orientation conveniently. The most important merit is that the mobile terminal requires no sensors in a ubiquitous environment with many base stations to achieve location- and orientation-based information support. When information is projected to a certain area, only information terminals with the correct location and orientation can receive information. One information system that utilizes this feature is a Talking Signs [6] system. The Talking Signs system allows a user to receive sound information through infrared rays from an electronic label (a source of light) installed in an environment such as a public space or mode of transportation. One typical application is to announce the traffic signal color to visually handicapped people. In this use, direction is critical. A Talking Signs terminal regenerates sound information with a built-in speaker or an earphone from frequency modulated (FM) signals.

However, it is not intended to realize interaction between the user and the Talking Signs. Interactive information support is preferable because the system cannot estimate the condition of the user easily. Furthermore, signals from the user are an efficient method to estimate his or her condition. Many systems such as C-MAP [7], Location-Aware Shopping Assistance [8], and Cyberguide [9] have achieved interactive location-aware information services using high function terminals like PDA that have small displays and rich communication devices.

It is important for a mobile information terminal to be both intuitive and easy to use in consideration of those people who have never used a computer or a PDA. No latency is also important because people can walk away while the terminal wakes up in a few seconds. A mobile user will not use a terminal if it is not compact. A design with no plug-in battery is also desirable to ensure low maintenance. Maintenance-free operation for at least several years, like a watch, would facilitate widespread use of this system. In fact, a mobile terminal with all the characteristics mentioned above (intuitive and interactive interface, no-latency, compact, and no-battery) is a feasible creation for a future ubiquitous world that has many base stations, display devices, sensor devices, and computers connected to internet.

Based on the above considerations, we developed a CoBIT [10], - a compact, battery-less information terminal - which can provide situated information based on a user's position and orientation. The CoBIT is a small, low cost communication terminal that functions using only energy from the information carrier and the user. We realized one example of CoBITs which downloads sound information and uploads position and orientation of the user and a sign from the user. However, previous work realized only earphone-type CoBITs; no detailed characteristics of communication between CoBIT and the interface system were discussed.

Therefore, we have investigated detailed characteristics of download and upload of the CoBIT system. We also developed two types of CoBIT and used them in demonstration services that have been used by more than 200,000 people.

The next section explains the information support system using CoBITs. In addition, sound download and position upload characteristics are investigated in Sections 3 and 4 respectively. Section 5 presents two demonstrations which lasted more than one month. Section 6 concludes this paper.

2. CoBIT system

Figure 1 shows a CoBIT system architecture diagram. The CoBIT comprises the three following parts.

1. A solar cell: This photovoltaic device converts available light into electrical energy. In our usage, it serves an antenna function as it receives radiant beams from an environmental light source device and reproduces sound information from the beam. It also serves as an electrical energy device - the original function of the solar cell. In other words, this device uses a single-beam channel as a simultaneous source of energy and information.

2. A speaker: This is an acoustic device that converts energy and information, which are received by the solar cell, into sound. And it is directly connected to solar cell and produces the audio information for the user.

3. A reflective sheet: This is an optical material that uploads user position and sign as a form of gesture signal to the interface system. It is reasonable to use materials such as corner-cube prisms, which reflect much light toward the incident direction of light, to process images easily. The infrared projection camera, which is the first element of the interface system we will mention, can detect only reflective sheets of the CoBIT system as a bright spot by installing a visible-light cutting optical filter, as shown in Fig. 2.

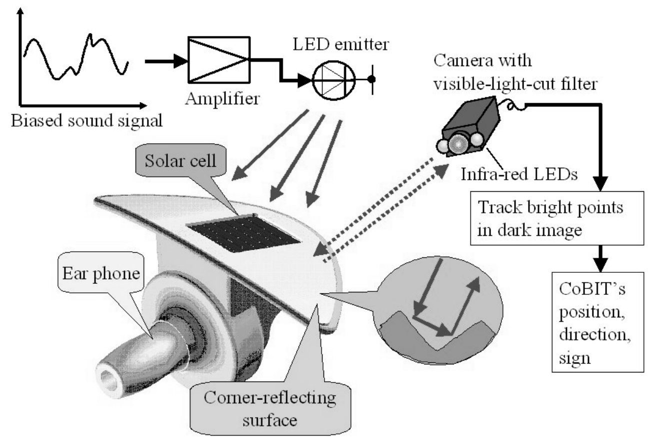

Figure 1. Basic CoBIT system architecture

Segmentation of objects in the image is simplified accordingly. The interface system observes movement of the reflective sheet through an infrared projection camera. This observation allows the system to recognize user signals and thereby estimate a user's position and direction.

Figure 2. Image sample of the interface system camera

The interface system basically comprises the following two devices.

1. An infrared projection camera: This sensor captures existence and movement of a reflective sheet of CoBIT: they define the user's position and orientation. A gesture recognition engine analyzes this information and identifies user signals.[11]

2. A light source: This optical device sends energy and sound information to the user as a form of light beam. This device enables location- and orientation- based communication using light direction.

As explained before, the user can send his position and signals to the interface system by moving the CoBIT or changing its reflection rate. Advantages of this visible-light cutting technique include the following:

1. Privacy problems do not occur because the system records no personal facial image;

2. The system can recognize a user's position, direction and a signal more robustly than recognizing a person from a normal camera image;

3. Pointer operation is possible by linking movement of the reflective sheet to a mouse;

4. It can easily interact with plural users and count their number.

A user can "hear" information as a form of a sound just by looking at interesting objects, as shown in Fig. 3. This is a location-and-orientation-based information service.

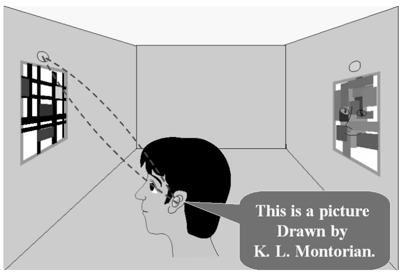

Figure 3. Location-and-orientation-based information service Sound information is provided by looking at a proper direction at a proper position with a CoBIT.

In a future ubiquitous system, the interface system will be incorporated with other sensors (microphones, etc.) and display devices (large monitors, etc.). It may also connect to various function modules, as shown in Fig. 4. The user situation and environmental situation can be estimated using outputs of various sensors.

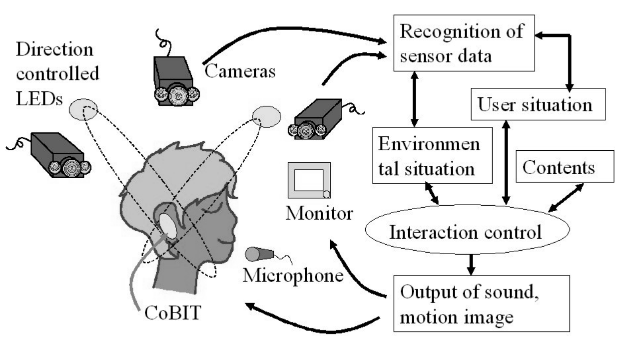

Figure 4. System configuration of a future information service using CoBIT.

3. Characteristics of sound download

In this section, synthetic characteristics, from light module input to solar cell output, were evaluated. Figure 5 shows results with frequency on the horizontal axis and with output voltage of the solar cell on the vertical axis. Gain peaked when a 1 kHz signal was input; gain decrease was less than 1/2 in the range from 200 Hz to 20 kHz. The condenser effect of the solar cell decreased the gain in the high frequency range. In addition, the amplifier decreased the gain in low frequency because it was designed wrongly in this prototype system. Still, the sound quality was good enough for voice information support.

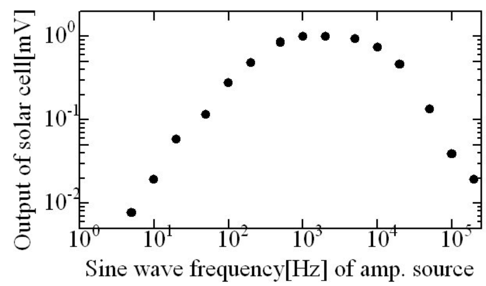

Figure 5. Sound download frequency characteristics.

4. Detection of the reflective sheet

Position and signal upload is achieved by detecting the reflective sheet on CoBIT using a light-emitting infrared camera. We implemented CoBIT using a reflective sheet, 3970G (3M Co.), which has small corner cubes on it and reflects back in the incident direction. Here, we denote the observation angle as that between the incident and reflected beam as shown in the right portion of Fig. 6. The right figure shows the reflective sheet according to the incident angle, for which the observation angle is fixed to 0°. A mirror has a reflection only when the incident angle is 0°. This reflective sheet has about a 30° half-intensity angle.

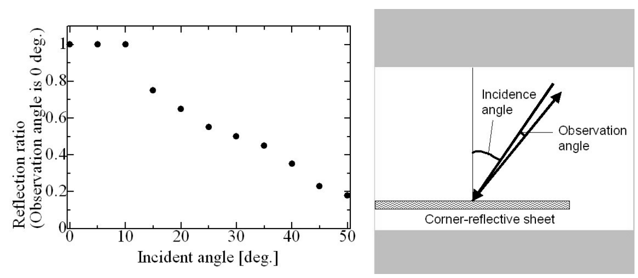

Figure 6. Reflective ratio of the reflective sheet when incident angle is changed. Observation angle is fixed to 0°.

5. Demonstrations

5.1 Ceramic-phone type CoBIT

Figure 7 shows the ceramic-phone type CoBIT and its sample usage. A ceramic phone is connected directly to a solar cell. The solar cell is crystal silicon; it is 12 mm wide and 17.5 mm high. It has a visible-light cutting filter (IR84) on its surface.

This type of CoBIT was adopted by a designer, Tastuya Matsui, and was used by about two hundred thousand people in The Doraemon, 2002.7.13-9.23 in Osaka, Japan. Two CoBIT light sources were installed in a translucent window and in a closet.

People with one CoBIT in each ear heard sounds of cars and peoples' conversation from the window and a sound of vacuuming the floor and washing in a bathroom from the closet.

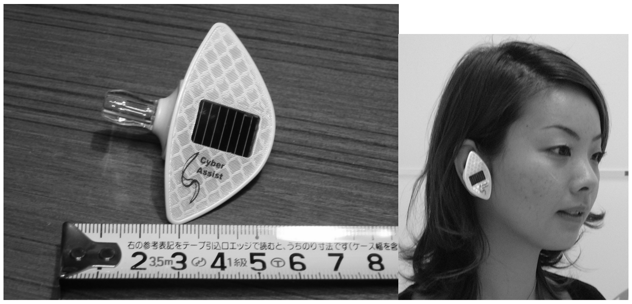

Figure 7. Ceramic-phone type CoBIT and its sample usage. Wearing one CoBITs on each ear, a user could detect the light source direction quickly.

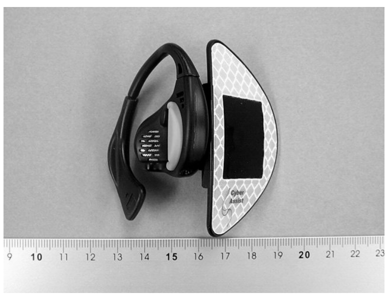

Figure 8. Dynamic phone type CoBIT.

Figure 9. Infrared LED emitters for CoBIT above each monitors. Audio information of video was provided through CoBIT.

5.2 Dynamic-phone type CoBIT

To rent CoBITs with less maintenance and damage, we produced a dynamic phone type CoBIT offering better sound quality and secure ear placement. Figure 8 shows the dynamic-phone type CoBIT; it can be hung on the earlobe and is robust because the thickness of the solar cell component was increased, thereby realizing lower maintenance and damage. The headphone is a SE-E03II (Pioneer Corp.); the solar cell is 30 mm wide and 32 mm high. This type of CoBIT was used after 5 years' exhibition, 2002.10.4-10.30, in Tokyo, Japan. There were 25 CoBIT light sources installed at the exhibition. Most of them are above video monitors emitting audio information to CoBIT users as shown in Fig. 9. No CoBIT was damaged at the exhibition. Some users complained about the CoBIT loudness. The system was also used in The Doraemon, 2003.3.15-5.15 in Yokohama, Japan.

6. Conclusion

The CoBIT system was explained and detailed characteristics of the download and upload are investigated. Two types of CoBIT were produced and used for demonstrations showing effectiveness of CoBIT information support.

In the future, an interface system will comprise more sensors and display devices; it will be connected to various AI modules achieving intelligent information support *via* very simple mobile terminals.

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