Intelligent Wearable Interaction System for Interactive Electronic Media

Hyun S. Yang[1], Jin Choi[2], Yong-Ho Seo[3], Taewoo Han[4], Juho Lee[5]
AIM Lab., CS Dept., KAIST[1,2,3,4,5]
{ hsyang[1], jin_cho[2], yhseo[3], bluebird[4], jhlee[5]}@paradise.kaist.ac.kr

Abstract

The wearable computer that can understand the context of human life and communicate autonomously with various electronic media in a ubiquitous computing environment would be very useful as an assistant for humans. In this paper, we present a wearable computer that interacts with both humans and electronic media. The developed wearable computer can sense the interactive electronic media that a user wants to use and also communicate with it. Utilizing these interaction capabilities, it intermediates between each media and the user and offers a friendlier interface to the user who wears this system. We also show some demonstrations of the development system.

Key words: wearable computer, human computer interaction, interactive electronic media, environment sensing, assistance system

1. Introduction

Passing through the age of huge main frame computers in the 1960s and the age of personal computers in the 1980s, we are now surrounded by many computing devices like desktop computers, notebook computers, personal digital assistants (PDAs), cellular phones, etc. This drift may be kept up, as well as be more quickly accelerated.

Mark Weiser first defined the phrase "ubiquitous computing." in 1988. Ubiquitous computing means that every object has computing devices, due to advance of computing device technologies. In the near future, we will frequently interact with various electronic media in a ubiquitous computing environment that will be scattered around us [1]. With the continued growth of ubiquitous computing, we may come to feel burdened by different electronic media that daily life requires them to interact with. Therefore, to alleviate our suffering, a system that assists us in interacting with those electronic media in our daily life is required. This burden may be alleviated if we could easily use the different electronic media without having to study the technical manual of each electronic media (IETM; Interactive Electronic Technical Manual [2]).

Wearable computers are highly compact computers that can be worn on the human body. As computational technology becomes part of our everyday lives in a much more immediate and intimate way than in the past, it becomes a general trend that wearable computer are used in our real life. Researches on wearable computers have been done since the 1970s and the recent interest in wearable computer is explosive. Steve Mann, one of main researchers, defines a wearable computer as a computer that is subsumed into the personal space of the user, controlled by the wearer, and that is always on and always accessible [3]. In this regard, wearable computers differ from hand held devices, laptop computers and PDAs. The most fundamental issue in wearable computing is personal empowerment. Wearable computers allow humans to perform works that were impossible in the past, as well as to execute the wasteful works more comfortably and quickly.

Unlike the research on battery power, input/output devices, small processing device, and etc., this paper is not concerned with advancing the assorted component technologies required for wearable computing, though such research is very challenging and worthwhile. Instead, we focus on developing a wearable computing platform and an application technology.

Feature	Ubiquitous computing	Wearable computin g
Privacy	X	O
Personalization	X	O
Localized information	O	X
Localized control	O	X
Resource management	O	X

Features provided by ubiquitous computing versus wearable computing are summarized in a above table [4]. It tells us that research mixing both ubiquitous computing and wearable computing are necessary to overcome disadvantages of both. Some researches about that are proceeding and our research is included in those researches. We expect that the wearable computer would play an important role in a ubiquitous computing environment since systems that control electronic media will be needed, although those media would be more intelligent than before.

In this paper, we describe the development of an intelligent wearable assistance system called IWAS. In ubiquitous computing, the IWAS is an agent that helps a person interact with numbers of media, as well as an interface that links the person with them. This system can understand a user's intention or preference, and can communicate intelligently and efficiently with various interactive electronic media.

2. Definitions

2-1. IEM

We define Interactive Electronic Media (IEM) as electronic media that are not only controlled by a user's orders but that also respond to context or the user's emotional state in a home networking environment. The IEM is similar to objects in ubiquitous computing. However it has narrower meaning than the objects in ubiquitous computing, focusing on the interaction. For example, the IEM includes not only electronic appliances such as a television or a video player, but also the curtain that rises or falls according to a user's access, the lamp that controls the intensity of light according to a user's emotional state, and so on. The IEM is, thus, a concept that involves a number of interactive everyday objects with embedded computer chips or sensors.

2-2. IWAS

The Intelligent Wearable Assistance System (IWAS) is a kind of wearable computer that can sense, control and communicate with many IEM. Its main objective is to provide intuitive and convenient communication between a user and electronic media. A user can easily control and interact with each component of electronic media dispersed throughout a ubiquitous computing environment through this interface even though the user does not have any manual or detailed knowledge about those devices (Figure 1).

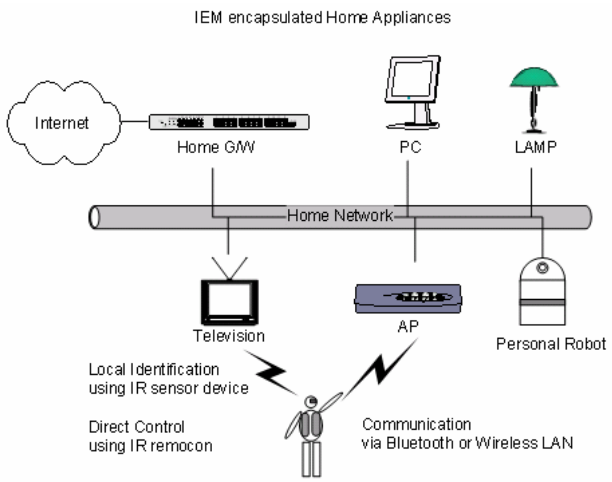

Figure 1 Overview of IWAS

Utilizing its sensing and communication capabilities, the IWAS intermediates between each media component and the user and offers a friendlier interface to the user who wears this system. The IWAS must be able to automatically detect the intentions of the user who wants to use any specific electronic media and then get the information about that device. Furthermore, the IWAS also has to perform some prepared functions on electronic devices with satisfying the user's intention.

In summary, we can say that in ubiquitous computing is the IWAS both an agent that let a person comfort and an interface that intermediates between the person and the IEM.

3. A Prototype of IWAS

3.1 Hardware Configuration and Components

Figure 2 A prototype of IWAS

A developed prototype of IWAS is shown in Figure 2. We designed IWAS as a type of a wearable computing suit, considering a user's convenience in living environment.

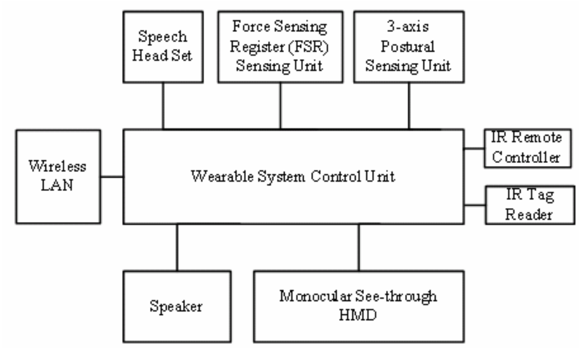

Figure 3 Hardware architecture of the IWAS

Figure 3 shows the hardware architecture of the IWAS. When we designed the input devices of the prototype, we intended that they be hands-free devices. Thus, the developed prototype has several input devices such as a microphone for voice command input, FSR (Force Sensing Register) sensing units from Tekscan, Inc. for touch input, and a 3-axis postural sensing unit, MI-A330LS manufactured by MicroInfinity Corporation for gesture detection (Figure 4). The FSR sensors are used to measure the pressures on the attached points when a user touches the suit. The 3-axes postural sensors calculate three rotation angles which are called roll, pitch, and yaw in 3-axes and three acceleration values at each axis. The sensors output the result data via an RS232 interface. The FSR sensors are attached on the chest part of the suit and the 3-axis postural sensor fixed on an elastic sports band is located on the arm wrist. As output devices, two small speakers and one monocular see-through HMD are attached on the wearable platform.

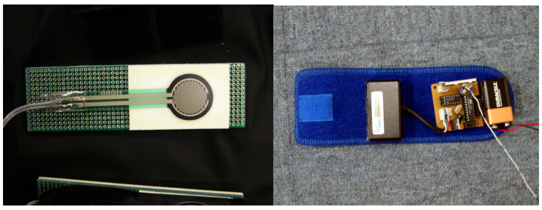

Figure 4 FSR sensor and 3-axes postural sensor

A mobile mini note PC from JVC was chosen as a main computer. That has the advantages of quick and easy development and compatibility with various peripherals like wireless LAN, USB, PCMCIA, and IEEE1394 devices. We made an inner pocket at the back part of the suit to insert a main computer.

For communication with the IEM, the prototype uses a wireless LAN adapter and a Bluetooth RS232 module, so that it interacts with the IEM in a general manner.

To get the information of a wearer's location, we developed an infrared ray identification (IRID) tag transmitter and an IRID reader (Figure 5). Each IRID tag transmitter is attached to the corresponding electronic media such as TV, video, audio, and etc. and an IRID reader is attached to the HMD. The location of the IRID reader in the prototype suit is based on the tendency for a user to look at an object first when he is interested in using it. We also developed a universal remote controller to communicate with the existing non-interactive electronic media in home environments,

With the help of these devices, the proposed prototype can detect the user's location when a user approaches the specific electronic media. In addition, the prototype can control various kinds of existing non-interactive electronic media through the developed universal remote controller.

We built a customized control board for the measurement of the analog data from an IRID reader and FSR sensors (Figure 5). ATmega163, an 8-bit microcontroller from Atmel Inc., which has an 8-channel 10bit A/D converter and three 8bit PWM timers for sensing and control, was used to develop the control board. To supply electrical power to several sensors, the HMD, and the control hardware, a 7.2V 2000mAh NiMH battery is embedded in the vest. All hardware control boards described above are connected to the main computer via USB port. At last, we show a figure that a user is wearing the developed prototype (Figure 6).

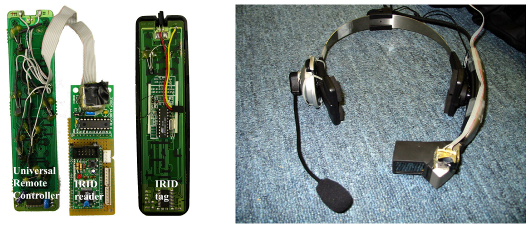

Figure 5 Uiniversal remote controller and IRID reader and IRID tag (left). The IRID reader attached to the see through HMD (right).

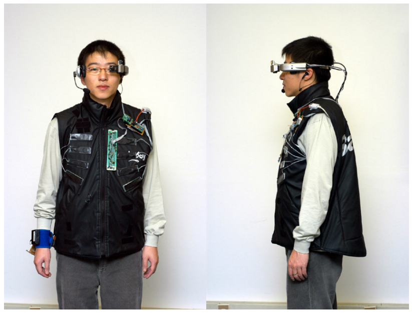

Figure 6 A user wearing the developed prototype

3-2. Automated Media Identification System

The current location and direction of the user is the most fundamental aspect of the context of the user. Even though the gesture recognition or the speech recognition may be used as a means of detecting the user's attention, both of these methods will require some specific convention. The location information is most intuitive and simply detectable. It also may be a good indicator as to which media the user wants to interact with. If she wants to watch TV, for example, she must be in front of that TV. The IWAS, therefore, must be able to automatically identify which media a user is in front.

Some research has already been conducted on automatic identification systems. There are a few proposed methods such as computer vision identification systems [5], radio frequency identification (RFID) systems [6], and infrared ray identification (IRID) systems [7].

We present an automated media identification system (AMIS) similar to the infrared ray identification system (Figure 7). This system is comprised of three main components. The first of them is the IRID tag, which is located on the IEM to be tracked and the next is the IRID reader which reads data from the IRID tag. The third is the data process subsystem, which analyzes the data gotten from the IRID reader.

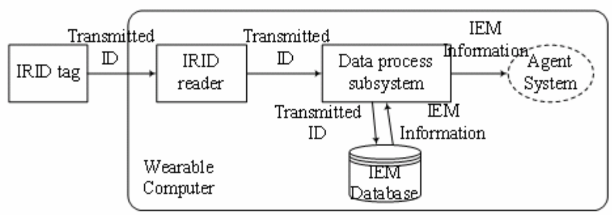

Figure 7 An automated media identification system

IRID tags are attached to the corresponding media. Every IRID tag transmits its own ID five times per sec. When a user wearing the prototype goes into an active region of the IRID tag and looks at the IEM, the IRID reader senses the transmitted data. Figure 8 shows an IRID reader sensing when a user walks around a room where two IEM exist. In this case, the two IEM are lain on a parallel line, while the IEM A is transmitting 4 of ID and the IEM B is transmitting 9 of ID. As the chart shown, there are two clearly distinct areas with some noise. Therefore, the subsystem accumulates the data to reduce hasty changes.

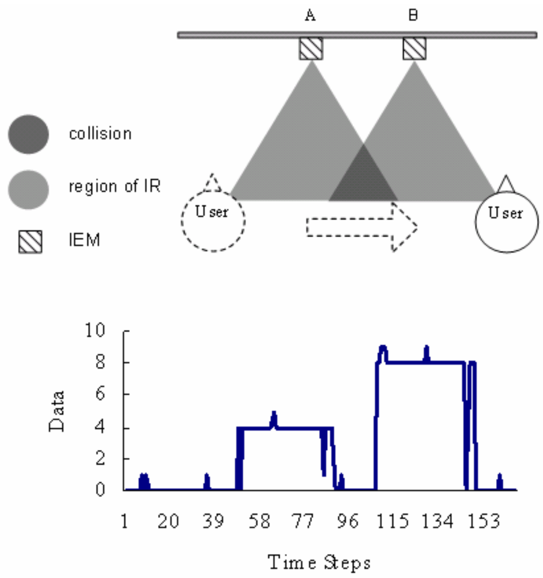

Figure 8 An example of the IEM induction in parallel setting

We present another example of the IEM induction. Like the above example, the IEM A is transmitting 4 of ID and the IEM B is transmitting 8 of ID. But the two IEM are lain on two different sides, facing toward each other. And a user stands on the center where is influenced by both the IEM. The user looks at the IEM A and turns to the IEM B and looks at it. A chart of

Figure 9 shows the result sensed by the IRID reader within above situation. Two stable areas of the chart allow us to identify the IEM in a collision region.

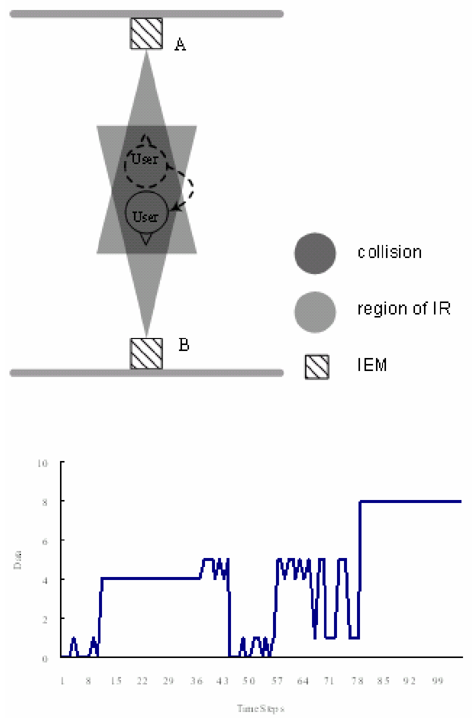

Figure 9 An example of IEM induction in a case that two IEM are facing toward each other

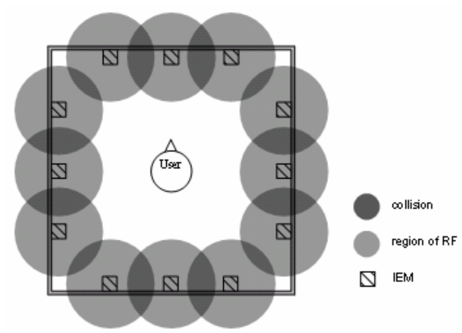

Figure 10 An example of an RFID system in use

This system provides several advantages. First, it is inexpensive to make, easy to install, and requires little maintenance. Also, it is robust to the illumination change. Finally, it is somewhat exclusive because it uses infrared rays that have a fixed direction and whose active range is narrow. In other words, this system may take more chances to identify only one media at one time while practical. For examples, in an RFID system, a user must be close to the IEM as shown in

Figure 10. Even though the region of the RF is amplified, a lot of collision will occur. On the other hand, through this system, the IWAS is able to handily identify the IEM (Figure 11).

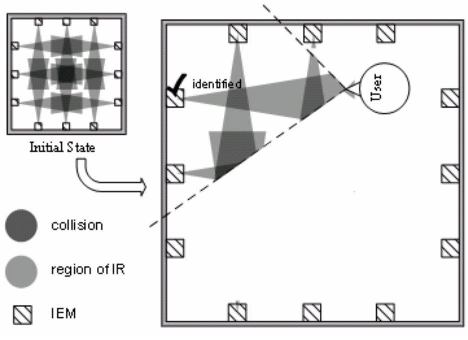

Figure 11 The left small box shows a state before a user appears. Through the AMIS, one IEM is identified depending on the user's direction and location.

3-3. Agent System

We developed the agent system that has multimodal interfaces, so that diverse and non-professional users can more easily access the IWAS and the IWAS has more expressive power.

As AMIS recognizes the IEM and a user has a continual interest in it, the agent system responds to the user. This system enables a user to get the information about the identified IEM through both visual and aural interfaces (Figure 12). In particular, by using the IEM information that is obtained from the AMIS, the agent system shows the function or explanation of the IEM through HMD and simultaneously tells the user which IEM is identified.

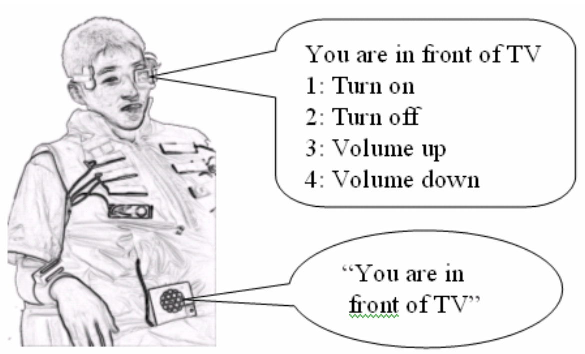

Figure 12 The agent system informs the user of the identified IEM through the HMD and speaker.

By using see-through HMD, we implement basic augmented reality (AR) that is the process of overlaying and aligning computer-generated images over a user's view of the physical world. In particular, an internal half-silvered mirror of the HMD combines images from an LCD display with the user's vision of the world.

We use OpenGL, a graphic library for graphic rendering. Also, for speech synthesis, we use a Text To Speech (TTS) program developed by Cowon Sytems, Inc. It produces natural Korean and English sentences. If the IEM allows a user to choose a variety of options, it is difficult for the user to scan all the choices for the desired one. Therefore, we record the selected choices in order to briefly show frequently used choices.

This system utilizes the user's speech, touch, and gestures, as input interfaces, without disturbing the hands. The speech recognition system is the primary component but it is supplemented by several other components. For speech recognition, we use an HMM speech recognition system developed in our laboratory that can recognize about 50 words. For touch recognition, this system analyzes the input signals from the FSR sensors and decides which parts are touched. This interface is important when various inputs are needed at one time. For tracking a hand motion, this system also analyzes the input signals from a 3-axes postural sensor and figures out the difference of data. These interfaces can be mixed. For instance, it is possible that a user says "volume" and raises his hand to increase the volume of TV.

Figure 13 A user interact with IEM by gesture

In IWAS, we mainly use a speech recognition system for input interface. The speech recognition system is an intuitive and common interface, but it has limitations. Ambient noise from a TV, a radio, and something in the house causes the poor recognition result. Moreover it is impossible to control when the wearer is talking. So the gesture recognition as natural interfaces except speech recognition is needed. Many researches on gesture recognition have been studied based on Computer vision. But computer vision based gesture recognition is not suited in the house, because it is very sensitive to luminance variation. Therefore we propose a wearable gesture recognition system for the input interface of IWAS. It allows the wearer to control IEM by an arm gesture (Figure13).

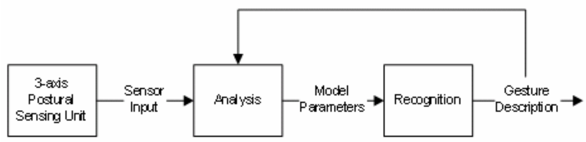

Figure 14 Overview of wearable gesture recognition system

We apply the general approach of computer vision based gesture recognition system to our system (Figure 14). When the user wearing the sensor on his wrist like a watch makes a gesture, that motion is tracked. And we analyze this sensed data. Then we recognize a gesture based on model parameters from analysis. For recognition, we use HMM technique.

In a ubiquitous computing environment, this system communicates with the IEM through a wireless LAN adapter, the data packet of which is based on the User Datagram Protocol (UDP) because data loss is not critical but fast communication is needed. Additionally, this system commands the non-IEM such as the existing TV, video, and audio through a universal remote controller.

4. Demonstration

Figure 15 A demonstration for IEM-encapsulated electronic appliance

To verify the overall performance of the developed IWAS prototype, we present a demonstration. We make a scenario for the demonstration. Then we get the developed IWAS prototype tested within the scenario. This demonstration shows how to conveniently extend the existing electronic home appliances to IEM. The IRID tag and the universal remote controller make that possible.

In this demonstration, a user is in front of TV and he has interest in it. The IWAS, therefore, shows him a menu while it tells him about the TV. The user says “Turn on” and the IWAS turns the TV on. The IWAS, without being prompted, changes the channel to his favorite one. While watching, the user controls the TV by speech, touch, and gesture (Figure 15).

5. Conclusions and Future Work

In this paper, we defined Interactive Electronic Media (IEM) and Intelligent Wearable Assistance System (IWAS). And we developed an IWAS prototype that helps a user interact with lots of IEM and also intermediates between the user and IEM in ubiquitous computing. Subsequently, we present two demonstrations to verify the overall performance of the developed IWAS prototype.

Through our wearable system, a user may focus on useful jobs, instead of wasting his energy on numbers of interactions with objects. And it will cover a heavy burden that the user should have knowledge of objects. Also it allows the user to interact with objects in intimate ways. Finally, it has much potential to be practically used in various works. The closer we come to the ubiquitous computing environment, the more it is important.

In order that a person uses this system more friendly with more interest, 3D elements are necessary when we display the menu or the manual of the interactive electronic media. We hope to extend our research, by utilizing the wearable computer, to research on augmented reality. As well, we will research context awareness beyond simple IEM recognition. We will bring the concept of open agent architecture into the IWAS, in order to cooperate with the existing other agents.

Acknowledgement

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