Intelligent Wearable Assistance System for Communicating with Interactive Electronic Media

Jin Choi, Yong-Ho Seo, Taewoo Han, Juho Lee, and Hyun S. Yang

Artificial Intelligence and Media Laboratory
Department of Electronic Engineering and Computer Science
KAIST
373-1, Guseong-dong, Yuseong-gu, Daejeon 305-701, Korea
{ jin_choi, yhseo, bluebird, jhlee, hsyang}@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 scenarios and applications of the development system.

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

1. Introduction

In the near future, we will frequently interact with various electronic media in the ubiquitous computing environments that will be scattered around us [1]. With the continued growth of ubiquitous computing, we may soon come to feel burdened by the variety of 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 [2]. This burden may be alleviated if this variety of electronic media could be used easily without having to study the technical manual of each electronic media (IETM; Interactive Electronic Technical Manual [3]).

Wearable computers are highly compact computers that can be worn on the human body. Many different scientists have been conducting research into wearable computing for about 20 years [4-9].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 the wearable computing platform and application technology. 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 [4].

In this paper, we describe the development of an intelligent wearable assistance system called IWAS. This system can understand a user's intension or preference, and can communicate intelligently and efficiently with various interactive electronic media. We define the interactive electronic media in section 2, and explain the concept of IWAS in section 3. In section 4, we describe a developed prototype of IWAS and discuss its hardware architecture and agent systems. We present a prototype of interactive electronic media for evaluating the usability and convenience of the developed prototype of IWAS in section 5. Additionally, we explain scenarios in which the developed system could be used in section 6 and introduce some applications in section 7. This paper is concluded with some proposals for future research in section 8.

2. 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. 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 everyday objects with embedded computer chips or sensors.

3. IWAS

The Intelligent Wearable Assistance System (IWAS) is a kind of wearable computer that can sense, control and communicate with many IEM. Its 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).

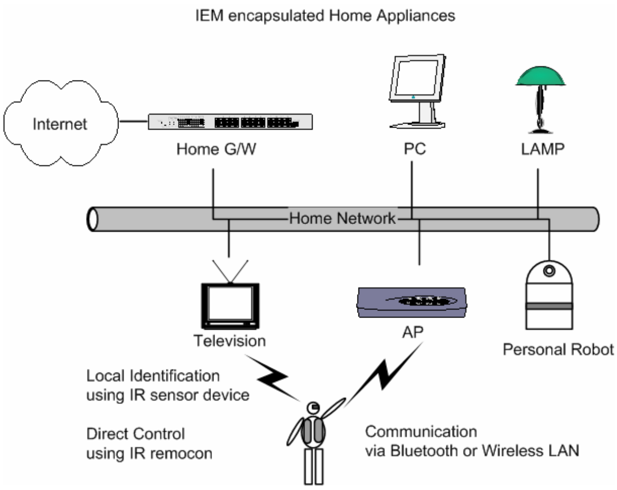

Figure 1. Overview of IWAS

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.

4. A Prototype of IWAS

In this section, we describe the hardware configuration, the input output components, and the automated media identification system of the IWAS prototype. The developed IWAS prototype has several input devices such as touch sensors, a gesture detection sensor, and a microphone. As output devices, small speakers and monocular see-through HMD are attached to the wearable platform. To sense and communicate with each interactive electronic media in home environments, an infrared ID tag reader and universal remote control hardware are developed. These hardware components are connected to the main computer via a USB port

4.1. Hardware Configuration and Components

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 2. A prototype of 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.

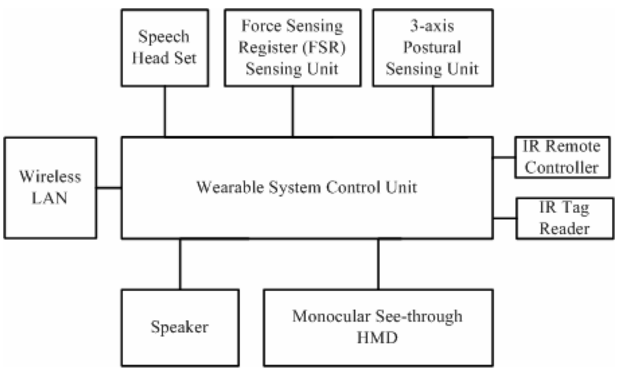

Figure 3. Hardware architecture of the IWAS

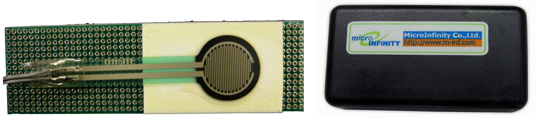

Figure 4. FSR sensor and 3-axes postural sensor

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 and a universal remote controller to communicate with the existing non-interactive electronic media in home environments, 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 placed beside 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.

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

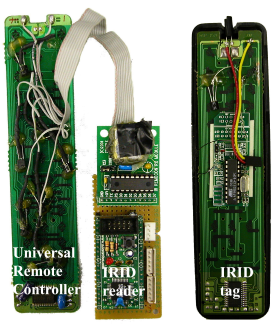

Figure 5. Universal remote controller and IRID reader and IRID tag

We built a customized control board for the measurement of the analog data from an IRID reader and FSR sensors. 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.

4.2. Automated Media Identification System

The current location 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 done into automatic identification systems. There are a few proposed methods such as computer vision identification systems [10], radio frequency identification (RFID) systems [11], and infrared ray identification (IRID) systems [12].

We present an automated media identification system (AMIS) similar to the infrared ray identification system. 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.

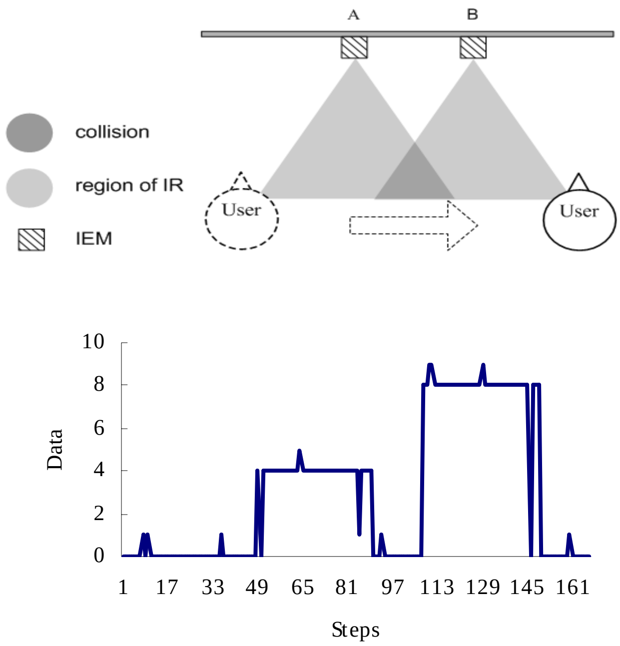

Figure 6. Example of the IEM induction

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 in an active region of the IRID tag and looks at the IEM, the IRID reader senses the transmitted data. Figure 6 shows an IRID reader being sensed when a user walks around a room within two IEM. There are two clearly distinct areas with some noise. Therefore, the subsystem accumulates the data to reduce hasty changes.

This system provides several advantages. First, it is inexpensive to make, easy to install, and requires little maintenance. Also, it is robust about illumination effect. Finally, it is 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 7. 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 7).

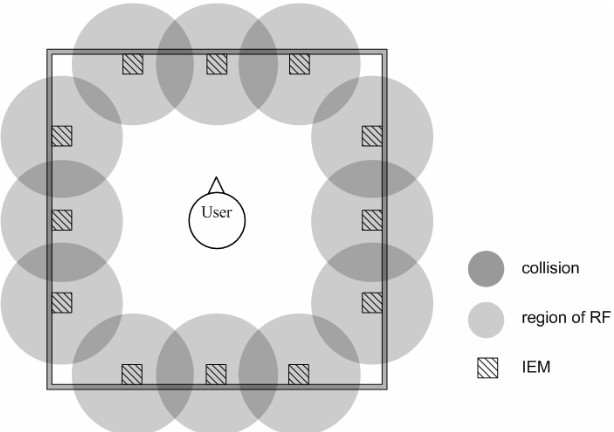

Figure 7. Example of an RFID system in use.

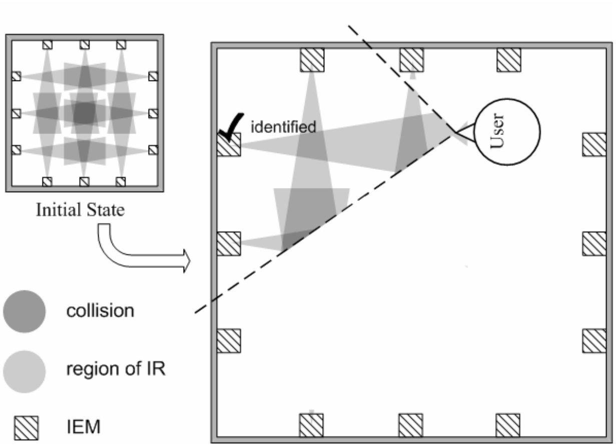

Figure 8. The left small box shows a state before a user appears. Through the AMIS, one IEM is identified depending on the user's direction and location.

4.3 Agent System

We developed the agent system that has multimodal interfaces, so that diverse and non-specialist users can more easily access the IWAS and the IWAS has more expressive power [13][14].

If AMIS recognizes the IEM and a user has a continual interest in it, the agent system becomes active. Then, this system enables a user to get the information about the identified IEM through both visual and aural interfaces (Figure 9).

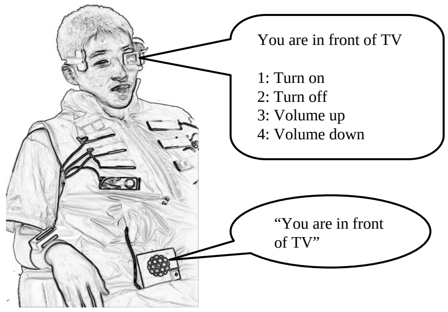

Figure 9. The agent system informs the user of the identified IEM through the HMD and speaker.

We use OpenGL, a graphic library for graphic rendering. Also, for speech synthesis, we have a Text To Speech (TTS) program developed by Cowon Sytems, Inc. It produces natural Korean and English sentences. Every IEM has its own function and manual, so the information of the IEM is stored in the IEM database. If the IEM allows the user 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 gesture recognition, 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.

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.

5. Prototype of IEM

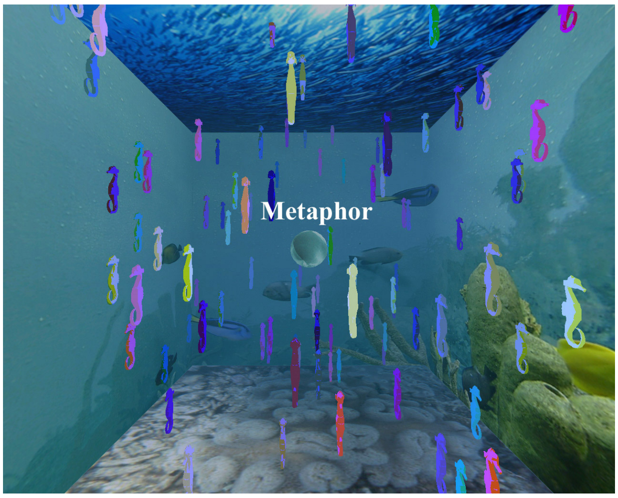

Figure 10. Virtual aquarium system

To evaluate the IWAS prototype presented above, we developed prototypes of the IEM, an interactive virtual aquarium system using fluid dynamics. It has the shape of typical TV and has an embedded computer.

This system is based on an evolutional model which uses genetic algorithms. We use a fluid dynamics solver to simulate the natural movement of artificial life [15][16].

At the beginning of the simulation, we set up the environmental parameters in the virtual aquarium. Each artificial life has its own genotypes that are created randomly at the initial stage. This genotype is simulated by bits. The shape, the color, and the sound of artificial life are decided by genotypes. This system tracks the speed of user's hand and uses it as an external force in the virtual aquarium. Then, that force results in the change of the flow of the fluid in the virtual aquarium based on a fluid dynamics solver. Finally, this simulated flow change causes a change in the simulated movement of the artificial life. When one artificial life meets another artificial life, an artificial life that has new genotypes is created using a genetic algorithm. Through these processes, we can make various artificial lives.

Figure 10 shows the initial state of the virtual aquarium system. In this figure, some artificial lives of various shapes and colors are scattered randomly throughout. At the center of that scene, there is a metaphor for interacting with a user.

6. Scenarios

6.1 IEM-encapsulated Electronic Appliances

In this scenario a user is in front of TV, which suggests to the IWAS that 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 11).

Figure 11. A user has interest in a TV.

6.2 IEM

An interactive virtual aquarium system hangs on the wall. A curious user looks at it. Then, he says "move" while swinging his hand. The flow of water in the aquarium changes, the direction of the change depending on his hand movement (Figure 12).

Figure 12. A user is curious about a virtual aquarium system.

7. Applications

Figure 13 shows some applications of the IWAS. The IWAS can be used to help people with disabilities, elderly people, and children. It can also help engineers in a plant manufacture as an advisor and also it can help mechanics for repairing. In a museum or gallery, an individual visitor may need information about the exhibits. The IWAS can act as a tour guide. The IWAS is a good interface for interactive media art.

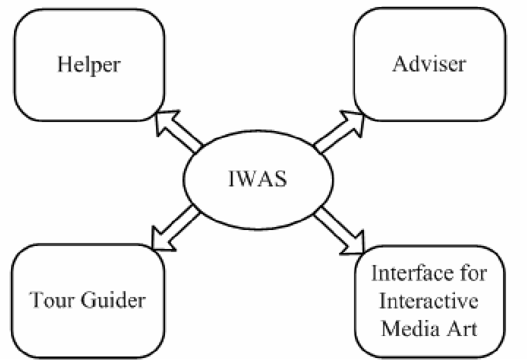

Figure 13. Applications of the IWAS

8. Conclusions and Future Work

We developed a wearable computer as a method by which to interact with electronic media in a ubiquitous computing environment. A user wearing this computer can control various electronic media, which will respond to the user's behavior. This research will be more important in the future computing environment.

For more fun, interest, and natural usability, 3D elements are necessary when we display the menu or the manual of the electronic media. We hope to extend our research, by utilizing the wearable computer, to research on mixed reality. As well, we will research context awareness beyond simple recognition of a user. To expand the usability of the IWAS, We will bring the concept of Open Agent Architecture into the IWAS.

Acknowledgement

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