A Wireless Glove-Based Input Device for Wearable Computers

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Abstract: Existing input devices for desktop computers are not suitable for wearable computers because they are neither easy to carry nor convenient to use in a mobile working environment. Different input devices for wearable computers must be developed. In this paper, a wireless glove-based input device for wearable computers is proposed. The proposed input device consists of a pair of chording gloves. Its keys are mounted on the fingers and their chording methods are similar to those of a Braille keyboard. RF (Radio Frequency) and IrDA (Infrared Data Association) modules are used to make the proposed input device wireless. Since the Braille representation for numbers and characters is efficient and has been well established for many languages in the world, the proposed input device may be one of good input devices to computers. Furthermore, since the Braille has been used for visually impaired people, the proposed one can be easily used as an input device to computers for them.

Keywords: glove-based I/O device, chording, wearable computer, wireless, RF, IrDA

1. INTRODUCTION

Recently, many researches about wearable computers have been performed because they can be used to aid inspection, medical, navigation, communication, and cognitive tasks [1-3]. Workers can perform more tasks using wearable computers [4-6]. Since wearable computers can be used in a mobile environment, their input devices must be wearable that is different from those of desktop computers. Chord keyboards have been proposed as input devices of small portable products such as Personal Digital Assistants (PDA), cellular phones, and wearable computes [7-10]. Since chord keyboards require a small number of keys, they do not need large space different from ordinary keyboards such as the QWERTY keyboard. In chord keyboards, the user presses multiple key combination to enter an input instead of using one key for each character in ordinary keyboards. Glove-based devices recognizing hand gestures or contact gestures directly have been also proposed as input devices to computers [11, 12]. These devices are well suited for use in a mobile environment because the gloves can be worn instead of held and are lightweight and take up little space. However, it is difficult to recognize enough separate gestures to allow useful text input. In [8], a glove-based input device called the chording glove has been proposed in order to combine the portability of a contact glove with the benefits of a chord keyboard.

In this paper, a pair of chording gloves is proposed as an input device for wearable computers. Its keys are mounted on the fingers of each glove and the characters associated with all the chords, which is called the keymap, are designed similarly as in a Braille keyboard. Also, RF and IrDA modules are used to make the proposed input devices wireless. In section 2, a pair of chording gloves is proposed as an input device. In section 3, the proposed chording gloves are implemented in order to connect them to wearable computers without wires. In section 4 and 5, the characteristics of the proposed devices are discussed and the conclusion is described, respectively.

2. A PAIR OF CHORDING GLOVES

2.1 Braille

A Frenchman named Louis Braille first developed Braille about 1820. Braille is a medium allowing visually impaired people to read text by touch and is also a method for writing tactile text. It consists of arrangements of raised dots that make up letters of the alphabet, numbers, and punctuation marks. The Braille cell consists of six dots arranged in the formation of a rectangle as in Fig. 1. The numbers of six dots are determined according to their positions. Fig. 2 shows some examples of the Braille code. Frank H. Hall invented the first Braille writing machine, Hall Braille writer, in 1892, which had one of the earliest chord keyboards (Fig. 3). The Hall Braille writer has a keyboard of only six keys and a space bar. These keys can be pushed separately or altogether to represent Braille symbols for visually impaired people. Each key among six ones corresponds to each dot in Braille cell as Fig. 2.

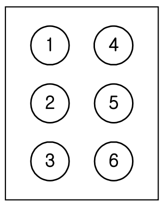


Fig. 1. The Braille Cell.

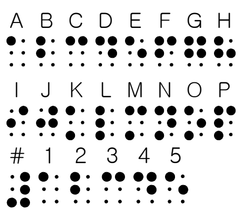
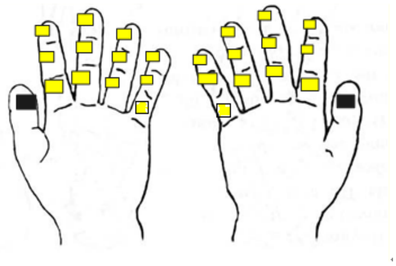


Fig. 2. The Braille Code.

Fig. 3. A Hall Braille writer.

2.2 A Pair of Braille-Based Chord Gloves

A pair of chord gloves as in Fig. 4 is proposed and each chord glove has twelve keys. Each key consists of conductive silicone ink. When the ground point of thumb touches one key, its corresponding information is detected. Three keys at the fingertips except little fingertip of each glove correspond Braille dots, of which the number is exactly same sequence as in a Braille keyboard. Some keys perform the same function as pressing all three keys at the fingertips altogether, the function of the space bar or the backspace bar, and the function of carriage return or enter, respectively. The other keys are reserved for future use. Therefore, the chording method in the proposed chord gloves is similar to that in a Braille keyboard, which has been already a standard for visually impaired people.



(a) Twelve key positions

(b) Implementation

Fig. 4. A pair of Braille-based chord gloves.

3. A WIRELESS CHORDING GLOVE

If some input devices in wearable computers are connected to the CPU board through wires, these wires do not allow us to put each input device arbitrary location away from the CPU board in a wearable computer. As more input devices are added, the CPU board becomes larger in order to have their corresponding connectors. In order to avoid these problems, we implement the proposed chording gloves to connect them to wearable computers without wires.

3.1 RF-based wireless chording gloves and their communication module

Fig. 5 shows RF-based wireless input devices and their communication module. The communication module is connected to a main computer through a serial port such as USB or RS-232c. It can exchange information with wireless input devices by RF signals. Since each input device uses the same frequency band, it has its own identification (ID) code to avoid the frequency interference. In order to initiate the communication, the communication module sends some information containing one ID code as in Fig. 6. If the input device of that ID code responds to send some data, the communication module receives the data and stores them. If there is no or invalid response during the predefined time, the communication module assumes that the called device is off and sends other information containing another ID code. The communication protocol consists of start, ID, data, and end fields as in Figure 7 and Table 1. When the CPU in the main computer asks the data about input devices to the communication module by polling, the data are sent from the communication module to the CPU through the serial port. From these data, the CPU can get the information of each input device.

As in Fig. 8, an ATMEL 8-bit RISC controller Atmega128L and a RadioMetrix RF module BIM-433 are used to implement a communication module.

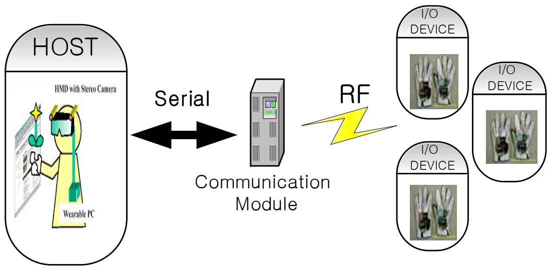


Fig. 5. RF-based configuration.

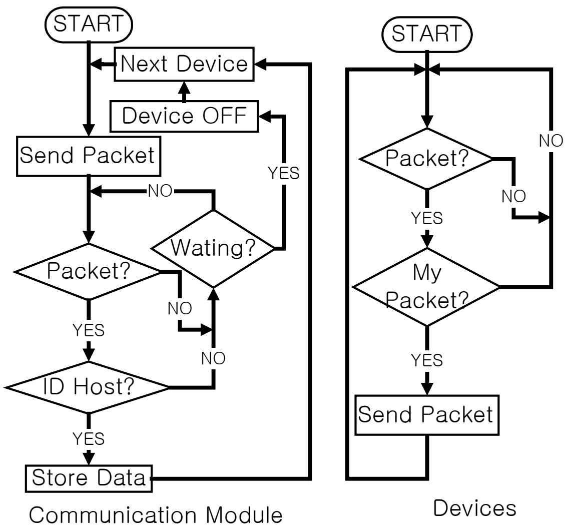


Fig. 6. Flow-chart of communication.

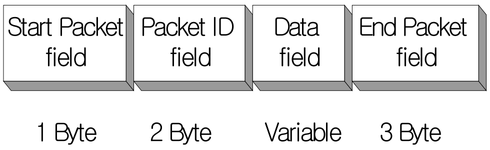


Fig. 7. Protocol Packet.

Table 1: Packet Field

Offset	Field	Size	Description
1	Start Packet	1	Packet Direction
2	Packet ID	2	ID to receive part (Device or Host)
[*]	Data	Variable	First byte is Data length
[*]+3	End Packet	3	Announcement Packet End

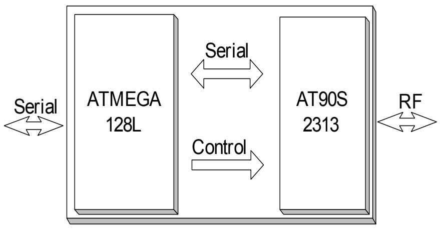
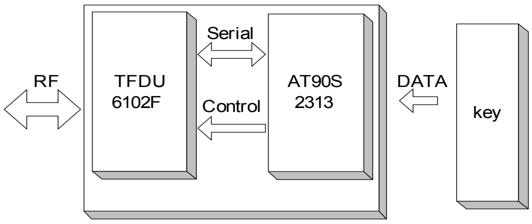
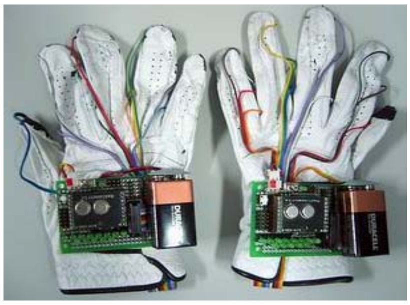


Fig. 8. Block diagram of communication module.

An 8-bit RISC controller AT90S2313 and a RF module BIM-433 are used to implement the controller of each wireless chording glove as in Fig. 9. The controller can detect the pressed keys and corresponding information is sent to the communication module through the RF module. Due to the antenna optimization problem, the maximum rate that one 8-bit RISC controller can transmit to one RF module BIM-433 without any error is 19,200 bps. In order to communicate between two RF modules, each RF module should switch once between transmitting and receiving modes and the stabilization time for switching is needed. The switching time is 3 msec. Thus, the maximum rate that two RF modules can communicate is a little bit less than 19,200 bps. The protocol as in Fig. 7 can be changed to accommodate various wireless devices and to improve the reliability of data. Fig. 10 shows the wireless connection of the implemented RF-based chording gloves as an input device to a PDA. Fig. 10-(a) shows some message on GUI of MS-Embedded Visual C++ 4.0 from the chording gloves. The communication module is connected to the PDA through RS-232c as in Fig. 10-(b)

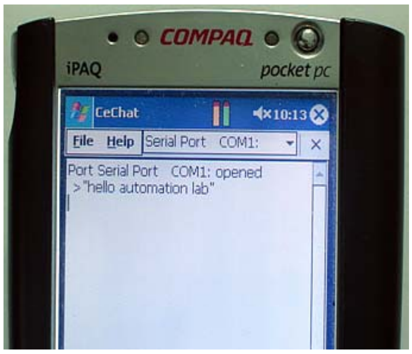


(a) Controller Block Diagram



(b) Prototype

Fig. 9. RF-based chording gloves.



(a) A message displayed on PDA.

(b) Configuration

Fig. 10. The connection of RF-based chording gloves.

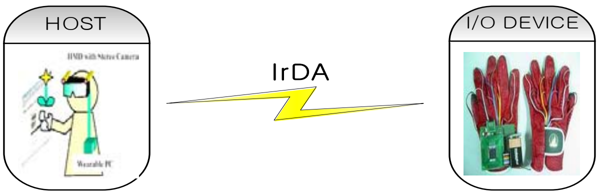
3.2 IrDA-based chording glove

IrDA was established in 1993 to set and support hardware and software standards that create infrared communications links. The association's charter is to create an interoperable, low-cost, low-power, half-duplex, and serial data interconnection standard that supports a walk-up, point-to-point user model that is adaptable to a wide range of applications and devices. IrDA standards support a broad range of computing, communications, and consumer devices. IrDA released extensions to SIR (Serial IrDA) standard including 4Mb/S in October 1995. The IrDA Standard Specification has been expanded to include high-speed extensions to 16 Mb/S.

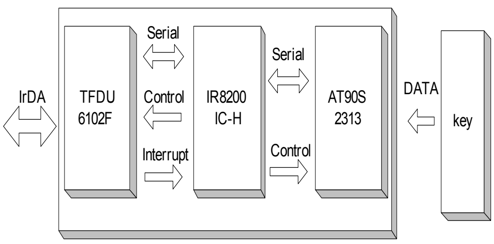
IrDA communication is performed under the following sequence: station discovery, connection set-up, information exchange, and link disconnection. Station discovery is the procedure to try to connect available other stations within the range. Connection set-up means that connected two stations try to negotiate about the connection setting. That is, connection parameters such as baud rate and data size are negotiated between both stations. Information exchanges is possible to peform after connection set-up. A frame packet, I (information) packet, can transmit desired information. Both stations connected can perform link disconnection. If a link disconnects, both stations are initialized before station discovery.

Fig. 11 shows IrDA-based chording gloves. Since IrDA is a standard communication, additional communication module is not needed, which is different from RF-based gloves. While one controller can be used for each chording glove in RF-based chording gloves, only one controller can be used in IrDA-based chording gloves. As in Fig. 11, an 8-bit RISC controller AT90S2313, an infrared controller IR8200IC-H, and a low power infrared transceiver module TFDU6102F are used to implement the IrDA-based wireless chording gloves. IR8200IC-H infrared controller is compatible with IrDA 1.0 (SIR) and TFDU6102F transceiver module supports the maximum 4.0 Mbit/s transfer rate. The actual transmission rate of the implemented IrDA-based chording gloves is set to 19,2kbps.

Fig. 12 shows the wireless connection of the implemented IrDA-based chording gloves to a PDA. Fig. 12-(a) shows some message on GUI of MS-Embedded Visual C++ 4.0 from the chording gloves. The communication between chording gloves and the PDA is performed with IrCOMM protocol.

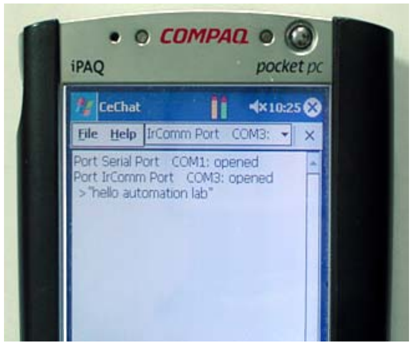


(a) IrDA-based Configuration



(b) Controller Block Diagram

Fig. 11. IrDA-based chording gloves.



(a) A message displayed on PDA

(b) Configuration

Fig. 12. The connection of IrDA-based chording gloves.

4. DISCUSSION

Since the proposed chord gloves use two hands to input some characters or numbers instead of using one hand, it has some advantages over one hand chord keyboard, which include fast typing and low error rate [7]. Also, the proposed chord gloves have clear space advantages over both a ordinary keyboard and a chord keyboard [8]. In order to develop the keymap for the chord keyboard, either a strong spatial correspondence to the visual shape of the typed character has been used or strong link to a well-built semantic knowledge base has been created [7, 8]. The keymap for a pair of chord gloves proposed in this paper resembles the grade 2 Braille, which is different from [7, 8]. Therefore, it may take longer time to learn the keymap for the proposed chord gloves than to do keymaps in [7, 8]. However, after learning, the speed rate for text inputs by using the proposed chord gloves will be much higher than those of [7, 8] because Braille is a faster recording medium. Experiments of the proposed chord gloves are still in progress and the performance will be evaluated based on experimental results. Since the Braille codes for many languages in the world and special symbols including mathematics and music notations have been already defined, it does not need to design new keymap for them. Furthermore, The visually impaired people who have used a Braille keyboard can use the proposed chord gloves directly with no learning.

5. CONCLUSION

This paper proposes a pair of wireless Braille-based chord gloves for wearable computers and implements it. Since the proposed chord gloves have some advantages such as fast typing, low error rate, and space saving, they will be one of good input devices to wearable computers as well as small electronic products. Furthermore, since the proposed chord gloves have the same keymap as in a Braille keyboard, they can be well used for visually impaired as well as visually non-impaired people. Thus, the proposed chord gloves may help visually impaired and non-impaired people to communicate and understand with each other even though visually non-impaired people usually see characters or numbers rather than touch and read Braille

By using RF and IrDA modules, the wireless chording gloves are implemented. They do not need any wire to connect wearable computes. It means that they are easily connected or disconnected to wearable computers, and they can be located to any place. Since both RF-based and IrDA-based chording gloves use their own protocols, several pairs of chording gloves can used as input devices simultaneously and furthermore there is no interference even when other wireless devices exist nearby.

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