Magic Ring: A Self-contained Gesture Input Device on Finger

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ABSTRACT

Control and Communication in the computing environment with diverse equipment could be clumsy, obtrusive, and frustrating even just for finding the right input device or getting familiar with the input interface. In this paper, we present Magic Ring (MR), a finger ring shape input device using inertial sensor to detect the subtle finger gestures and routine daily activities. As a self-contained, always-available, and hands-free input device, we believe that MR will enable diverse applications in the intelligent computing environment. In this demonstration, we will show a prototype design of MR and three proof-of-concept application systems: a remote controller to control the electrical appliance like TV, radio, and lamp using simple finger gestures; a natural communication tools to chat using the simplified sign languages; a daily activity tracker to record daily activities such as room cleaning, eating, cooking, writing with only one MR on the index finger.

Categories and Subject Descriptors

H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces- Input devices and strategies, Prototyping, User-centered design General Terms, Design, Human Factors

Keywords

Wearable computing; hand gesture; application; Magic Ring

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1. INTRODUCTION

Hands are good at precise manipulation. Therefore, they are indispensable in many routine daily activities like manipulate remote controller to control TV, mouse to control PC, smartphone to send message, and so on. However, as computing environments become more diverse, we often find ourselves in the circumstance that we cannot, or reluctant to, explicitly interact with a physical device in hand.

In view of above issues, previous researches have explored the hands-free input methods using various sensing modalities. For example, computer vision and speech recognition allows for hands-free interaction [4, 7]. But they have several inherent limitations such as relatively sensitive to environment factors like light and noise, higher handover cost on setting the sensor to proper position to ensure a satisfactory accuracy.

Another branch of technologies featured as directly affixes some

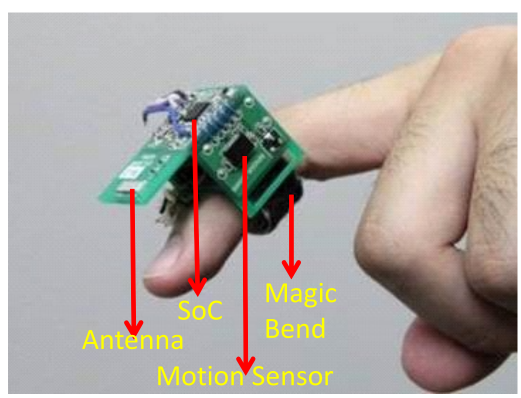

Figure 1. Magic Ring Prototype

sensors onto the finger, wrist, or arm. For example, bone conduction uses the wristband or armband microphone to detect the sound at the fingertips, which conducted by the bones of hand and wrist [1, 3]. But the discernible actions for each finger are very limited. Magnetic tracking use a finger-attached magnet for 1D or 2D input on very small mobile device like wristwatch [2, 5]. It is totally unpowered on the ring side and could detect the small motion in the magnetic field so that it allows subtle control. But similar with bone conduction method, the ring side device is not self-contained. It takes hassle for setting the device and is prone to position error.

Using inertial sensors to detect hand gesture is not a new idea. Acceleration Sensing Glove (ASG) [9] was proposed 20 years ago, which put six 2-axis accelerometer to the fingernails and back of hand to detect the static hand gestures. The paper even gives a conceptual design of a milli-scale device which could be attached on fingernail. But for data gloves like ASG, fingertips are covered by glove, which hinders finger tactile sensation. FingerRing shows the feasibility to using finger-mount accelerometer to identify the vibration of finger-tapping gestures [1].MIDS [8] presents a portable small size motion detector for robot hands to control the movement like grasping a ball. But similar with the other existed methods, they are not based on a self-contained design for the ring.

Based on previous research, we propose Magic Ring, a self-contained gesture input device on finger. A prototype of MR is shown in Figure.1. The MR is self-contained with all necessary components to fulfill the finger or hand gesture recognition. Weight of MR with battery is about 10 grams, which is in the same level of a traditional ring.

2. BENEFIT AND LIMITATION

MR is used for detecting the subtle finger action and various hand manipulations. Comparing with the existed finger gesture input methods, it shows the following features: first, inertial sensor is immune to many environment factors like light and noise; second, MR is self-contained so that it can greatly reduce the setting time and sensor position error; third, one MR can detect both static finger orientation and dynamic finger trajectory; fourth, besides the pose and movement of the finger or hand, MR can detect various daily activities as well; fifth, MRs could be flexibly combined to detect more complex hand gestures like sign language.

Limitations exist in the current prototype. The dimensions of current prototype are larger than the ring. Current prototype is mainly for the in laboratory experiment on the recognition method. And we are developing a new prototype of MR which would be much smaller than current version with water-proof cover for the daily life experiment.

3. HARDWARE OF MR PROTOTYPE

Three pieces of rigid PCB form a U shape to increase the area for placing all required electric parts around the small space of finger. A 3-axis accelerometer (Freescale Semiconductor MMA7760) is placed at one side vertically to detect the static orientation and dynamic acceleration of the finger. A SoC (TI CC1110) with a 8 bit 8051 core MPU and a RF transceiver (adjustable below 1GHz, carrier frequency 315MHz in this experiment) is placed on the top side for signal processing and wireless communication. To minimize the dimension, we use a chip antenna which is much shorter than quarter wave length so that we put the inductance to match the target frequency. MR works at 3.3V powered by the rechargeable 110mAh Li-Po battery. Magic band is used to affix MR to the finger to reduce the sensor position errors in the recognition.

4. MR FOR CONTROL

4.1 Gestures Definition

Four kinds of static gestures are defined based on the static finger orientation (Figure.2). Each gesture could represent different command on different appliance as shown in Table 1.

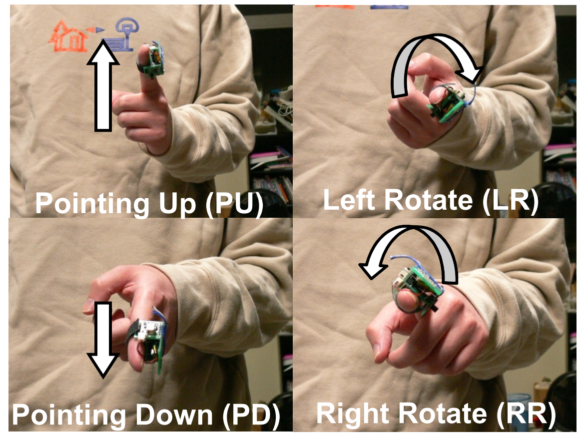

Figure 2. Static Gestures for remote control

Table 1 Gestures and commands

Name	Home appliance		
	Lamp	**CD Radio**	**TV**
RR	Brightness up	Volume up	Volume up
LR	Brightness down	Volume down	Volume down
PU		CD selection (+)	Channel(+)
PD		CD selection(−)	Channel(−)

4.2 Gesture recognition

An accelerometer is used to detect the predefined static gestures. The acceleration range of the accelerometer is set to ±6 g (gravity unit: 1 g = 9.8 m/s2). The sampling rate of sensor data is 100 Hz (100 times per second). A short time standstill at a position is used to annotate the start and end of a gesture. If the pitch and rotate degree are within a given range of a predefined gesture, then the gesture is identified and the according command will be automatically triggered.

4.3 Translate from Gesture to Infrared Command

Most of the electrical appliances could be remotely controlled by infrared signal in a line-of-sight distance. But format of these infrared commands are not compatible. Therefore, we develop a middle device to translate the gesture command into the infrared signal for the specific control target like TV, lamp, electrical fans, etc.

For the usage of the middle device, each appliance binds with a middle device, which is put in front of the infrared receiver of the appliance. First, the middle device setting in the learning model will

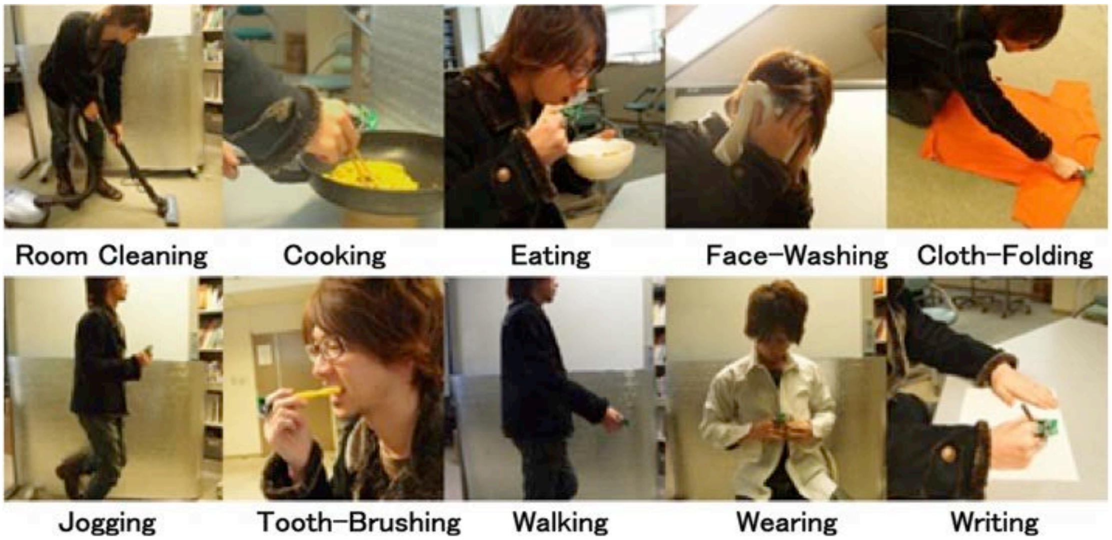

Figure 4. Ten kinds of daily activities

record the wavelets of the four infrared commands from the remote controller. Then, the middle device is switched to the translator model which will send out according infrared command based on the received gesture. Through the preliminary experiment, we can control most of the electrical appliances using a small set of simple finger gestures.

Figure 3. Gestures for hand talk

5. MR FOR COMMUNICATION

5.1 Gesture Definition

When we define the gestures for communication, we referred to the Japanese and American sign language with some simplification so that both handicapped and healthy person could use it with little effort. We pick up 8 simple and frequently used vocabularies for the demo (Figure.3).

5.2 Gesture Recognition

We use KNN to calculate the similarity of feature vector between the income gesture and samples. At first, the similarity is calculated separately for both hands. In this step, a similarity top-ranking list is generated for both hands, which consists of three most similar pre-reserved gestures. Then, if there is the same answer among the three most similar gestures between both hands, the top-ranking command gesture is the answer. Otherwise, we select the gesture with minimum distance as the answer.

6. MR FOR LIFE RECORD

6.1 Target daily activities

In this demo, we show that one MR could detect and recognize multiple kinds of daily routine activities with high recognition rate. They include walking, running, eating, cooking, tooth-brushing, face-washing, wearing, cloth-folding, room-cleaning, and writing (Figure 4). Most of these activities are hard to be detected using other sensing modality.

Table 2. Candidate feature set for feature selection

Time-domain	Frequency-domain
(1)Mean (TMean)	(8)Spectral Mean (FMean)
(2)Standard Deviation(TSD)	(7)Standard Deviation (FSD)
(3)Energy	(6)Spectrum
(4)Entropy	(5)Amplitude

6.2 Activity Recognition

In the preliminary experiment, 5 subjects joined the data collection. Each subject took 100 sections (10 sections per behavior). Feature selection is performed on 8 groups of features from time-domain and frequency-domain (table 2). We run three kinds of recognition algorithm (C4.5, KNN algorithm, and Naïve Bayes) using ten-fold cross verification. The highest recognition rate is 97.2% when the feature set include (1)TMean, (3)Energy, (4)Entropy, (5)Amplitude, (6)Spectrum on the KNN method.

7. Conclusion

In this demonstration, we gave a brief introduction of the MR hardware and software design. The usage of MR as a gestural input device is illustrated through three demo applications.

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