Ring GINA: A Wearable Computer Interaction Device

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Abstract. The Ring GINA platform is capable of sensing and interpreting a user's hand and finger movements to emulate and enhance the functions of classic input methods to smartphones, tablets, and heads-up displays. A wearable platform frees the user from the need to know hand position relative to a keyboard or touchscreen, and grants the ability to perform gestures in open space or on any surface. Here, a method is presented that utilizes these rings as a text input system. In moving forward, efforts are being focused on creating a library of gestures to perform additional tasks, as well as further miniaturizing the mote and ring.

Keywords: wearable computing, sensor networks, input device, ring GINA.

1 Introduction

Mobile text entry is a challenege that constantly plagues cell phone users. Typically text entry is done on a standard QWERTY keyboard displayed on a touchscreen. The QWERTY keyboard layout works well for a standard desktop or laptop computer because the typist's fingers are constantly acquiring feedback as to their position. The typist does not need to constantly look at the keyboard because he/she obtains tactile feedback during the entire text entry process, is aware when two keys are hit instead of one, et cetera. This feedback is absent when typing on a smartphone touchscreen. The screen might vibrate when a key is pressed, but this vibration gives no valuable feedback; It does not help reorient the user or inform which key was pressed. Additionally, due to device size, users are typically forced to type with just their thumbs, and often with just a single thumb if one hand is occupied.

In an attempt to address these issues, we present Ring GINA which allows users to enter text using just a single hand. A wireless sensor enabled ring is worn on each finger and allows the user to input text requiring neither a special surface nor direct contact with the target device. The first smart ring was published in 1997[1]. This device uses a one-axis accelerometer on each finger. These accelerometers are physically wired to a computer where the signals are

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interpreted. Since then there have been numerous advances in the capability and functionality of smart rings[3,4,5]. Perng et al.[8] created an accelerometer sensing glove. This glove contains a two-axis accelerometer on each fingertip and can be used to determine static hand poses. These acceleromters are also wired to a receiving computer.

2 Ring GINA Platform

The Ring GINA system is comprised of four identical rings that are worn on the fingers of the dominant hand. Figure 1 shows the components that make up a single ring. Each one is 3D printed with a custom plastic (VisiJet) using a ProJet 1500. A custom PCB, Figure 1b, fitted with a 20 mAh battery and connector is fixed into the top of the ring. Lastly, a GINA[7] mote, 1c, is plugged into the connector and the ring is fully assembled and functional, 1d. GINA is comprised of all off-the-shelf components. It contains two three-axis accelerometers, a three-axis gyroscope, a three-axis magnetometer, a microprocessor, and an 802.15.4 radio.

Each ring is part of a simple OpenWSN[6] based wireless network. This wireless protocol allows each ring to reliably transmit the salient information gleaned from processing the inertial data obtained from the various sensors on the mote. The wireless communication is low bandwidth, transmitting only a few bits per second. As discussed in section 3, all of the gesture recognition signal processing occurs on the motes themselves. This removes the need to transmit the raw sensor data which decreases power comsumption on the ring and reduces the computational load on the receiving device. For all experiments performed in this paper, the receiving device is a laptop with an accompanying 802.15.4 USB dongle as is shown in Figure 2.

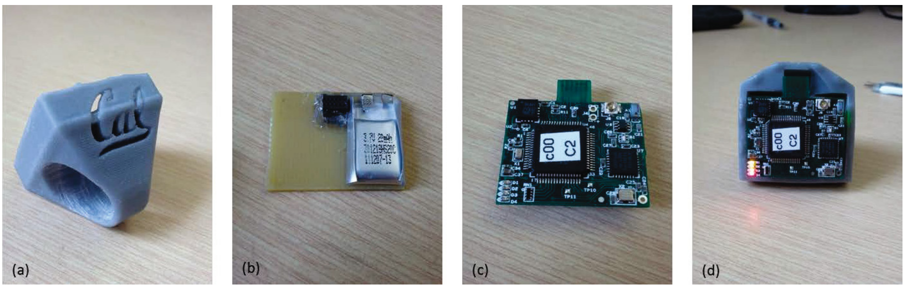

Fig. 1. Teardown of a ring. (a) A 3D printed ring. (b) PCB and battery. (c) GINA mote. (d) Fully assembled device.

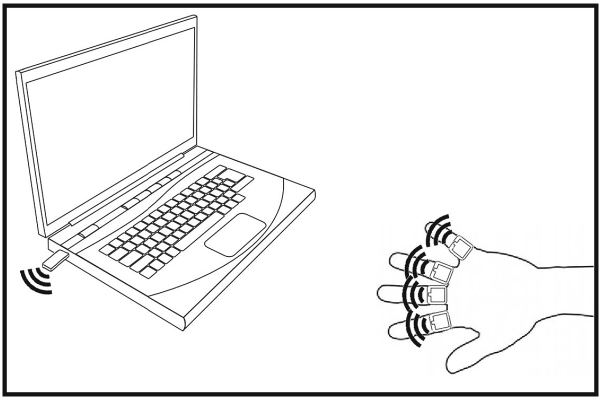

Fig. 2. Ring GINA System

3 Signal Processing

Text entry is performed by abstracting a chorded keyboard from finger taps. The user taps on any surface with one or more fingers to input characters. With four rings worn on a single hand, there are 15 different possible chords that a user can type. When the inertial data is processed, and it is determined that a user has tapped a finger, that ring sends a signal to the target device. Figure 3a shows a chord being typed wherein the pointer finger and ring finger are tapped and the remaining two fingers are not. For each gesture, a four-bit binary signal is created with ones corresponding to tapped finers and zeros corresponding to non-tapped fingers.The fingers are aligned in order, with the pointer finger being the most significant bit and the pinky finger being the least significant. The signal from each ring is sent to the host device where it is referenced against a lookup table, Figure 3b, to determine what letters or actions to type or perform.

This technology hinges on the ability to reliably detect these tapping gestures. Though there is a wealth of inertial sensors on the mote, the signal processing is done entirely on a single axis of the accelerometer. The z-axis of the accelerometer is orthogonal to the plane of the mote, and thus aligned with the axis in which the finger tap occurs. Therefore a tap produces a strong signal on this axis of the accelerometer. Figure 3c shows traces of the z-axis of the accelerometers from each of the four rings during a 300 ms time period in which the gesture shown in 3a was performed. It is clear that the signals from the pointer finger and ring finger (the fingers that were tapped) are much stronger than the signals of the two fingers that were not tapped. However, a simple threshold would not be sufficient to selectively determine when taps occur. If a user were to wave his/her hand around while wearing the ring, or possibly even just tilt the ring and change how the acceleration of gravity aligns with the accelerometer, a tap event might be detected.

To ensure that the tap detection algorithm is robust to various motions, the algorithm ensures certain characteristics are present before declaring a tap and sending the appropriate signal. The algorithm determines a dynamic baseline signal by applying a low pass filter to the input stream and averaging. The user's hand may reorient with respect to gravity, and this will throw off the sensing if not taken into consideration. From this baseline, the algorithm searches for deviations in the accelerometer data that exceed a certain threshold. This threshold is calibrated for each finger and mote. Lastly, once the potential tap is complete, the accelerometer signal must return to a value within 5% of the baseline. This is important in ensuring that the user is not simply gesticulating or performing some unrelated hand motion. If all of these criteria are met, a tap has occurred, and the mote sends a signal to the host device.

Signal	Action	Signal	Action
0	-------	8	o/p
1	a/b	9	q/r
2	c/d	10	s/t
3	e/f	11	u/v/w
4	g/h	12	x/y/z
5	i/j	13	Space
6	k/l	14	.
7	m/n	15	Next

(b)

(c)

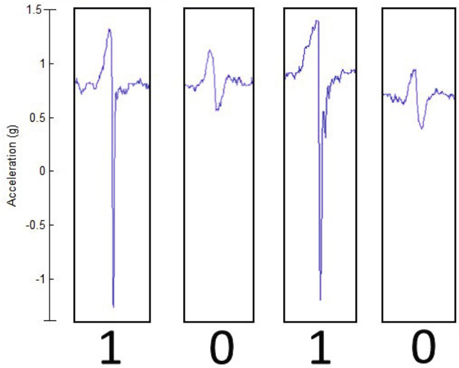

Fig. 3. Chorded input. (a) A user typing a chord. (b) Table correlating each chorded input signal with output letters or action. (c) Traces from the accelerometer of each ring, over a 300 ms period, with corresponding binary signals.

4 User Application and Performance

The host device runs an application that receives the signals sent from each ring and displays the desired text to the user. Each four-bit signal from the rings corresponds to either one action or a series of characters. Actions can be "Next," entering a space, or entering a period. If the user wants to type the word "cot" for example, the user would type the chords 2-8-10 (see Figure 3b), and the search algorithm would determine that the word made from the letter combinations c/d, o/p, and s/t is cot. If the user actually meant to type the word "dot", which would be the same chord combination, the user would type the chord 15, which corresponds to the "Next" action. This "Next" command would display the next word that corresponds to that same chord combination, if one exists. Once the user selects the desired word, a space or period can be typed and the next word is begun.

Preliminary tests have been conducted to validate the performance of the system. The platform will need to be refined before a study involving the general population can be performed, and thus all experiments were conducted by graduate student researchers. These tests have produced typing speeds of 20-30 words per minute depending on the experience level of the user. It has been shown that dual handed mobile text entry averages are between 20 and 40 words per minute[2]. The speeds presented here are within that range, even with no attempts at optimization to increase typing speed. Possible enhancements could be predictive text entry based on the preceding word and user history, mapping more commonly used letters to more dexterous fingers, and separating commonly interchanged letters to different chords.

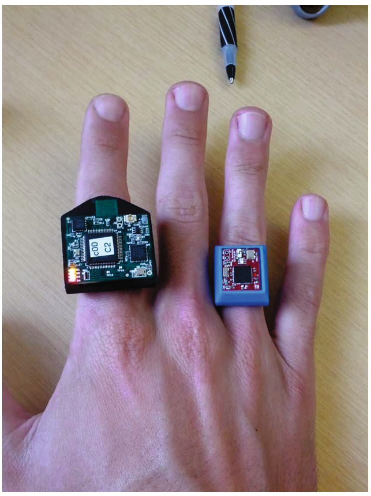

Fig. 4. Side by side comparison of two GINA boards

5 Conclusion and Future Work

Text entry for smart devices has lagged considerably behind the incredible advancements in mobile computing as a whole. The trend in mobile electronics is that smaller and less obtrusive is better, but that leaves the big challenge of how to actually interact with the devices. One goal for this technology is to pair Ring GINA with a smart watch. The combination of this always available display and this novel input system could revolutionize how we respond to emails and text messages in non-standard situations. The motes used throughout this paper all contain an 802.15.4 radio, however a new board has recently been spun that is less than half the size of the original board (see Figure 4) and uses a Bluetooth 4.0 radio. These new motes have already been shown to pair natively with various Bluetooth 4.0 enabled smart phones and tablets. The previously mentioned algorithms will be ported to the Bluetooth enabled rings and truly mobile applications can start to be developed. There is an abundance of unused inertial data that will eventually be utilized to create a richer library of gestures which will lead to the development of even more advanced and interesting mobile applications.

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