The Interactive Bracelet: An input device for bimanual interaction

C. Wacharamanotham Jonathan Meyer Jonathan Diehl Jan Borchers
RWTH Aachen University
Ahornstr. 55
52074 Aachen, Germany

{chat, diehl, borchers}@cs.rwth-aachen.de, jonathan.meyer@rwth-aachen.de

ABSTRACT
The size of a mobile device limits its input capabilities. To address this problem, we propose the Interactive Bracelet, an input device worn on the wrist that brings bimanual gestures to the mobile or ubiquitous computer. We describe example scenarios that illustrate how we imagine the device could be used, and we discuss how the device can be implemented and what sensors and actuators should be included.

Categories and Subject Descriptors
B.4.2 [**Hardware**]: Input/Output Devices

General Terms
Design, Human Factors.

Keywords
Bimanual Interaction, Wearable Computing, Wrist Interaction.

1. INTRODUCTION
Human expressiveness is hindered by the limited input capabilities of mobile interactive systems, mostly due to their small size. Increasing the size, however, is not an option because of the loss in portability. The interactive bracelet, we describe in this paper, provides new input capabilities to the mobile computer by allowing bimanual interaction of the mobile computer and the interactive bracelet. Similarly, it can be used to control ubiquitous interactive systems, such as large public displays and to connect the bridge between the ubiquitous and the mobile computer.

1.1 Example Scenarios
The following examples illustrate our vision for this project.

1.1.1 Text Recording
Common mobile voice recording systems rarely provide ways to edit or lay out the text. Even though one could imagine a system providing such functionality through voice commands, this is unlikely to be an efficient solution for many reasons. The interactive bracelet could be used to augment voice recording by using gestures to perform edit and layout tasks, such as flicking your fingers to navigate the text, and moving your hand to indent a paragraph. Further, the interactive bracelet could detect natural hand gestures that many people commonly conduct while talking (see [8]), to detect characteristics of the spoken text.

In a collaborative setting, people in the audience could naturally vote for a speaker's poll or rate the presentation by giving a thumbs up or down, which can be detected by the interactive bracelet.

1.1.2 Screen Navigation
Some mobile devices already facilitate gestures on or with the device to perform navigation actions. By separating these gestures from the device to the other hand wearing the interactive bracelet, we avoid occlusion and other problems that cause the device to be unreadable while navigating.

Since very simple gestures are conceivable for navigation (like flicking your fingers) that do not require the user's attention, her focus can remain on the mobile computer allowing her to work efficiently without distraction. Both a mobile and a ubiquitous system can benefit from this interaction.

Further, hand gestures allow multi-dimensional input that can be mapped naturally to a multi-dimensional hierarchy. E.g., moving your hand back and forward could navigate the first dimension, moving sideways the second, etc.

1.1.3 Including the Real World
There are many applications that benefit from or require the user to make reference to an object in the real world, such as a city guide, a navigation system, a remote control, or an encyclopedia. The most natural way to make such a reference is to point at the object in question. The Interactive Bracelet enables mobile computers to respond to such pointing gestures.

Pointing could be used to pair the device with another interactive device, such as a large public display, or to control a device, such as an appliance in the eHome. It could also be used to make reference to a non-interactive object to enquire information about it (city guide, encyclopedia) or to validate the instructions given by the mobile computer (street navigation). To ensure precise selection, location and distance should be considered as well as direction.

Finally, the mobile computer could pair itself with another person's computer by detecting a synchronous handshake gesture, while both users are shaking their hands.

By building and studying a prototype of the interactive bracelet, we want to explore the applicability of the presented scenarios,

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discover more usage scenarios, and determine the usefulness of bimanual interaction with mobile and ubiquitous interactive systems. Our research is driven by the following questions:

· What are good gestures for augmenting mobile interaction?

· Can we design a natural gesture language for bimanual interaction that applies across different tasks?

· What can be controlled conveniently through gestures?

· What sensors can detect these gestures reliably?

· What feedback is appropriate? When and where should feedback be given?

2. RELATED WORK

Rukzio et al. show that people prefer touching and pointing over scanning to select a device for interaction if the device is touchable or visible [10]. Krol et al. compare visual, aural, and haptic feedback for remote pointing tasks [6]. Haptic feedback is most efficient from the measurements, even though users perceive aural feedback as being most efficient, and prefer visual feedback to all the others. Therefore, haptic feedback should be supplemented with aural or visual feedback. Oaklay et al. show that there are little performance differences between a hand-held, a backhand-mounted, and a wrist-mounted pointing device [9]. However, the study does not include finger-pointing gestures, which is the first choice of pointing gesture people use. Cossan et al. show that people can target an object accurately by wrist rotation [2]. The insights from these studies are helpful to guide the design of the interactive bracelet.

Several interactive systems use the wrist as an input/output channel. SNAP&TELL provides audio information by pointing to an object [5]. Gauntlet employs arm gestures in a game [7]. Berlin et al. combine an RFID antenna with an accelerometer to recognize which and how an object is held [1]. iBand exchanges social data by shaking hands [4]. The possibility of implementing a low-power hand-worn device equipped with Bluetooth, an accelerometer, a bend sensor, and a gyroscope is explored by [11]. In Abracadabra, Harrison and Hudson detect a magnet, worn on the fingertip, to interact with a small, wrist-worn display [3]. None of these systems offer the capabilities presented in this paper for use with mobile and ubiquitous interactive systems.

3. INTERACTIVE BRACELET

The interactive bracelet is a device, worn on the wrist, which contains a number of sensors and actuators to be used for interacting with a mobile or ubiquitous computer. The integrated sensors are optimized to detect any natural gesture a human can conduct by wrist or hand movement. The actuators are designed to enhance the interaction by providing localized feedback.

The heart of the device is a microcontroller that reads and interprets the input from the integrated sensors and controls the feedback actuators. The microcontroller communicates with the host computer through a wireless Bluetooth connection using a standardized protocol, which is yet to be defined. This way, the device is capable of detecting simple gestures by itself and providing instant feedback as appropriate.

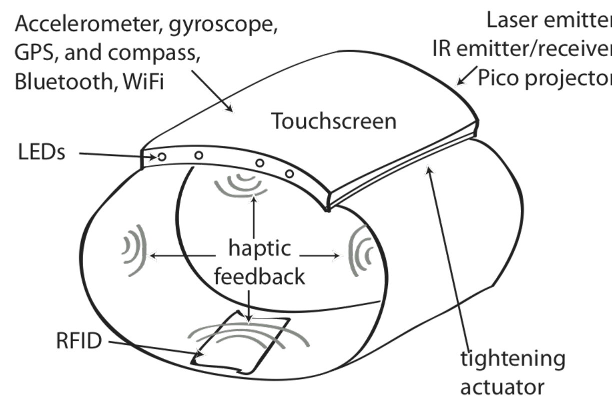

Figure 1: The Interactive Bracelet

After pairing the device with a mobile computer, it can be used bimanually by holding the mobile computer in the one hand and wearing the interactive bracelet on the wrist of the other hand. In this situation, the user's locus of attention will be on the mobile device, and the interactive bracelet should serve mostly as a dedicated input device, similar to the mouse and keyboard for the desktop computer.

Similarly, the device could be paired (directly or through the mobile computer) with a ubiquitous interactive system, such as a large public display. Here, the user's locus of attention will be on the ubiquitous system and both the mobile computer and the interactive bracelet should serve as pure input devices. If the mobile computer is equipped with gesture sensing technology, both devices can be used in combination to allow bimanual interaction.

Finally, the interactive bracelet can be used for pointing towards an entity in the real world to include it in the interaction with the mobile computer. In this situation, the locus of attention will be shared between the real-world entity and the interactive bracelet, thus visual feedback should be provided on the interactive bracelet, not the mobile computer.

3.1 Input Capabilities

The device should be able to detect the following gestures and states reliably:

· Physical location

· Pointing direction

· Proximity to an external entity

· Finger, hand and arm gestures

· Wrist rotation

· Human pulse

To achieve this, we propose to install the following sensors:

· Accelerometer and Gyroscope, to detect gestures through relative motion, and tilt and wrist rotation through gravity.

· RFID tag and reader to detect proximity; alternatively, 2D barcodes and a camera could be used

· Infrared emitter and sensor to detect pointing and allow interaction with supported hardware

· Digital compass to measure pointing direction

· GPS or WLAN to measure the global position

For finger gestures, we propose a second device, which is worn on one or multiple fingers, providing additional sensor data to be used by the main unit. By comparing these measurements, e.g. acceleration, with the data from the main unit worn on the wrist, we expect to gain precise information about finger movement.

Further, the usefulness of additional sensors, such as a general-purpose touch screen, distance measurement, or audio/visual sensors (microphone, camera) should be explored.

3.2 Output Capabilities

The device should also be able to provide general-purpose feedback. We suggest exploring the following actuators:

- Haptic feedback through vibration, poking the skin, or tightening the wrist band
- Light emitters or a small display for visual feedback, located on the side pointed towards the user's body or the top
- Pico-projector
- Speaker for audio feedback
- Laser pointer

These feedback channels should be used to provide instant feedback for common gestures, such as pointing detection, and made available to the mobile or ubiquitous computer.

3.3 Interaction Methods

This section illustrates, how we imagine to use the Interactive Bracelet for common interaction tasks. The presented methods are just examples, and we plan to explore alternatives as well.

3.3.1 3D Navigation

The bracelet acts as a position controller that the user can use to move the viewpoint in 3D space relative to the position of the bracelet. Movement in the third dimension can also be mapped to zooming on a 2D plane.

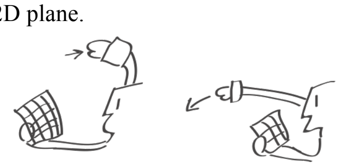

Figure 2: Navigation in a zoomable interface

When reaching the boundary of a virtual canvas, the bracelet provides haptic feedback by vibrating on the corresponding side of the boundary. The vibration intensity increases as user push further through the boundary. For the depth dimension, the bracelet tightens when the user pushes or pulls beyond the virtual boundary.

Figure 3: Haptic feedback at a virtual boundary

3.3.2 Point-and-wiggle to select

User selects an object by pointing to the object, flipping the hand, and wiggling the finger. This gesture can be used to select a device to pair with. For example, a user holding a mobile phone performs point-and-wiggle to the wireless keyboard to pair it with the phone.

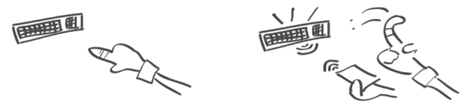

Figure 4: Point-and-wiggle gesture for device selection

3.3.3 Hands-up and Grab-and-throw

In a meeting room situation, collaborators can employ multi-user gestures to share information, e.g. by transferring files. The users who want to receive the file hold their hands up and the user, who has the file, uses her hand to grab it from her mobile phone and throw it in the direction of the recipients.

Figure 5: (Left) Hands-up gesture for receiving files, (Right) Grab-and-throw gesture to distributing files

3.3.4 Activate gesture

To prevent false input, the user can activate the bracelet by quickly rotating her wrist twice. Once activated, the bracelet is tightened briefly to provide haptic feedback. Additional feedback, such as audio and visuals, can be provided through other devices in the ensemble, like the mobile phone or a headphone.

Figure 6: Rotating to activate the Interactive Bracelet

Instead of activating the bracelet, this gesture could also be used to activate the entire ensemble, i.e. unlock your mobile phone, turn on the headset, etc.

4. WORKSHOP CONTRIBUTION

At the workshop, we want to discuss the affordances and limitations of the interactive bracelet and for what kind of interactions it can be useful. We expect many of these interactions to be new in the field of mobile computing because of the bimanual nature of the gestures. Further, we want to discuss how the interactive bracelet can fit into an on-body ecology of devices. By itself, the interactive bracelet is a very specialized input device for wrist and hand input and, we believe, it would be very worthwhile to think about how the device can be combined with other devices worn on the user.

5. ACKNOWLEDGMENTS

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