Wearable RFID for Play

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ABSTRACT

Radio Frequency IDentification (RFID) technology has recently been moving into everyday use contexts. Previous work has shown wearable RFID systems to be a viable mechanism for collecting data about a user's interactions with her environment. In this paper, we present wearable RFID systems as a promising new direction in tangible game interfaces. We provide an overview of the affordances of RFID for game-play, and present some existing and future wearable RFID-based games. We also describe the construction of a cheap, easy-to-build wearable RFID system and present a how-to resource for other researchers interested in building off our work.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *input devices and strategies, interaction styles*;
H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *collaborative computing, synchronous interaction*.

Keywords

Wearable computing, RFID, tangible interfaces, game interfaces.

1. INTRODUCTION

Radio Frequency IDentification (RFID) is a popular technology that allows for easy proximity sensing of specially-tagged objects. Objects tagged with a small passive (unpowered) RFID tag, can be reliably sensed at ranges from a few centimeters to half a meter or more. All RFID tags contain unique identification numbers (sometimes along with other data) that easily allow for exact identification of objects from a very large set. Passive RFID tags are inexpensive (currently as little as $0.10 USD per tag), which makes it possible to tag large collections of objects.

Because of their low cost, RFID systems are becoming common for inventory tracking and other industrial uses. Government and commercial uses are quickly emerging, too: RFID tags can also be found in instant payment devices such as ATM/credit cards (e.g. Speedpass and Go Pass), passes for public transportation systems (e.g. BreezeTickets for Atlanta's MARTA, or the CharlieCard for Boston's T), and, most recently, inside passports. Even with these new uses, however, RFID technology is not yet likely to be found in most homes or offices.

In this paper, we explore wearable RFID systems. These are designed to be worn by the user for the purposes of recognizing her interactions with objects in her physical surroundings. Wearable RFID systems usually take the form of an RFID reader built into a glove or a bracelet. Recent research has made use of wearable RFID systems in the context of eldercare and activity recognition [[1], [2], [3], [5], [6], [7]]. Gaming is also becoming a popular theme in the development of wearable RFID systems [[4], [9]]. We wish to further explore the properties and affordances of these systems, with respect to gaming applications.

2. PREVIOUS WORK

Some of the earliest research in Wearable RFID technology was done by Schmidt, Gellersen, and Merz, who embedded a RFID tag reader's antenna into a work glove [8]. The reader's electronics, power, and a radio transponder were housed in a casing worn on the user's belt. The authors presented two applications: "real world bookmarks" in which RFID IDs are mapped to simple web pages, and integration with mySAP.com, which allowed for tasks such as inventory management and logistics execution to be performed using the wearable RFID glove.

Much of the current work on wearable RFID systems focuses on activity recognition and detection of user interaction with objects. One major application of this research is in assisting with elderly care – specifically with recognizing Activities of Daily Living (ADLs). As part of this, their studies of wearable RFID focus on it as a sensing platform for activity recognition.

Philipose and colleagues at Intel Research Seattle and the University of Washington have developed the Proactive Activity Toolkit (PROACT) [[6], [7]], a probabilistic system for recognizing and recording ADLs. PROACT uses RFID tags placed on household objects, a wearable SkyeTek RFID reader embedded in a glove, and a probabilistic activity-inferencing engine. The wearable reader has a range of approximately three inches around the user's palm. The PROACT system proved to be durable and had encouraging precision/recall for many simple activities. A more recent project, Guide [[2], [5]], also addresses the problem of activity recognition, but with the intent of improving the variety of activities that can be recognized.

The two wearable RFID systems developed by Intel Research Seattle scientists for the projects just described, and others, are the iGlove (Figure 1) and iBracelet (Figure2) [3]. The iGlove uses the SkyeTek M1 13.56 MHz reader for its RFID reader, and a Mica2Dot mote radio to send tag data to a nearby computer. The

Figure 1 The iGlove from Intel Research Seattle.

RFID-sensing antenna consists of a single coil of wire sewn into the palm of the glove. The read range of the iGlove is tuned to a few centimeters, so as only to detect tags within the user's grasp. Due to the miniature size of the iGlove's components, they are easily encased in a small box that sits on top of the user's hand.

The iBracelet is a re-configuration of the iGlove's components that fits in a bracelet to be worn by the user. The antenna of the iBracelet loops around the user's wrist. The read-range of the device is increased to 10cm, allowing fairly accurate detection of objects that are grasped near their RFID tag. Though the iBracelet is more prone to detect false positives (because of its increased read-range), its aesthetic and non-intrusive form make it quite suitable for everyday use.

ReachMedia [1] is a system developed by Feldman and colleagues to detect users' interactions with everyday objects. Similarly to the iBracelet, the system takes the shape of a bracelet worn around the users' wrist. The RFID reader used is a SkyeTek M1-mini, which has a diameter of less than twenty five millimeters and a thickness of less than two millimeters. Information about the tagged objects that the user is holding is transmitted to a host computer. In addition to object detection, the ReachMedia bracelet uses accelerometers in order to allow for gesture-based input.

The authors are aware of only two wearable RFID games that have been implemented. Tagaboo [4] is a multi-player children's game loosely based on the game of tag, and the Real-Life Sims (RLSims) project [9], which one of the co-authors was involved with, is a game inspired by the computer game The Sims[1]. Both of these will be discussed in more depth in section 4.

3. OFF-THE-SHELF WEARABLE RFID

While previous research into the design and applications of wearable RFID systems is extensive, all of the systems that have been described are expensive and challenging to construct. The SkyeTek RFID readers are expensive devices, with current prices from the manufacturer being around $1000 USD for a development kit. The amount of electrical engineering knowledge that goes into building the systems is also non-trivial. Thus, the goal of our research is two-fold. First, we wish to further explore the design space of wearable RFID-augmented games. At the same time, we wish to provide a resource for other researchers (as well as amateurs) looking to construct their own wearable RFID systems, especially when faced with limited funds, time, or hardware knowledge. In this section of the paper, we describe our current wireless RFID reader prototype and our further plans for its development. We are in the process of building a how-to website for interested parties, which will be available at http://www.gvu.gatech.edu/ccg/resources/wearableRFID.html

3.1 Building a Wireless RFID Reader

We have built a prototype of a wireless, wearable RFID system from a SonMicro SM3005 RFID Development Kit[2] and a Socket Cordless Serial Adapter[3]. The SonMicro SM3005 Kit comes with an RFID reader and with two detachable, quasi-flexible antennas which may be inserted or sewn into a glove. The Socket adapter allows a computer to communicate with the RFID reader's serial port over Bluetooth, giving an approximately 10 meter range of operation. The two devices can be powered for a number of hours off a regular 9V battery. The SonMicro RFID reader is pre-built with a 9V battery connector, and the Socket can be powered by running a lead from the battery's positive terminal to pin 9 of the SonMicro reader's serial port. Figure 3 shows our current prototype.

The reader from the SonMicro SM3005 kit works in the 125 kHz range. Though 125 kHz tags are slightly more expensive than 13.56 MHz tags, they are not affected by water or metals. We use 30mm Global Tags from Phidgets[4] (many different tag styles are available). With these tags, the smaller of the two antennas gives us perfect detection within 4-5 cm of its center, which is sufficient for detecting tagged objects which are touched or grasped.

Our current prototype consists of approximately $200 USD worth of hardware and requires a minimal amount of basic soldering. We are exploring the use of an alternative serial-over-Bluetooth adapter[5] that might further decrease the cost and amount of soldering. Additional, up-to-date information can be found on our project website: http://www.gvu.gatech.edu/ccg/resources/wearableRFID.html.

We have also explored using a waysmall gumstix[6] connex computer and STUART expansion board to drive the SonMicro RFID reader and communicate with a remote computer. The gumstix is a fully functional Linux computer in a very small form factor. These characteristics not only make developing for them easy for persons with UNIX development experience, but also allow the wearable itself to perform complex computations without relying on a remote computer. Using these configurations

Figure 2 The iBracelet from Intel Research Seattle.

[1] http://thesims.ea.com/

[2] http://www.sonmicro.com/125/sm3005.php

[3] http://www.socketcom.com/product/CS0400-479.asp

[4] http://www.phidgetsusa.com/cat/viewsubcategory.asp?category=3000&subcategory=3200

[5] http://www.aircable.net/serial.html

[6] http://www.gumstix.com/

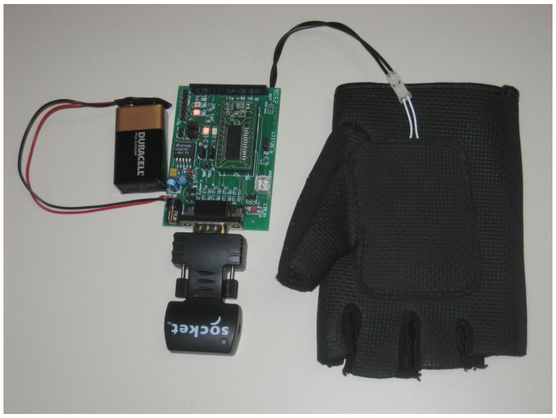

Figure 3 SonMicro and Socket Adapter prototype.

might make it possible to create tangible gaming experiences independent of any infrastructure other than the wearable(s) themselves – the gumstix could keep track of game state, drive a wearable video or audio display, etc. Such gaming interfaces could be used over wide territories (e.g. a large mall, or a city's downtown district) and other environments where an always-on Bluetooth connection to a host computer is not possible.

However, our current focus is on simplicity and low cost. While we have documented our experience with the gumstix on our website, we have not built a fully functioning wearable prototype with it.

3.2 Future Work

We are currently constructing a casing for our prototype. Due to the fairly bulky size of our prototype, we are considering a forearm mounted enclosure (possibly in two pieces – one for the electronics and one for the battery). We are unsure as to whether this setup will be more or less comfortable than an enclosure mounted on top of the hand. Since we are designing for gaming interactions, both comfort and durability are important considerations – and a forearm mounted encasing might be less likely to be hit against things than one mounted on the hand. Finally, miniaturization might also not be desirable if a bigger, more "techie"-looking encasing is actually more engaging for players.

4. WEARABLE RFID GAMES

In this section, we explore the interesting affordances a wearable RFID system brings to gaming interactions. We then describe Tagaboo and RLSims, two games that use wearable RFID systems as part of their interfaces. We finish by presenting two other multi-player game ideas that we are exploring, which make use of the unique interactional properties afforded by wearable RFID.

4.1 Affordances of Wearable RFID

The most obvious property of a wearable RFID system is that it localizes a proximity sensor on the user's body (namely, in her palm). Therefore, it is not necessary to have other in-world sensors to detect interactions with objects. Since RFID tags can be very small, they can be incorporated without difficulty into existing game pieces (such as chess pieces) or everyday objects (such as furniture) [9]. Non-traditional "game objects," such as locations on players' bodies, can also be easily tagged [4]. All of these different types of objects may then be used as game objects. See [10] for an alternative implementation of such functionality.

Another property of wearable RFID systems, which is especially convenient for multi-player games, is the ability to easily distinguish between the actions of different players. Since each player's wearable system uses its own separate Bluetooth connection to the host computer, the system can easily keep track of which players are interacting with which in-game objects. Thus, for any reasonable number of players, it is possible to know which player is interacting with which object, for how long, and their history of interactions.

Furthermore, it is possible to increase the complexity of this input modality by giving players wearable RFID readers on both hands. Especially if combined with a small, wearable Bluetooth accelerometer[7], this type of system could allow for the detection of a large and varied number of player gestures and activities – shaking, throwing, multi-handed interactions, etc [1].

4.2 Tagaboo

Tagaboo [4] is a tag-like game played by two or more children. Though its designers describe several variations on the theme, the game's interface consists of a vest with a number of RFID tags in different pockets, and a wearable RFID glove with an onboard microcontroller. Each child wears a vest and a glove. The object of the game is to touch different points on other players' vests with the glove. Different RFID tags may correspond to different game actions, and players are encouraged to run around during the course of the game.

Tagaboo's design is interesting for a number of reasons. First, it highlights wearable RFID's potential to easily turn non-traditional objects – in this case, sites on the players' bodies – into game objects. Also, because the RFID sensors and the score-keeping logic are located on the players' hands, players are free to run around and play in a large area, unconstrained by the strength or availability of wireless connections (scores are tallied only after a round is over). Finally, the game's designers creatively give the gloves an overstuffed, Mickey Mouse®-like look, which provides space for the electronics and padding, as well as being fun for the game's participants.

4.3 Real-Life Sims

Mazalek and von Hessling have built Real-Life Sims (RLSims), a wearable RFID a game inspired by The Sims [9]. In the game, a player performs common, everyday activities that implicitly control an avatar living in a virtual home. Objects around the player's home or office are tagged with RFID tags, and the player wears a wireless RFID reader. As she proceeds through her day, the game interprets her activities and her avatar mirrors her actions. An interesting aspect of this type of interaction is that distributed players – such as couples in long-distance relationships – can interact naturally in the same virtual space while going about their daily lives separately.

To experiment with this game design, Hessling and Mazalek tagged furniture and various objects around a constructed lab space and created an application that tracks and infers a user's activities from the objects she interacts with. The application then updates a visualization showing the various activities that players are engaging in, as if they were performing them in the same physical environment.

[7] http://www.gvu.gatech.edu/ccg/resources/btacc/

Figure 4 Children interacting with the DiamonTouch Simon game.

Real-Life Sims highlights the ability of a wearable RFID gaming interface to easily turn interactions with everyday objects into game actions.

4.4 Proposed Games

4.4.1 Multi-Player Simon

Researchers at the Georgia Institute of Technology have built a variation of the popular Simon sequence-memorization game to help therapists teach autistic children turn-taking. The game is deployed on a DiamondTouch[8] table, an expensive touch-screen device which is able to recognize which user is touching it at a given moment. The game flashes a sequence of colors across a virtual Simon interface, and the children must take turns re-inputting the order of the sequence. Figure 4 shows children interacting with the game under the supervision of a therapist.

Such a game would be easy to re-create using a real Simon game fitted with RFID tags under each of the four color buttons. Since the host computer would know which player's wearable RFID system touched which tag, it would know whether players acted out of turn and could provide appropriate feedback. For maximum simplicity, the sequence of colors presented by the Simon game could be inputted into the computer in real-time by the therapist in charge of the session.

We do not make any claims as to the effectiveness of such a game in treating autistic children (and, indeed, the original game turned out to have a number of flaws). Rather, we wish to highlight the ease in which it may be possible to appropriate and augment existing, familiar interfaces for use in games with wearable RFID input devices.

4.4.2 Multi-Player Whac-a-Mole™

A multi-player modification of the popular Whac-a-Mole™ game can be played with a wearable RFID interface. The game board can be constructed out of a large piece of cardboard, with many colored areas, each tagged by one or more RFID tags. The computer can instruct players to hit one color or another, keeping track of which players hit the areas the quickest, or which succeed in hitting the most areas of the same color. It is not difficult to think of other variants and modifications of this simple concept.

The design of this game highlights the ease of prototyping some forms of tangible games with wearable RFID systems. With RFID tags, it is possible to make nearly any surface or object into a game board or game piece.

8 http://www.merl.com/projects/DiamondTouch/

5. CONCLUSION

In this position paper, we hope to have motivated our interest in wearable RFID systems as a promising interface for tangible games. We have described our wearable RFID system prototype, with its focus on low-cost and simple reproducibility. We have also presented some games, both developed and which are currently being designed, which make use of the unique interactional properties that a wearable RFID system offers.

A how-to and updated information on this project are available at http://www.gvu.gatech.edu/ccg/resources/wearableRFID.html

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