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Project 2 Progress Report
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Motivation

Based on our research in Project 1, we discovered that the majority of work in wearable RFID systems has been completed by researchers at Intel Research Seattle and the University of Washington. However, these researchers do not provide many details as to what components their readers are built from and how they are built. Also, they have focused mainly on using RFID systems for activity recognition, such as recognizing Activities of Daily Living (ADLs) for use in elderly care. Thus, not much research has been done regarding how wearable RFID systems can be used for fun or for social and collaborative purposes. For this reason, we are pursuing this application of RFID technology with Project 2, and thereby hope to build a game using our wearable RFID reader(s). Along with this, we are building our own wearable RFID reader using off-the-shelf components, and documenting this process.

Project Overview

This project is a continuation of our Project 1, where we are developing a wearable RFID reader from the SonMicro RFID kit we received during Project 1. We are hoping to improve this reader over the Phidgets wearable reader we built during Project 1 by making it wireless and therefore less distracting to the user and also more aesthetically pleasing. We are exploring this through two possibilities. First, we have connected the SonMicro RFID reader to a Gumstix computer, allowing us to make an "intelligent" reader that is also easy to develop for (currently the SonMicro reader can be given some intelligence through its on-board microcontroller, but it must be programmed in assembler). The reader can also transmit data over Bluetooth. Secondly, we have connected the RFID reader to a Socket serial-over-Bluetooth module, making a sub-$200, wireless RFID reader. We will document our progress on these two configurations on a website so that other researchers might have an easy reference as to how to build their own wearable RFID readers.

We intend to use our reader to build a simple game. To create this game, we are considering new interaction modalities offered by RFID tags – for example, easy detection of which game piece is being held, by which player, and for how long. Another interesting possibility offered by RFID is actually putting tags on players' bodies. This might allow for an exercise game that can easily detect correct completion of an instruction (e.g. touching your ankles). Additionally, we may consider building a game consisting of tangible objects that users can manipulate and arrange to collaboratively build a 3D piece of abstract art. With this idea, users can add to the art piece asynchronously over time, and the system would know what changes were made to the piece of art, using which objects, and by whom. The final deliverable will be a prototype

of the RFID-enhanced game, as well as a how-to of how to build the reader described and how to use it to build the game.

Currently, we have only one wireless RFID system. Depending on what our sponsors decide, we may acquire the necessary parts to build another one (or more). However, this circumstance will affect the sophistication of our final deliverable. If we have two or more wireless systems, we would try to construct a social game or task. With a single device, we may go for a single-player game, or, given a very compelling social activity, try to evaluate it using one working system and having a Wizard of Oz setup for the other necessary devices.

We are also writing a position paper for the Research and Design for Tangible and Tabletop Games Workshop at the 2007 Intelligent User Interfaces Conference. Depending on our final prototype and the recommendation of Jay and Thad, we may also try to submit a Late Breaking Result or Demonstration to Pervasive 2007.

Technical Details

We have developed two prototypes of wearable RFID readers. One involves connecting the SonMicro RFID reader to a gumstix waysmall computer, and the other one involves using a Socket serial-over-Bluetooth module to relay serial data from the SonMicro to a laptop.

SonMicro + gumstix

For our first prototype, we connected the SonMicro reader to the gumstix computer via the STUART board. Then we wrote a C program for the gumstix that puts the SonMicro into continuous read mode and forwards all RFID tag data from the SonMicro over Bluetooth to a server program (written in Python using the PyBluez module) on a laptop. This is the most versatile solution, because the SonMicro can drive an LED display, and the gumstix + STUART board can also drive a number of outputs as well as provide sophisticated processing, data storage, etc. Also, this portable setup might prove to be more energy efficient – the gumstix could intelligently schedule Bluetooth writes, put itself and the SonMicro into low power mode when not in use, and store data locally when a Bluetooth connection is not available.

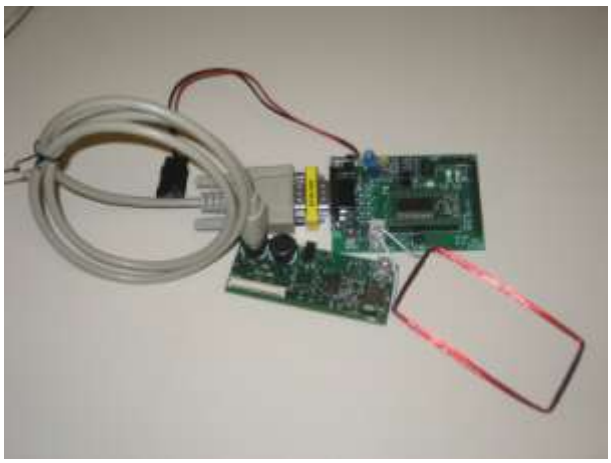

Figure 1. SonMicro + gumstix configuration (unpowered)

In order to make this setup truly wearable, we would need to replace the bulky serial port connector of the gumstix (connecting the SonMicro serial port directly to the STUART board). We would also need to power the gumstix + STUART board setup using batteries.

This could be done trivially using either 3 Li AAA batteries or 4 rechargeable AAA batteries or, with a little more work, by regulating down the voltage from the 9V battery that powers the SonMicro.

SonMicro + Socket serial-over-Bluetooth module
Given that our current needs do not warrant using the full power of the gumstix, we also constructed another prototype wireless RFID system from a SonMicro RFID reader and a Socket serial-over-Bluetooth module. We wrote a Python application to connect to the Socket module, send the commands to the SonMicro to put it into continuous read mode, and then read the tag data directly. We powered the Socket serial-over-Bluetooth from the same 9V battery that powers the SonMicro.

This setup required soldering on the SonMicro board, which means we can no longer connect it to the gumstix if it is being powered by the 9V battery (because it now sends 9V over pin 9 of the serial port, which may or may not damage the gumstix board). Because of this, and because we do not currently need the computational complexity of the gumstix board, we will be using this prototype as we proceed with the next phase of our project – making the prototype wearable and evaluating it.

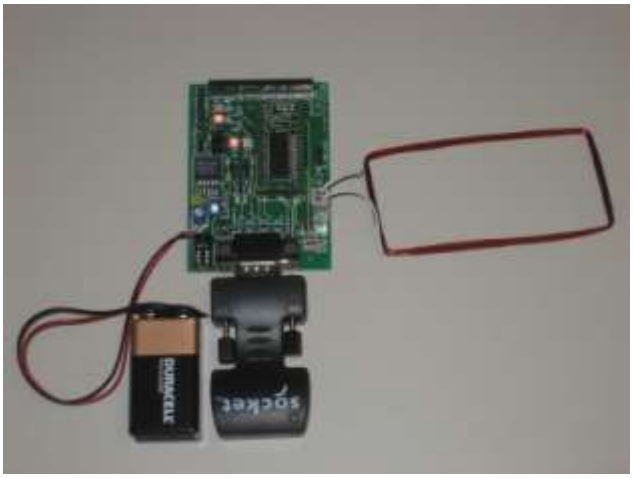

Figure 2 SonMicro + serial-over-Bluetooth module (final version)

Challenges
To this point, the main challenges we have encountered have been, unsurprisingly, configuring the hardware. Setting up the gumstix and cross-compiling programs to it requires a steep learning curve. However, once the system is set up, it functions like a regular Linux machine. Therefore, getting it to read from the serial port and broadcast over Bluetooth were fairly straight-forward tasks (not counting the time spent brushing up on UNIX sockets, signal handling, and Bluetooth programming in C).

For our second prototype, we initially had problems getting the Socket module to receive and send data. We determined that the source of the problem was due to the fact that the Socket module expected CTS-RTS hardware flow control from the device it was connected to, while the SonMicro RFID reader does not use flow control when communicating over its serial port. With Jay's help, we were able to emulate CTS-RTS flow control on the SonMicro by soldering together the CTS and RTS pins (7 and 8) on the SonMicro board.

Jay also helped us power the Socket module by helping us solder a lead from the +9V battery terminal on the SonMicro board to pin 9 of the SonMicro's DB9 connector. The Socket module can take up to 9V from that pin for power, so this allowed us to power both the SonMicro and the Socket module from the same battery.

These fixes have been tested and are working successfully. In the final stages of our project, the only main challenge we foresee is developing an interesting application for our wearable RFID reader. While we have been brainstorming several ideas, we have not yet found an idea that we believe is an exceptionally worthwhile application of our reader (or multiple, if we get the parts to build more). We will continue to brainstorm ideas and hopefully we will find one that truly demonstrates the ability of the hardware configuration that we have built and the implications such a configuration has for the field of mobile and ubiquitous computing.

Project Timeline

In our Project 2 Proposal, we listed various benchmark tasks to be completed during the course of Project 2. Below is a summary of the progress that we have made thus far in Project 2.

> ***October 30:*** Met with Ali Mazalek regarding submitting a position paper for the Tangible Play: Research and Design for Tangible and Tabletop Games Workshop at IUI 2007.
>
> ***November 10:*** Created a hardware configuring allowing the Gumstix to read data from the SonMicro RFID reader and send the data to a host computer over Bluetooth.
>
> ***November 14:*** Created a hardware configuration that will send data from the SonMicro to a host computer through a Socket serial-over-Bluetooth module. Powered the SonMicro/serial-to-Bluetooth module hardware configuration with off-the-shelf batteries (the SonMicro can operate with a 9V battery).

Based on the progress detailed above, we feel that we have made substantial progress towards our initial Project 2 goals. We anticipate meeting our initial project expectations on time, and the following represents a projected timeline that will guide us toward meeting these goals.

> ***November 17:*** Extend the antenna for the SonMicro RFID reader, allowing it to be housed in the glove while connected to the reader.

November 20: Submit a position paper for the Tangible Play: Research and Design for Tangible and Tabletop Games Workshop at IUI 2007

November 24: Construct a wearable holder for the components, including a glove that holds the SonMicro reader's antenna.

December 8: Build a wearable RFID game.

December 11: Document our process on a how-to website.

December 12: Evaluate our reader and its use in our RFID game, through a user testing.

December 14: Present project during class presentation and submit a write-up of our completed work.

January 26: (Possible) Submit a demonstration or Late Breaking Result to Pervasive 2007.

Evaluation and Further Work

We expect to be evaluated on the quality of the work we have exhibited in building the hardware configuration for the wearable RFID reader, as well as on our evaluation of our prototype(s) using a game or other task. We also hope that our submission to the IUI workshop will count toward our requirement of publication-worthy work (though we will also attempt to make our work good enough for a possible Pervasive 2007 Breaking Result or Demonstration). Additionally, we expect to be graded on the quality of our documentation and its usefulness to other researchers.