Reminding Short-Term Memory Sufferers to Complete Routine Tasks

Caitlin Lustig, Lorcan Coyle

University College Dublin, Dublin, Ireland
Technical Report UCD-CSI-2007-10
September 28th, 2007

celustig@cs.washington.edu
lorcan.coyle@ucd.ie

Abstract

With the general increase of life span that our advances in health care have afforded us, more people are suffering from short term memory loss than ever before. Short term memory sufferers often forget what they were doing in the middle of a task and can find themselves in dangerous situations, such as leaving the stove on and leaving the house. They could benefit from an RFID based reminder system that would determine what they were doing based on what objects they touch. To use the system, the user wears an RFID glove which has a reader in the palm. The RFID glove reads the tags on the nearby objects. Along with the RFID glove we are developing an application that enables the user to interact with a reminder application. The application alerts the user of important activities they may have forgotten they started and when an activity is interrupted. It also keeps a record of the list of activities they have performed and objects they have touched through out the day.

1 Introduction

Short term memory sufferers often get confused or distracted in the middle of complex tasks and as a result fail to complete them. This may lead to them being moved to a care facility because their spouse or family can no longer take care of them, particularly if their spouse is elderly. If the person still wants to live independently, it is particularly important that they are able to cook safely. Using an RFID (Radio Frequency Identification) collocation system, we can determine what the user is doing in the home and remind them to complete the task at hand.

To further explore the problem for society of short term memory loss we have to consider that as the life expectancy of the average person grows, so does our elderly population. The 2002 Irish census showed that 11.13% of the population are over 65 and that 28.5% of the over-65 population lives alone [Spiezia 2002]. As the elderly population increases, age-related memory loss (e.g., dementia and Alzheimers) becomes more common.

Studies have shown that electronic memory aids are beneficial to short-term memory sufferers [e.g., [Oriani 2003, Hart 2004], but there is a need to make electronic devices seem less foreign to users. If a device has complicated instructions or feels obtrusive, it is less likely to be desirable to users. Our goal is to gather information from the user implicitly, by monitoring the items they come into contact with during the course of their everyday activities [Lustig 2007]. We believe the presence of such colocation information to be a valuable resource for determining a user's current task and assisting in its completion.

In order to gather colocation information we use RFID technology because RFID tags are small, unobtrusive, and inexpensive. Our prototype RFID system is a glove with an embedded RFID reader. This is uncomplicated for the user as it gathers its information ambiently. This RFID glove gathers colocation information based on the glove coming into close contact with tags that are embedded in the environment. It sends this information wirelessly to a database on a base computer in the user's home. A program running on that computer can determine what the user is doing based on the tags seen by the reader – in other words, the objects that were touched – and from that determine what the user was doing.

In recent years, RFID has become a popular technology [Landt 2005]. Today RFID is used in Austrialian and American passports, in Japan, RFID is being used on rail passes, posters, in mobile phones. Walmart, the world's largest discount store chain uses RFID to track its shipments. Most applications of RFID, including these examples and Cox et al.'s Intellibadge [Cox 2003], use a stationary reader and mobile tags. Our system is different in that it uses a mobile reader and mobile tags.

2 Application

The central premise of our application is that by determining what a user touches with some attention to order and timing, we can determine what the user is doing. For example, if a user touches a box of tea bags, a kettle, a sink, and a mug, we can infer that the user is making tea. Of course, it is very easy for a human being to determine this, but it is more difficult for a machine to have this sort ability to analyze what is being touched or to have this sort of common sense. Our application overcomes the the problem of analyzing what is being touched by equipping the user with an RFID glove that can read RFID tags and labeling kitchen items with tags.

2.1 RFID Glove

Figure 1 shows images of our RFID glove. The base for the glove was a sports glove. A small RFID reader is housed in a pouch sewed into the palm of the glove. Although placing the RFID reader in the palm of the glove restricts movement, the reader only has a range of about 3 cm, so the palm of the glove was the best location for achieving the highest number of tag reads. We tried different placements for the reader where the reader was on top of the hand. However, because the human body is mostly water, the reader and the tag cannot communicate through the hand. We conjectured that because many of the targeted users would already have problems with their hands, such as arthritis, the restriction of the glove might not pose such a problem. Also attached to the glove are 4 AA batteries that power the reader, a LED that blinks when tags are being read, and a wristband with a small Gumstix computer attached.

Gumstix computers are small Linux computers that areapproximately the size of a stick of chewing gum. They connect together like LEGOs and you can mix and match parts to get a computer that does everything you need. Initially, using the Gumstix posed a challenge to us because it was very time consuming to build and reflash the filesystem image every time we needed to add a program to our Gumstix. The Gumstix comes with a suite of software that can be installed on it, but the software can only be built on a Desktop machine and then is flashed over the Gumstix. Once we got our issues with the Gumstix worked out, we used our Gumstix to read data from the RFID reader via a serial connection and to send the data over WiFi to a remote server. Originally we used a python script to read the serial port, but after intermittently getting segmentation faults, we switched over to a script that was a combination of C and python. The script access a webpage written in PHP on the computer that is running our application and passes in the tag reads as GET variables. The webpage then updates the local database with the tag reads. We chose to use a separate PHP script because we had a lot of difficulty getting Python to work with our remote database. We also looked into using Java, but that was equally difficult on the Gumstix.

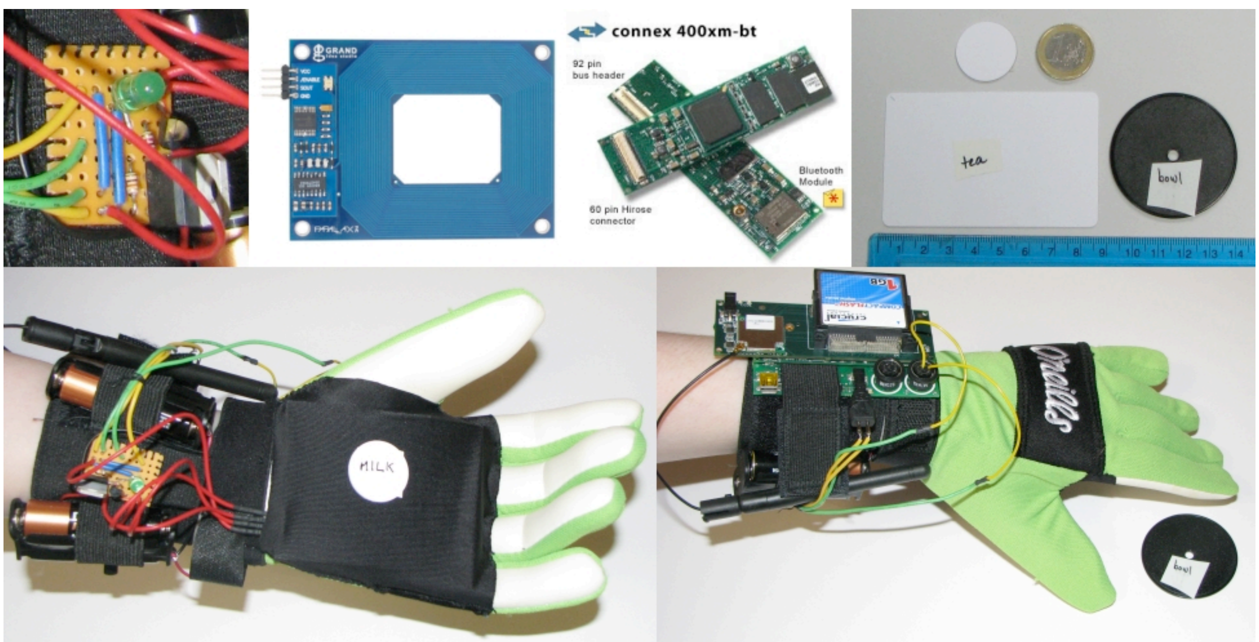

Figure 1: The RFID glove. Clockwise from top left: the circuitry connecting the RFID reader to the Gumstix; the portable RFID reader; the Gumstix motherboard; three types of RFID tags; the front view of the glove -- the circuitry and batteries are visible and the RFID reader is in a pouch under the palm; the rear view of the glove -- the Gumstix, serial connection, and WiFi antenna are visible.

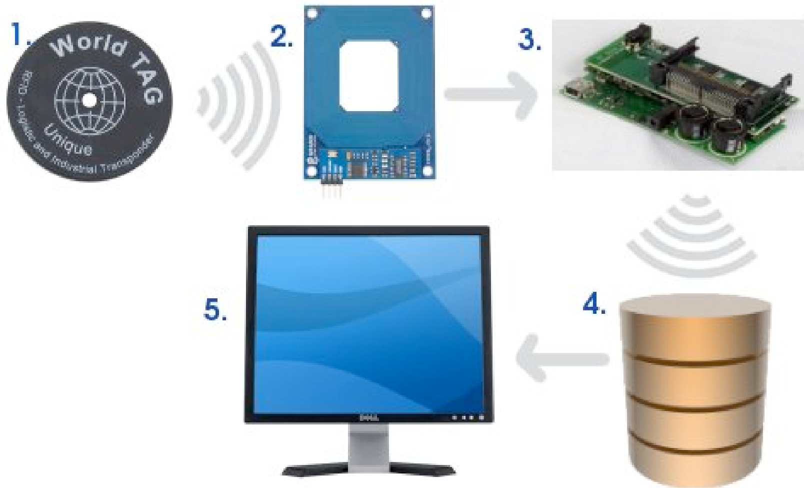

Figure 2: A flow diagram of our system. 1) The tag sends its unique identifier to the RFID reader in the glove. 2) The RFID reader sends the ID to the Gumstix via serial. 3) The Gumstix updates the database wirelessly. 4) The database interacts with our application. 4) The application produces output that lets the user know what they last touched, what they are probably doing, and if they might have forgotten they were doing a task or might have gotten interrupted.

2.2 Data Processing

In the related work section we discuss different ways we might have tackled the problem of data processing. Different methods employ a deep understanding of probability. We propose that a naïve model would be effective for this project as a proof of concept. In our database, we associate each activity with different tagged objects and determined if the user was doing a task by what percentage of the associated tagged objects they touched in the last 5 minutes. (Five minutes was chosen because activites in our trial setup have very short time limits, but this would need to be adjusted for activities with longer time limits). We set our measure of confidence at 50% or greater. Currently our simple system does not support multi-tasking. For example, if you are waiting for your cake to bake and want to wash some dishes while waiting, the system will think that you have gotten interrupted in the middle of baking a cake and will alert you that you may have forgotten about your cake.

In our system, we used a very simplistic method in which each activity was associated with different objects. For example, baking a cake would be associated with cake mix, eggs, measuring cup, and the hot water tap. Each activity had a final object associated with it that would always be the last thing touched at the end of the activity. In the case of baking a cake, the last object might be in the icing that goes on the cake. Each activity also had an average time associated with it. For example, on average, baking a cake might take an hour. Of course, we know that baking a cake will not always take an hour or less, so the user would not be alerted unless they had not finished the task in 125% of the average time. For example, if the user got distracted and never finished baking the cake (we would know this because they never touched the icing), the user would be alerted that they might have forgotten what they were doing .after an hour and 15 minutes had passed from the start of baking a cake.

In addition to just printing out alerts, the system also lets the user know when they have touched something and when it appears that they might be performing a certain activity. That way if the user is performing a particularly complex task, they can look back at what they did and remember what step they were on. For example, sometimes when baking a cake, someone might get distracted by something on the television. When they come back to the cake, they have forgotten whether or not they had put the sugar in and will have to taste the cake batter in order to attempt to find out. Our application can easily see if they had touched the sugar bowl recently.

3 Evaluation

We conducted a quantitive user study in which we asked 5 computer science undergraduates (two females and three males) to wear the RFID glove while touching tagged kitchen related objects (the kitchen domain was well studied by Patterson et al. [Patterson 2005]). We had users pick up a fork, a kettle, a cup, and a box of tea bags. We picked these objects because they had a good distribution of different shapes and sizes. Users were encouraged to move the tags to locations on these items in such a way that they got best contact with the reader on the palm of the glove. Afterward a few minutes of interacting with the glove and kitchen items, we asked users:

- On a scale of 1 to 10, how restrictive did you find the glove?
- On a scale of 1 to 10, how useful did you find the glove?
- Do you feel that the system has potential?
- What would you recommend changing about the glove?

We also gathered whatever comments and criticism these users supplied. The results were mixed – the average value for restrictiveness was 7.2 – indicating that users found the glove quite restrictive, and the average value for effectiveness was 5.2 – indicating that users saw only some effectiveness when interacting with tagged items. None of the users said the glove was comfortable, the following quotes are revealing: *"my hand cannot breath"*, *"it is uncomfortable to hold things"*, *"if the palm was more flexible it would have made the glove a lot more flexible and effictive"*, *"the biggest problem is the palm"*, *"I can't bend my fingers fully, I can't form a fist"*, *"I couldn't lift a full kettle"*, *"the glove is too small"*, *"my fingers won't bend"*. Three of the participants suggested that the fingers be cut out of the glove. Overall, the palm came through as the biggest problem with the implementation. The rigidity of the RFID reader is the main cause for complaint. If the reader could be made flexible and woven into the material of the glove these problems could be overcome. Other suggestions were made relating to the wrist band (which contains the Gumstix computer): *"could you connect the wristband with the glove?"*, *"could you make the bracelet [wristband] flexible? The smaller the better."*; to the placement of tags: *"the placement of tags [on household items] needs to be personalised."* The final suggestions related to the overall implementation and future work: *"It would be better if the user wore a writ band instead of the glove. They would be able to forget that it was even there and the application would 'just work'"*, *"I wouldn't use it in this form. Make it look like a [wrist]watch – use the digital display [to communicate with the user]"*, *"it is* *dangerous, if lifting hot water*". "*you could add functionality to detect if the user falls over to call for help*". While this feedback is prodominently negative it mostly relates to the implementation of the glove, which is just an initial prototype. When asked about the system's potential all participants were positive.

Next we will perform a naïve evaluation of the activity recognition software. We will have each user perform four tasks. The first two tasks would be to perform each activity without distractions. In order to simulate confusion, the next task would be to perform most of an activity and then just do nothing (ie making tea but not pour it into the cup). After the time limit for making tea is exceeded, the system will remind them to finish making tea. The last task would to start one task (i.e., washing the dishes) but get distracted midway through and start another task (ie making tea) instead. When it is detected that tea was being made, the system will remind them to finish making tea. To supliament this quantitive evaluation, each user will be given a survey that asks:

- What did you like about the glove or the computer application?
- What did you dislike about the glove or the computer application?
- What would you recommend changing about glove or computer application?
- Do you think this system will be helpful for people with short term memory loss?

4 Related Work

The earliest research done on RFID gloves was done by Schmidt et al. [Schmidt 2000]. They used a work glove and suggested that the glove could be used as a input device to a computer, much like a keyboard or mouse. After this project there were a number of projects that followed in its footsteps. More recent work was done by Kuwamura et al., who developed a prototype system called ``Ubiquitous Memories'' [Kuwamura 2007]. Their prototype includes a wrist mounted RFID reader to record and index user experiences based on touch.

Our approach closely follows the research done by Intel Seattle which included making an RFID glove and a more compact RFID bracelet [Patterson 2005]. Their research focused on efficient and effective algorithms for detecting activities-of-daily-living (ADL). They used Hidden Markov Models with learned and mined models from internet how-to websites and found that the learned models were more effective overall [Wyatt 2005]. They further refined their learned model by using WordNet to associate each object with its hypernyms. Hypernyms are where the meaning of a word is a subset of another. They also applied shrinkage algorithms which so that even if the model that they used was incomplete, it should still have a high chance of working [Munguia Tapia 2006] . They sped up their algorithms by implementing context-aware pruning which vastly decreased the number of objects being considered at any given time based on the context of the user's situation. For example, the kitchen sink being used is unlikely to effect anything in the bathroom and thus all the bathroom objects can be ignored while the focus is on the kitchen sink [Pentney 2007].

Our work proposes a unique angle to this pre-existing work because we wish to determine when an event not only takes place but is interrupted or not completed. Our work is also unique because it proposes using extremely simple algorithms to determine which activities are being performed.

5 Conclusions

This paper presents an implementation of an RFID-reading glove that is well suited to assisting sufferers of short-term memory loss to live independently in their homes. An application has been developed to monitor ongoing routine kitchen tasks and to issue warnings when these are not completed fully, e.g., if a kettle is boiled, and tea bags are opened, then a cup of tea should be made, even if the user is distracted. This application scenario is compelling because it fills a clear need and has a low cost in terms of infrastructure and cognitive load. The information generated also has the benefit of being owned by the user — no information leaves their home without their permission.

We performed a qualitative evaluation of our implementation that suggests that our implementation needs significant improvement before being usable in the real world. Future work on this track will focus on the improvement of the design, comfort, and effectiveness of the glove. We will also investigate the development of alternative form factors, e.g., a more powerful reader embedded in a watch or wristband.

Our research is a work-in-progress; we have completed our hardware implementation, we have outlined the scenarios we intend to tackle, and we have proposed an evaluation framework to test the efficacy of our approach. The next stage of our work is to implement the necessary routine detection algorithms and perform evaluations of our application of the scenarios.

6 Acknowledgments

This work is supported by Science Foundation Ireland under grant 04/RPI/1544. Caitlin Lustig is supported with funding from the Online Dublin Computer Science Summer School (ODCSSS).

Thanks to Jakub Dostal, Romain Muller, Olga Murdoch, Nanthana Trakarnratanakul, and Jeff Wright for participating in the qualitative survey.

References

[Cox 2003] D. Cox, V. Kindratenko, and D. Pointer. Intellibadge : Towards providing location-aware value-added services at academic conferences. In UbiComp 2003: Ubiquitous Computing, pages 264–280, 2003.

[Hart 2004] T. Hart, R. Buchhofer, and M. Vaccaro. Portable electronic devices as memory and organizational aids after traumatic brain injury: a consumer survey study. Journal of Head Trauma Rehabilitation, 19(5):351–365, September/October 2004.

[Kuwamura 2007] T. Kawamura, T. Fukuhara, H. Takeda, Y. Kono, and M. Kidode. Ubiquitous memories: a memory externalization system using physical ob jects. Personal Ubiquitous Comput., 11(4):287–298, 2007.

[Landt 2005] J. Landt. The history of RFID. IEEE Potentials, 24(4):8–11, October/November 2005.

[Lustig 2007] C. Lustig, H. Novatchkov, L. Dunne, M. McHugh and L Coyle. Using Colocation to Support Human Memory. Procs of MeMos 2007: Supporting Human Memory with Interactive Systems. Workshop at the 2007 British HCI International Conference. To Appear.

[Munguia Tapia 2006] E. Munguia Tapia, T. Choudhury, and M. Philipose, Building Reliable Activity Models Using Hierarchical Shrinkage and Mined Ontology. In Proceedings of PERVASIVE 2006, B. Heidelberg, Ed. Dublin, Ireland: Springer-Verlag, 2006.

[Oriani 2003] M. Oriani, E. Moniz-Cook, G. Binetti, G. Zanieri, G. Frisoni, C. Geroldi, L. De Vreese, and O. Zanetti. An electronic memory aid to support prospective memory in patients in the early stages of Alzheimer's disease: a pilot study. Aging & Mental Health, 7(1):22–27, January 2003.

[Patterson 2005] D. Patterson, D. Fox, H. Kautz, M. Philipose. Fine-Grained Activity Recognition by Aggregating Abstract Object Usage. Proc. of IEEE 9th International Symposium on Wearable Computers (ISWC) 2005.

[Pentney 2007] W. Pentney, M. Philipose, J. Bilmes and H. Kautz. Learning Large Scale Common Sense Models of Everyday Life. In Proceedings of the 27th Annual Conference of AAAI, 2007.

[Schmidt 2000] A. Schmidt and C. M. Hans-W. Gellersen. Enabling implicit human computer interaction - a wearable rfid-tag reader. In Proceedings of the International Symposium on Wearable Computers (ISWC2000), pages 193–194, October 2000.

[Spiezia 2002] V. Spiezia. The greying population: A wasted human capital or just a social liability? International Labour Review, 141(1/2):71–114, 2002.

[Wyatt 2005] D. Wyatt, M. Philipose, T. Choudhury, "Unsupervised Activity Recognition. Using Automatically Mined Common Sense", In Proc. AAAI, 2005.