HoTAAL: Home of Social Things Meet Ambient Assisted Living

Asangi Jayatilaka
The Auto-ID Lab
The University of Adelaide
asangi.jayatilaka@adelaide.edu.au

Yang Su
The Auto-ID Lab
The University of Adelaide
yang.su01@student.adelaide.edu.au

Damith C. Ranasinghe
The Auto-ID Lab
The University of Adelaide
damith.ranasinghe@adelaide.edu.au

***Abstract*—Population ageing is a global phenomena demanding novel technological developments as a result of increased healthcare costs and wishes of older people to stay in their own homes for longer. Combining the ubiquity of Internet connectivity in homes with pervasive and intelligent sensors to exploit user interactions with everyday home appliances create the possibility to build a new generation of assistive technologies for smart homes. We present a demonstration of HoTAAL (Home of Things for Ambient Assisted Living) where appliances exhibit seamless social interactions with each other and older people to provide assistance with daily living activities, especially in meal preparation tasks. These technologies are unobtrusive and able to coherently interconnect with older people in a naturalistic manner.**

***Index Terms*— Internet of things (IoT), Home of Things, Ambient Assisted Living, Social Appliances**

I. Introduction

According to a recent United Nation's report on world population ageing, there will be 392 million people aged 80 years or over by 2050 which is more than three times that at present. Dementia—an umbrella term for decline in mental ability—is a major challenge affecting many older people with socio-economic consequences for society in general. As a result of cognitive decline, their ability to perform basic activities of daily living such as meal preparation decreases [1]. Even though older people have clearly expressed a desire to 'live at home for as long as possible' [1] and government policies encourage this to reduce health care costs, a substantial amount of support is needed to realize these ambitions [1].

Opportunities for technological innovations have been identified to promote independent living for older people with dementia [1]. However, such technologies need to be carefully designed in order to accommodate requirements associated with cognitive impairments. Previous studies have clearly highlighted the importance of in-home technologies to be unobtrusive and maintenance-free in order to ensure their ability for monitoring or assisting older people with cognitive impairments in free living conditions [1], [2]. For example, body-worn technologies are found to be less desirable for older people with cognitive impairments as they may forget to wear those monitoring devices daily and recharge them [2].

Unobtrusive in-home monitoring technologies are emerging to provide alternative solutions. These approaches are predominantly based on sensors attached to the environment, to detect changes in the environment as a result of human activities [3]. Examples of such sensors include switches, passive infra-red (PIR) sensors and proximity sensors. On the other hand, a limited number of studies have moved from simply attaching sensors to embedding sensors in objects or appliances at home [4], [5], [6]. These types of appliances or objects used heterogeneous communication mechanisms and were mostly designed as stand alone solutions.

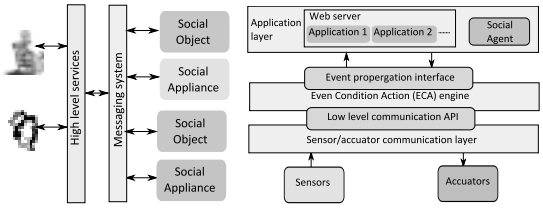
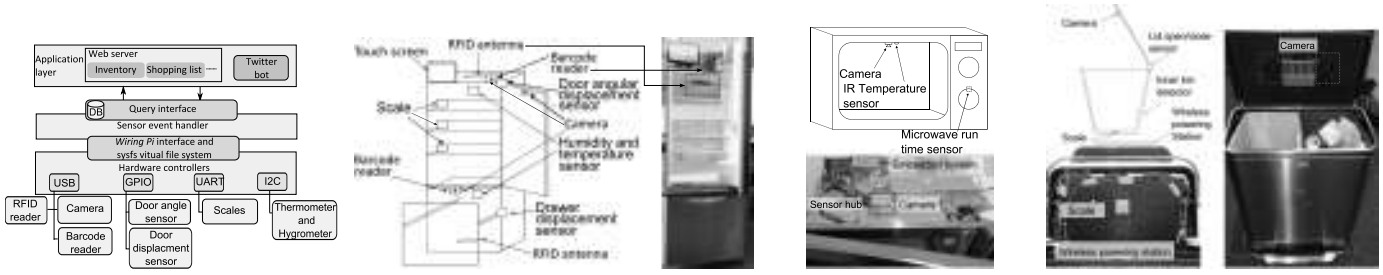


Fig. 1. a) The high level architecture of a home of connected things; b) The architecture of a social thing

With the recent emergence of Internet of things (IoT) and related technologies such as miniature sensors and tiny processors, everyday objects at home have been made intelligent and interconnected via the Internet [7]. However, things not only capable of sensing, actuation, and Internet connectivity, but also social interactions with other things as well as humans in a seamless manner—that is *social things*—create new possibilities to design innovative ambient assisted living applications. Such a social home facilitates seamless integration of heterogeneous set of pervasive technologies with older people where they are free to carry out their daily routines in an unobtrusive manner. In this paper, we present a demonstration of social appliances to support independent living in the context of our project HoTAAL. In light of research highlighting issues faced by older people diagnosed with dementia during meal times [1], [8], we base our demonstration in a meal preparation scenario in a kitchen environment.

II. HoTAAL architecture

The proposed high level architecture for HoTAAL is illustrated in Fig. 1a. We have employed a publisher subscriber architecture with a messaging system such as message-oriented middleware or a lightweight messaging protocol –for example



(a) (b) (c) (d)

Fig. 2. Implementations of the social kitchen appliances: a) implementation of a social thing architecture in Fig 1b to realize a social refrigerator; b) social refrigerator; c) social microwave; d) social bin.

MQ Telemetry Transport (MQTT). The social things in a home publish messages using messaging system and subscribe to messages of interest.

Fig.1b illustrates the high level architecture of a social thing. Multiple sensors such as thermometer (temperature), hygrometer (humidity) and scale (weight) may be embedded in a social thing. Additionally a social things may include actuators. Sensors and actuators communicate with an Event Condition Event (ECA) engine through a low level communication Application Programming Interface (API). This communication can take place over any communication mechanism such as Bluetooth, Inter-Integrated Circuit (I^2C). ECA engine manages and exposes the low level capabilities of the social entities. The application layer can send and receive notifications to and from ECA. The application layer includes a web server which can host multiple applications such as inventory control, event history. The social agent at the application layer employs a messaging system, a message-oriented middleware or a lightweight messaging protocol such as MQTT illustrated in Figure 1a to manage communications and social interactions.

III. Implementation

We have implemented three social appliances: i) a social refrigerator; ii) a social microwave; and iii) a social bin. Their capabilities are listed in Table I. We used the Twitter social computing platform [9] as the messaging system and have used a simple message format for communication: $<sender><receiver><message>$. Using the privacy options available in Twitter we protected the Tweets. Only those are authorized by an older person – for example family members and formal caregivers will receive Tweets from a single social appliance eco system.

All the social appliances were developed based on off-the shelf kitchen appliances. The social refrigerator (see Fig. 2a and Fig. 2b) is equipped with a Radio Frequency Identification (RFID) reader (Thingmagic M6e) connected to three RFID antennas, two cameras, two bar-code readers and scales to identify and quantify food in the refrigerator cabinet. These sensors are sampled using a Raspberry Pi single board computer. The social refrigerator also contains switches to identify door movements, and thermometer and hygrometer to measure the environmental parameters within the refrigerator. The implementation details of the social refrigerator are illustrated in Fig. 2a and it is currently capable providing high level services such as inventory management (based on bar codes and RFID tagged products), cook book and an automated shopping cart based on monitoring food consumption and product expiry dates.

TABLE I
Capabilities of the social kitchen appliances

Appliance	Capabilities
Fridge	Detecting open and close events of the refrigerator doors Detecting door angular displacement Capturing bar codes of the content in the refrigerator Capturing RFID tag information of the objects in the refrigerator Capturing images of what's inside the refrigerator Detecting the temperature, humidity inside the refrigerator Detecting the weight of each plate
Microwave	Detecting open and close events of the microwave door Capturing an image of the food inside the microwave after cooking finished Detecting the user selected cooking time Detecting the temperature when the microwave is working
Bin	Detecting open and close events of the bin Capturing an image of what's inside the bin when the bin lid is opened Capturing the weight of the contents in the bin Recognizing when the bin is full Detecting when the inner bin is misplaced Wireless powering capability

The Fig.2c illustrates the social microwave realization. It has a camera and a non-contact IR thermometer both mounted on the celling of the cooking chamber (between the inner and the outer chassis). Additionally, a travel switch is attached to the timer dial to capture user selected time information. The microwave is capable of capturing an image while it is working and record the temperature of the food being heated.

The social bin (Fig. 2d) employs a stainless steel bin equipped with two cameras (for land fill and recycle bin) and switches. Additionally, weighing sensors attached to the bottom of the bin measures the amount of garbage.

IV. Demonstration

We base our demonstration on a meal preparation scenario using food provided by Meals on Wheels which is a popular provider of nutritious meals to older people living in their own homes. The demonstration will: i) highlight the capabilities of the implemented social kitchen appliances; ii) illustrate the social interactions between the social microwave and the social refrigerator (*i.e* machine to machine communication); iii) illustrate social means of people interacting with kitchen appliances; and iii) illustrate the assitive services realised.

According to the continuum of assistance proposed in [10] for assisting older people with dementia in home environ-

ments, assistive services should incrementally increase from simply guiding attention and creating awareness to providing suggestions and explicit instructions. In this demonstration we firstly show how HoTAAL can be used for creating awareness among older people about status of the food in the refrigerator. Particularly, this will include guiding attention to food items in a refrigerator that are going to expire soon. Furthermore, in light of literature [10], [8], [1] which suggest that issues in remembering the cooking instructions is a common problem in older people with dementia, we will demonstrate how the cooking instructions can be prompted when required.

a) Demonstration scenario: Our demonstration is based on a scenario centred around Elizabeth who is aged 82 years, diagnosed with dementia and living alone in her own home. The demonstration scenario is described below. A twitter feed extract related to the demonstration is illustrated in Fig. 3.

One day, Elizabeth's social refrigerator discovers that a frozen meal, is going to expire within a day. The social refrigerator notifies about this to Elizabeth to create awareness. The information is displayed on a screen and an alarm is used draw attention to an important event. Elizabeth takes a frozen meal out of the refrigerator for her lunch. The social refrigerator recognizes that the frozen meal is taken out and notifies the microwave to be ready to receive the frozen meal.

Elizabeth heats the meal using the social microwave. However, Elizabeth forgets the heating instructions and only heat the meal for 3 minutes. Elizabeth throws away the food container to the social bin and social bin takes a photo of the bin content and uploads it to the HoTAAL twitter feed. Once cooking is finished microwave takes a photo of the food inside it and reports the status via the Twitter feed. Furthermore, the social microwave recognizes that the meal is undercooked hence another 1 minute is needed to fully cook the meal based on information received from the social refrigerator. This information is provided as suggestion to Elizabeth. After having the meal, Elizabeth throws away the leftovers to the social bin. With the newly added rubbish, Elizabeth's social bin recognizes that it is in full state, hence reminds Elizabeth that it needs to be emptied. After emptying the social bin, Elizabeth forgets to place the inner bin back correctly and the social bin instructs Elizabeth to do so.

b) Demonstration requirements: The requirements to create a social kitchen at the PerCom demo venue is to have Internet connectivity and a screen to display Twitter feeds. We will bring in the social bin and microwave and due to practical reasons we will only bring the parts of social refrigerator that are relevant for the demonstration to the venue. The demonstration will be accompanied by a video showing the full scenario that will include the complete social refrigerator.

V. Conclusion

We believe that this research will open up a new research paradigm where many useful applications for older people living at home, formal caregivers and family members can be developed. For example, intelligent, social kitchen environments can be used in designing exciting ambient assisted living applications focusing on shopping assistance, meal planning, detection of functional decline and remote nutrition monitoring. Currently we are extending the platform to support anomaly detection and automatic analysis and interpretation of twitter feeds to synthesize knowledge, such as an older person has taken their meal on time based on learnt knowledge or prompting when regular meal time tasks are missed. Interested readers are referred to the project website (http://autoidlab.cs.adelaide.edu.au/HoTAAL) for more details. Additionally, other ways of socially interacting with the residents, such as social robots, will be explored in the future.

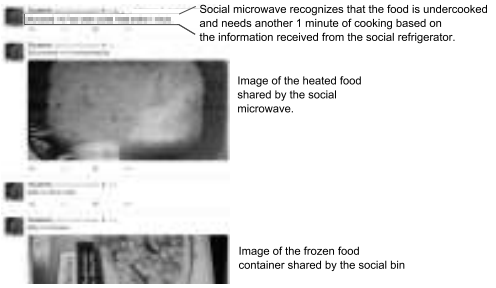


Fig. 3. Social interactions of the kitchen appliances using the Twitter

VI. Acknowledgements

This research was supported by a grant from the Australian Research Council (DP130104614).

References

[1] J. P. Wherton and A. F. Monk, "Technological opportunities for supporting people with dementia who are living at home," *Int. J. Hum.-Comput. Stud.*, vol. 66, no. 8, pp. 571–586, 2008.

[2] R. Steele, A. Lo, C. Secombe, and Y. K. Wong, "Elderly persons perception and acceptance of using wireless sensor networks to assist healthcare," *Int. J. Med. Inform.*, vol. 78, no. 12, pp. 788–801, 2009.

[3] X. Hong, C. D. Nugent, M. D. Mulvenna, S. Martin, S. Devlin, and J. G. Wallace, "Dynamic similarity-based activity detection and recognition within smart homes," *International Journal of Pervasive Computing and Communications*, vol. 8, no. 3, pp. 264–278, 2012.

[4] K.-h. Chang, S.-y. Liu, H.-h. Chu, J. Y.-j. Hsu, C. Chen, T.-y. Lin, C.-y. Chen, and P. Huang, "The diet-aware dining table: Observing dietary behaviors over a tabletop surface," in *Proceeding of the International Conference on Pervasive Computing*. Springer, 2006, pp. 366–382.

[5] L. Xie, Y. Yin, X. Lu, B. Sheng, and S. Lu, "ifridge: An intelligent fridge for food management based on rfid technology," in *Proceedings of the ACM conference on Pervasive and ubiquitous computing adjunct publication*, 2013, pp. 291–294.

[6] A. Thieme, R. Comber, J. Miebach, J. Weeden, N. Kraemer, S. Lawson, and P. Olivier, "We've bin watching you: designing for reflection and social persuasion to promote sustainable lifestyles," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2012, pp. 2337–2346.

[7] L. Atzori, A. Iera, and G. Morabito, "From smart objects to social objects: The next evolutionary step of the internet of things," *Communications Magazine, IEEE*, vol. 52, no. 1, pp. 97–105, 2014.

[8] J. P. Wherton and A. F. Monk, "Problems people with dementia have with kitchen tasks: The challenge for pervasive computing," *Interacting with Computers*, vol. 22, no. 4, pp. 253–266, 2010.

[9] M. Kranz, L. Roalter, and F. Michahelles, "Things that twitter: social networks and the internet of things," in *What can the Internet of Things do for the Citizen Workshop at The Eighth International Conference on Pervasive Computing*, 2010, pp. 1–10.

[10] M. Morris, J. Lundell, E. Dishman, and B. Needham, "New perspectives on ubiquitous computing from ethnographic study of elders with cognitive decline," in *Ubiquitous Computing*. Springer, 2003, pp. 227–242.