Schreier G, Hayn D, Ammenwerth E, editors. Tagungsband der eHealth2011. 26.-27.Mai 2011; Wien. OCG; 2011.

WIRELESS SENSOR PLATFORM FOR AAL AND TELEHEALTH APPLICATIONS

Graf H[1], Morak J[1], Schreier G[1]

Abstract

Important aspects of Ambient Assisted Living are to detect changes in mental constitution, e.g. by monitoring activities of daily living (ADL) and monitoring health parameters, preferably via the same user interface. We developed a prototype of a wireless RFID scanner worn at the wrist, for reading out medical data and unobtrusively recognizing RFID-tagged objects of daily living. The prototype was evaluated for monitoring ADL and health parameters in a real home environment. Although potential improvements were identified, feasibility of the system could be demonstrated.

Keywords – eHealth, Ambient Assisted Living, Telehealth, Near Field Communication

1. Introduction

Ambient Assisted Living (AAL) offers technological solutions to increase the quality of life of elderly people at home. Hence, it decreases costs for caretakers, personal nursing services or the transfer to nursing homes, and increase benefits for the individual (increasing safety & wellbeing), the economy (higher effectiveness of limited resources) and the society (better living standards) [6]. AAL systems should provide more security and autonomy, complement social contact and include medical assistance without intrusion of privacy and without replacing contact with people [2].

1. 1. Monitoring of Activities of Daily Living (ADL)

One important aspect of AAL is to detect and react on changes in mental constitution. Changes in daily behavior, such as sleeping, housekeeping, entertainment, food preparation, and exercises, can be indicators for physical or mental problems, especially in elderly people. The major challenge is to accurately measure specific ADL. This provides health researchers with information to implement strategies for encouraging people's behavior related to diet, exercise and medication adherence [7]. ADL are "*the things we normally do in daily living including any daily activity we perform for self-care (such as feeding ourselves, bathing, dressing, grooming), work, homemaking, and leisure*" [5]. An overview is given in *Figure 1*.

One promising approach for monitoring of ADL uses objects in people's environment to recognize certain activities which are performed when interacting with these objects. This is realized by Radio Frequency Identification (RFID) technology [1]. The subject wears an RFID reader that recognizes when a tagged object is touched or used.

1 Safety and Security Department, AIT Austrian Institute of Technology GmbH, Graz

Figure 1: Overview of Activities of Daily Living (ADL)

1. 2. Telehealth

Regular monitoring of physiological parameters is also a use case of information and communication technologies in groups of elderly people especially in those suffering from chronic diseases. *Meystre* points out that telemonitoring is the most promising application for the long-term disease monitoring of patients at home in order to reduce problems due to the increase of chronically ill people [4]. This application field is also based on mobile computing and wireless communication technologies to provide patients with virtual communication channels to stay in contact with their care givers. One example is the Keep in Touch (KIT) telehealth system developed by the Austrian Institute of Technology and operated by the general hospital of the Elisabethinen in Linz in Upper Austria [3]. This system is based on mobile phones and Near Field Communication (NFC) technology and provides an intuitive touch based user interaction.

In the past AAL and telehealth systems have been developed separately with different user interfaces and technologies often incompatible to each other.

1. 3. Objectives

The objective of this work has been to develop and evaluate a prototype of a wireless sensor platform to be worn by an elderly person suitable for both applications:

- unobtrusively monitor ADL by reading tagged objects while using them
- interrogate medical sensor devices by actively touching them

2. Methods

2. 1. Development of a prototype

An RFID reader called *KIT wand* was developed prototypically, intended to be worn at the wrist (*Figure 2a*) to detect RFID tags and NFC enabled devices, consisting of the following components:

- NFC reader chip (PN 531, NXP, Eindhoven, Netherlands)
- NFC antenna
- Bluetooth module (BNC4, Amber Wireless, Cologne, Germany)
- Microcontroller (MSP430F123, Texas Instruments, Dallas, Tx, USA)
- Rechargeable battery (BL-5B, Nokia, Espoo, Finland) with DC/DC converter
- Light emitting diode (LED)

a) b)

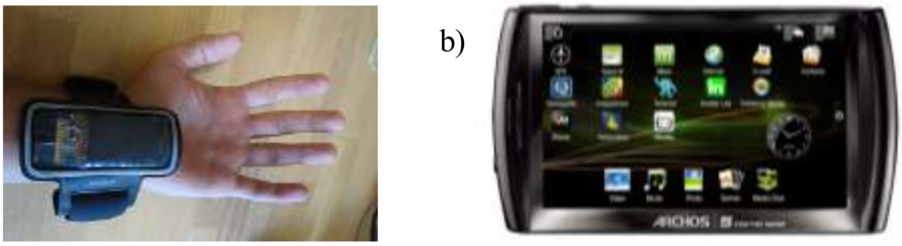

Figure 2: a) KIT wand prototype attached to wrist, b) Archos 5 Internet Tabled used as terminal device

The microcontroller (µC) was the main part of the KIT wand. It operated the NFC chip to periodically scan the environment for RFID tags or NFC enabled monitoring devices. Once a target was recognized, the data were read and stored on a stack of the µCs internal memory. Then the µC activated the Bluetooth module which automatically opened a preconfigured connection to a remote terminal device. Once the link was established all data from the stack were transmitted to the terminal device. Then the stack was deleted and the connection was closed by disabling the Bluetooth module. If a connection couldn't be established, the stack kept filled to be transmitted next time when the process was triggered again by recognizing a target.

The terminal device (*Figure 2b*) was represented by an Internet tablet (Archos 5IT, Archos, Igny, Essonne, France) running Android (Donut, Google Inc, Mountain View, Ca, USA). This device provided a personal area network by means of Bluetooth and the ability to connect to the Internet via WiFi network. A terminal software application was developed prototypically to receive, store (log file), and display the data scanned by the KIT wand. These data were either context sensitive data from objects meaning a special action or measurement data from NFC enabled blood pressure meters (UA767 Plus NFC, A&D, Tokyo, Japan) or body weight scales (UC321PL, A&D).

2. 2. Evaluation

To evaluate the feasibility of the prototype, a test environment similar to a real application scenario has been utilized. A standard living area was prepared for usability tests. Therefore, the terminal device was placed at an easily accessible position in the living/dining room next to the TV set. The knobs of a dishwasher and a cupboard, the remote control, the entrance door, and a kettle full of water were equipped with RFID tags. *Figure 3* shows these objects in the test environment.

Five test persons were asked to perform the following tasks while wearing the KIT wand:

- Open the dishwasher and take out some plates
- Open the cupboard and put the plates in it
- Close the cupboard
- Close the dishwasher
- Take the kettle and fill a glass of water
- Watching TV (using the remote control)
- Leave the room through the entrance door

Part one of this feasibility test was to show, if the events were recognized by the KIT wand. This was examined through the red LED on the KIT wand, which indicated when read data were processed. The second part of this feasibility test was to show, if the collected data were successfully forwarded to the terminal device.

In order to show the feasibility of interrogating health data from devices, the NFC enabled blood pressure meter and body weight scales were used. Five test persons were asked to measure their blood pressure as well as body weight and to touch the respective device with the KIT wand right after the measurement was finished. Successful data acquisition was examined through verification of the messages visualized on the terminal device after data were transmitted via Bluetooth.

a) b) c) d) e)

Figure 3: Objects in the test environment attached with RFID tags:
a) cupboard, b) dish washer, c) entrance door, d) kettle, e) remote control

In addition to the feasibility test regarding ADL monitoring and acquisition of health parameters the system was tested to point out the maximum operating distance of the Bluetooth link. For this reason both components were used in a real home with four rooms, a kitchen, two bathrooms, and two toilet rooms on a single floor with a dimension of 10.7 x 9.6 meters.

3. Results

The evaluation of the developed prototype showed the following results. Five test persons (2 female, mean age 23.2 ±2.2 years) were equipped with the KIT wand and had to perform certain ADL tasks in order to show the successful data processing of KIT wand and the terminal device. *Table 1* outlines the results of this test. The events "Open dishwasher", "Open cupboard" and "Use kettle" were performed successfully in 80 percent of all conducted tests. "Close cupboard" and "Close dishwasher" performed successfully in 100 percent of the tests. Bluetooth transfer of "Use remote control (RC)" and "Open door" was successful in 80 percent, although KIT wand data processing was successful in 100 percent of all conducted tests.

Table 1: Results of performing ADL tasks with the KIT wand

Test person	Open dishwasher	Open cupboard	Close cupboard	Close dishwasher	Use kettle	Use RC	Open door
Nr.1	passed	passed	passed	passed	passed	passed	passed
	passed	passed	passed	passed	passed	failed	failed
Nr.2	passed	passed	passed	passed	passed	passed	passed
	passed	passed	passed	passed	passed	passed	passed
Nr.3	passed	failed	passed	passed	passed	passed	passed
	passed	/	passed	passed	passed	passed	passed
Nr.4	passed	passed	passed	passed	failed	passed	passed
	passed	passed	passed	passed	/	passed	passed
Nr.5	failed	passed	passed	passed	passed	passed	passed
	/	passed	passed	passed	passed	passed	passed
Success [%]	80	80	100	100	80	100	100
	80	80	100	100	80	80	80

KIT wand data processing
Bluetooth transfer

The test case of health data acquisition was performed by the same five persons. The results of this test revealed that in case of the blood pressure meter all persons were able to interrogate the blood pressure meter's data by touching the device with the KIT wand. In case of reading the recent measured body weight one person failed.

The results of the maximum Bluetooth range test within the home environment demonstrated that a connection between the terminal device placed in the kitchen and the KIT wand used in every room could be established every time. In order to find out maximum ratings, the prototype was tested in a bigger office building complex. The maximum Bluetooth range without any walls was 45 meters. Bluetooth transfer through two plasterboard walls was feasible over 8 meters. One concrete wall and one plasterboard wall decreased the maximum reading distance to 6.5 meters. Bluetooth transfer through three walls failed.

4. Discussion

The feasibility test to show the KIT wand's ability to recognize ADL tasks revealed a positive outcome. The results of test person Nr. 1 show an unsuccessful Bluetooth transfer during "Use remote control" and "Open door". Due to an incorrect data transfer within "Use remote control", the terminal device went into an undefined state and was not able to process any further data. This result demonstrated that Bluetooth technology is affected by instabilities, which can disturb precise operation of devices. The unsuccessful events of test person Nr.3, Nr.4 and Nr. 5 resulted due to the short operating range of NFC. The test persons did not touch the attached RFID tags as precisely as needed, which caused a loss of these events. This could be improved by optimizing the antenna or even by replacing NFC by another RFID technology.

Considering the results of the acquisition of health data with the KIT wand, it turned out that the prototype performed as expected. The failed data processing during data acquisition with the scale through one test person appeared due to wrong handling of the KIT wand prototype. The acquisition of health data is a conscious activity. The patients are expected to touch the health devices with the KIT wand in order to transfer data. Thus, the loss of data due to incorrect handling of the KIT wand could be avoided through an acoustic alarm or a short vibrating of the KIT wand. This would signalize a patient that the action was performed correctly and data are transferred. The KIT wand only has to give this feedback if the person is acquiring health data. Within ADL recognition, which should be unobtrusive, there is no feedback necessary after an ADL task is performed. This will be taken into account in a future version of the KIT wand.

NFC and Bluetooth technology were used for this prototype due to the fact that these wireless technologies are already integrated in off-the-shelf consumer devices like Internet tablets and mobile phones. Thus, the given prototype shows drawbacks regarding battery life and tag reading performance. From a technical point of view other technologies could provide better characteristic in terms of energy consumptions and operating range. The current prototype is based on Bluetooth version 2.1 which lacks an appropriate energy management. Successor versions of this Bluetooth standard or ZigBee consume less energy which could help to extend battery life.

Improving the operating range for reading RFID tags is more complex due to the fact that depending on the used frequency range greater distances may require bigger antennas and/or more energy. Materials also have a deep impact on the behavior of RFID systems and strongly have to be considered when choosing an RFID system.

5. Conclusion

Technologies in the context of AAL are becoming more and more important to ensure a longer independent life for elderly people in their homes. Furthermore, due to the high prevalence of chronic diseases in elderly people, telehealth services play an important role for the patients and the healthcare system. Both fields need to be developed in a parallel manner to be used in the same environment with a single user interface.

We developed a prototype of a KIT wand to unobtrusively monitor ADL on the one hand and to acquire health related parameter for closed loop telehealth application on the other hand. Although this prototype showed some potential for optimization the system could be tested successfully and allowed the intuitive acquisition of health parameters and the recognition of ADL of elderly people through interaction with tagged objects in a home environment. The results show that telehealth services combined with AAL technologies give opportunities to counteract healthcare and ageing related future problems. Based on the given prototype a successor version focusing on the combination of vital signals and nutritional behavior is going to be developed and evaluated in the Austrian LiKeIT project. In a pilot trial a group of elderly patients will be asked to collect this kind of data on a daily basis intended to help doctors and nutritionists to detect, understand, and react on changes in daily behavior.

6. References

[1] FISHKIN, K. P., PHILIPOSE, M., RAE, A., Hands-On RFID: Wireless Wearables for Detecting Use of Objects. Ninth IEEE International Symposium on Wearable Computers. Seattle, USA, 2005, pp. 38-41

[2] GEORGIEFF, P., Ambient Assisted Living - Marktpotentiale IT-unterstützter Pflege für ein selbstbestimmtest Altern. Fazit-Schriftenreihe Marktanalyse / Band 17, 2008, from http://www.fazit-forschung.de/fileadmin/_fazit-forschung/downloads/FAZIT-Schriftenreihe_Band_17.pdf (German)

[3] KASTNER, P., MORAK, J., KOLLMANN, A., et al., Innovative telemonitoring system for cardiology: from science to routine operation. Applies Clinical Informatics 2010;1(2):165-176

[4] MEYSTRE, S., The current state of telemonitoring: A comment on the literature. Telemed J E Health. 2005 Feb;11(1):63-9.

[5] Medical Dictionary definitions of popular medical terms easily defined on MedTerms. Retrieved July 21, 2010, from http://www.medterms.com/script/main/art.asp?articlekey=2152

[6] STEG, H., STRESE, H., LOROFF, C., HULL, J., SCHMIDT, S., Europe Is Facing a Demographic Change, Ambient Assisted Living Offers Solutions. Berlin: VDI|VDE|IT

[7] TAPIA, E. M., INTILLE, S. S., LARSON, K., Activity recognition in the home setting using simple and ubiquitous sensors," in Proceedings of PERVASIVE 2004, vol. LNCS 3001, A. Ferscha and F. Mattern, Eds. Berlin Heidelberg: Springer-Verlag, 2004, pp. 158-175

Corresponding Author

Jürgen Morak
Safety and Security Department, AIT Austrian Institute of Technology GmbH
Reininghausstr. 13/1, A-8020 Graz
Email: juergen.morak@ait.ac.at