Environment-Aware System for Alzheimer's Patients

Ana Barreto, Renato Oliveira and Filipe Sousa
Associação Fraunhofer Portugal Research
Rua Alfredo Allen – 455/461, 4200-135
Porto, Portugal
Email: {ana.barreto, renato.oliveira, filipe.sousa}@fraunhofer.pt

Artur Cardoso† and Cândido Duarte ‡,†
† Department of Electrical and Computer Engineering
Faculty of Engineering, University of Porto
‡ INESC TEC (formerly INESC Porto)
Porto, Portugal
Email: {acardoso, candidoduarte}@fe.up.pt

***Abstract*—Alzheimer's disease is a major cause of disability in older people and because of its nature and symptoms it is a huge weight on the caregivers and health system. The aim of this project, developed at Fraunhofer Portugal, is to create a remote monitoring system for patients suffering from Alzheimer's disease. This system comprises a device able to monitor the environment temperature and humidity, the patients location, using GPS, as well as the patient's movements, including falls. The device sends this information to the caregiver via SMS, and also to a server, where it is stored in a database developed in this work, and which the caregiver can access via a smartphone, using an application also developed in this project. This system therefore affords a close surveillance of the patient's status as well as access to historical data of the patient's information.**

Keywords—Alzheimer's disease; dementia; GSM-GPRS; GPS

I. INTRODUCTION

The population of Europe has been aging in these past few decades and Portugal is not an exception. Alzheimer's disease (AD) affects in Portugal about 90,000 people [1], which makes this disease a public health problem. Alzheimer's is a type of dementia[1] that causes problems with memory, thinking, discernment and behavior. Alzheimer's has no current cure and its symptoms cannot be stopped yet from developing, they can only be provisionally slowed down to improve the quality of life of patients and caregivers [2].

AD is a neurological disorder caused by the death of brain cells which causes memory loss and cognitive decline. It was named after a German psychiatrist, Alois Alzheimer, in 1906. This disease represents more than 60% of all dementia cases [2]. The onset of the disease is gradual, and patients get progressively worse, eventually becoming unable to recognize their family, communicate and care for themselves, requiring round-the-clock care in later stages of the disease. It happens often that AD patients wander and get lost, and also tend to be unaware and unresponsive to the surrounding environment temperature and humidity, often being under or overdressed.

The system presented in this article comprises a wearable electronic device with the ability to monitor the patient's level of physical activity, including possible falls (by means of a 3-axis accelerometer), the patient's geographical location using a GPS receiver as well as the environment humidity and temperature for their safety. The device sends alarm messages and regular status information to the caregiver's cellphone, via SMS, and also to a server. The device communicates through Global System Mobile (GSM) communication and General Packet Radio Services (GPRS).

The data sent to the server are stored in a database. It can be accessed from a smartphone using an Android application developed in this project, allowing access to the historical data concerning each patient.

This system is intended to give assistance to caregivers by providing environment conditions and location of the patients, in typical care situations either at home, in a day-care, retirement home or a clinical environment.

A series of tests of the system was conducted with patients in a retirement home, validating the concept and obtaining some preliminary patient data.

II. STATE OF THE ART

Several commercially available systems exist to support the care for elderly patients, in particular patients with AD. Also some rather more experimental systems have been proposed for activity monitoring and classification.

In the US, Omnilink, a company providing location services for goods and people, using a combination of GPS and cellular based location, with dedicated devices or cellphones, also provides, in association with Alzheimer's Association [2], a location service for AD patients called Comfort Zone Check-In [3]. This system uses a wearable location device or a cellphone to locate the patient, allowing the caregiver to access the location via the company website. Similar systems exist from other companies, like GPS Smart Sole, from GTX Corp in the US [4].

A similar system for AD patient caregivers sold by a Spanish company Vision under the name Keruve [5] uses a GPS watch and a receiver, with no service subscription necessary.

Again in the US, a wearable device in the form of a watch, the LocateMe GPS WatchTM is marketed for AD patients [6]. It is able to provide the caregiver with the wearer location, via a SMS sent to the caregiver smartphone, at his request.

All of these systems offer one function only, the localization of an AD patient.

A system that monitors activity and falls has been set up at the Caussade hospital in France. This system uses a network of indoor IR sensors combined with an electronic device worn by the patients to identify the patients, follow their activities and detect any falls [7], [8]. This system was not developed

[1]Dementia is the progressive decline of cognitive functions and ability to process thoughts.

MOBIHEALTH 2014, November 03-05, Athens, Greece

DOI 10.4108/icst.mobihealth.2014.257523

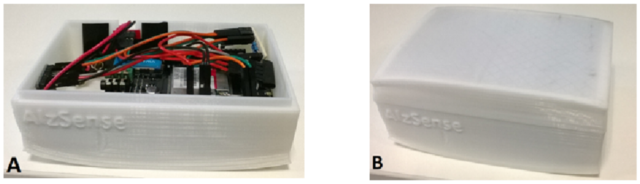

Fig. 1. A – Electronic device worn by patients; B – Electronic device casing. The case is $115 \times 76 \times 54$ mm and contains the Arduino, sensors, communication module and battery.

specifically for AD patients, but in the more general context of care for elderly patients.

A study about the detection and classification of activities has been published, which uses a regular sports watch, the eZ430-Chronos watch, containing an accelerometer, a temperature sensor and an altimeter. The combined information of the three sensors was shown to give a reasonable discrimination of activities of daily living [9].

Another published study uses body-worn accelerometer sensors to monitor sleep-wake cycles of elderly patients in a nursing home [10].

The system proposed in this paper combines the functionalities presented before in one single wearable electronic device and a backend server to store the information. The wearable electronic device includes GPS localization, environment monitoring, and activity and fall detection. Moreover, the caregiver can follow any number of patients location, activities and environment conditions with an Android application.

III. System Description

The wearable electronic device developed for this system uses an Arduino Uno board to acquire data from the sensors and GPS receiver and control the data transmission via the GPRS/GSM link. The Arduino is therefore coupled to the following peripherals:

- The 3axis accelerometer ADXL345 [11] was used for the physical activity and fall detection.
- To monitor the environment temperature and humidity the HTU21D [12], which combines both sensors, was chosen.
- The GPS and wireless communication was implemented using the DFRobot GPS/GPRS/GSM shield V3.0 [13], an Arduino-compatible module.

The complete device, with a battery, fits in a relatively small box (Fig. 1), small enough to be carried in a pouch around the waist (Fig. 5). It does not require any interaction with the patient, which is an advantage with this type of patients. Since this is a proof of concept using off-the-shelf modules, no effort was spent to make it smaller. Obviously a future device, designed for this purpose, can be made smaller and lighter.

The main structure of the program that runs in the Arduino is shown in Fig. 2. When the device is turned on or reset, the sensors are initiated and a GPRS connection is established; the interrupt is enabled and the program goes into a wait loop.

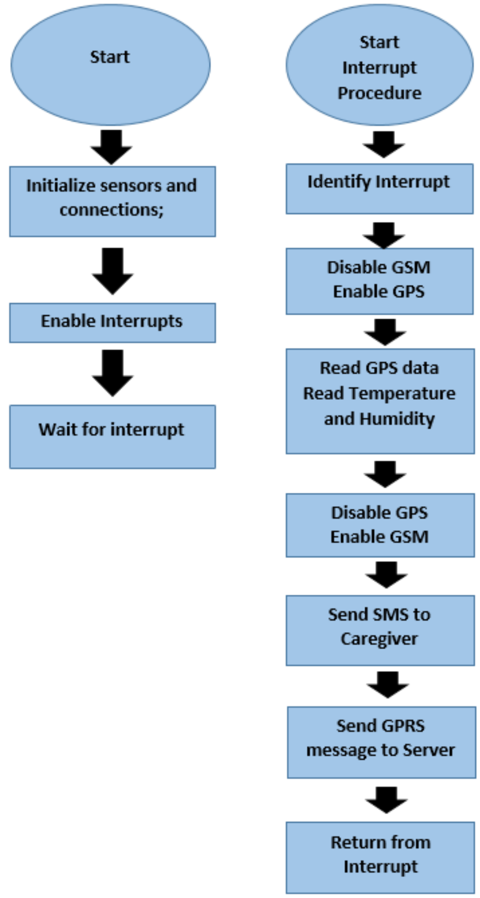

Fig. 2. Arduino program flow chart.

The interrupt is triggered by the accelerometer, either because of activity or fall detection, or by a programmable timeout.

Once the interrupt is activated, the data from the temperature and humidity sensors, as well as the GPS location is sent via SMS to the caregiver's cellphone (Fig. 3), and also to the server.

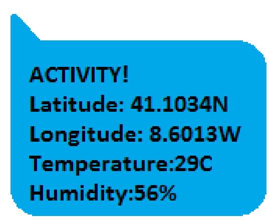

Fig. 3. SMS received by the caregiver.

In the server, the data are stored in a MySQL database. Each record contains the patient's personal data, emergency contacts, and the data collected with a time-stamp.

An Android application was developed to provide the caregiver with the possibility of accessing the patient's information on the server. The application presents an initial screen display (Fig. 4-A) from which the user can select one of three types of data to visualize, such as activity (Fig. 4-B).

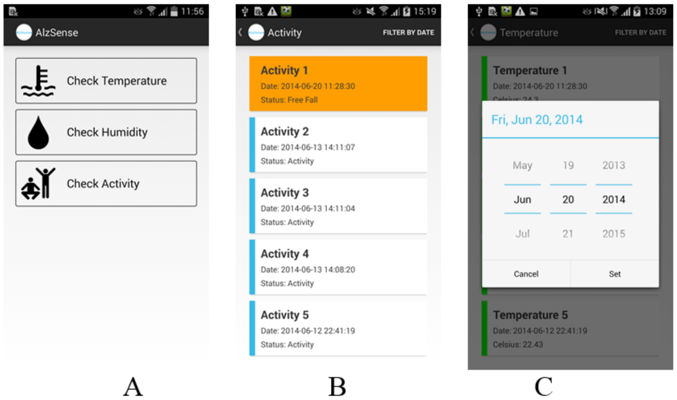

Fig. 4. Android app screens: A - Initial screen display, B - Activity screen, C - Filtering by date.

Fig. 5. Patient wearing the device.

The application communicates via HTTP with the server, which responds with the relevant data in JSON format; the application then parses it to fill the display list (as exemplified in Fig. 4-B). Data is presented in chronological order, and can be filtered by date (Fig. 4-C).

IV. Results

Tests were performed with five subjects, all women, with ages above 75 years. Relevant information about these subjects and their caregivers is shown in Table I.

Each subject carried the device in a waist belt for approximately one hour. The device position can be seen in Fig. 5. During that time the device reported all data collected to the server database and sent status messages to a cellphone.

The data points were obtained approximately at every 3 minutes.

The results from each patient can be seen in Fig. 6.

Subjects D and E did not have AD and the caregiver of subject A was not available for the interview.

Subject A had been diagnosed with the disease for a year and was still very active, participated regularly in the gym class and interacted with other people in the day care center.

Subject B had AD diagnosed approximately eight years ago. She spent most of the day sitting on a sofa, most of the time just sleeping.

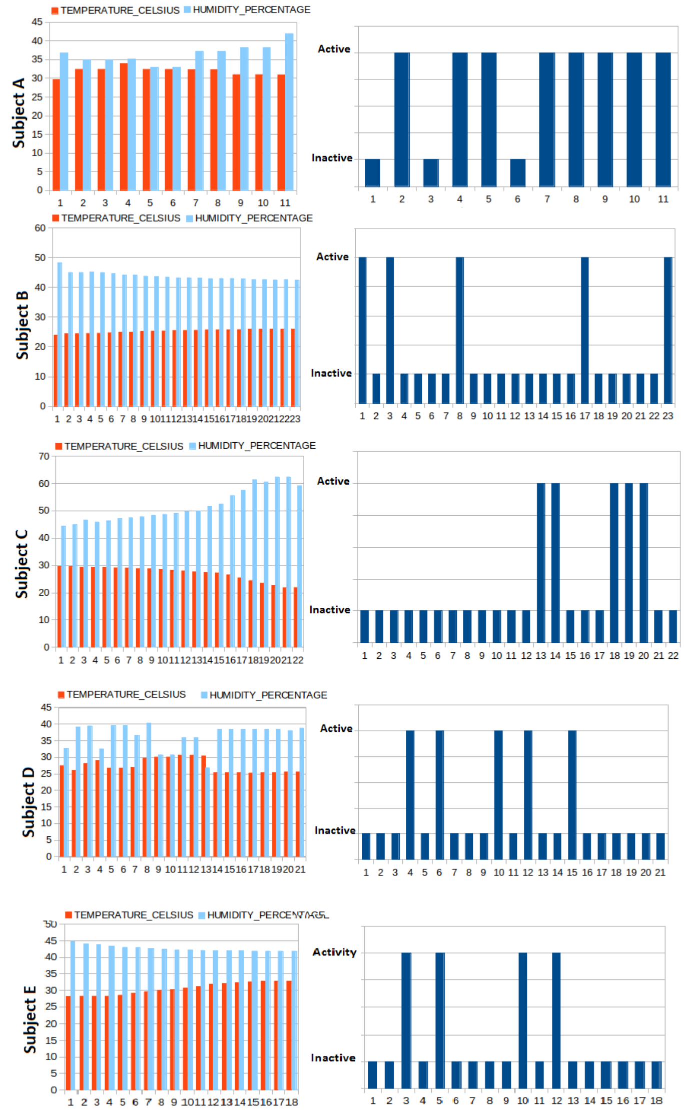

Fig. 6. Test results – vertical axis represents the values of temperature and humidity while the horizontal the number of the measurements.

Subject C had been diagnosed with AD for one year but she was much less active than subject A (which was diagnosed with AD for about as long). She spent most of the time sleeping on a sofa near subject B.

Subject D at the time of the test, was participating in a Boccia game.

Subject E suffered from falls rather frequently, and therefore spend most of her time sitting on a chair.

Since no subject fell during the tests, fortunately, fall detection was tested in the laboratory. The device was dropped from approximately 70 centimeters on a flat area. The results from a trial of 10 drops were 8 correct detections of a fall and 2 false negatives.

All the above tests were performed indoors. For that reason, the GPS was tested by bringing the device outdoors, and acquiring the coordinates on the cellphone.

TABLE I. SUBJECT'S AND CAREGIVER'S PERSONAL DATA.

Subject	Age	Already suffered a serious fall?	How long with the disease?	How many hours spent in the clinic?	How much time by yourself?	The subject caregiver uses smartphone	Caregiver's age?
A	80	No	1 year	5	0	–	60
B	85	No	8 years	24	0	No	73
C	90	No	1 year	8	0	Yes	65
D	79	No	–	3	20	No	60
E	75	Yes	–	4	0	No	76

V. DISCUSSION

While wearing the device the patients were observed and the data reported by the device was found to be consistent with the subject's movements and environment measures.

Environment data is different between subjects because they were taken at different times, and different places, since only one wearable device was built.

Results obtained indicate that most of the subjects did not feel uncomfortable wearing the device. Only subject A said it was uncomfortable and for that reason she only wore it for half an hour and suggested that the device should be smaller and more discreet. Two of the other patients reported no discomfort, and two were unable to answer.

Generally the results show that this system, capable of detecting physical activity, falls, and measuring the patient's environment parameters, and capable of transmitting this information to the caregivers, is a useful tool to monitor AD patients, supporting caregivers and improving the quality of care for AD patients.

VI. CONCLUSION

The system presented here aims to help AD patient caregivers, and comprises an electronic device capable of monitor an AD patient regarding environment temperature and humidity, physical activity and detection of falls, thereby providing constant support to the caregivers by reporting all this information timely. At the same time all the information is stored in a database set up for this purpose, which the caregiver can also access with a smartphone application, also developed in this project.

The system was tried out with a group of subjects in a real clinic scenario while performing their daily tasks.

During the tests the system was found to be consistent with the environmental measures and physical activity performed.

For future work the authors propose to decrease the size of the device, create an interface where the caregiver can insert the personal data of the patient in the database, include an emergency button on the device, perform additional tests, both with AD-affected people and their caregivers to test the application and system acceptance, increase the device autonomy and integrate the device existing intelligence with external sensors that would allow for instance for indoor positioning and increase reliability in fall detection.

ACKNOWLEDGMENT

The authors would like to thank Dr. Marta Melo and Dr. Sandra Miranda as well as the seniors and caregivers of Associação Social e Cultural de S. Nicolau and Centro de Convívio da Junta de Freguesia de Rio Tinto for their gracious contributions to this work.

Project AAL4ALL, co-financed by the European Community Fund FEDER through COMPETE – Programa Operacional Factores de Competitividade (POFC).

REFERENCES

[1] Apifarma. (2014, Jun) Dia mundial da pessoa com Alzheimer. [Online]. Available: http://www.apifarma.pt

[2] The Alzheimer's Association. (2014, Jun) Alzheimer's disease and dementia. [Online]. Available: http://www.alz.org

[3] O. Systems. (2014, Sep) Confortzone checkin. [Online]. Available: http//www.confortzonecheckin.com

[4] G. Corp. (2014, Set) GPS SmartSoles. [Online]. Available: http://www.gpssmartsole.com/

[5] Keruve. (2014, Sep) Localizador familiar directo. [Online]. Available: http://www.keruve.es

[6] 3-Locate. (2014, Sep) LocateMe GPS watch. [Online]. Available: http://www.3locate.com/GPS_Bracelet_Locator.html

[7] Y. Charlon, N. Fourty, W. Bourennane, and E. Campo, "Design and evaluation of a device worn for fall detection and localization: Application for the continuous monitoring of risks incurred by dependents in an Alzheimer's care unit," *Expert Systems with Applications*, vol. 40, no. 18, pp. 7316–7330, 2013.

[8] Y. Charlon, W. Bourennane, F. Bettahar, and E. Campo, "Activity monitoring system for elderly in a context of smart home," *IRBM*, vol. 34, no. 1, pp. 60–63, 2013.

[9] S. Chernbumroong, S. Cang, A. Atkins, and H. Yu, "Elderly activities recognition and classification for applications in assisted living," *Expert Systems with Applications*, vol. 40, no. 5, pp. 1662–1674, 2013.

[10] J. Biswas, J. Maniyeri, K. Gopalakrishnan, L. Shue, P. J. Eugene, H. N. Palit, F. Y. Siang, L. L. Seng, and L. Xiaorong, "Processing of wearable sensor data on the cloud-a step towards scaling of continuous monitoring of health and well-being," in *Annual International Conference of the IEEE: Engineering in Medicine and Biology Society (EMBC)*, 2010, pp. 3860–3863.

[11] A. Devices. (2013) ADXL345: 3-axis $\pm 2/\ g \pm 4/\ g \pm\ g/16\ g$ digital accelerometer. [Online]. Available: http://analog.com

[12] M. Specialties. HTU21D: digital relative humidity sensor with temperature output. [Online]. Available: https://www.sparkfun.com

[13] DFRobot. (2014, Mar) Gps/gprs/gsm shield. [Online]. Available: http://www.dfrobot.com