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Multi-sensory Tracking of Elders in Outdoor Environments on Ambient Assisted Living

Javier Jiménez Alemán

Fluminense Federal University, Niterói, Brazil

jjimenezaleman@ic.uff.br

Abstract. Ambient Assisted Living (AAL) is an emergent area that provides useful mechanisms that allows tracking elders through opportunistic sensoring, for example, using mobile devices. In that sense, it is necessary a permanent attention to these people by caregivers and relatives and a growing necessity to create mechanism to support this task. In our proposal, we have a network of caregivers that work together to ensure the wellbeing of elders in their daily activities. This paper aims to model the interaction process of different actors with SafeRoute, an AAL system that pretends monitoring elders in their day-to-day daily living activities in outdoor environments. SafeRoute merges sensor data provided by different sensors built in mobile devices to provide alert mechanisms for caregivers.

Keywords: Interaction model, AAL, sensors, mobile application.

1 Introduction

The increase in life in Brazil and all over the world expectancy brings with an increase in the prevalence of health problem, such as physical limitations (balance problems), perceptual problems (vision and hearing problems) and cognitive problems (loss of memory, di cult to make parallel tasks). Events such as falls tend to occur frequently when persons are older. That fact implies an increase of the permanent attention to these people by his caregivers and relatives and a growing necessity to create mechanism to support this task [1].

Ambient Intelligence (AmI) refers to a vision in which people are empowered by an electronic environment that is sensitive and responsive to their needs, and is aware of their presence. Its target is improving quality of life by creating the desired atmosphere through intelligent and inter-connected systems. Inside AmI, Ambient Assisted Living (AAL) can be defined as the use of information and communication technologies (ICT) in a person's daily living and working environment to enable them to stay active longer, remain socially connected and live independently into old age [2]. These technologies can supply security for people with a wide range of physical and cognitive challenges, although the focus is often on supporting elders. AAL uses sensing technology embedded in objects, or in the environment to promote health and enhance wellbeing. Furthermore, AAL technologies also allow best communication between elders with his relatives and friends [3].

Concerning AAL, Smart Homes concerns the methods, concepts, electronic systems, products and services that assist elders or people with disabilities in their daily lives in a controlled environment. However, the sense of security changes dramatically when elders are in an uncontrolled environment where the risk to accidents is multiplied. It is very important to increase the safety of this people, to reduce the response time in emergency situations (fall, loss). Nowadays, smartphones not only work like communication devices, but also are equipped with several sensors like accelerometer, GPS system and camera. All these sensors make possible a wide range of applications like the assistance to elders and people with disabilities.

Attending that, was created the SafeRoute project, a system able to assist elders with activities related to their day-to-day activities in outdoor environments that use geo-localization technologies built-in mobiles devices. The purpose of this work is to present the SafeRoute projects, who aim to monitor elders who follow predefined routes and to notify to their caregiver in case of emergencies (losses and falls). We considered the inclusion of actors and other elements in our model that contribute to improve the monitoring process of elders and to reduce response time in case of emergencies.

2 Related Work

In the case of AAL systems, it is necessary to provide to elders the simplest way to interact with the systems, to minimize as much as possible the error product of this interaction It is recommended limiting the possible options, dialogues has to be linear and parallel tasks must to be avoided. For example, Kopal [4] is a system, which provides a feedback mechanism based on speech, which helps people with dementia and their caregivers. The caregiver may use the own mobile for ask for information to the elder through the own mobile. OutCare [5] is an example of an AAL application that attempts to help people with Alzheimer's and their caregivers. In this case, the authors implemented a multiagent sys-tem (MAS) that monitoring outdoor daily routines for people with Alzheimer, sending alerts to their caregivers in case of deviation via SMS, e-mail, and voice.

Another system that tries to help people with mental diseases is AlzNav from Fraunhover Portugal [6]. This system intends to help elder and people in general who are in early stages of dementia. This open source project proposes an interface that guides the user through a compass indicating the right direction to go on the trip. Furthermore, it provides a location system that allows caregiver to send a SMS with the location for the people who need care.

Another system that attempts help people with cognitive disabilities in their day-to-day journey is [7]. In this case, it consists in a system location to assist caregivers to be aware of current location of these disabled people. The system is divided in three main parts: one application for the person with cognitive im-pairment, and two apps for your caregiver (mobile and web server).

The author proposes a decision algorithm for creating alerts whenever necessary and used augmented reality to provide help to user through few options. The user can choose a fixed destination (generic location, such as shopping, work or home) according to the type of destinations stored in the database.

Authors of [8] presented a sensor-based map navigation approach in very early stages for users who due to disabilities or lack of technical knowledge. They vision is that artificial companion can be achieved based on the integration of a variety of information sources which includes both user pro les and real-time sensor data. They described the challenges and potential solutions related to this vision and provide a number of scenarios that illustrate its utility. The main contributions of this paper is to provide an AAL system in the context of AAL that allow monitoring elders in outdoors, using a set of sensors available in smartphones and other information sources.

We also proposed an interaction model of a hybrid context that combine traditional elements of an AAL environment with new human actors and functionalities in our system, finding to create a safety network around the city. This new social actors will act as sensors and actuators, to detect emergencies and reduce the response time in this cases.

3 Interaction Model

In this section, we define our interaction model, considering several elements and actors. In the studied context, our objective is to monitor the daily routines of elders in outdoors, and acting according the diagnostic product of the mentioned status. There are different people involved in the care for the elders. Relatives and health attendants will be monitoring constantly the elder status, doctors will be alerting in case of and medical emergency and standworkers will be receiving information about the status of elders in the proximity of their workplaces and will help elders in case of emergency. It is possible to infer a diagnostic of the elder status, for example, if elder falls, his health condition or his motor activity (walking, standing, etc.).

We defined different kinds of actions that will act over the correspondent actuator, and according the previous diagnostic, we divide actions in communication actions and human help actions. Other important aspect that we realized is concerning the different information sources that our system can consume to diagnose the elder status. We taking in consideration not only the sensor observations of sensor built-in the smartphones, but also other external information (maps, environmental information located in the web, pro le information of elder), and we also included ambient devices and wearable devices, but focused mainly in smartphones as main sensoring tool. We consider smartphones as other sensor inside our Ambient Intelligence system.

Summarizing, relatives and health assistants will form a safety network that will be monitoring the elder status in their daily activities; also, doctors would receive alerts in case of severe emergencies. In addition, finding to reduce the risk of accidents, we include an innovative tracking system formed by stand workers who work in these newsstands that often are geographically distributed through out cities in Brazil, these people will be aware of the elders circulating in the vicinity of their workplace, to provide quick help in case of emergency.(Figure 1).

Fig. 1. Interaction Model.

4 Safe Route System

In order to develop a computational tool that would resolve our interaction model and to help elders in outdoor environments was developed, a system called SafeRoute. We describe in detail the developed system: we present the architectural design that guided the development of the SafeRoute System and we presented their components.

4.1 Architectural Design

The SafeRoute system is a solution to the interaction model previously presented. The proposed approach consists in a system to help caregivers in the care of elders who are doing their daily activities outdoor. The system is composed by three main components: the Android application CareofMe, the SafeRoute web system and a display panel to visualize the elder general status. These components work in combination to merge data from the different sensors embedded in the smartphone as other sources of information, finding to visualize the elder state. Figure 2 presents the architecture of the SafeRoute system, composed by the CareofMe Android application and the SafeRoute web system. The display panel is not detailed in this representation since it only show the elder status provided by the SafeRoute web system.

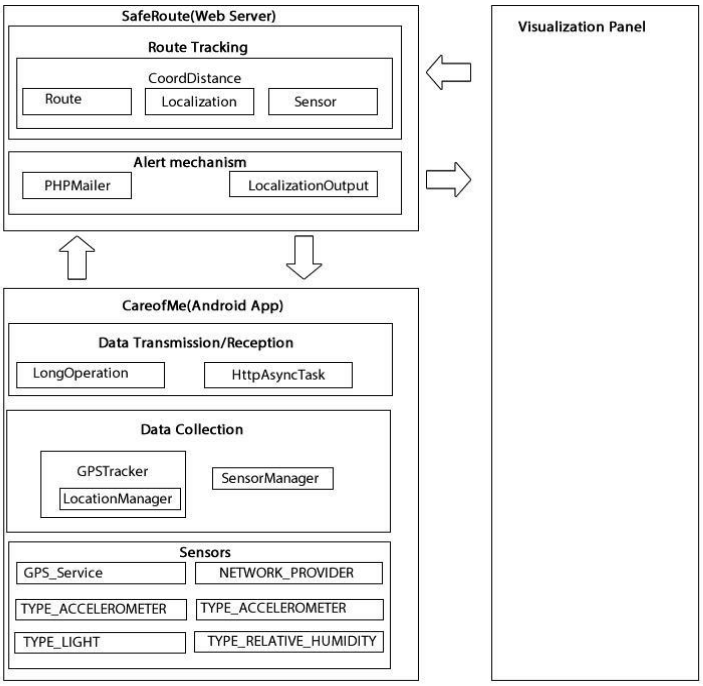

Fig. 2. SafeRoute system architecture.

4.2 Android Application CareofMe

The Android application CareofMe uses a combination of sensors technologies available in smartphones to identify possible risk situations for elders. Regarding the elder localization functionality, the GPS sensor integrated into smartphones provide the elder location with an error margin between 3 to 7.8 meters. However, the battery life consumption of the smartphone when this sensor is usually considered very high, for this reason, an alternative for the elders localization was considered, in this case, through Internet (Wi-Fi). GPSTracker is the class in charge for managing the elder location data through the LocationManager class belonging to the GoogleMap Android v2 API. The accelerometer sensor embedded in the smartphone was used to develop the functionality related to the elder's falls identifications. The SensorManager class is responsible to man-age the accelerations axes values, and to identify falls when abrupt changes in these values are identified.

CareofMe allows choosing a route or a safety net. Once the elder start his movement, the application allows identifying his exact geographical location (Figure 3). In the interface implementation, it was considered typical usability requirements for elders, who may have vision problems or memory problems. For this reason, the application interface has been designed trying to minimize the elder's interaction. In addition, the letters and buttons size was designed trying to facilitate its visualization.

Regarding the feedbacks at risk situations for the elders, these are some of the alarms that the application can provide:

- **Movement away of a predetermined route or safety network:** If a movement away of the allowed area is detected, an alert action will be issued to the elder (Figure 4). In addition, another alert will inform to the elder how to return to the route or secure network that he is following.
- **Fall detection:** If a fall for an elder is detected, the application will ask to the elder about their condition (Figure 5). If a help request is confirmed by the elder, the application will automatically inform to the caregiver. The application also allows to the elderly inform that he is right, finding to minimize the amount of false alarms, but if a reasonable time elapses between the fall detection and the response of the elder, an alert is issued for the caregiver.

Fig. 3. Route and safety networks monitoring in CareofMe.

4.3 Web SafeRoute System

The decision to develop a web platform emerged as the most natural choice; since according to the proposed model, it is necessary facilitate the access to data provided by the different sources and their subsequent fusion. The web system SafeRoute was designed as a tool to provide constant monitoring of the elder state and have the responsibility for the routes and predefined secured networks management Figure 6 shows the edition interface of a safety network.

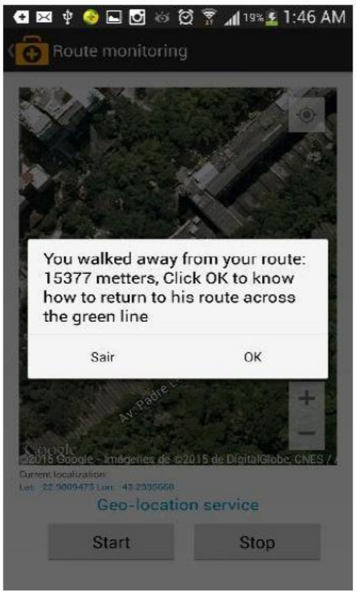

Fig. 4. Movement away feedback issued by CareofMe.

Fig. 5. Fall detection feedback by CareofMe.

In addition, the web system will process the alerts to caregivers in case of a dangerous situation inferred for the elder status. The monitoring feature uses the CoordDistance class to calculate the distance between the elder's location in real time (Localization) and the locations of predefined routes or network (Route). This distance is calculated by the CoordDistance class following the Haversiana formula between two geographical points. The proposed approach considers distance between the elder's geographical location, the route points and the lines connecting them. A PHPMailer class is responsible for sending alerts to caregivers about the elder's situation through an e-mail with the elder's current position.

Fig. 6. Safety networks in the SafeRoute Web system.

4.4 Control Panel

In order to create a mechanism to improve the monitoring process of the elders' activities in outdoors was created a display panel to visualize the elder status. In this way, caregivers who are monitoring the elders activity will have an overview of the elder's geographical location, as well as their status (movement away of the route or safety net, falling, etc.) and of the environmental variables.

The information presented in the panel is the result of the feedback of the SafeRoute web system, which carried out all the reasoning and inference of the elder state.

5 Evaluation

To evaluate our work we carried out a user-centered test with three elders. Our test consisted in that every elder followed a predefined route (Figure 7) inside our safety network. We simulate falls (in a controlled environment) and intentional departures from the safety network. Our objective with this test was to compare localization accuracy using localization sensors provided by the Arduino platform with the geographic localization obtained by sensor embedded in the smartphone and used by the CareofMe application (GPS, Wi-Fi).

Results showed in Figure 8 and Figure 9 showed a better accuracy for locations obtained by the CareofMe application in comparison with location sensors of Arduino. However, the results showed the necessity to implement calibration functionalities and to find alternatives to get localization, not only GPS and localization through Internet, finding to improve the localization accuracy.

Fig. 7. Predefined Route.

In addition, the obtained results allowed us to measure a set of relevant values for our system, for example, we measured the average displacement speed of elders and the delay in alerting to the caregiver. We took these values in consideration or make corrections in our system, for example, we changed frequency, which our system sends the user's position to the web system, considering that a low frequency can affect the lifetime of the battery of cell and affect the proper functioning of the application.

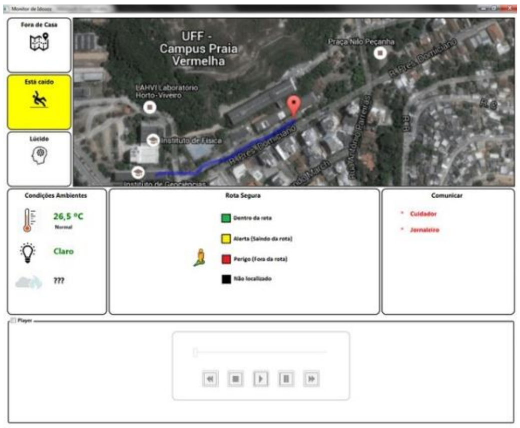

Fig. 8. Tracked route through the Control Panel and using the App CareofMe.

6 Conclusion and Future Work

In this paper, we presented an application to tracking old persons in outdoor environments in the context of the development of the SafeRoute system. We presented a social interaction model for represents the interaction between caregivers and elders that are being monitored in the context of the SafeRoute AAL system.

We showed that it is possible helping elders better and to reduce the time response in case of emergency in this context with the inclusion of new social actors as the stand workers, who acts like sensors and actuators in our model. With our model, we described a hybrid context, when caregivers and embedded technologies work together to create a safety network for care elders in outdoors environments and how is it possible that using our system, the response time in case of emergencies could be reduced.

Fig. 9. Tracked route using Arduino sensors.

In addition, we showed the results of an initial user-center test that had the objective to compare the localization accuracy between our proposed localization method and an alternative method provided by the Arduino platform. We showed that with the combination of different localization methods our system obtain a better accuracy that an alternative method that only use a simple localization sensor.

However, we considered indispensable to make a more extensive experimental phase. We aim to evaluate prototype through a technology evaluation consisting in some post-test questionnaires to measure the satisfaction level of users. We also plan to develop some new intelligent functionalities that respond automatically to user and to the environment behavior to allow a faster response in case of emergency, such as the inclusion of other available sensors and other information sources (environmental sensors, location sensor, accelerometer, camera, etc.), for example, we pretend manipulate the camera for automatically taking photos of users in case of emergency.

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