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Opportunistic Sensoring using Mobiles for Tracking Users in Ambient Intelligence

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Abstract. The necessity of using new technologies to monitoring elderly people in open-air environments by their caregivers has become a priority in the last years. In this direction, Ambient Intelligence (AmI) provides useful mechanisms and the geo-localization technologies embedded in smartphones allows tracking elderly people through opportunistic sensoring. The aim of this paper is to show a practical example to how to combine some technologies for monitoring elderly people through the system *SafeRoute*. We describe the two components of this system: the Android application *CareofMe* and the web system *SafeRoute.* The proposed system uses GPS, Wifi and accelerometer sensoring, GoogleMaps functionalities in Android and web environments and an alert system for caregivers.

Keywords: Opportunistic sensoring, Ambient Intelligence, elderly tracking, fall detection, geo-localization technologies.

1 Introduction

In recent decades, there has been a global trend of increasing average age of the population and life expectancy. According to the statistics of the census of the Brazilian Institute of Geography and Statistics (IBGE) in 2010, the Brazilian population over 65 years old increased in a 10,3%, this percentage will reach 29% in 2050 and 36,1% in 2075[1]. In [2], authors estimate 1 million 200 thousands people living with Alzheimer disease in Brazil, with 70% living in their own homes. This fact implies an increase of the permanent attention to these people by caregivers and an increasing demand of support mechanisms for these tasks.

The European Community's Information Society Technology (ISTAG), belonging to the European Commission, defined the concept Ambient Intelligence (AmI) in 2001. Ambient Intelligence is an emergent topic that attempts to answer human needs through

adfa, p. 1, 2011.

digital and technological environments, allowing innovative ways of human-computer interactions [3]. The Ambient Intelligence based technologies for the support to daily activities are also called tools of Ambient Assisted Living (AAL). AAL can be used in prevention of accidents and to improve the health conditions and comfort of the elderly people [4]. These technologies can supply security to the elderly, developing response systems for mobile systems, fall detection systems and video surveillance systems [5].

Nowadays, most of the smartphones not only serve as communication devices, but also are equipped with several sensors like accelerometer, gyroscope, proximity sensors, microphones, GPS system and camera. All these sensors make possible a wide range of applications like the assistance to people with disabilities, intelligently detecting and recognizing the context.

The unobtrusive sensoring is also called opportunistic sensoring and represents a desirable characteristic of the AAL systems. There are several initiatives to develop techniques of opportunistic sensoring in mobile devices in the last years, allowing the creation of a new kind of mobile applications in the context of the Ambient Intelligence for the care of elderly people.

To fulfil the needs of tracking, current mobile phones are equipped with several positioning methods that are based on the Global Positioning System (GPS), WiFi or Cell-Id, which mostly results in a high-energy demand and thus quickly drain the device's battery [6]. While GPS allows for an accuracy location up to 5 to 10 meters, it requires several seconds to minutes to determine the position. In addition, the functionality is limited, for instance inside buildings. Wifi based location is sufficiently accurate with 30 to 50 meters. However, it required the availability of a registered wireless hotspot, which may only be found in densely populated areas. Cell based location is available as long as there is mobile network coverage. The downside of this technology is that it is less accurate with a deviation of several hundreds of meters [7]

Fall detection is an important component of many AAL systems because approximately half of the hospitalizations of the elderly are caused by fall [8]. Not only are fall related injuries the number one reason for emergency room visits, it is also the leading cause of injury-related deaths among adults 65 years old and older [9].

Taking into account all these considerations, we conclude that elderly people often suffer problems of aging such as memory loss, difficulty walking, etc. Many times, these people have to stay at home alone for long periods, but they normally do various activities outside the home during this time (go to the market, visiting friends, etc.). Once they are in outdoor environments, elderly people are at risk of fall down or getting lost on the way. In these cases, it is very important that elderly people can communicate with their carivegers for help and receive orientations in real time.

The purpose of this work was to presents the system *SafeRoute*, a system able to assist elderly people with activities related to their day-to-day activities in open-air environments, and using the geo-localization technologies inside of mobiles devices. We attempt to develop a system that opportunistically monitored elderly people who follow predefined routes and efficiently notified their caregiver in case of emergency.

The paper is organized as follows: Section 2 presents the analysis of some studies about the use of mobiles as AAL tools for the monitoring of elderly people in open-air environments. Section 3 describes the design and the implementation of *SafeRoute* with its contributions and limitations. Finally, in Section 4, some conclusions are given and future improvements are proposed.

2 Related Work

The availability of smart phones equipped with a rich set of powerful sensors at low cost has allowed the ubiquitous human activity recognition on mobile platforms. There are several advantages in the use of smartphones, for example, the developments kits (SDK), APIs and mobile computing clouds allow developers to use backend servers and collect data from a large number of users.

Recent studies show that smartphones are suitable for tracking, monitoring the position of the elderly and alerting in case of estrangement from a predefined route. *SmartShoe*[10] is a system where the authors combine use of a device in the shoe of the elderly person, equipped with technologies GPS and Bluetooth and a web interface to allow caregivers to make an efficient tracking. *Navitime* [11] is another system that helps pedestrian to find the best route to his destiny through different kinds of transport and attending parameters like the estimated delay time or the estimated amount of carbon dioxide that can be expelled. This system guides users through maps, predefined routes, voice alerts and vibration. *Navitime* accuracy is 10 meters in unobstructed areas and 3 meters in highly urbanized areas, in these cases using map matching methods and estimation techniques through cell towers positioning.

Several strategies for monitoring and tracking, and related types of interventions have been implemented with mobile phones: 1) tracking people trying to optimize the use of energy in the mobile device [12-14]; 2) the inclusion of social networks [15-17].

The authors of *EnLoc* [12] focused their work on the optimal use of energy when location sensors in smartphones are used. They developed a localization framework that is able to detect the user optimal localization and to predict the estimated time of the energy use through heuristical predictions.

LibreGeoSocial [15] is a very interesting study that combine healthcare and social networks. Authors created a mobile social network, which allows creating virtual communities to facilitate communication between elderly persons and their caregivers in case of loss. There are different scenarios, for example, carivegers can put a perimeter around a predefined route or at home for the elderly and the system will send an alarm and a message through the network to report the current position if distancing.

There are also studies that deal AAL modeling knowledge through ontologies as COMANTO [18], SOPRANO [19] and SSH [20]. On the other hand, there are studies that emphasize classification algorithms for reasoning about knowledge already represented: 1) tree decisions [15, 18]; 2) K-Means algorithm [21].

COMANTO is one of the examples mentioned above of modelling of knowledge using ontologies. COMANTO authors focused their attention on creating a generic ontology based in a localization context; they try to describe a general context of interrelations between concepts in a nonspecific situation in pervasive and distributed environments. Among the main classes in this ontology, the class “Person” is the central class. In addition, there are properties that make possible to incorporate the relations to the context like “friendOf” to represent the associations “Person” to “Person”. There are other important classes like “Place“ that represents the abstraction of a physic spatial place, “Activity”, “Agenda”, “Physical Object”, “Sensor” and “Preferences. Finally, the class “Time” represents the crucial information related with the actual time, acting as timestamp for that context information that can change over time.

Different examples show how AAL systems provide useful information in real time. Many systems implement web services because of friendliness of the web interfaces for most users. The web services are very useful because the involved technologies (HTTP, XML) are independent of programming languages, platforms and operational systems. For example, [10] makes possible do the tracking of an old person’s route through a web site that sends alerts in case of distancing. On the other hand, in [17], authors implement a solution that provides the exact position of the old person in Google Maps using a social network and shows the user location through a radar when the map information is lost or disabled.

In our approach, we create a system that combines functionalities of route monitoring and fall detection through sensors built-in smartphones to sends alerts to carivegers in case of emergency. System is composed by two main components of the system (the Android application *CareofMe* and the web service *SafeRoute*). These two components work in a combined way and merge information from sensors embedded in mobiles devices for tracking elderly people. It is also presented as future work, a group of challenges to implement in our system to improve the quality of life of older people in outdoor environments.

3 SafeRoute

The proposed system (Fig. 1) is composed by two components: the Android application *CareofMe* and the web system *SafeRoute*.

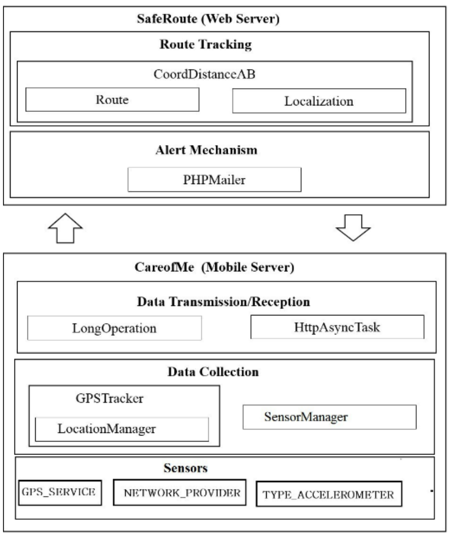

Fig. 1. System Architecture

The *CareofMe* app works as follows; for both functionalities, firstly, the monitored user chooses a predetermined route to follow (Fig. 2). *CareofMe* application uses a combination of *GPS* and Wifi technologies to show the current user localization in an open-air environment. We decide to include the use of the Wifi service because is a service built-in inside smartphones that can be used like support operation in case of fails in the *GPS* service and increases the saving of energy. In the case of route monitoring (Fig. 3), *GPSTracker* is the responsible class for managing position dates through the class *LocationManager*, belonging to the API responsible for working with maps in mobile environments: GoogleMap Android v2. For fall detections, we used the accelerometer sensor to measure the coordinates (x, y, z) of the smartphone position and detect abrupt changes to indicate a fall. *SensorManager* is the Android class responsible to manipulate the values of the accelerometer sensor. In case of fall detection, the app will send the geo-localization coordinates to the web server if detect a fall and will ask to user if he need some kind of help. (Fig. 4.)

On the other hand, *SafeRoute* system was conceived as a web service for the constantly monitoring of the user's status and the sending of alerts to carivegers and the elderly person in case of distancing or fall. The Route Tracking functionality uses the *CoordDistanceAB* class to calculate distance between user locations received in real-time (*Localization*) and the locations of the predefined route (Route). *PHPMailer* sends an email to the cariveger with the exactly position of the elderly person in case of distancing.

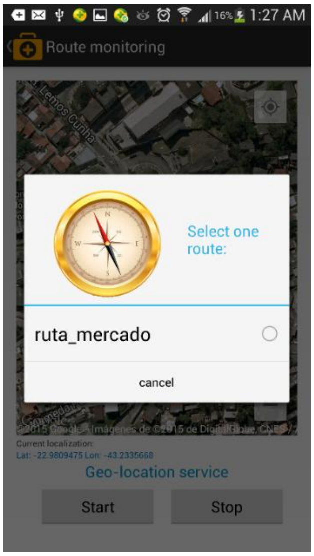

Fig. 2. Predefined route selection

Fig. 3. Route monitoring

Fig. 4. Fall detection

On the other hand, it was conceived the web system *SafeRoute* (Fig. 5) as a web service for the constantly monitoring of the user's position and the sending of alerts to the old person in case of distancing or fall. The reasons for using web technology were some of the advantages mentioned above, for instance, the non-dependence of any programming language to access this type of system.

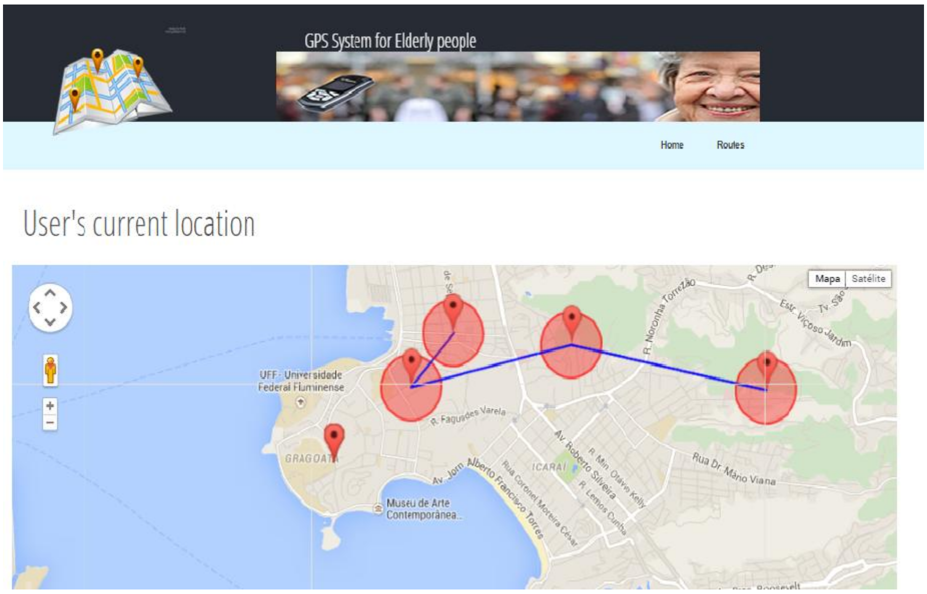

Fig. 4. *SafeRoute*

SafeRoute was developed using PHP 5.0 and Javascript, the predetermined routes of the users and the localization data were stored in a MySQL database. In addition, the

adfa, p. 6, 2011.

system use the GoogleMap v3 and Google Maps JavaScript API v3 APIs. These APIs allow the use of a group of functionalities like the drawn of polylines for the routes and circles to indicate the radius of allowed distance of distancing in each point.

4 Conclusions and future work

The use of mobile devices is increasing gradually, making these devices a new source for developing solutions in various technologies. In AmI, AAL is gaining more prominence by providing mobile response systems, fall detection systems or video surveillance systems that can supply security to the elderly and to their caregivers.

The potentialities of the geo-localization technologies built-on in smartphones has been used in the last years for tracking elderly people in open-air environments.

In this paper, we presented the AAL system *SafeRoute*, wich combines two geo-locations based functionalities for the care of elderly people: route monitoring and fall detections.

We believe that our system can improve its operations in many aspects and we identified a group of future works. For instance, we think that mechanism of feedback proposed is considered poor because only reported to the old person about the distance of the predetermined route and not report to old people's caregivers about the position of the elderly person in case of distancing. We also find problems in the web interface of *SafeRoute* because it´s not enough intuitive considering all the potentialities of the web design (Example: The system could propose path to follow in case of distance of the old person). We also believe that it is possible using other sensors built-in smartphones to create new functionalities in the system, ambient temperature, relative humidity, light and proximity sensors could be used to create intuitive mobile interfaces that respond to user necessities automatically.

In response to the deficiencies detected in the original version of *SafeRoute*, we propose some improvements for new versions of our system, such as the improvement of the *CareofMe* and *SafeRoute* system's feedback.

The proposed solution has demonstrated to be useful for the elderly care in open-air environments, enabling effective monitoring mechanism for caregivers. Our work demonstrated the validity of combining a group of well-recognized technologies in the AAL context through the development of a simple application.

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