Mobile follow-up system for elderly and disabled people

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***Abstract*— This paper focuses on elderly and disabled people who live alone and run certain risks, such as frequently falling, entering dangerous places within the house (the second floor, the attic, the basement) or being unable to handle certain problems. Each person has particular needs which must be considered. It is even necessary to foresee that they may not face difficulties only in their houses, but also when they go shopping or for a walk. In such occasions, they may lose their sense of direction. Mobile technologies can provide solutions to these problems, generating a non-invasive control system which may be monitored by family members and friends. Using an app with such characteristics helps the person feel free and safe at the same time. This paper presents a mobile app prototype for planned care and follow-up of elderly or disabled people. The app uses the sensors in devices such as GPSs, accelerometers, barometers, etc, and enables a non-invasive control and follow-up system. The Android-developed app can be easily installed on a wide variety of devices, and facilitate its portability towards android based wearable platforms such us Wear OS and Android Wear. This makes the use of this app more transparent, safer, and less invasive.**

***Keywords*—m-health, health-care, mobile, tracking, sensors**

I. Introduction

"Aging inevitably results in the reduction of sensory acuity... less resistance and muscular strength, disadvantages in mobility, diminution of mental clarity and alterations in stability... The shocking acceleration in the number of chronic patients together with the increase in costs of public health services and the probable shortage of direct care workers... show the need for a radical change in the process of caring for the elderly "[1].

In many cases, technological solutions can be implemented that allow even in the home environment to take information and generate alerts when difficulties arise, allowing person's relatives or close contacts to assist them. For this, there are different strategies. There are several articles that consider monitoring by means of smart homes where the sensors are integrated into the environment (concept of ubiquity). This is a solution that can be low cost, depending on the way it is implemented, but it does not cover a range of needs that can happen outside the range of coverage (environment prepared for monitoring), a situation that could occur with people who can leave their homes and have difficulties outside the range of coverage where those sensors were embedded. That is why it generates a great advantage to think of wearable devices, that the person does not feel any difficulties because they are taking with them additional elements that they notice are monitoring, but that at the same time can be monitored beyond the environment where they are. In this sense smartwatches are an efficient solution. The essential advantage of the wearable elements is that they allow monitoring without being invasive, being able to monitor the person at any time and place.

"The use of "wearable" technologies has increased remarkably in recent years, allowing us to measure different physiological, environmental and movement variables, through devices attached to the wrist and/or the user's clothes... Although most of the use of this type of technology was used in sport, many applications could be implemented in the diagnosis and treatment of neurological, cardiovascular and pulmonary diseases such as: asthma, seizures, hypertension and arrhythmias. For its part, motion sensing can help in the prevention of falls, rehabilitation, control of home automation systems, etc. "[2].

This article is structured as follows; in section 2, existing works in this area are presented, in section 3 the proposed application is addressed explaining its functionalities and details of the development carried out. Section 4 discuss some issues about implementing the application and finally in section 5, the conclusions and future works are presented.

II. Existing Works

The first results in this area were planned, for example, for the manual upload of health data to have monitoring information by means of a cell phone that allows uploading the data to the cloud, which can be consulted by a doctor [3]. Other projects expect to have medical equipment such as a tensiometer that has bluetooth and in this way, all measurements performed can be taken from an application made in android and thus have a medical record [4].

More complex systems include the taking of automatic values through the monitoring of the person. For example, the article [5] presents a proposal for tracking the position of patients within the hospital through watches with RFID [6]. Some jobs perform a dedicated hardware that can be connected to an android smartphone and take sensed information such as [7] blood pressure, temperature, electrocardiogram and blood oxygen level. Other works already use a dedicated hardware that autonomously connects via Wi-Fi and uploads data to the internet of sensed information (for example in article [8]: heart rate and temperature).

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Even to detect falls there are works that mention smart tiles to promote smart floors where each tile has a set of sensors that allow detecting the movements that will be made on it. The cost associated with this proposal is really high and implies the realization of an enclosed environment in which the person could be monitored [9].

There are more specific applications such as a medicine alarm, which can be considered with different complexity. In some cases, a hardware that allows to recognize whether or not a pill was taken, is included. For that, some works propose extremely complex solutions such as the article [10] that includes a bottle of pills, an electronic scale that weighs with sufficient precision the bottle which has to be taken by a camera of a computer to obtain the value of the weight to indicate if the pill was taken or not. This is too difficult to be used.

Other systems do not foresee embedding sensors in the environment but rather people can carry with them those sensors incorporated into wearable elements. This is the focus of the present article. As an example, we consider the work [11] that suggests a wearable household system to recognize emotions based on physiological signals. While the works [12], [13], raise the idea of giving notifications to relatives about the location of the person in an emergency.

III. Proposed Application

The speed with which technology leaves in the past the existence of what was once impossible to realize, is an aspect that no longer surprises; attention begins to focus on the creative ideas that arise from the plurality of tools that generate present and build future.

The application built, which we call Vigia, is a piece of software that works in solidarity with mobile devices for the purpose of monitoring the activities of people who require constant observation and who cannot receive the necessary attention. By collecting data that is generated as the user manages during the day, those who ensure their safety receive information about the activities, allowing them to know if the bearer of the device is in a safe area, if he moves into an area whose permanence should be restricted to a certain period of time, if he has remained immobile, he has fallen, among other issues related to motor skills.

A. Aplication Architecture

Vigía is developed in Java for its execution on Android mobile devices due to issues including the maturity of the programming language, stability, availability of resources and documentation, to market penetration that the operating system has, the maintainability of the source code and the simplicity with regard to portability for its operation on other hardware.

At this moment, the construction is in an initial stage and the use of telephone devices as a basis for prototyping was very appropriate for everything presenting a priori. In later stages, the objective will be to transfer Vigía for using it in smartwaches and/or other wearable devices, offering the user greater freedom and comfort.

The application has been developed in five layers, which are presented in Fig. 1 and described below:

1. User interface layer: it combines the xml files in which the components are represented and against which the user interacts, and the files of the controlling classes that provide support for the execution of validations and calls to the business layer that it is immediately after.
2. Business layer: it groups together at the logical level all the classes in charge of the operations, delegating responsibilities and encapsulating the algorithm in order to respect the premises of the SOLID concept [14]. SOLID stands for Single responsibility, Open/closed, Liskov [15] substitution, Interface segregation and Dependency inversion which are five software design principles. Following this principles software will be more flexible and maintainable making easy future changes and adaptations. It´s use is fundamental on this prototype because it will make easier migrating to wearable technologies. Principally, the classes identified as Managers are highlighted, which mostly arbitrate the use of one functionality of the mobile device; while the GpsManager class involves all aspects related to satellite global positioning, AccelerometerManager operates on everything related to the accelerometer. The helpers that gather assistance functions are also located in this layer.
3. Mapper layer: is responsible for translating the entities of the business model into generic structures that can be consumed by the data access layer; in this way it is possible to change the implementation of this last layer without altering the business layer even when, in the case of extreme factorization, the mapping layer has to be overwritten.
4. Data access layer: At the last level is the data access algorithm, responsible for the persistence and recovery of the data that feed the system. At present, the preferences file is being used as a base, although the use of SQLite seems to be the most appropriate option because it offers better mechanisms to operate on the data.

Crosswise to all the layers are the business entities, classes of the POJO type (Plain Old Java Object) that transport data from the GUI layer (controllers) to the Mapper layer.

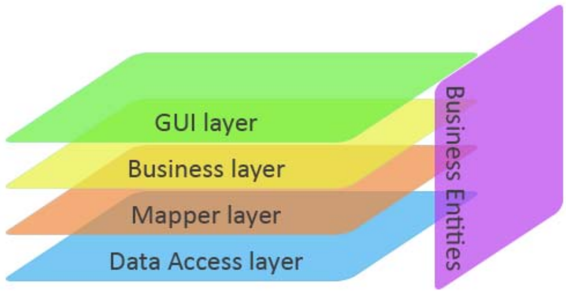

Fig. 1. Application layers

Fig. 2 shows the configuration screen where you can set the basic information necessary for the functioning of the application. It should be emphasised that for each user of the application it is possible that there are functionalities that you do not want to use, in this way depending on the particular needs of each user, certain functionalities can be enabled or not.

The modules of the application are described below.

B. *Functionalities*

In the configuration screen presented in Fig. 2, 6 options can be observed which are explained below.

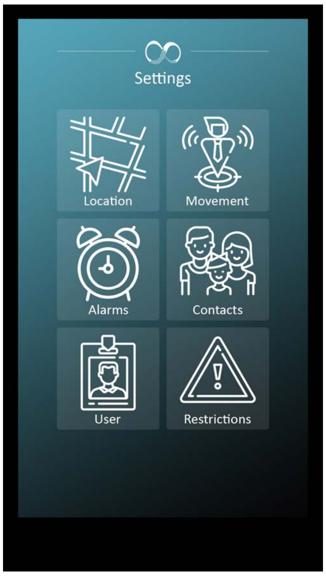

Fig. 2. Configuration screen

- User: This section is reserved to include information about the user of the device. This is important for the cases in which the person is not able to provide information about their identity or conditions.
- Contacts: The solution requires that at least one trusted contact be configured to receive notifications about the different activities, through different configurable means. In this moment it is possible to define as a communication channel the electronic mail or sms, although in later releases it will be possible to use other types of media such as social networks. The list of possible contacts is retrieved from the mobile device's contact list, which is why there is no need to manually entry any data. When defining trusted contacts, it is possible to indicate to the system which of them will be part of the list of quick access contacts, which will appear on the main screen so that the Vigia user can call if necessary.
- Location: This is one of the most important sections given that here the security zone is defined, an area in which the user can remain unlimited amount of time without triggering any alarm (usually the home or residence where it is located) , a control area that is an area in which it is possible that the Vigía bearer can perform some activity during a limited period of time (for example, a convenience store), and the maximum time of permanence before giving notice to the trusted contacts about the excess of permanence in the control zone. All the transitions between the zones trigger informative messages, which bring together a total of four:
  - Entrance to the control area, from the security zone
  - Entrance to a restricted area
  - Entrance to the control area, from the restricted area
  - Entrance to the security zone

It is possible to disable this functionality if it is not of interest.

Fig. 3 shows the screen where the zone of permanence is configured, the operational range that makes up the safe zone (which can be configured as seen in Fig. 4) and the maximum distance that is taken as a control zone.

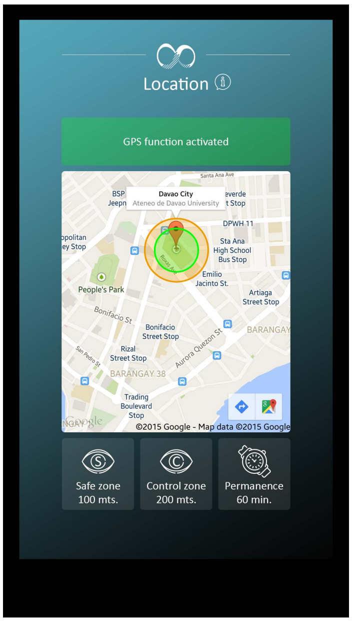

Fig. 3. Location screen

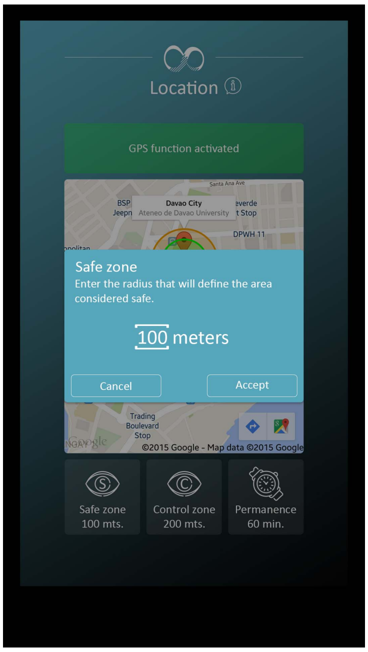

Fig. 4. Safe zone configuration

- Movement: Regardless of geo-positioning, it is possible to maintain the monitoring of the user's activities through the accelerometer, which is crucial when for some reason it is not possible to use satellite positioning; in addition, it is valid to remember that geo-positioning does not provide information if there is no traslation. The functioning is based on the definition of a time limit from which the system, if it does not register movement, triggers an alert to trusted contacts to take the actions they consider appropriate. To avoid false positives, the section includes the option to define time ranges in which it is plausible that the user is at rest. As it occurs with the location functionality, it is also possible to deactivate this feature. Future releases will include mechanisms that detect falls, in order to offer a more finished scenario of the situation of the Vigia bearer.

- Alarms: This module goes beyond the basic functionalities offered by the operating system by incorporating the use of NFC (near field communication) tags as a mechanism to validate that the activity for which the alarm was configured was performed. Imagine the scenario in which a person requires medication and, for some type of eventual distraction, he forgot to take the medication once the reminder was deactivated; depending on the treatment, this could be extremely harmful. Being able to configure an NFC tag [16] that can be attached to the medication container with the order to stop the alarm when the phone is close enough, for which a conscious act is required, could minimize the forgetting of the intake. This is one of several uses that the alarm system with NFC configurable set off can receive. Vigia also shows notification on the main screen to remind the user when he should take the next pill (see Fig. 5).

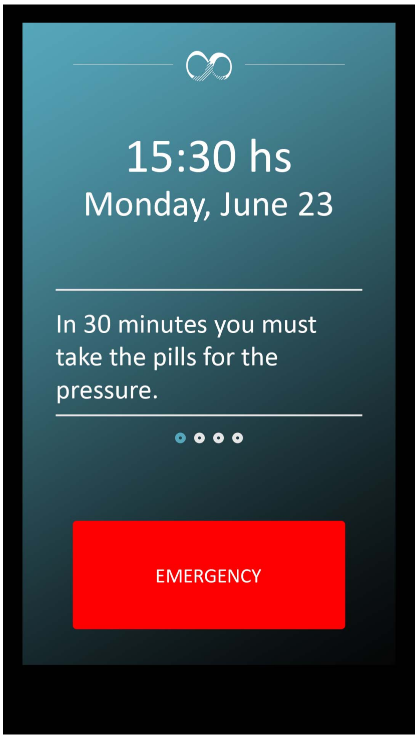

Fig. 5. Main screen with reminders and emergency button

- Restrictions: There are certain places in the house that can be dangerous for elderly or people with reduced mobility, for example, a second floor, a terrace or a basement. However, many times people also access these areas with the risk that this entails. The application through the use of the barometer can monitor when the person is changing floor and give an alert warning that there is a risk and can also notify the contacts if an inappropriate area is accessed.

Each of these functionalities can be disabled if they are not required. This allows that according to the needs of each person some actions can be monitored and not others. Once the different options are configured, it is possible to make use of the desired functionalities for which they have been developed.

IV. Implementation

At this moment, the application is functional and on testing stage. This first prototype was developed for Android phones and it can be seen how effectively the sending of alerts helps family members to be able to assist these people. In some cases, simply call to speak with the Vigia user and confirm whether he is fine or not. Migrating the application to a smartwatch will be an important progress for not having to depend on that person carrying the cell phone with them at all times and places, something that is common in new generations but not in elderly people, being these one the main potential users of the application. Wear OS is an operating system based on Android for smartwatch, which is why it will not be difficult migrating the application for these devices. On the other hand, the smartwatch can be visually identical to the more traditional watches in Fig. 6, the LG Watch W7 is shown as an example, which even has the mechanical hands. A wide variety of watches has a small screen for displaying notices and alerts, but also exists the possibility that the person, who uses it, sees it and feels like a traditional watch, which is essential for older adults unaccustomed to the use of TIC. For applications where they do not generate alerts or specific notices for the user, which only upload monitoring information later displayed from the web or send alarms to relatives, it would be a significant solution not showing the presence of technology in the watch.

Fig. 6. LG Watch W7 with Wear OS operating system and mechanical hands

However this proposal can also be implemented for people who have a disability and are more familiar with ICT. In this case, there are several watches with operating system Wear OS, many of them also show a traditional watch design on their screens (see Fig. 7, taken from [17]).

Fig. 7. Wear OS smartwatches

An Android application that can be used in any Smartphone will be more massively used, since yet smartwatches are not so popular resulting in an additional cost for Vigia users. But of course, it is easier to wear a watch on the wrist that has the necessary applications integrated than carrying the cell phone at all times so that monitoring can occur. Vígia will offer both available versions.

V. CONCLUSIONS AND FUTURE WORK

Having a tracking system for taking care of people, helped by mobile technologies, is a great advantage. This system allows, with a low cost, monitoring the location and status of a person sending alerts only in case that any anomaly or possible problem is detected.

The large number of sensors that mobile devices incorporate, facilitate monitoring and centralize in a single equipment all the necessary things, including connectivity for sending alerts.

Development was carried out in such a way that the application can easily be migrated to wearable technologies when they became mature enough and became massively used, which will also bring a reduction in equipment costs.

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