Adaptive Augmented Reality in Mobile Applications for Helping People with Mild Intellectual Disability in Ecuador

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Abstract: Adaptive Augmented Reality (A^2R) is an emerging technology that can support users in their daily life with useful information for their activities, which are really adapted to the user's characteristics, as well as the environment and the context where the activities are taking place. In Ecuador, mild intellectual disability is being considered as part of the government policies, for this reason we considered developing an app to help locate people with mild intellectual disability who at one time may feel lost and may not know how to return home. So the app allows caregivers to always know where their dependents are every time. We adopted A^2R approach for developing this app so we had to model both user needs and their interests. Apart from User Model, we will also show the other A^2R models required.

1 INTRODUCTION

The last census was held in Ecuador in 2010. According to its forecasts, the life expectancy of the population in Ecuador has been growing, and it is expected that in 2050 it will be 80.5 years old on average[1], a little higher for women, with 83.5 years, compared to 77.6 years for men.

"The range of possible intellectual disability, based on both intellectual and social criteria, is commonly divided into four levels: mild, moderate, severe and profound. The level of intellectual disability is the main factor that determines the degree of outside assistance the person with intellectual disability needs to live a comfortable and productive life".[2].

As can be seen in table 1, in Ecuador, people with intellectual disabilities according to census of INEC, 2010 [3] were 192.496, an 1,33% in relation to the total number of 14.483.499 Ecuadorians.

In addition, table 2 outlines the population belonging to each level of disability in 2010. As can be observed, the largest group of people with intellectual disabilities corresponds to that of mild intellectual disabilities.

Table 1: People with intellectual disabilities in 2010. Source: Census of INEC 2010.

People	**Number of People**	**Percentage**
With intellectual disabilities	192496	1,33 %
Without intellectual disabilities	14291003	98,67%
Total	14483499	100%

Table 2: People with intellectual disabilities in 2010. Source: Census of INEC 2010.

Type of intellectual disability	**People**	**Percentage**
Mild intellectual disability	163622	85 %
Moderate intellectual disabilities	19250	10%
Severe intellectual Disability	7700	4%
Profound Intellectual Disability	1925	1%
Total	192496	100%

Considering these data, and observing the projec-

[1]http://www.inec.gob.ec/proyecciones_poblacionales/presentacion.pdf

[2]https://www.dads.state.tx.us/news_info/publications/brochures/intellecutaldisabilitybrochure.html

[3]http://www.inec.gob.ec/cpv/index.php?option=com_content&view=article&id=232&Itemid=128&lang=es

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tion in life expectancy of Ecuadorian population presented before, we believe that our country will face an increasing number of population with mild intellectual disabilities in the coming years. This paper describes a project that aims at improving the quality of life of people with mild intellectual disability in Ecuador.

Nowadays, mobile and ubiquitous computing, supported by tools such as maps and augmented reality can enhance the traditional ways in which disabled people and their caregivers cope with their situation.

Adaptive Augmented Reality (A^2R) is an emergent technology that offers users new possibilities to interact with their environment. This kind of systems gives answers to the user's needs and interests in a particular context in real time. A^2R provides the ability to create applications that help disabled people because these systems present useful information overlapping reality which can be adjusted to their interests and individual characteristics (Vera et al., 2014).

In this paper, it is presented the development of an app, which is an ubiquitous and mobile application that allows dependents to come back home and allows caregivers to always know where their dependents are. The application monitors the location of person with mild intellectual disabilities and allows caregivers to be informed.

We are particularly interested in the adaptibility of augmented reality. In this project we study what happens when an augmented reality app is used by elderly people. Consequently this app is developed observing this group. A research question has been raised: What will happen when augmented reality is used by elderly people?

The paper is organized as follows. Section II introduces all characteristics of the implementation based on the android mobile platform. In Section III a usability analysis is presented and finally, Section IV provides conclusions.“

2 APP DEVELOPMENT

”Mobile Return” is an app designed to comply with the following objectives:

1. Allow one or more caregivers to know where the dependent is.
2. Help people with mild intellectual disabilities to return to their homes.

The design of an application with user adapted interaction should be driven by the following sources of knowledge (Fischer, 2001):

- knowledge about the communication agent. For a simple definition of the users we define stereotypes. For this app, there are two types of users:
  - Caregivers: they know how to use a computing device such as computer, phone, watch or other, and they are interested in being informed about the whereabouts of the people they care.
  - Dependents: they are not required to have previous knowledge of the use of a computer, only being required to have and wear a mobile device.
- Knowledge about the problem domain: for this app we consider that:
  - The user can move within the area of a circle around a safe place. This radius is variable and can be adjusted.
  - The return route to the safe place will depend on the sites known by the dependent.
  - The dependent may have more than one caregiver. Each of them has a priority for alerts.
  - The caregivers will define both the radius of the permitted area as well as the places known by the dependent or user.
- Knowledge about communication process: the way in which the information structures that control communication is accessible and changeable by the user. In this application:
  - The user interface comprises two alternatives views: Map and Augmented Reality. In both views the return path is shown.
  - The moment in which a dependent leaves the permissible area, the system should warn his/her caregivers by sending a message with the information on where the dependent is.
  - The caregiver can see where the person is through any device such as tablet, computer or smart phone.

2.1 Architecture

Considering both the objectives of the app and its restrictions, the first step is to define its architectural model. We applied the MVC [4] pattern as it is presented in figure 1.

The components of the MVC pattern in this app are the following:

- *View*, as the user's position continuously changes, the user interface logic needs to update frequently the visualized return route and the visualized location of the user. This information is presented

[4]Model View Controller

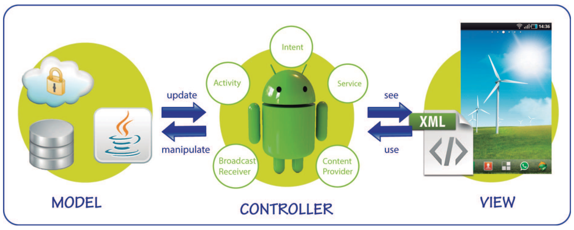

Figure 1: MVC design pattern for app ”Mobile Return”.

both in the map view and in the augmented reality view. The GPS needs to be activated in the dependent's device in order to track the user's location. Normally, the GPS allows to know the position of the user with a possible error of some meters (Van Diggelen, 2009).

- *Controller*, it manages user's events and sends raw data to the model for analysis. It also collects the information provided by caregivers and sends it to the model. In addition, it receives the information required to update the view from the model.
- *Model*, it comprises the business logic and the data model. Every time the app receives from the GPS a new position of the user, it works out the return route. On the other hand, if the user gets out of the allowed radius, the app warns the caregivers and sends messages with the information required to locate the dependent. This component implements the following models: User, Adaptation, Context, Interaction, Content and Environment.

A further decomposition of the MVC components can be found in figure 2. Modules or libraries with specific features were designed so that they can be reused in subsequent projects.

2.2 Models Proposed for the A^2R app

Besides the architecture, the proposal for A^2R models extends previous works in web applications (Brusilovsky, 2001), (Brusilovsky and Millán, 2007), (Heckmann, 2006) with information that becomes relevant when considering A^2R systems (Tenemaza et al., 2015b), (Tenemaza et al., 2015a). Here a description of each model proposed is described.

- **User Model.** In terms of the personal and cognitive data represented, the user model is similar to that of web systems. However, the user model in A^2R can go far beyond, because the user's physical features (for example their stride length or walking mean velocity) and behaviour (for example their walking route) can also be taken into account and analysed in real-time.

  In this app, the User Model also included user interests, represented as the important places for the user, such as his/her home, and familiar landmarks.
- **Context Model.** This model represents a snapshot taken from the situation in which a user is using the system. It is different from a traditional context model because it takes into account the real environment.

  In this App, the Context Model observes the current user position with respect to his/her home, considering whether the user came out of the allowed area within a specified range. This information is obtained from the GPS and compass.
- **Interaction Model.** This model represents the evolution of the user-system-environment interaction. What distinguishes it from the context model is that the context is an instant snapshot, while the interaction model registers the history of interactions and the evolution in the context. It serves as a data source for enriching the user's model.

  In this app, the Interaction Model registers the trajectory that the user has followed. Based on this information, it is possible to infer patterns of movement of the user. This data will be useful to update the user model with new places known by the user.
- **Environment Model.** This model represents attributes of objects, persons, places, and all other aspects related to the real physical environment in which the user utilizes the system. In this app, the Environment Model takes from Google Cloud the names of streets, buildings, parks, special places.
- **Content Model**, specific information about each place that can be displayed to the user in the maps and A2R.
- **Adaptation Model.** The system should adapt content, navigation and presentation. The proposed model defines how to adapt output data coming from the content model taking into account interests and other user's characteristics represented in the user model. Moreover, it will consider defined restrictions in the environmental model and, if necessary, data from the interaction model. Also, the adaptation should take into consideration the current context. The resulting information should be presented in a user-friendly, multimodal form, without forgetting the importance of the human-computer interface, both for mobile phones and other A^2R devices (Heufemann et al., 2013).

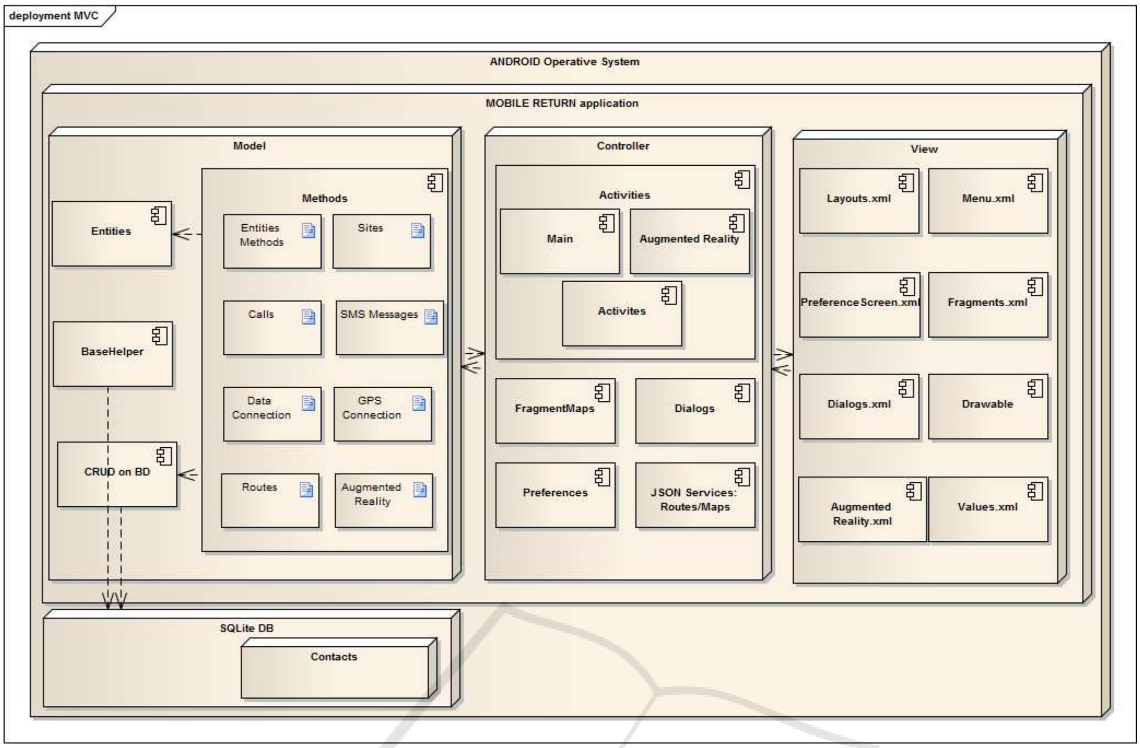

Figure 2: Architecture for app "Mobile Return".

2.3 Analysis the User's Departure Allowed Area

Models and architecture must be complemented with control algorithms. the algorithm analyzes the area of motion enabled user. It receives the distance of user's home to the current position of user, This distance is calculated by the formule of Haversine [5]. This formule define the distance between two points in the terrestrial surface by using latitude and longitude.

If the distance calculated from position of device is greater than the area of movement allowed, the app sends alerts through messages and calls Caregivers.

The distance is calculated at the moment updates GPS updates, then compares with the radius of movement allowed.

This method sends messages and calls to the caregivers.

2.4 Analysis of Adaptive Augmented Reality

To complement the information required for the development of this type of app. The use of augmented reality as another interface is proposed. We used BeyondAr and objects of augmented Reality. These objects were designed in an activity.xml as observed in Figure 2.

In the Augmented Reality a compass, the reality and information of each places known are shown.

The objective of augmented Reality is to offer the user an other option to return home. The user needs to observe the compass to see the orientation in the camera. In order to recognize each of the defined sites.

The adaptability was observed in the definition of the route because the user will see a route according to the places known. The calculation of the path is not a straight line. The current position of the user is analysed by the route defining.

Although, the GPS tracker only works outdoors. The GPS tracker used determines the position and orientation of the user. Aditionally, the position data consists of two-dimensional coordinates (the altitudinal measurement is very imprecise) and an orientation angle from a magnetic compass (Reicher et al., 2004). This information and the position of sites Known are sent to the module of Augmented Reality.

2.5 Results

Once we have analised how the app was built. Analysis of results is presented. The app runs in a context

[5]http://www.genbetadev.com/cnet/como-calcular-la-distancia-entre-dos-puntos-geograficos-en-c-formula-de-haversine

of verification of acceptance criteria specified by each user. This specifications were defined in the user stories in the Product backlog in our agil Methodology for developing this app. Two situations are described:

1. Data input to initialise the application. There are three groups of data:
   - Personal data of Caregiver and data of user. This app gets the data of caregiver directly of the phone that he will use, or, if he does not have register his information in his device, It will be necessary to write this information.
   - Other information that the caregiver needs to records is the places known by the user. this information can be recorded directly from the map. In this operation, the app captures the longitude and latitude of each place choosen, Observed in Figure 3.
   - The Caregiver needs to register the radius. It specifies the area move allowed. The origin point for this radius is the user's home. It is observed in Figure 3, 6.
2. App care to the user:
   - When the user comes out of allowed area, the caregiver will receive calls and messages. The message contains a URL with the position of the person. The position can be viewed by using a web browser or the Google maps application of this device. To observed in Figures 4, 5.
   - Return path. The user can see the return path both on the map and augmented reality, it may be observed in Figure 7. The return path for the observed person, considers the known points by the user.
   - Augmented Reality The user has of other option for return his home. Known places are shown and the distance to your home is specified through Augmented reality. This result are show in the Figure 8.

Figure 3: Configuration App.

Figure 4: Emergency message received by managers.

3 USABILITY ANALISYS

Once the results were presented, it is necessary to consider the usability of the application, as this is one of the main quality characteristics of a system and the one more closely related to the acceptability of the system. Analysing usability required measuring effectiveness (completion task, number of errors), efficiency (time taken to complete the task), satisfaction (users's, rating of experiencies) and learnability (amount of instruction/study required). A successful design requires a balancing of all the different aspects (usability, functionality, aesthetics etc) (Ian et al., 2011).

For the usability evaluation, the sample taken was 10 elderly people. After interaction with the app they and their caregivers answered a questionnaire. Figure 9 summarizes the results.

The questions applied to the users are listed below in the Tables 3, 4.

For the conception, planning and implementation of this system it was necessary to take into account both people with mild mental disabilities and Care-

Table 3: User survey.

Question number	Question
1	The application works correctly? (Yes/not)
2	The app works as expected? (Yes/not)
3	The route back to your home is understood on the map? (yes/not)
4	You needed assistance to use the system? (Yes/not)
5	Augmented Reality seems useful ? (Yes/not)
6	Would you recommend this application? (Yes/not)
7	The map application helps to return to your place of residence when you doubted about its location? (Yes/not)
8	Additional comments about the application

Table 4: Responsible survey.

Question number	Question
1	You received SMS notifications that were sent by the app? (Yes/not)
2	When the notification was received, it was easy to identify on your mobile device the person's location?
3	The app presents any malfunction in the user's device of which you are a caregiver? (Yes/not)
4	The app works as expected? (yes/not)
5	Did you have difficulties learning this app? (Yes/not)
6	In the configuration of the application, what was the biggest difficulty you had (enter user data; enter caregiver data; enter the radius of movement; select the home site on the map; select known sites on the map; data entry interval alerts)?
7	You required assistance to use the system? (Yes/not)
8	The media used to communicate that a user requires help were clear? (Yes/not)
9	Would you recommend this application? (Yes/not)
10	Does this application help to communicate easily with caregivers at the time of alert? (Yes/not)
11	Additional comments about the application

givers. We proposed two complementary interfaces, the Map and the Adaptive Augmented reality, which were useful for both caregivers and users.

The system was well received by the caregivers, with a 82.5% of positive responses, while the acceptance rate of elderly users is 81% (Eden, 2005).

The interface for caregivers was found to be easy to learn and use, and it did not require typing a lot of data. The caregivers had two interfaces to enter information. The personal information is registered from the phone and the information of sites known by the dependent is obtained from the map. The app was very effective to send messages to and call the caregivers, and caregivers could easily find the dependents.

The dependents did not have to write any data. But for these people, it was more difficult to understand the maps and the augmented reality, specially the compass. Learning to use the app required more time because many dependents did not use smartphones. Some dependents forgot to activate their GPS. This was the principal error. When the caregiver set the GPS for them, the system worked very well. Other error was related to the Internet connection. This app needs both for normal functionning.

The return path on the map is clearly marked with a color for easy identification and it is updated as the user moves in both deployment environments. Caregivers were very quickly interpreting the information, while the dependents had more difficulty to return home with only the maps and the augmented reality.

Regarding user satisfaction, the app was found very pleasant for the caregivers and less pleasant for the dependents. 100% of the caregivers claim they would use it, while 83% of dependents are satisfied with the application.

Globaly, the results show that the application meets the expectations.

Figure 5: Emergency call received by Caregivers.

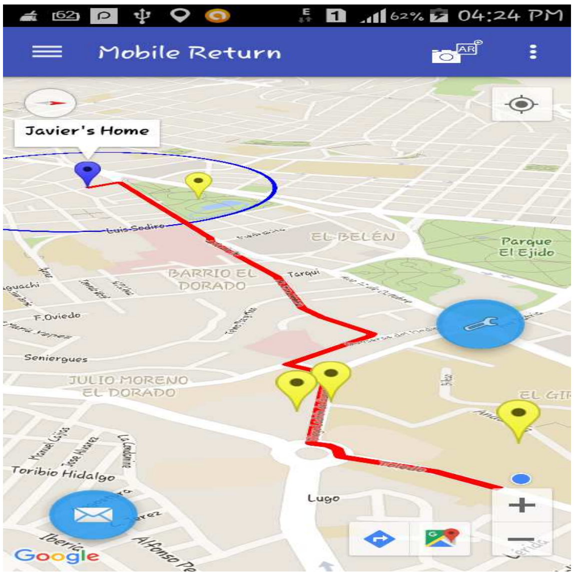

Figure 7: Return path.

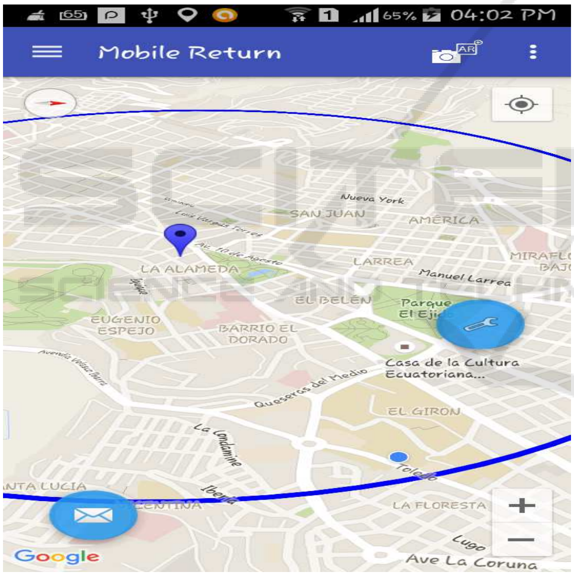

Figure 6: Area allowed.

Figure 8: Augmented Reality.

4 CONCLUSIONS

An app was designed for people with mild intellectual disabilities in Ecuador. The government policies in Ecuador are giving priority to elderly and disabled people, and this application is a step forward in this direction.

Usability in these systems is a key point both for entering data and displaying information for the user. Data entry, if any, should be easy and simple, and the display of results should be clear and adjusted to this type of users. Augmented Reality has proved to be a useful alternative to provide information, but elderly and disabled people need to get familiar with this new technology.

Based on our results, we have confirmed that the interaction model is very useful to identify potential routes preferred by the user. Based on this information we can get to know the movement patterns of the user in order to help locate users.

For the future, we will complete the implementation of the Mobile Return app considering further analysis of user interests and behavior patterns.

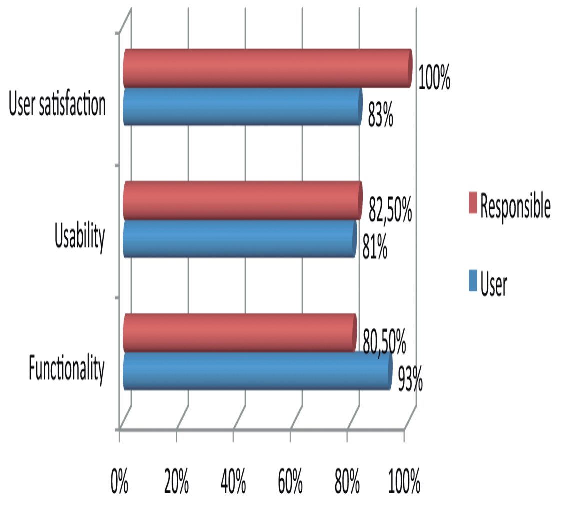

Figure 9: Results of processing the survey.

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