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Enriched elderly virtual profiles by means of a multidimensional integrated assessment platform

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Abstract

The pressure over Healthcare systems is increasing in most developed countries. The generalized aging of the population is one of the main causes. This situation is even worse in underdeveloped, sparsely populated regions like Extremadura in Spain or Alentejo in Portugal. The authors propose to use the Situational-Context, a technique to seamlessly adapt Internet of Things systems to the needs and preferences of their users, for virtually modeling the elderly. These models could be used to enhance the elderly experience when using those kind of systems without raising the need for technical skills or the costs of implementing such systems by the regional healthcare systems. In this paper, the integration of a multidimensional integrated assessment platform with such virtual profiles is presented. The assessment platform provides and additional source of information for the virtual profiles that is used to better adapt existing systems to the elders needs.

Keywords: Situational-Context; Multidimensional integrated assessment platform; Virtual Profiles; Mobile Computing; Internet of Things.

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1. Introduction

The aging of the population is a confirmed fact in most developed countries. Over 20% of people in developed countries are elderly (65 or more years old), and the growth of this age group means that it is likely to reach some 26% of the population of these countries in 2030 [1].

This trend is even more acute on rural European regions like Extremadura in Spain or Alentejo in Portugal. These regions have a lower population density than the average of the European Union (EU), ranging from 14,8 people per km^2 on Baixo Alentejo and 31,9 people per km^2 on Badajoz compared to the 116,6 people per km^2 averaged on the EU. And even lower than the averaged population density of the rural regions of the EU, averaged on 48,4 people per km^2. Additionally, these regions keep losing its young population, due to migration to more socioeconomically developed regions, which is increasing the aging ratio.

As a result of these conditions, these regions have a higher than average aged population, which can be understood as a signal of development. However, the reality is that these are economically disadvantaged regions with an especially fragile cultural and socioeconomic context. Literacy index is lower than average in these regions and, due to the low population density and migration of the young population to richer regions, the elders frequently live alone. Therefore, public health policies, that are already suffering to cover the aging population in more developed regions, are stretched to their limits in these regions.

In recent years, healthcare companies and researchers have made significant efforts to improve the quality of life of the elders. Particularly, from a technological point of view, areas like Ambient Intelligence and e-Healthcare are trying to bring technological advances to eldercare. Works like [2] [3], propose different solutions that will result in an improved quality of life of elders with some specific diseases. However, most of these works do not take into account the particular conditions of rural sparsely populated areas and their socioeconomic context.

To address this situation, the authors of this paper are working on the creation of comprehensive virtual profiles of the elderly [4]. These virtual profiles are built around the Situational-Context [5], a model to analyze the conditions that exist at places where Internet of Things (IoT) systems are present. We propose to use this model to gather all the information about the elderly that is available from the different devices and systems they interact with in their normal lives. By using the Situational-Context the information gathering is transparent for the elderly and, therefore, no technical skills are needed. Then, these profiles can be used to automatically adapt the behavior of IoT systems to the specific needs and preferences of each elderly.

In this paper we present the integration of a multidimensional integrated assessment web platform with the virtual profile of the elderly. The multidimensional integrated assessment platform is a tool designed for healthcare professionals that allows them to monitor several aspects of the elders abilities to take care of themselves and their evolution through time. This information is used to provide the most appropriate care for each elder. The integration of this platform with the virtual profile of the elders provides an additional layer of information that can be used to improve the interactions of the elders with other system.

To describe the proposed integration between the multidimensional integrated assessment platform and the virtual profiles of the elderly, the rest of this paper is organized as follow. Section 2 presents the motivations of this work and details the virtual profiles of the elderly for rural sparsely populated regions and the environment of tools and systems that surround them. In section 3 the multidimensional integrated assessment platform is explained in detail alongside is integration as an information source for the virtual profiles. In this Section special attention is paid to the different ways in which this integration can be exploited to improve the elders interactions with other system. And finally, Section 5 presents the conclusion of this work.

2. Virtual profiles of the elderly

The Situational-Context [5] can be defined as the composition of the virtual profiles of all the entities involved in a situation. Where entities includes not only the users physically present in a place and represented by their smartphones, but also the different sensors and actuators of IoT systems. For a meaningful composition of these profiles, we consider that they contain, at least, the following information:

- A *Basic Profile* containing the raw information about the entity's status, the relationships with other devices and its historic information. This Basic Profile is represented as a timeline with the contextual changes and interactions that happened to the entity.
- A *Social Profile* with the information obtained as a result of high level inferences performed over the Basic Profile.
- The *Goals* that detail the status of the environment desired by the entity. These Goals can also be deducted from the Basic and Social Profiles.
- The *Skills* or capabilities that an entity has to make decisions and perform actions capable of modifying the environment and aimed at achieving Goals.

The result of composing the virtual profiles of the involved entities is not only the combined information of all entities. It contains the combined history of the entities ordered in a single timeline, the result of high level inferences performed over the combined virtual profiles, the set of Goals of the entities and their Skills. From the combined information of the Situational-Context, strategies to achieve Goals based on the present Skills should be identified. These strategies will guide the prediction of the interactions that must emerge from the context.

The use of the Situational-Context is particularly interesting for providing healthcare to the elderly in sparsely populated regions like Extremadura or Alentejo. The elderly in these regions, as in many others, can be characterized by comorbidity (presence of two or more illness in the same person) and a progressive reduction of their functional capacity (defined as the potential of the elderly to take care of themselves). Additionally, these regions have low literacy, high loneliness due to low population density and emigration, and economic vulnerability.

Traditionally, health and social care in these regions are provided by a network of hospitals in the biggest cities, often located more than one hour away of the living places of the elderly, and a network of primary health centers. However, these services are rendering insufficient for the everyday older population with their associated health problems. They are also very limited in terms of their capacity to bring technological advances to these regions.

The use of the Situational-Context technology to create virtual models of the elderly living in these regions provides a very cost-effective way to introduce technological advances in these regions without the need of technical skills from the elders or healthcare professionals. To create these profiles, the system transparently gathers information from several sources and combines it. Then, these comprehensive profiles of the elderly are used to improve the coordination between different healthcare solutions and to generate a scenario that favors the implementation of new technological advances in less developed regions. Figure 1 shows the basic architecture of the generation of the virtual profiles. Each of the different sources of information for the creation of the virtual profiles is described below:

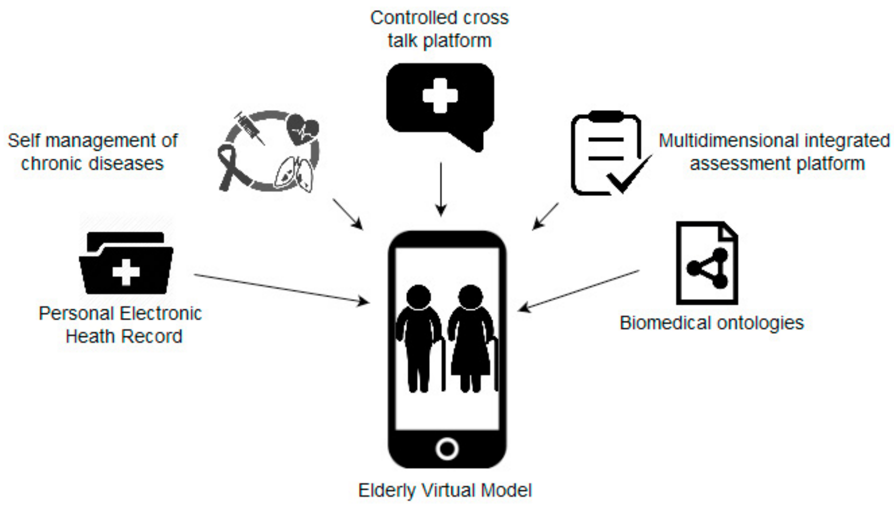

Figure 1. Virtual Profiles of the elderly

- *Personal Electronic Health Record*. As in most healthcare systems, the access to comprehensive health information of the elderly is key. In this approach, the PEHR of each elder is gathered and kept in a companion device, usually a smartphone. By using the Situational-Context, this device constantly updates the PEHR with information obtained by its own sensors and also with information obtained through any other entities that interact with the elder, either at home or in public places such as health centers.
- *Self management of chronic diseases app*. This application, also present in the elderly companion device, records the day to day activities and any incident regarding different chronic diseases managed by the elderly. The study of the behavior of self-care in the elderly can result in a predictive indicator of care needs for that age group in different contexts [6]. By providing this information to other entities in the system through the Situational-Context caregivers and health professional can provide better attention to the elderly and optimize the use of resources.
- *Controlled cross talk platform*. The goal of this system is to serve as the interface between the elderly and their professional caregivers. To simplify these communications this platform translate the medical language of the professionals to the natural language of their users. In order to do that, a clinical controlled language is used that appears perfectly natural, but it is in fact a formal language that is computer-processable and can be unambiguously translated [7]. By accessing the information of the previous applications through the Situational-Context, the platform can provide richer communications between the elderly and their caregivers.
- *Representation of knowledge guided by biomedical ontologies*. All the health care information interchanged between the different application is represented by biomedical ontologies. This allow the system to have the information semantically controlled with all the technical and scientific validation assured [8].
- *Multidimensional integrated assessment platform*. As mentioned above, this web platform is designed to be used by health professionals. It allows caregivers to apply a model of care based on a multidimensional assessment of the elderly functionality. Once the functionality and care needs of the elderly are established, they are integrated into the virtual profile so they can be later consulted by other devices. The next Section describes the details of this platform and its integration with the virtual profiles of the elderly.

3. Multidimensional integrated assessment platform for the elderly

The multidimensional integrated assessment platform provides a way to evaluate the elderly persons functionality, based on the International Classification of Functionality (ICF) [9]. This web platform is designed to be used by health professionals, who periodically fill the assessment information of each elderly patient. Figure 2 shows the different dimensions of the elderly functionality assessed by the platform.

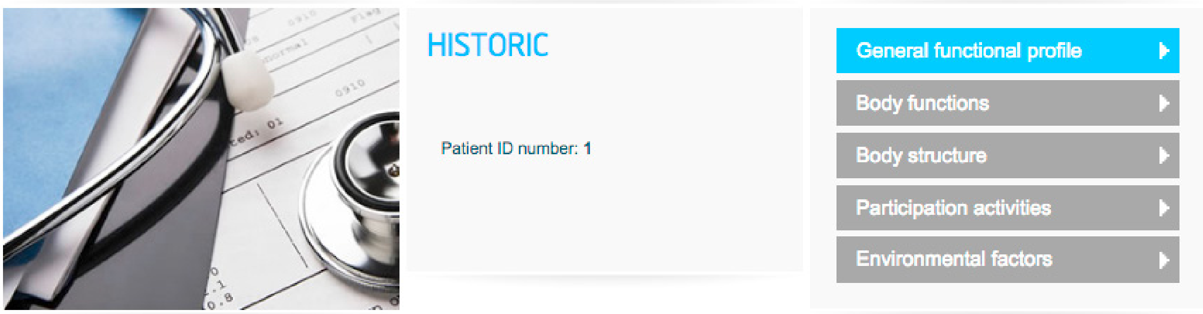

Figure 2. Different dimensions of health information assessed by the platform

- *General functional profile*. In this dimension matters such as self-management, learning and memory functions, communication or relationship with friends and caregivers are evaluated. In addition, all personal information such as age, marital status, weight, height, etc. is recorded in this dimension.
- *Body functions*. In a similar way, this dimension evaluates matters such as consciousness functions, orientation functions, attention functions, sensation of pain, etc.
- *Body structure*. This dimension is used to evaluate the condition of the skin, bones, etc.
- *Participation activities*. This dimension is used to evaluate if the elderly can carry out a daily routine, have a conversation, can wash themselves o take care of areas of their body, etc. Figure 3 shows a fragment of the user interface of the assessment platform used for this dimension.
- *Environmental factors*. Finally, other aspects are evaluated in the platform such as family environment, friends, personal care providers, personal assistants and the elders health professionals.

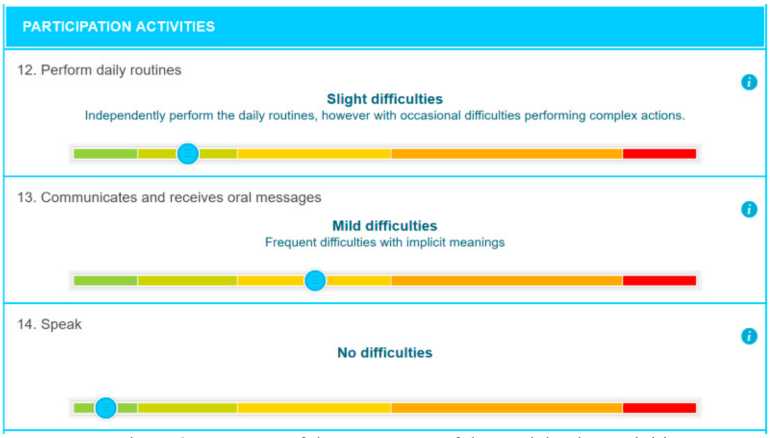

Figure 3. Fragment of the assessment of the participation activities

As the health professionals use this platform to perform different assessment of an elder over time, all the information is stored. Figure 4 shows a fragment of an elder functional assessment an its evolution through time.

Figure 4. Fragment of an elder's historical assessment

At the same time, the multidimensional integrated assessment platform is linked with the elders' smartphones. Therefore, each time a health professional performs an assessment of an elder, the updated information is stored in the virtual profile of the elder kept in the smartphone. The following Section details how this information is used to improve the interaction of the elder with other systems.

3.1. Functionality assessment as part of the virtual profile

Integrating the information provided by the multidimensional integrated assessment platform with the virtual profile of the elderly provides two benefits. First and foremost, the enriched virtual profile of the elderly simplify the interaction with other systems. And second, the integrations with the virtual profile allow us to use the rest of the profile information to notify health professional when the elder functionality suffers a change that is not represented in the assessment platform and even to automatically update the platform.

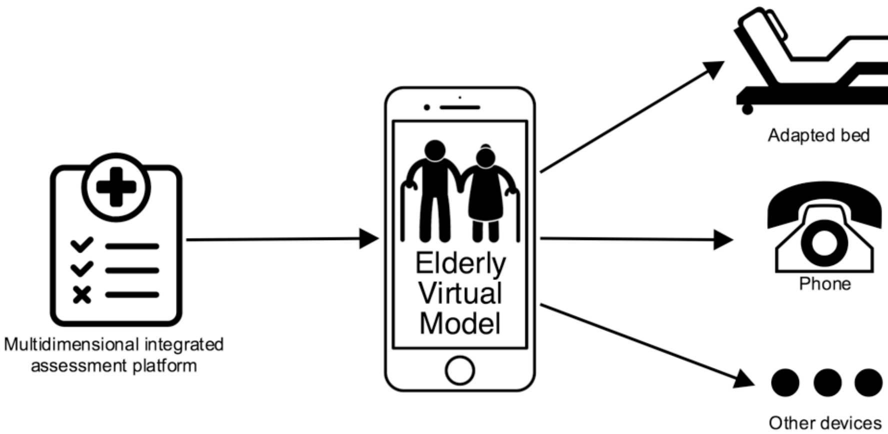

Figure 5. Examples of use of the assessment information as part of the virtual profile of the elderly

Figure 5 shows some examples of how the assessment information can be used from the virtual profile stored in the elders smartphones. This information will be provided from the smartphone so other systems can use it to adapt to the elders classification of functionality. For example, if the assessment of the participation activities of the elder determines that she has mobility problems, an adapted bed can detect this information and provide additional help when the user wants to stand up. Similarly, if the assessment detects hearing problems, the phones and other devices used by the elderly can dynamically adapt its volume to their user's needs, and even other people can be automatically notified when interacting with the elderly so they can make the appropriate adjustments.

Additionally, Figure 6 shows an example of how the information stored in the virtual profile of the elderly can be used to automatically update the assessment. As show in the Figure, one of the most relevant aspects of the virtual profile are the elderly daily routines [10]. The virtual profile store the routines followed by an user and detects possible deviations from the routines to raise alarms and notify the appropriate caregivers. This information can be used to update the information in the assessment platform. For example, if the number of detected deviations from routines increases, it could cause an update in the assessment of the participation activities to reflect the new functionality levels of the elderly or an alert can be sent to a health professional indicating the need of an updated assessment.

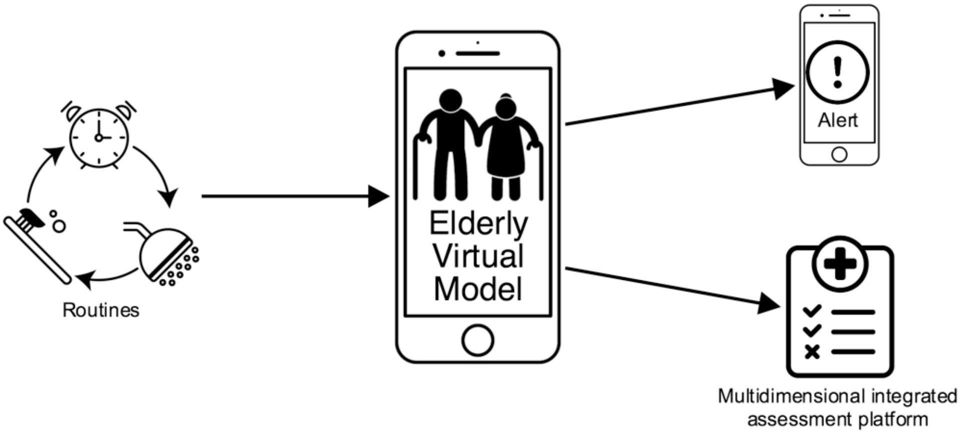

Figure 6. Example of the use of the virtual profile to automatically update the assessment

4. Related works

As mentioned above, the authors of this paper are working in the use of the Situational-Context to create an ecosystem of tools and systems to improve the quality of life of the elderly living in sparsely populated areas. As part of this effort, works like [10] or [4] present different techniques and proposals to this end.

Furthermore, eldercare is a very relevant topic and several researchers have proposed different alternatives to create virtual profiles of the elderly. For example, works like [11] propose the use of a virtual profile of the elderly to assist them in their daily activities and to notify their relatives of potentially risky situations. Similarly, works like [12] propose the use of IoT devices to increase the information gathered by the virtual profiles of the elderly. Finally, works like [13] propose the use of ontologies to improve the monitoring of the elders. All these works share several aspects with the one presented here. However, only this work is focused on the design of solutions for the healthcare systems of aged, sparsely populated regions.

5. Conclusions and future works

The comprehensive virtual profile of the elderly enriched with the information originated from the multidimensional integrated assessment platform will simplify the elderly and caregivers interaction among themselves and also with IoT systems. They will also create a breeding ground for innovation in eldercare in sparsely populated areas.

In that regard, the authors are working on several aspects emerging from the described virtual profiles. First, the creation of an advanced age ontology. An extension of the existing biomedical ontologies that takes into account all the details and specificities of the elderly living in lowly populated regions.

Second, the profiles can be used to improve non-invasive monitoring applications, like the one presented in [10]. By having a common representation of the elderly information through the Situational-Context, monitoring applications can gather richer information from IoT systems.

And third, with more advanced monitoring applications more seamless interactions with other systems can be orchestrated transparently for the users. As stated above, elderly living in sparsely populated regions like Extremadura or Alentejo usually does not have the technical skills needed to interact with complex technological systems. There- fore, the use of the richer information gathered can be used to decrease the burden of interacting with healthcare solutions.

Acknowledgements

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