UNIVERSIDAD DE EXTREMADURA

Escuela Politécnica

Máster en Ingeniería Informática

Trabajo de Fin de Máster

Technological developments for an ageing and rural society

Sheila Bonilla Plaza

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Resumen

El incremento de la población anciana año tras año es un hecho. El índice de mortalidad disminuye, lo que hace que aumente este colectivo de personas. Adicionalmente, el aumento de la edad provoca que las personas suelan tener mas enfermedades, dolores o incluso empezamos a ser más dependientes. Por todo ello, es necesario estudiar la posibilidad de ayudar a estas personas, para facilitarles su día a día lo máximo posible e incluso, poder detectar enfermedades en un futuro.

El Instituto Internacional de Investigación e Innovación del Envejecimiento (4IE) se encarga de estudiar a este grupo de personas y tiene como objetivo, encontrar soluciones tecnológicas que ayuden a complementar la vida del anciano y mejorar sus hábitos diarios. En concreto, se encarga de estudiar las zonas rurales de Extremadura (España) y Alentejo (Portugal) ya que la tasa de ancianidad en estos lugares es más alta que la base de la población europea.

De aquí surgió la idea de crear una plataforma de evaluación multidimensional de la funcionalidad, con la que los profesionales de la salud puedan hacer evaluaciones al anciano, rápidas, sencillas y que consigan obtener los datos necesarios para comprobar el grado de funcionalidad de los ancianos. Estos datos son relevantes a la a medio y largo plazo, para poder detectar problemas que puedan surgir en un futuro e incluso corregirlos.

La plataforma multidimensional de evaluación parte de una plataforma existente. Con las mejoras llevadas a cabo en este trabajo, los expertos en el cuidado de la salud, podrán detectar el grado de funcionalidad del anciano. Esto se consigue mediante la realización de una serie de preguntas básicas relacionadas con la memoria y el razonamiento entre otras muchas. Además, los profesionales tendrán un historial para controlar las mediciones que van tomando del anciano, compararlas con mediciones pasadas y poder predecir mediciones futuras. Esta plataforma además, está integrada con dispositivos IoT. Estos dispositivos, mandan la información a un smartphone y este se comunica con la plataforma a través de una API. Estos datos serán primero recogidos y almacenados en el móvil. Posteriormente desde la plataforma podremos enviar la solicitud de obtener todos los datos almacenados en el móvil utilizando el paradigma PeaaS.

Con el objetivo de añadir más información en el perfil del móvil del anciano, se ha realizado adicionalmente un estudio de las emociones. Este estudio tiene como objetivo recoger la información del sentimiento emocional del anciano y almacenarlo en el dispositivo. Esto se realiza a través de reconocimiento facial. Esto ayuda a enriquecer aún más la información del anciano.

Los avances desarrollados en este trabajo ya empiezan a ser utilizados por profesionales de la salud en el área de Alentejo y los resultados iniciales son muy prometedores.

Palabras clave — Internet de las cosas, Personas como servicio, Internet de las personas, Ancianos

Abstract

The increase in the elderly population year after year is a fact. The mortality rate decreases, which increases this group of people. In addition, the increase in age means that people tend to have more illnesses, pain or even become more dependent. For all these reasons, it is necessary to study the possibility of helping these people, in order to facilitate their daily life as much as possible and even to be able to detect illnesses in the future.

The International Institute for Research and Innovation on Ageing (4IE) is in charge of studying this group of people and its objective is to find technological solutions that help complement the life of the elderly and improve their daily habits. Specifically, it is responsible for studying the rural areas of Extremadura (Spain) and Alentejo (Portugal) as the rate of old age in these places is higher than the European population base.

This led to the idea of creating a multidimensional evaluation platform for functionality, with which health professionals can make rapid, simple evaluations of the elderly and obtain the necessary data to check the degree of functionality of the elderly. These data are relevant to the medium and long term, in order to detect problems that may arise in the future and even correct them.

The multidimensional evaluation platform is based on an existing platform. With the improvements made in this work, health care experts will be able to detect the degree of functionality of the elderly person. This is achieved by asking a series of basic questions related to memory and reasoning among many others. In addition, professionals will have a history to monitor the measurements they take of the elderly, compare them with past measurements and be able to predict future measurements. This platform is also integrated with IoT devices. These devices send the information to a smartphone and it communicates with the platform through an API. These data will first be collected and stored in the mobile. Then from the platform we can send the request to obtain all the data stored in the mobile using the PeaaS paradigm.

In order to add more information to the profile of the elderly person's mobile phone, a study of emotions has also been carried out. The aim of this study is to collect information on the emotional feeling of the elderly and store it in the device. This is done through facial recognition. This helps to further enrich the information of the elderly person.

The advances developed in this work are already beginning to be used by health professionals in the area of Alentejo and the initial results are very promising.

Keywords— Internet of Things, People as a Service, Internet of People, Elderly

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Chapter 1

Introduction

The ageing of a population is understood as the increase in the proportion of elderly people in relation to the total number of individuals, which is usually expressed as a percentage [3]. It can also be defined as a progressive and generalized functional deterioration, causing a loss of the adaptation response to aggression or, an increase in the risk of age-related diseases.

Population ageing by itself is not a problem. However, elder people get sick more often than younger people. The main reason for this is, because of their longer lives, they have been exposed to external behavioural and environmental factors that cause illness for a longer period than their younger counterparts [4].

Older people are more likely to suffer from non-communicable diseases, i.e. the main causes of death in the elderly are heart disease, stroke and chronic lung disease. Causes of disability include sensory impairment, neck and back pain, chronic obstructive pulmonary disease, depressive disorders, falls, diabetes, dementia and osteoarthritis [5].Most of the causes are due to their physical and social environment, which also determines their developmental possibilities and health habits. It should not be forgotten that these factors influence ageing from childhood onwards: an elderly person born in a disadvantaged environment is more likely to have health problems and probably less access to the services and care he or she may need [5].

Most of the illnesses mentioned above make it difficult for a person to perform routine tasks such as going for a walk, to their health centre or to go shopping. Difficulties in carrying out daily activities are associated with reduced quality of life, low self-esteem, anxiety and social isolation of both the elderly and their carers, as it affects not only the elderly person, but also the lives of their carers [6] (usually their own families) who are forced to be constantly concerned about the well-being of the elderly person. In developed countries, older people often want to have some autonomy, so that, whenever possible, they adapt their routines by adding new elements to their homes and/or using new technologies that facilitate the performance of their daily tasks and, at the same time, allow carers not to have to accompany them constantly.

Even though they are more likely to suffer from disease than the rest of society, this group of people increases every year in most developed countries. More than 20% of the people in these countries are older people (65 years or older), and the growth of this age group means that it is likely to reach 26% of the population of these countries by 2030 [7].

If we focus on Europe's rural regions such as Extremadura in Spain or Alentejo in Portugal. These regions have a lower population density than the European Union (EU) average, ranging from 14.8 people per km2 in Baixo Alentejo and 31.9 people per km2 in Badajoz [8] compared to 116.6 people per km2 averaged in the EU. And even lower than the average population density of rural regions in the EU, an average of 48.4 people per km2. In addition, these regions continue to lose their young population, due to migration to more socio-economically developed regions, which is increasing the proportion of ageing.

The average age in Extremadura in 2016 was 43.8 years, being much higher in municipalities with less than 1,000 inhabitants, with an average age of 53.2 years, which confirms the growing ageing of the population in rural areas. The population over 65 years old is 20.2%, while the population over 85 years old is 3.5% of the total population. The ageing rate in Extremadura is 146.15, with a significant difference between its two provinces: Cáceres, with 178.82 is older than Badajoz, with 129.70. In Extremadura, almost half (49.4%) of single-person households were occupied by persons aged 65 or over, according to INE Household Survey 2016. Of this percentage, 69.6% are women, which suggests a certain feminization of loneliness in old age in Extremadura. This is part of a logic of historical migration from the region of Extremadura, traditionally with an economic sector dedicated almost exclusively to agricultural and livestock activity, to the more industrialized regions of the country [9].

As a result of these conditions, these regions have an ageing population above average, which can be understood as a sign of development. However, the reality is that these are economically disadvantaged regions with a particularly fragile cultural and socio-economic context. The literacy rate is lower than the average in these regions and, due to low population density and the migration of young people to richer regions, the elderly often live alone.

The ageing of the population may be the result of two demographic factors appearing in the region, with increasing force. On the one hand, the continuous loss of population each year that indicates the sequence of data from the National Statistics Institute (INE), where, although urban areas are losing population in recent years, it is in rural areas where this trend is increasingly alarming. On the other hand, there has been a substantial improvement in life expectancy, resulting in greater longevity.

In recent years, health care companies and health researchers have made significant efforts to improve the quality of life for the elderly. This has led to significant progress in the development of software systems and devices that improve the monitoring and treatment of the elderly [10].

However, these advances are rarely applied in regions such as Extremadura and Alentejo due to the characteristics mentioned above. This further worsens the conditions of the elderly in these territories.

1.1 Instituto de Investigación e Innovación en Envejecimiento

The International Institute for Research and Innovation on Ageing (4IE) was created with the intention of proposing solutions to one of the realities currently facing southern European countries: the ageing of the population and its consequences for health and care systems. Through a mixed methodology and the meeting of different knowledge and research practices, it seeks to develop technological solutions that help improve the quality of life of older people in rural contexts in the regions of Extremadura (Spain) and Alentejo (Portugal).

The Institute consists of a cross-border project between Extremadura (Spain) and the Alentejo region (Portugal). Within these are several associated entities such as:

- University of Extremadura.
- University of Évora.
- Polytechnic Institute of Beja.
- Polytechnic Institute of Portalegre.
- Alentejo Regional Health Administration.

In addition, an extension of the original project has been granted. Financed with funds from POCTEP for the years 2020-2021, these institutions are also joined by the Ministry of Health and Social Policies of the Regional Government of Extremadura through FUNDESALUD. The institutions participating in this Institute are all of recognised prestige, especially higher education institutions.

A total of 26 researchers in Spain, 19 in Portugal and five people hired exclusively make up the 4IE research team. All of them form a multidisciplinary team that includes computer engineers, nurses, doctors, economists, anthropologists and sociologists.

The work between the different universities and the public resources of the two countries highlights the importance of addressing the problem, joining forces on both sides of the border and the need to cooperate to address common problems. Ageing is a sign of potential threat to maintaining the quality of life standards that our societies have helped to create due to fear, increased pressure on economic resources and public spending. Working to change the current demographic trend has to be a key challenge in the coming years.

This Institute aims to understand the biomedical, functional and psychological aspects of ageing in specific contexts, generate new models and processes of care for the elderly and technological solutions that contribute to their health and quality of life and the sustainability of services. These issues have been addressed in these regions in isolation and without depth. The similarities in the context between these territories and the exploitation of competencies achieved through coordinated work, with a scientific focus and common objectives and a strong emphasis on results, improves the impact and potential for international dissemination of results, which gives rise to far-reaching effects for a current social challenge.

It is therefore intended to create an organisational research structure, based on a virtual platform that fully understands the ageing process, as well as the contexts in which it takes place. In addition to developing to develop new models and processes of care, anchored in ICT, that contribute to improving indicators of quality of life and health of older people, to improving the effectiveness and efficiency of support services for older people and, ultimately, to generating solutions that can be developed in other regions.

Due to this, the need arose to be able to address this issue with technological solutions. This is where the Institute for Research and Innovation in Ageing (4IE) came from.

The overall objective of 4IE is the development of knowledge on the ageing process, with the creation of new models, processes and technologies to improve the provision of care for the elderly. In addition, this project aims to create an organisational structure for research, based on a virtual platform (4IE), which will allow us to deepen our knowledge of the ageing process, as well as the socio-cultural contexts in which it takes place, in order to develop new models and processes of care, anchored in ICTs, which contribute to improving the quality of life and health indicators of the elderly, to improving the effectiveness and efficiency of support services for the elderly and, therefore, to generating solutions that can be transferred to other regions under competitive conditions.

This work has been developed through the line of research that follows 4IE. This is because I am currently holding a position in this research project. This end-of-master work focuses on applying current technologies to improve the quality of life of the elderly.

Through a functionality evaluation platform, doctors will be able to follow a detailed history of the elderly, in addition to being able to fill out various questionnaires that follow the law of dependency [11], which the health professional will evaluate the degree of functionality of this group of people. On the other hand and thanks to the incorporation of several intelligent devices, we will be able to extract more detailed information of the patients as it can be: the weight, the kilometers that walks daily... This information, will be stored in the smartphone of the elder. The doctors, through the platform, will be able to obtain the patient's data in order to evaluate them. This allows to detect possible important variations in the daily activity of the elderly person. Also, to continue enriching the information of the elder, a study has been carried out on emotions. Through this study, we can obtain information on emotional feeling at different stages of the day. These data, together with the other values mentioned above, can help to find problems or solutions in the daily life of the elderly.

It is important to note that an initial version of the aforementioned platform has been developed prior to this works. This is work is responsible for completely remaking the existing platform using a different programming language, making it more usable, more updated, with more features and new additions of IoT devices. All the information about the work performed for this master thesis are detailed in the rest of this document. This work is responsible for creating a new version, more usable, more updated, with more features and new additions of IoT devices.

The rest of this master thesis will be ordered according to the following structure: in chapter 2 we will talk about the technological motivations to improve the quality of life of the elderly, then, in chapter 3, we will detail in a list the proposed objectives. In the following chapter, chapter 4 we will tell the methodology that the project has followed, in chapter 5 we will talk about the architecture, tools and system developed to help improve the quality of life of the elderly.In chapter 6, we will see the tools that currently exist whose objectives are similar to ours and we will compare both solutions. To continue, we will detail some small conclusions and the following lines of work that continue this process. Finally, I will contribute a personal opinion to this work. In addition, in the following pages, we will find an annex with the user's manual to use the platform properly.

Chapter 2

Motivations

Contents

This chapter takes us to study the current technology that we can use to help improve the quality of life of the elderly, specifically, in this case, in the rural areas of the territories of Extremadura (Spain) and Alentejo (Portugal). In both regions, every year, the level of old age increases significantly, which leads us to consider providing solutions to this group of people. Nowadays, with the help of technology, we can favour their daily life, facilitating them with routine tasks as we mentioned in the previous chapter. The technologies studied to meet our objectives are those developed within the lines of research of 4IE.

2.1 Internet of Things (IoT)

One of the current challenges is to improve the quality of life of those who still have some autonomy and live at home rather than in the centres of care, through the application of new information technology paradigms. One of the paradigms that has the most potential in this context is the Internet of Things (IoT) [12]whose main objective is to integrate information technology with people's daily lives [[13],[14]]. This integration generally aims to obtain information from the environment to automate repetitive tasks.

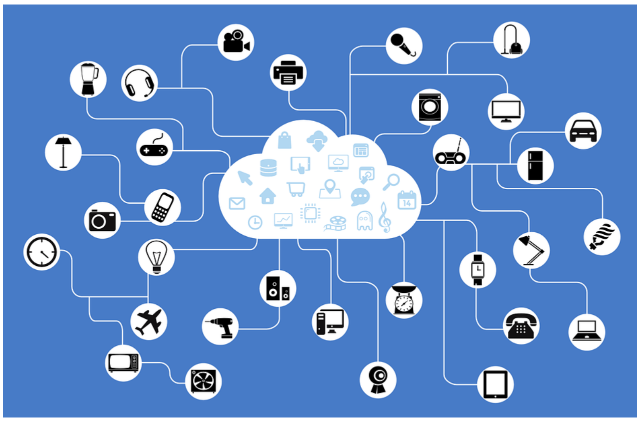

Figure 2.1: Smart devices IoT

Smartphones, smart clocks and other portable devices such as several of those shown in figure 2.1 are now used to monitor the location and vital signs of the elderly. Caregivers can therefore be alerted when a specific parameter deviates from its normal values, for example, when the heart rate exceeds the values set by the caregiver. Currently, there are a number of commercial applications that use one or more devices to improve elderly care and increase autonomy. Examples are Project Lifesavers PAL (Protect and Locate) Tracking system [15] and Tweri [16]. These applications require the elderly person and/or caregiver to set a large number of parameters to adapt the application to their particular needs.

The integration of the IoT paradigm with such devices and applications is markedly susceptible to improvement. There is still a large gap between the network where the information collected by the devices is processed and exchanged and the reality of physical life and its context [16]. In general, several parameters of the system in question must be set manually, and this is far from making the technology work for people, as it forces them to be aware of the need to introduce new routines or modify parameters each time there is a change in their habits. Therefore, if an older person using one of these applications changes their walking routines, the caregiver has to actively change them in the application. In a more appropriate IoT scenario, technology should take into account the context of the people it should serve, learn from the context and at all times take proactive action according to the situation and expectations. [17],[18].

There is ongoing research on the processing of contextual information obtained from specific devices with the aim of detecting people routines and anomalous situations, allowing applications to learn from contextual information without the need for any active configuration.

In [19],the authors define an approach that reduces the amount of contextual information that must be defined by elders and their caregivers in order to control the sequence of steps followed during the execution of household chores. In this case, the caregivers must describe the tasks and the places where they are performed, and this information is then combined with a specification of the available sensors and actuators to build a working model that is capable of analysing the ongoing activities. CoReDa [20] is an approach that guides older people to complete their activities of daily living (ADLs). In [21], the authors propose an algorithm to process the GPS trajectories of elderly people to model the movement trajectories of an individual and to identify remote paths in real time, defining a pattern of wandering or deviation as possible cases of disorientation.

These works focused on learning techniques applied to specific contextual information to facilitate the definition of routines and the monitoring of certain activities. However, carrying out these activities generally involves additional environmental elements, so more contextual information is needed. For example, the task of preparing and drinking a cup of coffee will be different if the older person is alone from the moment she is accompanied by a caregiver or friend. Similarly, they may have a routine of walking alone, but if accompanied by a caregiver, it may be acceptable to break their routine for a longer walk. Therefore, to allow for more comprehensive routines and improve supervision of older people in different settings, it will be necessary to consider and process more contextual information.

2.2 People as a Service (PeaaS)

As we talked about including richer contextual information, it is proposed in the People as a Service (PeaaS) model. [1]. PeaaS is based on the use of smartphones as sociological virtual profiles of IoT users in the sense that they contain the timeline of all the data and actions that their sensors have collected along with the information that can be inferred from that timeline (i.e., users, preferences, activities, moods, professions, goals, etc.). These devices are highly personalized, and accompany their owners in all their daily activities, accumulating an immense amount of information [22], [23]. In addition, they can be combined with external elements that can provide more precise information for certain parameters. Examples are biometric sensors, indoor sensors and other connected household devices. PeaaS is a social model that emphasizes the smartphone as a service provider.

As an example belonging to PeeaS we can highlight [24]. This model, on the one hand, facilitates interactions with other users' smartphones, also taking these interactions into account as part of each user's context, and, on the other hand, allows owners to control the information provided by their mobile devices to maintain data privacy and security.

In the figure 2.2 we can see a PeeaS architecture based on an example described below:

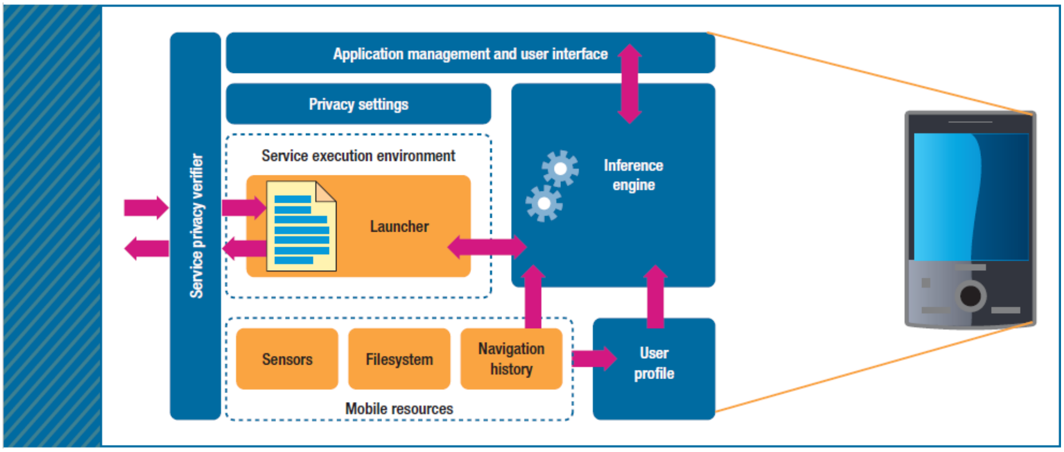

Figure 2.2: PeeaS general architecture [1]

The objective of this example system is to detect the different daily routines of the user (schedules, movement patterns, etc.). The smartphone then monitors the user's daily activities and acts if any deviation is detected (for example, guiding the elderly person to finish an activity or alerting family members). The identification of routines is based on all available contextual information, such as time, location (indoors or outdoors), biometric data, family members or caregivers accompanying the elderly person or the weather [24]. The analysis of this information makes it possible to detect a wide variety of recurrent activities, along with all the contextual information associated with those activities. Identified routines are stored along with their contextual information (including variations of any single routine where only specific contextual elements change) and the transitions between them that the user follows. Finally, an algorithm is defined to identify deviations from routines, and to detect when, depending on the contextual situation, it is necessary to activate an alert. All this makes it possible to identify a greater number of activities, to better control the conditions in which each activity must be carried out and to detect which deviations from the routines must trigger an alert. Monitoring all this information improves the efficiency of the system, and this improvement in efficiency improves the quality of life of people with cognitive impairment by mitigating the anxiety, low self-esteem and social isolation that can result from the person's difficulties in performing daily activities [24].

2.3 Internet of People (IoP)

Continuing with the aim of adding more contextual information, the idea of Internet of People (IoP) arises. IoP arises because the technology used, must take into account the context of people, learn from it and take proactive measures depending on their situation and expectations, avoiding as far as possible the intervention of the user. Smartphones play a central role in this approach, being the interface between people and the Internet and the devices connected to it. The IoP concept proposes to equip smartphones with two essential capabilities to improve the connection between people and the IoT. These capabilities are, first, a set of elements that allow a smartphone to learn about its owner and its owner's context and, second, the ability to transparently monitor, negotiate and propose interactions with other devices, reacting to stimuli and managing relationships.[24]

To give an example for this model, it could be used to monitor any elderly person and turn the smartphone into an interface between that person and other devices, such as an intelligent band or intelligent clock, in order to capture the person's vital signs, or to serve as a beacon to identify the person's location inside the house. Any application based on this concept must follow a set of guiding principles. These principles are:

- Sociable. IoP-based applications should support interactions with the different types of devices people use.
- Personalized. The devices must be aware of the context, adapting their behaviour to the context and sociological profiles of all participants.

- Proactive. Devices must be able to automatically trigger actions or interact with other devices depending on the context.
- Predictable. Actions should be triggered based on specific situations that users have previously defined or validated.

Chapter 3

Objectives

As we have discussed in previous chapters, our work follows the line of research of 4IE. Therefore, by applying the technologies mentioned above to the daily life of an elderly person (a group of people to whom the research is directed), we contribute to improving their quality of life. For all of this, the set of objectives to be met are as follows:

- Create new version of multidimensional functionality evaluation platform.
- Incorporate new questionnaires based on the Dependency Law [11], intended for the use of health personnel.
- Historical to obtain a global vision of the patient.
- To evaluate by percentages the patient's history, focusing on the International Classification of Functioning (ICF) [25].
- Application for the mobile that is capable of storing information of the elderly in the device and through requests, the health personnel can obtain those stored data.
- Integrate IoT devices with the smartphone to store daily information about the elderly.
- Display devices IoT measurements through graphs.
- Add more information to the elder's smartphone through emotion detection.

- To be able to integrate all the technology mentioned in the most transparent way to the user.

Chapter 4

Metodology

In this section, we will explain the methodology followed in the development of the work and then we will show the time dedicated to different tasks, from the beginning to the end of this work.

Contents

The Behavior Driven Development (BDD) methodology (figure 4.1) has been used in this work. As its name indicates, it is not a testing technique, but a development strategy (as well as TDD, which is test driven development). What it proposes is to define a common language for the business and for the technicians, and to use that as an initial part of the development and testing [26].

BDD is looking for a common language to unite the technical and business parts, and that it is from that common language where Testing starts and, from there, development.

In these first phases of work, the platform has been tested with the help of health professionals from the Évora Faculty of Nursing. We have even made several trips to these cities to finalize with them the details of the development. Through certain defined patterns, the graphical interface was redefined again, always considering their opinions. Likewise, in the internal part for storing, selecting or editing data, the objectives were always redefined if they were not

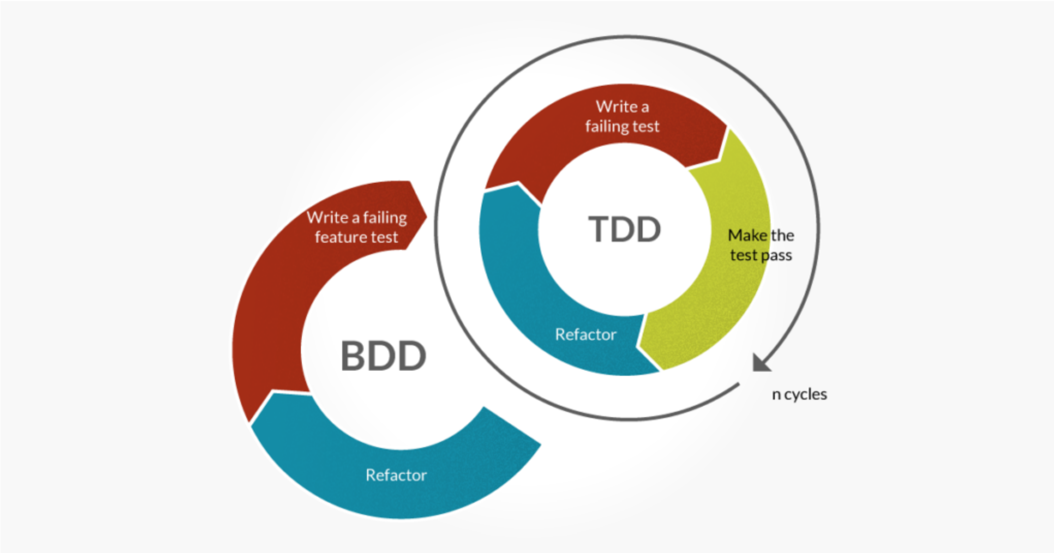

Figure 4.1: Stages of development BDD

the correct ones.

4.1 Schedule

In this section, we will briefly detail each of the tasks that have been performed at work. In the following figure 4.2, all the steps that have been carried out are shown. Finally, we will make a brief description of each of these steps following the Gantt diagram.

1. **Literature review for emotions**: During the time period of literature review (conducted at an interval from September to December), a study was conducted on facial recognition of emotions in an elderly person. As described in previous chapters, the article Facial Recognition of emotions with smartphones to improve the elder quality of life [27] has been published in a scientific conference.

2. **Approach to the new platform**: a detailed study of the current tools and their characteristics was developed in order to be able to choose more accurately the ideal tools for the platform. A previous search for information, was carried out, after gathering this information, a selection of languages of programming to use and with it a selection of

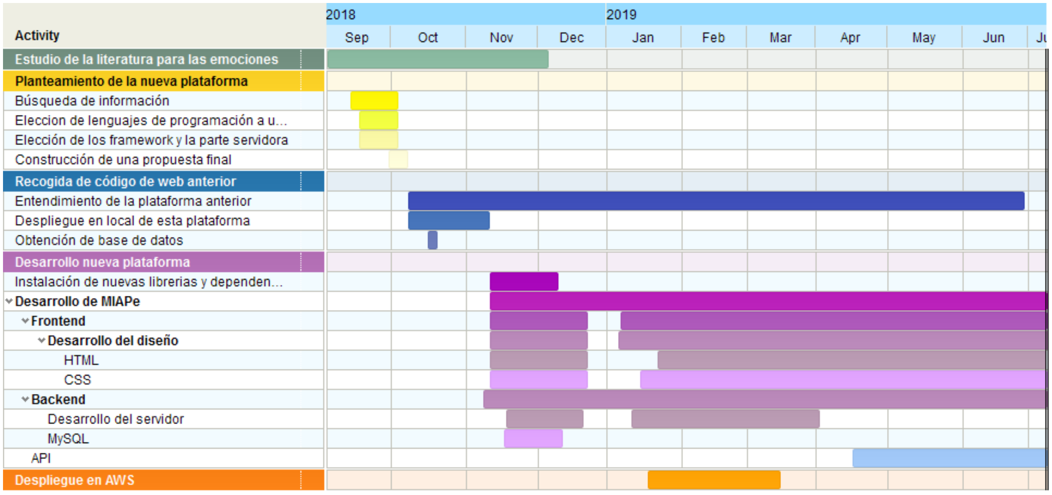

Figure 4.2: Gantt Diagram

the framework and the servident partand finally, construction of the final proposal to demonstrate that the chosen tools and languages were suitable for our platform.

3. **Collection of code from the previous website**: for the development of the platform, it was previously necessary to collect data from the previous platform in order to transfer it to the new one. For this, the first step was understanding of the previous platform, to be able to explore its content, it was necessary the deployment in local and thus be able obtain the database used, to follow the same table structure and use the same storage.

4. **New platform development**: previous installation of libraries and dependencies that would later be used to carry out the development.

   (a) **Front-end**: visible part of the platform that the client can observe. The design consists of several parts:

   - **Design development**: the front of the platform comprises: HTML and CSS. Both allow to design the visible area of the platform and the CSS gives the style. Fragments of JQuery and Javascript have also been used.

   (b) **Back-end**:this part is internal to the platform and makes it give movement and availability. Inside back includes the server development and the development of the new database in MYSQL along with the new tables included.

   (c) **API**: development and implementation of the API, using intelligent devices such as: smart band and scale. These devices are capable of sending data to our platform from the mobile. So it was necessary to develop communication between them.

5. **AWS Deployment**: this last interval was done to be able to access our platform from the internet. For this, a choice of instance was necessary. In the beginning the chosen instance was the t2.micro because it was free and our first version. When more data was added to the platform, the instance failed because it was not powerful enough. Because of this, we chose a payment instance with more power than the previous one, in this case it was called t2.small.

Chapter 5

Multidimensional Integrated Assessment Platform of Elderly (MIAPe)

Contents

After having explained the motivations, the defined objectives and the methodology used. In this chapter, we are going to link the three to get to detail the developed proposal. To this end, this chapter will describe all the phases of the development of a software project, from the analysis of the requirements to the deployment.

5.1 Requirement analysis

The need was detected to develop a new multidimensional platform to help nurses evaluate their patients. Previously, a functionality evaluation platform was available. This page was only in Portuguese and did not have internationalization mechanisms that would allow a quick translation. The file structure was very complicated, it had many directories with many subdirectories inside and it was almost impossible to remember the file structure underneath. In addition, it was developed using a framework called Yii, a challenge that at first seemed very simple but over time, ended up being very complicated (lack of documentation, therefore, predefined functions in their own code that were difficult to understand). Yii, is a framework that uses PHP as an internal language.

Because the platform had to be brought into production and the development with Yii was very slow, it was decided to change the language. After making several comparisons between current frameworks and programming languages, it was decided to use NodeJS.

To make a comparison between NodeJS and PHP, we can say that PHP is a programming language that needs to be compiled every time it runs, which makes it a slow process. However, NodeJS cannot be classified as a programming language, but as a platform that allows us to execute JavaScript on the Server. Therefore the very language you use below is Javascript [28]. On the other hand, with PHP we needed at least two applications, on the one hand we had PHP (which executed our program written in the PHP programming language) and on the other hand we had the web server (Apache) that redirects requests from our domain to PHP. With NodeJS we don't have that problem since it incorporates everything.

The main difference that lies in both, is that there are currently a multitude of hosting that allow you to upload pages made in PHP because it separates client and server. However, it is currently difficult to find a hosting that allows you to upload pages made in NodeJS because it integrates server and client [29].

Therefore, after comparing speed, understanding of code, programming in a single language and graphics such as figures [5.1 5.2], it was decided to start development again with this new technology.

In addition, to work with NodeJS, on the client side, the most used framework is AngularJS. Both come together very well because they combine development in Javascript. One of them, as we have mentioned, provides the client side and the other the server side [30].

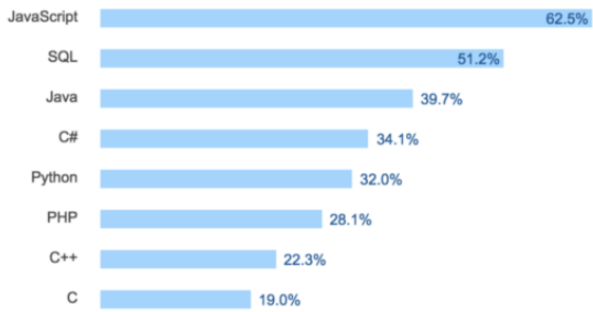

Figure 5.1: Programming Languages 2018

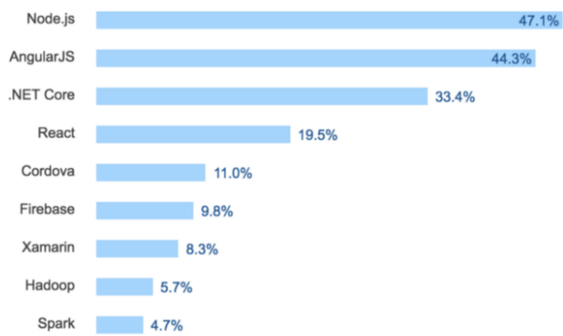

Figure 5.2: Frameworks, libraries and other technologies 2018

5.2 Design and architecture

A multidimensional Integrated Assessment Platform of elderly (MIAPe) has been developed to support healthcare personnel. This multidimensional platform provides a way of assessing older people based on the International Classification of Functionality (ICF). Through it, health professionals carry out a questionnaire with different sections (sociodemographic identification and characterisation, questions relating to the functions of the human body, its structure, participation activities and environmental factors) in order to assess the patient, check how their daily assessment has been (improvement or worsening) and thus be able to act accordingly. The evaluations developed in the platform follow the law of dependency [11], that is, health professionals through various questionnaires will be able to determine the degree of functionality of each patient in treatment.

In addition to using ICF issues, there are two types of evaluations that bring new data to patient assessment. These types of forms are:

- Blessed dementia scale (BDS): Blessed scales are one of the oldest and best-known instruments for assessing and quantifying functional and emotional changes in patients with dementia. Instruments include: dementia scale (BLS-D), information scale (BLSI), memory scale (BLS-M) and concentration scale (BLS-C) [31].
- Mini mental state examination (MMSE): The MMSE was developed to be used in the clinical practice of assessing cognitive status change in geriatric patients. It examines temporal and spatial orientation, short-term memory (immediate or attention) and evocation, calculus, movement coordination, language and visual-spatial skills. Can be used as a screening test for cognitive loss. It cannot be used to diagnose dementia [32].

With all the data from our questionnaires, conclusions are drawn through an automated history, in which we can observe the percentage of functionality that corresponds to the elder (ability to perform routine tasks by himself). Consulting the general functionality score (overall percentage of the degree of seriousness of functionality of elderly people), the percentage of self-care capacity, the percentage of learning and memory functions, the percentage of communication capacity and, in short, a percentage of the relationship of friends and caregivers.

Another very important aspect is the increase in computational capacity of embedded and mobile devices in recent years. Thanks to this trend, the importance of IoT has also increased in different fields. However, the use and configuration of these systems require users to have certain technical skills, which is not always possible, especially in areas such as elderly care. Therefore, solutions are needed to seamlessly and effortlessly integrate user preferences and needs into the IoT system. In this sense, and to give use to the mobile device, we have added to our platform different IoT devices, which we can see in the following figure:

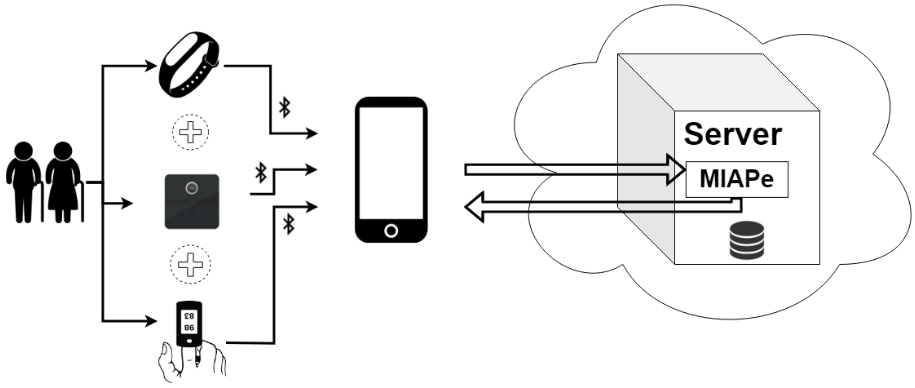

Figure 5.3: Mobile connection with IoT devices and database

We have integrated integrate several IoT devices, in particular for this work have been used those that are observed in the figure 5.3, which are: smart band, scale and an oximeter. Each patient can have any of these devices or all three at the same time and also a mobile phone.

Thanks to the Bluetooth connection of the IoT devices with the smartphone and through a developed API, it will capture the data and store them in the database used in our platform in a way that is totally transparent to the user.

With this stored data, we will enrich the elder's virtual profile and the information will be stored in his own device through PeaaS [1]. From the platform, health professionals will be able to make requests to the elderly's mobile phone in order to obtain these data and be able to obtain an even richer set of data in the history. Thanks to these data, if a deviation in their measurements occurs, the health professional can obtain a notification indicating that the patient has high values in a specific measure and the professional can act accordingly. The general scheme of the development corresponds to figure 5.4

In addition, and with the aim of enriching the virtual profile of the elderly, a study has been carried out related to emotions [27]. This study is in charge of demonstrating that it is possible to detect emotions through a mobile device and the obtaining of this information, added to the virtual profile,enriches much more its own information. The fact that the person is sad may be due to the fact that he has not gone for a walk with his friends, as he usually does, because then the smart band will have a lower number of steps than the rest of days.

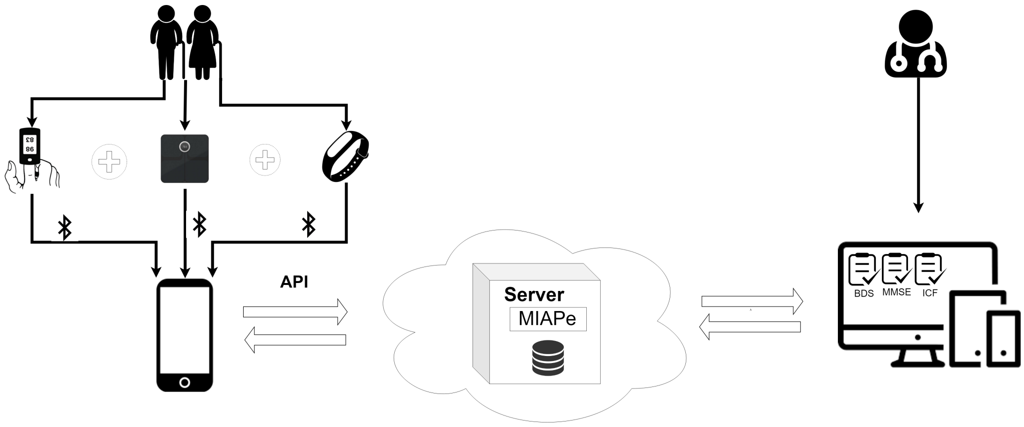

Figure 5.4: General architecture of the proposal

These articles have been published in the book: Communications in Computer and Information Science by Springer: Gerontechnology and another is in the process of publication in the book Exploring the Role of ICT's in Healthy Aging.

5.3 Implementation and test

In this section, we will detail the steps and tools used to develop our platform, on the one hand, we will explain the client side (front-end) and then the server side (back-end).

5.3.1 Client

For the development of the client part the Angular framework has been used (version 7.0.4), HTML and CSS. The main page of our platform can be seen in figure 5.5:

As we can see, we have several sections. Starting from the right I will comment on the indicated sections.

In the left part, above, we can see a blue rectangle, inside this rectangle, we have the three forms previously commented in a few paragraphs above

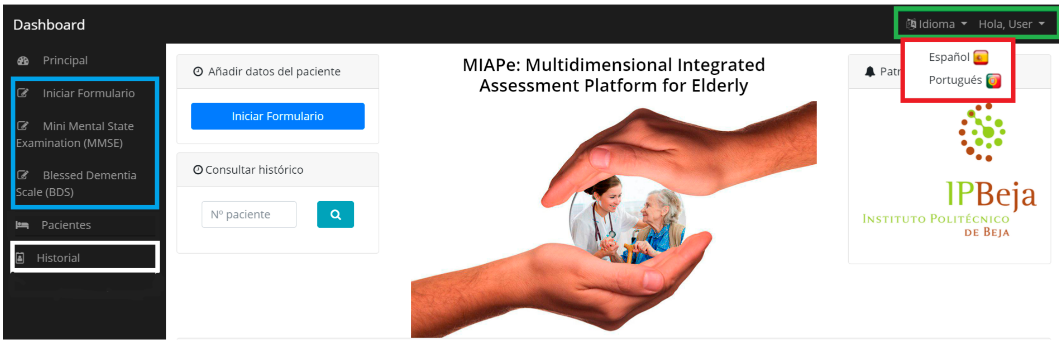

Figure 5.5: MIAPe Home Page

(MMSE, BDS and ENCS).

In the area to the left and at the bottom, the rectangle is now white. In this section we highlight the history of users.

On the other hand, from the right side, above we can see a green square in which you specify the user name. In our platform there are two types of users, the administrator mode that is created automatically when you first start the website and the user mode, which are the rest of people who join the platform. The main difference between the two modes is that the administrator has access to deleted editions and insertions of multiple database tables, while the user can only make insertions related to patient questionnaires.

Finally and in the part marked in red we find the two languages that the platform is developed (Portuguese and Spanish).

In order to have a more specific view on the questionnaires of the platform, below is a screenshot of each type of questionnaire:

- The following image corresponds to the ENCS questionnaire following the CIF rules. The sections are divided like this. A question, a slider bar to move the bar according to the degree of severity of that question, a "+" button that displays a dialog box showing relevant information for the health professional to evaluate this issue and a set of successive questions in the same way.

  Similarly, in order to simplify the understanding of the questionnaire for injuries to the elderly, images of the human body have been used. These images are selectable and the damaged part of the body can be chosen. It is only possible to choose one part of the body, as it is considered to

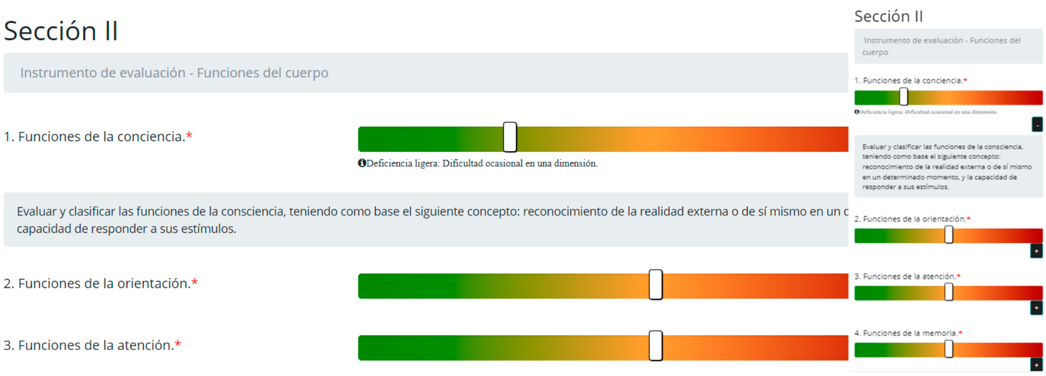

Figure 5.6: ENCS Questionnaire

be the most serious. In addition, in the centre of both images, the body part that has been selected appears in a text four, as can be seen in figure 5.7.

Figure 5.7: Selectable body parts

- The image below corresponds to the BDS questionnaire [31]. This questionnaire is based on basic questions and is listed according to a range of values. These values are static and start with the 0 in which there is no deficiency, then there is the 0.5 which means you have a slight deficiency and finally, the 1 which has a complete deficiency.

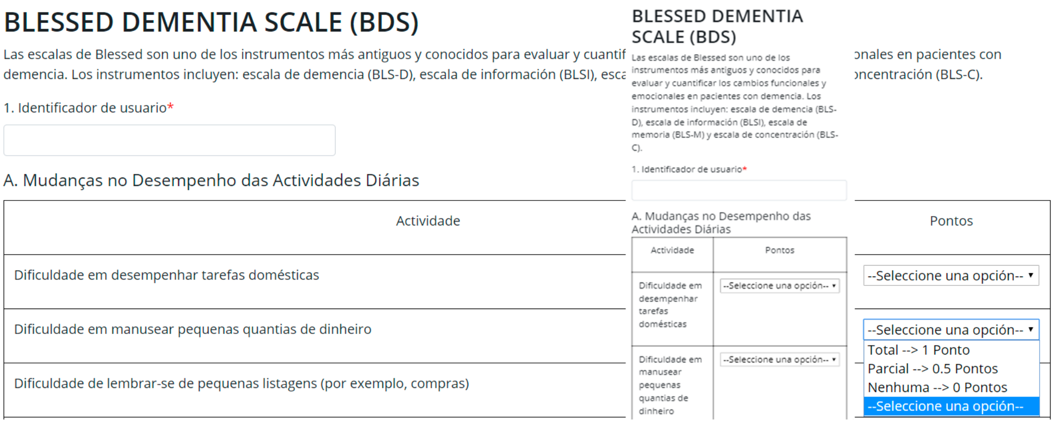

Figure 5.8: BDS Questionnaire

- Finally, in the following image we have the MMSE questionnaire [32]. Unlike the previous ones, this questionnaire is an affirmative or negative answer. It is only possible for the patient to be able to answer the question correctly or not, but there is no mean interval as in the previous ones.

Figure 5.9: MMSE Questionnaire

On the other hand, another important section is the patient's history. This history contains an overview of the patient's progress. The history shows the patient's data, the evaluations ordered by evaluation day and allows to download a PDF version. Within the evaluation day, the evaluation percentages are shown according to an internally developed statistical formula. These percentages correspond to the dysfunctional degree of the elderly person. And they are ordered around this rating:

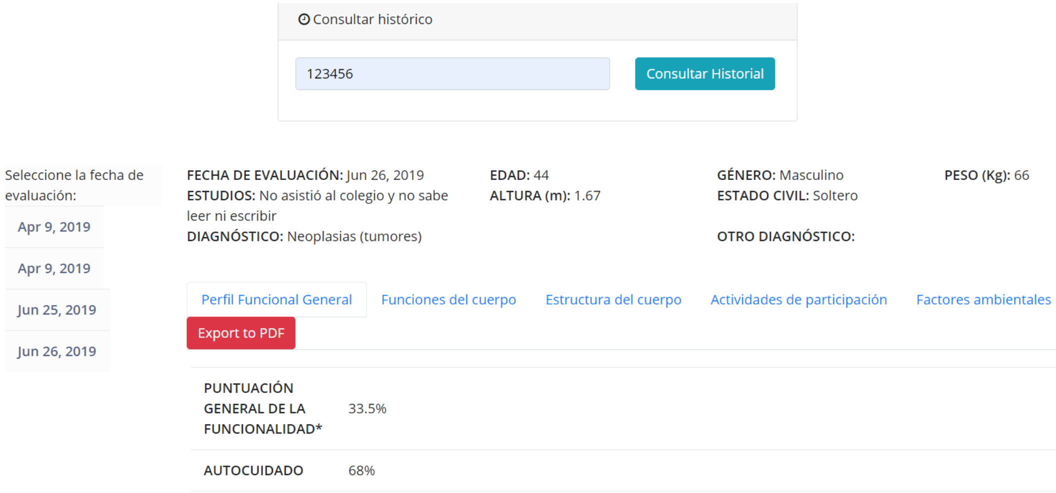

Figure 5.10: Patient History

- No deficiency: 0 - 4%
- Moderate deficiency: 25 - 49%
- Severe deficiency: 50 - 95%
- Complete deficiency: 96 - 100%

Both the statistical formula and the percentages have been extracted from the study [33]. This study has been developed by researchers from Évora (Portugal) with whom we have collaborated in the development, as we have already mentioned in the section on BDD. In this study, the percentages that have been established are indicated, and what they are based on to affirm these values. To make this part more visual, we can observe in the following image, a history of a patient, with all its calculated data.

5.3.2 Server

On the server side, the server is developed in NodeJS version 8.12.0. Besides, Node needs a framework (in this case Express.js) to communicate with Angular.js in a simple way. For the database, MYSQL has been used in its version 5.7.26.

The first versions of the platform were added to a docker container since the main objective of this platform is to install it in various institutions and that these at the same time, can act independently. Thanks to the docker container the implementation of the platform is simpler.

AWS

Once we had everything developed, the platform was taken to an instance of Amazon, this first time, free instance Amazon Elastic Compute Cloud (EC2) in particular, the instance t2.micro. Amazon EC2 provides scalable computing capability in the Amazon Web Services (AWS) cloud. Using Amazon EC2 eliminates the need to initially invest in hardware, so you can develop and deploy applications in less time. Amazon EC2 can be used to launch as many virtual servers as you need, configure security and networks, and manage storage. Amazon EC2 allows you to scale up or down to control changes in requirements or popularity peaks, reducing the need to forecast traffic [34].

Amazon EC2 provides a wide selection of types of instances optimized to adapt to different cases of use. Instance types span various combinations of CPU capacity, memory, storage, and networking. They give you the flexibility to choose the right mix of resources for your applications. Each instance type includes one or more instance sizes, allowing you to scale your resources according to the requirements of the target workload [2]. The large groups types of Amazon EC2 instances are:

- General use
- Optimized for computing
- Optimized for memory
- Accelerated computing
- Optimized for storage

The instance used EC2 is in the general use group and corresponds, within the group, to the t2 calls. T2 instances are scalable performance instances that provide a base level of CPU performance with the ability to expand above the base level.

Unlimited T2 instances can retain high CPU performance for as long as a workload requires it. For most general workloads, unlimited T2 instances

Modelo	CPU virtual*	Créditos por hora de CPU	Memoria (GiB)	Almacenamiento	Rendimiento de red
t2.nano	1	3	0,5	Solo EBS	Bajo
t2.micro	1	6	1	Solo EBS	De bajo a moderado
t2.small	1	12	2	Solo EBS	De bajo a moderado
t2.medium	2	24	4	Solo EBS	De bajo a moderado
t2.large	2	36	8	Solo EBS	De bajo a moderado
t2.xlarge	4	54	16	Solo EBS	Moderado
t2.2xlarge	8	81	32	Solo EBS	Moderado

Figure 5.11: Types of T2 instances [2]

will deliver extensive performance at no additional charge. If the instance requires greater CPU usage over an extended period of time, you can also do so with an additional fixed charge of 5 USD cents per hour of virtual CPU.

Base performance and expandability are governed by CPU credits. T2 instances receive CPU credits continuously at a fixed rate based on instance size, accumulating CPU credits when inactive and consuming them when active. T2 instances are a good choice for a variety of general workloads, such as microservices, low-latency interactive applications, small and medium databases, virtual desktops, development tasks, build and test environments, code repositories, and product prototypes [2]. The types of EC2 instances are those shown in figure 5.11. Specifically, for this first version of the platform, the selected orange instance was used.

For later versions, we started using the t2.small located just after the orange reference in the previous figure 5.11, because it was necessary to add more memory to the instance in order for it to boot correctly and not give any memory failure.

5.3.3 API

The API specification was made through OpenAPI-Swagger 3.0. The OpenAPI specification (formerly Swagger specification) is an API description format for API REST [35].An OpenAPI file allows you to describe your full API, including:

- Available endpoints (/users) and operations at each endpoint (GET /users, POST /users).
- Input and output parameters for each operation.
- Authentication Methods.
- Contact information, license, terms of use and other information.

API specifications can be written in YAML or JSON. The format is easy to learn and readable for both humans and machines.

OpenAPI is built through Swagger, a set of open source tools created around the OpenAPI specification that can help you design, build, document, and consume REST APIs[36].Swagger's main tools include:

- Swagger Editor: browser-based editor where you can write OpenAPI specifications.
- Swagger UI: represents the OpenAPI specifications as interactive API documentation.
- Swagger Codegen: generates server appendices and client libraries from an OpenAPI specification.

In particular, Swagger Editor was used to develop the platform [37]. Following the OpenAPi specification and with the interface provided by this tool, it is possible to create an API in a very simple way, having a final vision of the specification. On the other hand, the file can be downloaded in multiple languages, in our case has been a file .yaml. Also, to make the development easier, from Swagger Editor, it is possible to download the server in NodeJS, which allows to integrate it to 100% in our platform.

5.3.4 Smart Devices

For our proposal, as mentioned in previous paragraphs, it would be possible to integrate a large number of intelligent devices to our platform. But, according to the study we are following, for now, the devices we will use will be:

- Smart band: The bracelet used in our case is a Xiaomi Miband 3, for more information or features of this device can consult the following link: https://www.mi.com/es/mi-band-3/. With the bracelet we will be able to measure the steps, distance (km), calories, the percentage of battery and finally the cardiac rhythm.
- Oximeter: This oximeter is from the oximeter we can indirectly obtain the oxygen saturation of the blood. In our case, we are studying the possibility of obtaining the data, since it is a certified device, which implies a greater security and an expensive access. The device used is Pulse Oximeter from IHealth. For more information: https://ihealthlabs.com/fitness-devices/wireless-pulse-oximeter/
- Scale: The scale, like the first device, belongs to Xiaomi, its name is Mi Body Composition Scale, for more features check https://www.mi.com/es/mi-body-composition-scale/. With this, we can measure the patient's weight, bone mass, BMI, body fat, muscle, water, protein and visceral fat.

With these three devices we can detect possible ailments early or something like that, not that we prevent any health problem. Thanks to these data, in the future we will be able to prevent any health problem of the patient. In this section we integrate the PeaaS to add to the smartphone a set of relative information of the patient and from there the health personnel will take charge of collecting it in their history.

At the moment, in the history, we have a graph in which it details the number of steps of the person daily, according to his smart band, as we can see in the image next:

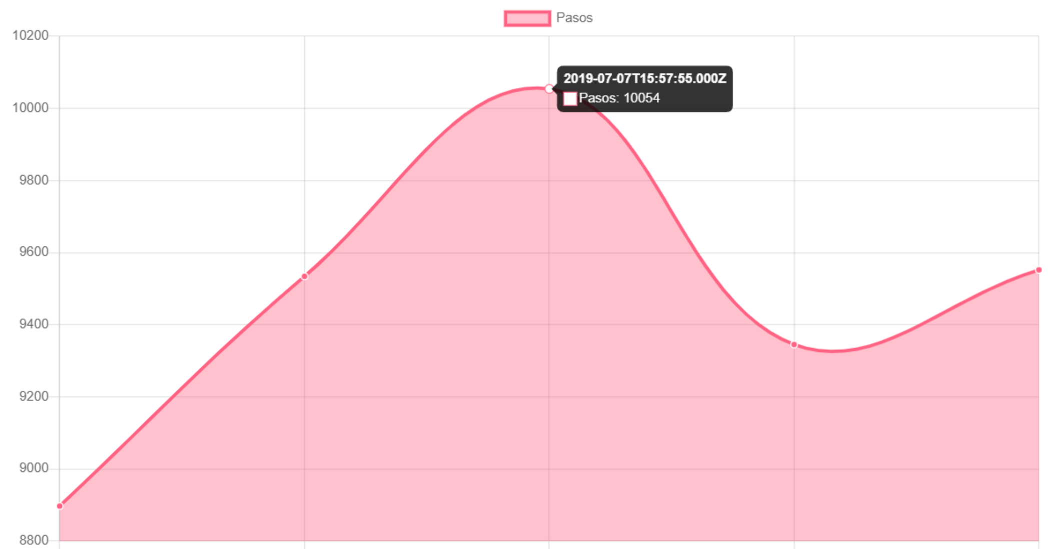

Figure 5.12: Step measurement with smart band

5.4 Deployment

The website is currently in production in Évora. Different people related to the health area are testing the platform. During the 15th and 16th of July, it will be presented at the Summer Schools on Gerontechnology 2019 in Portugal, in a permanent stand to which everyone can access, and the former Minister of Health of Portugal, will be one of the attendees of the event and will perform tests on our platform.

Chapter 6

State of the Art

Once the proposal is detailed, it is necessary to compare our developed platform with the platforms and/or applications currently on the market. According to previous studies carried out in the literature, as far as we know, there is currently no known tool that has the same features and functions that we have developed. In this chapter, comparisons will be made with other applications developed to help the elderly in their daily life, their family or caregivers to have control of this group of people. The most relevant applications found in this field may be the following:

- An application that allows us to interact with the mobile device can be Safe365 [38]. Application designed to care for the elderly from a distance, developed for Android and IOS. This APP sends locations to family members in real time, as well as the status of the mobile. In addition, habitual locations of the elderly can be stored, which implies that when leaving those established zones, the app will send a notice to the person in charge of the elderly. On the other hand, they send warnings when the elder's battery is about to run out. One of the most striking features it has is an emergency button called a panic button to ask for help from family members, so when the elderly is in poor condition, you can press this button and call the emergency services and send notification to family members. It works for everyone for free.

  Unlike our platform, this application allows you to locate a person, but you can not constantly monitor their heart rate, heart rate, pulsations, weight, etc. In addition, thanks to MIAPe we also have the possibility that not only is controlled by a family member or caregiver but also by a health professional with such a large amount of data, can sense a worsening in the person and be able to act on it. In addition, it is not completely transparent to the user as it requires a button warning of a dangerous situation or, where appropriate, a change in the health of the elderly.

- Another solution based on IoT can be We-Care [39].In this case they used an intelligent bracelet as a means to enable a more personalized, preventive and collaborative form of medical care. They built a wristband called We-Watch that is capable of monitoring and recording vital patient information, as well as providing mechanisms to activate alarms in emergency situations. Thanks to its low cost, low consumption and finally that it is wireless, make it can be used anywhere. They carried out numerous experiments and demonstrated a good performance of the system for the implemented features and the autonomy of the wristband was around 306 hours.

  Comparing these functions with our platform and our devices. In addition to a smart band we also have other devices (such as the scale and the oximeter) and thanks to which we can monitor and extract more information for the context that surrounds us is even richer. In addition, we also have the part of the web platform, thanks to which we can observe the data belonging to those devices and be able to take a more personalized control.

- An example between an intelligent device and a mobile app can be the Abuelómetro. [40]. Real-time health monitoring system for older adults living in nursing homes. The system was developed to help caregivers have better control over their patients' health monitoring and have closer communication with their patients' families. They built a prototype using a biometric bracelet connected to a mobile application, which allows real-time visualization of all the information generated by the sensors (heart rate, body temperature and blood oxygenation) in the bracelet. Using this data, caregivers can make decisions and intervene in the outgoing state of their patients. The application consists of a login to which only the caregiver has access, the medical history, a part of communication with the family through instant messaging which allowed direct communication of caregivers and family members. Remote monitoring where the caregiver can view the information generated in real time through sensors in real time. Finally, the alert notifications, through algorithms that analyze the data obtained in real time, so that if it detects a deviation from normal parameters, the screen will indicate the alert using color codes, depending on the severity. These notifications are sent to the caregiver and the family member in charge of the elderly (data stored in the history).

The main difference in our developed work is that it can not only be used in geriatric residences, but that the elderly will have certain intelligent devices at home. These devices send the measurements to the mobile and these are stored internally in the device. After this, the health professional will be able to collect data from the device through the platform and will be able to have a detailed control of all its parameters.

Chapter 7

Conclusions and Future Work

In this work, a new version of the multidimensional functionality evaluation platform has been developed. This platform has added two types of questionnaires, which are Blessed and Minimental. In the ENCS questionnaire the final statistics have been corrected as they did not follow the parameters established by ICF. IoT devices such as the wristband and the scale have been added. In addition, this information communicates with the platform through an API also developed. The data are stored in the person's smartphone and when the health personnel indicate it, it is obtained in the platform. Also, graphs have been added corresponding to the daily steps and weight of the person, in addition to obtaining more information from the wristband to know the battery level, calories, kilometers travelled, etc. Therefore, in conclusion, we can say that we have met the objectives set at the beginning of this work.

As far as future work is concerned, the maintenance of the platform will continue, since, as we have commented previously in the document, it is currently in production in Portugal. The historical information will be updated with the Blessed and Minimental questionnaires to provide more information to this section. On the other hand, following in the history section, its design will be modified in order to have a more complete view of the daily evaluations and to be able to make comparisons at a glance. Users and administration will be improved, as in the future this platform will be deployed in large hospitals. These centers have a multitude of staff, whether doctors, nurses, administrative, etc.. According to the position entrusted in the company, these people will have a different dashboard available according to their credentials. For example, a doctor will have information about all the patients he treats, but will not have access to the centre's economy, such as the economist. Finally, with regard to IoT devices, the platform will fully integrate the oximeter commented and a blood pressure monitor that is already being researched.

All this data will grow and with it, the information related to the patient.

Chapter 8

Personal Reflection

As we can see throughout the work developed, the data obtained by the platform can be of great relevance. Mixing our technological area with the health branch, can help to simplify the work for nurses, doctors... Currently the means used by health professionals to evaluate people are not current and do not integrate IoT devices that can help them to have more relevant information of the patient.

As we have discussed in previous chapters, the oximeter we have in our work (iHealth Air (PO3M)) is an approved product with a health and safety certificate. This implies that they have a great commitment to patient data. This product, as well as the others that present a homologation, its objectives are to guarantee confidentiality, accessibility and traceability. Therefore, in this work it has not been possible to integrate this device into the developed platform. The security is very high, which does not allow access to data or even the connection of the mobile with the device's own Bluetooth, because when trying to access from an application other than yours, asks for a pin code to access the Bluetooth connection, which we do not have.

To solve these security problems, it is starting with the collaboration of a Portuguese company, responsible for creating custom IoT devices. That is to say, from a specification, they manufacture the device. This way we will be able to obtain the data easily and we will not have security problems as it was happening to us.

Personally, I think it's been a long and hard work, especially in the early stages of development. In addition, the visits to Évora (Portugal) made to check that everything was going well were at first complicated by the change of language. As the project progressed, the development became calmer and the understanding with the people of Portugal became easier.

The platform that was originally created for the exclusive use of 4IE researchers, as time has gone by, solutions have been taken and put into production. For this reason, we still have a long way to go, changes in functionality, design and even more importantly, add security to the platform, as we can deal with sensitive patient information.

I think that in the near future, where we have millions of IoT devices around us, we will need tools that integrate all these devices. Also relating it to the elderly, these devices will be able to help health professionals to manage people's needs, diseases, that is to say, help them to improve their quality of life.

Appendix A

User guide

To test the platform, we currently have deployed an instance in Amazon, which can be accessed through the following URL: http://4ie.spilab.es/multidimensional2. In addition, for access, we have two existing users:

- Administrator mode:
  - user: admin@admin.com
  - pwd: admin

- User mode:
  - user: user@gmail.com
  - pwd: user

Next, we will make a user guide to test the platform.

A.1 Login

Registration is required to login. To do this, you must login to create an account:

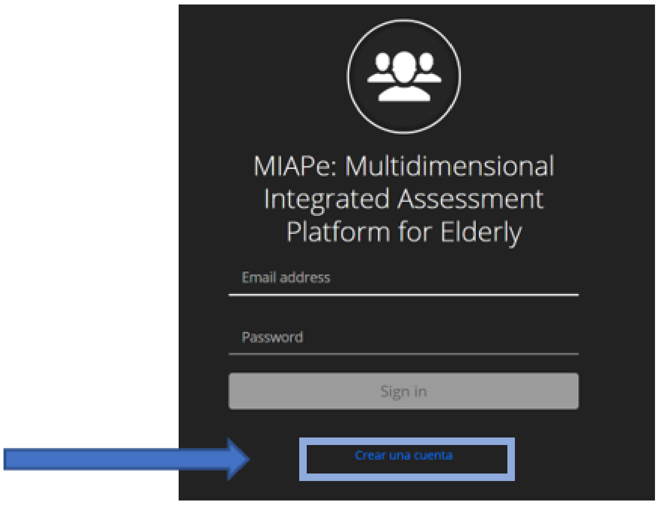

Figure A.1: Login main screen

A.2 Register

The next step will be to fill in all the data of the registration form. It is important to note that the password must be a succession of letters or numbers or both, but must always have a number greater than or equal to four. The email must always contain the @ symbol. Finally, click on "create account".

The next page will be to confirm the registration. Pressing the button that appears, we will access the main page of the login, as we can see in the first image. We will fill in our data as we have specified in the registration and we will access the main page. It will show us a page like the next one:

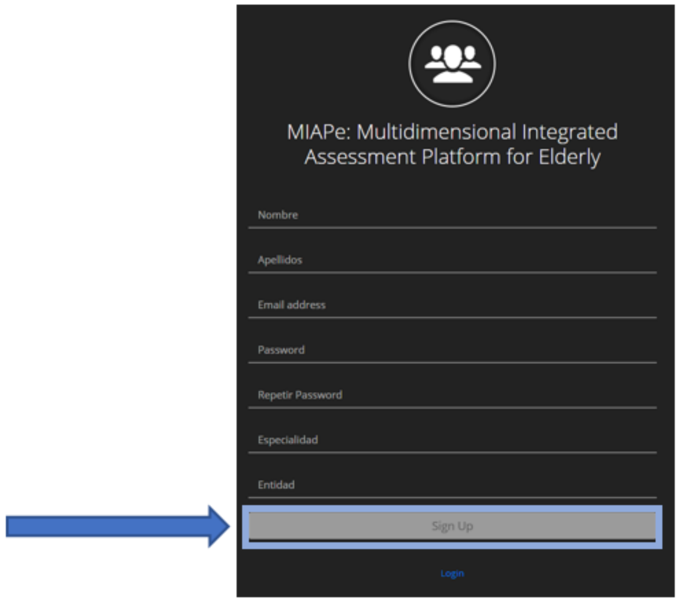

Figure A.2: User registration

Figure A.3: Platform main page

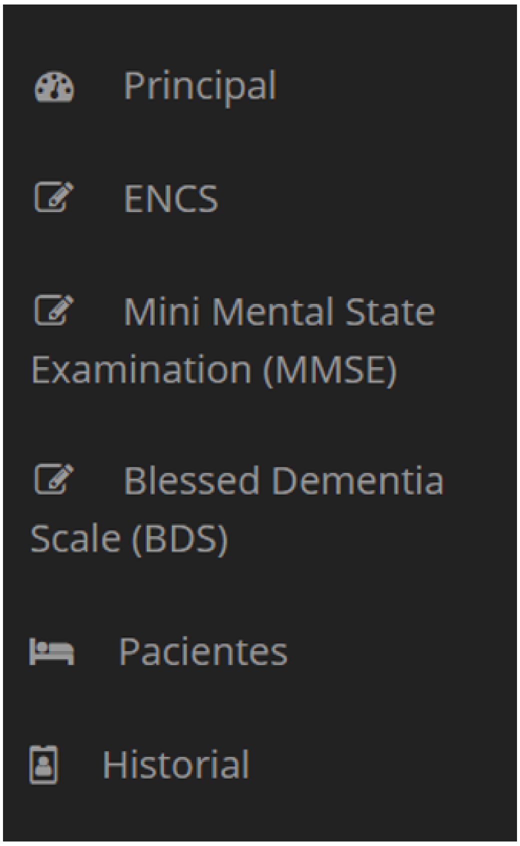

Figure A.4: Main page menu

At the top left, we have all the functions that will be relevant to our use. The first link, called "Main", corresponds to the dashboard, that is, the home page of the web when we enter (corresponds to the image above). Then there are three forms:

- ENCS
- MMSE
- BDS

These three forms will be explained in more detail later in the document. Next, we have the patients, through this link we will access the patients who are on our platform and who have been registered from the ENCS form. The history will show the evaluations made of the patient we want.

A.3 Elderly Nursing Core Set (ENCS)

This type of form can be accessed from the left sidebar of the main page or from the "ENCS" button on the main page corresponding to the "add patient data" section. Our page will be shown in the following way, as we can see in the image. It is necessary to follow the following detailed tips after the image, for its correct use.

In order to successfully complete the changes, the following recommendations must be followed. All fields marked in the questionnaire with * must be filled in .The fields that are not marked, it will not be necessary to fill them. For the user ID, located in the upper left image in blue, must be: always a number of up to 11 digits and this number will be unique to each patient, it will be the number we identify with to our patient (never enter letters). In addition, in some fields, it is specified how should be the format to be entered, in the case of weight, number eight, is in KG and separated by "," just as the height is in meters and separates with ",".

Figure A.5: Elderly Nursing Core Set (ENCS) Questionnaire

In the following sections of the questionnaire, we will find this type of answer. This bar has a total of five positions to move, according to the five colors that appear. From left to right according to the severity of the patient. When moving the bar, just below it, there is an explanation of the degree of severity that we are selecting. If we don't understand the type of question, we have a black button on the right that displays a gray box with more information about that question. As in the previous sections, it is necessary to fill in all the fields with *.

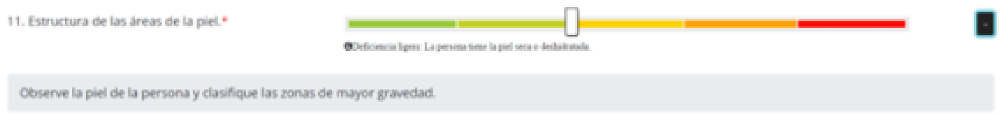

Figure A.6: ENCS questionnaire questions

In addition, some sections of the questionnaire refer to injuries to the body. For this, we have two dolls like the following. In order to be able to evaluate these areas, only one part of the body needs to be pointed out. If we want to change the selection, we must click on the selected part, so it will return to its original color (light blue) and from there we can select the new part. In other words, only one part of the body can be selected.

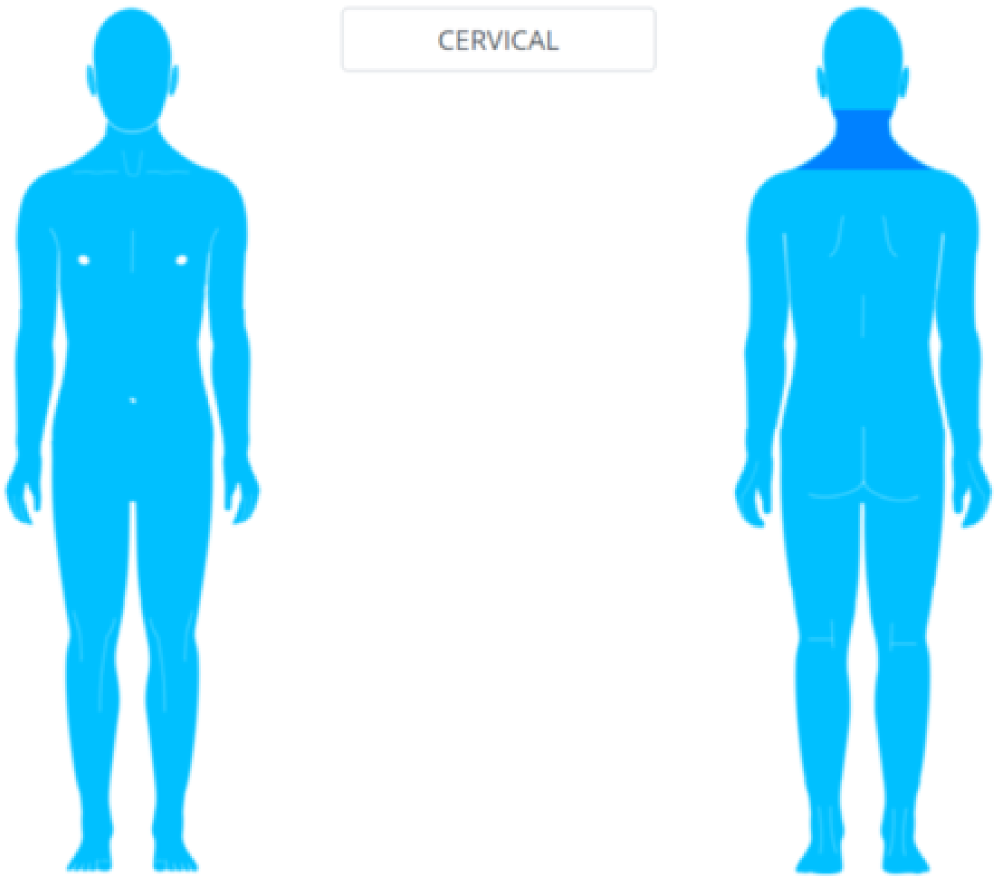

Figure A.7: Parts of the human body

A.4 Mini Mental State Examination (ENCS)

This questionnaire has a different structure to the previous one, as I have commented in the ENCS, all the fields marked with * are mandatory to fill in, the rest may be empty. For this questionnaire, the person in charge of the patient will ask a series of questions or tests as specified in the questionnaire and the only thing you will have to answer is YES or NO, if the patient has answered your question correctly. The user identifier located in the first field of the form must be the same as that specified in the ENCS for the same patient, so we can relate both questionnaires on the same patient.

Figure A.8: Mini mental state examination

A.5 Blessed Dementia Scale (BDS)

In this questionnaire, all fields must be filled in. In the first section, indicated in orange, there is a drop-down menu, in which the difficulty that a person presents to be able to carry out a daily activity will be evaluated through a scale from 0 to 1. In the second part of the questionnaire (marked in blue), only one option of habit changes will be selected. Finally, in the section marked black, it is necessary to indicate each of the changes in personality and behaviour, whether or not the patient fulfils the task.

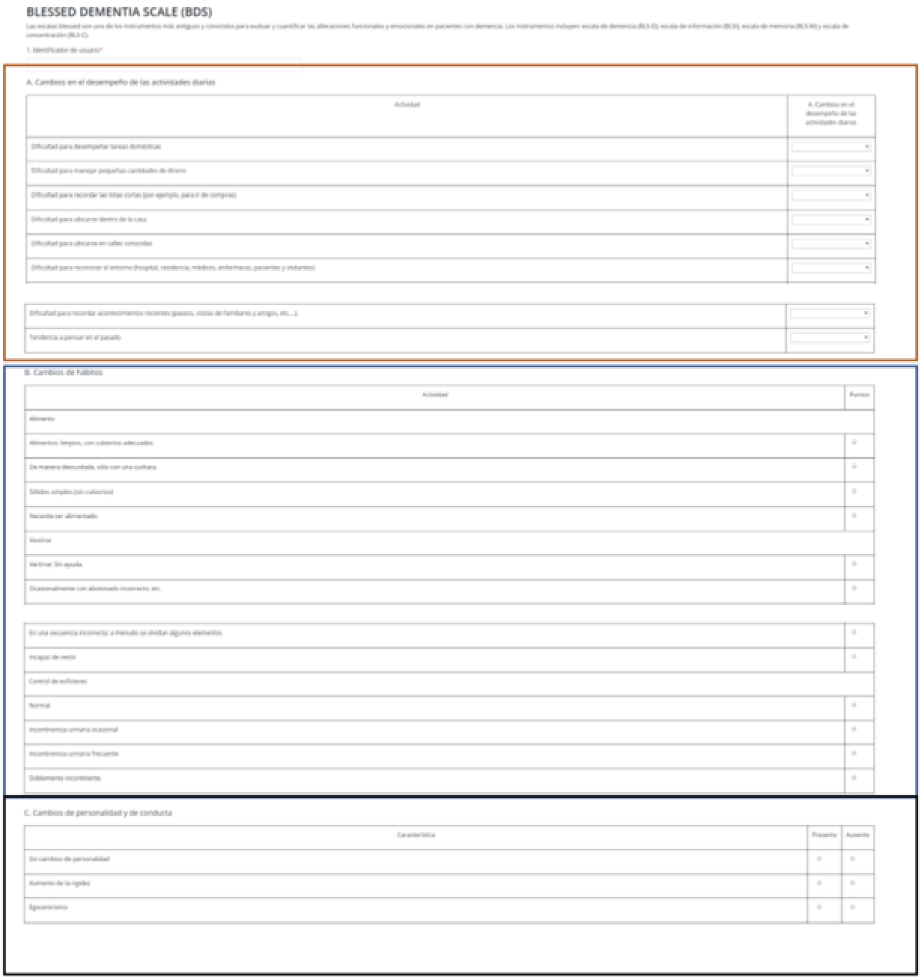

Figure A.9: Blessed Dementia scale examination

A.6 History

In order to consult the patient's history, we must enter the unique identifier of that patient in the search engine and press the "search" button. Next, click on the evaluation date that you want to consult and we will obtain the data from that evaluation. Finally, we can generate the PDF of the evaluation of the selected history by clicking on the "generate pdf" button.

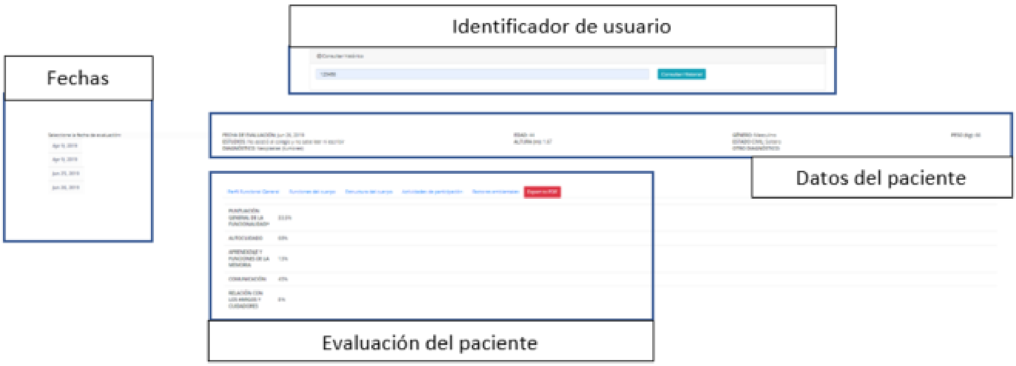

Figure A.10: History of registered patients

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