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Dissertação apresentada ao IADE - Faculdade de Design, Tecnologia e Comunicação da Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Design de Produto e do Espaço realizada sob a orientação científica da Doutora Hande Ayanoglu Vangolde do IADE, Universidade Europeia, e do Doutor Bruno Miguel Correia Silva do IADE, Universidade Europeia.

English Abstract

Assistive technology-based innovation is a promising idea that aims to achieve and improve the well-being of humans. Currently, the focus of technology has changed, seeking to serve specific populations, especially the elderly, reducing the barriers they face on a daily basis when conducting outdoor activities. Most research carried out in an assisted environment is concentrated mainly in private spaces, such as homes, nursing homes and others. This research aims to propose design solutions based on the concept of an assisted environment on a city scale. By doing so, the elderly population can experience and live in collective and public environments (specifically in a public park) independently. In this context, interviews with specialists and observation studies were developed to understand the problems and needs of this specific population. Interviews were targeted to obtain insight from experts regarding the use of technology to solve the elderly's problems in cities. However, the results did not give adequate insight to use within the study. Next, observations were also carried out in a public park in Campo Ourique, Lisbon to acquire insight from the field to observe/witness the problems of the elderly from a first-person point of view. The observation results showed the difficulties that the population in question faced. Consequently, design solution ideas were proposed to design a smart public park which might overcome the problems that were found in the literature and in the user observations. During the observations, it was seen that the elderly population is very active and highly values an outdoor space to spend time. In this sense, the design proposal could improve and facilitate the lives of the elderly, seeking as much as possible to reduce the barriers that were both observed and reported by experts throughout the interviews. Due to COVID-19, the study had limited access to the users and an evaluation phase could not be done. However, as a future work, user studies will continue to discover more about the elderly's problems and eventually the scenarios and proposed solutions will be evaluated by them. Furthermore, applicability, usability and feasibility of the proposed ideas will be tested by more users (i.e., experts, stakeholders).

Portuguese Abstract

A inovação baseada em tecnologia assistiva ainda é uma ideia promissora que visa alcançar e melhorar o bem-estar dos humanos. Atualmente, o foco da tecnologia mudou, buscando atender populações específicas, principalmente os idosos, reduzindo as barreiras que eles enfrentam no dia a dia na realização de atividades ao ar livre. A maioria das pesquisas realizadas em ambiente assistido concentra-se principalmente em espaços privados, como residências, asilos e outros. A pesquisa tem como objetivo propor soluções de design baseadas no conceito de ambiente assistido à escala da cidade, onde a população idosa pode vivenciar e viver os ambientes coletivos e públicos (especificamente num parque público) de forma independente. Nesse sentido, foram desenvolvidas entrevistas com especialistas e estudos de observação para entender os problemas e necessidades dessa população específica. As entrevistas foram direcionadas para obter *insights* de especialistas sobre o uso de tecnologia para resolver os problemas dos idosos nas cidades. No entanto, os resultados não forneceram percepções adequadas para serem usadas no estudo. Em seguida, foram também realizadas observações num parque público do Campo D'Ourique, em Lisboa, para obter *insights* do campo para observar / testemunhar os problemas dos idosos do ponto de vista da primeira pessoa. Os resultados da observação evidenciaram as dificuldades enfrentadas pela população em questão. Consequentemente, ideias de soluções de design foram propostas para projetar um parque público inteligente que pudesse superar os problemas que foram encontrados na literatura e nas observações do usuário. Durante as observações, percebeu-se que a população idosa é muito ativa e valoriza muito um espaço ao ar livre para passar o tempo. Nesse sentido, a proposta do projeto poderia melhorar e facilitar a vida dos idosos, buscando ao máximo reduzir as barreiras que foram observadas e relatadas pelos especialistas ao longo das entrevistas. Devido ao COVID-19, o estudo limitou-se ao acesso aos usuários e não foi possível realizar a fase de avaliação. No entanto, como um trabalho futuro, os estudos de usuários continuarão a descobrir mais sobre os problemas dos idosos e, eventualmente, os cenários e as soluções propostas serão avaliados por eles. Além disso, a aplicabilidade, usabilidade e viabilidade das ideias propostas serão testadas por mais usuários (ou seja, especialistas, partes interessadas).

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1. Introduction

This study is a final master degree research aiming to make an intervention in a public space to improve the conditions of the elderly. The main idea of this work is to enhance the wellbeing of the elderly in outdoor spaces. Studies show that on a daily basis, they face hazards and barriers that prevent them from being active and performing daily outdoor activities (Barnsley *et al.*, 2012). Previous research showed that most of the ambient assisted living, are focused in indoor environments, such as smart homes, using information from sensors in the environment and on the person (Rashidi & Mihailidis, 2013). However, if the solutions can be implemented within an outdoor scale, the elderly can perform more activities. This can play an essential role in increasing the quality of life and autonomy of the elderly. Mostly, outdoor assistive technologies are based on wearable devices that the elderly do not feel comfortable wearing (Li *et al.*, 2018).

While researching risks and undesirable situations the elderly population face in their outdoor daily activities, it was possible to find some that are more frequent, such as, indoor falls are generally common in inactive older people, whereas outdoor falls are more common in healthy older people (Duckham *et al.*, 2013). The frequency of going out is a useful indicator for frailty for physical function and health related quality of life among elderly. A potential idea can reduce the burden and cost of giving care to elderly people while maintaining safety and autonomy (Sou-Young Jin, 2012).

The research provides a look into how smart technology may help elderly population properly when adapting the environment to the user instead of adapting the user to the environment. In this sense, for this work, naturalistic observations were made to understand the behavior of the elderly in a specific outdoor space in Lisbon. An analysis of behaviors, patterns and activity flows will be analyzed to obtain opportunities to introduce assistive technologies. This specific paper shows the results and analysis of user observation.

1.1 Problem

The elderly population is exposed daily to dangers and barriers that prevent them from being active and performing outdoor activities, these barriers are not only physical, but also psychological and social, as stated (Barnsley *et al.*, 2012). According to the conclusion presented

in a study (Yang *et al.*, 2013), the elderly tends to become less active and more prone to social isolation and loneliness with the decrease in physical activities and social interactions. This data ends up directly influencing the quality of health of these individuals, as well as increasing the probabilities of premature death. As a way of trying to mitigate the consequences, the concept of Ambient Assisted Living (AAL) was developed, being predominantly focused on indoor (residential) environments, capturing and processing information about the elderly, through sensors installed in frequently used rooms and objects (Rashidi & Mihailidis, 2013)

1.2 Motivation

This work will be developed, based on the problems that exist today in relation to the elderly population, and all the limitations that they may face while living their daily lives in big cities, whether due to limitations inherent to each one of them, or even, limitations of space, (i.e., problems of conservation of public space, lack of spaces / activities aimed especially at them, or even inability to follow technological development). As a result of this, there will be a wide review of literature that will seek to better understand the study gap. The study gap being, the interaction of the elderly with the city, through technology, in public and outdoor space.

1.3 Objectives

The main objective of the research is to propose smart solutions for a public park, namely Jardim Teófilo Braga, to solve the problems that elderly people face. For this purpose, secondary objectives are defined as:

1. To investigate literature reviews based on the current population, smart cities and smart outdoors;
2. To obtain expert opinions regarding problems and possible solutions of the elderly in the context of a smart city;
3. To investigate risks and undesirable situations that the elderly face within the public park through observations.

1.4 Critical factors for success

During the preparation of this work, two critical points were observed, the first of which was to be able to get in touch with experts in order to collect the necessary information. The second was to be able to get in touch with the elderly, in order to better understand the needs, they had for the park. Both situations were strongly affected as a result of COVID-19, which made the interviews with experts online, due to limited contact. Due to COVID restrictions interviews with the elderly, were not possible through an online means.

1.5 Study diagram

Based on the User-Centered Methodology, this study was divided into six distinct stages, as shown in Figure 1.

Figure 1. Study diagram

1.6 Document organization

In the first chapter, there is a brief explanation of what led the author to develop this work, also the problems, research questions and contributions. In the second chapter there is a background review which will present research on the topics that structured this work, such as Elderly; Smart city; Smart Outdoor; Smart solutions for the elderly; Smart devices; Smart projects. The third chapter divulges the state of the art, and the existing solutions based on the main subjects of this work, such as Smart solutions for elderly, smart devices, and smart outdoor projects. The fourth chapter explains the methodology used to develop the entire research. The fifth chapter explains the parks involved in the investigation of this work, starting with the observation, then the interviews, personas, scenarios to finally reach the smart proposal of the park. The sixth chapter presents the conclusion of this work, and also some limitations that showed up during the development, and also future work. The seventh chapter presents all the references used to build this work.

1.7 Contribution

This research has 2 main contributions. A part of the project was presented in an international conference and another part of the project was accepted as a paper in an international conference to be presented. The references are as follows:

(accepted paper) Satte, F., Silva B.M.C., & Ayanoğlu, H. (2021, July). Elderly in Outdoor Environment: Naturalistic Observations. 12th International Conference on Applied Human Factors and Ergonomics (AHFE 2021).

Satte, F., Silva B.M.C., & Ayanoğlu, H. (2019, November). Elderly in Outdoor Environment (Unpublished presentation). 10th UNIDCOM/IADE International Conference Senses & Sensibility – Lost in (G)localization, 27-29 November. Lisbon: Sociedade de Geografia de Lisboa.

2. Literature Review

In this chapter, the concepts and studies carried out up to date in the following disciplines will be discussed. Elderly; Smart city; Smart Outdoor; Smart solutions for the elderly; Smart

devices; Smart projects. Each of these themes will assist in the development of a scientific basis for this research. Bearing in mind that this study seeks to propose solutions to the problems faced daily by the elderly who live near the district of Campo de Ourique and use the *Jardim da Paragem*, as a space for leisure and socialization. The literature review, elaborated in an objective way and directed to the main subjects to be addressed, works as an excellent source of knowledge for the development of this study.

After collecting and analyzing some articles to be addressed in this section, it can be concluded that when research is done on the subject of Smart Outdoors, aimed at the elderly population, there is a great lack of knowledge. The results are always directed to the population in general or directly related to the evolutionary context of Smart Cities and this theme ends up overlooked. This study, in turn, seeks to combine diverse information for future analysis and interpretation, in order to be able to gather all the information in a compendium that will serve as a basis for the rest of the preparation of this work.

2.1 Elderly

Many authors have referenced the slow population growth that started in the 2000s and the consequences that this generated in all modern societies. With the growth of the population in large cities, the elderly population in turn increases, thus, increasing the need for specific services, not only in an urban context, but also in the universal character, to provide a better quality of life for this population. (Mulero *et al.,* 2018) (the cited author declares that the rapid acceleration of the urbanization process seems to be a vital sub-result of the globalization process. As a result, cities become the first housing option for the population. For this reason, architects and urban planners seek new design options for the future of 21st century globalized cities.

Analyzing the population through groups of generations, wrote that the phenomenon called "baby boom", was one of the main causes of age reality today in Europe. (Lanzieri, 2011). In addition, in the second half of the 20th century, the progressive decline in the mortality and birth rate has the most significant consequence of aging in the European population. Migration processes also directly influenced this population gap. Immigrants arriving in new countries are already young adults, or even adults, and end up densifying another group, differently from the others. In the year 2060, almost all, if not all, baby boomers will have already died, and a new generation will be responsible for the title of the elderly.

After analyzing the population context worldwide, states that as the elderly population grows, the demand for health care increases in the same proportion.(Maswadi *et al.*, 2020). For this reason, there is an increase in the search for technologies complementary to the already known treatments to meet the needs of this population group. These technologies, called Smart, help to increase the quality of life of the elderly and are an extra help for caregivers who are responsible for some elderly people.

As reported, in 2040 the world's elderly population would reach 21%. With the number of elderly people growing worldwide (Khosravi and Ghapanchi, 2016). Different types of solutions must be adopted to provide a better understanding of the needs of each citizen, so that it is possible to imagine a sustainable and economic future for society as a whole. Over the years, the human body has different types of weaknesses and behaviors, which are not always viewed positively by the individual or by society. This causes greater vulnerability and exposure to risks when left aside, often bringing more damaging consequences than expected. For this reason, studies have sought to improve the quality of life of the elderly, making them more comfortable and safer on a daily basis. This occurs through the use of Internet technologies, which seeks to monitor daily activities, in addition to, predicting risky situations and unusual behavior in users. Through this more efficient and well-targeted monitoring, as stated, the cost of treatments ends up being reduced, and the results are expected to be more efficient (Mulero *et al,*. 2018).

With the continuous development of the economy worldwide, the number of elderly people increases and the space necessary for them to perform outdoor activities as well (Qingfen, 2019). Currently, in Lisbon, the percentage of the population over 65 is over 28% (Pordata, 2019). For this group, some barriers that are easily overlooked by others, end up being significant conditioning factors of their attitudes, such as loss of vision, difficulty in locomotion in irregular environments and also different types of pavement (Kim, 2018). Thus, public spaces must be designed in such a way as to attract the elderly population to receive them in an inclusive manner, and provide well-being.

Through the evolution of medicine and with the advancement of technology, the population shows an increase in life expectancy. Consequently, this leads to the emergence of health concerns that are more significant than in the past (Gaddam *et al.*, 2019).

When looking at the city from an intelligent point of view, it can be concluded that citizens do not strictly live inside of their homes; they live and interact regularly in communities. Therefore,

individual needs must be met by the place where they live, in order to fully cover needs in all aspects, such as housing, social participation, health, community services, leisure and culture. Thus, being able to make the urban environment more friendly and inviting for the elderly population. For this reason, it is cited Information and Communication Technologies as an essential element for the integration of the home environment with the external environment in order to increase the safety reach of the elderly population, improving the quality of life and decreasing the costs associated with specific care, traumatic powers for the health system (Mulero *et al*,. 2018). To this end, the European Union promotes an investment fund that aims to provide numerous programs that encourage the industry to invest more resources in Ambient Assisted Living (AAL) (Stefanizzi *et al.*, 2017). Thus, seeking to promote the offer of the most innovative and technological system to provide the best service to the population. Such technological advances may be responsible for ensuring a more comfortable life for the elderly and also complete monitoring when taking into account the AAL technology, always seeking to carry out this control in a non-obstructive way and without the user's interference capacity (Mainetti *et al*,. 2015).

A significant part of social life of the elderly occurs due to the involvement with urban life in public spaces. In the same proportion that being outdoors is beneficial for this population, the fact that they do not frequent these spaces is extremely harmful, as this ends up weakening the capacity for perception, cognitive and motor responses. Often the elderly will isolate themselves, presenting cases of depression, a disease that is extremely harmful to their physical and mental health. (Hubl, 2019).

Based on a report prepared by the World Health Organization (WHO, 2019), spaces for the socialization and interaction of the elderly are important factors for improving the quality of life of this population, thus allowing people to remain healthier, independent and autonomous over the years. The creation of spaces that are friendly to the elderly is one of the solutions with greater and faster capacity to respond to the aging of the population, thereby increasing the indices of sustainable life. Through direct contact with these spaces, the elderly create new social bonds, greater involvement with society and greater predisposition to carry out healthy activities, creating environments more suitable for these groups.

The elderly population is being encouraged to leave the house and practice physical activities near green spaces, however, these spaces must be properly equipped to receive this type of operations, some of these specifications being (Zhai *et al.*, 2018).

- Safe spaces providing a favorable place for physical activities
- Spaces with lighting, vegetation and coverage suitable for rainy and / or intense sun days.
- Spaces with support equipment, such as cafes, bathrooms and stores, offering products for daily use.
- Open, organized spaces, with frequent maintenance.

In order to design a suitable space, in addition to these elements, users' needs, such as their behaviors and a pattern that is sometimes repeated, must be taken into account. In addition, it must be considered that the same space can receive different groups during the practice of different activities, and that all must have the same type of conditions.

The elderly population is exposed to risky situations on a daily basis. The severity of these problems increases significantly, as the number of active elderly people in society increases. As a result, the number of elderly people in social isolation and less physical activity increases, sometimes causing premature deaths. (Yang *et al.*, 2013).

The increase in the participation of older people in social activities has been an improvement in the cognitive abilities of those adults with age, thus also improving the quality of life (Krueger *et al.*, 2009).

As presented in a study, the elderly face several barriers that expose them to risky situations (Yared and Abdulrazak, 2015). Three of the biggest causes are presented by the author in this study, and also the most frequent consequences, which are:

- Psychological: resulting in fear of additional dangers and risks, anguish and embarrassment.
- Social: results in loss of independence, mobility and social ties, in addition to a high probability of moving to a home / health establishment / care.
- Financial: results in high costs and medical efforts linked to the treatment of risky situations. This burden can fall on governments, health insurance and family members.

It is widely reported that falling is one of the main factors that is harmful to the elderly population. This implies high recovery costs, and possible complications that may result in some type of limitation. This type of problem, in addition to the factors already mentioned, can occur due to the weakening of the muscles of the lower limbs, due to a sedentary lifestyle (Moreland *et al.*, 2004).

According to reports, falls of the elderly in outdoor environments are almost always during the climbing of steps (Chippendale and Lee, 2017). When falling, the individual is rarely able to soften the impact in order to reduce injuries. Usually, waiting for medical care is necessary and accompanied by third parties who make the call to the emergency room. The causes of falls in indoor and outdoor environments always result in injuries in the same proportion which are almost always dangerous, but for different reasons. Whether due to medication, irregularities in the pavement, lack of balance or flexibility.

In a study presented by Şansal *et al.* (2020), with the increase in sun exposure, the elderly showed a significant improvement in the quality of sleep, thus having less night disturbances. This study concluded that a 63% increase in sun exposure in the elderly population studied, resulted in improvement of the well-being of this group. A study reports the direct relationship between decreased sleep quality and a greater tendency to fall, decreased motor activities and chances of death for the elderly population (Neikrug & Ancoli-Israel, 2010).

According to Gabriel and Bowling (2004), one of the main topics mentioned, when referring to quality of life, is having a good interpersonal relationship, support when necessary and living in a neighborhood where it is pleasant, comfortable and possible to carry out activities outdoors with tranquility and security, whether for specific events or leisure. Staying active in society and also socially is a factor that directly influences the psychological perspective of the elderly population. Dependence is always seen as a harmful and limiting factor, whether through fear, trauma or even the simple result of a long-confined time. This study also mentions that many of the elderly after retirement, affirm that they will now have more time to dedicate themselves to what pleases them, either learning new activities or participating in recreational activities.

During the performance of activities in an external environment, the elderly population is faced with challenges that, many times, are not even perceived by younger people. These challenges often end up being the most significant limitations they encounter, so this portion of the population, instead of adapting to the conditions of space, ends up avoiding (Julian & Laura, 2020)

Fietkau (2019) presented some of the main factors regarding why the elderly stay at home more rather than outside.

- lack of public toilets
- Dangerous paths

- insufficient lighting
- few opportunities to rest
- very long distances

In a study by Trzpiot and Szołtysek (2017), some benefits of outdoor activities for the elderly were reported, such as

- preventing exclusion and contributing to improving the lives of elderly, at all ages
- Respecting the choices and decisions of the elderly as to their way of living
- Anticipating possible treatments, which in the future may be more difficult to treat

As previously mentioned, falls are the greatest threat to the well-being of the elderly population. Most events occur outside of the home, usually causing mild or moderate injuries, accompanied by a feeling of shame and fear of falling again. (Samuel *et al.*, 2013).

Falls in adults over 65 are responsible for more than 50% of hospital admissions and 40% of deaths from any type of injury. Numbers that make the elderly spend most of their time locked inside the house, out of fear (Finnes *et al.*, 2013).

Falls are seen as an essential and constant way of learning and studying the elderly population. Assessment and risks of falling require an intervention based on real numbers and evidence (Houry *et al,.* 2015). Otherwise, these episodes ended up being repeated, with no possibility of improvement.

Falls are seen as a consequence of other events, such as physical or motor disturbances (Speechley, 2011). This phenomena cannot be studied in isolation, nor treated taking into account only the motor cause of the fall, but also the entire space where it occurred to expand the field of study and see all conditions, to seek the best solution (even though this involves other elements such as motor, socioeconomic, geographical and also design conditions) (Kalula, 2011).

When questioned in a study by Fucahori (2014), the elderly report that the fear of falling ends up being a conditioning factor of several activities. These, out of fear, often fail to leave the house, socialize, meet with family and friends. Thus, being susceptible to a sedentary lifestyle and dependent on several professionals, not just private ones, who end up assuming the role of facilitators, with high added costs and not always accessible to the entire population.

The elderly population often avoids going to public places without the aid of favorable assistance, for fear of being exposed to risky situations, or even for fear of not getting support, in emergency cases (Zimpel & Hubl, 2019) . This fact, as presented, ends up directly influencing the

social life of the elderly population, often leading to total isolation within their own homes, as demonstrated by Carte *et al.* (2001). As a solution to this problem, Bastos *et al.* (2015) report that outdoor activities, when performed with the help of the Internet of Things (IoT), reduce the negative impact of this isolation and provide more security to users.

Seeking to increase the interaction of the elderly with technologies, Aleithe (2018) states that the use of Smart Urban Objects is of great importance to increase familiarization with this type of gadget. These devices help the elderly by being connected to the internet and by being in environments familiar to users who end up facilitating their use, thus stimulating the first contacts with technology.

Although technological solutions seeking to improve the quality of life of the elderly exist all over the world, few urban projects and public parks contemplate this target audience (Othman & Fadzil (2015). Currently, there is a constant search to improve these spaces and also to collect data that is useful for use in public services in a non-obstructive way.

2.2 Smart Cities

Today the concept of a smart city is not just a conglomerate of passive actions: it is a conglomerate of active structures, implemented in complex environments that are capable of producing responses in real time, while activities are being carried out, communicated and also generating innovations (City Sense, 2012). The development of cities in the face of accelerated urbanism, resulting from waves of migration from the rural population to large cities, ends up generating several problems, which must be faced by architects and urban planners in an attempt to seek autonomous, more innovative and sustainable solutions to create more livable, efficient and informative environments together with the evolution of cities (Gupta *et al.,* 2019). New technologies are encouraging designers to create new logical processes of idealization to build the cities of the future. The phenomenon of urbanization in the 21st century is called by Abella *et al.* (2019), "Smart city" "Wise City", "Digital city", "Information city" and / or "Self-sufficient city".

Lyons (2018) mentions that the world is currently in the smart age. However, the definitions of Smartness seem somewhat elusive, being possible to find several synonyms for this concept, without a unified and comprehensive description. Brenner (2007) compared ´smart´ and ´dumb´ technologies, affirming that the human being uses dumb technologies in a passive way, and starts to use smart when he is able to perform some type of interaction with it.

As presented by Palmisano, president of IBM (2008), at a conference in Istanbul, the Global System for Mobile Communications (GSMA) has predicted that by 2025 the number of devices with intelligent technologies would reach 25.2 billion. Thus, giving more prominence to the digital age and presenting new challenges. To serve this entire population, storage servers must be able to store all this information in a space (not necessarily physical) that captures it, analyzes it, and can make some decisions, when necessary, thus creating Big Data, which is an open inquiry.

Big Data means that the information collected through these devices called smarts is available for consultation and use by the entire population. This alternative has the consequence of incorporating this data in several other related projects, not only aiming to improve the city, but also interpreting them for different purposes. This generally ends up being cost savings, since the sharing of information ends up accelerating the development processes, reaching a final result in less time, Ruohomaa *et al.*, (2019).

The amount of information currently held by sensors already in cities around the world helps make cities smarter and more dynamic. The group that most benefits from this type of information, are the so-called elderly young people, aged between 60 and 69 years, who begin to present the first needs of the elderly phase, but still able to interact with the urban environment, without significant limitations , (Forman *et al.*, 1992).

The first definition of a smart city emerged in the early 1990s, referring to the use of Information and Communication Technologies (ICT) and new and modern structures for cities (Albino and Berardi, 2015). Since then, the idea of Smart has evolved and never reached a pure and direct definition. There is a lot of research around this concept and also a lot of variations (Alawadhi *et al.*, 2012). Some authors, such as Quijano-Sanchéz *et al.* (2020), claim that a city cannot be considered intelligent unless it emphasizes the use of technology as one of its most significant advances. The integration of sensors that communicate with each other, with other devices and with human-operated software creates a complete chain that provides a more considerable evolution.

Asstates Robertson (1995), one of the precursors to the concept of smart cities, each city is a global phenomenon, both in terms of local and global scope. They have unique characteristics. Therefore, it becomes a challenge to create a unique model that can be replicated everywhere in the world, such as geographic location, ways of life, habits and customs specific to each region.

For that, it is not necessary to think of two capitals on opposite continents of the globe, one can only think of cities in the north and south of the same country.

Shapiro (2003) created a strategy based on fundamental pillars for the creation of Smart Cities, thus being able to provide significant impacts on the social structure of cities and also on the quality of life of the citizens who live there, increasing social inclusion, providing more significant opportunities for jobs and social innovation.

Giffinger, in a project called European Smart Cities (2007), defines six possible fields for the implementation of a smart city, namely, Smart Economy, Smart Governance, Smart Life, Smart People, Smart Mobility and Smart Environment.

Caragliu *et al.* (2011) argued that the Smart City is an emerging strategy that seeks to improve the lives of citizens through the use of innovative technologies that directly address the needs of the city in which it is being implemented.

Nam and Pardo (2011) characterize Smart City as an unclear concept, both in the literary and real sense of the word, listing three main elements that must be taken into consideration, when the subject is Smart City, namely:

- Human - represents the capacity for learning and innovation of residents who faced the innovations proposed by the city.
- Technological - represents the factors that structure and assist the physical part of smart cities.
- Institutional - refers to the skills of government officials to manage the city.

Kourtit *et al.* (2012) argue that Smart Cities are not just a technology-based strategy. Even so, the implementation of this concept requires a lot of financial involvement for the results to be achieved. Anthopoulos and Vakili (2012) are the first authors to cite the concept of the city associated with the internet, making use of the IoT and also of E-services. Dameri and Cocchia (2013)oriented characterize Smart City as an innovative and trend-strategy for the management and management of existing cities. Lee and Lee (2014), emphasize that a city to be considered Intelligent, needs to develop a variety of innovative services to offer residents information on the most diverse aspects of the city, both physical and management. According to Liu *et al.* (2014) to better meet the needs of the population, it is necessary to connect the most modern technological tools and public services, to provide better experiences for citizens.

Smart City is a multidisciplinary field shaped by technological and urban advances (Gil-Garcia *et al.*, 2015). Cohen *et al.* (2015) state that the Smart City idea was developed to seek to solve the problems arising from the rapid urbanization that cities around the world faced. This phenomenon occurs due to the rural exodus, where a large part of the population from rural areas moves to large urban centers in search of better living and employment conditions. As a result of this migration that occurred in a non-gradual way, cities started to not only have a larger population, but an overload of all their services and infrastructure, causing major management problems. Smart City is a term that covers a multidisciplinary field that is shaped by advances in urban development and technologies. (Meijer *et al.*, 2016). Meijer mentions that leadership in Smart Cities deals directly with new forms of human collaboration through the use of Internet communication technologies to seek better results and a more transparent way of governing. According to Paolini *et al.* (2016), the main idea behind the concept of Smart City is to collect personal data on people's behavior through the use of simple and low-cost technologies and in a non-invasive way. Smart Cities, according to Anthopoulos (2017), is a fundamental part in the management of cities by those responsible, because, through technology, it can reduce internal expenses. (I.e., NYC, Barcelona), through real-time monitoring of situations such as air quality, street safety and traffic, thus being able to better meet other essential needs of the city, enabling the integration between the parties with technology and not gifted parties, through transport services, which when serving unconnected areas, capture information, passing it on in real time.

Yeh (2017) states that smart cities can promote better services to citizens, thus improving their quality of life. They seek to make improvements in services such as transportation, education and health. According to Yung & Lieberknecht (2018), researchers defined Smart Cities as a means for the evolutionary transformation of cities. The objective is to optimize and coordinate the capture and processing of information in real time. Smart cities connect citizens to service providers through information technology. (Webster and Leleux, 2018)

For Ruohomaa *et al.*, (2019) Smart City brings together government and different levels of society through the IoT and Artificial Intelligence. These facilitators assist the development of the city in different areas, not only with a focus on the structures of the cities, but also on their citizens, authorities and service providers. A smart city, as defined by Pupek *et al.*, (2019) was one of the strategic trends of the year 2019, this represented the interaction between humans and technologies for the creation of a digital environment, which would become intelligent and autonomous, only

when reaching five essential elements, namely openness, connectivity, coordination, intelligence and scope.

Beccali & Bonomolo (2020) affirm that, when discussing the quality of spaces for citizens, visual comfort should always be one of the priorities. Bearing in mind that lighting is an essential element for the comfort and safety of the areas and the best use of the items inserted in that space.

Due to the continuous population growth in large cities, governments face difficulties in the economic, social and environmental spheres. The forecast is that worldwide, by the year 2050, the population will grow by 70%, thus increasing the demand for products, services and resources. The correct management of cities can make the consequences of this growth lessened. To better understand how to face this process more efficiently, Shahidehpour *et al.* (2018) explains how to set up a smart city. Shahidehpour claims that a smart city is the urban center that integrates a wide variety of solutions to improve the performance of city structures to achieve cohesive urban development. The adoption of the Smart model has as its main consequence the resolution of issues related to offers and services to the inhabitants of that city. The author states that it is a very arduous task to develop a city from scratch, this will end up being a utopia and will not be part of people's lives, an identity and a sense of belonging with the place will be lacking. Therefore, the best alternative is to seek the solution of the problems of existing cities, through the concept of smart cities and to solve the need, improving the place, promoting a sustainable vision of urbanization to grow as a whole.

IoT together with the system that interconnects sensors, connects thing to thing, human to thing, human to human, through an internet network, and capable of performing identification, analysis and intelligent management of this data, results in construction of a complex system capable of sharing information in real time, thus creating the concept of IoT in 1998 at the Massachusetts Institute of Technology (Conti, 2006). For Brokhman *et al.* (2017), the concept of IoT emerged around the year 2007, with the idea of a world of connections and data sharing. Currently, this type of technology is present in the most diverse daily uses. The popularization of this system ends up generating a reduction in the manufacturing cost, facilitating its purchase. With the fall in prices, the greater variety of instruments can support the system, increasing the range of services that include this technology, making the environment in which they operate more dynamic and modern. When Smart Cities are planned, they must always take into account that there will be

a need to implement these technologies. These bands can appear to complement or replace what already exists, expanding the interconnection network.

In the last decades, as stated by Cortés-Cediel *et al.* (2019), initiatives to implement smart cities have received more frequent support to achieve greater sustainable development in urban spaces. This solution has been progressively adapted to alleviate urban problems arising from rapid urbanization and population growth.

The phenomenon called IoT is considered the central element in the use of devices that help in the concept of Smart Cities. Another important fact for the implementation is the use of Open Data (information available to the entire population), facilitating the development of public services in several areas (Murgante & Borruso, 2015). Based on the IoT paradigm, objects acquire the characteristic of Smart when they are equipped with processors and locators that collect, transmit and locate data. IoT is not just a prediction of how things will be in the future, it is a reality that is already presently in use and impacting the lives of all human beings. This technology allows us to share information quickly with a cloud, collecting, analyzing and recording new data flows.

Currently this technology is already implemented in many home devices, helping to track the elderly population during their daily life activities in an unobtrusive way (Miori and Russo, 2017).

As presented by Zanella *et al.* (2014), the IoT must incorporate, transparently and straightforwardly, different types of systems, providing various kinds of open access to some types of information retained by the network, in its many kinds of devices.

Atzori *et al.* (2010) state that the IoT paradigm can bring us even closer to a vision of the city of the future. The amount of microsensors that are capable of being installed in the most diverse types of devices make the field of operation much larger, and also more complete, due to the intercommunication that exists between the instruments—thus creating an entire and integral IoT network.

When analyzed in the urban context, IoT, without a doubt, brings benefits to the management and optimization of various services, such as lighting, transportation, preservation of the cities' heritage, garbage collection, among others. In addition to information technology, IoT can assist the control of schools, hospitals, and the treatment of city infrastructure (such as sewage and water systems). With this complete and well-structured network, citizens feel more belonging

to the city, engage more with urban issues, interact more clearly and directly with the government, and expose their needs better, thus creating new services opportunities that best serve the population as a whole (Cuff *et al.*, 2008).

It is difficult to find a definition that covers all the complexity that the purpose of IoT requires; however, Dobre *et al.* (2019) summarized and simplified the concept as being ´´objects of daily use that can be equipped with the ability to intercommunicate among themselves, and also with other devices and services over the internet, to achieve their goal´´.

According to Hui *et al.* (2017), the advancement of Iot facilitated the emergence and popularization of Smart Cities and Smart Homes. The purpose of these Smart´s environments is to provide residents with an essential quality of life, respond to its basic needs, and monitor health services. (Obaidat *et al.*, 2016)

The main characteristic of the IoT when thought of in the urban context, is that it has the capacity to integrate different types of technologies with the communication system, to carry out the evolution of the devices, expanding the urban connection network, facilitating the understanding by authorities and citizens, in search of solutions for specific problems. Mulligan & Olsson (2013)

Iot is defined by He & Zeadally (2015) as objects with a unique identity and characteristic in smart spaces using intelligent interfaces to connect and communicate with social, medical, and daily user networks.

The IoT technology is capable of interconnecting several devices between them, with applications and services, among the citizens' most diverse needs. This facilitates communication between machine to machine and machine to man at various scales. Iot can integrate physical objects with digital management by capturing data, improving them, and creating new opportunities to improve their functioning.

Smart Cities need to be equipped with the latest information technology, and this will help create a more sustainable and economically viable environment. These cities need to respond directly to the needs of the population that is aging in it, and mainly to support the independence of this age group. The use of ICT can assist in elaborating cities/houses that meet the needs of users in a personalized way, creating an intelligent service network. (Zanella *et al,*. 2014)

Meijer *et al.* (2016) claim that a smart city's leadership is structured through the development of new forms of participation by the inhabitants through technology. In Smart Cities,

the importance of information directly connected with citizens and service is what keeps the interaction between the individual and the service provider (Webster & Leleux, 2018)

Daffara (2011) mentions that designers must think about tomorrow's cities today, and thus enable citizens to act with foresight, creating resilient and habitable environments to live.

Liu *et al.* (2014) cite some facts that must be taken into account to realize a Design of Service to the Smart Citizen:

- identify scenarios and episodes;
- specify service plans;
- characterize the citizen's experience; and
- constellation of design services.

For Abella *et al.* (2019), the user experience becomes something basic when designing services in a smart city. The technology and innovation in the creation of the services presented make them more different and attractive than others already known, thus increasing the search and popularity.

Klijn *et al.* (2012) says the city services must adapt in a way to the needs of users. Vanolo (2013) states that citizens need to adapt to the shape of the city, becoming smart citizens to participate in the development of cities. For Opromolla et al (2017), the population is the focus of the cities' design process, as these are the primary users of this type of service.

As Hammi & Khatoun (2018) stated, a summary of the concept of a smart city is a city connected through information and telecommunications technologies in search of improving the lives of its inhabitants. To achieve that title, you need to achieve two goals.

- Provide adequate and advanced urban infrastructure with the ability to process and collect information from other devices, to try to anticipate any type of problem or anomaly.
- Allow users to interact with the environment through applications, thus creating sustainable environments, with fewer pollution levels improving the quality of life.

González-de-la-Hoz *et al.* (2015) states that the services encompass emotions such as frustrations, insecurities, and concerns; however, engagement with these activities may end up exceeding the expectations of citizens. The author reports that users are often unable to recall the last time they use certain services unless they have some kind of emotion involved (whether positive or negative).

The idea of a smart and sustainable city is directly related to the architects' works in designing environments that are a physical platform for the implementation of solutions and spaces that are elderly-friendly. Currently, as Tymkiewicz (2019) said, this is a gap that exists in the literature. The replacement of outdated and/or weakened structures in a city are expensive and time-consuming operations, which are not always possible to be implemented. Based on this, digitizing and connecting structures, to make them smart, is likely to do, without the existing one being discarded, but instead adapting it, to maintain the quality of life of users, without impact in a gross way.

"In smart cities, the citizens' activities are not limited to their homes; they live their lives in an entangled society. Health care is important for citizens in general and, in particular, for the elderly. Smart cities need to address older adults' needs, such as housing, social participation, health care, and community support services, leisure, and culture, to make the smart city environment more elderly-friendly. ICT will enable this integration into the home and urban environment where older adults live. For the EU between 2010 and 2060, total government spending on pensions, health care, long-term care, unemployment benefits, and education will increase by almost 20 percent, while expenditures for long-term care will double." (Alam *et al.*, 2012).

Clift *et al.* (2015) States that a critical element of the urban grid is mobility, especially mobility between people. In a study conducted by Artmann and Chen (2017), the fundamental concept that was addressed was that of what vision should be had, regarding Smart Cities, whether a technological view or a holistic view, a double or quadruple-helix model of collaboration, top-down or bottom-up approach, mono-dimensional or integrated intervention logic. In a Smart City, the citizen cannot be seen only as an element to adapt the news existing in the place where he lives, and he must be an active part of this change and one of the components that triggered such improvement. (Vanolo, 2014)

In addition to many other well-known definitions of smart cities, Quijano-Sanchéz *et al.* (2020) define as pieces of urban areas that are articulated and functional to use Information Communication Technologies, as a way to solve city problems sustainably and efficiently.

In the study presented by Winter (2019), the strategies of a Smart City are given, better to explain the concept of Smart and Livable cities, being these.

• Smart traffic lights, to improve traffic in large cities,

• Smart buildings, with cameras and sensors capable of informing the capacity/occupation of these spaces, adapting equipment to increase the feeling of comfort (temperature/ventilation/lighting)

• Kiosks with WI-FI and map with points of interest in the city.

• Dustbins are equipped with electric, solar panels, for signal transition, according to their capacity, thus reducing odors and possible attraction of insects.

• Self-driving vehicles, capable of lowering locomotion stress, better use of parking spaces, and fuel consumption.

To achieve the concepts of Smart and Livable cities, in addition to encompassing these items mentioned above, must include citizens in their implementation strategies, and govern transparently. Thus, the government gets more significant support from companies, engaging the population, making the process much easier and more dynamic.

Innovation, especially in technology, ends up helping governments face the challenges of contemporary management, improve the urban environment, stand out in global competitiveness, and cooperate with the increase of collective and sustainable thinking.

´´Communication, interaction, involvement, and the contribution of key constituents are vital to achieving smart city goals. Smart technologies, such as Artificial Intelligence, capable of self-monitoring, analysis, and reporting, can be effective only if they address a real problem and meet real needs´´ (Mainetti *et al.*, 2017).

Bellagente *et al.* (2018) state that one of the objectives of a smart city is to reduce health spending, thus also seeking to prolong the quality of life and independence of the elderly. It is common to find elderly people, not very advanced, living alone, and often receiving visits or calls from family members, caregivers, or service providers. Currently, the elderly population represents most part of the population, for this reason, several governments around the globe, are supporting the development of innovative solutions for this segment of the community, to seek to increase their quality of life, reducing social isolation, and occupying idle time with various activities, be they recreational, or qualifying.

The proposed health care implicit in the concept of Smart Cities is the capture of information to the patient through sensors installed inside the patients' homes, which capture images and audios of the same, to transmit to a control center (Ali *et al.*, 2017).

Studies developed by Skouby *et al.* (2014) demonstrate that smart cities can play a fundamental role in supporting the elderly population while alternative solutions support innovation in the towns in different aspects to provide greater comfort, whether in energy, sustainable, or transportation issues.

Datta (2015) states that Smart Cities are 21st-century utopia. Simultaneously, Vanolo (2013) argues that Smart City is not a well-defined concept because it allows different interpretations and accepts different ideas, which give them different meanings in different parts of the world, resulting in different solutions. Hence, it is just one competitive view of cities through the eyes of society. In 2016 Vanolo reformulated its concept and stated that Smart Cities are cities that are endowed with vegetated areas and have technologies capable of capturing and transmitting the information.

As an example of a smart city, we can say that Barcelona, until today, is considered a model city when talking about Smart Cities. Griffinger (2007) listed 70 cities in Europe, based on a concept by its author, highlighting six dimensions that a city should adopt smartly to stand out.

"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens. In turn, Barcelona was the one that best responded to this list". A few years later, Berrone & Ricart (2015) created an index with a few more categories than Griffinger, creating the Cities in Motion Spain project. Based on those two authors, the comparative table was developed to simplify the way of understanding the differences (Table 1).

Table 2. Comparative between Griffinger(2007) and Berrone & Ricart (2015)

Griffinger (2007)	**Berrone & Ricart (2015)**
Smart Economy (competitiveness)	Human Capital
Smart People (Human and social capital)	Social Cohesion
Smart Governance (Participation)	Economy
Smart Mobility (Transport and ICT)	Public Management
Smart Environment (Natural resources)	Governance
Smart living (Quality of life)	Mobility
	Transportation
	Environment

	Urban Planning
	International outreach
	Technology

Through smart cities, urbanization processes turn out to be more horizontal, more inclusive and bring together different sectors, connecting the extremes of a city to promote a common good. (United Nations, 2016).

2.3 Smart Outdoors

Qingfen (2019) affirms that a space designed to betray the elderly population should take into account that they are still part of society, for this reason, the conditions for them to interact with public spaces, must be analyzed and taken into consideration, to avoid segregation and consequently their isolation.

According to Gordon Coullen's theory, in Townscape (1968), when a public space is being designed, there must be three aspects in particular.

- Optical - it consists of a sequence of visuals that configure the space, such as the street, which leads to the park where the monument is inserted.
- Location - refers to the sense of location, where one space starts and another ends.
- Content - encompasses all the characteristics of the place, such as colors, textures, scales, styles.

Elements of "natural environments" in urban environments, for example, parks, can, in part, mitigate some of these threats by improving air quality, encouraging physical activity, and reducing stress (Hartig and Kahn, 2016).

Environments with many plants and vegetation can decrease the temperature of the site due to oxygen ions that the plants naturally release, reduce noise due to volume/density, and filter the existing air in the place thus reducing pollution. In a study conducted by Qingfen (2019), it was found that the elderly population feel better in spaces with more vegetation and often move to the place, just to observe. Some design decisions can directly influence this moment of leisure that the elderly have, such as the positioning of the seats.

Kabisch *et al.* (2015) present research that point out the importance and benefits of the contact between a man and the environment in green spaces.

Urban Green Spaces (UGS) have had their importance increasingly cited, due to the wellbeing that it causes the population that lives in large cities. In an era of slowing population growth, an aging population and rapid urbanization, UGS is gaining much more relevance due to the scarcity of open/green spaces in homes. A study presented by Artmann *et al.* (2017) shows the importance of gardens situated within care institutions for the elderly. Elderly-friendly spaces are an additional element in maintaining the well-being of the population. Along with these spaces, the elderly can socialize, develop physical and leisure activities.

As presented by Seresinhe *et al.* (2015), people who live in contact with or close to green areas have better health conditions than those who live further away. These also present better mental health and well-being. (Gascon *et al.*, 2015). A lower risk of mortality has also been cited by (James *et al.*, 2016).

Spaces that combine trees with large canopies and water elements are the spaces preferred by the elderly population, interviewed in a study prepared by Arnberger *et al.* (2017). Areas for reading, without the presence of animals and with mild temperatures, were mentioned in the study, along with proximity to service places (i.e., cafes and toilets), and few noises.

Several studies cited by Kuo (2015) point out improvements caused by UGS regarding health, especially for the elderly. Improvements such as reduction of chronic stress, and diseases related to this, more significant cognitive and social development, increase in the percentage of people active in society and also decreased autoimmune diseases and allergies. With that being said, it should be mentioned that the relation created among the elderly population and smart objects, increased the quality of life of this portion of the population, bringing them more independence.

3. State of the art

3.1 Smart Solutions for Elderly

Within the project entitled Horizon 2020, there is a smaller project, called City4Age, which proposes the creation of spaces that focus on being elderly-friendly. With technology, this system can monitor risky situations to improve the daily activities of the population. This system uses several tools that assist the following non-obstructive forms, collecting information on a city scale, which can be both indoor and outdoor. The program does not limit the number of sensors per

house/building. Still, it seeks to capture the most considerable amount of information, to create a complete and complex network, looking for pattern's atypical situations in the daily lives of users, always anonymously. Monitoring is performed through cameras and sensors that capture voice messages (Bilbao *et al.*, 2016).

A smart home is a system that comprises different applications that seek to monitor the home environment, through intelligent technologies to provide a network of services, known, to facilitate control from home (Alam *et al.*, 2012).

Maswadi (2020) affirms that Smart homes can be understood as an environment that connects services and technologies through a network system to provide a better quality of life for its users. Examples of Smart Homes are Zware and ZigBee, both systems, perform the monitoring through network technology, making several connections with family members, caregivers, and/or even with hospitals, for faster responses, when in emergencies. Systems that also perform the monitoring in a passive and non-obstructive way.

The idea of boosting Smart Homes, according to Pirzada *et al.* (2018), is to offer non-intrusive monitoring that can assist and improve the well-being of the elderly, identifying routines and detecting anomalies, acting in a way to respond in emergencies. The system works in such a way; first, sensors/actuators are installed, then gateway information is processed, and stored to create the residence structure.

Almost all reports of older adults and/or their family members, when questioned after an accident involving falls, reported fear of falling again. As stated by Fucahori (2014) this is one of the biggest causes of isolation in the elderly, causing sedentarism, greater dependence on other people or professionals who help them to move around to try to control fear and avoid the decline of activities (Abdalda, 2017)

Smart homes are equipped with passive and listenable sounds. They are equipped with information and communication technology to carry out continuous and remote monitoring of the health of the inhabitants of that residence. These technologies are often adopted because they have a lower cost than keeping a person doing this monitoring. These, in turn, end up performing remote control, acting only in specific cases. (Majumder *et al,.* 2017)

Smart Homes aims to assist in the independence of the elderly, within their own homes, as facilitators. The combination of different systems make this network much more productive and

complete, being able to meet the diverse needs that the user may have, without the need for external interference. (Kon *et al.*, 2017)

Smart solutions are essential to adopt when facilitating independence for the elderly population. Ambient Assisted Living (AAL), is one of the best alternatives currently existing, to the point of being an emerging and innovative strategy. This alternative seeks to reduce the costs of an independent life for the elderly population, increasing self-confidence and autonomy so that they feel safe and capable. (Oess, *et al.*, 2012)

In addition to monitoring resident activities, smart homes can control physiological and environmental factors, such as temperature, humidity, heart rate, body temperature, blood pressure, and oxygenation. Exercising communication in the same way with external agents and acting whenever necessary for an intervention. (Majumder *et al.*, 2017)

AAL is one way to monitor the elderly and ensure that they are in safe conditions to carry out their activities daily. Some monitoring devices even have alarms to control the frequency and attendance of medications. (Mainetti *et al.*, 2017).

According to Maswadi (2020), Smart Technologies can act in several monitoring fields, to ensure better quality for the elderly population. Among the various types of monitoring we find:

- Physiological is the type of monitoring that allows you to carry out extensive population studies and the effects that certain situations cause on the population through the control of blood pressure, sugar levels, and other features of the human body.
- Functional - This monitoring relates to an assessment of the essential functions of the body
- Security - This monitoring analyzes possible hazards that arise to impair daily activities or abnormalities that occur, causing changes in the elderly's behavior. Whenever necessary, this system triggers alerts both for the monitored person and for those who monitor remotely.
- Social - This monitoring tracks online interactions, calls, and even what the elderly watch (television programs, films, news, etc.) to create a matrix that helps interact with the individual.

- Cognitive - This monitoring allows sensors to function as extra memory for the elderly, sending messages whenever necessary, reminders, and alerts to create safer behaviors.

AAL is a technology that allows reducing health expenses without even having to interrupt the user's daily activities. The technology seeks to evolve to better serve the user without the need for the user to adapt new systems/updates continuously. In nursing homes, these technologies already cover the most diverse types of monitoring, such as cameras, clothes, accessories, watches, and devices attached to shoes. (Koutli *et al.*, 2019)

Studies that include AAL cannot ignore the concept of IoT, which in these circumstances, can act in two ways: directly interacting with humans, through alerts or reports, or between devices, sharing information to better create the information/monitoring network. (Miori & Russo, 2017). Nowadays, due to the rapid development process, the needs of the elderly population are not limited to the indoor environment, it is necessary to seek solutions that go beyond the limits of their houses, and also serve them in a broader way, thus being in the outdoor space .

3.2 Smart Devices for Urban Design

Smart Urban Objects (SUO) are objects endowed with technologies capable of capturing and transiting information or changing their behavior to meet the user's needs. Examples of this are Smart Benches, Smart Street Lights, Information Panels and Smart Parking Lots. These objects are designed and more stringent to help the population in an urban context, either by identifying barriers, dangers, assisting in choosing paths, and/or finding a parking space. (Zimpel & Hubl, 2019)

To be categorized as Smart Urban Objects, objects must contain five elements: Sensors, actuators, the possibility of personalization, interaction, and parallelization sensor (Skowron *et al.*, 2019).

Smart Furniture can be defined as designed furniture connected to a network, endowed with intelligence and control operated by the user. This type of furniture must be able to communicate and anticipate the user's needs using different sensors and actuators, within the environment in which they are installed, to adapt Krejcar *et al.* (2019).

Gaddam *et al.* (2019) conceptualized Smart Furniture, which is a piece of furniture connected to the internet and can be used both indoors and outdoors. Those objects, in turn, are

capable of mapping paths, and walking gait. This mentioned study, presents two pieces of furniture specifically, one of them Smart Sensory Bench and the other Smart Sensory Path. In this case, both devices require user identification through an electronic tag that stores and transmits all the information after using the object. This information can be transferred to an online server and can be consulted by anyone who has a register, and can also be consulted briefly on the smartphone of the user (if he has one).

The Smart Sensory Bench, after identifying the user, presents basic instructions on how to use the product, after which a 60-second timer begins to count. The device starts to monitor how many times the user repeats the movement of sitting and standing. (Gaddam *et al.*, 2019).

The Smart Sensory Path uses a technology similar to that presented in the Smart Sensory Bench. After the user starts the activity through the electronic tag, the sensors along the platform are activated, and the user can start his walk along the route. The sensors located right at the beginning, perform only the user's posture/walking mode, spaced 5000mm from these, are the sensors that will measure the conditions of the route, once the person has reached average speed and continues walking. The same occurs just before the end of the journey. Information such as gait speed, step length, and foot pressure are measured and analyzed. Unlike the bank, this device does not have a time limit for carrying out the activity, but the information is transmitted in a way, to consult the results later. There is no need to tag off, as the sensors identify the last step and automatically end the process. (Gaddam *et al.*, 2019)

Adaptive Lighting System is a system equipped with technology that improves the feeling of security in the elderly, especially in darker areas. These objects must be strategically positioned for better functionality. Among its adaptive characteristics, it is possible to control light color and intensity (Aleithe *et al.*, 2018).

Adaptative Park Bench is a system of benches that have smart seats adjusted according to each user's measurements. Thus, the possibilities of usability and comfort vary from person to person, as the dimensions vary according to each user's anthropometric measurements. This bench also assists the user when sitting and standing, as sensors built into it, recognize movement, and act as a shock absorber when sitting similar to a spring, propelling the person when standing. These movements are justified since the elderly generally present weakening of the musculature, mainly of the lower limbs. (Hubl *et al.*, 2018).

Information Radiator is the category of devices capable of transmitting dynamic information about a specific location. Installed in strategic locations and managed by a server connected to the internet network, it always presents up-to-date information about the situation in question, in addition to being able to interact with it, to obtain specific information about a particular space, such as zones of shade or sun in the park, flooded areas, empty spaces, etc. (Aleithe *et al.*, 2017).

Many authors suggested different approaches for different problems that elderly in general face. Since falls are the most frequent cause of injuries in the elderly, Wang *et al.* (2016) cites some systems for monitoring and detecting such events; Vaidehi *et al.* (2011) make use of a camera positioned inside the environment to detect changes in the user's positioning for a specific time and gross changes in position; Hsieh *et al.* (2014) use a device that must be worn on the wrist to detect the fall. This device consists of an accelerometer with three axes, which locate the fall. However, it is not able to inform the location of the user; Wang *et al.* (2014) cite the system based on sensors that must be attached to the body, which uses domestic communication networks to detect falls in the elderly only in indoor spaces; Bai *et al.* (2012) cite a system also based on an accelerometer, coupled with a smartphone that detects the fall and transmits information and locations based on the GPS embedded in the smartphone.

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EnVibo is a device that has small sensors that can establish communication through wireless technology, to perform remote monitoring of physiological signals, without having to interrupt daily activities. This equipment is also wearable and emits warning signs in case of an emergency. (Majumder *et al.*, 2017).

Shien & Singh (2017) in a study carried out presented the problems found in many of the devices for tracking people, especially elderly in Smart Cities, these being:

- Limited coverage of tracking and monitoring services
- Security problem with sensitive information
- The higher cost of a technology-based system

Paolini *et al.* (2017) mentions the essential elements of functioning smart objects for the elderly population:

- Create a profile of each user by date of capture
- Detect changes in behavior, based on embedded patterns in the system

- Intervene whenever necessary, either to alert or infer (if needed).

Tacken *et al.* (2005) cite the main reasons for the aging/denial of the elderly, given the technologies.

- Fear of the New
- The motivation for the use
- Complexity of use
- Lack of support for the use

After studying all these Smart Devices for Urban Design, it was understood that many of them do not work in isolation, they are often part of projects developed at the city scale.

3.3 Smart Outdoor Projects

Urban GreenUp project was a project founded in 2017, within the European Union program, called Horizon 2020. This project consists of performing mimesis of existing functions in nature, to solve problems arising from the accelerated urbanization process. (Turhan *et al.*, 2017)

City4age was a project started in December 2015 that aimed to facilitate the transformation of cities into spaces which are age-friendly. With this, it sought to reduce the exposure of the elderly to situations of risk, through ICT use. This study took place at the same time in six cities around the world. Each of them addressed different types of aspects of daily life, including socialization, mobility, security, daily activities (ADL), and involved different types of Smart Service while trying to capture the most considerable amount of data possible. City4Age.

During the first 15 months, the project prototyped the first iteration of the City4Age platform, consisting of the following main components:

- The general modeling framework, including geriatric risk modeling and behavior change modeling.
- A data collection reference architecture, based on discrete detection technologies and (smart) city data sets.
- A shared repository and data management system merges and stores data collected by pilot cities and reconstructs appropriate behaviors from them. This includes an experimental activity.
- Tools to train geriatricians, social workers, and possibly end-users themselves, to assess behavior and detect potential MCI / frailty risks.

- A mechanism to carry out relevant and personalized interventions, based on consistent communication flows delivered to end-users, which aim to encourage positive changes in behavior
- A framework to provide open, regular and privacy-aware access to data collected by City4Age pilots.

Behavior reconstruction is achieved through two different approaches:

- Collection of low-level elementary actions (LEAs),
- A second approach is to use LEAs (low-level elementary actions)

To be able to recognize more complex activities directly related to the monitored behaviors it's knows:

- Risk assessment panel visualizes, for each selected end-user, the evolution of geriatric factors and subfactors, computed as previously illustrated, highlighting positive or negative behavioral changes.
- Open access to data. The data collected by City4Age is a significant asset for organizations and actors interested in preventing the health of the elderly.
- When health deterioration risks are detected

The intervention phase at City4Age consists of message flows (Intervention through communication), transmitted through a variety of multimodal channels that aim to "persuade" the elderly to adopt healthier behavior. Based on a universal model of conduct, which suggests that capacity, opportunity, and motivation are fundamental to the behavior's performance and, therefore, are also the three main levers available to induce behavior change. This model has been used to boost the City4Age intervention system, applying it to behaviors known to affect CCL and frailty, such as physical activity or healthy eating.

The DALIA

The project focuses on optimizing the service to information in the AAL sector. It consists of a personal virtual assistant that implements a service-oriented architecture on a smartphone. (http://www.dalia- aal.eu/)

GIRAFF +

It is combining social interaction and long-term monitoring to promote an independent life. The GIRAFF+ is a project developed based on the concept to be more of an addition than a substitute for human contact. The system consists of a network of household sensors that measure, blood pressure, temperature, or detect whether someone occupying a chair, falls or moves inside a room.

There is also a telepresence robot, Giraff, which is a mobile communication platform, equipped with a video camera, display, microphone, and speakers, and which helps the user to maintain their social contacts. (http://giraffplus.eu.)

eWall

For the Active Long Living project, it developed devices and sensors to monitor internal activities. The signals from networked devices and sensors are processed to extract the nursing home's status and occupants (not yet released) (http://ewallproject.eu/).

SafeMove

The Safe Mobility project for the elderly close to home and on the road develops new services that aim to support the elderly during their normal daily life while promoting their normal mobility both inside and outside. (http://www.safemove- project.eu/)

4. Methodology

For the elaboration of this work, qualitative research methods were used, this type of method seeks to understand the behavior and the motivation that leads this fact to happen. Among the qualitative research methods, research groups, individual or collective interviews, discussion groups, etc. can be mentioned. The result is achieved through discussion and analysis of the responses obtained throughout the investigation process.

In addition to qualitative methods, a User Centered Design method was used, which is an iterative research process, where the researcher focuses on users and the needs they have at each stage of the process. This method also focuses on whether the result at each stage meets the expectations by the researcher. Among the phases of the project's understanding process, one must understand the context in which such product/solution will be implemented, then specify the user's requirements, propose a solution based on what meets the needs and ultimately evaluate the result against the initial requirements and seek validation methods for this theory.

4.1 Methods

4.1.1 Literature review

The systematic literature review was based on reading several scientific articles, conference papers, websites of projects under development that encompassed the theme of smart cities and elderly. The main tools for obtaining publications were:

- Google academic;
- B-on platform;
- IEEE, and;
- Research Gate.

Smart City; Elderly; Aging Population; IoT; Smart Outdoors; Smart Urban Objects; Ambient Assisted Living were the keywords that were used to search references. Later, Mendeley application was used to manage the references.

4.1.2 Expert Interviews

Expert interviews are commonly used aiming at collecting knowledge about or investigating a particular area of operation. With this method, it was intended to move beyond the focus on explicit expert knowledge by emphasizing the experts' individual perspectives about elderly, technology and smart city concepts.

4.1.3 Naturalistic Observations

Naturalistic observation allows the researchers to directly observe the subject in a natural setting. The intention was to get a first-hand look at social behavior and notice things that might never have been encountered in the literature or expert interviews. The observation was meant to serve as inspiration for further research, and the collected information could lead to insights that can be used to improve the public park and eventually improve elderly's well-being.

4.1.4 Personas

A user persona is an archetype or character that represents a potential user. Personas were created to help the study to target the design proposals around users. It was essential to have clear, accurate potential users of the proposed system, therefore, detail the user's background, goals, motivations, and needs related to the product.

4.1.5 Scenarios

Since a Persona is usually combined with scenarios, a scenario was dedicated to each Persona which described the problems, and how and why the Persona would use the space and proposed design ideas to overcome the problem. The purpose was to visualize how the users interact with the environment. This helped to determine design ideas.

5. Project Development

5.1 Phase 1: Definition of the Context

The chosen space to develop this work is a park located in Campo de Ourique, Lisbon in a relatively new neighborhood, not very central, but with public transportation, such as busses and trans. Based on this fact, this area has developed itself into a small town inside Lisbon, having all types of services and shops. Data gathered from the City Hall showed that 80% of the buildings in this area are residentials and 18% have mixed uses (having a commercial on the street level and housing on top). In addition, this area was selected based on the high concentration of elderly people residing in this neighborhood, and also some geographic and urbanistic conditions such as being a flat part of the city, well connected with the city center by public transportation.

5.2 Phase 2: Expert Interviews

The general perception of individuals, particularly experts, is that quality of life while aging is a principal factor when finding answers for better solutions involving comfort within older age brackets. The idea behind these qualitative interviews is to obtain different perceptions regarding issues related to the aging of the population, and also of the older population.

5.2.1 Method

The usage of expert interviews is a popular method when pertaining to social research. The role of the expert in these interviews is fundamental, as it allows the exploratory phase of the project to be more efficient and richer in data collection than just the method of exploratory observation. (Bogner & Menz, 2009). Expert interviews were selected to reach the objective. To reach a better understanding of the needs of the user, a mixed investigation method was used, being part qualitative, and part quantitative. On the quantitative, demographic information about the experts was collected, creating a better profile to then move to a qualitative method with the interviews. Results of expert interviews helped to detail the scenarios regarding the problems. Although the results did not serve a pivotal role when developing a technological solution, through a speculative design method the expert interview sessions were used to develop scenarios.

Scenarios were applied as a tool to better understand the various hazards the elderly face within the context of a city environment.

5.2.2 Participants

27 experts (14 men and 13 women) in architecture, urbanism, design and landscaping from Brazil and Portugal participated in this study. The experts' ages vary between 26 to 67 years old (*M= 36, SD= 12,93*). All participants have graduated from architecture. However not all experts exercise the profession, some of them having opened the range of areas that they could work on. 5 (18.5%) of the participants work with design, 15 (55.5%) architecture; 1 (3.7%) urban planning; 1 (3.7%) urbanism; 3 (11.1%) from the academic field; 2 (7.4%) landscaping.

5.2.3 Procedure

The interviews were conducted personally and virtually (using WhatsApp/ Skype or Zoom), respecting the isolation rules due to COVID-19, and manually transcribed to an answer sheet by the interviewer, to then be computed in a single online document and analyzed as a whole, seeking to create standards. In-person interviews took place in Brazil and Portugal. Specifically, the researcher conducted these within a cafe during periodically scheduled meetings. Various objectives were detailed to the interviewees prior to the meetings. The objectives were as follows: to better understand the elderly within the context of a public space, to gain familiarity with concepts regarding technology and smart cities and finally how the ideas could be connected to better solve problems exemplified. In order to understand if the interviewee could collaborate in the research, the researcher began by asking background history and collecting demographic information. Subsequently, the interviewees were informed that all information would be audio recorded. Each interview lasted roughly 25 minutes as the researcher took notes.

At first the interviewer explained the job in question and also the way the interview would be conducted, both online and in person, after the interviews took place in person only in Brazil and Portugal, when online, they were conducted through video calls. The expert was informed that the interview would be recorded, then began to be asked. The interviewer took note of important points that were mentioned during the interview, each interview lasted approximately 25 minutes, while the interviewer kept the notes for future analysis.

5.2.4 Materials

The unstructured questionnaire consisted of 8 questions which are shown in Table 3. The subject of the questions was dedicated to the following specific topics: the elderly, technology, and smart cities. During certain periods, additional questions were asked in order to clarify the subject matter of the questions. All answers then formally and further transcribed into a document for analysis. Questions were elaborated in Portuguese, due to the fact that the expert's native language is Portuguese

Table 3. Unstructured Questionnaire for Experts

Q1	Fact: The number of elderly people is growing worldwide. Elderly people tend to become less active and more subject to social isolation and loneliness with reduced physical activities and social interactions. Question: In your point of view and based on the knowledge you have; what kind of problems do the elderly have daily in the urban environment?
Q2	What do you understand about the word "technology"?
Q3	When it comes to your projects, what is your relationship with technology? When do you include it?
Q4	Would you know how to cite everyday problems that the elderly have in urban areas? If possible, exemplify.
Q5	How important do you believe technology is when it comes to solving everyday problems for the elderly on an urban life scale? Justify.
Q6	Have you heard about Smart City? If so, how would you define it?

Q7	If you answered the previous question in the affirmative, how do you believe that a Smart City can help to solve the problems mentioned by you previously?
Q8	Fact: Adequate spaces for the elderly are an essential element to maintain the well-being of the city. population. Next to these spaces, the elderly can socialize, develop physical and leisure activities. Question: Taking into account the existence of several parks in modern cities and the high number of elderly people living in urban centers, how do you believe that urban development can be improved to better meet the needs of the elderly population who currently live in urban centers?

5.2.5 Results and discussion

The results were analyzed by finding a pattern of the most mentioned/common topics/keywords.

Question number one was related to the fact that elderly people are becoming the most significant part of the population in big cities, and the problem they face when talking about physical limitations and social interaction. Experts were questioned about which type of problems they knew elderly daily face in the urban environment. For the first question which was dedicated to the problems of elderly in urban spaces the frequently addressed topics were mobility, maintenance and transportation and less focus was given to accessibility, security and signs/warnings.

Mobility, which often, due to physical disability, or problems in public areas, such as holes in the pavements, roots of trees that exceeded the limits of flower beds, loose and irregular stones, can reduce the ability for circulation of the elderly. The layout of spaces requires adaptation, which at times does not happen in certain areas. This can create a high-risk situation for the elderly who frequent these spaces for both leisure and mobility. Typically, these same spaces end up being remodeled to meet the needs of the younger populations, seldom taking into account all users. By only targeting a set population, a deficiency is directed at the older population, who in turn find these spaces less attainable. The effects of this can cause the elderly to not feel part of the whole.

The researcher found that some of the most cited topics in this study were echoed by the interviewees during the aforementioned interviews. Problems with accessibility, security and signage were reiterated and paralleled when spoken to the interviewees. These topics are worth noting, considering they are important and basic elements for the mobility of the entire population. When looking closer one must consider that these areas are significant due to the role they play for a group of people with physical and cognitive limitations. When these topics are inadequately designed, placed or used they can pose greater consequences, such as a lost sense of location, risk of falls and more serious injuries for the population at hand. An alternative to solving these problems, was the increase in technology, however, the question of the lack of encouragement / lack of familiarity of the elderly with the technologies arose. Whether due to shame, or lack of those who teach, this ends up risking the interaction with technological improvements for them, thus staying away from the whole again, entering a vicious cycle of isolation and loneliness.

Among the topics most cited during the interviews, those related to issues of urban mobility, both for the elderly as a pedestrian, and as a public transport passenger were repeatedly emphasized; The difficulties faced by them, often end up not being taken into account. Typically, when solutions are presented, they aim to serve the general population, while non intentionally setting this older generational slice of the population aside. Certain solutions typically generate more discomfort for the elderly. This is often seen when large investments, which seek to bring modern solutions by making use of new materials / technologies are used. Often, ready-made solutions from different countries are used which lack the characteristics of the location and its users. This creates a larger issue by generating greater discomfort and exclusion of these citizens from the rest of the city, either for fear of facing obstacles, or for lack of familiarity in the face of technological advances.

Question number two referred to what the experts understood of the concept of the word technology. The most common words can be highlighted as advancement, facilitator, innovation and automation. The idea of advancement in society and in the way it lives, through intercommunication of materials, techniques, skills and procedures, looking for improvement, evolution and more efficiency in the elaboration of daily activities, this is seen as a facilitator. It was also cited as a tool of life, which provides greater mastery and technical knowledge to develop something innovative; The digitalization of the media, where through a "click" we apply the

knowledge we have, in different aspects, with the aim of informing the largest number of people, thus improving the life of modern man; General theory and specialized studies on the procedures, instruments and objects proper to any technique, art or craft; applied science; Automation and replacement of activity human by robots, which when interconnected, cause the generation of goods; Advance of humanity in order to shorten the time of accomplishing tasks; Sharing information in real time; Way to achieve goals through science and engineering, bringing practicality, without necessarily involving digital media. Technology is everything we use as a technique or method to facilitate the performance of different tasks.

The definition most cited by the interviewees was related to advances and innovations. Part of this is due to the fact of the era in which we live, where the new is always related to the most modern, endowed with the most innovative technology, which seeks to meet all the needs of the user as an individual, not as part of a larger group. Electronic devices, cell phones and computers make the technology seen as a facilitator in carrying out tasks that were previously laborious. The sample studied, seldom mentioned or sought to extrapolate the concept of technology associated with internet / cell phones, limiting itself a lot to what is easier to use.

For question number three they were asked about how they use technology in their professional life, being either academic, urbanistic or architectural. Most frequent responses faced with were technology as a tool as well as automation of interiors In response to the third question, repeatedly technology has been cited as a work tool, an object that facilitates the design, printing and / or presentation of proposals for a client; It was also mentioned as BIM tools, where in real time, 2D and 3D drawings change simultaneously, thus decreasing working time; As for applications in works, it was mentioned as automation of home systems, such as lighting, internet connection, in order to open or close windows. Also cited as a search tool for new materials and options to be presented to customers, such as launches at international fairs, room automation, smart home technologies, such as voice assistants, and even new materials, such as curtain fabrics that have any component that makes them smart.

For this question, technology was only interpreted as a tool which can be used to communicate/share ideas with a client or a student but was expected to be cited on the vast conceptualization of the world. It was expected to be associated with improvement for a new

perception of old things, a way of helping the population and the city, rather than for helping each individual on their own. This may be based on the professional who may interpret it as a way to show a device or concept as new, or expensive, and not really worrying with how it will be applied to the end user. Nowadays the latest technology is associated with high value and innovation.

Question number four asked about problems that elderly face in their daily lives within the city context, and also asked for examples. On the fourth question more than half of the interviewees, when answering this question, mentioned problems related to mobility; accessibility and also decreased motor and cognitive activities; Lack of spaces intended for this segment of the population, whether focused on specific activities , such as outdoor gymnastics, activities that encourage motor activity, or even recreational activities, that make them connect more with space, or reserved seats, as in public transport, which are exclusive, since these in turn end up reaching fatigue faster than the rest of the population; Problems related to signage in cities and parks that sometimes end up confusing the elderly, or even not meeting their information needs , causing problems such as loss of reference, which in turn generates a situation of tension, which can lead to isolation, or even traumas that, over time, prevent the elderly from leaving their homes, due to this sum of small barriers that generate fear; Lack of collaboration of the rest of the population with this age group was also cited, as a form of prejudice and not inclusion in the design of the city, as they believe that future generations were already accustomed to technology, so the more modern / connected, the easier it will be in the future.

On this question, most of them referred to the same problems already mentioned in the first question, using very few examples and presenting the same concerns, this is believed to be justified by the limitation on the point of view of elderly in an outdoor environment. People don't typically see the city with different eyes, they stay connected to what they heard, or the accidents that have been noticed, but never really give the chance of getting to know what is really going on during those situations. They also mentioned the need for specific activities for the elderly target audience, where they could go out and be part of a group, such as gymnastics or specific activities, with that, their cognitive activities would be developed and they would be aging in better condition, being an active part of the city, not falling behind, thus failing to face many problems of isolation. This solution is believed to be helpful because it would reduce the fear of going out without reason for the elderly, and on top of that, it would be a motivation for outdoor activity. By doing so, the

elderly could associate themselves in a larger group setting, without the fear of being judged, not included or not being able to play a role in the group.

For the fifth question the experts were asked how could technology help elderly to solve everyday problems, and justify their answer., Regarding the responses obtained, there was no consensus on the importance of technology in solving problems that the elderly population faces on the urban scale, however most of the responses pointed out that it is extremely important to solve these problems with the help of technology, even more when it comes to issues related to their ability to move around the city and their reintegration into the daily life of the metropolises, it was mentioned that by increasing circulation and also with a greater reach of this population, previously limited to only residential neighborhoods, and with local commerce, vivacity and the feeling of belonging end up increasing, thus giving this part of the population more autonomy and independence.

This question was the most controversial of all, there was no straight line where the respondents followed the same reasoning, the importance of technology to solve problems was not unanimous. This can be related to the lack of conceptualization of technology. Most specialists could only come across a concept of technology, being somewhat limited, and not expanding the field of possibilities for technology as an aid in outdoor environments.

Question number six, referred to smart city, asking the experts to talk about what they knew and understood about the concept of Smart City. 16 of the experts (59.2%) said they had to define the concept of smart city and after saying what was on the question. The rest did not hear or are not familiar with the term (11 people). Among those who know the term, they cite definitions such as the green city, cities that use technology to help citizens' daily lives; neighborhood planning in large cities; Monitoring of transport and flows within the city, in order to meet the basic needs of the population; Automation through the use of sensors equipped with artificial intelligence; City that has intercommunicating means that seek, in addition to the previously mentioned, alternatives focused on the well-being of the elderly population.

Among all 27 responses, very few managed to explain the concept of the smart city as a way to help people live their daily lives. The idea of a smart city being related to urban planning, on a neighborhood scale or just by public transport, was the most common. Showing the

connection between software designers, better than urban architects / designers with the city, it can be said that most experts report the smart city directly with information technology and design the iteration, thus passing the ability to design these. Only within the technology sector was a difference shown, as the area relates to the development of new tools, rarely did they think of it in a way that is possible to interact and adapt.

Question number seven was related to the previous one, asking them how a smart city, solve the problems already cited by them. Among the people who answered affirmative to the previous question, on the seventh question the experts cited ways of solving the problems mentioned above were also mentioned, through ideas such as automation of traffic lights, in order to better coordinate car traffic; allow more signal time for the elderly population to cross the street; correction of irregularities on the sidewalks; Better control of public transport, seeking less waiting time, and less chance of creating fall accidents, in case users try to run to board the transport. Intercommunication between all the city's problems, in order to interconnect these and also make most of the population aware of the elderly's difficulties and able to help them.

Based on this example of a smart city, the question of whether the expert could justify what was said in question number six was asked with the concept of smart cities being misinterpreted by most experts. The last question showed the experts the importance of adequate spaces for the elderly in a city environment. After talking about this fact, they were questioned about how they believed the urban development could be improved in order to better solve the needs of the elderly population. Among the answers obtained on question number eight, it was possible to group them into 7 subgroups to better understand and seek to express a better result. These subgroups were titled: Better use of public space; Improvement in the daily life of the elderly population; Improvement for future generations; Resolution of existing and previously mentioned problems; Innovation and adaptation of already known solutions to routine problems; Remote assistance; Generation of activities for the inclusion of this population in the urban network again. The aforementioned topics are the topics which will be used in the following chapter. Specifically, they will be used in scenarios, to properly exemplify the need of elderly facing the challenge of being outside the park. The anticipation prior to this evaluation was that the experts would have a larger comprehension of the elderly and even more consciousness about technology. The sample interviewed was focused predominantly with small devices advancing and always on a small scale.

Regarding problems that elderly face, they seemed worried, but also without a bigger comprehension of what they really face and how they could solve those situations without being forced to avoid it.

5.2.6 Conclusion

After conducting interviews with experts, it is possible to obtain a more in-depth view on the real needs of the elderly and the importance that technology has, even though it has rarely been mentioned, technology in this case is a facilitator in the implementation and adaptation to these improvements. Throughout the analysis of the results, there was a lack of a straight line that would lead to the problem until finding one or more solutions. Due to this fact, it was sought to carry out naturalistic observations to complement what was said by the experts and also, to understand the real problems, needs and barriers of users in the real context.

5.3. Phase 3: Naturalistic Observations

The naturalistic observation was made in a public park, based on a theoretical concept. This type of observation is commonly used when observing subjects in their natural environment, sometimes anonymously, and without any type of intervention. This study took place in Campo de Ourique, Lisbon, during 9 consecutive days, during different hours, while trying not to create a connection or to be recognized by users. Through the anonymous observations, it was expected that the behavior of the users would not be influenced by the observer. By the observations, the needs of the users and the interaction between the environment the users will be analyzed in a matrix. With all this information, it was expected that there would be a possibility of finding a problem which could be improved by proposing design solutions for those daily activities /problems to improve the space.

The ambient assisted living (AAL) system is a socio-technical system that uses networked artifacts embedded in the environment to lead the flow of life to well-being (Abtoy *et al.*, 2020). Most of the AAL system is focused on indoor environments, such as smart homes, using information from sensors in the environment and on the person (Rashidi & Mihailidis, 2013). However, if the solutions can be implemented on an outdoor scale, the elderly can be confident to

perform activities outdoors. This plays an essential role in increasing the quality of life and has a longer independence of the elderly's life (O'Grady *et al.*, 2010).

Maddock (2018) emphasizes that the reason why the elderly seldom use public parks is not clear. Therefore, it is crucial to understand the needs of the elderly while using outdoor spaces (i.e., public parks) and they are reluctant to use them. Besides, understanding the interactions between the elderly and public parks will help to understand the problems and find solutions accordingly. In this sense, this paper focuses on user research. Naturalistic observations were done to understand the interactions and behaviors of the elderly in a public park in Lisbon. An analysis of behaviors, patterns, and activity flows was analyzed to find out different situations (i.e., risk and/or undesirable).

5.3.1 Method

The naturalistic observation was the chosen method and elaborated in a public and open park, based on a theoretical concept, of observing the elderly anonymously. This type of observation is commonly used when observing subjects in their natural environment, without any type of intervention (Somekh, 2005). This analysis was further explored within a matrix. The objective of the matrix is to find/see problems that affect the elderly's well-being.

5.3.2 The context

The park is located in Campo de Ourique (Figure 2), Lisbon in a relatively new neighborhood, not very central, but with public transportation, such as busses and other public transportations. Based on this fact, this area has developed itself into a small town inside Lisbon, having all types of services and shops. Some data gathered from the City Hall showed that 80% of the buildings in this area are residential and 18% have mixed uses (having commercial occupancies on the street level and residential on top). This area was also selected on the pretext of being highly concentrated with an elderly population within its neighborhood. Some geographic and urbanistic conditions were considered as well (i.e., being a flat part of the city and being connected to the city center via public transportation).

Figure 2. Park image, during observation session.

5.3.3 Sample

The sample consisted of 135 elderly (94 male and 41 female). They were observed in the different areas of the park, carrying out different activities.

5.3.4 Apparatus

An observation sheet (Figure 3) was developed to facilitate the taking of notes during each observation session. The following information was collected under these topics: task/activities elderly do, areas in the park, flux/path elderly follow, problems elderly face with, opportunities to improve the design of the park. A layout of the park was printed (figure 4), to register the connections between spaces, existing objects (e.g., drinking fountain, trees, pool), and solar exposure during the observation. A smartphone was also used to record moments by photos and videos.

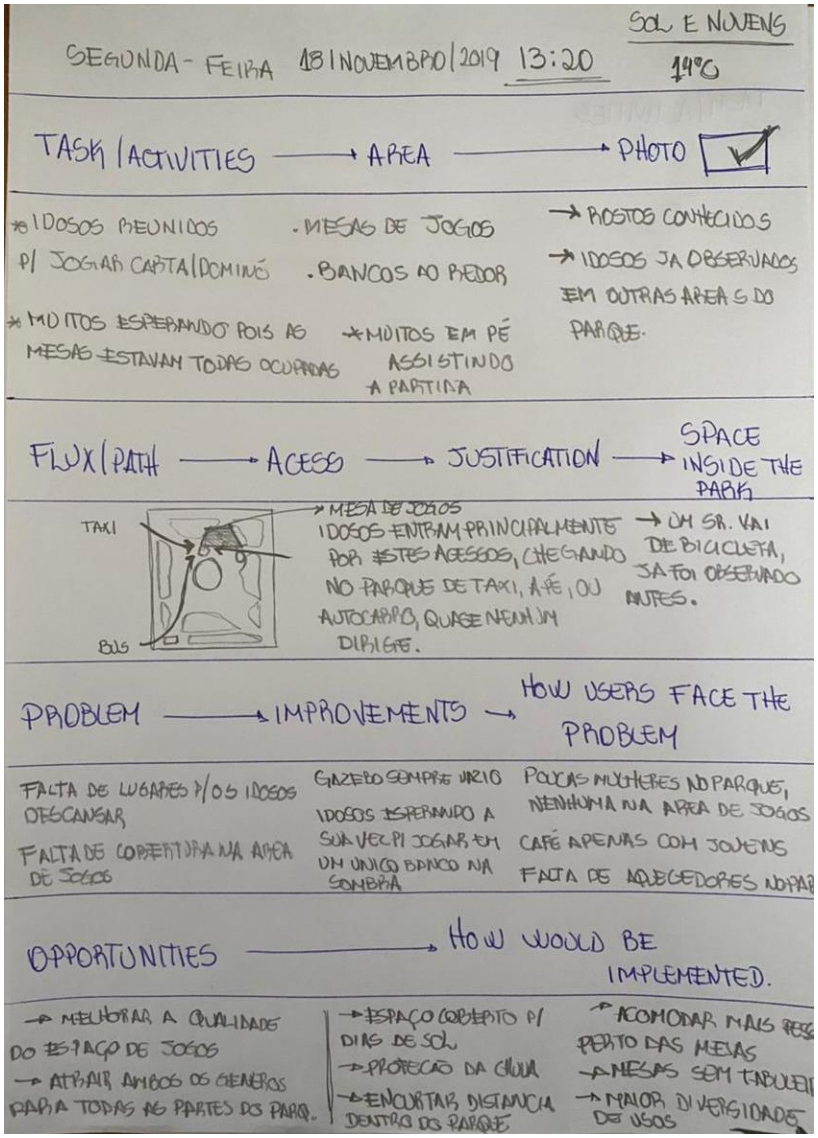

Figure 3. Example of filled observation sheet

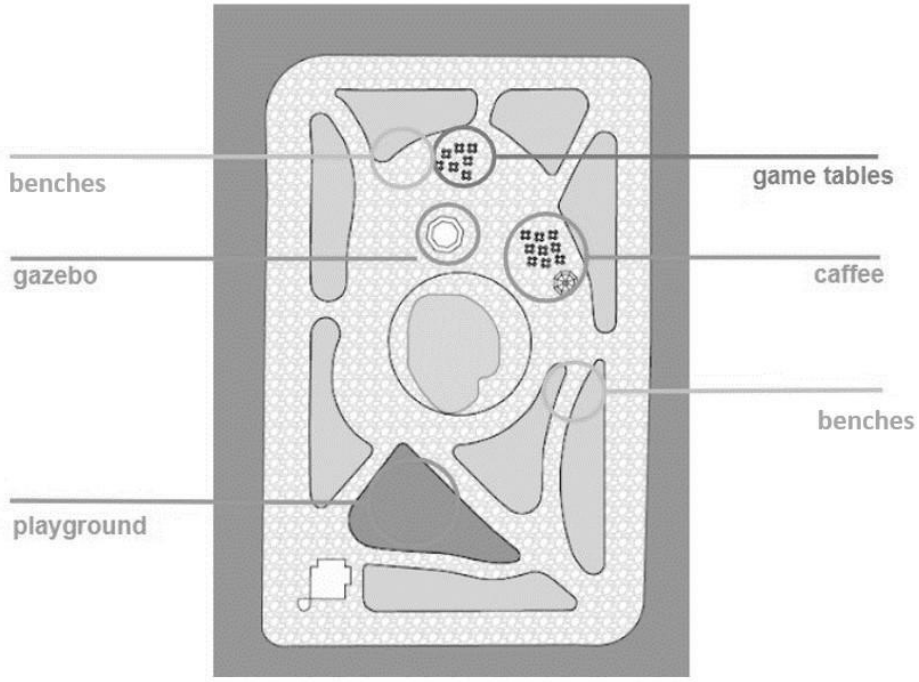

Figure 4. Park layout

5.3.5 Procedure

Observations took approximately 2 hours per day, during 9 consecutive days (7 days a week and 2 weekends), during different hours of the day, so as to not create a connection. A total of 18 hours of anonymous observations were done by a single observer. Users and other analysis were written in a diary by the author, for further analysis. By doing so, the observations captured the needs of the users and the interaction between the environment. Throughout the analysis period, users were observed performing daily and routine activities (e.g., meeting friends, playing card or board games, drinking coffee) in the park. The observer positioned himself in different places of the park, aiming to capture the greatest amount of information while not interfering with them in their activities. Notes were taken throughout these sessions, with pre-established topics on observation sheets. The observer did not make any contact with any of the observed samples. Photos and videos were taken/recorded to aid future analysis. All the information collected was transferred to an online document, to then be analyzed, categorized into activities; problems; and opportunities which were shown previously in Figure 2.bservations took approximately 2 hours per day, during 9 consecutive days (7 days a week and 2 weekend), during different hours of the day, so as to not create a connection. A total of 18 hours of anonymous observations were done by

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5.3.6 Results

After all the naturalistic observation sessions provided a systematic, rich and intuitive method of analyzing, the observer was able to detail the interactions, the users' needs with the park. The categorization of the problems, as well as the repetitions from the 9 days of analysis, were examined and transferred to a table. The collected data was summarized as the most frequent problems, explanation of the problem, and the categorized situations (i.e., risk and undesirable). In this sense, 7 main problems were identified of which 4 are classified as risk and 3 as undesirable situation:

1. Outdoor exposition (Risk): Elderly is exposed to rain/sun if not under the small shelter or trees;
2. Noise (Risk): Park is located in the route of planes landing and taking off;
3. Illumination (Risk): Street lights are not turning on time;
4. Segregation (Undesirable): Two main activity areas (i.e., game tables and benches) do not have interaction/relation;
5. Interaction (Undesirable): Bench disposition is not allowing easy interaction between elderly;
6. Maintenance (Risk): Leaves on the floor, overloaded trash bin, public toilets maintenance;
7. Location of equipment (Undesirable): Disposition of specific elements does not allow the elderly to use all the areas of the park.

The listing of the problems, as well as the explanations, and the categorization of the situation into risky or undesirable, helped to create a better understanding of everything that was analyzed in the park. Next, each of these problems, as well as their explanation, first the risky ones, then the undesirable ones are detailed.

Outdoor exposition, The small area with a shelter for the elderly to either stay in the rain/sun or adapt different and uncomfortable ways, to use the space, is a risky situation; Noise, This area is in the route of many plains, causing a loud noise, interfering with the hearing aid of the elderly, is also risky; Illumination, Different timetables for turning on the lights, cause the elderly to leave the park in certain hours, based on their limitations, also risky; Maintenance; Low-frequency maintenance, accumulating leaves on the ground, also risky; Segregation, Two main activity areas based on the disposition of the game tables and the benches do not have interaction/relation, is an undesirable situation; Interaction, Bench disposition, either people are side to side or limited for 4 in each table. Sometimes even sitting alone, also undesirable; Location of equipment, Disposition of water fountains/trash makes people walk only in the central area, is also undesirable.

5.3.7 Conclusion

The objective of this study is to analyze the data that was collected during naturalistic observations which were aimed to understand the population without interference to daily lives. The results show that the most repetitive problem is the outdoor exposition; the noise; illumination issues, the situation observed the most, was a risk, given that this is an analysis of the critical situations.

This study helps to find some opportunities where the public park's design can be improved for better usage of the space to enhance the elderly's wellbeing. The situations were categorized as risk and undesirable. Further user research will be done through interviews/questionnaires intended to justify the observed situations. Besides, to enrich the user needs, expectations and user-space interactions, Personas, and User Scenarios will be created. The next step of the project focused on the justified situations, and created smart solutions.

5.4 Phase 4: Personas

The elaboration of personas is based on qualitative and quantitative studies. First, one must seek demographic data about the sample being portrayed, then one seeks to represent in a realistic and reliable way the behavior of these personas, to try to validate in a more faithful way possible, as these characters are key to the smooth running of the study. For the elaboration of the scenarios, it was necessary to create primary and secondary personas, being the primary, the authors of the actions in question and who presents the problem, and the secondary ones that seek to reaffirm the story told by the primary, giving only more details and critical points , for a better understanding of the scenarios as a whole.

In this section, 5 primary personas will be presents, first one is Antonio Alberto (Figure 5), second one Helena Cristina (Figure 6) third one a couple Jose Maria e Amalia (Figure 7), the fourth Joao (Figure 8) and the fifth one Claudia (Figure 9)

This first persona represents an elderly man, who lives his entire life in Lisbon, and is very passionate about his family, on the other hand, is not a person to be called tech friendly.

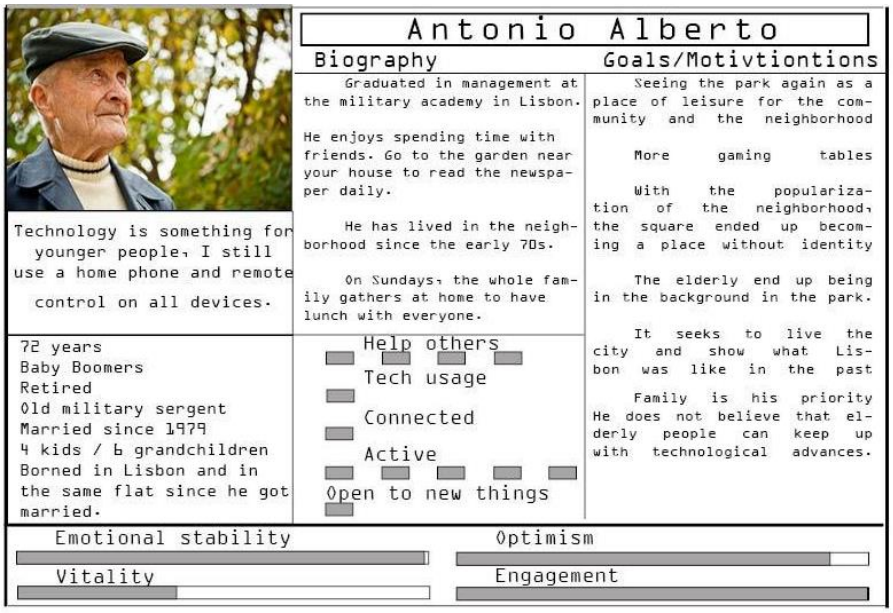

Figure 5. Persona 1

The second persona is an Elderly female who is a retired history teacher and recently became a widow.

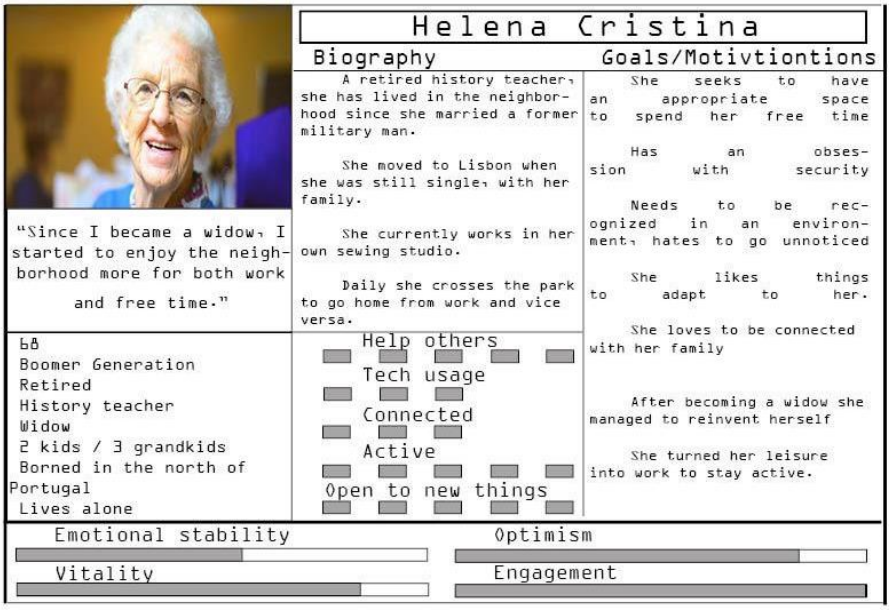

Figure 6 Persona 2

The third persona is a couple that is very passionate about their family, and love to spend some time with their grandchild.

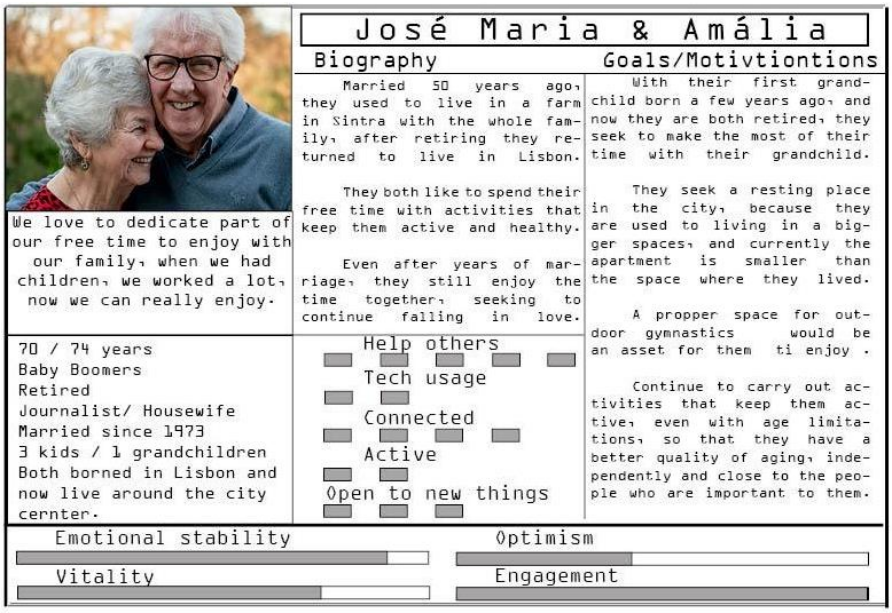

Figure 7. Persona 3

The fourth persona is an elderly man who has walking limitations and enjoying the city is a daily challenge for him.

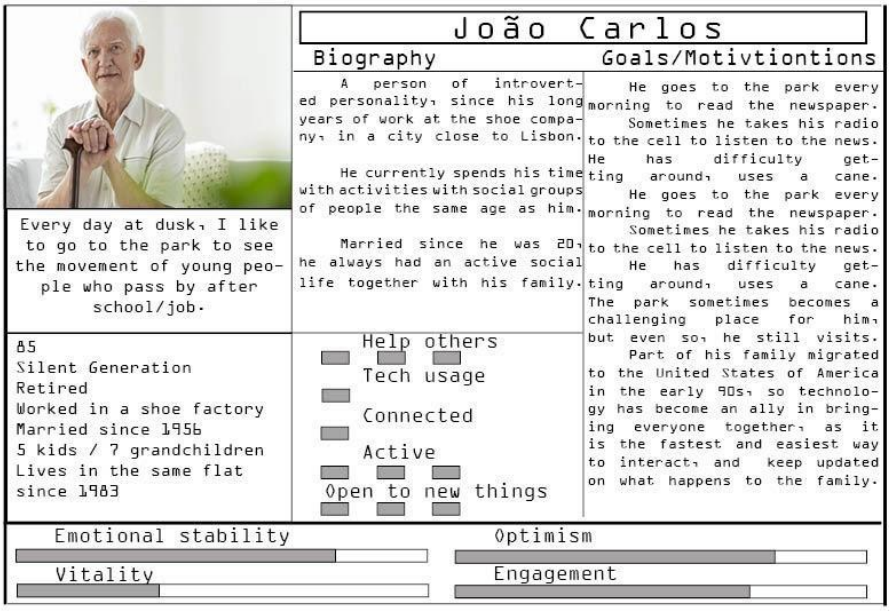

Figure 8. Persona 4

The fifth persona is also a widow who enjoys the world with her son's help.

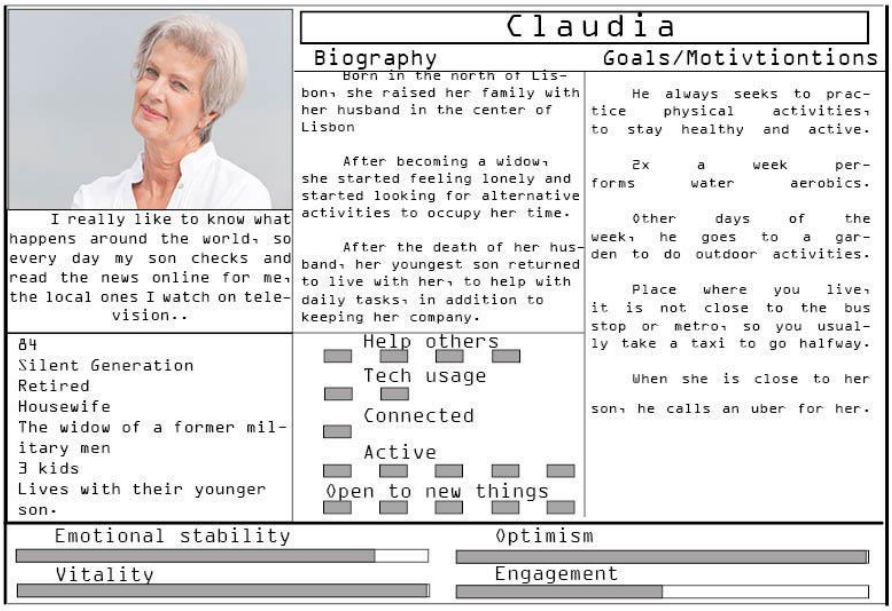

Figure 9. Persona5

5.5 Phase 5: Scenarios

Creating scenarios is a speculative design method based on stories that designers produce to exemplify how the user will act in situations, how they will achieve their goal, in addition to observing motivations, needs and limitations to optimize the design process (Lutz, 2020). Cross (1994) states that the customer's voice is the key to any product that is developed, they are the ones who define the paths that the product must follow and which decisions must be taken, this type of information is collected through research and used, as done previously in the interview with the expert's section.

To better exemplify and understand the needs and decisions of park users, scenarios were developed based on the problems observed during the process of naturalistic observation. The design strategy adopted was based on the one mentioned by Moggridge (1993) this process is developed in 4 stages: understanding, observing, visualizing possible solutions and finally evaluating them. Through this method, it will be possible to observe a more cohesive and structured set, looking for the point of greatest weakness, or the one that does not present desired results, and start over.

The scenarios created in this section, serve to support the discussion and seek resolution of problems. Those scenarios were created in a simple way of communication that allows the author to interact with different situations. Each scenario, as said by Cooper (1991) and Nielsen (2002) must be rich in details, to make a narrative as credible as possible, getting as close to reality.

Carroll (2002) states that the scenarios are a textual narrative, Nielsen (1990) previously said that the scenarios are based on heuristic views, therefore, they must communicate the fundamentals of the user to the audience that reads / evaluates, so with that it is possible to evaluate and better structure the thinking and theories of user centered design. Campebell (1992) affirms that the scenarios must be based on the final objective of those who create them, in order to illustrate all parts of the system, and thereby seek improvements that validate the theory.

For this part of the study, five scenarios were created to show everyday activities that take place in the park. The first situation is a male elderly playing card, second is two female elderly spending some time together, the third one, male elderly enjoying the sun and fourth one, an elderly couple with their grandson in the park.

First scenario. Around 2PM on a weekday in April in Lisbon, after consecutive rainy days, traditional in the Portuguese spring, an elderly man enters the park, through the entrance closest to the public toilet, as he got off the bus that brought him closer to this access. On his way to the game area, he observes other people deviating the shortest path, due to the accumulation of leaves on the ground next to the lake. Due to a memory of having fallen in a similar situation a few months ago, he decides to follow the other people and it also takes the longest path (figure 10). In this way, he observes luminous signs on the lampposts, which indicate the risk zone due to the accumulation of leaves on the floor. Before finally reaching the game tables, he meets some familiar faces and stays for a while to talk, until he finally reaches the tables, where he writes his name on the waiting list for the next round of the domino championship. After a few rounds, look at the digital scoreboard near this area and see that he had already been disqualified. He gets up and goes to a lady who frequents the park daily selling cakes and coffee. He buys a coffee and sits on a bench that is dry, even in humid weather, due to the heating system for water evaporation and observes people for a while, gets up and heads again to the exit next to the public toilet, and before taking the bus and going home to dinner with his wife, he observes a small sign that informs that the park is equipped with infrared cameras that monitors the park anonymously.

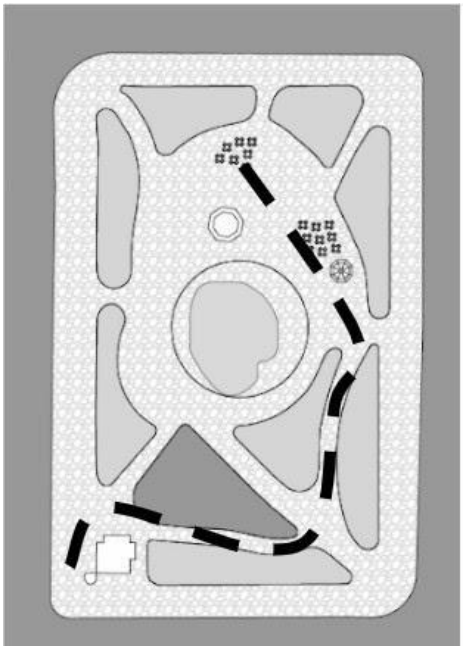

Figure 10. Path of first scenario

Second scenario. Weekday during autumn, right after the daylight-saving time change occurs, around 4:30 PM on a cloudy day, an elderly lady enters the park through the entrance next to the gazebo(figure 11), as she was nearby to go to the cobbler to change the sole of an old shoe. Next to the water fountain, she finds a neighbor, with whom she sits for a few hours on a bench talking. She doesn't realize that the sun is already setting, due to the adaptive lighting system. One of the elderly women decided to go to the bathroom, so she comments to her friend that the last time she went to the park, the bathroom was undergoing maintenance and she went all the way for nothing, and is informed that the park now has a light panel nearby to the bench where she is sitting, which informs the time, which had already gone unnoticed due to the cloudy day, and also the capacity of the garbage in the entire park, as well as the status of functioning of the bathroom, if it is in operation, maintenance, busy or free. Both say goodbye right there, one goes home, while the other checks on the panel that the bus that takes home goes in 15 minutes, so it goes to the public toilet is in full operation and free, then goes to the bus stop. bus, still 3 minutes in advance to go home.

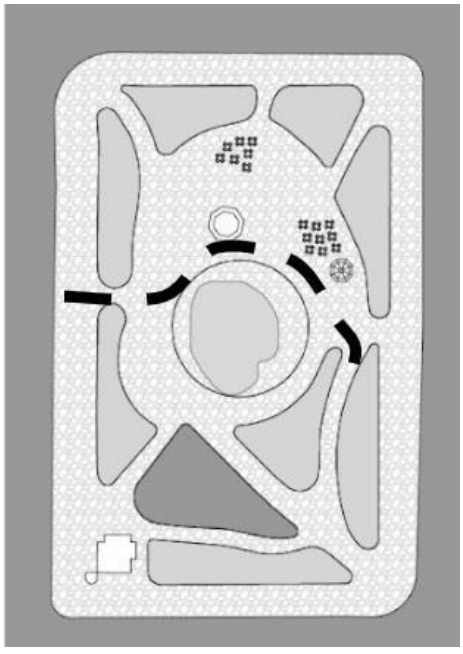

Figure 11. Path of second scenario

Third scenario. Summer day around 3:30 PM, a grandparent couple arrive at the park by bus (figure 12), together with their grandson after picking him up from school. They enter right next to the playground where the child starts to play with other children. Grandparents look for a bench to sit and watch their grandson. On this day the sky is clear, and the sun is very strong. Because they are used to going to the park before school holidays, when it was still spring and the position

of the sun has changed, they spend some time watching the small panel that indicates which bench will have shade earlier / longer, so as to avoid being exposed in the sun, and the risk that this presents when unprotected, considering that the roofs are located at the other end of the park, and in this area, the shade is given by the crown of the trees that surround the park. After finding a bench that indicates that they will be in the shade, within 15 minutes and will remain that way until nightfall, they both sit on this bench next to a tree and remain there until it is time to go home with their grandson.

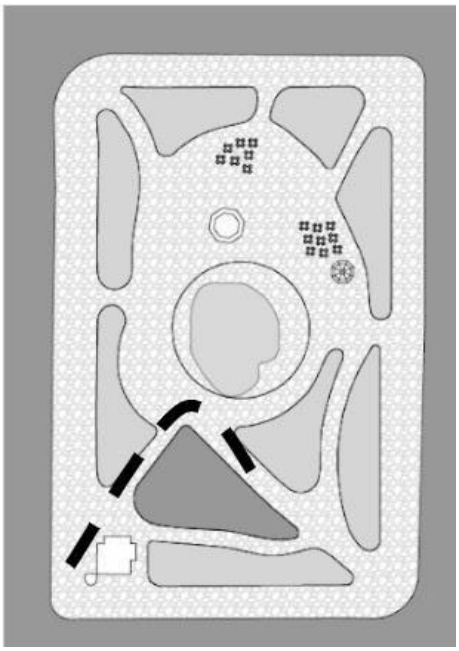

Figure 12. Path of third scenario

Fourth scenario. Winter day around 10AM, first day of sunshine, after a few cloudy days. An elderly man enters the park through the book cabin corner (Figure 13), goes towards the center of the park, having difficulty getting around, using a cane. Sit on a bench to rest, after this exhausting walk, and wait for the light and sound signal from the panel indicating that you have a table available to play. A player at table 3 decides to leave the game and go home, before getting up, tries to call the man who is on the bench to warn that his place will vacate. However, he cannot because he is distracted by eating cookies he brought from home and talking to a young man who drank coffee by his side, so he gives up and leaves the table without having a substitute. After a few minutes, the gentleman who was sitting on the bench, observes that the lamp posts, near the games area, change color, and an audible signal is emitted, indicating that table 3 needs a person for the game to continue, and his waiting number showed on the screen. He gets up, with the help

of the bench that propels him upwards, thus reducing the effort required to lift, places the now empty cookie pack in the trash bin that is on the way and has a green light indicating that it is not full, and goes in the table that this vacancy to start playing with the others.

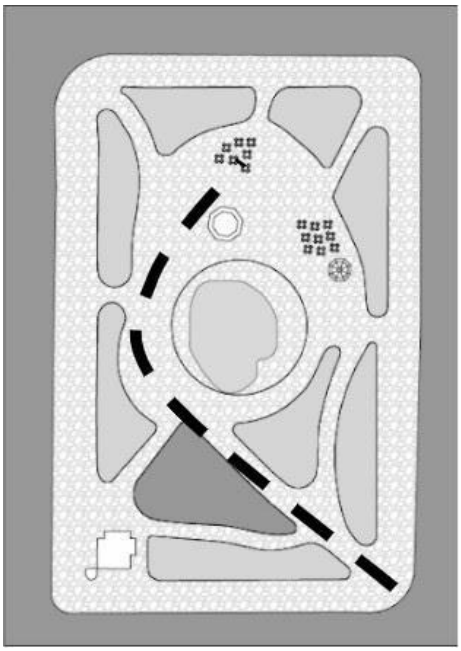

Figure 13. Path of fourth scenario

Fifth scenario. Mild summer day, around 3PM, two ladies meet in the square as usual to visit the arts and crafts fair that takes place in the square during the summer. After walking through the fair, they decide to sit down because they are both tired. After wandering for a few minutes without finding any vacant places, they check the existence of an electronic panel that informs the location of the free benches inside the park, so both walk to the benches that are close to the lake, where they get a view of the fair and also of the ducks that are fed by the children while their parents look at the fair (Figure 14). When one of the ladies decides to leave, she notices that on the same panel that informed the availability of the seats, there was a notice stating that the public bathroom was being cleaned and, in a moment, it would be ready for use. Therefore, they decide to look for another bench that is already in the shade and wait for the maintenance to finish to make use of the public bathroom and then have a coffee right there in the square.

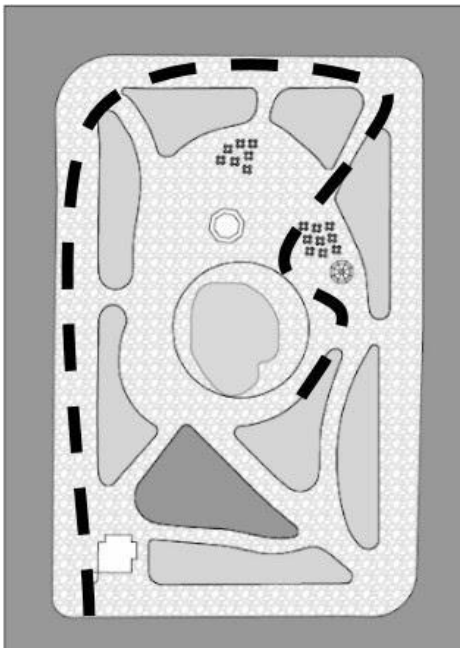

Figure 14. Path of fifth scenario

A table (see Table 4) is created to summarize each Persona and their goals in order to show the needs and problems they face with. As a result, the products and their functions are detailed to help to propose the design solutions for the smart public park.

Table 4. Characters in scenarios

Persona	Goal	Need	Barrier	Function/Product
Elderly man (scenario 1)	Reach the game area	Participate on the next round of games with his friend	Slippery floor leaves accumulated on the floor	Light sign on the light pole indicating the risky area Also, this can send this info to the cleaning stuff
	Participate on the next round	Be aware of the turns, so he won't miss it	If he doesn't pay attention, he might lose his turn or even loses the chance to play at another table	Panel indicating the turn/opponents and scores
Elderly lady I	Reach the other side of the park to	Cross the park	It's getting dark and the light	Adaptive light system, keeping

(scenario 2)	change her shoe sole at the cobbler		system won't be enough to illuminate the path	the same intensity
	Use the public toilet	Reach the other side of the park, hopping the public toilet is not under maintenance	Risk to reach the other side, and the public toilet is under maintenance	Light panel indicating information about the park conditions / status of equipment.
Grandparents (scenario 3)	Rest while their grandson is playing at the playground	Shadow area to rest during a sunny and warm day	The bench they normally sit is exposed to the heavy sun, due to the season	Bench with a display indicating the sunlight/shadow schedule during the entire day
Elderly man (scenario 4)	Play games at the vacant table	Walk towards the game tables to join the big group	Walk limitation, he uses a cane to help his mobility	Alarm on a screen appears indicating is his turn to play
	Reach the game area	Stand up from sitting on a bench to move towards the game tables	His leg strength	Adaptative bench system, helps him to stand up, pulling him up
Elderly lady I (scenario 5) Elderly lady II	Visit the arts and crafts fair	Rest after an exhausting walk	Empty spot to sit	Panel informing the availability of bench inside the park
	Cath a bus to go home	Walk until the bus stop hopping the bus is running on time, not like usual	She can't see the bus stop from that spot in the park, so she has to trust the timetable	Info panel showing the status of equipment's in the park, and also indicating the waiting time for the bus

5.6 Phase 6: Design Proposal

Alternative design proposals are sketched out to meet various needs/problems observed in the park. Among the ideas elaborated, some of them passed through modifications/adaptations, and some others were left behind, and for this reason they are explained briefly in this section. The first one is the smart bench (Figure 15) that was designed to help the user (especially with the reduced mobility) to sit down and stand up, cushioning the impact when sitting and boosting when lifting.

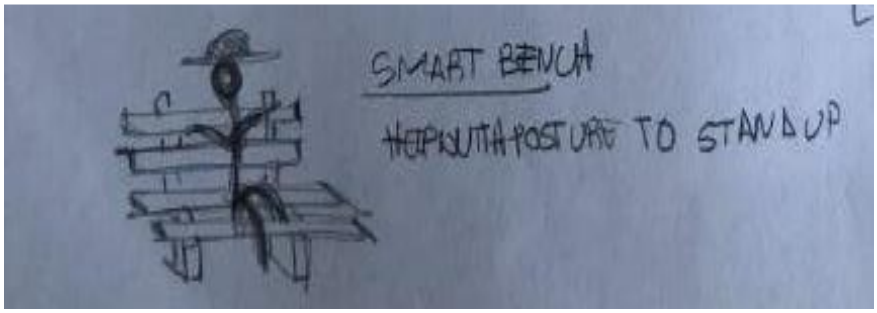

Figure 15. Smart Bench

A camera system (Figure 16), using infrared technology was thought to help capture information about the park in an unobtrusive way, and analyze the need of emergency interventions.

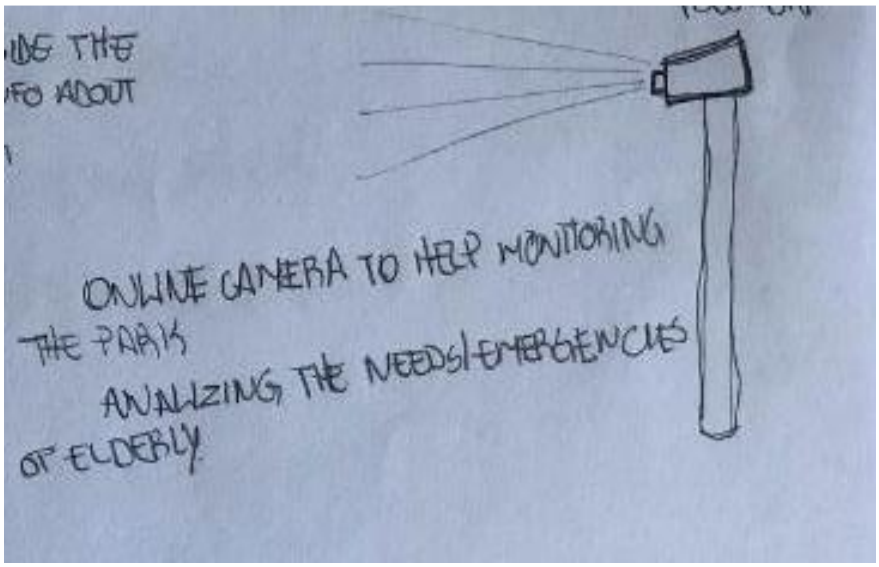

Figure 16. Infrared camera

As shown in Figure 17, an initial sketch was done for a smart lamppost. This type of product already exists on the market (**https://smartlamppost.com/**). However, the idea was dedicated to a park scale rather than dedicated to streets. Therefore, the design should match more

to a nature-based design. This proposal has the adaptive light system and changes colors whenever there's an adversity in the park, to warn the users.

Figure 17. Proposed lamppost

The idea of lamppost was improved later (Figure 18), which was able to capture information anonymously from the park, such as density, areas of shade/sun, accumulation of water/leaves on the ground, and in addition to transmitting this type of information to the Moopi, this objects is able to change color, in order to warn the environment with high, low or zero risk for the elderly. This is the most common object in the park, because other than a lighting tool, it will serve to collect and distribute important information, though the lights system prevents the elderly from being injured inside the park, taking in consideration the alert about any adverse situation.

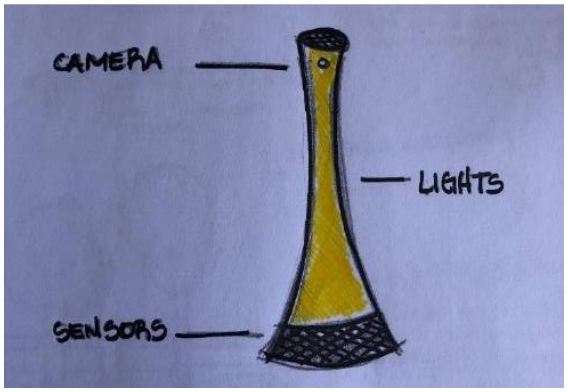

Figure18. Smart lamppost sketch

A smart sign (Figure 19) was also sketched out to guide the users to find the shortest path inside the park, indicating areas with less occupation, besides empty spaces.

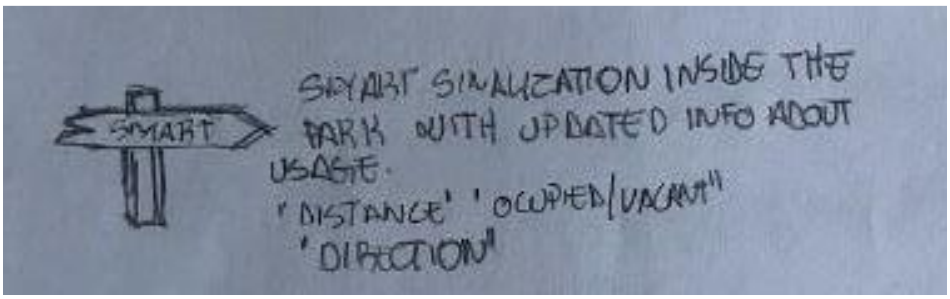

Figure 19. Smart sign

A smart walking platform (Figure 20) was also drafted that is equipped with a handrail capable of sensors. These sensors are meant to capture blood pressure and help stability, sensors implemented on the trees would capture the speed, flow and track anonymously, while the floor would gather information about weight of the users with mobility restrictions. All this system would be automatically turned on and off with a laser system positioned at both ends of the platform.

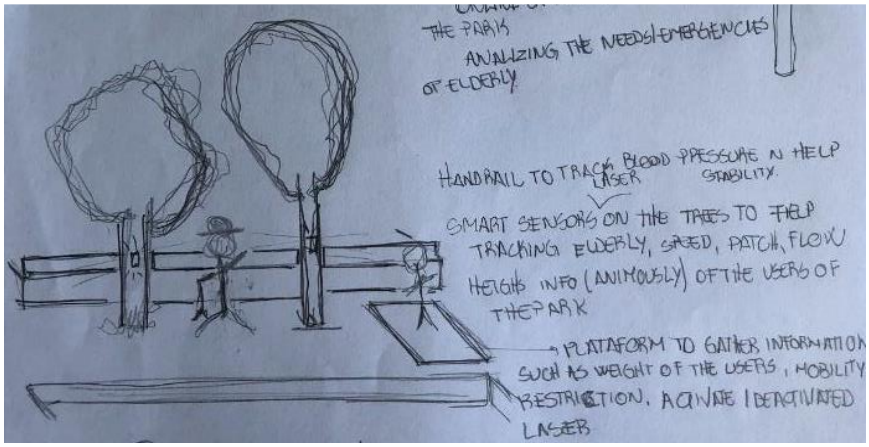

Figure 20. Smart platform

One of the products that was proposed in the development process was the Moopi (Figure 21) that is considered the main object of the park. This is based on the fact that this design is the one that allows the interaction between elderly and smart products, through the Wi-Fi system, it communicates with other objects in the park, to obtain information, and presents them on a screen. The information it shows as follows: places to sit in the park, wet areas with accumulation of leaves on the ground, game tables occupancy, public transport information, availability of the toilets and

level of occupancy of trash bins. Additionally, it serves as a communication channel informing about the neighborhood, and environmental issues, such as air quality, temperature, and level of pollution.

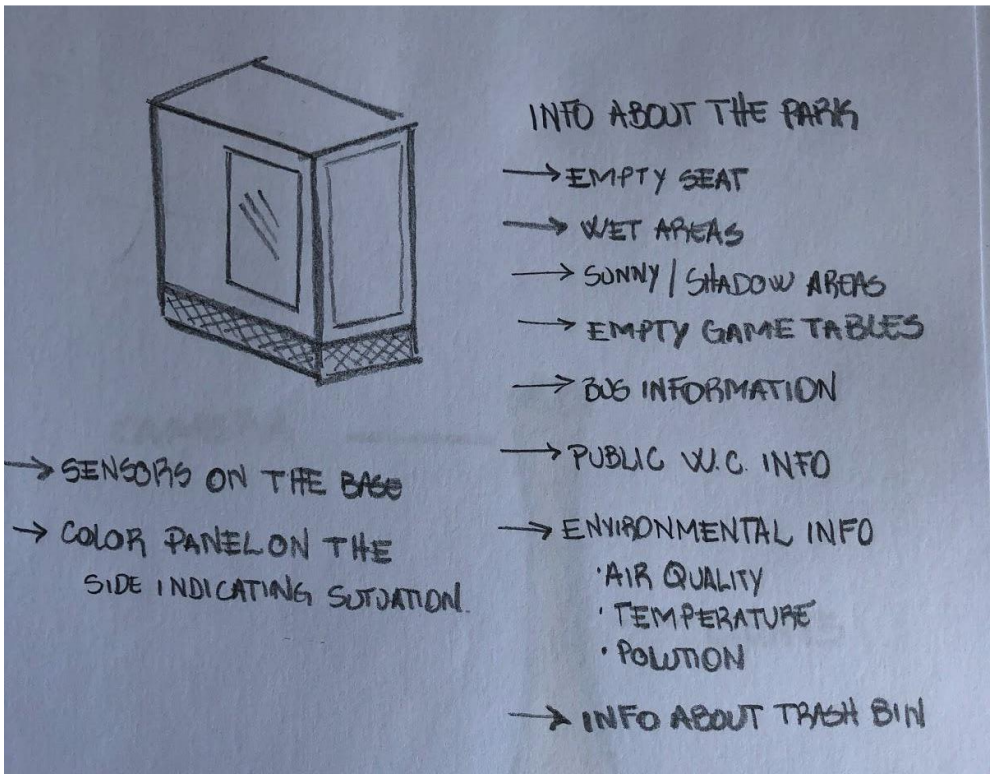

Figure 21. Moopi idea

For the gaming area, one of the most important needs that was observed was to create a covered space, which was mobile, to protect the elderly from the intense sun and also from the rain, taking into account that during the winter in Lisbon the users need a way to keep them warm, the shelter adapts itself based on the season and also weather condition. The elderly needs a certain amount of sun, to maintain vitamins, and to increase well-being. For this, a shelter idea (Figure 22) was proposed, which has a fixed base and a cover that changes position automatically when

activated, to protect the elderly, in addition to having lighting at the bottom of the fixed base it uses the same functionality of the lamppost.

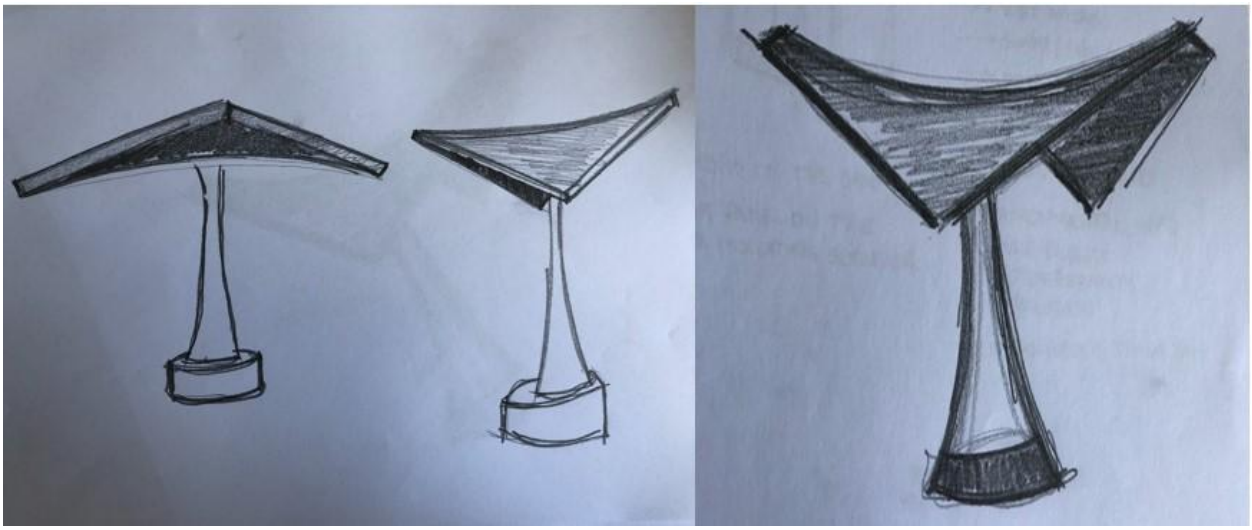

Figure 22. Shelter idea

The proposed design was based on the system as shown in Figure 23, where the park's system is based on capturing environment data, through sensors installed on specific objects in the park, to cover a larger area. After the collection of data by these sensors, they are transmitted to a big data (digital center that stores and processes all this data) and transmitted to other objects, in an automatic way, in order to assist in the best possible way, the experiences of park users (specifically elderly), either by changing behavior, in order to avoid risky situations, or even just facilitating the performance of daily activities.

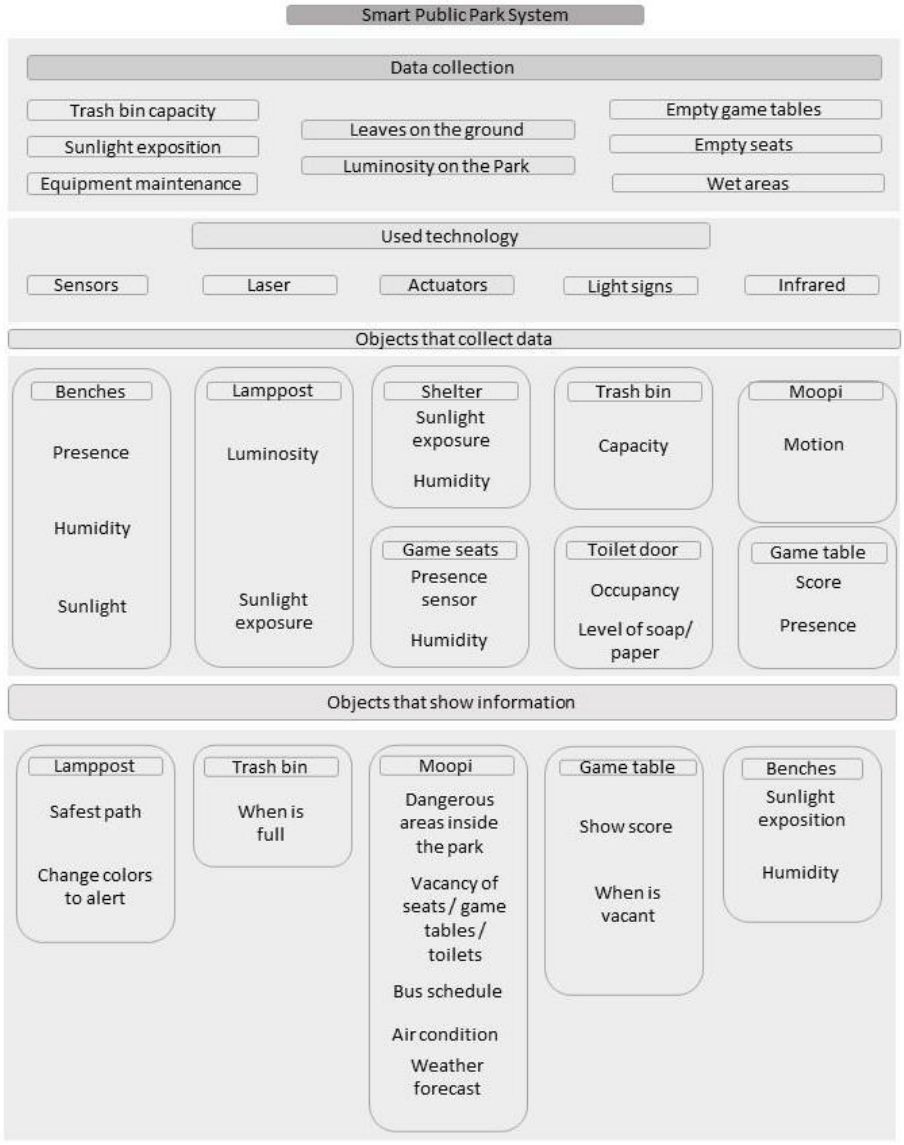

Figure 23. Smart public Park System

The user's hierarchy of the systems presents in Figure 24, consisting of three main users of this system. Elderly is the primary users and the secondary users are defined as Cleaning and Maintenance Staff. Eventually, the data that will be collected will be reached to a stakeholder (e.g., Camara Municipal).

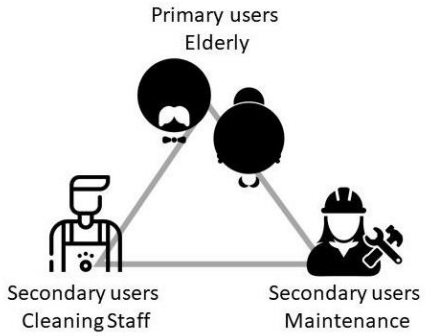

Figure 24. Hierarchy of users

The proposed ideas for the park were planned to intercommunicate devices and also allow the communication of the product with the human whenever any maintenance is necessary. The Figure 25 presents the proposed solutions for the park in order to facilitate the use by the elderly, bringing well-being for them, in a non-invasive way. The objects were conceived to be part of daily activities of daily life, not seeking to become something extremely technological that requires assistance from other people for use. A simple interface was designed, with basic options that can easily be included in the users' routine.

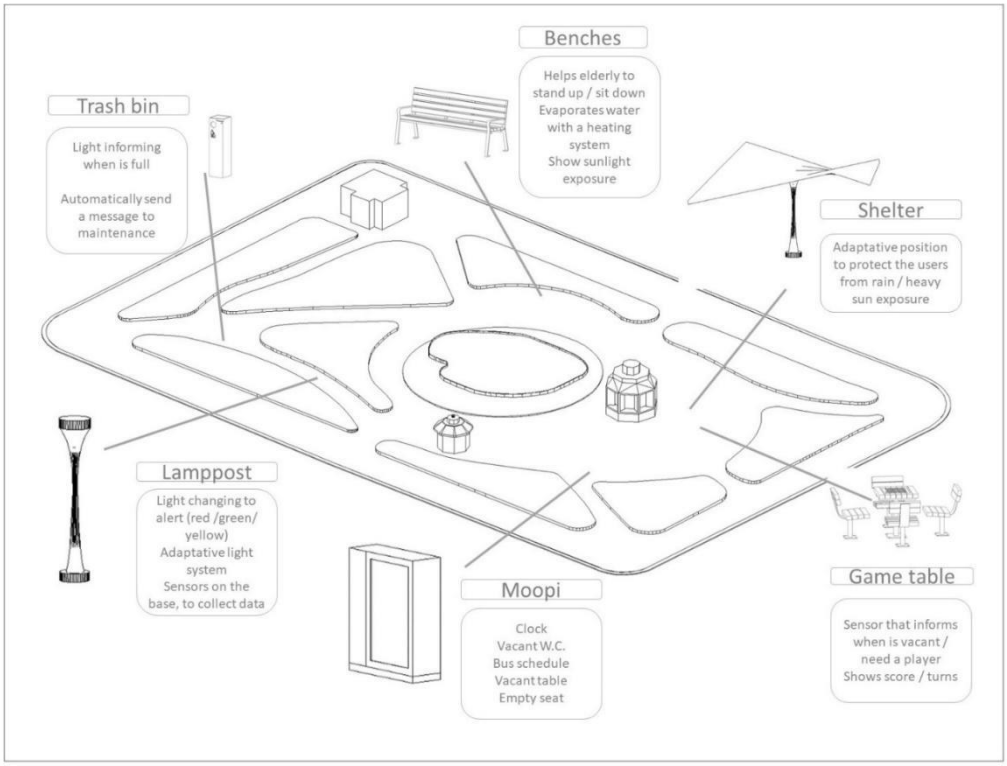

Figure 25. Park smart devices

After sketching out the design ideas, they were designed with the aid of software to demonstrate better, and also planned to bring better experiences to the elderly in the park not forgetting about their wellbeing was the crucial point for the development of this work. The concept of well-being and smart objects are the main idea of the proposal, based on the fact that those products are more than technological objects, they must meet the needs of the users, not becoming obsolete over the years. The Figure 24 shows how the gaming area is planned to be.

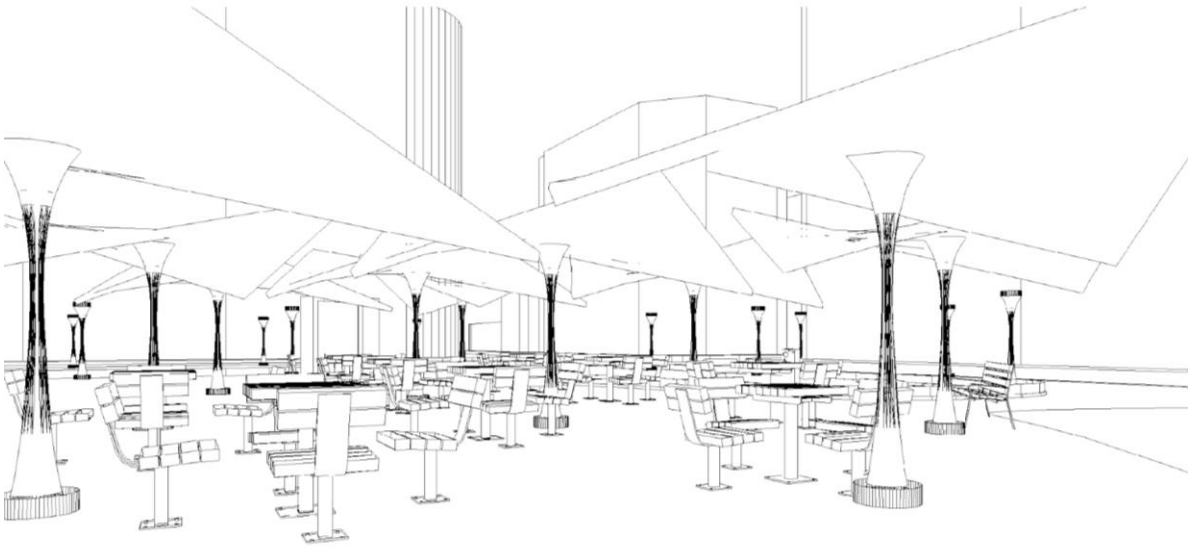

Figure 24. Proposal for the game area

Another section of the park around the game area was also planned to communicate with this part, bringing the technology closer to the elderly, in a way to facilitate their leisure time (Figure 25).

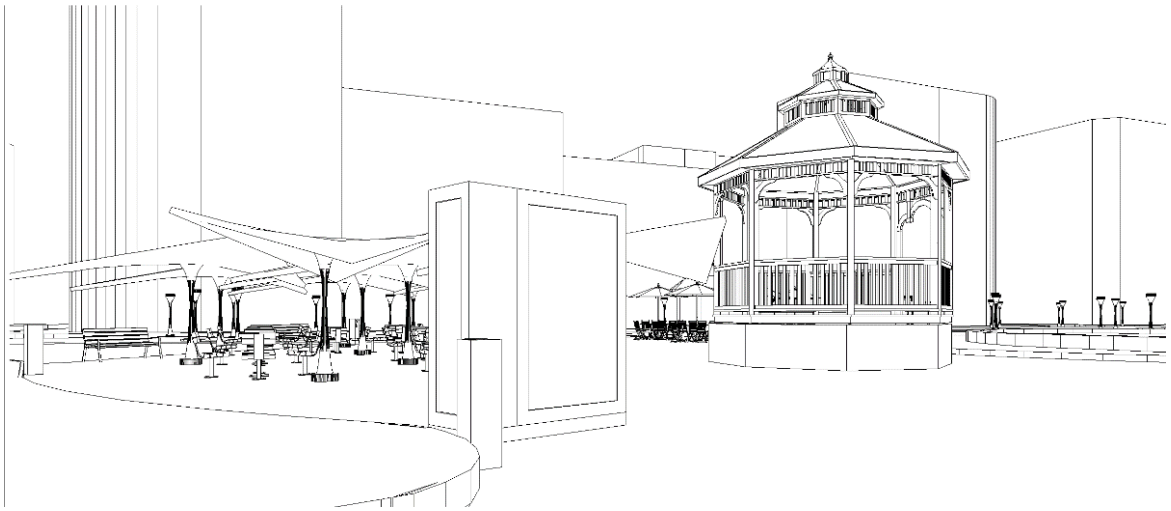

Figure 25. Game area entrance

The lampposts are distributed throughout the park, to better illuminate and also transmit information to users. These objects were not positioned in order to create a single path in the park, but to serve the space as a whole, making the entire space safe and well lit, in addition to serving as a sign for risk areas (Figure 26).

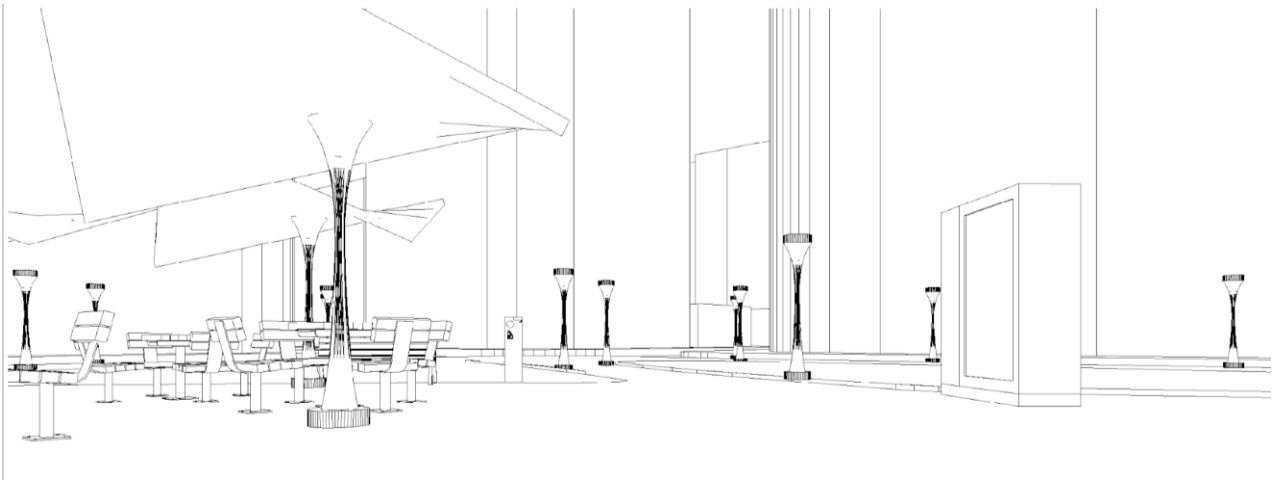

Figure 26. Lamppost distribution

The distribution of the smart objects is not the objective of this study but the idea of the proposals. However, the distribution of these new products must be well set to avoid deteriorating the design of the park.

6.1 Conclusion

The main objective of the research is to propose smart design solutions for a public park while improving the wellbeing of the elderly. It was intended that the Smart City concept and Internet of Things (IoT) would help to achieve the goal of this study.

In the literature, it is stated that the most serious problem of the elderly is the lack of physical activity/movement which causes the weakening of muscles, increasing the risk of falling both at home and on the street (Boukhennoufa *et al.*, 2019). Due to these events, the elderly obtain a fear that these events will happen on the street, causing shame, and thus isolation (Moreland *et al.* 2004). In addition, lack of belonging is a problem that has been studied (Miori & Russo2017). The elderly feel the need of belonging to a space, this as a consequence brings improvements to that environment that often end up being an extension of their home, because it is the place where they visit frequently. It is seen that by having independence and a routine of their own, the elderly end up increasing their life expectancy, in addition to the willingness and vitality to carry out various other activities (e.g., going to the supermarket alone, walking on the street without any type of supervision, visiting different places in the city) (Joore, 2007).

Expert interviews were carried out to verify the most common problems. The results of the interviews showed that mobility problems related to urban conservation were the most repeated. The current conditions of the cities in which the experts live in (Brazil and Portugal) fail to satisfy when it comes to proper paving, conservation and signaling of nearby areas. Moreover, the elderly seems to be limited to an area that they are already familiar with. Besides, they embrace the adversities that the environment offers, while constantly facing challenges that can lead to serious injuries, as well as psychological traumas that lead to loneliness. Public transportation issues were also addressed, as well as the lack of empathy of people who work and use public transportation. Activities and spaces aimed only for the elderly population, was also a subject addressed both in the literature review and in the interviews. In both cases, the issue of connection with space and belonging was mentioned. Regarding the relationship between technology and the elderly, the responses were quite diverse and there was no consensus regarding how technology could help. However, the experts believe it is of utmost importance to solve the current problems and to search for an environment capable of meeting all needs but without citing technology as a key tool for achieving this goal. Most of them gave limited examples when it came to technology (e.g.,

automation within the home). It may be related to the fact that few experts have been able to think of technology as something broad and varied.

Smart City can help to solve elderly's problems by introducing Ambient Assisted Living (Ref). Expert interviews were also intended to clarify how Smart City concepts could help to solve the existing problems of the elderly. The results showed that experts could not think of ways that Smart Cities could contribute to the subject. However, it was obvious that most knew about the concept since they used terms identified by the researcher when elaborating answers. Others alluded to a modern green city, where there is little pollution, where entire neighborhoods are planned in order to better use the space as much as possible. Few experts have actually linked Smart city to technology applied to objects, in order to improve the lives of users. It is believed that this little connection regarding this concept is due to the fact that many think that Smart city is directly related to the elaboration of complex systems, and encompasses only areas of technology applied to informatics/robotics, which is not in any case wrong, though it is a somewhat limited view of this concept. This study can show that the Smart City concept is not entirely dedicated to the technology field, nonetheless, design should be a part of the process to help find distinctive solutions.

The search for equipment/alternatives that were easy for the population to understand and that also did not generate fear for the elderly, should be crucial. It was stated that the elderly are afraid of everything that is new or highly technological. The fear that they are doing something wrong, generating some aversion to these technologies, making them always dependent on someone younger. In this project, we sought to bring the benefits of innovation, associated with their capacity for independence. The proposed technologies have always sought to assist the development of daily tasks performed by this population, in order to attract them, leaving them with the required independence, without being a departure from something that is necessary to learn in order to accomplish.

Expert interviews were followed by naturalistic observations which were intended to observe elderly in their normal, everyday setting. These observations offered the opportunity to observe elderly's behavior, and based on researchers' observations of the situation, had the possibility to generate new concept ideas for the public park. By the observations, seven repetitive problems were found out of which 4 are classified as risky and 3 as undesirable situation: outdoor exposition (risky), noise (risky), illumination (risky), segregation (undesirable), interaction

(undesirable), maintenance (risky) and location of equipment (undesirable). It was concluded that the design proposal should consider solving these repetitive problems in the park.

Personas were created to represent the primary users and scenarios were written to speculate the design solutions. These scenarios helped to start the sketching phase. Eventually, various product concepts proposed to collect data which would solve the problems that were found.

It is worth mentioning that concept design ideas were proposed but not how these ideas could be implemented into the space. More research must be done to understand the feasibility of the proposed solutions as well as the design of these objects if they fit in the specified context or where these objects would be placed.

6.2 Limitations and Future Work

More user studies, namely interviews, questionnaires and/or focus groups, were meant to be applied to get more insights from users (i.e., elderly) regarding the problems and possible solutions. However, due to the COVID-19 pandemic, it was impossible to reach this population, therefore, this phase was cancelled. A new procedure should be applied to collect more data regarding the users and their problems. In addition, the scenarios and the design ideas should be evaluated by the users to enhance the design process. The evaluations will give ideas about estimated user experience, moreover, the satisfaction and engagement.

As a future work, the proposed solution will be improved in terms of design, usability and technology. After, the system must be tested by the secondary users, stakeholders. Moreover, more experts in the diverse fields (e.g., urban design, architecture, product design, interaction design, engineering, etc.) must be included in the developmental process in order to reinforce the design proposal. The intention is to provide insights for designers and developers to create design guidelines in order to design better outdoor areas which address the needs and abilities of the fast-growing older adult's population.

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