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Design of a Framework for Cognitive Support in Dementia Care for the Elderly

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Dissertation

presented as partial requirement for obtaining the Master Degree Program in Information Management

NOVA Information Management School

Instituto Superior de Estatística e Gestão de Informação

Universidade Nova de Lisboa

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DESIGN OF A FRAMEWORK FOR COGNITIVE SUPPORT IN DEMENTIA CARE FOR THE ELDERLY

By

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Master Thesis presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Knowledge Management and Business Intelligence

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July 2023

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledge the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Ana Beatriz Coelho Mateus da Silva

Lisbon, 15 July 2023

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my sincere gratitude to the people who have contributed and impacted my journey while writing my thesis dissertation.

First, I am deeply thankful to Professor Vítor Santos for his exceptional guidance, expertise, and unwavering support throughout the entire process. This adventure started with his inspiration on this subject, and his profound knowledge, constructive feedback, and commitment to my academic growth have been instrumental in shaping this research work, and my future in this area.

I extend my heartfelt appreciation to my parents for their endless love, encouragement, and sacrifices. Without their support and motivation, my educational journey would not be successful (and we all know it could have ended in a totally different area). Their belief in my abilities, and their attention to my academic path since I was little have been definitely the driving force behind my interest in school.

A special note of appreciation goes to my sister, my number one cheerleader, and the biggest example of excellence, motivation and passion for academia. Her presence, patience, and belief in my abilities have been a constant source of inspiration. I can only dream of becoming as amazing and I know she will continue to be.

Last, but never the least, I want to thank Vítor Oliveira, my amazing partner for the past few years, who introduced me to this are of study. I know he shares the same passion for this field, and his patience, love, and belief in my capabilities have been my pillar of strength. I know he believes in my capacities more than I do, and that means the world to me.

I would also like to acknowledge my friends and family, for their intellectual discussions, collaboration, and support. A special word of appreciation goes to my aunts and uncles, always asking if I already was a master, and to Inês, Maria Inês, Cláudia and Ana. Their diverse perspectives, stimulating conversations, and shared experiences have contributed a lot to my focus.

I am grateful to Nova Information School for providing the necessary resources, facilities, and infrastructure that significantly enhanced the quality and rigor of my work.

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1 INTRODUCTION

This section provides an overview of the magnitude of dementia care in communities and health care systems. It introduces the background and context for the utilization of technology and digital solutions to address mental health issues in the elderly, specifically focusing on dementia.

The objective is to propose a design framework for the development of health technology that caters to caregivers of individuals living with dementia. A brief review of the latest studies related to the successful adoption of technology for dementia and cognitive impairment decline will serve as the foundation for the proposal of this thesis.

The following paragraphs approach the background and context of the healthcare problems related to ageing and introduce dementia from a technological perspective. The research question is presented, along with the proposed objectives to address that question. Furthermore, the relevance of this study within the context of information management is summarized.

1.1 BACKGROUND AND PROBLEM IDENTIFICATION

These days, mental health care is a topic of massive interest and research, in a context where the improvement of health care and well-being is defined as one of the United Nations Sustainable Development Goals. Globally, the ageing population is forecasted to double by 2050, with 152 million individuals expected to suffer from dementia.

A substantial amount of data related to the global ageing of the population is illustrated on the website of the European Commission. An interesting indicator that monitors the active and healthy ageing of the European population is the active ageing index. This index "measures the level to which older people live independent lives, participate in paid employment and social activities as well as their capacity to actively age", serving as a crucial indicator highlighting the growth of the elderly population (European Commission's Directorate General for Employment & Population Unit of the United Nations Economic Commission for Europe (UNECE), 2018).

The 2018 Active Ageing Index analytical report highlights distinct country clusters based on domain-specific scores. Portugal, along with Czech Republic, Estonia, Germany, Ireland, Latvia, and Lithuania, belongs to the blue cluster, exhibiting below-average scores in all domains except employment. While these scores are not the lowest among European countries, the Active Ageing Index for Portugal has shown consistent growth in recent years. In 2020, the index reached a value of 172.5, compared to 144.7 in 2015 and 121.6 in 2010

(2018 Active Ageing Index Analytical Report United Nations Economic Commission For Europe, 2019; Fundação Francisco Manuel dos Santos, 2022)

With ageing, there is an increased demand for health and care services. Individuals over 80 years old require specialized medical and long-term care services, therefore a top concern for societal adaptation to demographic ageing is preparing health and long-term care systems to meet the growing demand and promote healthy aging.

By 2030, the global cost of dementia care is projected to reach approximately $2 trillion per year, further burdening the healthcare sector (Lima et al., 2021; Nasr et al., 2021). The ageing of the population brings the need to invest more resources in healthcare and requires cities to provide services adaptable to the needs of their inhabitants (Almeida et al., 2019; Bravo-Torres et al., 2017; Paolini et al., 2016).

Despite the pressing need, only a few information and technology innovations have been developed and tested for older individuals suffering from chronic diseases (Bardaro et al., 2022; Göransson et al., 2020). However, leveraging technology to create automated therapeutic and telehealth solutions holds significant potential for promoting health in older adults and those suffering from dementia (Lima et al., 2021).

The proposal of a framework for a digital solution targeting dementia has been recently studied, promoting recommendations and guidelines for a successful implementation of digital solutions targeting dementia patients and dementia care (Bastoni et al., 2021; Christie et al., 2020, 2021).

Various technologies have emerged in the field of dementia care, some attempt to improve the early diagnosis of people with dementia disorders, whereas others focus on impacting the quality of life of these patients (Ye et al., 2022). Regarding this last group, ambient assisted living technologies have been categorized into different generations based on their evolution over time, including wearable alarms, hazard detection systems, in-home smart sensors, and emerging social and service robots (Thordardottir et al., 2019).

The unique needs of the elderly population bring concerns about the usability and adoption of digital solutions, which demands the design of solutions using specific features, like audio and voice recognition technology. Additionally, focusing on patient or user-centred research can help overcome barriers for engagement with digital tools in this age group (Boucher et al., 2022).

This research will therefore address the following foundational question:

Research Question: What factors in cognitive ageing care contribute to the demand for the design and deployment of a digital solution for elderly patients with dementia?

1.2 OBJECTIVES

To address the proposed research question, the main objective of this study is to develop a functional architectural model for a digital solution focused on mitigating the decline of brain functions in the cognitive ageing process, specifically in dementia disorder.

To achieve this objective the research will focused on the following intermediate objectives:

1) Conduct a comprehensive assessment of current research in software architectures and healthcare systems on the topic of dementia;
2) Define the most relevant topics in dementia prevention that can be addressed as potential input data for the solution;
3) Understand the integration of the AI model's architecture into a digital solution (mobile application, home device, virtual assistant);
4) Examine the older population's adoption to a digital solution and access its impact on their mental health;
5) Design an architecture of a digital solution to be used by elderly individuals suffering from dementia;
6) Validate the proposed architecture.

1.3 STUDY RELEVANCE

The debate on mental health issues has been gaining momentum, in a century anticipated to witness a new technological revolution. The proposal of a model that can impact the ageing process of the brain has the potential to garner interest from healthcare organizations, investigators, and pharmaceutical companies. Such a model could greatly impact people's lives and address societal health issues. Pursuing this research and further bringing a framework to life would influence communities to take an interest in such topics.

Another contribution of a study concerning digital solutions tailored for elderly individuals with dementia is the potential to support for caregivers (both informal and formal), by bringing solutions that enhance independent living of these populations, promoting their autonomy and reducing their dependence.

The use of technology, such as computerized screening tools for cognitive tests and remote assessments through video calls, can help maximize the time of the dementia care workforce and caregivers.

2 METHODOLOGY

This chapter adopts the Design Science Research (DSR) approach to develop a functional architectural model for a digital solution aimed at mitigating the decline of brain functions in the cognitive aging process, specifically targeting the elderly population affected by dementia. Design Science Research is a rigorous research methodology focused on developing and evaluating innovative artifacts to address real-world challenges in socio-technical information systems.

The utilization of the DSR methodology in this research provides a structured approach to developing and assessing the digital solution. This methodology combines theoretical knowledge with practical insights, ensuring the solution's relevance, effectiveness, and usability. The subsequent sections of the methodology chapter will delve into each step of the DSR process, elucidating how each component contributes to the development and evaluation of the digital solution for dementia in the elderly.

2.1 DESIGN SCIENCE RESEARCH

Design Science Research (DSR) develops and assesses IT artefacts to address organizational issues in the study of socio-technical information systems. This methodology has a rigorous research focus that demands the supply of new and transferrable information, which is a key distinction between itself and innovation in general. The primary goal of Design Science Research is to expand scientific and technological knowledge by discovering and developing innovative artifacts that address real-world challenges and improve environments (A. Hevner & Gregor, 2022).

This research method entails a thorough process to develop artefacts that address specific problems, contribute to research, assess the designs, and disseminate the findings to the relevant audience. The resulting “artefact” encompasses any constructed item that incorporates a solution to a known research topic (Peffers et al., 2014).

A design science research methodology includes three different components: conceptual principles that clarify the essence of design science research, procedural guidelines, and a methodology for conducting and presenting the study.

Design Science Research emphasizes the methodical creation and assessment of artefacts designed to address real-world issues. Therefore, the research process involves two main forms of analysis: 1) creating artefacts grounded in theory; and 2) assessing the generated artefacts (Morschheuser et al., 2018).

The main activities in design research are building and evaluation. Building consists of constructing an artefact with a specific purpose, and evaluation is the process of defining how well the artefact performs. Both the construction and evaluation of an artefact are highly linked to the environment in which it operates, which means that an inefficient understanding of the environment might result in difficulties during the design process (March & Smith, 1995).

Essentially, the process of creating an artefact should involve a hunt for a solution to a specified problem, drawing upon existing theories and bodies of knowledge. Ultimately, the research findings need to be effectively shared with the appropriate audiences to ensure their successful dissemination and impact.

In the context of this thesis, the objective is to design a functional architectural model for a digital solution focused on helping mitigate the decrease of brain functions in the cognitive ageing process. Considering the output as an artifact, Design Science Research is the appropriate methodology to employ.

When constructing an artifact to address a specific problem, it is crucial to conduct research on the context of the problem, including its causes and consequences. A literature review, earlier empirical investigations, exploratory studies, or domain experts, can all provide crucial knowledge about a problem's background, building a bridge between theoretical knowledge and technical knowledge.

The following section outlines the steps that Design Science Research must follow, as described by Peffers et all:

1. **Problem identification and motivation:** Define the precise research issue and justify the need for a solution. Conceptually deconstruct the problem to ensure that the solution adequately reflects its complexity. Justifying the value of the solution helps researchers comprehend the underlying idea behind their understanding of the problem. Understanding the problem's current status and the significance of finding a solution is a crucial resource for this step.

2. **Definition of solution objectives:** The design process itself is one of the solutions. Identified problems do not always directly translate into the goals of the artifact. Therefore, the next stage is to define the objectives for a solution. Utilize the problem statements and feasibility understanding to derive the solution's goals. The state of existing solutions and their effectiveness are valuable resources for this step.

3. **Artifact design:** A design research artifact is any designed item that incorporates research input into its design. In this process, the required functionality and architecture of the artifact are determined before the actual artifact is built.

4. **Demonstration:** The approaches for demonstrating the viability of the artifact can vary, ranging from simple demonstrations to more rigorous assessments. Applying the artifact to experiments, simulations, case studies, evidence, or other applicable tasks demonstrates how it can resolve one or more instances of the identified problem. Effective understanding of how to use the artifact to solve the problem is crucial during this phase.

5. **Evaluation:** This approach involves observing and measuring the artifact's effectiveness in contributing to a solution for the originally identified problem. Comparing the solution's goals to the results obtained during the demonstration is essential. Evaluation requires familiarity with relevant measurements and analysis methods. It can take various forms, such as comparing the artifact's functionality with the solution goals, using objective quantitative performance measurements, analyzing customer satisfaction survey outcomes, and simulations, or analyzing budgets or outputs. Evaluation should incorporate any pertinent empirical and logical data.

6. **Communication:** The resulting knowledge needs to be effectively communicated to researchers and other relevant audiences. This communication should educate them about the problem's relevance, the uniqueness and utility of the artifact, the rigor of its design, and its effectiveness. Understanding the culture of the discipline is essential for successful communication (Peffers et al., 2007, 2014).

2.2 DESIGN SCIENCE RESEARCH IMPLEMENTATION

A systematic understanding of the scientific principles that guide research projects' methods and findings is essential for conducting rigorous research in the information systems field. Therefore, thorough research must enable the successful application of the scientific method (process) and result in new knowledge (outcome) (A. R. Hevner, 2021).

In recent years, a growing percentage of studies have been published to identify and study the numerous health-related mobile apps that are currently accessible on the market. These studies aim to explore the characteristics and functionalities of these apps in relation to addressing health issues.

The following table (table 1) illustrates the methodology steps employed in this work to fully project a complete framework for a digital solution catering the needs of elderly individuls with dementia-related health problems.

Table 1 - Methodology steps followed

Problem identification	Study the problem context and its characteristics, and define the success metrics
Establish solution objectives	Characterise the purpose of building an artefact, while defining each part of its construction. Define the target user, its needs, and motivations.
Artefact choice and development	Design the framework prototype to be used by an end-user, enumerate the steps to a successful deployment
Application in a real-world context	Use the artefact in a specific context of the use
Evaluation: is the artefact successful?	Evaluate its performance and possible improvements, while identifying obstacles to its implementation. Gather evidence and experts' opinion
Communication of the solution	Publish the results of the investigation (thesis publication)
Monitoring	Monitor the artifact's success and identify future improvements needed

Initially, a comprehensive literature review should be conducted, to understand the current state-of-the-art health and dementia-related AI systems. The definition of key features to incorporate into the design of an architectural framework model, capable of being addressed as an AI digital solution is the next step, followed by the definition of variables to be considered in the AI model.

Subsequently, the model's adherence and viability should be evaluated with the target population, using inquiries to conduct interviews with subject matter experts and elderly individuals. The collected survey data should be analyzed to draw implications and identify any limitations.

The artefact design or construction process should follow guidelines based on theories found in previous research. This includes incorporating both the relevant theory in the context of the problem and identifying similar existing solutions that can serve as a foundation for developing a new solution.

The base technique of this study relies on two components to provide a holistic perspective on the subject matter: a collection of experiences from the literature review, and professional experiences from experts through interviews. The research adopts an organized and systematic approach, aligning with the defined goals and objectives.

The figure bellow depicts the sequential steps involved in applying the DSR methodology to guide the research process in this study

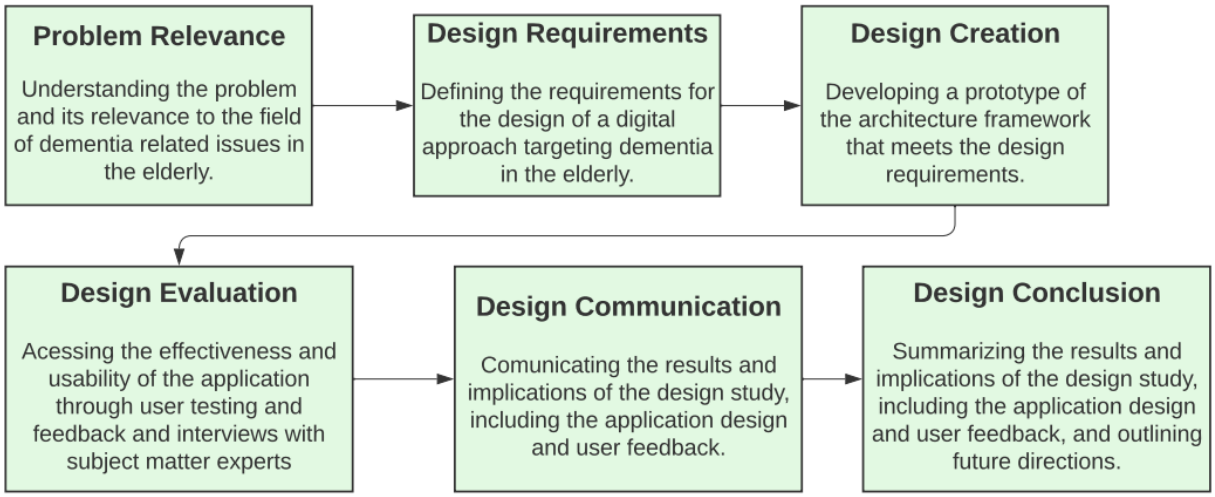

Figure 1 - Application of the DSR methodology in the present thesis

In conclusion, the utilization of Design Science Research (DSR) offers a structured and systematic approach to developing a functional architectural model that addresses the cognitive decline associated with aging, with a specific focus on the elderly population affected by dementia.

Throughout this chapter, the various components of DSR were explored, including problem identification and motivation, definition of solution objectives, artifact design, demonstration, evaluation, and communication. These components collectively guide the research process, ensuring that the solution addresses the identified problem effectively and meets the defined objectives. The rigorous approach of DSR ensures that the resulting artifact is grounded in theory, aligns with existing solutions, and is evaluated using appropriate methods and measures.

The implementation of Design Science Research in this thesis involves conducting an extensive literature review to comprehend the current state-of-the-art in health and dementia-related AI systems. Subsequently, key features and variables for the architectural framework model, serving as an AI digital solution, are defined. By adhering to established guidelines and theories from previous research, this study ensures that the artifact design is informed by existing knowledge and establishes a solid basis for a novel solution.

In summary, the adoption of DSR provides a systematic and rigorous approach to the development of a digital solution for dementia in the elderly, contributing to the advancement of scientific and technological knowledge while ultimately enhancing the lives of elderly individuals affected by dementia and their caregivers.

3 LITERATURE REVIEW

To further examine the existing design methodologies on dementia digital solutions, an extensive review was carried out. This review consisted of two cycles: first, identification of pertinent sources, keywords, and initial literature pieces; and second the interpretation and evaluation of the obtained results to ascertain their applicability and the identification of new sources.

The following table presents the keywords used in the research for this thesis.

Table 2 - Keywords and concepts used in the research

SUBJECT	CONCEPTS
Dementia	Dementia, cognitive impairment, neurocognitive disorder, a neurodegenerative disorder, cognitive dysfunction, cognitive decline, mental disorders, Alzheimer's disease
Information Systems	Information systems, apps, artificial intelligence, innovations, app, smart technology, health information technology

3.1 DEMENTIA OVERVIEW

One significant cause of disability and reliance among the elderly population worldwide is dementia. It poses a substantial burden on healthcare costs, with projections from the World Health Organization indicating a doubling of dementia prevalence worldwide over the next 20 years.

Around 50 million people worldwide currently suffer from dementia, and this figure is predicted to reach 152 million by 2050, particularly in low and middle-income countries, where almost two-thirds of dementia patients reside (Nichols et al., 2022).

In Portugal, a sample study of individuals aged 55 to 79 revealed a prevalence of 12,3% for cognitive impairment without dementia and 2,7% for dementia-related cognitive impairment. Comparatively, other nations, including the United States, have higher

prevalence rates, with 11% of individuals aged 65 and older suffering from Alzheimer's disease (Gonçalves-Pereira et al., 2017).

As a result, it is projected that dementia costs the world economy roughly USD 818 billion. The societal and financial burden of dementia is expected to increase over the next few decades due to the ageing population.

Among the elderly, the fastest-growing demographic category is individuals over 90 years old, highlighting the need to address their specific needs and improve their overall health.

Dementia research is a top global priority since it affects older individuals more frequently than any other age group, and is linked to significant impact on finances, emotions, and society. None of the irreversible causes of dementia have a treatment yet, despite years of study and several clinical trials (Woods et al., 2012).

Cognitive decline, along with persistently worsening physical and psychological symptoms that persist until the end of life, is what defines dementia as a medical disorder. The long-term care required for dementia patients places strain not only on the healthcare system but also on the families involved (Shin & Cho, 2023).

3.1.1 Related Concepts

The most common neurodegenerative disease is dementia, with Alzheimer's disease accounting for 60% to 70% of cases worldwide.

Dementia refers to the decline of cognitive performance, including memory, thinking, reasoning, as well as behavioral to the extent that it impacts a person's ability to carry out daily tasks. Furthermore, gait and balance abnormalities are typically present and appear to be more common in specific types of dementia, including vascular dementia, Parkinson's disease dementia, or dementia with Lewy bodies, compared to Alzheimer's disease.

Typically, age-related pathophysiological processes are responsible for the development of dementia. The most frequent causes of dementia in older individuals are Alzheimer's disease and the combination of Alzheimer's disease with cerebrovascular illness. Abnormal protein aggregates, both correctly and incorrectly folded, are often associated with dementia in various neurodegenerative diseases. The pathophysiological sequence of events begins years or even decades before noticeable clinical symptoms appear, leading to the diagnosis of dementia.

Risk factors for dementia can manifest early in life (education), middle age (hypertension, obesity, hearing loss, traumatic brain injury, and alcohol abuse), and old age (smoking, depression, physical inactivity, social isolation, diabetes, and air pollution). All these risk factors have strong supporting data, and some late-life conditions, such as depression, may

have a double effect and contribute to the prodromal stage of dementia (Livingston et al., 2020).

3.1.2 Associated Health Problems

A variety of neurodegenerative disorders, defined by a progressive decrease in cognitive function severe enough to affect social and/or occupational functioning, are together referred to as dementia. In addition to these symptoms, it may also manifest as behavioral abnormalities, linguistic difficulties, and a decline in daily living skills.

Dementia is an illness that affects cognition and is a key contributor to dependence and disability in older individuals. As the disease progresses, sufferers have challenges in cognition, thinking, functioning, as well as behavioral changes and, in the long run, depression. For older individuals with cognitive impairment, cognitive training is crucial to reduce the risk of cognitive decline and/or dementia.

The earliest feasible point in the trajectory and process of age-related decline, when disease burden is minimal, is when interventions and ageing strategies will be most effective. Among the most promising non-pharmacological approaches to slow the progression of cognitive impairment or dementia is the utilization of computer-simulated virtual reality.

The course of cognitive deterioration in people with cognitive impairment has been attempted to be slowed down given the lack of known cures for dementia. Numerous forms of psychosocial therapies that attempt to maintain and increase cognitive function have been developed in recent decades to delay the progression of dementia and enable people to age in place (de Marco et al., 2020).

Preventative measures should be implemented in dementia care, especially in the stage of mild cognitive impairment, where there is a decline in cognitive abilities, primarily episodic memory impairments. Patients can prevent becoming severely and chronically ill by receiving intervention at this early stage and assistance in maintaining a functional and healthy lifestyle (participating in mentally stimulating activities, getting physical activity, and eating a balanced diet). The goal of health care for senior citizens is to achieve a high quality of life regardless of the presence of cognitive impairment, by encouraging and empowering patients to keep their independence and functional capacity (Lee-Cheong et al., 2022).

The most modern pharmaceutical treatments for dementia can only somewhat lessen the symptoms; they cannot stop or reverse dementia. Therefore, until disease-modifying drugs are proven to be beneficial, dementia prevention through risk factor identification and adjustment remains of utmost importance.

Since there is currently no cure for dementia, current therapies concentrate on enhancing patients' quality of life and addressing behavioral and psychological symptoms. Non-pharmaceutical approaches to daily care that improve quality of life and support cognitive and functional capacities are included in these treatments. Music has been successfully used in daily care to alleviate dementia symptoms; therapists can provide systematic music therapy in one-on-one sessions, which is beneficial for individuals who have trouble speaking Music therapy based on video games, even when delivered by untrained caregivers, might lessen behavioral symptoms (Paay et al., 2022).

Music often accompanies key events in people's lives, and, in certain circumstances, the brain can preserve memories and feelings experienced during a musical event. Consequently, the music connected to these memories and emotions can prompt their recall. This impact may be helpful for people who have lost episodic or autobiographical memory – such as people with Alzheimer's disease. In these patients, music can be used as a powerful cue to evoke intense emotions and autobiographical memories. It has been proposed that musical memory, or memory for music, is partially autonomous from other memory systems. Case studies have shown that Alzheimer's disease patients still retain some of their musical recall despite suffering from rapid cognitive deterioration. Personalized music interventions have been effective in improving depression, anxiety, agitation, and behavioral and psychological symptoms of dementia (BPSDs), however the underlying brain mechanisms for these benefits are still poorly understood (Matziorinis & Koelsch, 2022).

Previous research suggests that some preventive measures, such as a Mediterranean diet and engaging in cognitive stimulation, managing cardiovascular disease risk factors, and physical activity, may prove to be effective in postponing or preventing the progression of mild cognitive impairment to dementia. The comprehension of controllable protective factors against cognitive decline must be advanced urgently, particularly in old age.

The two most important preventive factors for dementia that support cognitive functioning, according to the existing evidence, are physical activity and cognitive training. Physical exercise training acts as "hardware," protecting neuronal structural integrity and brain volume, while cognitive training acts as "software," enhancing the functioning and plasticity of neural circuits (Book et al., 2022).

Physical activity is currently receiving attention as a non-pharmacological dementia treatment. Accordingly, some evidence suggests that engaging in regular physical activity frequently impacts activities of daily living, quality of life, and cognitive or physical functions in dementia patients. Conversely, a sedentary lifestyle and lack of physical exercise are typically associated with an increased risk for metabolic abnormalities, cardiovascular disease, and various health problems that largely serve as mediators in the development or early onset of dementia.

The increased interest in non-pharmacological treatments is mostly driven by the ineffectiveness of pharmacological therapies and the recognition of neuronal plasticity of our brains. Currently, new therapies have been developed to delay dementia progression – cognitive stimulation is an example of a recent therapy that has been demonstrated to improve cognition in people with mild to severe dementia.

The term "cognitive stimulation" refers to a broad range activities that support cognitive and social functioning. A few examples of stimulation techniques that are widely applied in group settings include discussions, reminiscence therapy, and reality orientation. The goal of cognitive training is to preserve or improve a specific aspect of cognitive functioning using controlled and supervised practice (such as memory or attention exercises).

Ultimately, cognitive rehabilitation is a person-centered, individually tailored strategy that focuses on correcting deficits, promoting independent living, and enhancing or sustaining cognitive capacities related to daily task performance. It has been successful in halting the progression of cognitive decline in dementia patients, making it one of the most successful therapies (de Marco et al., 2020).

For individuals with mild-to-moderate dementia, cognitive stimulation is a highly recommended psycho-social intervention. By activating several cognitive processes at once, cognitive stimulation tries to enhance overall cognition and preserve function. Typically, this is done through group activities that place a strong emphasis on social interaction. This method differs from cognitive training, which emphasizes the individual, repetitive practice of standardized cognitive tasks to target isolated cognitive skills (such as memory). Cognitive stimulation differs from cognitive rehabilitation, which focuses on enhancing daily living by helping people create strategies for carrying out desired actions or tasks (Cafferata et al., 2021).

In the topic of cognitive stimulation, brain games are among the non-pharmacological therapies implemented. Computer-based cognitive-stimulating activities and challenges have gained popularity recently. According to most investigations, mental stimulation, such as the one offered by these brain games, was linked to a delay in the onset of cognitive impairment or even cognitive improvement in those who already had it (Anderberg et al., 2019).

Cognitive stimulation is the most popular psychosocial therapy for addressing the difficulties of dementia care and is frequently used in residential and long-term care facilities. It is designed to enhance cognitive and social functioning by promoting implicit learning, language skills, cognitive resources, and social engagement. The therapy provides a variety of tasks that stimulate thinking, focus, and memory in individuals with dementia, serving as a model for improving various cognitive abilities.

The use of repetitive tasks and games in cognitive stimulation therapy can help enhance brain connectivity, generate new synapses, and promote the myelination of neural circuits,

all of which can aid in the rehabilitation or remodeling of the neuronal structures underpinning cognitive skills. Engaging in interactive, game-based activities within the therapy may also increase participant interactions and alleviate depressive symptoms (Saragih et al., 2022).

Another interesting therapy is reminiscence therapy, a common psychosocial intervention in dementia care. Libraries of stimulation, such as old photos, are used to facilitate reminiscence and evoke memories, fostering meaningful interactions between patients and caregivers (Paay et al., 2022).

3.1.3 The Role of Information Systems

The field of computerized cognitive treatments has significantly advanced due to the rapid development of technology. To promote health and independent living in old age, traditional cognitive therapies are being modified, and new multimedia systems are being developed.

Many traditional cognitive interventions have been modified for use on modern technology devices like smartphones, tablets, and PCs, since they are considered a more cost-effective alternative. Digitally delivered cognitive training, stimulation, and rehabilitation are potential methods for preserving cognitive function in patients with mild cognitive impairment and healthy older adults. These computerized therapies not only enhance cognition, memory, and attention but also benefit the psychosocial functioning of individuals with mild cognitive impairment.

Computerized cognitive interventions offer several advantages over traditional methods in several ways. The training tasks are beneficial since they can be tailored to improve a particular cognitive function, continuously adjusted based on the participant's performance, designed to be highly immersive and enjoyable, offer immediate quantitative feedback, and can be actively accessed on portable digital devices. These features enhance the effectiveness and convenience of computerized cognitive interventions, making them a valuable tool for cognitive improvement and rehabilitation.

As a result, both the field of computerized cognitive therapies and the research initiatives including these technologies are expanding steadily. Recent research has examined the efficacy of computer-based cognitive interventions for dementia patients (de Marco et al., 2020).

For older individuals with early-stage or moderate dementia, several virtual reality technologies have been investigated as training and rehabilitation techniques. Virtual reality training has received a lot of attention from people with cognitive impairment to achieve positive physiological, psychological, and therapeutic outcomes. These interventions are

particularly effective when administered before the onset of dementia, during the early stages of cognitive decline.

The COVID-19 pandemic severely compromised the continuity of treatment for patients with cognitive impairment by drastically reducing community interactions. Concurrently, there has been much discussion on the value of using digital healthcare technologies to replace in-person interactions. For those experiencing cognitive decline, digital healthcare technology provides opportunities for specialized and cutting-edge programs that can enhance cognition and improve their overall quality of life. Through the effective distribution of healthcare services in the community, it is crucial to create a social safety net for people with cognitive impairment and alleviate the burden on their caregivers, including family members and friends (Sohn et al., 2022).

The development and validation of a new theory based on information and communication technology systems for monitoring, empowering, and motivating elderly people with mild cognitive impairment, to maintain their independence and functional abilities, improve their health status and quality of life, as well as social interactions, represents one of the most pertinent challenges of the next future (Cammisuli et al., 2021).

3.2 HEALTH INFORMATION SYSTEMS

3.2.1 Scope

The electronic system used for storing, sharing, and evaluating health information is known as health information technology (for example electronic health records, personal health records, and electronic prescribing). By avoiding repetitive medical testing, reducing medical errors, minimizing paperwork, allowing remote collaboration between medical experts, and lowering the cost of treating chronically ill patients, this technology has the potential to improve the quality of care (Sung et al., 2022).

The current COVID-19 epidemic promoted the implementation of digital transformation across various industries and areas. The epidemic has increased mobile health app adoption globally, motivating more people, including older adults, to improve their health. The closure of many memory clinics during the pandemic has underscored the need for international support in caring for individuals with dementia.

Digital healthcare encompasses a wide range of technology, including chatbots, the Internet of Things, 3D printing, artificial intelligence, smart software, virtual or augmented reality games, and telemedicine. Robots and other smart home technology can assist in rehabilitation or improve social functioning in people with health issues. Digital healthcare

technology not only enhances physical and mental well-being but also facilitates social relationships for individuals with cognitive disabilities.

Research on digital healthcare for cognitive impairment has seen significant growth since the late 2010s. Between 2018 and 2021, research on apps, games, and virtual/augmented/mixed reality has been particularly active, which contributed to a quantitative rise in digital healthcare research. Additionally, there has been an increase in research on big data/artificial intelligence and smart homes/telemedicine (Sohn et al., 2022).

A lot of assistive technologies are geared toward helping patients enhance their independence, safety, social interaction, mood, and overall quality of life. Remote patient monitoring, enabled by access to real-time health information, allows both healthcare professionals and informal caregivers to intervene more promptly. By promoting patient functioning and enabling aging in place, assistive technologies aim to reduce medical costs and caregiver burnout. Given that assistive technologies strive to be easily accessible to patients in all geographical locations, they have the potential to enhance health equity (Lee-Cheong et al., 2022).

3.2.2 Types

Consumers can be empowered to control their health proactively by using digital technology like apps. Over two billion people use low-cost mobile smartphone apps to measure, track, display, and share their personal health information. These digital tracking tools track various aspects of health, including medications, food and water intake, glucose levels, oxygen saturation, body temperature, weight, pain levels, sleep patterns, and a wide range of other activities.

There is a growing trend of elderly individuals using cell phones and mobile apps. Gait assessment apps, specifically designed for older adults, can help improve health outcomes and alleviate the burden of care. Numerous research has examined the reliability and validity of smartphone-based gait analysis.

However, there is still a stigma among older adults regarding the use of technology in their daily lives. It is vital to involve older individuals in the review of such apps to improve their design and acceptability and overcome these difficulties (Zhong & Rau, 2020).

In settings like nursing homes, advancements in health information technology to support direct care by nurses and caregivers have been slow. While many elderly care facilities use electronic documentation or care records to some extent, the degree of person-centeredness, as well as the usability of nurses and caregivers in the context of their

workflows, varies greatly. Few health information systems have been assessed for their impact on staff workflow satisfaction and targeted health outcomes for residents.

Technologies used in residential care settings include telecare, light therapy, robotics (such as robot companions), well-being and leisure devices (such as touch screen devices, and watches that monitor sleep cycles), simulated presence and orientation aids (such as audio/video recordings), and activities of daily living aids (e.g., handwashing, taking medication memory aids) (Haslam-Larmer et al., 2022).

Precision therapies, patient education, virtual help, and cost reduction are all areas of health care where artificial intelligence is shown considerable potential.

Tablet computers with touchscreens are increasingly being used to assist individuals with dementia. Tablets are used for daily living support, social interaction, and recreational activities. Studies have shown promising results regarding the use of tablets in improving communication between people with dementia and their caregivers.

The quality of life for older people with cognitive impairment and their informal carers can be enhanced by using health-focused mobile applications (mHealth applications) on devices like smartphones and PDAs. However, some research contends that the availability of individual customization following personal preferences is a requirement for older people with cognitive impairment to begin using computer-based technology. It is crucial to recognize the diversity of technological proficiency among individuals. For the development of useable technology, it is especially crucial to involve end users in the design and development process (Quintana et al., 2020).

3.2.3 Information Systems for Mental Diseases

In the twenty-first century, deep learning and machine learning-based artificial intelligence are quickly changing the medical industry. Machine learning models can be used in specialized and research contexts even though they integrate data typically not accessible to doctors (advanced neuroimaging, genetic testing, and cerebrospinal fluid biomarkers). Recent research has demonstrated the usefulness of machine learning algorithms in the early diagnosis of neurodegenerative diseases, highlighting the essential role of machine learning in mental disease research, and there is evidence that it may be used to plan care for individuals at risk of developing various dementia types using clinical data (Battineni et al., 2022).

Artificial intelligence, particularly deep neural networks, has been extensively employed in dementia research. One of the most complex machine learning techniques, deep neural networks, are often used with genetic and neuroimaging data to predict outcomes by identifying generalizable nonlinear latent patterns and early dementia detection. Artificial

Intelligence has also been used to improve other clinical measures, such as aberrant changes in speech, gait, and drawing, to effectively monitor brain health and disease progression. AI-driven technology, including assistive robots and smart sensors, have been created for dementia therapy, primarily focused on improving caregiving and management (Liu et al., 2022).

The COVID-19 outbreak has also contributed to the shortage of professionals in the health and social care sectors, leading to a decrease in the degree of assistance offered. Assistive robots can play a significant role in this era by offering emotional support, companionship, and automated homecare assistance to patients with dementia.

mHealth technology can assist older persons with Alzheimer's disease-related dementias in performing daily tasks, sustaining social interactions, preserving autobiographical memory, partaking in leisure activities, tracking their whereabouts, and monitoring their health.

More than 325.000 mHealth applications have been found, covering a range of medical, fitness, and health-related issues. These applications have demonstrated effectiveness in enhancing self-care, self-management, self-efficacy, medication adherence, and improving healthy behaviors such as sleep, nutrition, physical exercise, and mental health. Numerous studies have highlighted the advantages of mobile health, particularly for the population of older persons (Ahmad et al., 2020).

Studies have found that game-related metrics used in commercial games could measure the quality and level of various cognitive functions, including visuospatial function, visual search capability, mental flexibility, memory, and attention. Virtual reality has been explored for identifying cognitive abilities, such as spatial navigational deficiencies, which tend to deteriorate in individuals with dementia. Other papers have investigated the digitalization of traditional neuropsychological tests that are already in use.

For instance, Google's Project Relate is a communication tool that leverages artificial intelligence to facilitate communication for individuals with speech problems. This tool can "translate" speeches that would be considered difficult to comprehend into understandable dialogues by analyzing recorded speech using AI-powered algorithms. Such technological advancements, including social robots and personalized virtual villages, have the potential to significantly improve communication and engagement for dementia patients with speech problems. Project Relate's algorithms and logic may fundamentally alter dementia care technologies empowering patients to manage their care more effectively (Su et al., 2022).

Social robots are interactive machines that could provide companionship and help dementia patients' emotional or mental well-being. Recent research has examined socially assistive robots in the context of dementia care to further increase social connections among dementia patients. PARO, a robotic seal created especially for these patients, is arguably one of the most well-known social robots. PARO has shown promise as a social companion,

fostering interactions that result in more smiles and laughter between caregivers and individuals with dementia (Su et al., 2022).

Another interesting perspective on information systems is the technology systems used in care facilities. Electronic health records, medication management systems, handheld devices, multi-function systems for activities or illnesses, are among the health information technologies employed in residential aged care facilities. Qualitative approaches with a focus on staff acceptability and usability are predominant in this area of research (Bail et al., 2022).

3.2.4 Brain and Cognitive Games for Dementia Mitigation

Over the years, researchers have explored different strategies for mitigating the effects of cognitive decline, including the use of brain and cognitive games. These games are designed to stimulate different areas of the brain, aiming to improve cognitive functions, such as attention, memory, and processing speed. Several studies have explored the potential benefits and limitations of brain games in reducing the risk of dementia in the elderly population.

While some studies have reported positive effects of brain games on cognitive function, others have found limited or no evidence to support their use as a tool for reducing the risk of dementia. When developing an application targeting dementia in the elderly population, careful consideration of the design of brain and cognitive games is crucial to ensure their effectiveness. Factors such as the type of game, frequency, duration, and intensity of the game sessions, as well as the level of challenge presented in the game, are all crucial factors that may influence the effectiveness of the games.

Furthermore, the design of brain and cognitive games should be based on the specific cognitive domains that are affected by dementia, such as memory and attention. The software should also be user-friendly and engaging to ensure that elderly users are motivated to use the app regularly. In addition, the digital solution should provide feedback to users on their progress and performance, as this has been shown to improve motivation and engagement in brain training.

Research has been conducted to examine the potential benefits and limitations of brain games for mitigating the effects of cognitive decline and reducing the risk of dementia in the elderly population.

For instance, Nouchi et al. (2012) found that elderly individuals who played a brain training game for 12 weeks showed significant improvements in their cognitive abilities compared to the control group.

A different study conducted a meta-analysis of several studies investigating the impact of video game training on cognitive abilities in older adults. The results showed that video game training can significantly improve cognitive abilities such as attention, processing speed, and working memory in older adults. However, the studies included in the meta-analysis used various types of video games and cognitive tests, making it difficult to draw firm conclusions about the specific impact of video games on cognitive abilities in the elderly (Toril et al., 2014).

Hill et al. (2017) and Lampit et al. (2014) investigated the impact of computer-assisted cognitive training on cognitive abilities in elderly individuals with multiple dementia risk factors. The results showed that the cognitive training group exhibited significant improvements in cognitive abilities compared to the active control group, and these gains persisted for up to six months after the training ended.

In conclusion, brain and cognitive games have the potential to improve cognitive function in the elderly and mitigate the effects of cognitive decline. However, the limitations of the studies reviewed, such as small sample sizes, short durations, and limited population samples, highlight the need for larger, well-designed studies to determine the specific impact of brain games on dementia and cognitive decline in the elderly.

3.2.5 Challenges and Opportunities

Before these new assistive technologies may become widely used, legal difficulties relating to workplace safety rules, data privacy laws and regulations, and ethical issues in healthcare need to be addressed. Since many of the modern technologies being proposed aim to gather and keep enormous amounts of health data, some have acknowledged concerns with data ownership, data protection/privacy, liability, and consumer protection, all of which could prevent their adoption.

Despite the large benefits described by some authors, there are also risks to consider when employing digital healthcare technologies, such as physical accessibility issues, privacy concerns, and technical device use issues.

For instance, more than 50% of developing countries do not effectively use electronic health records systems, mainly because of the lack of technical and computer skills of the staff members, organizational incapacity, and resistance to switching to electronic systems. In any event, putting health information technologies into practice is a complex task, so it is crucial to consider the obstacles and enablers of its implementation (Sung et al., 2022).

Another issue is the fact that many older patients, especially those with dementia, are not yet familiar with specific technology like smartphones, tablets, and applications and may not even own such devices, making the learning process stressful and difficult.

Certain assistive technologies developed specifically for dementia patients may primarily target individuals with early or mild dementia, potentially leaving those with more severe forms without adequate support. As the disease advances, future ATs should be able to adapt to patients' changing requirements and capacities (Lee-Cheong et al., 2022).

Some studies have stressed different issues when adapting to the use of health technologies for dementia disorders. Cognitive decline can include issues with thinking, memory, reasoning, comprehension, planning, making decisions or judgments, or organizing ideas or actions. The inability to learn how to use the technology or having trouble remembering how to use it were both highlighted as cognitively associated mHealth usability hurdles that could hinder interaction. Other obstacles included being unable to complete or remember a lot of procedures, being uncertain about choosing choices because the tool's instructions were too vague, or being unable to recognize or comprehend, for example, icons or buttons (Engelsma et al., 2021).

Addressing these issues and developing user-friendly and accessible technologies will be crucial for ensuring the effective utilization of health technologies for individuals with dementia and cognitive decline.

4 PROPOSAL

4.1 DIGITAL SOLUTION IDEATION

The conducted literature review has identified several critical characteristics that should be incorporated into any medical application targeting dementia patients. These characteristics are critical for ensuring that the application is effective in supporting dementia patients and their caregivers, and include the following key characteristics:

- Simplicity and Ease of Use: the application should have a simple and intuitive user interface, making it easy for dementia patients to navigate and understand.
- Personalization: the application should be customizable to the user's needs and preferences, allowing them to personalize the experience.
- Reminders and Alerts: the application should allow the creation of reminders and alerts to help both the patient and the caregiver manage medications, appointments, and daily activities.
- Cognitive Training and Brain Games: this is a very important feature the application should include cognitive training and brain games must be present to help improve the patient's cognitive abilities.
- Communication: the application should include communication features that allow patients and caregivers to stay connected with each other and with healthcare professionals.
- Tracking and Monitoring: the application should include tracking and monitoring features to help caregivers track changes in the patient's behavior and health.
- Security and Privacy: the application should be designed with strong security features to protect patient data and prevent unauthorized access.
- Compatibility: the application should be compatible with different devices and operating systems to accommodate a wide range of users.
- Support and Resources: the application should provide access to resources and support services for patients and caregivers.

The first step is to create the content displayed on the software, based on the needs of the target population: elderly suffering from dementia. After evaluating the content's clarity and applicability, the design must include a series of technical requirements, to develop a prototype. Technical requirements and prototype development are the next step.

Experts from academia and industry should be consulted to guide the development of the application, ensuring that it meets the needs and preferences of its target users, is evidence-based, and follows best practices in software development. Involving both academic and industry experts can also ensure that the digital solution incorporates the

latest research findings and technologies while remaining practical and feasible for real-world implementation. Industry experts can provide knowledge on market trends, feasibility, and scalability, while academic experts can provide a scientific basis for the development of the software.

The following chapters include the requirements that the software should satisfy.

4.2 FUNCTIONAL REQUIREMENTS

Technology-based interventions, such as mobile applications, have demonstrated promising results in supporting dementia care, including improving cognitive and functional abilities, reducing caregiver burden, and enhancing social engagement. However, designing and developing effective and user-friendly dementia applications requires a thorough understanding of the functional requirements unique to the specific user group.

Functional requirements and design requirements are closely related in the development of an application targeting dementia in the elderly. Functional requirements describe what the application should do, in terms of its intended purpose and features, and focus on the functionality and capabilities of the application. Design requirements, on the other hand, refer to the specific functional and non-functional specifications that describe how the software will be implemented to meet the user's needs, and how users will interact with it. They are focused on the visual and user experience aspects of the application and should meet the needs and preferences of the target users.

Design requirements are informed by the functional requirements in that they are derived from the system requirements but focus on the details of the software’s behavior and interfaces, rather than the overall structure of the system. For example, the functional requirement of "providing tracking and monitoring features" might translate into a design requirement of "displaying a graph of daily activity levels for the patient."

Design requirements are integrated into the development process by guiding the design and implementation of the application. The development team uses the design requirements to create mock-ups, wireframes, and prototypes of the application. These designs are then tested with users to ensure that they meet the needs and preferences of the target users. Once the design has been finalized, the development team uses the design requirements to write code that implements the application's functionality and user interface. During development, the design requirements are continually reviewed and refined to ensure that the final product meets the needs and preferences of the target users.

The development of an application of this kind must follow requirements such as tracking and monitoring, cognitive training and brain games, communication features, reminders and alerts, personalization features and support and resources:

The application should provide **tracking and monitoring features** that help caregivers monitor changes in the patient's behavior and health. Tracking and monitoring features can include activity tracking, sleep tracking, medication tracking, and mood tracking. These features help caregivers to identify changes in the patient's health and behavior, allowing them to take necessary action to manage the patient's care effectively.

Cognitive training and brain games are essential features of the application. They help improve the patient's cognitive abilities and can help slow down the progression of dementia. Cognitive training and brain games can include memory games, puzzles, and other activities that stimulate the brain. These activities are designed to improve memory, attention, and other cognitive functions.

The application should include **communication features** that allow patients and caregivers to stay connected with each other and with healthcare professionals. Communication features can include video calls, messaging, and voice calls. These features can help reduce social isolation and improve the patient's quality of life. Caregivers can use communication features to update healthcare professionals about changes in the patient's health. In addition to the communication features, the application is expected to provide access to resources and support services for patients and caregivers. These resources could include access to healthcare professionals, support groups, and educational resources, that can be provided through links, directories, or other relevant means.

The application should allow the creation of **reminders and alerts** to help both the patient and the caregiver manage medications, appointments, and daily activities. Reminders and alerts can be customized to the patient's needs and preferences. They can help ensure that medications are taken on time, appointments are not missed, and daily activities are completed, and can also help users remember important information and events by using notes, and photo galleries.

The application should be customizable to the user's needs and preferences, allowing them to personalize the experience. **Personalization features** can include adjustable font sizes and color schemes, and other features that make the application easy to use for people with different levels of cognitive abilities. Personalization features can also include customizing the application's interface to suit the patient's preferences.

The application should provide access to **resources and support services** for patients and caregivers. Support and resources can include access to healthcare professionals, support groups, and educational resources. These features can help caregivers manage the patient's care effectively and improve the patient's quality of life.

Overall, the design requirements for an application targeting dementia in the elderly should be focused on providing support and assistance to users with cognitive impairment, while also considering the needs and preferences of caregivers. The application should be easy to use, accessible, and personalized to meet the needs of individual users. By providing these features, the application can help improve the quality of life for dementia patients and make caregiving more manageable.

4.3 NON FUNCTIONAL REQUIREMENTS

Non-functional requirements, on the other hand, represent the technical qualities or characteristics that a software application must possess to meet user expectations for performance, reliability, and usability. Non-functional requirements typically describe the technical attributes of the system, such as how fast it must be, how reliable it must be, and how easy it must be to use.

To be effective and user-friendly, an application targeting dementia in the elderly must include the following requirements: usability, accessibility, security, and privacy, to support the specific needs and challenges of this user group.

4.3.1 Usability

Usability is a critical functional requirement for developing a dementia application, as older adults may have age-related sensory, cognitive, and physical limitations that affect their ability to use technology. Therefore, the application should be designed to be easy to use and navigate, with clear instructions and feedback. The user interface should also be intuitive, and customizable, allowing users to adjust font size, color schemes, and other elements to suit their preferences. The dementia application must include the following specifications:

- A simple and intuitive user interface
- Large, easy-to-read fonts and buttons
- Minimal distractions on the screen
- Consistent navigation and design
- Clear, concise instructions and feedback
- The ability to customize the user interface based on individual user preferences
- Easy-to-understand language and terminology.

4.3.2 Accessibility

Accessibility is another critical requirement for developing a dementia application, as older adults may have visual, hearing, or motor impairments that require assistive technologies. The application should comply with accessibility standards, such as those established by the World Wide Web Consortium (W3C), and support alternative input and output devices, such as speech recognition, text-to-speech, and screen readers.

Some of the requirements to follow are:

- High contrast and adjustable color schemes
- Support for assistive technologies, such as screen readers, text-to-speech, and speech recognition
- Adjustable font sizes
- Large touch targets and support for gestures
- Text captions and audio descriptions for multimedia content
- An option to turn off or adjust any animations or visual effects.

4.3.3 Security

Security is a critical functional requirement for any health-related application, as older adults may be more susceptible to fraud, scams, and identity theft. The application should have robust security features, such as password protection, encryption, and secure data storage, to ensure user data is protected from unauthorized access or use. Security related features include:

- Robust authentication and authorization mechanisms to prevent unauthorized access
- Data encryption to protect user data during transmission and storage
- Regular security updates to address any vulnerabilities
- Emergency contact information for user's caregivers
- A strong password policy to ensure secure account access
- Two-factor authentication to provide an additional layer of security.

4.3.4 Privacy

Privacy is an important functional requirement for developing a dementia application, since the elderly population may have concerns about their personal information being shared or misused. The application should comply with privacy regulations, such as the General Data Protection Regulation (GDPR) and provide clear and transparent privacy policies to users. The application should also allow users to control their data and provide options to delete

or export their data, at any given time. Some aspects of privacy that should be considered are:

- A clear and concise privacy policy
- The ability for users to control their personal data, including the ability to delete or export their data
- A way for users to provide informed consent before sharing their personal data
- Secure storage and transmission of personal data
- Compliance with relevant data protection regulations such as the General Data Protection Regulation (GDPR).

In summary, an effective application targeting dementia in the elderly must meet a range of functional requirements, including usability, accessibility, security, and privacy. By addressing these requirements, developers can create applications that are easy to use, accessible, secure, and respect the privacy and dignity of older adults living with dementia.

4.4 TECHNICAL REQUIREMENTS

An application designed for dementia in the elderly must fulfil various technical requirements to ensure effectiveness and provide seamless user experience. These technical requirements can be broadly categorized into three main areas: platform compatibility, data management, and performance.

4.4.1 Platform Compatibility:

The application should be compatible with the platforms commonly used by elderly individuals, such as smartphones, tablets, and computers. Specifically, it should:

- Be compatible with a range of operating systems, such as Android, iOS, and Windows
- Support a variety of device screen sizes, resolutions, and orientations
- Have a responsive design that adapts to different device types and screen sizes (since elderly users may have different devices with varying screen sizes and resolutions)
- Be optimized for the performance of the devices it runs on.

4.4.2 Data Management:

The application should be designed to manage user data securely and efficiently, by following the next specifications:

- Have a robust and reliable data storage system that can manage large amounts of data.
- Ensure that user data is backed up regularly to prevent data loss.
- Have an effective data processing system that can handle user inputs and interactions with the application.
- Comply with relevant data protection and privacy regulations.

4.4.3 Performance:

The application should provide a smooth and seamless user experience. Specifically, it should:

- Have fast loading times to minimize user wait times.
- Be responsive to user inputs to provide a seamless user experience.
- Have minimal lag time and delays between user inputs and application response.
- Be optimized for low power consumption to extend battery life on mobile devices.

In summary, an effective application targeting dementia in the elderly must meet several technical requirements. By addressing these technical requirements, developers can create applications that are efficient, secure, and provide a seamless user experience.

4.5 ARCHITECTURE

4.5.1 Conceptual Architecture

Along with the design requirements, another crucial aspect of developing any digital solution is the software architecture, which refers to the overall structure of the software system. This includes the high-level modules, components, and interfaces that will be used to implement the software. The system architecture is concerned with how the software will be organized, how the different components will interact, and how the system will be deployed and maintained. It defines the macro requirements and constraints that will guide the design and development of the software.

In contrast, design requirements focus on the specifics of how the software will behave, while system architecture focuses on the overall structure and organization of the software system. Both are essential aspects of software development, and they need to be carefully designed and integrated to create a successful software product.

The digital solution is specifically designed to provide support for elderly users in managing their health and daily activities, with a particular focus on individuals affected by mental

health conditions such as dementia. To meet the design requirements set forth for this solution, a comprehensive software architecture has been meticulously developed. This architecture encompasses a diverse array of high-level modules, components, and interfaces, all working together harmoniously to create a well-organized and efficient software system.

Within this architecture, the platform incorporates two connections for monitoring web interfaces, facilitating seamless communication between the digital solution and healthcare practitioners responsible for monitoring and evaluating the patient's progress. Additionally, a dedicated component has been integrated to assess the presence, frequency, and level of distress associated with health concerns. This component possesses the ability to trigger alerts in emergency situations, ensuring swift and appropriate responses to critical incidents.

Furthermore, the digital solution ensures continuous access to evidence-based self-care advice, granting users a wealth of reliable information to aid in their personal health management. Additionally, the platform establishes connections to pertinent websites, providing users with a gateway to further resources and information specific to their needs. To promote cognitive well-being, the digital solution also incorporates interactive games designed to facilitate memory training.

Through the integration of these features, the digital solution seeks to empower elderly individuals, particularly those living with dementia, by offering comprehensive support and resources for their health-related concerns.

The conceptual architecture diagram presented bellow (figure 2) serves as a guide for the design and implementation of the digital software, providing a visual representation of the various architecture modules associated with the macro requirements. By employing this architecture, the digital solution aims to enhance the quality of life for elderly individuals by addressing their specific needs and challenges in managing their health and daily activities.

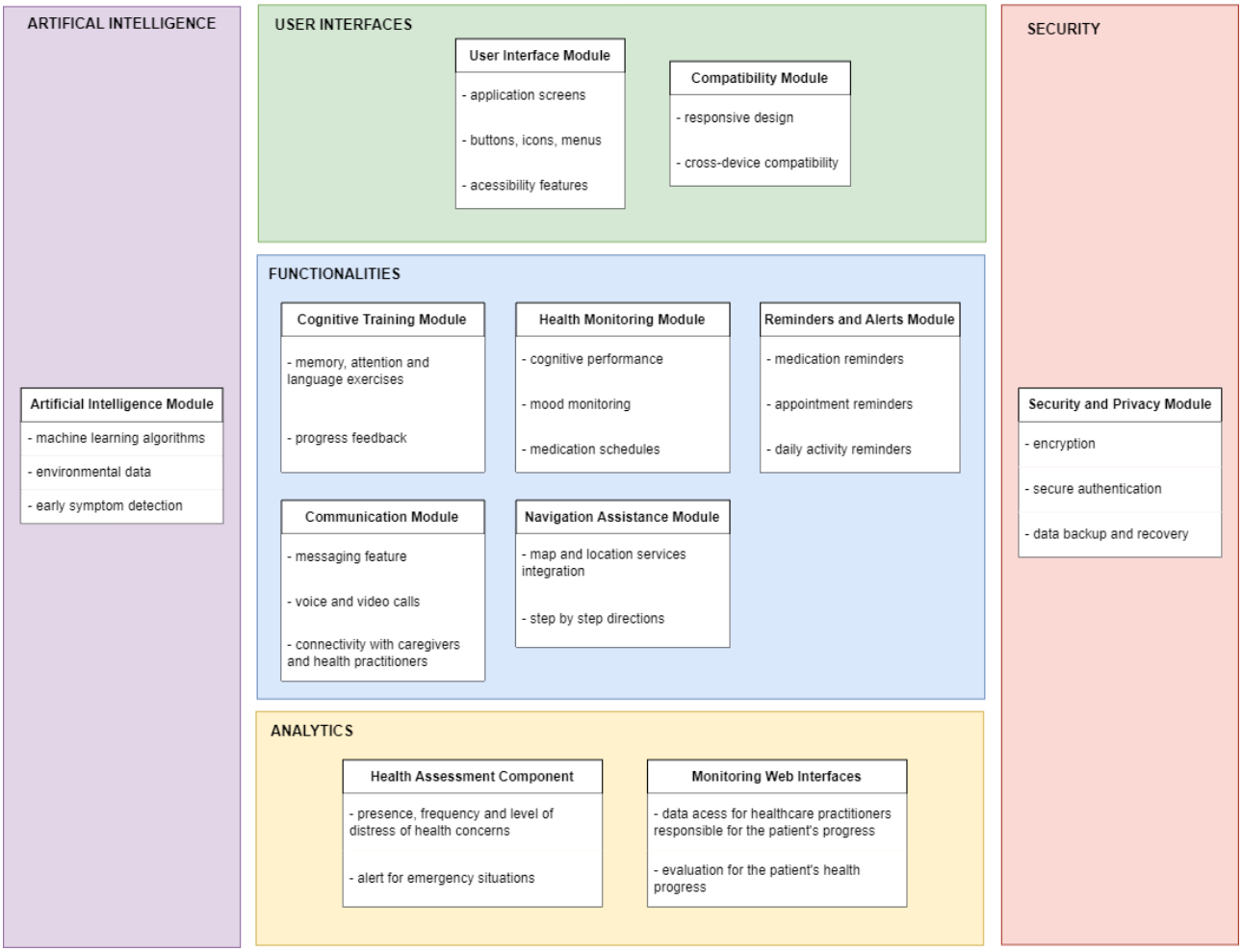

Figure 2 - Conceptual architecture diagram

User Interface Module: this module is responsible for managing the user interface of the application. It includes the design of the application screens, buttons, icons, and menus to ensure that they are user-friendly, accessible, and intuitive.

Cognitive Training Module: this module provides various exercises and activities to improve cognitive abilities such as memory, attention, and language skills. It includes designing activities that are challenging yet achievable and providing feedback on progress.

Health Monitoring Module: this module is responsible for tracking the patient's health data relevant to dementia and mental health, such as cognitive performance, mood, and medication schedules. It includes designing a user interface that allows the patient and caregiver to easily input and view this information.

Reminders and Alerts Module: this module is responsible for providing reminders and alerts for appointments, medication schedules, and daily activities. It includes designing a notification system that is easily understandable and can be customized to the patient's needs.

Navigation Assistance Module: this module is responsible for assisting the patient with navigation and directions, especially when going to unfamiliar places. It includes integrating with map and location services and providing step-by-step instructions.

Communication Module: this module is responsible for providing communication features to help patients stay connected with their loved ones and caregivers, as well as healthcare practitioners. It includes designing features such as messaging, voice, and video calls that are easy to use and accessible.

Compatibility Module: this module is responsible for ensuring that the application is compatible with different devices and operating systems. It includes designing the application to be responsive to different screen sizes and device capabilities.

Transversal Modules

Security and Privacy Module: this module is responsible for ensuring the security and privacy of patient data. It includes designing security features such as encryption, secure authentication, and data backup and recovery mechanisms.

Artificial Intelligence Module: this module assumes a pivotal role in the framework by enabling the system to adapt and learn from diverse data sources. Leveraging advanced machine learning algorithms, including those operating on patient records, environmental data, sensor readings, and user interactions, this module enables the system to provide personalized and context-aware support tailored to the unique needs of individuals affected by dementia. Additionally, this module facilitates intelligent decision-making processes by generating valuable insights and recommendations through continuous analysis of data from multiple sources. These outputs offer valuable guidance to healthcare providers, caregivers, and individuals with dementia, thereby supporting optimized care, early symptom detection, and personalized interventions. The AI module's capacity to dynamically adapt to evolving user needs and preferences enhances the overall effectiveness and efficiency of the digital solution in addressing the challenges posed by dementia in the elderly population.

By implementing this comprehensive conceptual architecture, the digital solution has the potential to significantly enhance the lives of elderly individuals affected by dementia. Through the seamless integration of these modules within the framework, the proposed solution strives to offer a holistic and innovative approach to dementia care, providing

crucial support to elderly individuals and their caregivers in effectively managing this complex condition.

4.5.2 Technical Architecture

The architecture of an application targeting dementia in the elderly should be designed to provide a stable, secure, and user-friendly experience. The architecture components refer to the individual building blocks or modules that make up an application's overall architecture. These components are designed to work together to create a cohesive system that meets the application's requirements, including data storage, user interface, security, and communication protocols.

The software architecture for an application targeting dementia in the elderly is a high-level representation of the structure and components of the application. It describes how the application will be organized and how its different parts will work together to achieve the desired functionality.

While the framework provides a structure for organizing and developing the specific features and functionalities of the application, the technical architecture defines the overall structure of the system in which the application will run, including its hardware and software platforms, data storage and processing, network infrastructure, and security. Both framework and technical architecture are critical to the success of a software, as they help ensure that the application is effective, user-friendly, scalable, and secure.

The next topics resume the different steps that must be followed to achieve a reliable architecture that has potential to be implemented in a digital software, with a description for the different components of such an application:

The presentation layer of the framework is responsible for displaying information to the user and receiving input from them. It consists of the user interface components, part of the front-end. The **front-end** should be designed to be simple, intuitive, and easy to use, with clear and consistent design elements such as buttons, icons, and fonts. The front-end should also be designed to be accessible to users with cognitive impairment and physical disabilities and optimized for touch screens and other input devices, such as voice commands. Examples of frontend frameworks that could be used are React Native, Flutter, or Ionic.

The application logic layer contains the business logic of the application. It is responsible for processing the user input, managing the application state, and communicating with the data access layer. In this layer, the **back-end** provides the server-side functionality of the application and is responsible for the data storage, retrieval, and processing. It should be designed to be scalable, flexible, and secure, with efficient algorithms for data processing and storage, mainly related to cognitive training and health monitoring. The back-end

should also be designed to ensure the security and privacy of user data. Examples of backend frameworks that could be used are Node.js, Ruby on Rails, or Django.

The data access layer is responsible for interacting with the application's data sources, such as databases or web services, and provides a way for the application logic layer to access and manipulate the data. The application **database** is accountable for storing and retrieving user data, such as personal information, medication schedules, notes, reminders, and preferences, as well as metadata related to the software (user management metrics and analytics data). It should be designed to be efficient and secure, with a clear and consistent data structure. The database should also be designed to handle large volumes of data and to ensure data integrity and consistency. Examples of database management systems that could be used are MySQL, PostgreSQL, or MongoDB.

The integration layer enables the application to interact with external systems and services, and it provides a way for the application to exchange data and information with these services. In this case, the use of APIs (Application Programming Interfaces) allows different components of the application to communicate with each other and to access third-party services (social media platforms, healthcare providers, location-based services). The APIs should be designed to be efficient, secure, and scalable, with clear and consistent interfaces. The APIs should also be integrated into the platform architecture in a secure and reliable manner. Examples of APIs that could be used are RESTful APIs, GraphQL, or SOAP.

Finally, the **infrastructure layer** includes the components that provide the foundation for the application to run, such as the operating system, web server, and database server. For medical software, the infrastructure layer needs to be designed with a focus on reliability, scalability, and security, ensuring that the application can handle large volumes of data and users.

The application should be rigorously **tested, and quality assured,** to ensure that it meets the design requirements and is stable, secure, and user-friendly. Testing should include functional, performance, and security testing, as well as user acceptance testing. It should be designed to be easily maintainable and updatable, with regular updates to fix bugs, improve performance, and add new features. The **maintenance and updates** should be designed to be seamless and efficient, with minimal disruption to the user experience.

The application will include a **security framework** to protect user data and the application itself from malicious attacks. This framework should include secure data transmission protocols, data encryption, and authentication mechanisms. Examples of security frameworks that could be used are OAuth2, JWT, or SSL.

By designing an effective architecture and framework, developers can create an application that is reliable, scalable, and provides a seamless user experience.

4.6 Design Concepts, Ideas and Prototyping

4.6.1 Concepts

While the software components are critical to the accurate development of the digital solution, it is equally important to establish the components that are presented to the end-user, adapted characteristics that must target the disease in its context.

The following design concepts were developed with the insights gained by the literature review conducted and aim to provide support and assistance to users with dementia, while also considering the needs and preferences of caregivers. Each concept has the potential to provide specific benefits to users, such as improved memory retention, medication management, or personalization of their experience.

Memory journal: a memory journal concept allows users to create a personalized journal with notes, photos, and reminders to help them remember important events and information. Users can add entries to their journal and set reminders for important events, such as appointments or birthdays. The journal could also include a photo gallery to help users remember people and places.

Medication management: some other interesting features include medication management tools, such as a medication schedule, dosage information, and reminders for when to take medication. It should also allow users to track any side effects or reactions they experience.

Daily planner: the daily planner concept helps users plan and organize their daily activities. The application could include a simple calendar interface, with the ability to add tasks and events. Users could also set reminders for upcoming events or tasks.

Personalized music player: the personalized music player concept provides users with a personalized playlist of their favorite songs and artists. The application could include a simple and easy-to-use interface, with the ability to search for songs and create playlists. Music has been shown to have a positive impact on mood and cognitive function, so this feature could be particularly beneficial for users with dementia.

Reminiscence therapy: The application should include features that allow users to revisit memories from their past, such as a database of historical events and cultural references. It should also allow users to add their own memories and stories to the database.

Emotional support: the application should provide emotional support for users, such as mood trackers and positive affirmations. It should also allow users to connect with others who have dementia, such as through a community forum.

4.6.2 Application Prototype

Building an application or software prototype involves several different aspects that need to be carefully considered and planned. Before describing the proposed prototype for the digital solution targeting dementia, it is important to consider the key aspects that need to be addressed when building an application or software prototype.

First, the purpose and objectives must be defined. This includes identifying the target audience, the main problem that the software will solve, and the specific features and functionalities that the software will include.

Once the purpose and objectives of the software have been defined, the next step is to gather requirements from stakeholders, users, and other sources. This involves identifying the specific features, functionalities, and performance criteria that the software must meet to be successful.

After the requirements have been gathered, the next step is to design the software's architecture and user interface. This includes creating wireframes and mock-ups, defining the data structures and algorithms that will be used, and deciding on the software architecture and technology stack.

Once the design and architecture have been finalized, the software development process can begin, followed by its implementation. This involves coding the software using the chosen technology stack and implementing the design and architecture decisions that were made in the previous steps.

After the software has been developed, it needs to be thoroughly tested and debugged to ensure that it meets the requirements and performs as expected. This involves testing the software under various conditions and scenarios, identifying, and fixing any bugs or issues, and optimizing the software's performance and usability.

Once the software has been tested and debugged, it can be deployed to the target environment and made available to users. Ongoing maintenance and support, different adjustments and test will be necessary not only to confirm the viability of the prototype implementation but also to ensure that the software remains up-to-date, secure, and performs as expected. This may include making changes to the software to fix any issues that were discovered during testing, as well as adding new features or functionality to meet evolving user needs. More specifically, security updates, compatibility, usability, and performance testing, as well as bug fixes are examples of adjustments that might be needed to ensure the software remains up-to-date and performs as expected.

Through user-centered techniques, the application must be assessed. This is where patients participate to explore the application's various interfaces, while researchers observe and ask

questions in accordance with the research criteria. Here some operational errors can be identified by the users, and the interaction satisfaction is to be accessed.

The design concepts defined in the previous chapter allow the creation and structure of the software prototype, that contains the different architecture modules to be implemented. When designing a prototype of an application targeting dementia in the elderly, it is important to consider the needs of the users and the functionality of the application.

The next topics include the description of different modules that could be included in the prototype and further converted into application screens:

Login screen: this screen is used to authenticate the user and provide access to the application.

Home screen: the home screen should provide an overview of the features and options available in the application, as well as any notifications or reminders.

Memory games screen: this screen should include a variety of memory games that are designed to improve memory and cognitive function in elderly with dementia.

Reminders' screen: this screen should allow users to set reminders for medication, appointments, and other important tasks.

Messaging screen: the messaging screen should allow users to communicate with their caregivers or healthcare providers, as well as other users of the application.

Personalized settings screen: this screen should allow users to customize the application to their individual needs, such as adjusting the font size or color scheme.

Activity tracking screen: this screen should allow users to track their daily activities and monitor their progress over time.

Caregiver dashboard screen: this screen should allow caregivers to monitor the activities and progress of the elderly with dementia, as well as receive notifications and communicate with the user.

Help and support screen: this screen should provide users with access to help and support resources, such as FAQs, tutorials, and customer support.

The design and developments of these different screens allows the creation of a prototype of an application that is intuitive and easy to use for elderly individuals with dementia and their caregivers. The screens should be designed with simplicity and clarity in mind, using large, easy-to-read fonts and simple graphics to help users navigate the application.

5 EVALUATION AND DISCUSSION

5.1 EVALUATION

To evaluate and validate the usability of the proposed framework targeting dementia in the elderly, a series of expert interviews were conducted, via online meetings. The primary objective of these interviews was to validate the proposed framework by soliciting critical comments and suggestions for improvements, as necessary, with the aim of addressing specific research gaps and determining the practicality and value of the chosen approach within a real-world context.

Experts were deliberately selected from both the industry and the academic sphere, as each domain provides distinct perspectives, diverse levels of experience, and complementary expertise. Prior to the interview phase, a concise presentation of the framework was delivered during these meetings, employing a slide deck that commenced with an overview of the study's background and objectives, serving as a foundation for comprehending the framework.

To ensure accuracy and thoroughness, meticulous recordings of these meetings were made. Both the feedback received and the responses to the interview questions were transcribed for subsequent analysis. The ensuing section presents the significant insights gained from these interviews, while the complete transcript of the interview questions and answers can be found in the annexes of this thesis document. It is worth noting that all participants willingly provided their consent for the utilization of insights acquired from the interviews within the scope of this thesis.

5.1.1 Interviews

The interviews were semi-structured, allowing experts to provide pertinent responses while also allowing for probing to produce rich answers to unscripted interview questions when necessary.

For reference, a comprehensive table listing the participating experts, their professional roles, and areas of expertise is included.

Table 3 - Expert interviews areas of expertise

AREA OF EXPERTISE	NAME
Assistant Professor	Professor Pedro Maia Malta (PMM) – assistant Professor at Nova Information School with expertise in the field of Information Systems
Psychiatrist	Professor Carlos Brás Saraiva (CBS) – psychiatrist with experience in Neurodegenerative Diseases
Psychologists	Professor José Pinto (JP) – psychotherapist and assistant Professor at Coimbra Nursing School Dr. Carlos Filipe Saraiva (CFS) – psychologist at Porto's Correctional Facility

This chapter presents the findings derived from expert interviews regarding the development of a framework for a digital solution targeting dementia in the elderly. The purpose of these interviews was to seek expert opinions on the utility of the proposed framework and gather recommendations for its improvement. The chapter begins with an overview of the interview questions, followed by an analysis of the experts' responses.

Table 4 - Interview questions

INTERVIEW QUESTIONS
Do you consider the proposed framework useful, and if so, why?
Would you consider implementing the proposed framework?
Do you have any recommendations or suggestions for further improvements of the proposed architecture?

During the interviews, experts were invited to evaluate the usefulness of the proposed framework. Their responses provided valuable insights into the practicality and potential benefits of the framework in addressing the challenges associated with dementia in the elderly. Overall, the experts recognized the practicality and potential impact of the framework, which encompasses a comprehensive conceptual architecture and a suite of software modules catering to diverse functionalities and analytical needs. They highlighted

its potential to improve the quality of care for individuals with dementia and enhance their overall well-being.

Moving on to the second interview question, the experts' viewpoints on implementing the proposed framework were sought. The feedback received indicated a unanimous consensus among the experts that the framework is a viable solution deserving serious consideration for implementation. They emphasized the importance of collaborating with appropriate stakeholders who possess the expertise to transform the conceptual foundation into a more analytically inclined framework. Additionally, the experts underscored the significance of identifying a reliable partner to oversee the development and implementation process. Their recommendations emphasized the need for a comprehensive implementation strategy, ensuring the successful integration of the framework into existing healthcare systems and practices.

The third interview question invited experts to provide recommendations and suggestions to enhance the proposed architecture. Their feedback encompassed a range of valuable insights. Firstly, based on the findings from the literature review, experts recommended deliberating on a possible appellation change to "Conceptual Application Architecture" to ensure conceptual clarity and equilibrium. They advised distinguishing the user interface from the functionalities as separate components and proposed incorporating the respective 'interface' terminology into the module nomenclature to achieve this distinction.

Furthermore, the experts suggested the creation of UML (Unified Modelling Language) diagrams to bolster the programming efforts of the development team. They emphasized the potential benefits of including a package diagram, illustrating the prominent areas comprising a future software system, as well as a subsequent database diagram supporting the technological architecture. These visual representations were deemed essential for enhancing reader comprehension of the conceptualization presented throughout the thesis development.

The experts acknowledged the challenges associated with implementation and recommended an iterative approach utilizing agile development techniques. They proposed exploring the Rational Unified Process (RUP) methodology, which involves obtaining partial acceptance from the client at various stages of the development process. This iterative approach allows for progressive adaptations over time, leading to a near-final decision after conducting comprehensive tests.

The inclusion of Pedro Maia Malta, an esteemed assistant professor at NOVA IMS Information Management School, as an expert in information systems, lends significant credibility to the evaluation of this project. Given his extensive experience in this domain, his opinion holds substantial value. The subsequent paragraphs detail the valuable insights derived from the interview conducted with him, addressing the three interview questions, respectively.

In addition to the insights provided by Professor Pedro Maia Malta, an interview was conducted with Professor Carlos Brás Saraiva, a renowned psychiatrist doctor specialized in dementia-related diseases, who possesses extensive experience in the field. Dr. Saraiva's feedback offers a valuable perspective on the proposed framework and its suitability for addressing dementia in the elderly.

The interview with the psychologist, Dr. Filipe Saraiva, shed light on the significance of combining cognitive and health strategies, incorporating music as a means of stimulation, personalizing the software to enhance patient engagement, enabling doctor access to patient data for better monitoring, and emphasizing the potential for transforming the solution into a comprehensive dementia intervention program.

The interview with Professor José Matos Pinto highlighted the significance of the program's structure, the role of memory tasks, the importance of user engagement, limitations related to population familiarity and complexity, and considerations for successful implementation. The psychotherapist also emphasized the potential of the program to engage the elderly population in general and the importance of memory and interactive processes in combating social isolation.

The following paragraphs describe the responses of each professional to the interviews' questions.

1 - Do you consider the proposed framework useful, and if so, why?

PMM: The objective of the work presented is twofold: to materialize not just a conceptual architecture but also a suite of software modules slated for construction. The illustrated representation, if considered as an application architecture, demonstrates coherence by encompassing hierarchical components that facilitate the utilization of a range of functionalities within applications, catering to either a data-centric or analytical focus.

CBS: As a psychiatrist specialized in dementia-related diseases, I find the proposed framework for a digital solution targeting dementia in the elderly to be intriguing. The framework presents interesting ideas; however, I must note that it seems more suited for a luxury nursing home environment. This observation stems from considering the cognitive decline typically associated with dementia and the relatively lower levels of literacy among the elderly population. It is essential to emphasize the significance of sociocultural activities and occupational therapy that involve physical engagement. These activities play a vital role in maintaining the overall well-being of individuals with dementia. Moreover, traditional outings to places like museums still hold great importance, as they provide meaningful experiences and cognitive stimulation. While recognizing the value of the proposed digital solution, it is crucial to adopt a comprehensive approach that integrates digital elements with physical interaction and cultural experiences.

CFS: I consider the proposed framework a highly interesting proposal, demonstrating clear innovation through its integration of cognitive and health strategies. Moreover, the inclusion of cognitive stimulation techniques is commendable, as it aims to evaluate the impact of mood changes on the progression of dementia. Notably, the idea of incorporating music into the solution is brilliant, as certain songs or sound cues hold significant meaning for dementia patients and can effectively stimulate their memory function.

JMP: I find the proposed program to be intriguing and well-structured, with a cybernetic model serving as its foundation. The steps are clearly defined, providing a strong framework. However, there is a complexity in terms of the program's response across all individuals with dementia. While it may be effective for the elderly and those in the early stages of dementia, it remains uncertain whether users in more advanced stages would easily access the solution due to their limited familiarity with technology and motor support.

One intriguing aspect that I would like to highlight is the significant role played by memory tasks. Studies conducted on individuals aged 55-65 have shown that memory-based activities aimed at enhancing mnemonic capacity result in memory improvement for the healthy population and memory recovery for those in the early stages of dementia. These studies also provide experimental support for the efficacy of such memory tasks, demonstrating a 13% increase in hippocampal mass in the healthy population.

Furthermore, the project holds potential as a reminder system for individuals, depending on the established bond. However, capturing and enticing individuals to utilize the solution depends on their level of engagement.

2 - Do you have any recommendations or suggestions for further improvements of the proposed architecture?

PMM: I contend that the model is substantiated; however, it may be worthwhile to consider a possible change in appellation to "Conceptual Application Architecture" based on findings from the literature review. Delineating the user interface as one facet and the functionalities as another would create a better balance. To this end, each module should undergo a renaming process to incorporate the respective 'interface' terminology ('Application Interface - with main functionalities' and 'Analytics Interface'). The proposed architecture encompasses specific objectives, with the module nomenclature imbued with a commercially suggestive undertone, accompanied by an explication of their respective functionalities. All definitions and elucidations pertaining to each module are characterized by a profusion of detail, resulting in more or less exhaustive requirement lists for each module. Hence, the term "conceptual architecture" aptly encapsulates its nature. An additional suggestion would be to devise UML diagrams to facilitate the programming efforts of the development team. A package diagram, illustrating the prominent areas constituting a future software system, and a subsequent database diagram supporting this

technological architecture, could be considered. A package diagram provides a holistic view of the software, thereby encompassing the four packages expounded in the architecture: user interface, application interface, analytics interface, and security module. This serves to enhance reader comprehension of the conceptions presented throughout the thesis development.

CBS: In terms of recommendations and suggestions for further improvements of the proposed architecture, I would advocate for incorporating a more comprehensive range of therapeutic interventions. The framework should integrate evidence-based practices, such as cognitive stimulation programs and person-centered care approaches, which have shown positive outcomes in dementia care. It would be advantageous to explore technologies that facilitate personalized interventions and support the diverse needs and preferences of individuals with dementia. Additionally, involving interdisciplinary collaboration with professionals from diverse fields, including geriatric medicine, occupational therapy, and social work, would enrich the framework and enhance its effectiveness.

CFS: One aspect of the framework that I would suggest modifying is the personalization of the software. Instead of solely functioning as an app, it would be beneficial to design an assistant interface that allows patients to establish a stronger connection with the application. For instance, considering the gradual memory loss experienced by Alzheimer's patients, long-term memories tend to persist. Therefore, integrating more meaningful images from the past, featuring loved ones or even their voices, could personalize the application and create a sense of ownership and familiarity for the user. Another valuable improvement would be to grant doctors access to patient data for monitoring and identification of potential improvements. For instance, if a patient displays increased sadness in the mornings but experiences improved mood in the afternoons, understanding the factors contributing to this change becomes essential. Was there a particular activity that triggered the improvement, or should medication adjustments be considered? Since dementia patients often lose their perception of mood changes and the events influencing them, granting medical professionals access to this data could facilitate better care and treatment.

JMP: Firstly, the issue of population arises. I question which individuals within the dementia population will have access to this solution if they lack familiarity with technology. To address this, considering the program as a means of entertainment and development would be beneficial. When reflecting on the activities in which the elderly engages at day centers, such as embroidery, painting, and watching television, it becomes evident that programs of this nature could be more useful if the elderly are actively involved in the projects. This applies not only to individuals in the early stages of dementia but also to all elderly individuals, as it provides occupation and entertainment. The more opportunities they have to participate in fulfilling projects involving music or photographs, the better. If they can autonomously engage in this process, it can empower the users and foster a sense of competence, which is crucial for this population.

Another issue lies in the complexity of the solution for individuals with dementia. It would be worthwhile to focus on prevention before dementia is diagnosed and to expand the target population to include healthy elderly individuals. As previously mentioned, many activities in day centers are predominantly passive and fail to captivate the interest of the elderly. Therefore, this program would prove highly beneficial, provided users possess some background knowledge of its usage. Consequently, it may be necessary to provide installation training, activate the program on various devices, and allow the elderly to experiment with it while simultaneously collecting and analyzing their behaviors, movements, and level of engagement. This process will provide insights into how the program can be effectively implemented.

3 - Would you consider implementing the proposed framework?

PMM: I consider the conceptualization of an endeavor in a highly pivotal domain like healthcare to be of immense utility. By engaging appropriate collaborators capable of transforming this conceptual foundation into a more analytically inclined framework, and subsequently securing a partner to oversee development and implementation, the proposed solution can be realized. Admittedly, the initial stages may present certain challenges in efficiently meeting all requirements. However, an iterative approach utilizing agile development techniques can pave the way for progressive adaptations over time. In this context, it would be prudent to explore the RUP method, whereby each iteration receives partial acceptance from the client. By anchoring the concept in a series of acceptances at various stages of the development process, a near-final decision can be attained after conducting a comprehensive battery of tests.

CBS: When it comes to implementing the proposed framework, I believe further considerations are necessary. While the framework shows potential, its suitability for broader implementation beyond luxury nursing homes may be limited. To determine its practical feasibility, a more detailed evaluation of its applicability in various care settings, including community centers and home care, would be beneficial. Factors such as resource availability, adaptability to different care contexts, and the potential for user acceptance should be thoroughly assessed before considering widespread implementation.

CFS: I firmly believe that transforming the proposed architecture into a comprehensive dementia intervention program, surpassing the realm of a mere computer program or patient-centered app, would be an ambitious and worthwhile endeavor. By operationalizing the framework to facilitate the study of disease behavior, patient feedback, effective communication with medical staff, and the collection of cross-sectional data on the impact of various interactions on the disease, such as outdoor activities, physical exercise, and visits

from family members, it would provide invaluable material for analysis and contribute to advancing dementia intervention practices.

JMP: Regarding implementation, I firmly believe that providing initial training is crucial. This aspect should not pose a problem for the elderly as long as they feel integrated and engaged. The activities provided by the program are more interesting than those typically offered at day centers. Moreover, I feel that this program would hold value for the elderly population in general, not exclusively for those with dementia. As dementia progresses, individuals experience increasingly fleeting memory, leading to incoherence in their speech, which significantly hinders the use of such solutions. Existing literature suggests that memory training in the early stages of dementia is highly beneficial for disease progression, a feature that is present in this program.

The strength of this program lies in its memory and interactive processes, which should be emphasized. Users have the opportunity to interact with caregivers, engage in games, and enjoy music, all of which combat social isolation. Observing the behavior of the elderly at day centers reveals a lack of stimulation for most individuals. This underscores the importance of this work, as it empowers and engages the elderly population.

In conclusion, the expert interviews conducted with Professor Pedro Maia Malta, an esteemed assistant professor in information systems, and Carlos Brás Saraiva, a psychiatrist specializing in dementia-related diseases, have provided valuable insights and perspectives on the proposed framework for a digital solution targeting the elderly with dementia.

Professor Malta's expertise and suggestions stressed the significance of developing a coherent conceptual architecture with well-defined modules and interfaces. His recommendation to explore agile development techniques emphasized the iterative nature of the project and the importance of comprehensive testing.

On the other hand, Professor Saraiva's feedback underscored the need to integrate digital elements with physical engagement and cultural experiences to ensure a holistic approach to dementia care. Moreover, his recommendations for incorporating evidence-based practices and fostering interdisciplinary collaboration further enhanced the potential effectiveness of the framework.

The responses provided by Dr. Carlos Filipe Saraiva shed light on the significance of combining cognitive and health strategies, incorporating music as a means of stimulation, personalizing the software to enhance patient engagement, enabling doctor access to patient data for better monitoring, and the potential for transforming the solution into a comprehensive dementia intervention program.

Finally, Professor José Matos Pinto feedback highlighted the importance of the program's structure, the role of memory tasks, the significance of user engagement, as well as the

limitations related to population familiarity and complexity. Moreover, the psychotherapist has emphasized the program's potential for engaging the elderly population as a whole, not just limited to those with dementia, and the significance of memory and interactive processes in combating social isolation.

Overall, these expert insights contribute to the comprehensive understanding and refinement of the proposed digital solution, paving the way for its successful implementation and improved dementia care for the elderly.

5.1.2 Experts' Recommendations Overview

The experts provided several valuable recommendations during the interviews regarding the proposed framework.

The first recommendation is to consider renaming the architecture to "Conceptual Application Architecture" based on the findings from the literature review. This renaming would better reflect the separation of the user interface and functionalities, bringing a better balance to the representation. Additionally, it is advised to rename the modules accordingly, incorporating the respective 'interface' terminology.

Secondly, the experts suggested developing UML diagrams, particularly a package diagram, to support the programming efforts of the development team. This would enhance the understanding of the architecture and concepts presented in the thesis. It is also suggested to create a database diagram that aligns with the technological architecture, further aiding in comprehending the system and its components.

Furthermore, it is recommended to engage appropriate collaborators who possess the expertise to transform the conceptual foundation into a more analytically inclined framework. Securing a partner to oversee the development and implementation of the proposed solution in the healthcare domain is essential for successful realization.

Considering the potential challenges that may arise during the initial stages, an iterative approach utilizing agile development techniques is advised. This approach allows for progressive adaptations over time. The Rational Unified Process (RUP) method can be explored, wherein each iteration receives partial acceptance from the client, leading to informed decisions after comprehensive testing.

Another valuable suggestion pertains to modifying the software's personalization aspect by designing an assistant interface to establish a stronger connection with the application. This could be achieved through the integration of meaningful images and familiar voices, thereby creating a sense of ownership and familiarity for the user. It was also proposed to grant

doctors access to patient data for better monitoring and identification of potential improvements in care and treatment.

The issue of population accessibility was highlighted, with a suggestion to consider the program as a means of entertainment and development for its users. Active involvement of the elderly in fulfilling projects involving music or photographs can foster a sense of competence and engagement. It was also proposed to focus on prevention by expanding the target population to include healthy elderly individuals, while providing installation training and analyzing user behaviors and engagement levels to effectively implement the program.

By implementing these expert recommendations, the proposed framework can undergo further refinement and alignment with the research findings, thereby enhancing the development process and increase the likelihood of successful implementation in the healthcare sector.

The expert interviews provided valuable insights into the development of a framework for a digital solution targeting dementia in the elderly. The feedback received affirmed the usefulness of the framework and supported its implementation in practice. The expert recommendations and suggestions offered opportunities for further improvement, including appellation refinement, the integration of UML diagrams, and adopting an iterative approach during implementation. Incorporating these insights into the development process will contribute to the robustness and effectiveness of the framework.

5.2 DISCUSSION

In general, the utilization of a dementia-targeted application among the elderly population holds the potential for a positive impact on their overall quality of life, facilitating prolonged independence. The development of a specialized application tailored to the unique needs of elderly individuals with dementia offers numerous advantages.

Primarily, the incorporation of cognitive exercises and memory games within the application can effectively stimulate the brain, leading to improved memory function. Such cognitive engagement plays a pivotal role in enhancing cognitive abilities and preserving mental acuity.

Furthermore, the digital solution holds the potential to alleviate stress by providing timely reminders for essential events, activities, and medications. This feature proves particularly valuable for individuals with dementia, who often encounter difficulties in recalling daily routines and significant appointments. By offering reliable prompts, the application contributes to the reduction of stress and assists in the management of daily tasks.

Additionally, the messaging feature embedded within the application fosters social connectivity for elderly individuals with dementia, enabling them to maintain contact with family and friends. By facilitating regular communication, this feature helps combat feelings of isolation and depression, ultimately enhancing their overall emotional well-being.

Another notable benefit of the application is its potential to support caregivers by equipping them with vital information concerning the condition and specific needs of their loved ones. It serves as a valuable resource for caregivers, aiding them in understanding and addressing the unique challenges associated with dementia. Furthermore, the application promotes effective communication channels between caregivers and dementia patients, fostering a better understanding of their requirements and enhancing the caregiving experience.

Moreover, the application's adaptability allows for personalization based on the specific needs and preferences of each elderly individual with dementia. This tailored approach ensures a more engaging and effective user experience, optimizing the benefits derived from the application by aligning it with the individual's distinct circumstances.

Lastly, the mobility of the application, accessible through mobile devices, ensures ease of use for both elderly individuals with dementia and their caregivers. Its portability enables convenient access and utilization, enabling seamless integration into their daily routines.

In conclusion, the development of a personalized and user-friendly application presents a significant opportunity to improve the quality of life for elderly individuals with dementia and their caregivers alike. By addressing key challenges associated with dementia and promoting cognitive stimulation, stress reduction, social interaction, caregiver support, individualization, and accessibility, such an application can yield substantial benefits for all stakeholders involved.

6 CONCLUSION

This thesis aimed to investigate the factors in cognitive aging care that create a demand for the design and deployment of a digital solution for elderly patients with dementia. The research objectives were to develop a functional architectural model for a digital solution focused on mitigating the decrease of brain functions in the cognitive aging process, specifically for dementia disorder.

Through an extensive literature review, this study aimed to consolidate knowledge regarding dementia in the elderly and health information systems within the healthcare sector. A systematic literature review was conducted to assess the current landscape of information systems related to mental diseases. The integration of an AI model's architecture into a digital solution was explored, alongside an examination of the older population's adoption of such a solution and its impact on their mental health.

Although a substantial body of scientific literature on this subject exists, a noticeable knowledge gap persists. Moreover, a growing interest in this topic is evident, particularly considering the ongoing pandemic. Therefore, it can be inferred that the proposed framework, the central objective of this study, not only demonstrates viability for development but also holds relevance within the healthcare sector.

To ensure the development of an effective digital solution, collaboration with experts from academia and industry alike was conducted. Discussion and analysis with numerous experts from both sectors supported the achievement of the objectives set in this work.

The final chapter provides a summary and conclusion of the research conducted within the scope of this thesis. Accordingly, the subsequent section is delineated into three distinct parts. The first part appraises the research findings by concisely summarizing and reflecting upon the insights gathered while addressing the primary research question. The second part focuses on scrutinizing the limitations inherent in the developed framework, considering environmental factors and expert knowledge. Lastly, the final section offers recommendations for future endeavors, drawing upon the identified limitations and proposed enhancements outlined in the guidelines.

In summary, this thesis has proposed a functional architectural model for a digital solution targeting elderly patients with dementia. The proposed architecture addresses the critical characteristics identified in the literature review and provides a framework for the development of a reliable, scalable, and user-friendly application. However, it is important to acknowledge certain limitations in the research. The proposed architecture requires further validation through empirical studies and user feedback to ensure its effectiveness and usability. Additionally, the implementation of the digital solution may face challenges related to technological constraints, resource availability, and ethical considerations.

6.1 SYNTHESIS OF THE DEVELOPED WORK

The development of this work followed a structured approach. Firstly, a comprehensive background analysis was conducted to identify the problem within the scope of the studied topic. This analysis aimed to comprehend the relevance and importance of the problem, subsequently leading to the definition of the research objective. Following this initial step, an extensive literature review was undertaken to acquire foundational knowledge on the two main subjects of study: dementia and health information systems. The literature review served to establish a robust theoretical framework for the research.

The subsequent step involved the execution of a systematic literature review, specifically designed to address the research question and provide the necessary insights. The findings from this review served as the cornerstone for the creation and development of the framework. The framework, the ultimate objective of this work, is anticipated to bring substantial benefits to both the industry and the academic community.

In accordance with the defined research strategy, the developed framework underwent rigorous scrutiny through a series of presentations to domain experts. These presentations served as a platform to collect invaluable feedback, critical evaluations, and recommendations for improvement. The subsequent discussions with the various experts culminated in a revised framework, incorporating the recommendations deemed pertinent.

The iterative process of presenting and refining the framework through expert engagement has enriched the outcome of this research. Incorporating expert recommendations has contributed to the enhancement and refinement of the framework, ensuring its applicability and effectiveness within the targeted domain.

The meticulous adherence to a structured approach, encompassing background analysis, literature reviews, framework development, and expert consultations, has facilitated the creation of a robust and well-informed framework for addressing the challenges associated with dementia in the elderly.

6.2 RESEARCH LIMITATIONS

Despite the comprehensive nature of this study, several limitations should be acknowledged.

Firstly, the proposed architecture requires further validation through empirical studies and user feedback to ensure its effectiveness and usability. While the framework has been developed based on extensive research and evaluated via expert consultations, its real-world application and performance need to be assessed through empirical studies involving

a diverse sample of elderly individuals with dementia. The feedback and experiences of users, including patients, caregivers, and healthcare professionals, is crucial for refining the digital solution and addressing any potential usability issues or unforeseen challenges.

Secondly, technological constraints may present obstacles during the implementation of the digital solution. The availability and compatibility of hardware and software components necessary for the functioning of the application need to be carefully considered. Additionally, the rapid pace of technological advancements requires continuous monitoring and adaptation to ensure the digital solution remains up-to-date and compatible with evolving technologies. The integration of emerging technologies, such as artificial intelligence or Internet of Things (IoT) devices, may also present technical challenges that need to be addressed to enhance the functionality and effectiveness of the digital solution.

Resource availability is another important limitation that should be considered. The successful implementation and sustainability of the digital solution may depend on factors such as financial resources, technical expertise, and infrastructure support. Adequate funding and access to skilled professionals are necessary to develop, deploy, and maintain the digital solution. Additionally, the availability of training and support for end-users, as well as the scalability of the solution to accommodate a larger user base or multiple care settings should be considered.

Ethical considerations also pose potential challenges in the implementation of the digital solution. Privacy and data security are of utmost importance, particularly when dealing with sensitive health information of elderly individuals with dementia. The collection, storage, and transmission of data should adhere to strict ethical and legal guidelines to protect the privacy and confidentiality of users. Furthermore, the ethical implications of using technology as a substitute for human interaction and the potential impact on the quality of care should be carefully examined and addressed.

Lastly, the evolving nature of the field of dementia care requires ongoing research and adaptation. New research findings, clinical guidelines, and best practices may emerge that require adjustments or enhancements to the digital solution. Keeping abreast of the latest developments in dementia care and incorporating them into the framework may be essential to ensure its continued relevance and effectiveness in meeting the evolving needs of elderly individuals with dementia.

In conclusion, while this study has made significant strides in proposing a digital solution for dementia in the elderly, it is important to acknowledge the limitations that exist. Further validation, technological considerations, resource availability, ethical concerns, and the evolving nature of dementia care are all factors that require careful attention and ongoing research to ensure the success and impact of the digital solution. Addressing these limitations will contribute to the refinement and advancement of the proposed framework, ultimately leading to better care and improved quality of life for elderly individuals with dementia.

6.3 RECOMMENDATIONS FOR FUTURE WORK

Future work should focus on validating the proposed architecture through user testing and iterative design processes. This would involve gathering feedback from elderly patients, caregivers, and healthcare professionals to refine the digital solution and enhance its usability.

Further research could also explore the integration of advanced technologies, such as machine learning and natural language processing, to improve the cognitive training and monitoring capabilities of the digital solution. Moreover, studies examining the long-term effects of using such a digital solution on the cognitive function and quality of life of dementia patients would be valuable.

In conclusion, this thesis provides a foundation for the design and deployment of a digital solution for elderly patients with dementia. By considering the identified characteristics and following the proposed architecture, developers can create an effective and user-friendly application that supports cognitive aging care and improves the well-being of elderly individuals with dementia.

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ANNEXES

A. TRANSCRIPTION OF THE INTERVIEWS WITH THE EXPERTS

The following pages provide a comprehensive transcription of all the experts interviews conducted for this study. These interviews were conducted entirely online using the Zoom platform. Each interview began with a brief presentation of the research work (showed in the Annex B) followed by an in-depth explanation of the proposed framework diagram, including detailed information on each module. Subsequently, the experts were presented with a series of questions related to the research topic.

Table 5 - Interview Questions

INTERVIEW QUESTIONS
Do you consider the proposed framework useful, and if so, why?
Would you consider implementing the proposed framework?
Do you have any recommendations or suggestions for further improvements of the proposed architecture?

Pedro Maia Malta (PMM) Interview

1 - Do you consider the proposed framework useful, and if so, why?

PMM: The objective of the work presented is twofold: to materialize not just a conceptual architecture but also a suite of software modules slated for construction. The illustrated representation, if considered as an application architecture, demonstrates coherence by encompassing hierarchical components that facilitate the utilization of a range of functionalities within applications, catering to either a data-centric or analytical focus.

2 - Do you have any recommendations or suggestions for further improvements of the proposed architecture?

PMM: I contend that the model is substantiated; however, it may be worthwhile to consider a possible change in appellation to "Conceptual Application Architecture" based on findings from the literature review. Delineating the user interface as one facet and the functionalities as another would create a better balance. To this end, each module should undergo a renaming process to incorporate the respective 'interface' terminology ('Application Interface - with main functionalities' and 'Analytics Interface'). The proposed architecture encompasses specific objectives, with the module nomenclature imbued with a commercially suggestive undertone, accompanied by an explication of their respective functionalities. All definitions and elucidations pertaining to each module are characterized by a profusion of detail, resulting in more or less exhaustive requirement lists for each module. Hence, the term "conceptual architecture" aptly encapsulates its nature. An additional suggestion would be to devise UML diagrams to facilitate the programming efforts of the development team. A package diagram, illustrating the prominent areas constituting a future software system, and a subsequent database diagram supporting this technological architecture, could be considered. A package diagram provides a holistic view of the software, thereby encompassing the four packages expounded in the architecture: user interface, application interface, analytics interface, and security module. This serves to enhance reader comprehension of the conceptions presented throughout the thesis development.

3 - Would you consider implementing the proposed framework?

PMM: I consider the conceptualization of an endeavor in a highly pivotal domain like healthcare to be of immense utility. By engaging appropriate collaborators capable of transforming this conceptual foundation into a more analytically inclined framework, and subsequently securing a partner to oversee development and implementation, the proposed solution can be realized. Admittedly, the initial stages may present certain challenges in efficiently meeting all requirements. However, an iterative approach utilizing agile development techniques can pave the way for progressive adaptations over time. In this context, it would be prudent to explore the RUP method, whereby each iteration receives partial acceptance from the client. By anchoring the concept itself in a series of acceptances at various stages of the development process, a near-final decision can be attained after conducting a comprehensive battery of tests.

Carlos Brás Saraiva (CBS) Interview

1 - Do you consider the proposed framework useful, and if so, why?

CBS: As a psychiatrist specialized in dementia-related diseases, I find the proposed framework for a digital solution targeting dementia in the elderly to be intriguing. The framework presents interesting ideas; however, I must note that it seems more suited for a luxury nursing home environment. This observation stems from considering the cognitive decline typically associated with dementia and the relatively lower levels of literacy among the elderly population. It is essential to emphasize the significance of sociocultural activities and occupational therapy that involve physical engagement. These activities play a vital role in maintaining the overall well-being of individuals with dementia. Moreover, traditional outings to places like museums still hold great importance, as they provide meaningful experiences and cognitive stimulation. While recognizing the value of the proposed digital solution, it is crucial to adopt a comprehensive approach that integrates digital elements with physical interaction and cultural experiences.

2 - Do you have any recommendations or suggestions for further improvements of the proposed architecture?

CBS: In terms of recommendations and suggestions for further improvements of the proposed architecture, I would advocate for incorporating a more comprehensive range of therapeutic interventions. The framework should integrate evidence-based practices, such as cognitive stimulation programs and person-centered care approaches, which have shown positive outcomes in dementia care. It would be advantageous to explore technologies that facilitate personalized interventions and support the diverse needs and preferences of individuals with dementia. Additionally, involving interdisciplinary collaboration with professionals from diverse fields, including geriatric medicine, occupational therapy, and social work, would enrich the framework and enhance its effectiveness.

3 - Would you consider implementing the proposed framework?

CBS: When it comes to implementing the proposed framework, I believe further considerations are necessary. While the framework shows potential, its suitability for broader implementation beyond luxury nursing homes may be limited. To determine its practical feasibility, a more detailed evaluation of its applicability in various care settings, including community centers and home care, would be beneficial. Factors such as resource availability, adaptability to different care contexts, and the potential for user acceptance should be thoroughly assessed before considering widespread implementation.

Carlos Filipe Saraiva (CBS) Interview

1 - Do you consider the proposed framework useful, and if so, why?

CFS: I consider the proposed framework a highly interesting proposal, demonstrating clear innovation through its integration of cognitive and health strategies. Moreover, the inclusion of cognitive stimulation techniques is commendable, as it aims to evaluate the impact of mood changes on the progression of dementia. Notably, the idea of incorporating music into the solution is brilliant, as certain songs or sound cues hold significant meaning for dementia patients and can effectively stimulate their memory function.

2 - Do you have any recommendations or suggestions for further improvements of the proposed architecture?

CFS: One aspect of the framework that I would suggest modifying is the personalization of the software. Instead of solely functioning as an app, it would be beneficial to design an assistant interface that allows patients to establish a stronger connection with the application. For instance, considering the gradual memory loss experienced by Alzheimer's patients, long-term memories tend to persist. Therefore, integrating more meaningful images from the past, featuring loved ones or even their voices, could personalize the application and create a sense of ownership and familiarity for the user. Another valuable improvement would be to grant doctors access to patient data for monitoring and identification of potential improvements. For instance, if a patient displays increased sadness in the mornings but experiences improved mood in the afternoons, understanding the factors contributing to this change becomes essential. Was there a particular activity that triggered the improvement, or should medication adjustments be considered? Since dementia patients often lose their perception of mood changes and the events influencing them, granting medical professionals access to this data could facilitate better care and treatment.

3 - Would you consider implementing the proposed framework?

CFS: I firmly believe that transforming the proposed architecture into a comprehensive dementia intervention program, surpassing the realm of a mere computer program or patient-centered app, would be an ambitious and worthwhile endeavor. By operationalizing the framework to facilitate the study of disease behavior, patient feedback, effective communication with medical staff, and the collection of cross-sectional data on the impact of various interactions on the disease, such as outdoor activities, physical exercise, and visits

from family members, it would provide invaluable material for analysis and contribute to advancing dementia intervention practices.

José Matos Pinto (JMP) Interview

1 - Do you consider the proposed framework useful, and if so, why?

JMP: I find the proposed program to be intriguing and well-structured, with a cybernetic model serving as its foundation. The steps are clearly defined, providing a strong framework. However, there is a complexity in terms of the program's response across all individuals with dementia. While it may be effective for the elderly and those in the early stages of dementia, it remains uncertain whether users in more advanced stages would easily access the solution due to their limited familiarity with technology and motor support.

One intriguing aspect that I would like to highlight is the significant role played by memory tasks. Studies conducted on individuals aged 55-65 have shown that memory-based activities aimed at enhancing mnemonic capacity result in memory improvement for the healthy population and memory recovery for those in the early stages of dementia. These studies also provide experimental support for the efficacy of such memory tasks, demonstrating a 13% increase in hippocampal mass in the healthy population.

Furthermore, the project holds potential as a reminder system for individuals, depending on the established bond. However, capturing and enticing individuals to utilize the solution depends on their level of engagement.

2 - Do you have any recommendations or suggestions for further improvements of the proposed architecture?

JMP: Firstly, the issue of population arises. I question which individuals within the dementia population would have access to this solution if they lack familiarity with technology. To address this, considering the program as a means of entertainment and development would be beneficial. When reflecting on the activities in which the elderly engage at day centers, such as embroidery, painting, and watching television, it becomes evident that programs of this nature could be more useful if the elderly are actively involved in the projects. This applies not only to individuals in the early stages of dementia but also to all elderly individuals, as it provides occupation and entertainment. The more opportunities they have to participate in fulfilling projects involving music or photographs, the better. If they can autonomously engage in this process, it can empower the users and foster a sense of competence, which is crucial for the this population.

Another issue lies in the complexity of the solution for individuals with dementia. It would be worthwhile to focus on prevention before dementia is diagnosed and to expand the target population to include healthy elderly individuals. As previously mentioned, many activities in day centers are predominantly passive and fail to captivate the interest of the elderly. Therefore, this program would prove highly beneficial, provided that users possess some background knowledge of its usage. Consequently, it may be necessary to provide installation training, activate the program on various devices, and allow the elderly to experiment with it while simultaneously collecting and analyzing their behaviors, movements, and level of engagement. This process will provide insights into how the program can be effectively implemented.

3 - Would you consider implementing the proposed framework?

JMP: Regarding implementation, I firmly believe that providing initial training is crucial. This aspect should not pose a problem for the elderly as long as they feel integrated and engaged. The activities provided by the program are more interesting than those typically offered at day centers. Moreover, I feel that this program would hold value for the elderly population in general, not exclusively for those with dementia. As dementia progresses, individuals experience increasingly fleeting memory, leading to incoherence in their speech, which significantly hinders the use of such solutions. Existing literature suggests that memory training in the early stages of dementia is highly beneficial for disease progression, a feature that is present in this program.

The strength of this program lies in its memory and interactive processes, which should be emphasized. Users have the opportunity to interact with caregivers, engage in games, and enjoy music, all of which combat social isolation. Observing the behavior of the elderly at day centers reveals a lack of stimulation for the majority of individuals. This underscores the importance of this work, as it empowers and engages the elderly population.

B. PRESENTATION USED IN THE INTERVIEWS

Digital Solution Ideation

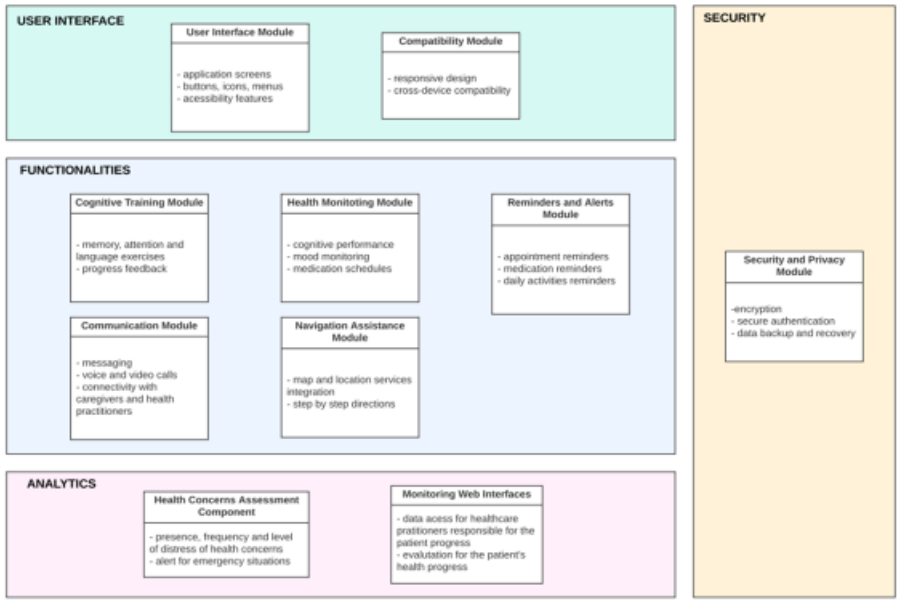
- Simplicity and easy of use.
- Personalization.
- Reminders and Alerts.
- Cognitive Training and Brain Games.
- Communication.
- Tracking and Monitoring.
- Security and Privacy.
- Compatibility.
- Support and Resources.

Architecture

Conceptual Architecture

- The digital solution aims to assist elderly users in managing their own health and daily activities, particularly those suffering from dementia.
- The platform includes two connections to monitoring web interfaces for healthcare practitioners responsible for following up on the patient's progress, and a component for assessing the presence, frequency, and level of distress of health concerns (this component can trigger an alert for emergency situations)

Conceptual Architecture



Conceptual Architecture

- **User Interface Module:** application screens, buttons, icons, and menus to ensure that they are user-friendly, accessible, and intuitive.
- **Cognitive Training Module:** provides various exercises to improve cognitive abilities
- **Health Monitoring Module:** tracking the patient's health data relevant to dementia and mental health, such as cognitive performance, mood, and medication schedules.
- **Reminders and Alerts Module:** includes designing an easily understandable notification system that can be customized to the patient's needs.

Conceptual Architecture

- **Navigation Assistance Module:** responsible for assisting the patient with navigation and directions. It includes integrating with map and location services and providing step-by-step instructions.
- **Communication Module:** responsible for providing communication features to help patients stay connected with their loved ones, caregivers, and healthcare practitioners.
- **Security and Privacy Module:** security features such as encryption, secure authentication, and data backup and recovery mechanisms.
- **Compatibility Module:** designing the application to be responsive to different screen sizes and device capabilities

Design Concepts, ideas and prototyping

Concepts

- **Memory journal:** allows users to create a personalized journal with notes, photos, and reminders. Users can add entries to their journal and set reminders for important events, such as appointments or birthdays. The journal could also include a photo gallery to help users remember people and places.
- **Medication management:** medication schedule, dosage, and reminders for when to take medication, tracking side effects or reactions.
- **Daily planner:** include a simple calendar interface, with the ability to add tasks and events.
- **Personalized music player:** provides users with a personalized playlist, since music has been shown to have a positive impact on mood and cognitive function.
- **Reminiscence therapy:** features that allow users to revisit memories from their past, such as a database of historical events and cultural references.
- **Emotional support:** mood trackers and positive affirmations, and connections with others who have dementia (community forum).

Application Prototype

- **Login screen:** authentication and access to the application.
- **Home screen:** provides an overview of the features and options available in the application, as well as any notifications or reminders.
- **Memory games screen:** designed to improve memory and cognitive function.
- **Reminders' screen:** allows users to set reminders for medication, appointments, and other important tasks.
- **Messaging screen:** allows users to communicate with their caregivers or healthcare providers, as well as other users of the application.

Application Prototype

- **Personalized settings screen:** allows users to customize the application to their individual needs, such as adjusting the font size or colour scheme.
- **Activity tracking screen:** allows users to track their daily activities and monitor their progress over time.
- **Caregiver dashboard screen:** allows caregivers to monitor the activities and progress of the elderly with dementia, as well as receive notifications and communicate with the user.
- **Help and support screen:** provides users with access to help and support resources, such as FAQs, tutorials, and customer support.

Questions

Questions

- Do you consider the proposed framework as useful and why? If not, please explain the reasons for your opinion.
- Would you consider implementing the proposed framework?
- Do you have any recommendation or suggestions for further improvements of the proposed architecture?


THANK YOU!
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