Kitchen Assistant

for Active Ageing at Home

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1 Introduction

In recent years, Portugal has witnessed significant demographic changes, with population growth. This trend [1] is due to society's emphasis on career advancement, resulting in smaller families. As a result, the elderly increasingly require specialized care to maintain quality of life, even if they face challenges associated with age-related health issues.

Currently, Portugal is among the leading European countries with a high proportion of individuals aged 65 and over [2], accounting for almost a quarter of the total population [3].

This percentage is expected to continue to rise, highlighting the urgent demand for tailored senior care solutions. This demographic shift [1] poses a significant challenge to health systems, social services, and families.

The choice of fewer children, driven by factors such as education, career aspirations, and economic stability, has allowed younger generations to adopt more independent lifestyles.

For seniors, maintaining an active and independent lifestyle is of utmost importance. They are more susceptible to various diseases and their physical and physiological abilities deteriorate slowly. Thus, it becomes important to promote activities that facilitate healthy growth. Research consistently reveals the positive effects of physical activity on reducing chronic disease risk, improving psychological well-being, and improving overall cognitive function.

Technology is still important in this paradigm shift. Innovations in healthcare technology, especially those focused on everyday tasks, are changing the transportation of the elderly.

Moreover, the concept of smart homes has gained significant traction in Portugal, offering a comprehensive solution for elderly care. These technologically advanced residences are equipped with an array of sensors, monitors, and assistive devices that enhance safety, security, and comfort for seniors. Smart homes can automate tasks such as lighting, temperature control, and even provide fall detection capabilities. This integrated approach fosters a sense of independence while simultaneously providing a safety net for unforeseen events.

The adoption of assistive technology in daily life gives seniors independence and self-reliance. These innovations not only improve their quality of life, but also reduce dependence on caregivers and reduce strain on health care systems. By harnessing the power of technology, we can usher in a new era of elderly care that prioritizes dignity, independence, and overall well-being, especially in Portugal where the aging population is a major concern.

1.1 Context

This project is being developed at the University of Aveiro, as part of the Computer Engineering and Informatics Project course. It is based on the Casa Viva+, a proof of concept developed at the University of Aveiro, with companies like OLI and the Rovisco Pais Rehabilitation Center as partners in its development.
The concept aims to understand the role of a Smart Home in the active development of an older population.

1.2 Motivation

The motivation for this works was to take advantage of the use of technology, smartphones, tablets, and voice assistance devices, to:

- **HELP ELDERS BE MORE INDEPENDENT** – Provide help throughout the cooking process, with step by step on the meal preparation.
- **COMBAT THE LACK OF INTUITIVE AND PROACTIVE ASSISTANCE** – There are few to no equipment's that is developed with the elder population in mind, minding their needs and problems.

  THE NEED FOR UNIFIED SYSTEM – Alerts when the commonly used products are not available in the pantry or when a product expiration date is near the end.

Having all these challenges in mind, the common goal seems obvious to improve the quality of life of the senior generation.
It is not hard to imagine that in the future most households will have top-tier technology. By then, people will have a better grasp of what is left surrounded by it and complementing your life, making it easy on the day-to-day chores. As people grow older physical limitations start to appear and by that time, we hope this project is in full motion and all these problems have become extinct.

1.3 Goals

The goal of this project is to create a prototype of a system that could help an elder generation living alone in their homes with the preparation of their meals through visual cues(display) and provide unified, natural language using voice.
Some of the additional capabilities are proactive alerts and information, such as stock maintenance, expiration dates of the products in one's pantry.

1.4 Document Structure

Between the Introduction and the Works Cited of this document there are five chapters.
Chapter 2 where the State of the Art and the related work is described. Chapter 3 presents the method used for the development of our project, it includes definition of *Personas*, scenarios, and extraction of the requirements. Chapter 4 describes the first system architecture draft, and where the main components are described. Chapter 5 gives an insight of what the next steps should be. As for Chapter 6, a small paragraph of the first conclusions taken during this development phase.

2 State of the Art

To better understand which methodology to use, what tools and technologies are necessary to develop our solution, we sought to find out about existing projects, their technologies, and the development process. To do this, we used Google Scholar by searching for keywords that fit our theme. Each group member was tasked with finding two articles, and after reading them, reporting the technologies and the keywords used, to an Excel document.
This way, we ensured there were no repeated articles, and we could gather the most data to make the most sensible choice.
There was a significant list of possibilities, but we wanted to focus on the latest technologies, with the oldest article being from the year 2014.
Out of the ten selected articles, we compiled a list of potential technologies to use, which include voice assistants and smart devices, communication and network technologies, sensors, and hardware, and finally, artificial intelligence, machine learning, and robotics.

In the Figure below, you can see the technologies grouped by their respective fields of interest, along with a table of the articles found, their year of origin, and the keywords that led to their discovery.

2.1 Related Work

To acquire all the related work, we conducted a comprehensive search on Google Scholar to gather relevant academic papers, utilizing specific keywords (*Smart + Kitchen, Virtual + Assistant + Kitchen, Smart + Kitchen + Elderly + people, Food + Product + Management, Kitchen Assistant + Voice Commands, Voice Assistant + Ageing, Kitchen + Elderly + IoT, Conversational + Assistant + Kitchen*) related to our research topic. This search allowed us to access a range of papers that are pertinent to our project.

The papers obtained through our search are presented in **Error! Reference source not found.**. It is important to note that we focused on selecting papers from the last 10 years to ensure the relevance and currency of the information. This approach helps mitigate the risk of relying on outdated technologies and ensures that our project is informed by the most recent advancements and insights in the field.

Table 1 - Related Work

Name	Year	Voice assistant	Portuguese Language
An Augmented Reality Virtual Assistant to Help Mild Cognitive Impaired Users in Cooking a System Able to Recognize the User Status and Personalize the Support [4]	2018	No	
Application of Artificial Intelligence in Smart Kitchen [5]	2018	Yes	Yes
An Adaptive smart system to foster disable and elderly people in kitchen-related task [6]	2016	Yes	No
Smart kitchen cabinet for aware home [7]	2012	No	
A Futuristic kitchen assistant – Powered by AI and Robotics [8]	2014	No	
Assistant for supporting the elderly staying at home [9]	2022	Yes	Yes
Appropriation and practices of working with voice assistants in the kitchen [10]	2019	Yes	Yes

Development and comparison of customized voice-assistant systems for independent living older adults [11]	2019	Yes	Yes
Commercial ICT Smart Solutions for the elderly: State of the art and future challenges in the smart furniture sector [12]	2020	Yes	Yes
"Phantom Friend" or "Just a Box with information": Personification and Ontological Categorization of smart speaker-based voice assistant by older adults [13]	2019	Yes	Yes

2.2 Technologies

From Table 1, we meticulously extracted the technologies utilized in each study. This extraction process was crucial in identifying the common technologies employed in similar research endeavors, as well as any unique or innovative technologies that could potentially be incorporated into our project. By analyzing the technologies used in the related works (Figure 1), we can gain valuable insights and make informed decisions regarding the technological components of our solution.

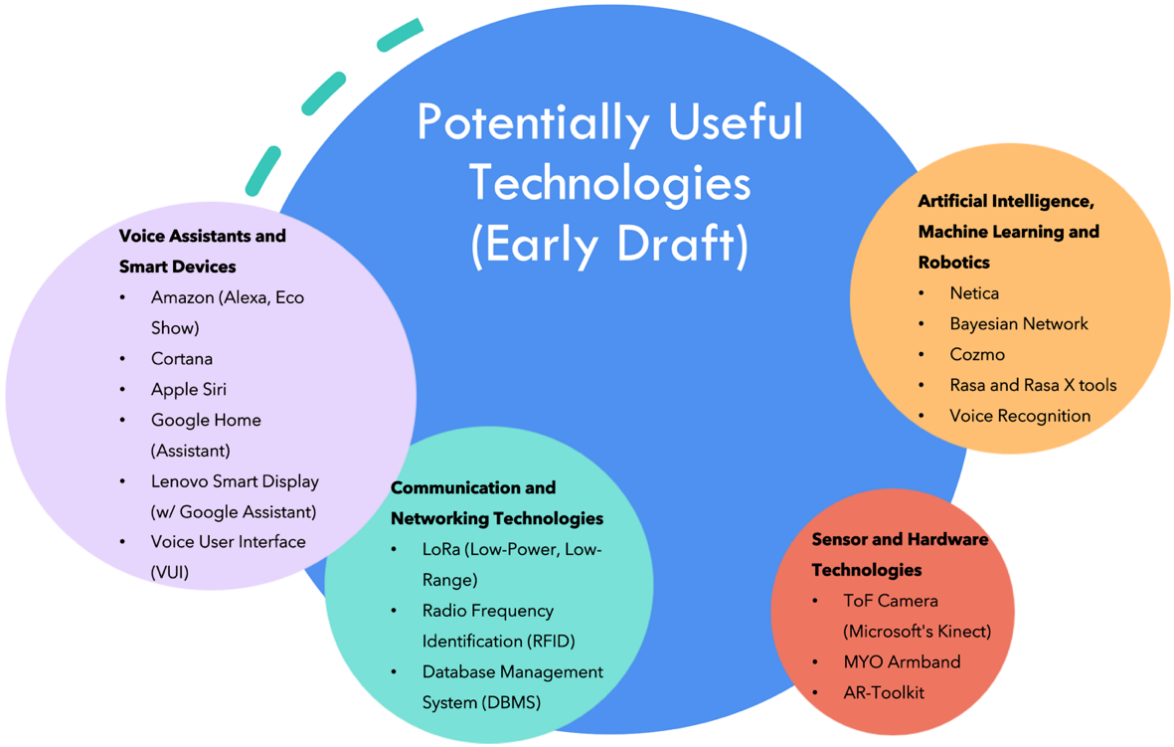

Figure 1 – Technologies Used by Related Works

2.3 Discussion

After understanding each of the articles, their objectives, their goals and also their solutions, we chose three that stood out the most to us and were closest to our own project:

1. **An adaptive smart system to foster disabled and elderly people in kitchen-related tasks:** The system focuses on intelligent kitchen interaction, providing support for various disabilities. It features an adaptable user interface that guides food preparation and controls kitchen appliances. The target users include individuals with mild to moderate dementia and slight motor impairments.
2. **Assistive technology for healthy ageing for the elderly: an intelligent multimodal kitchen-terminal:**
   This technology is developed to serve as a multimodal assistant specifically designed for the elderly. Its primary goal is to assess and support individual nutritional intake.

3. **Assistente para apoio a idosos em casa (Assistant for supporting the elderly at home):** Concentrates on a personal assistant for the elderly, enhancing communication with people and devices.

Comparing the three articles above (selected from Table 1) to our project, a common goal emerges: *enhancing the lives of elderly individuals through intelligent kitchen assistance*. These initiatives universally employ technology to aid the elderly, whether it's via advising on food preparation, assessing nutritional needs, or offering general support for aging comfortably at home.
What sets our project apart is its comprehensive approach. We integrate step-by-step cooking instructions with effective pantry management, facilitated by barcode scanning technology. Additionally, our system includes alerts for expiration dates, ensuring both safety and convenience. This comprehensive approach is further enhanced by our focus on creating a smart home environment, which is in line with the broader objective of utilizing technology to foster active and independent living for the aging population.

3 Personas, Scenarios, and Requirements

For our research project, we employed a User-Centered Design (UCD) approach [14], which places the users at the forefront of the development process, ensuring that the solution is tailored to their needs, preferences, and contexts. The UCD approach [14] involves several iterative stages, including user research, design, prototyping, and testing, with continuous user feedback sought at each stage to refine and improve the solution.

As part of our user research, we conducted a structured survey consisting of 15 questions, including fixed-response, quantitative, and open-ended questions. The survey was distributed to 11 individuals, with the sample population carefully selected based on age, gender, and living situation to match our target audience. The responses were then analyzed to extract valuable insights and identify key scenarios that will inform the design and development of our solution.

Furthermore, we have defined two personas that represent our target audience, each with distinct characteristics, needs, and contexts. Based on the survey results and personas, we identified four key scenarios that will serve as the foundation for our solution. Additionally, we have defined both functional and non-functional requirements to guide the development process and ensure that the solution meets the needs of our users while also adhering to technical and quality standards.

In conclusion, the UCD [14]approach, coupled with the structured survey, personas, scenarios, and requirements, has provided a solid foundation for our project. This comprehensive approach ensures that we are well-equipped to develop a solution that is not only functional and effective but also truly user-centric, addressing the unique needs and preferences of our target audience.

3.1 Personas

Mr. Mário

Figure 2 - Mr. Mário

Mr. Mário, a 71-year-old, lives in a serene seaside community where he enjoys a peaceful life post-retirement. He faces health challenges common in his age group, including hypertension, high cholesterol, and obesity, along with limited mobility due to arthritis. Technologically, he finds himself at a distance from the rapidly evolving digital world. His interactions with modern digital

interfaces and small mobile devices are often challenging, leading him to prefer simple and intuitive technology.

Mr. Mário's hobbies, which include fishing and carpentry, reflect his love for activities that offer relaxation and a sense of accomplishment. Recently, he has also started exploring basic culinary skills, adding another enjoyable activity to his leisurely days.

In essence, Mr. Mário values independence and ease in his interactions with technology. Products and services designed for him should be straightforward, accessible, and supportive of his lifestyle, enhancing his day-to-day experiences while respecting his need for simplicity and functionality.

GOALS:

- Achieve culinary independence with easy-to-follow voice-guided recipes.
- Support memory with clear, repetitive auditory prompts and display.
- Overcome technological barriers with a simple, intuitive interface.
- Manage pantry inventory with timely expiration and stock alerts.
- Adapt recipes to meet dietary restrictions and health requirements.

Mrs. Maria

Figure 3 - Mrs. Maria

At 73, Mrs. Maria lives alone in a rural area, supported by healthcare providers due to her health and mobility challenges. She faces daily struggles with motor disabilities that affect her coordination and balance, and she is partially deaf with weakened vision. Managing chronic conditions like hypertension and diabetes, along with cognitive challenges, particularly memory lapses, is an integral part of her routine.

Communication is a hurdle for Mrs. Maria, as she often finds it difficult to interpret and express written messages. Her lifestyle necessitates assistance with daily routines and tasks, making her dependent on her support network for both social interaction and practical help.

In her interactions with technology, Mrs. Maria values simplicity and accessibility. Products and services designed for her should be straightforward and supportive, enhancing her independence and quality of life while accommodating her specific needs and limitations.

GOALS FOR PRODUCT USE:

- Achieve autonomy in cooking with voice-guided, easy-to-follow recipes.
- Support memory with consistent auditory cues and visual prompts on the display.
- Manage pantry inventory efficiently with alerts for expiring products and items running low.

3.2 First Draft Scenarios

The Assistant helps manage the stock of food products

Every Friday morning, Mr. Mário goes grocery shopping and needs to keep track of his food stock. After a voice command, the Kitchen Assistant will inform Mr. Mário of the items that are running low and need to be replenished.

On Friday morning, Mr. Mário calls the assistant using the activation word.
"I'm going shopping. Can you tell me what I'm running out of?"
"In the pantry, you need Eggs, Onions, Rice, and in the fridge, you need Cheese and Yogurts," the Assistant replies.
Mr. Mário receives his shopping list (on paper or on his phone) and heads to the local market.
There, he purchases the items needed.
When he returns home, he opens the fridge and scans the yogurts and cheese with the "Scanner" [Req: a scanner is needed to read the products].
Next, he goes to the pantry and scans the products (Eggs, Onions, and Rice).
(No further interaction with the Assistant is required).

The Assistant notifies three days in advance of products with approaching expiration date

Mr. Mário dislikes wasting food and needs help managing the expiration dates of stored products, whether in the refrigerator or cabinets. So, after a voice order, the Kitchen Assistant will inform Mr. Mário of the products that are nearing their expiration dates.
Mr. Mário calls for the assistant using the activation word. He then asks, "I need to know what is approaching its expiration date." The Assistant, having the expiration dates stored in its database, responds with a list of products that will expire in the next three days.

The Assistant helps manage the stock of food products

Mr. Mário calls for the assistant using the activation word.

-"The doctor says I have high cholesterol, can you tell me what I can replace?"

The Assistant, having the products in its database, analyzes which ones are more calorie dense.

-"For this condition, you should buy fruits, nuts, and avocado. You should not buy bacon, cookies, or red meat."

Mr. Mário takes notes and after 5 minutes, the Assistant states:

-"I am glad to have helped. I'll be available whenever you need."

The Assistant notifies three days in advance of products with approaching expiration dates

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Mr. Mário calls for the assistant using the activation word. He then asks, "I need to know what is approaching its expiration date." The Assistant, having the expiration dates stored in its database, responds with a list of products that will expire in the next three days.

The Assistant suggests healthy alternatives to products

Mr. Mário has hypertension and high cholesterol and needs to change his diet to something healthier, following the recommendation of his family doctor. So, after a voice command, the Kitchen Assistant will inform Mr. Mário of the products he has stored with higher caloric value and recommend a healthier alternative to replace that same product.

Mr. Mário calls for the assistant using the activation word.

-"The doctor says I have high cholesterol, can you tell me what I can replace?"

The Assistant, having the products in its database, analyzes which ones are more calorie dense.

-"For this condition, you should buy fruits, nuts, and avocado. You should not buy bacon, cookies, or red meat."

Mr. Mário takes notes and after 5 minutes, the Assistant states:

-"I am glad to have helped. I'll be available whenever you need."

The Assistant suggests recipes with the requested ingredient

Mr. Mário has hypertension and high cholesterol and needs to change his diet to something healthy, following his family doctor's recommendation. So, the Kitchen Assistant will prioritize recipes that align with Mr. Mário's medical needs.

Mr. Mário calls for the assistant using the activation word. He then requests, "I need to make lunch, I need ideas. I feel like having something with chicken." The Assistant, having a wide range of recipes and products in

its database, will filter for recipes containing "Chicken," with ingredients available at home, and will sort them in ascending order by caloric level.

-"I suggest the following Recipe: Chicken à Brás," says the Assistant.

-"I already had that recipe yesterday," Mr. Mário rejects.

-"I suggest the following Recipe: Chicken with Almonds," the Assistant suggests again, using the second recipe from the ordered list.

-"Good idea, let's start cooking," Mr. Mário accepts.

-"Let us start the recipe then. First..." - The assistant verbally explains the steps of the recipe and provides more detailed visual information about the current step. (Scenario: The assistant adjusts the quantity of ingredients based on the number of people).

After the last step, the Assistant declares, "Recipe completed, I'll be available whenever you need."

The Assistant adjusts the quantity of ingredients based on the number of people

For this, Mr. Mário will call the assistant using the activation word. He then requests, "I want to make a Feijoada for 10 People."

-"Can you specify the type of Feijoada? We have the options: Portuguese Feijoada or Brazilian Feijoada."

-"Portuguese Feijoada," Mr. Mário declares.

-"The Feijoada for 10 people requires the following ingredients: 4 carrots, black pepper powder, 500g cooked red beans, tomato pulp, diced peeled tomatoes, 1 bay leaf, large onion, 4 garlic cloves, olive oil, 400g pork ribs, small cabbage, salt, pork chorizo, blood sausage, 100g pig's ear, 100g pig's snout, 100g bacon." - The Assistant verifies all the ingredients of the recipe.

The Assistant performs a small check of quantities in the pantry.

-"I confirm that you have the necessary ingredients for the recipe. Let us start then. First, wash the meat. When you are done, say Next" - The assistant verbally declares and visually shows the text "Wash meats".

-"Next," Mr. Mário says.

-"In a pot, start boiling the meats and chorizos in water seasoned with one teaspoon of salt. When you're done, say Next."

-"Next," Mr. Mário continues.

-"As they become cooked, remove them from the heat and cut them into pieces. Save the cooking broth. When you're ready for the next step, say Next."

After a few minutes, Mr. Mário says "Next."

-"Separate the cabbage leaves and wash them under running water. When you're done, say Next."

-"Next."

-"Peel the carrots and cut them into thin slices. Slightly cook the cabbage and carrots in water seasoned with 1 tablespoon of salt. Remove them to water and set aside. When you're done, say Next."

-"Next."

-"In a pot, sauté the finely chopped garlic and onion in olive oil and add the bay leaf. Let it brown. When you're done, say Next."

-"Next."

-"Add the meat, drained beans, and a bit of cooking broth. Let it cook for 10 minutes. When you're done, say Next."

10 minutes later, Mr. Mário says Next.

-"Add the chopped chorizos and cabbage. When you're done, say Next."

-"Next."

-"Finally, season with pepper and let it simmer over medium heat. Serve with white rice. When you're done, say Next."

After the last step, the Assistant declares: "Recipe completed, I'll be available whenever you need."

A Feijoada for 10 People is ready to be served by Mr. Mário.

3.3 Structured Survey

In this section, we present a careful analysis of the survey (Appendix A - Structured Survey) that is important in our research efforts. The survey which included 15 different questions, such as fixed response (yes/no), quantitative (0 to 5 scale), and open questions, was aiming to clarify and provide some insights to our problem.

The study reached a sample of 11 participants, selected based on age alignment with our project's emphasis on the elderly. As shown in the age distribution histogram in Figure 4 - Histogram of age Distribution, our participants comfortably expanded the target age range, reinforcing the resonance of our study.

In addition to age and demographics, the analysis went into detail on gender variables (see Figure 5 - Gender Distribution) and living arrangements (see Figure 6 - Living Alone Distribution) of the participants.

The gender distribution pattern shows the dimensions of male and female participants. These nuances of illuminating topic contribute greatly to our understanding of demography, facilitating a comprehensive analysis.

At its core, the study was intended to validate previously identified conditions relevant to our study. Through participant feedback, we not only confirmed our initial scenarios but also identified new possible scenarios. This careful design process ensures that our research remains grounded in the experiences and concrete needs of older people, resulting in targeted and impactful solutions.

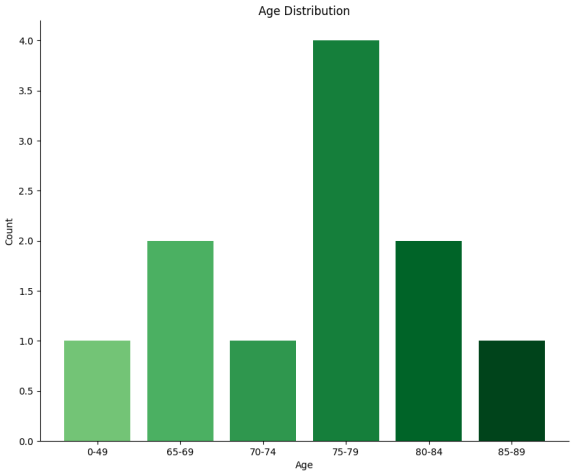

Figure 4 - Histogram of age Distribution

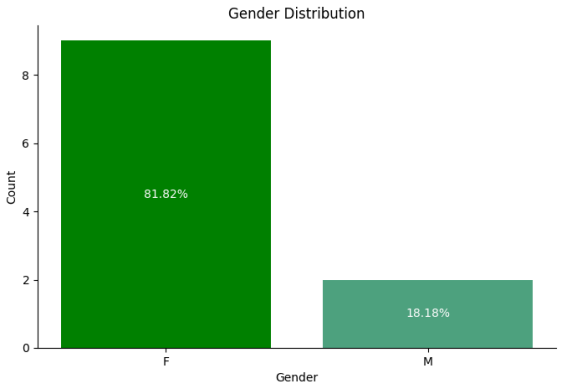

Figure 5 - Gender Distribution

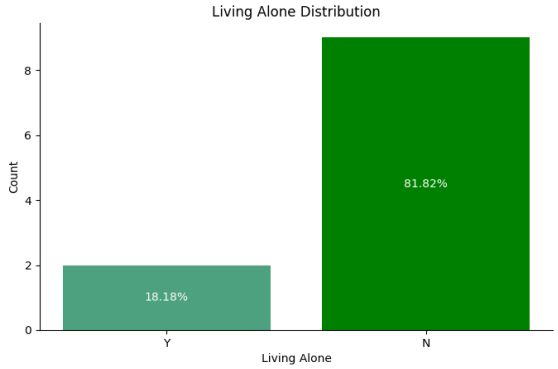

Figure 6 - Living Alone Distribution

3.3.1 Fixed Questions

We examined the responses of the five fixed-response questions designed to gauge participants' reactions to specific scenarios relevant to our research. Each scenario was encapsulated by a key term, with the terms provided on the y-axis of the graph (Figure 7).
The graph on Figure 7 - Stacked Bar Chart of Fixed Questions displays the percentage of "yes" and "no" responses for each question, offering a clear visual representation of participants reactions to the scenarios. This visualization enables us to easily discern which scenarios were most and least favorable to the individuals, thereby informing our subsequent analysis and discussion.

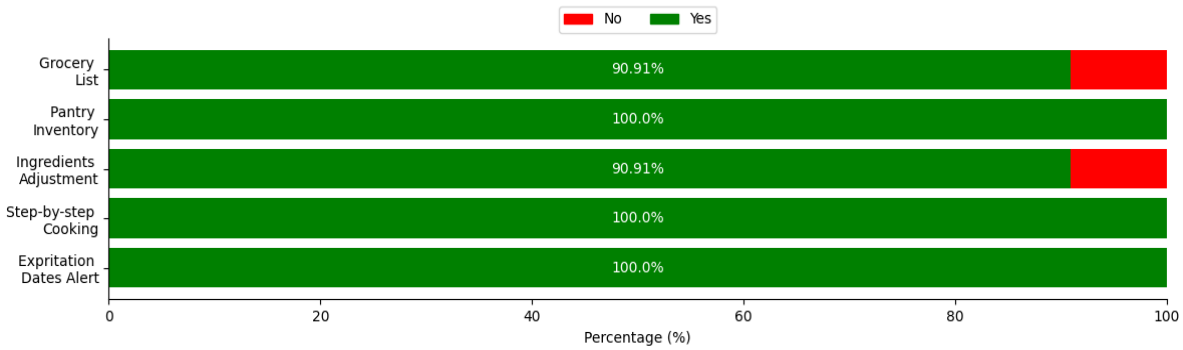

Figure 7 - Stacked Bar Chart of Fixed Questions

Interpreting the data in the context of our research, it is clear, that the scenarios we proposed were widely accepted. This leads us to define a few key scenarios:

- **Inventory Management**: This scenario revolves around alerting users to near-expired items and managing the inventory of ingredients, which in turn yields the following functionalities:
    - Adding a product to the pantry;
    - Generating an inventory list detailing available products and those that are missing;

- **Recipe Guidance & Adjustment**: Providing recipes and step-by-step guidance, as well as adjustments based on the number of people, gives rise to the functionality:
    - Step-by-step assistance in preparing a recipe.

- **Expiration Date Alert Integration**: Lastly, there was a desire for the inclusion of an expiration date alert system. This raises another important situation:

- Sending an alert via a predefined message system.

This small study highlights the importance of designing user-friendly solutions that not only address the culinary needs of elderly individuals but also prioritize their safety and well-being.

3.3.2 Quantitative Questions

We examined the responses to the five quantitative questions, which were designed to measure participants perceived usefulness of various functionalities. Each functionality was encapsulated by a key term, represented on the y-axis of the graph (Figure 8).
The graph (Figure 8) is structured as a stacked bar chart, where each bar represents 100% of the responses for a given functionality. The responses are color-coded according to the legend, facilitating a clear and comprehensive visual representation of the data.
This visualization allows us to easily discern which functionalities were deemed most useful by the participants, and conversely, which were considered less useful.
This analysis is crucial to the guidance of the development and prioritization of features in our project, ensuring that we focus on delivering the most value to our target audience.

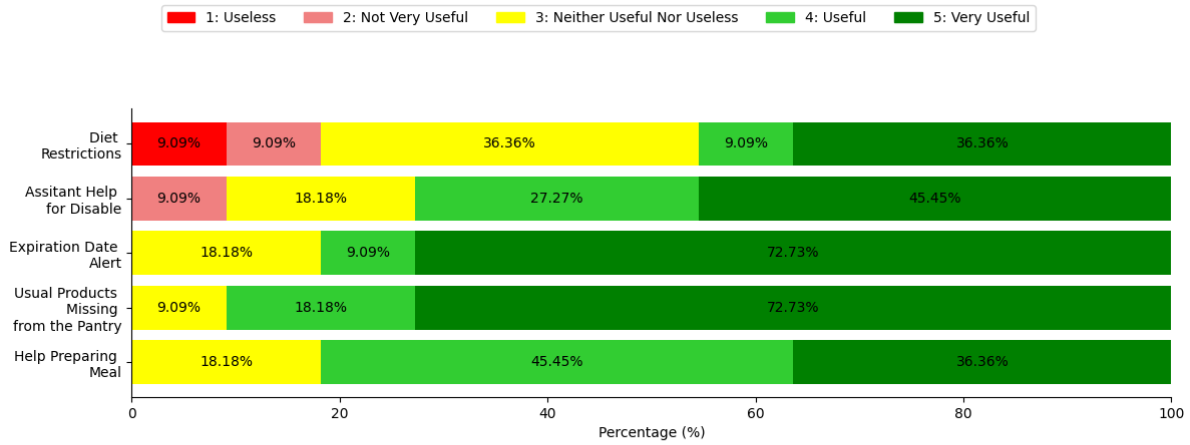

Figure 8 - Stacked Bar Chart of the Quantitative Questions

In conclusion, it can be confirmed that there is a unanimous agreement on the potential benefits of a Virtual Assistant in the kitchen, as well as the added value of having a food inventory system coupled with alerts for near expired products.

However, it is important to note that the dispersion of results observed in the last two questions may stem from distinct factors. Specifically, the dispersion in question related to “Assistant for Disable” (Q9 - Appendix A - Structured Survey) may be attributed to a potential incorrectly formulation of the question itself.
Meanwhile, the dispersion in the question related to "Diet Restrictions" (Q10 - Appendix A - Structured Survey) happens because most of the participants expressed an aversion to being monitored and restricted in terms of their dietary intake.
This analysis highlights the importance of clear and precise question formulation, as well as the need to carefully consider participants' preferences and concerns when designing functionalities and features for our project.

3.3.3 Open-ended Questions

To systematically analyze the responses, we employed a tokenization process, where each response was broken down into individual tokens, which could be a single word or a phrase of 2-3 words linked by a hyphen.
Given the wide range of tokens generated, we opted to focus on the top three tokens for each question to streamline the analysis. A word cloud (Figure 9) was subsequently created to visually represent the frequency of features mentioned or desired by the participants.
Furthermore, we compiled all the top three tokens from each question and created a graph (Figure 10) to illustrate the frequency with which each token appeared in the combined dataset of top three tokens. This graph provides a clear and comprehensive overview of the most mentioned features or themes, thereby highlighting the key areas of interest and concern for our target audience.

Figure 9 - World Cloud

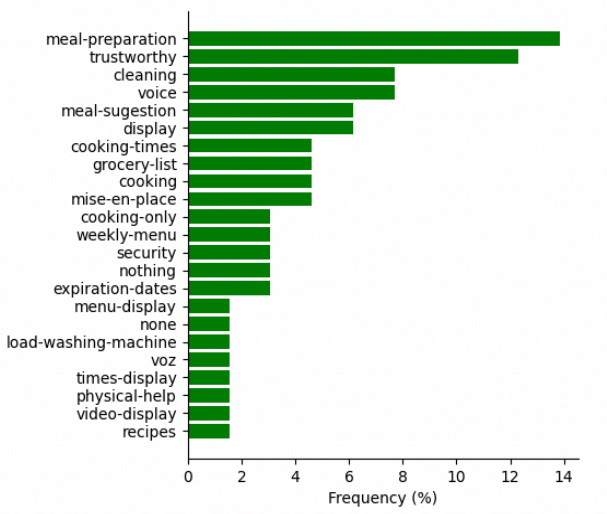

Figure 10 - Token Frequency histogram

The analysis of the word cloud generated from the open-ended responses revealed that the most prominent tokens were "meal-preparation," "trustworthy," "voice," "meal-suggestion," "display," "cooking-times," "grocery list," and "mise en place."

From these tokens, we can obtain several key insights:

- The presence of the token "*trustworthy*" indicates that there are no significant security concerns among the users regarding the assistant.
- The tokens "*voice*" and "*display*" suggest that while a voice interface is preferred, it should be complemented with a display for optimal functionality.
- "*Meal-preparation*" along with "*mise en place*" and "*cooking times*" highlight the importance of the assistant serving as a comprehensive guide during the meal preparation process.

- "*Grocery list*" emphasizes the need for a feature that can compile a list of missing grocery items.

However, it is essential to filter the data to align with the objectives of our project.
While we identified tokens such as "*cleaning*", "*physical help*" and "*loading washing machine*" these fall outside the scope of our project and therefore, were not considered in our analysis.
By meticulously analyzing the tokens and filtering out unrelated data, we ensure that our project remains focused and aligned with the needs and preferences of our target audience, leading to a more user-centric and effective solution.

3.3.4 Summary

From the structured survey study, we can draw several conclusions that, when aligned with the defined personas, will allow us to establish the following scenarios:

1. Add a product to the pantry.
2. Generate an inventory list detailing available products and those that are missing.
3. Send alerts for products approaching their expiration dates.
4. Provide step-by-step assistance in preparing a recipe, including adjustments based on the number of people.

Furthermore, we have determined that the implementation of the Virtual Assistant must be hybrid, incorporating both voice and display functionalities to optimize user interaction. Importantly, the study indicates that there are no significant security concerns among users regarding the Virtual Assistant.

In conclusion, the structured survey has provided valuable insights that are crucial in guiding the development of our project. The identified scenarios and the emphasis on a hybrid interface of voice and display will ensure that our solution is user-centric, addressing the needs and preferences of our target audience while also prioritizing their safety and well-being.

3.4 Revised Scenarios

Scenario 1: Add a Product to the Pantry

Mr. Mário activates the kitchen assistant using a voice command.

He requests the assistant to add something to the pantry stock.

He informs the Assistant by speech about the product he wants to add to the pantry. The assistant asks for additional details, such as quantity and expiration date, and then confirms the addition. The product is added to the pantry stock and the information is displayed on the screen.

Mr. Mário: Viva!

Kitchen Assistant: Bom dia, Sr. Mário! Como posso ajudar na cozinha hoje?

Mr. Mário: Adiciona feijão preto ao stock da despensa.

Kitchen Assistant: Claro, com prazer. Pode informar-me a quantidade de feijão preto a adicionar?

Mr. Mário: Adiciona um pacote de 500 gramas.

Kitchen Assistant: Perfeito. E a data de validade do feijão preto?

Mr. Mário: A validade é até 31 de dezembro de 2024.

Kitchen Assistant: Excelente. Estou a adicionar um pacote de 500 gramas de feijão preto com validade até 31 de dezembro de 2024 ao stock da despensa. Está correto?

Mr. Mário: Sim.

Kitchen Assistant: Feito! Feijão preto adicionado à despensa. Há mais alguma coisa em que possa ajudar?

Mr. Mário: Não, obrigado. Isso é tudo por agora.

Kitchen Assistant: Se precisar de mais alguma coisa, estarei aqui. Tenha um bom dia, Sr. Mário!

Scenario 2: Generate an Inventory List

Mr. Mário activates the kitchen assistant using a voice command.

He requests the assistant to generate an inventory list.

The assistant analyses the pantry and creates a list of available products.

The list is displayed on the screen and can also be sent to the user's mobile phone.

Mr. Mário: Viva!

Kitchen Assistant: Bom dia, Sr. Mário! Como posso ajudar na cozinha hoje?

Mr. Mário: Gera uma lista de inventário da despensa.

Kitchen Assistant: Claro, um momento enquanto analiso o stock da despensa.

Kitchen Assistant: Pronto! Gostaria de ver no ecrã ou prefere que envie por email?

Mr. Mário: Mostra no ecrã.

Kitchen Assistant: Excelente. Estou a mostrar a lista no ecrã, lista que mostra todos os itens disponíveis e dentro da validade.

Mr. Mário: Obrigado.

Kitchen Assistant: Se precisar de mais alguma coisa, estarei aqui. Tenha um bom dia, Sr. Mário!

Scenario 3: Send Alerts for Expiring Products

The kitchen assistant periodically checks the expiration dates of products in the pantry stock.

If a product is approaching its expiration date the assistant sends an alert to the user

The alert is displayed on the screen and can also be sent to the user's mobile phone.

The user can then take necessary action, such as consuming or discarding the product.

Kitchen Assistant: Bom dia, Sr. Mário! Tem um produto a expirar o prazo de validade.

Mr. Mário: O que se passa?

Kitchen Assistant: Detetei que o pacote de natas na despensa está prestes a expirar a validade. A data final de validade é daqui a 3 dias.

Mr. Mário: Ok, Obrigado.

Kitchen Assistant: Foi enviado um alerta para o seu email com esta informação, para que possa tomar as ações necessárias

Mr. Mário:OK, obrigado por me manteres atualizado.

Kitchen Assistant: Se precisar de mais alguma coisa, estarei aqui. Tenha um bom dia, Sr. Mário!

Scenario 4: Provide Step-by-Step Assistance in Preparing Recipe

Mr. Mário activates the kitchen assistant using a voice command. He requests the assistant to aid in preparing a recipe.

The assistant asks for the recipe name and the number of people to be served.

The assistant checks the pantry stock to ensure all required ingredients are available.

An ingredient is missing, the assistant notifies the user and suggests alternatives or the option to add the missing ingredient to the shopping list.

The assistant provides step-by-step instructions, adjusting the ingredient quantities as needed.

The instructions are displayed on the screen and delivered through natural voice.

The user follows the instructions to prepare the recipe.

Mr. Mário: Viva!

Kitchen Assistant: Bom dia, Sr. Mário! Como posso ajudar na cozinha hoje?

Mr. Mário: Gostaria de preparar uma receita.

Kitchen Assistant: Claro, qual é a receita e para quantas pessoas é?

Mr. Mário: Quero fazer lasanha para quatro pessoas.

Kitchen Assistant: Excelente. Vou verificar se tem todos os ingredientes necessários.

Kitchen Assistant: Parece que tem quase tudo, mas está sem queijo mozzarela.

Mr. Mário: Oh, isso é um problema.

Kitchen Assistant: Posso sugerir uma alternativa, como queijo cheddar, ou adicionar mozzarela à sua lista de compras.

Mr. Mário: Adiciona, mas no entretanto vamos usar cheddar.

Kitchen Assistant: Perfeito, vou ajustar a receita para usar queijo cheddar. Vamos começar com o primeiro passo. Pré-Aqueça o forno a 180º Celsius. Depois de ter feito este primeiro passo diga 'CONFIRMO' para prosseguir para o próximo passo.

Mr. Mário: Confirmo!

Kitchen Assistant: Agora, vamos preparar o molho. Vou guiá-lo através de cada etapa.

[continues with the preparations of the recipe waiting on each step for the confirmation from M.Mário to get the next step]

Kitchen Assistant: Finalizado! Pode retirar a lasanha do forno e está pronta a servir.

Mr. Mário: Perfeito, obrigado.

Kitchen Assistant: Quer adicionar à lista de compras os ingredientes que usou nesta receita?

Mr. Mário: Sim por favor.

Kitchen Assistant: Lista de compras atualizada.

Kitchen Assistant: Se precisar de mais alguma coisa, estarei aqui. Tenha um bom dia, Sr. Mário!

3.5 Requirements

When building a product or undertaking a project, it is crucial to keep requirements analysis in mind. In the development process, the team should determine what the product is meant to achieve. These objectives are termed 'functional specifications,' and identifying them is part of the requirement gathering phase.

These requirements should be measurable, detailed, and directly contribute to the final product. It's essential to also consider what the users want, ensuring that the result is as transparent and aligned with user expectations as possible.

The process we followed to extract the requirements from the scenarios was has depicted in Figure 11.

Scenario 2: Generate an Inventory List

Mr. Mário activates the kitchen assistant using a voice command. *[REQ: Voice activation using KWS]*

He requests the assistant to generate an inventory list. *[REQ: Understand natural language]* *[REQ: Have inventory information]*

The assistant analyses the pantry and creates a list of available and missing products. *[REQ: Check inventory list] [REQ: Create inventory list] [REQ: Returns a list of missing products]*

The list is displayed on the screen and can also be sent to the user's mobile phone. *[REQ: Capability to show the list of products on the display] [REQ: Send the list to the user's smartphone]*

Figure 11 - Requirements Extraction Example

Therefore, we decide to attribute a priority *(P0 – maximum priority, P1 – medium priority, P2 – minimum priority)* to each requirement to access the order of the implementation.
The shows the main requirements extracted and also the respective priority.

Table 2 - Table of Requirements Extracted from the Scenarios

Functional	Non-Functional	Interaction
Add products to stock (P0) Retain information about the product quantity (P0) See the recipe information (P0) Create alerts when products are closer to the expiration date(P1) Return a list with the missing products (P1)	Have a database where the product inventory (P0) Have a recipe database (P0) Barcode scanner technology (P1)	Understand natural language (P1) Voice activation with key words(P1) Give information through voice (P1) Ability to show information on display (P2) Capacity to give alerts and lists (P1)

4 System Architecture

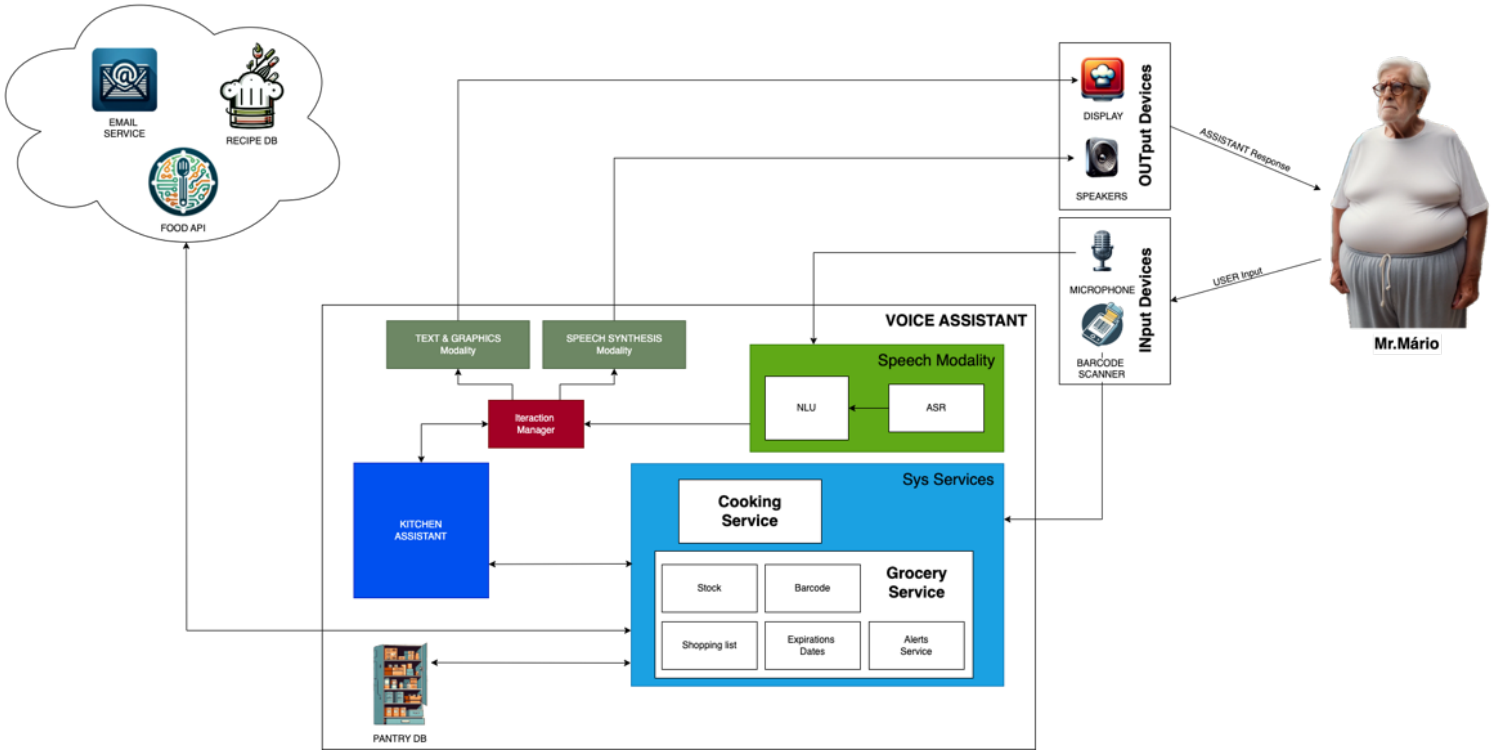

Figure 12 - System Architecture

4.1 I/O Devices

Input Devices:

- Barcode Scanner: Physical component responsible to scan the barcode;
- Microphone: Physical component responsible to record the user commands;

Output Devices:

- Speakers: Physical component responsible for give voice feedback to user;
- Display : Physical component responsible for display de information's to the user;

4.2 Voice Assistant

Speech Modality:

- Automatic Speech Recognition (ASR): Converts voice to text, often referred to as Speech-to-text (STT). It captures and transcribes spoken commands from users;
- Natural Language Understanding (NLU): Interprets user input, identifying intentions (intents) and relevant entities. This modulo requires training to recognize predefine entities and operates on voice commands.

Speech Synthesis Modality:

- Text to Speech (TTS): Converts text into spoken words, effectively enabling the system to communicate audibly with users;

Text & Graphics Modality:

- Display Management Module: Manages all content displayed on the user interface, including textual and graphical elements;

Interaction Manager:

- Information processing Module: Handles and process all information, directing it to the appropriate modules, namely the Text & graphics Modality and the Speech Synthesis Modality;

Kitchen Assistant:

- Service Selection Module: Responsible for choosing the appropriate services from the SYS Services based on user requests and system context;

Sys Services:

- Cooking Service: Provide step-by-step assistance for recipe preparations, guiding users through cooking processes;
- Grocery Service: Manages the pantry stock (PANTRY BD), including addition, deletion and monitoring of items;
- Barcode Service: interprets barcode information and communicates with FOOD_API for item data retrieval;

- Shopping List Service: Manages and organizes the shopping list, allowing for efficient grocery shopping and stock replenishment;
- Expirations Dates Service: Generates alerts for products nearing their expirations dates, ensuring timely usage or disposal;
- Alert Service: Captures the generated alerts and communicates with the Email Service for dissemination;

Pantry Database (PANTRY DB): A comprehensive database containing various items, accessible for shopping list, grocery list, etc.

4.3 Cloud Services

Recipe Database (RECIPE DB): A comprehensive database containing various recipes, accessible for cooking assistance;

Food Information API (FOOD_API): Provides detailed information about food items based on barcode data, enhancing inventory management;

Email Service: Facilitates the sending of shopping lists and expirations date alerts to users, ensuring they are informed and up-to-date;

5 Next Steps

As displayed in the diagram included in Figure 13, our project is progressing accordingly the established schedule.
The forthcoming phase involves a crucial step: Tool Selection. In this phase, we will meticulously identify and select the appropriate tools and technologies needed to initiate the development phase of our project.

This strategic selection process is pivotal to ensure a smooth transition into the actual development stage.

Workpackages and Milestones		Task Leader	Duration (months)	Start	End	Set	Out	Nov	Dez	Jan
T1 - Planning / State-of-the-art Research			**0.50**	**28-Sep**	**13-Oct**					
	Objectives definition		0.27	**28-Sep**	6-Oct	x	x			
	Workplan	PC	0.27	**28-Sep**	6-Oct	x	x			
	Prepare ppt + presentation		0.47	**28-Sep**	12-Oct	x	x			
	Research related work		0.47	**28-Sep**	12-Oct	x	x			
	Site / report		0.47	**28-Sep**	12-Oct	x	x			
T2- Requirement Gathering			**1.40**	**13-Oct**	**24-Nov**		x			
T2.1	Scenarios definition		0.50	**18-Oct**	2-Nov		x			
T2.2	Requirement gathering		0.20	**2-Nov**	8-Nov		x	x		
T2.3	T2 Overall Review (Presentation + Report)		0.03	**14-Nov**	15-Nov			x		
T2.4	MILESTONE 2		0.30	**15-Nov**	24-Nov			x		
T3- System Architectrure Design			**0.53**	**8-Nov**	**24-Nov**			x		
T3.1	Brainstorming of possible architectures		0.20	**8-Nov**	14-Nov			x		
T3.2	First Architecture Draft		0.27	**14-Nov**	22-Nov			x		
T3.3	Final SYSTEM ARCHITECTURE		0.03	**22-Nov**	23-Nov			x		
T4 - Tool Selection			**1.27**	**22-Nov**	**30-Dec**			x	x	
T4.1	Brainstorming of possible tools		0.23	**22-Nov**	29-Nov			x		
T5 - Iterative Development			**6.03**	**1-Dec**	**30-May**				x	x
			0.00							
T6- Demonstrators/ Integration with smart home devices			**2.17**	**1-Apr**	**5-Jun**					
			0.00							
T7- Technical Report & project presentations			**8.27**	**1-Oct**	**5-Jun**		x	x	x	x
			0.00							
T8- Management & coordination			**8.37**	**28-Sep**	**5-Jun**	x	x	x	x	x
						x	x	x		

Figure 13 - Project Schedule

6 First Conclusions

The project has reached a milestone, emphasizing comprehensive and user-centered design that meets the needs of older users. Notable features include comprehensive voice support, efficient information management, and integration of cloud services for efficiency.

The upcoming tool selection phase is important, prioritizing accessibility, functionality and security.

The potential impact of the system depends on the empowerment of older users, namely flexibility and flexibility for future development.

Subsequent phases should involve asking users for continuous feedback, refining system functionality and user interface through testing.

7 References

[1] E. Comission, "European Comission," January 2023. [Online]. Available: https://commission.europa.eu/system/files/2023-01/Demography_report_2022_0.pdf.

[2] EUROSTAT, "Eurostat," 16 March 2021. [Online]. Available: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210316-1#:~:text=Across%20the%20EU%20Member%20States,%25.

[3] PORDATA, "PORDATA," 2021. [Online]. Available: https://www.pordata.pt/db/portugal/ambiente+de+consulta/grafico/5837752.

[4] J. D. e. al., "An Augmented Reality Virtual Assistant to Help Mild Cognitive Impaired Users in Cooking a System Able to Recognize the User Status and Personalize the Support," Brescia, Italy, 2018.

[5] T. M. V. a. R. Khanna, "Application of Artificial Intelligence in Smart Kitchen," *IJITIS,* vol. 1, no. 1, pp. 1-8, 2018.

[6] S. C. R. M. a. M. G. F. Gullà, "An adaptive smart system to foster disabled and elderly people in kitchen-related task," in *Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '16)*, 2016.

[7] P. A. Karuppiah, "Smart Kitchen Cabinet for Aware Home," in *The First International Conference on Smart Systems, Devices and Technologies*, Stuttgart , Germany, 2012.

[8] J. Unger, "Assistive technology for healthy ageing for the elderly: an intelligent multimodal kitchen-terminal," *World Federation of Occupational Therapists Bulletin,* pp. 27-29, 2014.

[9] T. J. G. Almeida, "Assistente para apoio a idosos em casa," 2022. [Online]. Available: http://hdl.handle.net/10773/39393.

[10] D. Pins, "Appropriation and Practices of Working with Voice Assistants in the Kitchen," in *Proceedings of the 16th European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centred Computing an the Design of*

Cooperation Technologies - Doctoral Colloquium Papers, Reports of the European Society for Socially , 2019.

[11] S. L. T. R. E. L. K. P. G. S. M. Shalini, "Development and Comparison of Customized Voice-Assistant Systems for Independent Living Older Adults," in *Human Aspects of IT for the Aged Population. Social Media, Games and Assistive Environments. HCII 2019. Lecture Notes in Computer Science*, Springer, Cham, 2019.

[12] R. e. a. Frischer, "Commercial ICT Smart Solutions for the Elderly: State of the Art and Future Challenges in the Smart Furniture Sector," *Electronics,* vol. 9, no. 1, p. 149, 2020.

[13] A. Pradhan, L. Findlater and A. Lazar, "“Phantom Friend” or “Just a Box with Information”: Personification and Ontological Categorization of Smart Speaker-based Voice Assistants by Older Adults," *PACM on Human-Computer Interaction,* vol. 3, no. CSCW, p. 214, 2013.

[14] S. S. H. M. N. Chamberlain, "Towards a framework for integrating agile development and user-centred design," in *Extreme Programming and Agile Processes in Software Engineering*, vol. 4044, Berlin, Springer, 2006.

[15] D. M. N. H. A. e. a. Lopes, "Trajectories and determinants of ageing in Portugal: insights from EpiDoC, a nationwide population-based cohort," *BMC Public Health 23,* vol. 1564, 2023.

8 Appendix

Appendix A - Structured Survey

Uso de Assistente Virtual na Cozinha - Inquérito de Avaliação

Público-Alvo: Idosos

Objetivo: O propósito deste inquérito é obter informações sobre como um assistente virtual poderá ser útil na cozinha.

O propósito do assistente é auxiliar nas tarefas da cozinha com alertas sonoros e conversação. Estas tarefas podem ser obtenção de receitas, ajuste das mesmas, ajuda com o inventário de alimentos.

Nota: O inquérito é feito de forma anónima

Informações sobre o Respondente

Idade:

Género: ( ) Masculino ( ) Feminino

Vive sozinho ou acompanhado? ( ) Sozinho ( ) Acompanhado

Questões de Resposta Sim/Não

1. Se tiver produtos alimentares a terminar o prazo, gostaria que o assistente virtual o notificasse com 3 dias de antecedência?

Sim () Não ()

2. Seria útil ter um dispositivo que pudesse fornecer receitas e orientações passo a passo durante a confeção da receita?

Sim () Não ()

3. Gostaria de ter a ajuda de um assistente para ajustar as receitas consoante o número de pessoas para as quais vai cozinhar?

Sim () Não ()

4.Se tivesse uma funcionalidade para saber quais os ingredientes que tem na despensa, usaria?

Sim () Não ()

5.Gostaria que o assistente virtual enviasse uma mensagem com a lista de produtos em falta?

Sim () Não ()

Questões com Critério de Utilização

Avalie de 0(inútil) a 5(extremamente útil)

6.Quão útil pensa que um Assistente virtual seria para preparar e confecionar uma receita?

Resposta: 0() 1() 2() 3() 4() 5()

7.Quão útil seria saber que os produtos que costuma comprar e que estão em falta na sua dispensa?

Resposta: 0() 1() 2() 3() 4() 5()

8.Quão útil seria uma ferramenta que lhe desse alertas quando os itens que tem na despensa estão próximos do prazo de validade?

Resposta: 0() 1() 2() 3() 4() 5()

9.Quão útil seria a ajuda da assistente (em termos de deficiência móvel, questões de tempo, ETC.…)?

Resposta: 0() 1() 2() 3() 4() 5()

10.Quão útil seria se o assistente virtual ajudasse na gestão das suas preferências alimentares e restrições dietéticas?

Resposta: 0() 1() 2() 3() 4() 5()

Questões de Resposta Aberta

11.Tendo em conta a sua experiência, com quais funcionalidades acha que um assistente pode ajudar nas tarefas do dia a dia na cozinha?

Resposta:

12.Qual seria a tarefa do dia-a-dia na cozinha onde sente que precisa de ajuda de alguém?

Resposta:

13.Tendo em conta a sua experiência, qual seria a ação que gostaria de ver implementada (display ou voz) de forma a melhorar o seu dia-a-dia na cozinha ou nas tarefas que lá desempenha?
Resposta:

14.Gostaria que o assistente apenas ajudasse nos passos culinários? Ou que também tivesse a indicação dos passos a ter com os eletrodomésticos?
Resposta:

15.Tem alguma preocupação em relação à privacidade e segurança ao usar um assistente virtual na cozinha?
Resposta:

Inquérito Realizado por:

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