Proceedings of the 58th Hawaii International Conference on System Sciences | 2025

SeniorMedManagement: Assistive Solution to Help Older Adults Manage Treatment Using Social Robots and Virtual Assistants

Matheus Ancelmo Bonfim Pita
School of Arts, Sciences and Humanities
University of São Paulo
São Paulo, Brazil
ancelmo.matheus@usp.br

Marcelo Fantinato
School of Arts, Sciences and Humanities
University of São Paulo
São Paulo, Brazil
m.fantinato@usp.br

Patrick C. K. Hung
Faculty of Business and Information Technology
Ontario Tech University
Oshawa, Canada
patrick.hung@ontariotechu.ca

Abstract

With the natural decline in health, older adults increasingly require various forms of assistance. As the global senior population continues to grow, the demand for professional caregivers rises correspondingly. Throughout history, assistive technologies such as canes, walkers, and hearing aids have played a crucial role in senior care. Among the extensive range of available assistive technologies, robots and virtual assistants are particularly notable for their wide array of applications for both assistants and caregivers. By integrating a social robot with a virtual assistant, an assistive solution can be developed where their functionalities complement each other. This study aimed to create an assistive solution focused on the care of older adults by leveraging the combined functionalities of social robots and virtual assistants. To validate the proposed assistive solution, an experiment was conducted in which potential users simulated care and schedule management scenarios to examine the interaction between older adults and the employed technology. The positive feedback from the experiment indicated that the assistive solution would be both useful and appreciated, not only for care-related activities but also for daily tasks.

Keywords: social robots, virtual assistants, seniors, medical schedule management

1. Introduction

While some older adults choose to live in their own homes, others opt for or are taken to retirement homes, with the determining factors for the decision being the individual needs and conditions. Regardless of the choice, the care remains essential, whether for maintaining health or addressing the social needs inherent to every human being.

To address these necessities, technology has always played a role in aging support, from the most primitive forms, like canes and walkers, to advanced and refined mechanical prostheses and hearing aids (Bardaro et al., 2022; Spenko et al., 2006). With technological advancements, newer solutions are continually developed to assist in the aging process, providing more practical and effective assistive solutions aimed at improving the quality of life for users.

With more recent technology targeted at the care of older adults, it is possible to utilize wearable devices, sensors, and robots to address many of their needs and ease the workload of caregivers (Jacobs and Graf, 2012). The use of technology can provide real-time health monitoring with a level of accuracy and responsiveness that surpasses that of any human caregiver. By sharing responsibilities with technology, caregivers can allocate their attention to other patients or even have more time for their own needs, which often tend to be neglected when caring for a patient who requires a high level of attention.

Among all healthcare technologies, social robots emerge as a specific kind of technology designed for human interaction, employing dialogue and physical expressions. These robots can serve as a means to develop a wide array of new technologies to address various situations related to human aging, such as the loss of independence and autonomy, the constant need for attention, or the need for companionship and social interaction (Damiano and Dumouchel, 2018). Using robots in aging care and healthcare can help mitigate or even solve some of the problems in these areas.

Besides social robots, there are virtual assistants, a type of software designed to enable integration between different devices and allow users to control them through

URI: https://hdl.handle.net/10125/109055
978-0-9981331-8-8

its interface (Tulshan and Dhage, 2019). Virtual assistants can be activated by voice or specific interfaces, enabling users to interact with network-connected devices.

Virtual assistants and social robots can provide care to older adults in both abstract and physical ways, using the assistant's voice control and the robot's interactive capabilities. The combination of these technologies can help mitigate healthcare-related errors, prolong the quality of life, and extend the time an older person can remain in their own home without the constant presence and aid of a professional caregiver.

With the increasing need for care for older adults worldwide, the use of technology is already being studied and shows promise in sharing the workload and assisting healthcare professionals with their patients (Turja et al., 2022). There are robots capable of aiding in monitoring, locomotion, emergency prevention, and many other functions, designed to support the safe and healthy aging of individuals (Robinson et al., 2014). Additionally, virtual assistants can offer other healthcare solutions, such as reminders, alarms, and connectivity with different systems, providing an integrated environment that can be monitored and evaluated to address the user's needs.

The integration of social robots and virtual assistants remains relatively unexplored, and little is known about the potential of such a combination in healthcare for older adults. By integrating these technologies, it would be possible to create an assistive solution capable of managing treatments, medical schedules, and medication dosages, thereby reducing the risk of human error that could compromise treatment outcomes.

The objective of this paper is to present the development of an assistive solution focused on schedule management and dedicated to the healthcare of older adults, implemented through the combination of a social robot and a virtual assistant and their respective functionalities.

In this study, the design science steps and guidelines described by Hevner et al. (2004) were used to create and evaluate an artifact, ensuring its usefulness to the research problem with greater innovation or efficiency than related works (Hevner et al., 2004).

The remainder of this paper is organized as follows. Section 2 compares our study with literature review. Section 3 presents the proposal for our assistive solution, including the developed applications and components, as well as use cases. Section 4 presents the experiment and evaluation conducted. Section 5 discusses the results. Finally, Section 6 conclude the paper.

2. Literature review

To find relevant studies supporting the content of this research, an exploratory review was conducted to identify papers that would help analyze the feasibility and validity of the proposed assistive solution. The exploratory review serves as an initial stage of recognition and search, associated with discovery, creativity, and serendipity (Casula et al., 2020).

Given the nature of this study, the papers found were divergent in their goals. Some focused on the robotics and technical aspects, while others concentrated on analyzing virtual assistants, with application ideas and use cases. The group of analyzed papers comprised studies from different fields, which were not necessarily complementary. To categorize them, specific criteria were used to separate the papers, retaining those relevant to healthcare, environment interaction and connectivity, gerontology, and the care of older adults.

The chosen papers were separated into two categories: *Robots that could work with virtual assistants* and *Assistants that could work with robots*. Papers about robots were selected based on the publication date, from 1999 to 2021, due to the extensive amount of research in this field, the focus on healthcare and gerontology, and the use of social or service robots. Papers about virtual assistants were selected based on the publication date, from 2015 to 2021, reflecting the increasing amount of study and development in this field over the last decade, and the focus on virtual assistants, excluding general assistive technology. In addition to these criteria, the selected papers needed to align with the general goal of this study and focus on the use of technology in healthcare, excluding those that concentrated on user experience and behavioral evaluations.

3. Assistive solution proposal

This section address the proposed assistive solution, including an overview of the solution, how the integration between social robot and virtual assistance occurs, details of the technical implementation, a summary of its functionalities, and use cases.

3.1. Overview of the assistive solution

The artifact developed in this study, SeniorMedManagement, is an assistive solution designed to aid in health treatment management using social robots and virtual assistants. This solution aims to benefit the healthcare of older adults by assisting users with their treatments and medical appointments.

To develop the assistive solution, the gap explored was between studies that used only robots and those that used only virtual assistants, overlooking the potential benefits of combining these technologies. With this assistive solution, users can interact through both the robot and the assistant's interface, while their services communicate with each other using a web API.

The social robot and virtual assistant chosen for this study, Asus' Zenbo Jr. and Amazon's Alexa respectively, are responsible for interacting with the user, receiving commands, and sending them to the web API to be processed by specific endpoints. Using the web API, the services offered by both technologies can be integrated and combined, exchanging commands and parameters to deliver relevant results to the user.

To manage all medical appointments, schedules, and subsequent activities, the assistive solution interacts with the user through dialogue, alerts, and notifications, based on the upcoming or ongoing activity.

3.2. Integration of social robot and virtual assistant

The virtual assistant interface and the social robot serve as data entry points, used for making requests and general interactions. New functionalities can be developed if necessary, using the available development interfaces provided by the respective manufacturers.

The hardware used to interact with the virtual assistant depends on the chosen assistant and the user's resources. Different assistants have different usage methods and technical specifications. Virtual assistants can be invoked from devices such as smartwatches, speakers, and smartphones, and the user can decide how to utilize them.

To process the virtual assistant requests, the manufacturer's own cloud service was utilized. When using a proprietary cloud service, the responsibility for handling requests lies with the service provider, which must ensure its availability and support. These cloud services should be capable of sending requests to external servers to facilitate the necessary integration.

The web server, responsible for hosting the API, should be capable of handling incoming requests from both the social robot and the virtual assistant cloud service. Additionally, the server manages the database, which stores all data generated from the use of the assistive solution.

3.3. Technical implementation

To validate the assistive solution, a residential implementation was carried out to simulate interactions in a familiar and realistic environment for the participants. The chosen participants were older adults undergoing medical treatments and using medications, who would experience negative effects on their health and general well-being in case of failures in such treatments.

To set up everything correctly, it was necessary to choose an environment with internet access through a wireless connection, the standard for residential robots and smart devices used as interfaces for virtual assistants. The user profile outlined for this study is that of an older adult already familiar with technology and adept at using smart devices.

Three different kinds of software were utilized to compose the assistive solution: applications for the social robot, the web API developed in Flask, and applications for the virtual assistant.

The social robot chosen for this study was the Zenbo Jr., developed by Asus in 2018. The choice was based on the robot's availability, as it was accessible to students and researchers in the university laboratory.

The virtual assistant was chosen based on the frequency of mentions in the literature review. Alexa (Amazon), Google Assistant (Google), and Watson (IBM) were the most mentioned assistants, given the popularity of their manufacturers. The chosen assistant was Amazon's Alexa, which can be accessed through its mobile app and a wide array of smart devices.

3.4. Functionalities

The hardware chosen to host the web API was a Raspberry Pi 3b device, running on Raspberry Pi OS, a custom Linux distribution. The server is responsible for hosting the application server and the MySQL database.

To create the API, the programming language Python was chosen due to its compatibility with the rest of the technology utilized, as both Zenbo Jr. and Alexa are Python-compatible. The API was developed using Flask, a Python framework for web applications, which can manage and serve as the test server for some applications (Flask, 2010).

The development of each application was carried out considering the requirements of the involved components. Different implementations of this study could be achieved using various robots, virtual assistants, or programming languages, as long as the components continue to work in an integrated manner, maintaining the proposed assistive functions.

To develop applications for Zenbo Jr., one can use the web interface provided by the manufacturer, which employs block programming, or its own API, available in Java or Python. Each of these options has its own characteristics, and the choice of which to use depends on the study's needs and requirements.

After exploring the robot's functionalities, it was necessary to find a way to access it remotely and enable integration with other systems. This integration was achieved using the web API, which exposes endpoints to send parameters and commands to the robot.

Although a Flask API can function as a web server, it could not be hosted on the robot due to a conflict between the initialization process of the Flask web server and the robot's own applications. Therefore, an Apache2 web server was set up on the chosen Linux server to host the API and manage the application deployment process (Apache, 1995).

For the virtual assistant, a set of applications was developed with specific functionalities and characteristics inherent to the proprietary technology utilized. Alexa's applications, known as skills, are designed to add new functions and abilities to the assistant's repertoire and can be distributed to users worldwide. Within a skill, its functionalities are called intents, which the user can invoke to activate or start one of the skill routines.

To develop a new skill, it is necessary to use the Amazon Developer Console. Here, the developer can set up the skill's language, intents, machine learning models, and endpoints, as well as test and publish the final result.

With the selected hardware properly configured, the server and the robot were connected using the local network, each with their respective local IP addresses. Through the local network, the server can initialize applications and send parameters to the robot, which, in turn, can consume resources from the server.

Every Alexa request is sent to the cloud service for processing, which then transmits the response through the internet. To manage these requests effectively, it was essential to make the server accessible via the Wide Area Network.

3.5. Use cases

Once set up properly, the integrated parts can work together to form the assistive solution, which uses dialogue as its main form of data entry. The correct functioning of the system depends on the availability of an internet connection.

The relationship between the different applications developed for the assistive solution is illustrated in Figure 1, demonstrating the communication between components. The *Skill Alexa* component consumes the services offered by the *API* component, which also has its services consumed by the *PyZenbo* component. Unlike the *Skill Alexa* component, the *PyZenbo* component also provides services that are consumed by the *API* component.

Based on the exploratory literature review, several recurrent use cases were identified, which served as the foundation for developing the assistive solution. The scenarios underpinning these use cases appeared in various studies or were evidenced by users, such as the need for assistance in administering medications. Common and recurring situations were also considered, including schedule management and reminders for daily activities. The use cases developed for the experiment are illustrated in Figure 2, within the use case diagram.

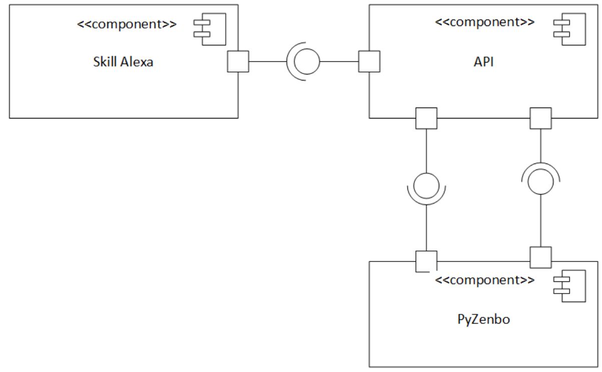

Fig. 1. Components diagram

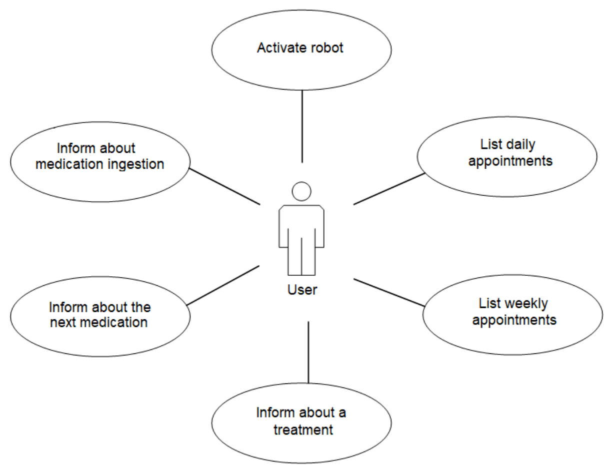

Fig. 2. Use case diagram

All use cases follow the same basic interaction flow, as represented in Figure 3. The interaction begins with the virtual assistant, where a request is sent to its cloud service for processing. The cloud service forwards the request to the application server, which activates the robot remotely. The robot is responsible for querying the database, processing the data, and retrieving the information for the user.

The first use case was created to demonstrate basic functionality, allowing for easy and quick utilization of the assistive solution's resources. The use case *Activate robot* enables the user to activate the robot with a voice command (e.g., *Where is the robot?*), prompting

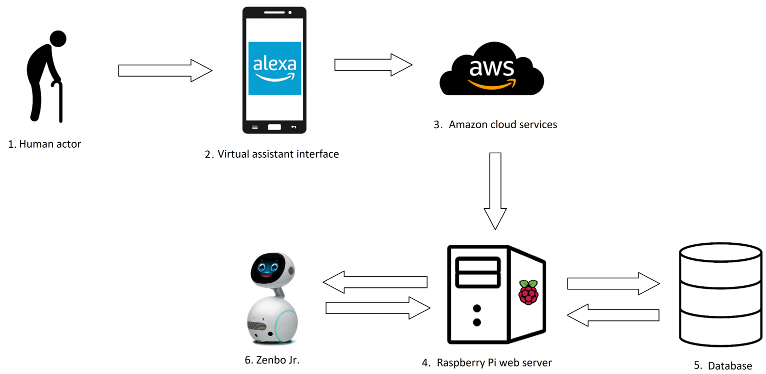

Fig. 3. Components communication diagram

the robot to respond to the user.

The second use case, *List daily appointments*, was created to help users remember their activities and appointments scheduled for the current day. As demonstrated in studies such as *Alexa Eldercare Toolbox: A Smarthome Solution for the Elderly* (Tan et al., 2020) and *Remembranza Pills: Using Alexa to Remind the Daily Medicine Doses to Elderly* (Jesús-Azabal et al., 2019), older users can greatly benefit from reminders and alarms, not only for health-related activities but also for their daily lives. To request information about their appointments for the day, the user can ask, for example, *What is my schedule for today?* The virtual assistant will send the request to the robot, which will query the database and retrieve the information.

Similarly, the third use case, *List weekly activities*, allows the user to search for information about appointments scheduled over the next seven days. The request must be made with a voice command (e.g., *What are my appointments for this week?*), which is sent to the social robot. The robot queries the database and responds to the user's question based on the provided parameters.

To help older adults not only with reminders or schedule management, the fourth use case, *Inform about a treatment*, allows the user to request information about a specific treatment. To retrieve this information, the user can ask with a voice command, such as *Tell me about my treatment*, followed by the treatment name. The robot will then retrieve data about related medications, appointments, treatment details, and other relevant information.

Beyond providing information about a specific treatment, the assistive solution can retrieve details about the user's medications. In the fifth use case, *Inform about the next medication*, with the corresponding voice command (e.g., *Which is my next medication?*) and the related treatment name, the application will retrieve information about the requested medication and indicate when it needs to be used or ingested.

The last use case, also dedicated to medication management, was developed to inform the user about medication ingestion. In the sixth use case, *Inform about medication ingestion*, the interaction can be initiated automatically, based on a scheduled program, or manually by the relevant voice command (e.g., *Did I take my medication?*). The interaction is based on treatment data, the last time a medication was used or ingested, and the current time. With this information, the robot can inform the user if any action is needed regarding a specific medication and can even record the user's response to the given information.

4. Experiment and evaluation

This section presents the experiment and evaluation of the proposed assistive solution, including the experiment design, the selection of participants, the methods employed for evaluation, and data collection.

4.1. Experiment design

To demonstrate the functionalities and feasibility of the assistive solution, practical evaluations were conducted with older adults to collect opinions, perceptions, and general comments from potential users. The experiment was designed based on the principles of software experimentation proposed by Wohlin et al. (2012), following steps of scope definition, planning, execution, analysis, and presentation (Wohlin et al., 2012). The goal of the experiment was to evaluate the object of study in terms of its potential benefits, feasibility, and usability from the user's perspective.

To properly carry out the experiment, the entire evaluation process was conducted in a residential context equipped with a wireless internet connection, involving lucid participants who were undergoing some form of medical treatment, regardless of its nature.

Within the described residential context, the hypothesis to be evaluated is that it is possible to benefit and assist senior citizens in managing their treatments and medical activities through an assistive solution that combines the functionalities of a social robot and a virtual assistant. The evaluation aims to verify with the participants the potential benefits of this technology in managing medical schedules and other daily activities.

The independent variable in this study is the use of assistive technology to help manage medical appointments. The assistive technology employed combines the services of a social robot and a virtual assistant to carry out the proposed activities. The dependent variables to be analyzed are the participants' general perceptions of the proposed assistive solution, its potential to improve treatment management, and the overall benefits for the users.

4.2. Participant selection

To conduct the experiment, seven individuals aged 60 or older, of both sexes, were selected. All participants were involved in some type of medical treatment and were users of continuous medications. None of the participants had been previously diagnosed with dementia or other health problems that could compromise their participation in the experiment.

To understand the perceptions, perspectives, and opinions of older adults, as well as their relationship with the proposed technology in their daily lives, a qualitative evaluation was conducted. In qualitative evaluations, the focus is on the environment as the source of data and on the meaning people attribute to their experiences. The *qualitative evaluation* employs a set of diverse techniques to decode contexts and bridge the gap between theory and data. Qualitative studies involve interpretative procedures applied to everyday phenomena, where data can be found in various contexts (Neves, 1996).

4.3. Evaluation methods

In this study, to conduct the qualitative evaluation, forms were used during individual interview sessions. Participants provided their opinions and evaluated the assistive solution and their interactions with it. Through text answers, grades, or scale assessments, participants were able to express their opinions, with responses ranging from very negative to very positive.

To ensure construct validity, all interviews were conducted face-to-face, and all questions were read and explained to the participants as many times as necessary to mitigate divergences and misunderstandings that could compromise the experiment results.

Internal validation was ensured during the interviews, where only the participants' responses were considered, with minimal or no influence from the researcher. During the analysis stage, the collected data were analyzed as a set without identifying the participants, and opinions or viewpoints outside the scope of this study that could influence the results were disregarded.

External validation was achieved through the literature analysis and the research problem of this study. The literature analysis identified common situations already assessed in different studies. Additionally, the research problem highlights the interest of a broader population beyond the interviewed participants.

To ensure the reliability of the obtained results, all interviews were conducted in a manner suited to the participants' understanding of the proposed questions, ensuring they were confident in their responses. This approach allowed participants with different profiles and backgrounds to register their perceptions and opinions based on their own experiences, with minimal external influence.

To collect the data used in the experiment, interviews were conducted, allowing participants to answer online forms to provide the required information. The first form, the characterization form, was designed to outline the participant's profile and identify any prior knowledge and experiences with social robots or virtual assistants. The second form, the evaluation form, was administered after the practical part of the experiment to document the participants' experiences, evaluations, and opinions about the experiment and the assistive solution itself.

To address ethical considerations, participants were required to fill out an agreement form to acknowledge the activities, risks, and personal data necessary for this study. After completing the agreement form and characterization questionnaire, participants were registered in the assistive solution to allow the use of real data in the experiment, ensuring more realistic and credible interactions. Once registered, participants interacted with the assistive solution through the robot and virtual assistant interfaces, following the proposed use cases and using their real data.

4.4. Data collection

To conclude the experiment, participants were prompted to complete the evaluation form to record their opinions, evaluations, points of view, and suggestions that could assist in improving and further developing this study.

During the experiment, participants were assisted upon request with the online forms and the use of electronic devices. This support aimed to address any doubts and ensure a clear understanding of the questions, thereby obtaining coherent and precise answers.

5. Analysis and results

This section discusses the results obtained, including an overview of participant profiles, their familiarity with technology, the evaluation of the proposed solution, and an overall assessment and user feedback.

5.1. Participant profiles

With the answers provided in the characterization questionnaire, a descriptive statistical analysis was conducted to identify the participants' profiles and their familiarity with the technologies used in the experiment. The same type of analysis was performed on the evaluation form results to understand the given evaluations and any changes in opinions compared to the initial responses.

The group of participants consisted of five women and two men, with ages ranging from 64 to 81 years old. Four out of the seven participants were married or had a partner, three were widowed, and none were single.

Beginning with the characterization form, in questions about treatment and schedule management, five out of the seven participants (71.4%) reported being responsible for these activities. Only one participant (14.3%) shared the responsibility with family members, while another (14.3%) had their treatment entirely managed by others.

To identify any previous knowledge about the technology used, some questions were designed to be answered on a scale ranging from 1 to 5. The scale measured various aspects, with 1 representing less significant indexes (e.g., low impact, low frequency, low familiarity) and 5 representing high significance indexes (e.g., high impact, high frequency, high familiarity).

Part of the form's questions focused on the need for full-time assistance with treatment and medical activities. Three out of the seven participants (42.9%) indicated no need for full-time assistance, while the other participants required minimal assistance or were neutral on the topic.

Three participants (42.9%) reported minimal failures, delays, or forgetfulness in managing their medical treatments. Another three participants (42.9%) indicated few failures, and only one participant (14.3%) claimed the occurrence of occasional failures.

During the interviews, participants reported that the low number of occurrences and failures in managing medical activities was due to their habits, routines, and the necessity of medication for maintaining their health condition.

According to the participants, failures in the administration of medications would result in little or no consequences for their general well-being. Four of the seven participants (57.1%) claimed not to notice any side effects from possible treatment management errors. One participant (14.3%) indicated that such impacts would be minimal, while two participants (28.6%) stated that the impact would be more noticeable. The participants mentioned that, in cases of forgetfulness, they could experience headaches, dizziness, worry, stress, or even delays in the treatment as a whole if they missed medical appointments.

5.2. Familiarity of participants with technology and initial evaluations

Three out of the seven participants (42.9%) stated that they had no previous knowledge or familiarity with virtual assistants. As shown in Figure 4, two participants (28.6%) reported having some prior knowledge about the subject, one participant (14.3%) claimed to know more about virtual assistants, and one participant (14.3%) stated that this technology was already part of their daily life.

In questions related to familiarity and previous knowledge about virtual assistants, three of the seven participants stated they had no prior knowledge about virtual assistants, two were neutral about it, while one participant mentioned that the technology was already part of their daily life, and one participant knew more about virtual assistants.

Four participants reported having had contact with Alexa, the virtual assistant, while three were familiar with Google's Google Assistant. None of the participants had previous contact with Apple's Siri or Microsoft's Cortana. Additionally, two participants had no prior knowledge of any virtual assistant.

Out of the five participants who had some prior experience using virtual assistants, one was neutral about the previous experiences (20%), one stated they had a positive experience (20%), and three (60%) reported that their previous experiences with virtual assistants were very positive. Regarding their experience with the virtual assistant's dialogue interfaces, two participants (40%) rated the experience as average, another two rated it as good (40%), and one rated it as great (20%).

Unlike the evaluations of virtual assistants, in the assessments of social robots, six of the seven participants

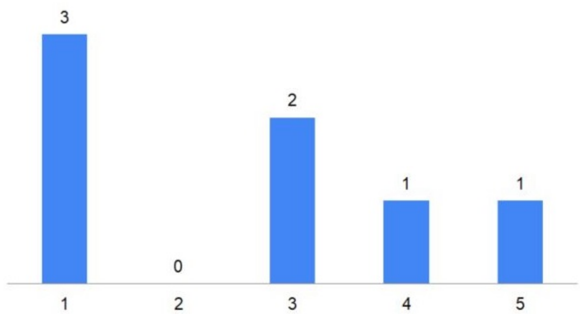

Fig. 4. Familiarity levels with virtual assistants

(85.7%) responded that they had no experience or familiarity with social or service robots. Only one participant (14.3%) claimed to have previous experience with such technology, as shown in Figure 5. However, despite the lack of familiarity, most participants (57.1%) responded that robots could be very useful in their daily activities. One participant (14.3%) rated robots as potentially useful, while two participants (28.6%) were neutral in their assessments.

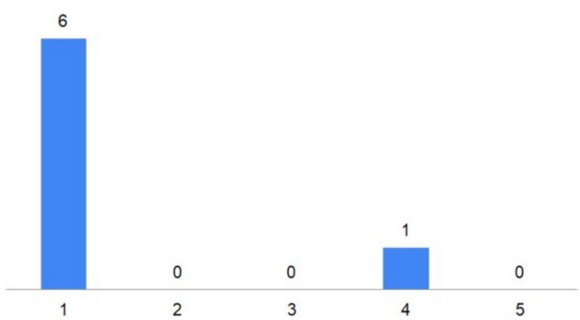

Fig. 5. Familiarity levels with social or service robots

5.3. Evaluation of the assistive solution

After completing the characterization form, the participants were registered in the assistive solution and allowed to interact with it, following the proposed use cases. After the interactions, an evaluation form was administered with a new set of questions to capture the participants' evaluations and perceptions.

In the first question of the evaluation form, participants assessed the potential of being assisted by a robot in their daily lives and activities. Unlike their responses in the characterization form, where participants had little to no experience with robots, their answers this time were based on real experience. Three participants (42.9%) said that being helped by a robot in daily activities would be very useful, another three (42.9%) answered that it would be useful, and only one (14.3%) found no potential utility in it. Most participants (71.4%) rated the combination of a social robot and a virtual assistant as very useful for daily activities, one participant rated it as useful, and only one said that such a combination would not be useful in their daily lives, as shown in Figure 6.

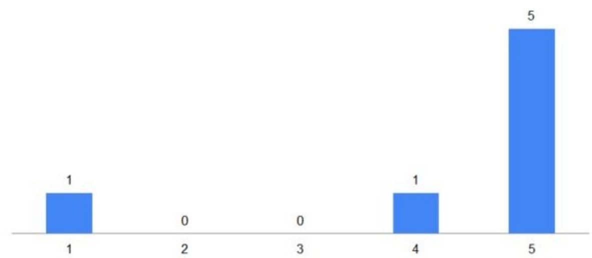

Fig. 6. Potential utility of the combination of a social robot and a virtual assistant working together in daily activities

Focusing on the primary aim of this study—the use of social robots and virtual assistants in treatment and medical schedule management—the participants assessed the usefulness of the proposed assistive solution in managing their treatments. As shown in Figure 7, five of the seven participants (71.4%) rated the assistive solution as very useful, one (14.3%) rated it as useful, and one (14.3%) indicated that it would be of little use for this purpose.

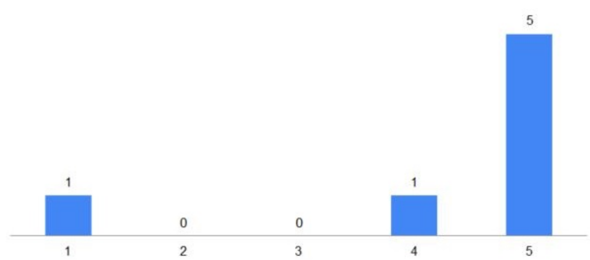

Fig. 7. Potential utility of the combination of a social robot and a virtual assistant working together managing treatments and medical schedules

Shifting the focus from medical-related activities to daily activities, six participants answered that the assistive solution would be very useful, while only one participant found it not very useful in this context.

5.4. Overall assessment and user feedback

At the end of the evaluation, participants were able to assess the experiment as a whole, including their interactions with the technology and the proposed assistive solution. They were also invited to record suggestions for future improvements and provide general comments. On a scale from zero to ten, one participant (14.3%) graded the experiment with a ten, five participants (71.4%) evaluated it with a nine, and one participant (14.3%) graded it with a two.

With the data obtained through the interviews, it was possible to outline the user profile: older adults who are concerned about and responsible for their treatments and medical appointments. Few participants reported receiving any help with these activities, emphasizing the importance of managing medical treatments either for health maintenance or as a long-standing habit. Instead of relying on family or professional caregivers, the interviewees stated that they used tools such as labeled medicine boxes or alarm clocks to help keep track of their treatments.

In line with the answers obtained in the interviews and the hypothesis presented in this study, the positive evaluations and perceptions from the participants indicate that the use of the proposed technologies would be very welcome in the lives of older adults, both in activities related to medical schedules and everyday tasks. The assistive solution developed in this study, with its offered features, could replace alternative measures used to avoid failures, unifying them into a single computational solution.

Medicine boxes labeled with the days of the week and timestamps could be replaced by the virtual assistant's schedule management function. Notes could be replaced by voice notes through the robot's interface, which could also perform the functions of alarms and specific alerts more fluidly, using natural language.

The assistive solution also proved beneficial in providing an interface that could facilitate user interaction with technology. As highlighted by the participants, the dialogue interface and the social skills of the robot can enable individuals with little or no familiarity with technology to be effectively assisted.

6. Discussion and lessons learned

The development and evaluation of the SeniorMed-Management assistive solution have yielded valuable insights into how social robots and virtual assistants can be integrated to manage medical treatments and schedules for older adults. This study underscores both the potential and challenges of employing advanced technologies to improve care quality and independence for older adults.

6.1. Integration challenges and solutions

One of the main challenges during implementation was ensuring seamless integration between the social robot (Zenbo Jr.) and the virtual assistant (Alexa). A web API developed in Flask facilitated this integration, enabling effective communication between the two technologies. Overcoming compatibility issues and ensuring reliable connectivity were key initial hurdles. Using a Raspberry Pi as the server was effective, but future iterations might benefit from more robust hardware to handle increased loads and ensure higher reliability.

6.2. User interaction and usability

Usability tests with older adults provided significant insights into the user experience. Participants generally found the combination of social robots and virtual assistants beneficial, especially for managing medical appointments and daily schedules. The natural language processing capabilities of Alexa and the interactive nature of Zenbo Jr. contributed to a positive user experience. However, some participants faced initial difficulties in interacting with the technology, highlighting the need for intuitive user interfaces and possibly more extensive user training or onboarding processes.

6.3. Perceived benefits and limitations

Participants reported that the assistive solution helped reduce the cognitive load associated with remembering medication schedules and appointments. They particularly appreciated the ability to receive reminders and interact with the system through simple voice commands. Despite these benefits, the study revealed some limitations. The dependence on a stable internet connection was a significant concern, as connectivity issues directly impacted the system's functionality. Additionally, the study's small sample size and specific demographic (tech-savvy older adults) may limit the generalizability of the results. Future studies should include a more diverse group of participants to validate the findings across different user profiles.

6.4. Implications for caregivers and healthcare professionals

Integrating social robots and virtual assistants can significantly reduce the burden on caregivers and healthcare professionals by automating routine tasks and providing real-time health monitoring. This allows caregivers to focus on more critical aspects of care that require human intervention. However, successful implementation of such technologies requires careful consideration of user training, system reliability, and ongoing support to address technical issues.

6.5. Future directions

This study opens several avenues for future research and development. Enhancements to the system could include more sophisticated health monitoring capabilities, such as integrating wearable health devices that provide real-time data on vital signs. Expanding the system's functionality to include features like medication stock control and more complex interaction capabilities could further improve its utility. Additionally, localized implementations that support multiple languages and cultural contexts would make the solution more accessible globally.

In conclusion, while the SeniorMedManagement assistive solution shows considerable promise, ongoing research and development are essential to address challenges and expand its applicability. Positive feedback from participants underscores the potential benefits of such technologies in supporting the health and well-being of older adults, ultimately contributing to a higher quality of life and greater independence.

7. Conclusion

It is well known that with advancements in medical treatments, personal hygiene, nutrition, and healthcare in general, life expectancy tends to increase worldwide, leading to a growing older population.

Based on the difference between life expectancy and healthy life expectancy, it is possible to identify an average period of 12 years during which care-related activities become necessary in the lives of millions of people around the world (WHO, 2020).

The goal of this study was to develop an assistive solution capable of managing treatments and medical schedules by combining the functionalities of a social robot and a virtual assistant, addressing the growing demand in the care sector.

With the developed assistive solution, it was possible to evaluate the general perception and its potential to improve the proposed activities for its users. According to the participants, the product of this research could be beneficial in replacing the alternative means used to manage medical tasks, automating manual activities, centralizing functionalities, and assisting in daily activities.

Future work could include localized implementations using technologies that support different languages, in addition to developing more functionalities focused on treatment management and health monitoring. To further advance this study, new features such as medication stock control, more immersive dialogue trees, and assistive functions designed for treatment follow-up and health monitoring could address the suggestions obtained from the experiment.

References

Apache. (1995). About apache. https://httpd.apache.org/ABOUT_APACHE.html

Bardaro, G., Antonini, A., & Motta, E. (2022). Robots for elderly care in the home: A landscape analysis and co-design toolkit. *International Journal of Social Robotics*, *14*(3), 657–681.

Casula, M., Rangarajan, N., & Shields, P. (2020). The potential of working hypotheses for deductive exploratory research. quality & quantity. *Energy Policy*.

Damiano, L., & Dumouchel, P. (2018). Anthropomorphism in human–robot co-evolution. *Frontiers in Psychology*, *9*(1-2), 468.

Flask. (2010). Flask. https://palletsprojects.com/p/flask/

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*, 75–106.

Jacobs, T., & Graf, B. (2012). Practical evaluation of service robots for support and routine tasks in an elderly care facility. In *Proceedings of ieee workshop on advanced robotics and its social impacts, arso* (pp. 46–49). Institute of Electrical; Electronics Engineers Inc.

Jesús-Azabal, M., José Agustín Medina-Rodríguez, J. D.-G., & García-Pérez, D. (2019). Remembranza pills: Using alexa to remind the daily medicine doses to elderly. In C. F. José García-Alonso (Ed.), *2nd international workshop on gerontechnology* (pp. 151–159). Springer.

Neves, J. L. (1996). Pesquisa qualitativa: Características, usos e possibilidades. *Caderno de pesquisas em administração*, *1*(3), 1–5.

Robinson, H., MacDonald, B., & Broadbent, E. (2014). The role of healthcare robots for older people at home: A review. *International Journal of Social Robotics*, *6*(4), 575–591.

Spenko, M., Yu, H., & Dubowsky, S. (2006). Robotic personal aids for mobility and monitoring for the elderly. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *14*(3), 344–351.

Tan, K., Sekhar, K., Wong, J., Holgado, J., Ameer, M., & Vesonder, G. (2020). Alexa eldercare toolbox: A smarthome solution for the elderly. In P. R. (Ed.), *Proceedings of the ieee annual ubiquitous computing, electronics and mobile communication conference* (pp. 0806–0812). Institute of Electrical; Electronics Engineers Inc.

Tulshan, S. A., & Dhage, S. N. (2019). Survey on virtual assistant: Google assistant, siri, cortana, alexa. In S. M. Thampi, O. Marques, S. Krishnan, K.-C. Li, D. Ciuonzo, & M. H. Kolekar (Eds.), *Advances in signal processing and intelligent recognition systems* (pp. 190–201). Springer Singapore.

Turja, T., Taipale, S., Niemelä, M., & Oinas, T. (2022). Positive turn in elder-care workers' views toward telecare robots. *International Journal of Social Robotics*, *14*(4), 931–944.

WHO. (2020). Life expectancy and healthy life expectancy data by country. https://httpd.apache.org/ABOUT_APACHE.html

Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., & Wesslén, A. (2012). *Experimentation in software engineering* (1st ed.). Springer Berlin, Heidelberg.