CareCompanion: A Personalized Virtual Assistant for Enhancing Support and Independence in ADRD Patients and Older Adults

Wordh Ul Hasan
Department of Computer Science
North Dakota State University
Fargo, USA
wordh.hasan@ndsu.edu

Kimia Tuz Zaman
Department of Computer Science
North Dakota State University
Fargo, USA
kimia.zaman@ndsu.edu

Mohammed Shalan
Department of Computer Science
North Dakota State University
Fargo, USA
mohammed.shalan@ndsu.edu

Xin Wang
Department of Computer Science
North Dakota State University
Fargo, USA
xin.wang.2@ndsu.edu

Juan Li
Department of Computer Science
North Dakota State University
Fargo, USA
j.li@ndsu.edu

Bo Xie
School of Information, School of Nursing
The University of Texas at Austin
Texas, USA
boxie@utexas.edu

Cui Tao
Department of Artificial Intelligence and Informatics
Mayo Clinic
Rochester, USA
tao.cui@mayo.edu

***Abstract*— Alzheimer's Disease and Related Dementias (ADRD) patients and older adults face challenges related to memory loss, navigation difficulties, and social isolation, impacting their daily tasks, appointments, and social connections. To address these multifaceted challenges, this paper presents the design, development, and preliminary evaluation of "CareCompanion," a virtual assistant tailored specifically for this population. Leveraging advanced AI technologies such as natural language processing, machine learning, and knowledge graphs, CareCompanion provides personalized reminders, navigation assistance, and social connectivity features. Preliminary evaluation results demonstrate the potential of CareCompanion in improving the quality of life, independence, and social engagement for ADRD patients and older adults. Further research and development can enhance its effectiveness, usability, and customization, catering to the unique needs of this population, while fostering connections and mitigating the impact of memory loss, navigation difficulties, and social isolation.**

Keywords*— *Alzheimer's Disease and Related Dementias, knowledge graph, natural language processing, virtual assistant, memory loss

I. INTRODUCTION

Aging is a global phenomenon that poses numerous challenges for individuals and societies worldwide [1]. As life expectancy continues to increase, so does the prevalence of age-related health issues [2], [3]. One of the most prevalent conditions affecting older adults is Alzheimer's Disease and Related Dementias (ADRD), which has garnered significant attention in recent years. ADRD refers to a group of neurodegenerative disorders characterized by cognitive decline and memory loss [4]. It is estimated that globally, around 50 million people are currently living with dementia, with Alzheimer's disease accounting for the majority of cases [5]. As the global population ages, these numbers are projected to increase significantly, placing a growing burden on healthcare systems and caregivers.

Memory loss is a common and prominent symptom of ADRD [6], [7]. It manifests in various ways, impacting the individual's ability to remember and recall information. For instance, individuals with ADRD may experience difficulty in remembering recent events, important appointments, or even familiar faces and names. They often struggle with short-term memory, frequently repeating questions or conversations within a short span of time. This memory impairment can lead to frustration, confusion, and a diminished sense of self for individuals with ADRD.

In addition, individuals with ADRD may encounter challenges in remembering to perform routine tasks, such as taking medication or maintaining personal hygiene. They may forget to eat meals or leave appliances turned on, posing

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potential risks to their well-being and safety [8], [9]. These memory-related problems not only impact the individuals themselves but also place significant strain on caregivers and family members who assume the responsibility of providing support and supervision [10].

Another symptom associated with memory loss in ADRD is spatial and navigational difficulties [11]. Patients may have trouble recognizing familiar places or finding their way home, even in familiar environments. They may experience disorientation and get lost easily, increasing their vulnerability and dependence on others for assistance.

Moreover, individuals with ADRD often find it challenging to stay connected with their local community and maintain social interactions. They may struggle to engage in conversations, remember names and faces, and actively participate in community activities. This isolation can further exacerbate feelings of loneliness and contribute to a decline in overall well-being. As their cognitive abilities decline, they may become less aware of local news, events, and activities happening around them. This disconnects from their immediate surroundings can lead to feelings of detachment, isolation, and a diminished sense of belonging.

To address these challenges, we propose an innovative virtual assistant, "CareCompanion, that can support individuals with ADRD and older adults in managing their memory loss, navigation difficulties, and social isolation. CareCompanion utilizes advanced AI technologies, including natural language processing, machine learning, and knowledge graphs, to provide a range of functionalities aimed at addressing the multifaceted challenges faced by this population.

Preliminary evaluation results demonstrate the potential of CareCompanion in improving the quality of life and independence for individuals with ADRD and older adults. However, further research and development are essential to enhance its effectiveness, usability, and customization, ensuring it caters to the unique needs and preferences of this population.

II. Related Work

In recent years, there has been growing interest in developing technologies and interventions to support individuals with ADRD and older adults and improve the quality of their lives. This section provides an overview of relevant research and technological advancements in this domain.

Memory support technologies have been widely explored to assist individuals with memory impairment. Electronic reminder devices, such as medication dispensers with alarms[12], have shown effectiveness in promoting medication adherence and daily routine management. Digital calendars and smartphone applications have also been developed to provide reminders for appointments, tasks, and events [13].

In a study by Scullin et al.[14], the feasibility and effectiveness of smartphone-based strategies for improving prospective memory in older adults with cognitive impairment were investigated. Participants were trained to use either a digital voice recorder app or a reminder app to assist with prospective memory tasks. The results indicated that the intervention was acceptable and feasible, with participants reporting improvements in daily prospective memory functioning. Ferguson et al. [15] conducted a study that demonstrated the potential benefits of task reminder prompts delivered via smartphone calendars. The results revealed a significant improvement in task completion rates when smartphone reminders were utilized. Furthermore, a thematic analysis uncovered that these reminders contributed to improvements in personal independence, confidence in coping with memory difficulties, and general mood. In another study by McCallum et al.[16], Google Calendar was explored to address prospective memory issues in a patient with Alzheimer's disease. The patient was required to remember basic daily life activities and targeted events, such as attending a weekly bridge game, with the targeted events cued by Google Calendar. The study found that the patient omitted fewer targeted events during the intervention phase than in the baseline phase, pointing to the beneficial effect of Google Calendar in improving prospective memory in patients with mild Alzheimer's disease.

Navigation assistance technologies have gained significant attention in supporting individuals with ADRD who experience spatial and navigational difficulties. Global Positioning System (GPS) trackers and wearable devices equipped with location tracking capabilities have been utilized to help locate individuals who wander or get lost. Virtual reality-based navigation training programs have shown promise in improving spatial orientation skills and wayfinding abilities[17]. Notably, [18], [19] Manderson and Sohlberg emphasize the challenges faced by cognitively impaired individuals while navigating their surroundings and underscore the importance of adopting strategies to mitigate these difficulties. In Pillette's comprehensive review [20] of literature on navigation assistance systems for people with dementia, the author identifies the obstacles encountered and potential solutions for future advancements in this field. Furthermore, Cogné [21] explores the use of virtual reality in assessing spatial navigation disorders and the influence of navigational aids, thereby offering insights that can inform the development of navigation technology for ADRD patients. Collectively, these papers suggest that navigation technology tailored to the specific needs and challenges of individuals with ADRD must be meticulously designed in order to address the unique demands of this population. However, these solutions primarily focus on providing assistance during critical situations rather than offering continuous support in daily navigation tasks.

Several initiatives have sought to connect individuals with ADRD and older adults to their local communities. Social robots have been employed to facilitate social interactions and engage individuals in meaningful activities [22]. Online platforms and virtual communities have also been established to promote social connectivity and peer support [23]. An intergenerational, telephone-based reminiscence program incorporating digital storytelling (DST) was found to yield significant benefits for older adults with ADRD [24]. Overall, existing research suggests that peer support and intergenerational connections are promising initiatives for promoting social connectivity and mental wellbeing among ADRD patients and older adults[25]. However, these approaches often lack the personal touch and

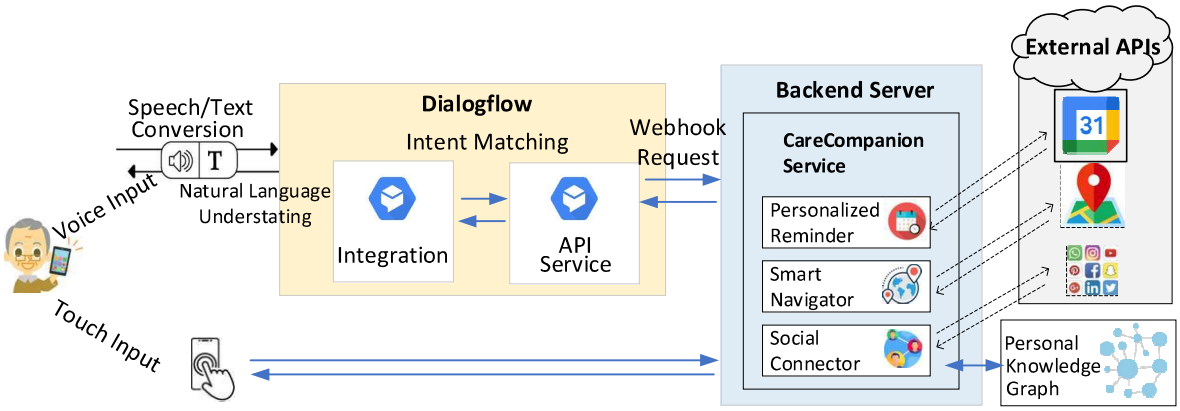

Fig.1 System architecture

familiarity that comes with connecting to one's immediate surroundings and local community [26].

In summary, while various technologies and interventions have been developed for assisting individuals with ADRD and older adults, existing solutions have certain limitations. Firstly, many of these solutions focus on providing individual functionalities for each specific need, resulting in a fragmented user experience. Additionally, these existing solutions often lack personalization and fail to adapt to the unique needs and preferences of individuals with memory loss. They may offer generic features that do not consider the user's specific context, such as their daily routines, personal relationships, or preferences. Furthermore, some of these solutions may not effectively address the emotional and psychological aspects of memory loss and social isolation.

In contrast, our proposed solution aims to address these limitations by providing a comprehensive and integrated system in a single interface. By incorporating advanced AI technologies, such as natural language processing and machine learning, our system can offer personalized reminders, intelligent navigation assistance, and meaningful social interactions tailored to the individual's needs. Moreover, our solution takes into account the emotional well-being of the user by creating a sense of companionship and familiarity. It utilizes personalized features such as addressing the user by name, understanding their family and social relationships, and providing relevant information based on their specific interests and preferences. This personalized approach enhances the user's engagement, establishes a stronger connection with the virtual assistant, and fosters a sense of trust and support

III. System Design

As shown in Fig. 1, The CareCompanion mobile app offers a multimodal interface that supports both voice-based and touch-based interactions. Users can communicate with the app using voice input, utilizing Google's Dialogflow [27] for speech processing. Additionally, users can access the app's features through touch-based interactions, providing flexibility in how they interact with the virtual assistant. The backend server hosts the CareCompanion services, which include the personalized reminder service, smart navigator, and social connector. These services are responsible for the core functionalities of the app. They utilize external APIs to enhance their capabilities.

The personalized reminder service leverages the Google Calendar API to provide timely and context-specific reminders for appointments, medication schedules, and important events. This integration with Google Calendar ensures accurate and synchronized reminders for the users. The smart navigator component of CareCompanion utilizes the Geofence API and Google Maps API to assist individuals with ADRD in navigating their surroundings. It provides directions, guidance, and location-based information to help users find their way and reach their destinations safely. The social connector feature integrates with various social networks APIs and RSS feeds to deliver local news, updates on community events, and facilitate communication with family and friends. This integration enables users to stay connected and engaged with their social circles, reducing feelings of isolation and enhancing their overall well-being.

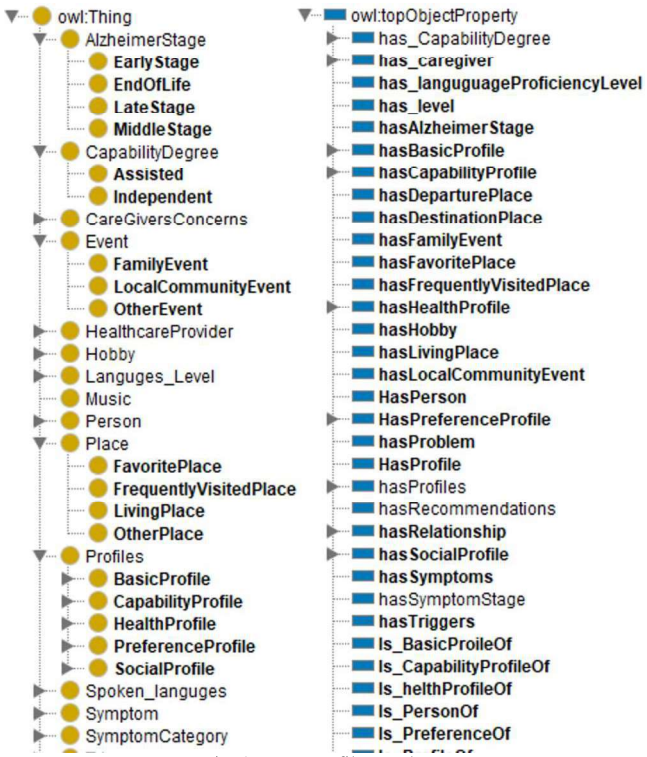

Fig. 2. User profile ontology

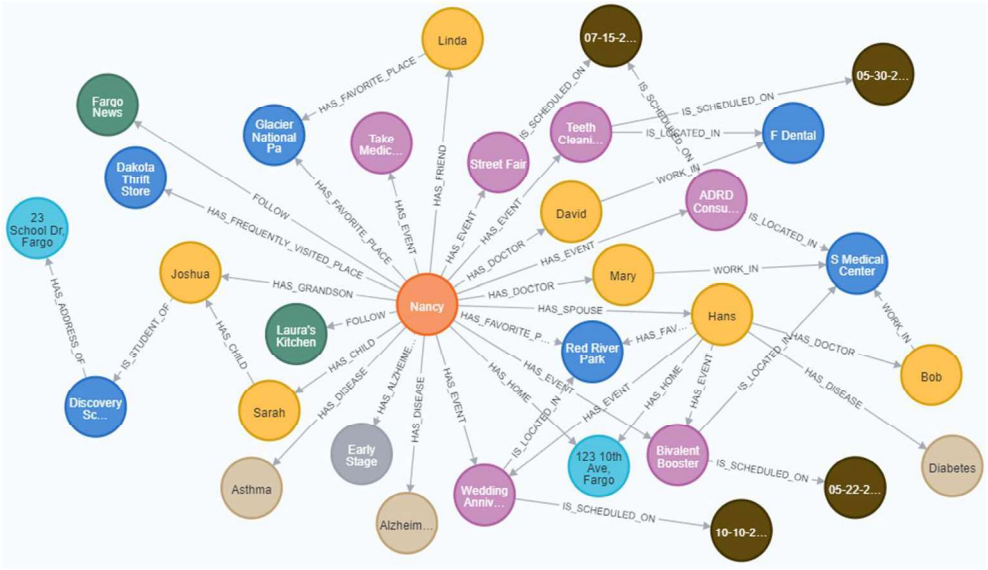

Fig.3 User Nancy's personal knowledge graph

In addition, CareCompanion leverages a personal knowledge graph to enhance the personalization of its services. The personal knowledge graph includes the user's demographic information, family and social relationships, preferences, and other relevant details. By incorporating the personal knowledge graph, CareCompanion ensures that its services are highly personalized and tailored to the individual user's needs and preferences. This personalized approach enhances the user experience, promotes independence, and supports individuals with ADRD in managing their daily lives more effectively.

A. Personal Knowledge Graph

One of the primary characteristics of CareCompanion is its emphasis on personalization. Whether in Personalized Reminder, Smart Navigator, or Social Connector, CareCompanion requires a substantial understanding of users' personal information that frequently needs to be added, updated, and efficiently queried. For this purpose, we construct a personal knowledge graph to provide personal knowledge for the user.

In contrast to other databases, Knowledge Graphs store data as nodes (entities) and relationships as edges and prioritize the significance of relationships. This attribute makes knowledge graphs particularly well-suited for situations where relationships play a central role in the data model, as with CareCompanion. New personal knowledge can be easily added into the graph as nodes and edges without modifying the entire database structure. This flexibility enables graph databases to adapt to changing and expanding requirements.

The knowledge graph was constructed based on a high-level user profile ontology as shown in Fig.2. It defines the most important concept and relationships of the user profile. This ontology is extracted and adapted from our previous work [28], which model ADRD patients care ontology.

Graph databases offer rapid query performance, especially when dealing with highly interconnected data. Traversing relationships within a graph is typically more efficient than performing joins in conventional relational databases. Fig.3 shows an example personal knowledge graph of user Nancy. For instance, if Nancy states, "Navigate to my grandson's school," a general navigation system would not be able to understand this command, as it cannot identify who the user's grandson is, let alone the specific high school he attends. However, using a personal knowledge graph, CareCompanion can handle this query well. As the query can locate *Nancy—has grandson—Joshua*, *Joshua—is student of — Discovery High School*, *Discovery High School— has address of —23 School Dr.* Even if the user forgets the grandson's high school name, CareCompanion enables a smooth arrival. Consequently, CareCompanion can provide timely and effective assistance, significantly enhancing the convenience and enjoyment of daily life for individuals with ADRD.

B. Voice Assistant

CareCompanion is built upon advanced Natural Language Understanding (NLU) and Natural Language Processing (NLP) techniques. CareCompanion interface is proposed to utilize Google's Dialogflow. Dialogflow serves as a platform for NLU which is represented as a virtual agent. An agent handles the conversation with the end users depending on the following components:

- Intent: represents the end user sentences or phrases which is a specific action the user wants the agent to perform. When the end users interact with the agent, they are typically trying to achieve specific intent. For instance, phrases like "Set a reminder for my doctor's appointment" or "When is my next medication due?".
- Entity: An entity is a specific type of data that is used to represent different objects. For example, an entity could represent an appointment, a date or an event. An entity is a key-value pair wherein the key signifies the object, and its values represent its various synonyms. In the previous example, "my doctor's appointment" could be identified as a key. The value for this key could be phrases like "medical visit", "doctor's visit" or "check-up".

- Fulfilment: A feature that is used to communicate backend services to generate dynamic response or initiates particular actions such as API calls or executing specific code.

C. Personalzied Reminder

CareCompanion offers a range of personalized reminder features to support individuals with ADRD in managing their daily tasks and maintaining routines. These reminders are delivered through a combination of push-based and pull-based techniques, ensuring timely assistance and facilitating medication adherence.

The push-based reminder functionality of CareCompanion acts as an intermediary between calendar services, such as Google Calendar, and the patients or their caregivers. The calendar server sends scheduled reminders for important events, and CareCompanion customizes these reminders to suit the individual's needs. For example, if there's a doctor's appointment, CareCompanion provides advance reminders at strategic intervals, such as one week ahead, a day before, and 30 minutes prior to the appointment. This proactive approach ensures that individuals are well-prepared and more likely to attend their appointments promptly.

In addition to push-based reminders, CareCompanion enables pull-based question answering, allowing users to interactively communicate with the virtual assistant. Users can inquire about various aspects of their schedule and medication regimen, such as the next dentist appointment, their grandchildren's birthday, or if they have taken their medication. CareCompanion responds by providing relevant information, such as the medication's name, dosage, and timing. This interactive question answering capability empowers individuals to stay informed and actively participate in their healthcare, ultimately enhancing medication adherence and overall well-being. By combining push-based reminders with customized scheduling and pull-based question answering, CareCompanion ensures personalized and comprehensive support for individuals with ADRD. The virtual assistant acts as a reliable companion, assisting with timely reminders, answering queries, and promoting medication adherence, thus empowering individuals to maintain their routines and stay on top of their important commitments.

D. Navigation Assistance

CareCompanion integrates navigation assistance to support individuals with ADRD in overcoming spatial and navigational challenges. By providing directions and guidance, CareCompanion ensures users can navigate unfamiliar surroundings and find their way home or to familiar places. Additionally, the system addresses wandering behavior by sending real-time warnings to family members and sharing the user's location for their safety. To cater specifically to Alzheimer's patients, we have developed a dedicated Navigation Assistance system, comprising a mobile app with voice capabilities. This system incorporates various features to prioritize user safety and convenience.

One key feature of the app is the utilization of geofencing technology, which establishes a designated safe zone perimeter. By monitoring the user's location, the system can detect if the patient wanders beyond the safe zone. In such situations, caregivers receive immediate notifications along with real-time location tracking, allowing them to take prompt action and ensure the patient's well-being.

Furthermore, the system includes a personalized knowledge base for each patient. This knowledge base contains information about the user's regular destinations, such as grocery stores, doctor's offices, workplaces, home, parks, and other frequented locations deemed safe for the patient. By leveraging this information, CareCompanion can provide tailored assistance based on the user's specific needs and preferences.

The app's interface is designed to accommodate the diverse input preferences of the patients. Users can either verbally express their desired destination or choose from a user-friendly menu that offers quick access to the curated list of locations. Once a selection is made, the app seamlessly integrates with Google Maps, providing voice-guided navigation to the chosen destination. This curated list streamlines the user experience by eliminating the complexities of conventional map features found in applications like Google Maps or Apple Maps. In situations where the patient wishes to search for a specific location not included in the predefined list, the app still allows manual searching through the Google Maps search API. The app provides suggestions and displays locations within the specified city limits, ensuring the patient's safety while accommodating their desire for independent exploration.

E. Social Connections

To enhance the social connection experience, we have implemented a robust system that seamlessly integrates personalized community-related information. Our goal is to keep users connected and informed about the happenings in their immediate surroundings. Here's how we achieved it:

We utilize our knowledge graph to gather relevant information about each user's social relations and local community. This data serves as the foundation for sourcing personalized social connections, including news, community events, and family updates that are specific to the user. To provide up-to-date local news, we retrieve RSS links corresponding to local news sources and integrate them into our backend server. This allows us to gather local news and provide users with accurate and timely updates. For community events information, we leverage sources such as Facebook pages and other platforms. Automation tools like Zapier are employed to generate an RSS feed, ensuring that users receive comprehensive and relevant information about community events.

Through this comprehensive approach, CareCompanion empowers users to stay connected and informed about the happenings in their immediate surroundings. By fostering a sense of belonging and engagement within their local communities, our app promotes social connections and enhances the overall social well-being of our users..

IV. Evaluation

To ensure the effectiveness and suitability of the CareCompanion app for individuals with Alzheimer's Disease and Related Dementias (ADRD), it is essential to conduct a thorough evaluation before its implementation with real users.

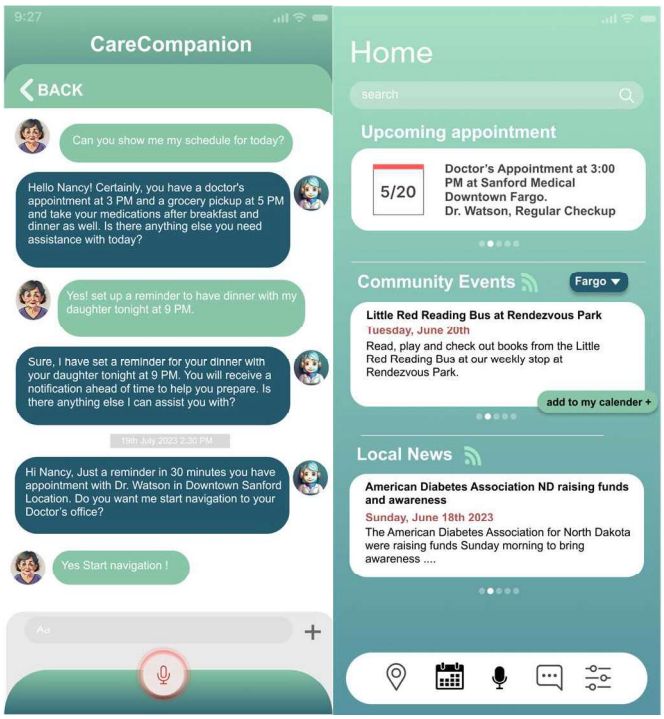

Fig. 4 Reminder and social connection cases

As the target audience for the app comprises ADRD patients, it is crucial to assess its functionalities, feasibility, correctness, and appropriateness to meet their specific needs. The evaluation process involves a comprehensive approach that encompasses both use case testing and role-playing based testing. Through these evaluation methods, we aim to gain valuable insights into the app's performance and user experience, allowing us to refine and optimize its design for maximum effectiveness.

A. Prototype Implementation

The CareCompanion virtual assistant is powered by Google's Dialogflow platform, specifically designed to meet the needs of ADRD patients and older adults. Our technology stack includes Dialogflow for intent recognition and a serverless Webhook application for intent fulfillment. The fulfillment process involves communication with our backend server, implemented using a Spring Boot Java application, which integrates with various APIs. To ensure seamless integration with reminder events, we utilized Google's Calendar API. For smart navigation, we employed Google's geofencing API, geolocation API, and Google Maps API. The Zapier API was leveraged to interact with community pages, generate RSS feeds, and gather social news and community events. The personal knowledge graph was stored in a Neo4j graph database. The end product was developed using Flutter, a framework for building mobile applications. Through voice commands, users can access navigation assistance, utilize various app functionalities, interact with social connectors for local and community news, and receive personalized reminders based on Google Calendar events and the knowledge base..

B. Use Case study

Our case study encompassed various scenarios about how users use the system. The evaluation aimed to assess the performance of CareCompanion in real-life situations and its ability to address the multifaceted challenges faced by individuals with ADRD. Here we use one case to illustrate the use case study. Assume Nancy is a 76-year-old woman who has been diagnosed with early-stage AD. She lives with her 77-year-old husband, and they have a daughter who frequently visits them. Nancy's memory loss has started to impact her daily life, making it challenging for her to remember appointments, take medications on time, and navigate her surroundings. CareCompanion, the virtual assistant, is designed to support individuals like Nancy in managing their memory loss, navigation difficulties, and social isolation. Here's how CareCompanion assists Nancy and her family:

Reminder cases: Nancy benefits from personalized reminders for appointments, medication schedules, and events through CareCompanion. With the voice-activated function, she effortlessly schedules necessary appointments and receives timely alerts a week, a day, and 30 minutes before each appointment. These reminders promote her independence, ensure attendance, and reduce forgetfulness-related stress. Caregivers can also set up appointments, enhancing support and collaboration. For medication management, CareCompanion sets up schedules, provides reminders, and offers post-medication alerts. Overall, CareCompanion consistently helps Nancy manage her daily activities, participate in events, and maintain a well-structured routine.

Navigation cases:

Finding the way home: Nancy decided to take a walk around the neighborhood but became disoriented and unsure of the route back home. Feeling lost and anxious, she activated CareCompanion and expressed her need to return home. The virtual assistant promptly provided clear step-by-step directions,

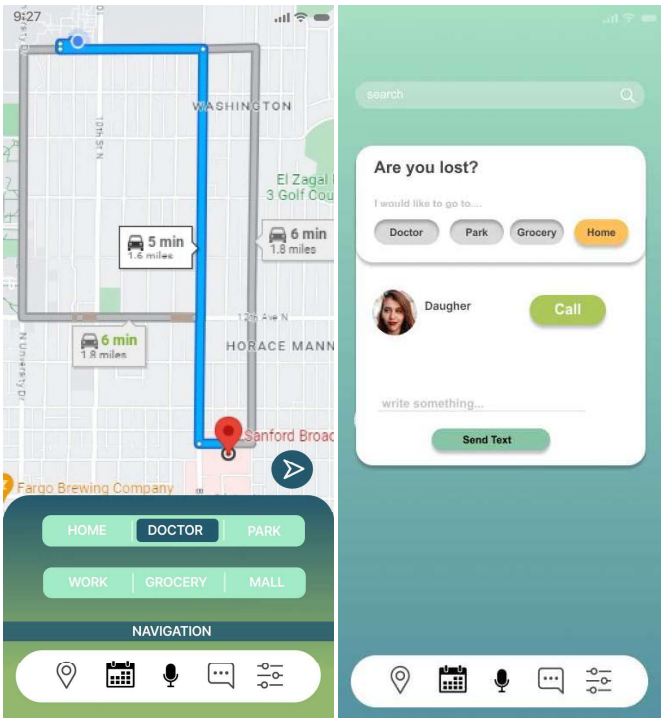

Fig. 5 Navigation and wondering warning cases

guiding Nancy back to her residence. With CareCompanion's assistance, Nancy felt reassured, reducing her anxiety and ensuring a safe return home.

Navigating to a familiar location: Nancy had a scheduled doctor's appointment at a nearby clinic but struggled to remember the location and route. With CareCompanion, she shared her intention to visit the doctor. Leveraging its knowledge base, which includes information about Nancy's regular destinations, such as the clinic, CareCompanion quickly accessed the relevant details. It presented Nancy with clear directions and offered voice-guided navigation, ensuring she arrived at the correct location for her appointment.

Ensuring safety during wandering behavior: Nancy occasionally exhibited wandering behavior, which raised concerns for her safety. As Nancy unintentionally crossed the predefined safe zone boundaries, the virtual assistant detected the deviation and immediately sent a notification to her husband and daughter. The notification included Nancy's precise location, allowing her caregiver to intervene promptly and ensure her safety. CareCompanion's monitoring and timely alerts offered peace of mind to Nancy's family and helped mitigate potential risks associated with wandering.

Social connection cases:

Engaging with local news updates: CareCompanion regularly provides Nancy with personalized local news updates sourced from local news portals and public social media communities in her area. Every morning, Nancy engages in a conversation with the virtual assistant and receives a summary of the latest news and events in her community. For example, the voice assistant informs Nancy about upcoming events in her neighborhood, local initiatives, and news relevant to her interests. This helps her stay informed and connected to the happenings around her, fostering a sense of belonging and engagement.

Discovering community events: CareCompanion actively notifies Nancy about upcoming community events and activities that match her interests. For instance, it informs Nancy about local social gatherings like art exhibitions, support group meetings, or recreational events suitable for older adults. By staying updated on such opportunities, the virtual assistant informs Nancy well in advance, enabling her to plan and participate in these social engagements. This feature encourages Nancy to maintain an active social life and expand her network within the community.

Facilitating communication with family and friends: CareCompanion serves as a communication tool, allowing Nancy to connect with her family and friends. Through the virtual assistant, Nancy can initiate conversations, make calls, and send messages to her loved ones. Whether it's a quick check-in or a longer conversation, CareCompanion ensures that Nancy stays connected with her support system, reducing feelings of isolation and promoting social connections.

Nancy's user case exemplifies how CareCompanion can effectively address the challenges faced by individuals with Alzheimer's Disease and provide valuable support to both the individuals and their caregivers. By utilizing CareCompanion, Nancy experiences improved memory support, enhanced navigation assistance, and increased social connections, all tailored to her specific needs. The virtual assistant's user-friendly interface, personalized approach, and context-aware capabilities make Nancy feel supported and connected, providing a sense of security and independence despite her early-stage AD.

C. *Role-Based Testing*

To thoroughly evaluate the effectiveness and performance of CareCompanion before applying it to older adults or individuals with ADRD, a role-based testing approach was adopted. In this approach, lab researchers assumed the roles of ADRD patients and their family members to simulate real-life scenarios and interactions with the virtual assistant. This test last two weeks. The testing process involved the following steps:

- Scenario Design: Different scenarios were designed to mimic common situations encountered by older adults or individuals with ADRD and their family members. These scenarios included tasks related to reminders, navigation assistance, social connections, and other information retrieval. Each scenario was carefully constructed to evaluate specific functionalities and features of CareCompanion.
- Role Assignment: Lab researchers were assigned specific roles, such as ADRD patients or their family members, based on the scenario requirements. Researchers taking on the role of ADRD patients simulated the cognitive impairments and memory loss typically associated with the disease, while researchers in the family member role represented the caregivers or relatives seeking support from the virtual assistant.
- Interaction and Performance Evaluation: Lab researchers interacted with CareCompanion as per their assigned roles. They made requests, asked questions, and engaged in conversations with the virtual assistant to accomplish the tasks outlined in the scenarios. During the interactions, researchers recorded key performance metrics, including success rate, accuracy of information provided by CareCompanion, and the overall user experience.
- Data Analysis: The recorded data from each interaction session was thoroughly analyzed to assess the performance of CareCompanion. Success rates were calculated to measure the system's ability to fulfill user requests and provide accurate and relevant information. Researchers also evaluated the system's responsiveness, ease of use, and the extent to which it met the needs and expectations of ADRD patients and their family members.

Table 1 shows the results of the role-based testing. The table is divided into different scenarios, each representing a key functionality of the system: Reminder Management, Navigation Support, and Social Connections.

For each scenario, the table lists the roles involved (ADRD Patient and Family Member), the tasks they perform, the expected outcome of each task, the success rate of the task execution, the accuracy of the information provided by the system, and a user experience score on a scale of 1 (worst) to 5 (best).

Table I. Performance Test Evaluation Table for Role-Based Testing

Scenario	Role	Tasks	Expected Outcome	Success Rate (%)	Information Accuracy (%)	User Experience* 1(worst) – 5 (best)
Reminder Management	ADRD Patient	Receive reminders	Timely and accurate reminders	100	100	5
		Ask for schedules	Accurate Schedules	100	100	5
	Family Member	Set reminders	Reminders set successfully	98	100	4
Navigation Support	ADRD Patient	Request direction to familiar place	Accurate directions provided	100	100	5
		Request direction to a specific address	Accurate directions provided	100	100	5
	Family Member	Set favorite locations	Locations set successfully	96	100	4
		Get warning for wandering behaviors	Get wondering notification successfully	100	100	5
Social Connections	ADRD Patient	Get local news	Relevant local news provided	100	100	4.5
		Get Community events	Community events notification provided	100	100	4.5
		Communicate with family members	Call and SMS sending were successfully	100	100	5
	Family Member	Subscribe news and events	Successful subscription to news and events	100	100	5
		Communicate with patients	Call and SMS sending were received and sent successfully	100	100	5

*User experience includes system's responsiveness, ease of use, and the extent to which it met the needs and expectations

Here's a breakdown of each column:

- Scenario: This represents the key functionality being tested. It includes Reminder Management, Navigation Support, and Social Connections.
- Role: This indicates whether the task is performed by an ADRD Patient or a Family Member.
- Tasks: These are the specific actions that the ADRD Patient or Family Member performs within each scenario.
- Expected Outcome: This describes what the system is expected to do when each task is performed.
- Success Rate (%): This shows the percentage of times the system successfully achieved the expected outcome.
- Information Accuracy (%): This indicates the percentage of times the system provided accurate information in response to the task.
- User Experience (1-5): This is a score representing the user's experience with the system during each task, on a scale of 1 (worst) to 5 (best).

The table shows that the system generally performed well across all scenarios, with high success rates and information accuracy percentages. The user experience scores were also high, indicating that users found the system easy to use and effective in meeting their needs. The only instances where the scores slightly decreased were during tasks performed by family members, specifically when they attempted to set reminders and favorite locations. Although the interface was user-friendly for manual inputs, the system occasionally struggled to accurately interpret voice commands. As a result, family members sometimes had to repeat their commands, which slightly impacted the overall user experience.

The User Experience score was derived using a process that involved lab members rating each interaction with CareCompanion on a scale of 1 to 5, with 1 representing a poor user experience and 5 representing an excellent user experience.

Each lab member was assigned to assess various facets of the system, including its responsiveness, ease of use, and the

extent to which it met the needs and expectations of users. These facets were carefully chosen to encapsulate critical aspects of user experience, ensuring that the scoring process was comprehensive and provided meaningful feedback about the system's performance.

Once all the interactions for each scenario and role were completed, and each lab member provided their individual scores, these were then compiled and analyzed. The average score was calculated by summing up all the individual scores for each scenario and role, and then dividing by the total number of scores.

By adopting this role-based testing approach, the evaluation of CareCompanion became more comprehensive and realistic. Lab researchers, assuming the roles of ADRD patients and family members, could closely simulate the challenges and requirements of real users. This approach allowed for in-depth analysis of the system's functionalities, strengths, and areas that required further refinement.

The findings from these role-based tests provided valuable insights into the performance of CareCompanion, enabling researchers to identify any limitations, bugs, or areas for improvement. The data collected during these simulated interactions informed iterative design and development processes to enhance the system's accuracy, usability, and effectiveness. It is important to note that although role-based testing with lab researchers provides valuable insights, further evaluation with real ADRD users is necessary to validate the system's performance in real-world settings. The data gathered from role-based testing serves as an essential step towards ensuring that CareCompanion is well-prepared for the next phase of testing and eventual deployment to actual ADRD users.

V. Conclustions

This paper presents the design, development, and preliminary evaluation of CareCompanion, a virtual assistant tailored specifically for individuals with ADRD and older adults. CareCompanion utilizes advanced AI technologies, including natural language processing, machine learning, and knowledge graphs, to address challenges related to memory loss, navigation difficulties, and social isolation. Preliminary evaluation results demonstrate the potential of CareCompanion in improving the quality of life, independence, and social engagement for individuals with ADRD and older adults. However, it is important to acknowledge the limitations of this study, including the absence of real user studies. While lab researchers simulated real-life scenarios, conducting studies with actual users would provide more accurate insights into the performance and effectiveness of CareCompanion in real-world contexts.

Future work will focus on conducting real user studies to further evaluate and refine CareCompanion. These studies will involve individuals with ADRD and older adults, allowing for a more comprehensive assessment of the virtual assistant's functionalities, usability, and customization. User feedback will be incorporated to enhance the accuracy, responsiveness, and user experience of CareCompanion. Overall, CareCompanion shows promise in addressing the multifaceted challenges faced by individuals with ADRD and older adults. Further research and development, including real user studies, will contribute to the continuous improvement and optimization of CareCompanion, ensuring it effectively supports individuals in managing their daily tasks, appointments, and social connections, while mitigating the impact of memory loss, navigation difficulties, and social isolation.

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