V-CARE: VR Cognitive Assistance and Recommendation Engine

Zhengyang Feng

School of Computer Science, University of Technology Sydney, Ultimo, NSW, Australia, Zhengyang.feng@student.uts.edu.au

Jayan Chirayath Kurian

School of Computer Science, University of Technology Sydney, Ultimo, NSW, Australia, jayanchirayathkurian@uts.edu.au

Mukesh Prasad

School of Computer Science, University of Technology Sydney, Ultimo, NSW, Australia, mukesh.prasad@uts.edu.au

Nimish Biloria

School of Architecture, University of Technology Sydney, Ultimo, NSW, Australia, nimish.biloria@uts.edu.au

Priya Saravanakumar

School of Nursing and Midwifery, University of Technology Sydney, Ultimo, NSW, Australia, priya.saravanakumar@uts.edu.au

Dementia affects over 55 million people globally, with prevalence projected to reach 139 million by 2050, creating significant clinical and economic challenges. Virtual reality (VR) has demonstrated potential to improve emotional well-being, cognitive engagement, and social interaction for people living with dementia (PLWD). However, adoption in aged care remains limited due to insufficient personalization, caregiver training gaps, and organizational barriers. This study has four objectives: (1) identify available VR therapies for PLWD; (2) examine how demographic and contextual factors, such as dementia stage and cultural background, shape VR preferences; (3) explore caregivers' perspectives on integrating VR into individualized care; and (4) develop V-CARE, an AI-driven VR cognitive assistance and recommendation engine. Using a PRISMA-guided literature review and Gioia-based caregiver interviews, this research informs V-CARE's design to deliver personalized VR therapy, reduce caregiver burden, and support scalable, context-aware implementation, ultimately enhancing the quality of life for PLWD and improving dementia care delivery.

Keywords: Virtual Reality (VR), People living with dementia (PLWD), Recommendation Engine

1 INTRODUCTION

Dementia affects more than 55 million people worldwide, with prevalence expected to increase to 78 million by 2030 and 139 million by 2050 (World Health Organization [WHO], 2023). It is the seventh leading cause of death globally and a significant driver of disability and dependency among older adults (WHO, 2020). The economic burden is profound, with the global cost of dementia care estimated at USD 1.3 trillion in 2019, approximately half of which is borne by informal caregivers, primarily women (WHO, 2017). These figures underscore the urgent need for scalable, person-centered interventions that not only mitigate symptoms but also improve quality of life for people living with dementia (PLWD).

While pharmacological approaches remain common, they often provide limited relief and may be accompanied by adverse side effects. As a result, there is increasing interest in non-pharmacological, technology-enabled interventions to address the multifaceted needs of PLWD. Virtual reality (VR), in particular, has emerged as a promising tool capable of enhancing emotional well-being, stimulating cognitive engagement, and promoting social interaction (Saredakis et al., 2020; Rose et al., 2021). By immersing users in meaningful, multisensory environments, VR can trigger reminiscence, reduce behavioral disturbances, and foster a sense of connection with past experiences.

However, despite encouraging evidence, the integration of VR into aged care remains limited and fragmented. Barriers such as insufficient personalization, lack of caregiver training, organizational constraints, and infrastructural limitations continue to impede widespread adoption (Matsangidou et al., 2023; Windle et al., 2023). Most commercial VR platforms offer static content libraries with minimal adaptability to the cultural, emotional, or cognitive needs of residents, reducing their therapeutic value (Brooks et al., 2024). Moreover, aged care staff often lack the training or confidence to facilitate VR therapy effectively, leading to inconsistent use even when hardware is available.

To address these challenges, this paper introduces V-CARE (VR Cognitive Assistance and Recommendation Engine) - an AI-driven system that integrates user profiles, caregiver insights, and contextual data to deliver personalized VR experiences for PLWD. By embedding adaptive feedback loops and leveraging machine learning, V-CARE aims to enhance personalization, improve safety, and support scalable integration of VR into dementia care routines.

2 RESEARCH OBJECTIVES

Based on the gaps identified in the literature and qualitative fieldwork, this research is guided by four objectives:

1. To identify the types of virtual reality (VR) therapies available for people living with dementia.
2. To examine how demographic and contextual factors (such as dementia stage, cultural background, personal interests, and profession) influence the preferences of people living with dementia.
3. To explore caregivers' perspectives on incorporating personalized VR therapies into individualized care plans.
4. To develop and propose V-CARE, an AI-driven VR cognitive assistance and recommendation engine that addresses personalization and implementation challenges in aged care.

These objectives align with the broader goal of advancing the implementation of AI-enabled assistive technologies in aged care through the integration of socio-technical frameworks, including the NASSS (Nonadoption, Abandonment, Scale-up, Spread, and Sustainability) model (Greenhalgh et al., 2017).

3 METHODOLOGY

The V-CARE concept is grounded in findings from a two-stage research design that combines systematic evidence synthesis with qualitative inquiry.

3.1 Systematic Literature Review

A PRISMA-guided review was conducted across AIS eLibrary, IEEE Xplore, Scopus, and PubMed, focusing on studies published between 2020 and 2024. A total of 98 studies were included after screening 8,532 initial results. These studies were mapped to the seven NASSS framework domains to identify the key barriers and facilitators of VR adoption in dementia care.

Key findings from this stage revealed that while VR can improve emotional well-being and social engagement (Rose et al., 2021; Matsangidou et al., 2023), its adoption is hindered by limited personalization, insufficient staff training, infrastructural constraints, and lack of long-term implementation strategies (Baudin et al., 2024). These findings informed the design principles of V-CARE, particularly its focus on personalization and adaptive learning.

3.2 Qualitative Interviews

Stage two of the study employed semi-structured interviews with aged care professionals from four Australian states, including facility managers, lifestyle coordinators, and frontline caregivers. Using the Gioia methodology (Gioia, Corley, & Hamilton, 2013), interview transcripts were systematically coded to identify first-order concepts, which were then grouped into second-order themes and further distilled into seven aggregate dimensions: emotional engagement and social connection, behavioral regulation and cognitive stimulation, therapeutic customization, financial and safety constraints, integration into care workflows, caregiver training and confidence, and organizational readiness. This rigorous, iterative approach ensured that the findings remained grounded in participants' experiences while enabling the development of higher-level theoretical insights. The results will highlight the critical role of caregiver facilitation and the importance of culturally resonant content in sustaining VR use, underscoring the need for an intelligent recommendation engine, such as V-CARE, to reduce staff burden and enhance therapy personalization.

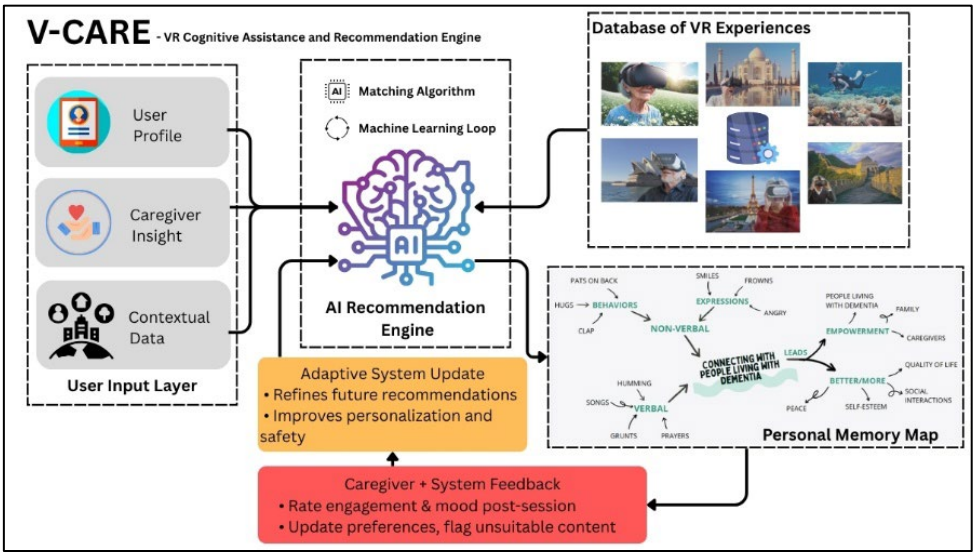

Figure 1: The system architecture of V-CARE

4 V-CARE SYSTEM ARCHITECTURE

V-CARE operationalizes these insights through an AI-driven framework (see Figure 1):

1. **User Input Layer:** Combines user profile data (e.g., cognitive status, preferences), caregiver insights (e.g., observed reactions, interviews), and contextual data (e.g., facility resources, weather).
2. **AI Recommendation Engine:** Employs a matching algorithm and machine learning loop to deliver tailored VR experiences, refining future recommendations based on engagement data.
3. **Database of VR Experiences:** A curated library of VR therapies.
4. **Personal Memory Map:** Maps user interactions and emotional responses as well as their demographic and contextual factors to create a dynamic profile of therapeutic preferences.
5. **Feedback Mechanism:** Integrates caregiver ratings on resident engagement and mood, enabling continuous system refinement and flagging of unsuitable content.

This adaptive system not only personalizes therapy but also supports caregivers by streamlining content selection, reducing trial-and-error, and embedding VR more seamlessly into routine care.

5 EXPECTED IMPACT AND CONTRIBUTIONS

V-CARE offers significant contributions to dementia care and digital health research by enhancing personalization through machine learning and adaptive feedback, enabling the dynamic tailoring of VR therapy to residents' cognitive stages and cultural contexts. It also supports caregivers by providing decision-support tools that streamline VR facilitation, reduce uncertainty, and boost staff confidence and engagement. Moreover, V-CARE has the potential to improve the quality of life for people living with dementia (PLWD) by fostering emotional well-being, stimulating cognitive engagement, and strengthening social connections while alleviating caregiver burden.

REFERENCES

Deborah Brooks, Katy Wyles, Nancy A. Pachana, Elizabeth Beattie, and Joseph E. Gaugler. 2024. Tailored videoconferencing counselling program to support family carers of people living with dementia during the transition to permanent residential care: a pilot and feasibility randomised trial. *BMC Geriatrics, 24,* 375. DOI: https://doi.org/10.1186/s12877-024-04907-4

Dennis A. Gioia, Kevin G. Corley, and Aimee L. Hamilton. 2013. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods, 16,* 15–31. DOI: https://doi.org/10.1177/1094428112452151

Dimitrios Saredakis, Hannah A. D. Keage, Megan Corlis, and Tobias Loetscher. 2020. Using Virtual Reality to Improve Apathy in Residential Aged Care: Mixed Methods Study. *J Med Internet Res 2020;22(6):e17632*. DOI: https://doi.org/10.2196/17632

Gill Windle, Greg Flynn, Zoe Hoare, Patricia Masterson-Algar, …, and Joshua Stott. 2022. Effects of an e-health intervention 'iSupport' for reducing distress of dementia carers: protocol for a randomised controlled trial and feasibility study. *BMJ Open 2022;12:e064314.* https://doi.org/10.1136/bmjopen-2022-064314

Katarina Baudin, Angelina Sundström, and Helen Lindner. 2024 Informal carers' experiences in everyday life and the use of digital assistive technology for time management in persons with dementia or mild cognitive impairment. *BMC Geriatrics, 24.1 (2024): 365*. DOI: https://doi.org/10.1186/s12877-024-04979-2

Lora Appel, Eva Appel, Orly Bogler, Micaela Wiseman, Leedan Cohen, Natalie Ein, Howard B. Abrams, and Jennifer L. Campos. 2020. Older adults with cognitive and/or physical impairments can benefit from immersive virtual reality experiences: A feasibility study. *Frontiers in Medicine, 6,* 329. DOI: https://doi.org/10.3389/fmed.2019.00329

Maria Matsangidou, Theodoros Solomou, Fotos Frangoudes, Ersi Papayianni, and Constantinos S Pattichis. 2023. Offering Outworld Experiences to In-Patients With Dementia Through Virtual Reality: Mixed Methods Study. *JMIR aging 6.1 (2023): e45799*. DOI: https://doi.org/10.2196/45799

Trisha Greenhalgh, Joseph Wherton, Chrysanthi Papoutsi, Jennifer Lynch, Gemma Hughes, Christine A'Court, … and Sara Shaw. 2017. Beyond adoption: A new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *Journal of Medical Internet Research, 19,* e367. DOI: https://doi.org/10.2196/jmir.8775

Vienna Rose, Inga Stewart, …, and Maria Matsangidou. 2021. Bringing the outside in: The feasibility of virtual reality with people with dementia in an inpatient psychiatric care setting. *Dementia, 20(1), 106-129*. DOI: https://doi.org/10.1177/1471301219868036

World Health Organization. 2017. Global action plan on the public health response to dementia 2017–2025. Retrieved from https://www.who.int/publications/i/item/global-action-plan-on-the-public-health-response-to-dementia-2017---2025

World Health Organization. 2020. Dementia. Retrieved from https://www.who.int/news-room/fact-sheets/detail/dementia

World Health Organization. 2023. Global status report on the public health response to dementia. Retrieved from https://www.who.int/publications/i/item/9789240033245