Home Integration of Conversational Robots to Enhance Ageing and Dementia Care

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ABSTRACT

Conversational technology provides an accessible interface for verbal engagement and support in daily living. However, bridging the gap between robotics research for ageing and dementia care and deployment in everyday life remains a significant challenge. My research investigates how conversational robots can support the independence and well-being of older adults and people living with dementia (PLWD) at home. We analysed interactions with commercial conversational agents deployed in homes with PLWD over 6+ months. We introduced a framework to map behaviour by correlating activities detected by environmental sensors with voice interactions. Using a participatory approach, we underscored key feasibility challenges to support PLWD in different cultural and economic contexts (UK and India). Future work will design and analyse human-robot natural language interactions to promote and monitor cognitive health in target populations.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; *Usability testing*; *Interaction design*; *Natural language interfaces.*

KEYWORDS

Conversational AI; socially assistive robots; ageing; dementia care

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1 INTRODUCTION AND BACKGROUND

With the global population ageing and dementia prevalence rising, its care, early detection, and prevention are public health priorities. Today, over 55 million people live with dementia worldwide, with 60% residing in low-and middle-income countries [31]. PLWD often rely on informal carers to help them with activities of daily living. This places an enormous financial and emotional burden on families and carers [7]. Socially assistive robots (SAR) and conversational AI are recognized for their potential to support healthy ageing and dementia care [1, 14, 21]. Speech has been argued as the most effective mode of interaction for SAR to engage with end-users [12]. By combining voice with other interactive features (e.g., facial expressions, gestures, embodiment), conversational robots provide an intuitive interface with potential to promote independence, well-being, and safety at home. Past research underscored their utility in home assistance, including medication reminders [6], cognitive stimulation [30], companionship [2], and daily living [28], while reducing the burden placed on carers [9]. When integrated with environmental sensors, SAR can enhance safety by monitoring behaviour at home and alerting stakeholders to risks, such as cognitive decline or a fall [17, 26]. As large language models (LLMs) continually change the landscape of contextual dialogue [8], their integration with SAR offers a new horizon for human-robot engagement [32]. Yet, the ethical implications in the context of engaging with older people with cognitive care needs remain to be addressed. There has been emerging interest in applying machine learning, particularly speech and natural language processing techniques, to detect early signs of dementia and cognitive decline [11, 15] from acoustic and linguistic features [3–5]. These can be extracted from HRI over time, which represents a promising direction. Yet, few studies have used SAR in cognitive assessment scenarios [10, 23, 25, 27].

Despite the promise of conversational SAR, its direct impact on supporting dementia care in daily living remains underexplored. This work reviewed the literature [18] to understand design trends and current applications to support target populations. Key gaps were identified: 1) gathering *longitudinal* HRI data from older people and PLWD in real-world settings (e.g., homes), 2) *adapting HRI* to individual health and cognitive needs for personalized care, and 3) leveraging *participatory research* to identify meaningful support scenarios, understand user preferences and concerns to design desirable and non-intrusive HRI for long-term utility at home. This doctoral research explores how conversational SAR can support the independence and well-being of older adults and people affected by dementia. Specifically, this work targets: 1) in-home behaviour monitoring, 2) longitudinal user engagement, and 3) feasibility of implementation across different cultural and economic contexts. We follow user-centred design methods [20] while incorporating the invaluable expertise of people with lived experience of dementia for iterative development and testing. This work is guided by the following research questions:

RQ1: Can conversational technology and environmental sensors map behaviour to support dementia care?

RQ2: How do stakeholders perceive and conceptualise SAR for dementia care in different cultural settings (UK and India)?

RQ3: How can human-robot natural language interactions give insights into cognitive health?

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2 RESEARCH APPROACH

Monitoring Behaviour and Well-being at Home. This work investigates conversational social robots that verbally engage with target users to: 1) query health and well-being, 2) map behaviour at home, and 3) provide personalised assistance in daily activities. We conducted a longitudinal study in homes of PLWD (N = 14) over 6+ months to explore the integration of conversational AI in smart homes [17]. Participants interacted with a commercial conversational agent (Alexa) to complete a daily well-being questionnaire and trigger topics of interest.

We found a significant decrease in engagement after the novelty phase (> 3 months [29]) as measured by technology usage. We argue this decline is due to a lack of perceived utility and adaptative interactions to individual needs and preferences over time. We propose future directions to sustain engagement with target populations by designing HRI that is user-friendly, contextually responsive in the home environment, adaptive to individual needs, and fosters human connections between PLWD and carers.

This work introduced a novel framework to map behaviour and well-being within smart homes using conversational technology. Our behaviour analysis correlated in-home activities detected by environmental sensors (e.g., motion, use of kitchen appliances, taking vitals) with Alexa voice interactions. Findings suggest the potential to directly query PLWD, verifying health symptoms or behavioural changes captured by environmental sensors. We envision this approach as promising for providing proactive verbal support in response to safety risks at home and initiating alerts for timely interventions.

Amplifying the Voices of People Affected by Dementia. Engaging stakeholders in the scoping of conversational robots is key to designing meaningful interactions that meet the changing needs of target users [13, 24]. We conducted a series of participatory workshops to involve people with lived experience with dementia and frailty (N = 20) in our research [16]. Through participatory group activities and individual HRI prototype testing, participants were encouraged to think critically about technology features and support scenarios that are acceptable and desirable for long-term utility in dementia care at home.

Participants underscored the value of using conversational AI to support daily routines with personalised verbal guidance, monitor behaviour to mitigate risks at home, and enhance cognitive engagement. Discussions revealed key design features that drive user acceptance, such as adaptation of interactions to varying cognitive abilities and familiarity with technology, a task-based and encouraging communication style that respects user autonomy, and transparency of robot capabilities to avoid mistrust.

We identified barriers to adoption, including accessibility, trust, and reliance on the carer for operation. Additionally, we translated our findings into design guidelines [16] to improve human-robot natural language interactions for dementia care while addressing existing adoption challenges.

Exploring Cultural Feasibility in India. Our ongoing work addresses the cultural feasibility of SAR in different cultural and economic contexts to ensure culturally tailored deployment in the real world. This work introduced the first robot for dementia care in India, a low-cost affective robot combining virtual facial expressions and speech. In collaboration with a geriatric mental health clinic in India, the robotic platform was culturally validated with older people (N = 26) and PLWD (N = 14) with demonstrated potential for remote cognitive engagement in India [19, 22].

We then undertook a mixed-methods participatory study with stakeholders, including PLWD, carers, and clinicians (N = 29), to explore their perspectives on the cultural feasibility of conversational robots for dementia in India. PLWD engaged with three robotic platforms with varying interactive modalities in single HRI sessions: Alexa, a virtual affective platform built upon our previous work in [19], and the commercial social robot Miko. We assessed engagement in HRI, robot acceptance and user preferences for robot features via behaviour observation and questionnaires.

This study offers culturally tailored insights for adapting robots to India's culture. Key findings include the need to improve speech processing in noisy settings and local accent interpretation, culturally adapt the robot's interaction style and appearance, and promote familiarity with prototype deployments in local clinics.

3 PROPOSED WORK

Future work will use the proposed framework to map in-home behaviour and well-being, aiming to develop more personalised HRI for enhanced ageing and dementia care. Specifically, we envision conversational AI offering *automated verbal support* in response to activity changes or safety risks to enhance independence at home and relieve the burden on carers. We identify the following use cases for future investigation: 1) encourage behavioural changes to promote well-being, such as by suggesting an activity or a drink for hydration at appropriate times and 2) offer verbal guidance in the event of perceived agitation or confusion.

Based on the findings from participatory cross-cultural studies in the UK and India our future work will iterate the current HRI design and robot prototypes with *guidance emerging from stakeholders*. We are also interested in exploring how to leverage LLMs to foster long-term engaging interactions with target populations and the ethical implications involved in this context.

This doctoral work will investigate the use of SAR to promote and monitor cognitive health among target populations. We believe this forms a step towards tracking cognitive state from regular natural language HRI with the potential to identify individuals requiring a more comprehensive evaluation. Additionally, future analysis will use machine learning models to explore acoustic and linguistic features for early dementia screening.

4 CONTRIBUTION

This work follows an iterative process of stakeholder involvement (PLWD, carers, clinicians), technical development, and user testing. We offer novel insights and unprecedented long-term data acquisition for home integration of conversational robots to enhance independence and well-being in ageing and dementia care. We are shaping the trajectory of our research by considering the voices of stakeholders and their distinct experiences with dementia. Finally, this research paves the way for a more inclusive and culturally aware HRI design for dementia care worldwide.

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