FEASIBILITY AND ACCEPTABILITY OF A ROBOTIC ASSISTANT FOR EARLY-STAGE ADRD SUPPORT

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Meeting the Moment: Robotic Assistance to Support ADRD Caregivers

Alzheimer's Disease and Related Dementias (ADRD) represent one of the most pressing public health challenges facing our society today. With an aging population, the number of individuals impacted by ADRD continues to grow, placing an increasing strain on caregiving resources, healthcare infrastructures, and family members. The disease progression often leads to a loss of independence, increased reliance on caregivers, and heightened vulnerability to complications such as falls, medication mismanagement, and social isolation. Traditional caregiving approaches, while essential, struggle to meet the expanding needs of this demographic.

Robotic assistant technologies offer a pathway to address these challenges, enhancing traditional caregiving practices and potentially transforming the care landscape for individuals with early-stage dementia. By integrating artificial intelligence, real-time monitoring capabilities, and responsive interactions, robotic systems such as the **RUYI robotic assistant** developed by our industry partner **NaviGAIT**, hold potential to support independence, improve daily functioning, and alleviate the caregiving burden. Unlike conventional assistive technologies, robotic systems can adapt dynamically to individual needs, monitoring critical parameters—such as posture, gait, activity engagement, and social interactions—and responding proactively to emerging risks.

Our project, funded by the **National Institute on Aging (NIA)** through the **Johns Hopkins University Artificial Intelligence and Technology Collaboratory (AITC),** seeks to evaluate the feasibility, acceptability, and practical impact of the RUYI robot within a real-world caregiving environment. By collaborating with **Judson Senior Living in Cleveland**, we will gain direct insights into the effectiveness and user perceptions of robotic care solutions in an authentic setting. Our mixed-methods approach integrates quantitative validation of RUYI's monitoring technologies with qualitative assessments exploring user experiences, acceptance, and ethical considerations.

Goals of the RUYI Project

Our project aims to evaluate the feasibility, acceptability, and practical impact of the RUYI robot within a caregiving environment. **Our primary objectives include:**

Technical Validation

Employing advanced quantitative methods to verify the accuracy and reliability of RUYI's integrated monitoring systems, including gait analysis, posture tracking, activity engagement, and real-time pose estimation.

User Acceptance and Experience

Gathering qualitative insights through interviews and focus groups with independent-living residents, family members, and caregiving staff, to evaluate usability, and the integration of RUYI into daily caregiving routines.

Interdisciplinary Collaboration

Leveraging expertise from NaviGAIT, Judson Senior Living, and CWRU's Weatherhead School of Management and School of Medicine to understand and enhance the use and effectiveness of robotic assistant technologies.

The **overall goal** of our project is to establish a clear, evidence-based foundation for future interventions and policies in dementia care. We seek to inform scalable implementations, support regulatory and ethical guidelines, and contribute to the broader conversation about responsible integration of robotics into eldercare.

At a Glance: Project Milestones and Methods

Our study is conducted in three phases, each involving distinct research procedures:

Phase 1

Acceptability Focus Groups

Structured focus groups will be conducted with independent-living residents (both ADRD and non-ADRD) at Judson Senior Living, family members, and caregiving staff and management. These groups will explore general attitudes towards robotics in elder care and gather perceptions about the potential use of the RUYI robot.

Key Objective:

Assess general mindsets regarding the use of technology and robotics in home assistance.

Phase 2

RUYI Short Visits

The RUYI robot will be introduced into the homes of selected ADRD residents for short visits lasting 1-2 hours. During these visits, the robot will collect data on posture, gait, and daily activities, such as mobility and personal care tasks. RUYI will also converse with residents to learn about their potential likes, dislikes, and hobbies – building a profile of potential social topics and/or activities to engage with the participant during a potential extended visit. Follow-up interviews will be conducted to gather feedback on the experience.

Key Objectives:

1. Evaluate RUYI's ability to adapt in home environments, navigating throughout a single-level household and avoiding obstacles as it performs monitoring functions.
2. Assess perceptions of RUYI as a functional tool or potential companion through reflections on the robot's appearance and actions, curiosity, or hesitation during the short interactions.

Phase 3:

RUYI Extended Visits

A subset of residents will be selected for overnight placement of RUYI in their homes, allowing for more natural interaction and the collection of continuous data on daily activities, movements, and behaviors. RUYI will converse with residents in several programmed scenarios:

- **Hydration Reminder**
  "It's time to drink some water. Staying hydrated keeps you healthy!"
- **Personalized Social Engagement**
  "Would you like to listen to music, hear a story, or play a memory game?"
- **Direct Intervention to Inactivity**
  "I noticed you've been sitting for a long time. Would you like to stretch or walk?"

RUYI will also capture detailed information about posture, gait, transitions, activities, behavior, and interactions with the resident.

These metrics provide a view of individual physical function to identify mobility decline, cognitive-motor impairment, and environmental hazards.

Key Objectives:

1. Analyze and validate RUYI device data to determine if the robot performed according to designed specifications and understand potential contributing factors to performance deviations.
2. Assess perceptions of RUYI's responsiveness and perceived strengths and limitations in enhancing safety, independence, and routine assistance.

RUYI's Integrated Technology Capabilities

RUYI employs advanced sensing technologies to capture and analyze mobility and behavior in real-time:

Orbbec Femto-Series Depth Camera

- Captures detailed 3D depth data with a wide field of view
- Combines high-definition RGB video with infrared depth sensing

Nvidia TensorRT Pose Estimation Model

- Utilizes deep learning to identify joints and limbs with high accuracy to estimate human skeletal poses
- Supports multi-person pose estimation, suitable complex environments

Analyzing RUYI's Raw Data Capture

We use several quantitative techniques to validate key captured metrics such as gait and balance parameters to derive meaningful insights and actionable trends for mobility, activity performance, and fall prevention:

Dynamic Time Warping

Compare temporal sequences of movement data, such as gait cycles, to detect irregularities or deviations from normal patterns.

Principal Component Analysis

Reduce the dimensionality of complex data, such as multi-point pose estimations, to help identify dominant patterns or anomalies in gait and posture data.

Hidden Markov Models

Model sequential activity data, such as transitions between walking, standing, and sitting, to identify probabilistic patterns for detecting subtle changes in mobility routines.

Support Vector Machines

Classify data points based on extracted gait and pose features for building predictive models that combine multiple mobility-related parameters.

Fourier Transform Analysis

Analyze frequency components of movement data, such as sway or balance oscillations, to assess stability, identifying repetitive patterns in motion that may signal underlying impairments.

Unlocking Potential: Key Takeaways and Next Steps

Our project will inform the further development and commercialization of the RUYI robot while also enhancing our understanding of how robotic assistance can improve the quality of life for older adults with dementia. We see this project as initiating larger-scale studies to broaden the scope of robotic caregiving interventions. **Some future objectives include:**

Scale-Up Studies:

Implementing broader deployments of RUYI robots across multiple residential settings to further evaluate feasibility and integration on a larger, more diverse scale.

Policy and Ethical Guidelines Development:

Informing policy discussions and developing clear regulatory and ethical frameworks for integrating robotic technologies into dementia caregiving.

Technological Refinement and Innovation:

Leveraging data insights and user feedback to refine RUYI's functionalities, enhancing user experience, and expanding technical capabilities for broader caregiving applications.

The evaluation and insights gained through this multi-phase project will significantly advance the understanding and integration of robotic caregiving solutions, providing a strong foundation for future innovations and interventions in dementia care.

Acknowledgement

We want to thank the Johns Hopkins University AI & Technology Collaboratory for Aging Research (AITC) as the funding source for this project, under a grant provided by the National Institute on Aging (P30AG073104).

See an animation of RUYI in action!