Preliminary Hardware and System Design Investigation for an Affordable and Mobile Assistive Robot for Elderly Care

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Abstract— **This work proposes the development of a robot to perform appropriate tasks to assist low income older adults based on the merging of two previous studies, one which focused on task investigation and deployment of mobile robots in elder care facilities and the other on design investigation for a socially assistive robot using low-cost and modular hardware and software design. We identified that hydration, walking and socialization were tasks appropriate for the robot and most impactful to the older adults. Another outcome was the level of importance of the HRI component in the implementation of these tasks, thus merging both studies to initially investigate preferences in service robots for elder care is proposed.**

I. INTRODUCTION

The increase worldwide of the elderly population for the next 30 years [1] demands creative solutions to facilitate older adults independence in Activities of Daily Living (ADLs) or Instrumental Activities of Daily Living (IADL) [2]. In particular, a low-cost autonomous robot can aid caregivers by interacting with elders, promoting physical exercise and hydration while maintaining health logs of elder interactions. Previous research on elder care robotics includes social assistive robots (SAR) [6] emerging both academic and commercially [5], entertainment and reminders [3]. In particular, SAR systems have been shown to increase user engagement in exercises [7], improve adherence to prescribed lifestyle [8] lower stress [9], and stimulate socialization [10]. SAR platforms must be capable of recognizing social signals, reason over those signals, and generate appropriate behaviors in response [11]. Requirements such as affect expression and gesture production necessitate degrees of freedom (DOFs) on HRI platforms for which most non-social robots have little use. The human face, for instance, provides the richest, most unambiguous signal of affect [12] and robots with actuated or projected faces can exploit this to convey their own emotional cues. The utility of reflecting human features extends beyond facial features; affect and demeanor can be expressed more subtlety through body language. Meaningful gestures such as deictic gestures (pointing) are most easily issued with arms, despite the fact that they are not used for physical manipulation.

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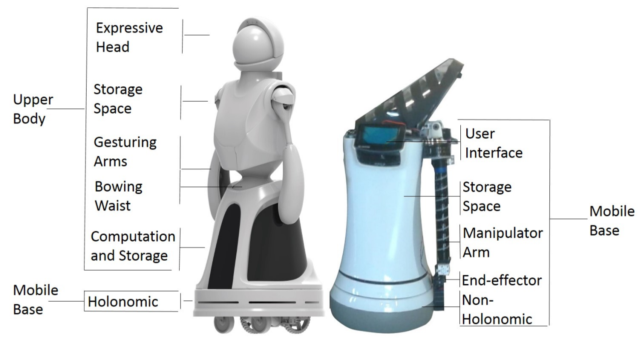

Fig. 1: Quori (left) and adapted Savioke Relay (right) mobile robot bases employed in previous studies.

II. INITIAL INVESTIGATION ON ROBOT FORMS: HARDWARE AND SYSTEM OVERVIEW

Initially, this study seeks to determine elder's preference of humanoid versus non-humanoid form factors using focus groups of clinicians and elders. Protocols will be developed to determine what expectations and the impact of missed expectations of robot capabilities will have. Following the initial study, a low-cost (about USD 5,000) prototype will be created with features determined from the investigation. Lastly, the robot will be deployed in a Program of All-Inclusive Care for the Elderly (PACE) Center to evaluate its service features in autonomous operation, performing various tasks to test different aspects of functionality while recording health monitoring information.

A. Savioke Relay

The Savioke Relay robot[1] was designed for applications such as item delivery in hotels (Fig. 1, right). Capable of autonomous navigation, the robot was modified with custom software and a manipulator able to reach the ground, retrieve objects weighing up to 1 kg and manipulate them in limited workspaces [17]. The adapted arm is a 2 DOF telescopic manipulator based off the spiral zipper extension technology [18]. The arm can retract to $20\,cm$, giving the robot ability to avoid collisions and transit in dynamic or cluttered environments.

B. Quori

Quori (shown in Fig. 1) is made of:

- Holonomic Mobile Base: a diff-drive base with a turret achieves holonomic motion of the upper torso [16].

[1] www.savioke.com

- Spherical Projection Head: To maximize flexibility and minimize cost, Quoris head consists of a retro-projected animated face (RAF).
- Gesturing Arms: The arms (not meant for manipulation) have two DOF shoulders. Safety concerning proximity to humans is achieved by limiting the torque on the motors as well as using lightweight materials.
- Spine: In order to support the torso, a 1-DOF spine allows the robot to lean forward or backward. The spine can also minimize possible vibrations due to the robot's motion, resulting in natural motion.

III. Testing procedures for Human-Robot Interaction

An initial approach is to determine elder users' preferences for the robot shape and architecture and whether these preferences would significantly affect the usability and acceptance of a social robot for the tasks identified above, which can be summarized as:

- Demonstrate each robot prototype (Relay and Quori) to a focus group of users and assess their reactions.
- Question-based and scenario-based assessment.
- Pre-trial, mid-trial, end-trial, and post-trial users'test.
- Preferences ranked via the questionnaires based on UTAUT, Almere and SAM models [4].

Conventional content analysis of focus group transcripts will be the analytical technique chosen to attain insight and knowledge into users' perception of the robot and its usefulness [13]. This technique involves several steps: immersion into the data, reading the transcripts to derive highlighted key thoughts (known as codes), sorting the codes into categories based on how the codes relate, and then clustering the emergent categories into themes [14]. The transcripts are uploaded into qualitative software used for data storage, retrieval, coding and management. Such methodology was previously applied and tasks such as hydration, walking, and interactive physical games emerged [15]. Following the focus groups, the task validation process will employ both qualitative and quantitative data analysis methods, using standard tools for evaluating whether users' needs were met by the technology. In order to verify the robot tasks, a mixed-methods approach (focus groups, questionnaires/surveys, and video assessment) will be employed. Survey and questionnaires such as the ones reported in [15] will be used to assess all users' perception of the robot doing companion tasks. Users will be asked to judge the robot's social ability, friendliness, usefulness, competence for the task, and features. Only clinicians will be asked to assess the robot's health monitoring features.

IV. Conclusion and Future Work

We propose an initial investigation employing both qualitative and quantitative data analysis methods to determine form factors of a service robot in elderly care settings. Results will guide a prototype design which will be deployed at a PACE center for autonomous interaction with the older adults and a further study will judge the robot's features and whether demands on the design and tasks by the stakeholders were met.

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