

# Symposium

## **Empowering Independence: Human-Centered Robotics to Support Everyday Living for Older Adults**

P. Bhowmick (Convener). *Gerontechnology* 25(s)

**Participants:** L. Figueredo (UK), S. Kumar (Israel), A. Raji (Canada), P. Bhowmick (US)

**ISSUE:** Robotic systems are increasingly proposed as scalable solutions to help older adults maintain independence, dignity, and safety in daily life, particularly as aging populations intensify pressures on home care and long-term care systems worldwide [1, 2]. Advances in sensing, autonomous control, and dexterous manipulation have unlocked unprecedented potential for robots to support everyday functioning, not only through monitoring and mobility assistance, but also through contact-rich, physically supportive actions that address essential self-care needs [3]. However, significant challenges remain before robots can provide meaningful support in homes and care settings. Systems must be capable of safe and reliable physical interaction while also remaining intelligible, predictable, and trustworthy to individuals whose cognitive, perceptual, and motor abilities vary widely across the aging spectrum. Furthermore, technology acceptance and long-term engagement hinge on designs that respect personal routines, privacy expectations, emotional well-being, and care relationships. These gaps underscore the need for human-centered approaches that integrate engineering innovation with the lived experience of aging. This symposium brings together four interdisciplinary studies spanning gerontechnology, human–robot interaction, rehabilitation robotics, and assistive design to explore strategies for ensuring that emerging robotic systems align with the priorities, capabilities, and dignity of older adults. Together, the speakers explore how robots can: (1) safely execute functional, real-world ADL support in home and care environments, (2) communicate and adapt to maintain shared understanding with users, (3) deliver personalized, motivating rehabilitation aligned with meaningful daily tasks, and (4) support autonomy in private and physically challenging self-care contexts such as showering.

**CONTENT:** 1. Luis Figueredo (UK) examines real-world care contexts through the Geriatrics Lighthouse Initiative, identifying high-value ADL tasks, such as serving drinks and grocery transport, that are physically demanding yet routine. By integrating stakeholder insights with safety-critical technical development and Delphi-style expert evaluations, this work highlights where humanoid and service robots are nearing deployment readiness and where barriers remain. 2. Shikhar Kumar (Israel) introduces a novel framework for robot understandability, operationalized as the discrepancy between a robot’s intentions and a user’s mental model. A Hidden Markov Model that estimates misunderstanding from behavioral cues demonstrates a pathway toward adaptive, communicative robots, a core requirement for trust and usability among older adults. 3. Aisha Raji (Canada) advances rehabilitation robotics for older stroke survivors through personalized, object-based reach-and-grasp training that leverages familiar household items. Early trials reveal promise for improving functional reach and supporting motivation, ecological relevance, and confidence, aspects that are central to long-term recovery and aging in place. 4. Pallabi Bhowmick (US) focuses on a critical yet understudied self-care ADL – showering. Interviews with older adults with long-term mobility disabilities and caregivers emphasize the need for voice-first control, hybrid interactions, and privacy-protective sensing in robotic shower technologies that reinforce dignity and autonomy. **CONCLUSION:** Through these distinct but interconnected contributions, the session advances a unified agenda for robots as empowering partners in aging, not merely technological tools. Together, these four studies illuminate a shared agenda: enabling robots that can act safely, communicate clearly, and address real functional needs of older adults across home and care environments. By integrating engineering innovation with human-centered inquiry, this symposium offers actionable design insights and evaluation strategies that move gerontechnology closer to delivering meaningful, respectful assistance that supports healthy aging and continued participation in everyday life.

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**Main Affiliation and Country of Convener** College of Applied Health Sciences, Department of Health & Kinesiology, University of Illinois Urbana–Champaign, United States

**Email Address of Convener:** [pallabib@illinois.edu](mailto:pallabib@illinois.edu)

**ORCID:** Bhowmick (0000-0002-3692-0197)

# Symposium

**Geriatrics in the View of Robot Applications and Capabilities for Activities of Daily Living** L. Figueredo, S. Stahl, A. Teirmoordeh, S. Haddadin, K. Bengler, I. L. Salvamoser. *Gerontechnology* 25(s)

**Purpose** Population ageing and the healthy-ageing agenda place activities of daily living (ADLs) at the centre of independence and dignity in later life [1]. The EU Commission has acknowledged such challenges, and funded numerous projects on robotics and AI for older adults [2]. Nonetheless, surveys have demonstrated only a modicum of those are focused on manipulation-capable support for physical, household, instrumental, or self-care ADLs [3]. This leaves a structural gap for contact-rich assistance (for example feeding, safe transport of food and medication) and for robust physical safety in domestic and care environments. With rapidly emerging humanoid robots and growing interest in home care, safe physical interaction and reliable support for instrumental and self-care ADLs are therefore becoming central design challenges [2]. **Method** These needs motivated the Geriatrics Lighthouse Initiative in Bavaria, which explores how humanoid and service robots can respond to priorities of older adults, informal carers, and professional staff. Initial studies in nursing homes identified everyday helping scenarios such as shopping support, serving drinks and snacks, and clearing dishes [3]. A second phase used longitudinal demonstrations in a model apartment to refine technical, interactional, and organisational requirements, while subsequent work focused on safety-critical physical human–robot interaction, including safe contacts, ergonomics, and formal safety strategies for liquid and food transport and communication. Building on these efforts and the broader robotics and AI literature for older adults, we link these findings to an expert study that maps robotic capabilities for ADL-related care activities in inpatient care. Multiple video vignettes of real care staff performing representative tasks are rated by robotics experts (motion planning, manipulation, navigation, HRI, robot cognition) for the feasibility of a general-purpose assistive robot for each activity and compared with the perspectives of care professionals. **Results and**

**Discussion** Preliminary insights from the needs analysis and Geriatrics pilots show strong interest in robotic support for physically demanding yet routinised tasks, particularly serving and collecting drinks and dishes (Fig. 1). Across 71 stakeholders, participants highlighted reduced physical strain and time pressure as key benefits, while insisting on clear safety assurances, escalation procedures, and transparent responsibility boundaries. In model-apartment studies with 19 participants, three humanoid-assisted scenarios (beverage and snack service, table clearing, kiosk-like shopping) were successfully executed; verbal interaction was perceived as intuitive, while haptic and proximity cues were experienced as more sensitive and context-dependent. These observations align and guided our technical work on layered safety, safe robot reflexes, and shared autonomy for slish-free liquid transport, which demonstrates that reflex modulation and task-aware trajectory shaping can reduce contact forces and spillage while maintaining task performance, reflecting about and addressing some of the challenges raised. Ongoing Delphi-style ratings of 17 ADL-related vignettes suggest that experts already view some ADL tasks as feasible at pilot or early-adoption levels, whereas some still require to overcome some technological barriers, e.g., body-care tasks. Overall, these initial findings indicate where robotics is close to safe pilot deployment, where it remains experimental, and where interaction or technical barriers persist, while outlining concrete near-term opportunities for Geriatrics to provide safe, manipulation-capable ADL support, stakeholder priorities, and preservation of autonomy and dignity.

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**Keywords:** mobility impairment, older adults, caregiving and independence, assistive showering technology, robotics

**Main Affiliation and Country of First Author** Cyber-physical Health and Assistive Robotics Technologies (CHART), School of Computer Science, University of Nottingham, UK

**ORCID:** Luis Figueredo (0000-0002-0759-3000)



**Fig. 1.** Overview of the stakeholder needs analysis and model-apartment pilot scenarios (serving food, drinks, and snacks scenario).

# Symposium

**Improving Robot Understandability by Bridging Human–Robot Discrepancies** S. Kumar, Y. Edan and S. Bensch. *Gerontechnology* 25(s)

**Purpose** As robots become increasingly autonomous, ensuring they remain understandable to users is critical for both performance [1] and safety [2]. Age-related changes in perception and expression occur among older adults, and this impacts the understanding of robot interactions, making clarity and predictability essential for fostering acceptance [3]. Robot understandability has been defined as the knowledge a robot holds about the user's state of mind [4]. This can be modeled as a discrepancy  $D = |M_R - m_r|$ , representing the difference between the robot's own state of mind  $M_R$  and the user's internal model of the robot  $m_r$ . When this discrepancy exceeds a certain threshold, a communicative action must be generated to address it for successful interaction, thereby enhancing trust in robotic assistance. **Method** To evaluate the discrepancy model, we conducted an exploratory pilot study with younger adults ( $N = 36$ , age =  $26.16 \pm 1.53$ ) and a robotic arm (Sawyer Robot manipulator – 7 degrees of freedom). The exploratory study identified human behavior cues (e.g., verbal utterances, gestures, smiles, task performance, help-seeking, participants' actions, participants' responses) that could indicate a discrepancy. Participants were divided into two groups: primed (informed of task goals) and non-primed (uninformed). Data from video recordings and questionnaires were analyzed using a mixed-methods approach. Insights from this exploratory study informed the development of a Hidden Markov Model (HMM) to estimate discrepancy during interaction. Behavioral cues were treated as observable states, and each hidden state represented a level of discrepancy. We tested HMMs with two, three, and four hidden states; the four-state model yielded the most interpretable structure and achieved the best predictive performance for estimating discrepancy. The overall process is shown in Fig. 1. **Results (a) Discrepancy analysis:** Although both primed and non-primed participants reported similar perceptions of the robot, their observable behavior differed substantially. The primed group, experiencing lower discrepancy, performed the tasks more successfully and followed the robot's short or vague instructions more effectively. Video analysis also revealed clear differences in the number and type of robot-generated utterances and actions, as well as in participants' responses and task-related behaviors. **(b) Discrepancy Estimation Model:** The HMM produced two expected outcomes: correct human actions corresponded to lower discrepancy states, while incorrect actions aligned with higher discrepancy states. This demonstrates that discrepancy reflects users' understanding of the robot. The model enables continuous estimation of discrepancy during interaction, allowing the robot to detect misunderstandings through behavioral cues and adjust its communicative actions accordingly. When the discrepancy is high, the robot can provide more detailed, supportive explanations to reduce it. **Discussion** Estimating interaction discrepancy and adapting robot behavior are essential for effective human–robot interaction. Although this pilot study involved younger adults, the approach is directly applicable to older adults, and future work will evaluate it in that population. Continuous discrepancy estimation allows robots to adapt explanations in real time based on the current discrepancy state, enabling efficient, user-tailored behavior. This is particularly relevant for older adults, whose interaction needs may differ in speech pace, vocabulary complexity, and contextual detail due to age-related changes in perception and cognition. For example, during assistive tasks such as medication reminders, an older adult may expect slower speech, simpler language, and more explicit explanations. In our framework, such mismatches are modeled as observable discrepancy parameters and continuously estimated using an HMM from interaction cues (e.g., delayed responses or clarification requests), allowing the robot to dynamically adjust its communicative behavior and maintain shared understanding.

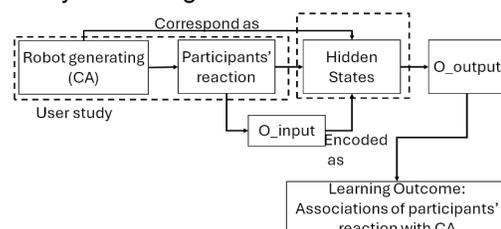
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**Keywords:** Understandable Robot, Discrepancy Model, Hidden Markov Model

**Main Affiliation and Country of First Author:** Ben-Gurion University of the Negev

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**Fig. 1.** Overview of discrepancy evaluation between human and robot states of mind using a Hidden Markov Model based on encoded human behavioral cues from a user study.

# Symposium

## **Robotic Rehabilitation to Retrain Functional Reach and Grasp with Everyday Objects After Stroke A.**

Raji, C. Marquez–Chin, M. Popovic. *Gerontechnology* 25(s)

**Purpose** Stroke is a leading cause of long–term disability among older adults and upper–extremity impairment substantially restricts functional independence, community participation, and aging in place [1, 2]. Despite advances in rehabilitation technology, many robotic systems rely on planar movements, virtual tasks, or simplified object interactions, reducing ecological validity for older adults whose rehabilitation goals center on performing meaningful, everyday tasks [3, 4]. There is a need for adaptive, safe, and individualized robotic systems that present real objects in 3D space to promote functionally relevant reach–and–grasp practice after stroke. In this proof–of–concept study, we developed and evaluated an adaptive robotic system designed to support older adults post–stroke by delivering personalized training using modified everyday objects to enhance engagement, relevance, and motor recovery [5]. **Methods** We integrated a robotic arm with custom safety systems, real–time reach–and–grasp detection, and eleven modified everyday objects from the Toronto Rehabilitation Institute–Hand Function Test (TRI–HFT) [6]. The system used an event–driven algorithm to map each participant’s reachable 3D workspace and automatically generate object–placement tasks tailored to their capabilities. The algorithm placed objects both within and beyond users’ voluntary reach to support progressive challenge, promote active engagement, and reduce compensatory strategies that are particularly common among older adults with chronic stroke. Three older adults post–stroke (aged 61–78) completed 20 training sessions consisting of extent–of–reach capture and repeated object reach–and–grasp trials using objects designed to encourage different grasp types. We collected performance metrics (reach detection accuracy, extent of reach), clinical assessments (ARAT, FIM self–care sub–score, and FMA–UE) [6, 7], and participant feedback focused on usability, motivation, and relevance for older adults. **Results and Discussion** The system consistently operated safely, reliably detected reach events in real time, and consistently adapted task difficulty through real–time workspace mapping. Participants demonstrated increased reachable workspace and engaged their affected arm throughout training. The robot provided individualized, functionally relevant challenge by varying object distance, height, and orientation; 75% of placements were within reach and 25% were strategically beyond it, supporting progressive practice aligned with motor–learning principles. Participants reported that interacting with familiar household objects felt meaningful, enhanced motivation, relevance, and sensory feedback. Notably, all participants reported improved smoothness in their walking after the sessions, suggesting broader benefits such as increased confidence, better postural control, or increased overall sensorimotor activation, areas particularly important for older adults working to maintain mobility and independence. User feedback highlighted strong acceptance. As one older adult remarked, “I wish I had access to this kind of exercise after my injury,” while another described the system as “the most challenging occupational therapy I have ever done.” Overall findings support the feasibility, safety, and acceptability of this object–based robotic system for delivering meaningful upper–extremity training to older adults post–stroke. The approach shows promise for supporting rehabilitation services and supporting older adults as they work toward functional recovery and improved daily participation.

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**Keywords:** Rehabilitation robotics, Stroke, Upper–extremity function, Collaborative robots, TRI–HFT

**Main Affiliation and Country of First Author:** KITE Research Institute, University Health Network, Toronto, Canada & Institute of Biomedical Engineering, University of Toronto, Canada

**ORCID:** Aisha Raji (0000–0001–9222–2484)

# Symposium

## Showering Barriers and Interaction Preferences of Older Adults with Mobility Disabilities for a Robotic Showerhead P. Bhowmick, K. Shahid, Z. Ren, G. Krishnan, W. A. Rogers, I. M. Rice. *Gerontechnology* 25(s)

**Purpose** Bathing and showering are among the most challenging daily activities for individuals with long-term mobility impairments, requiring significant physical effort, coordination, and environmental support [1]. The purpose of this study was to understand the showering challenges experienced by older adults with long-term mobility disabilities and to evaluate user and caregiver perspectives on three innovative Soft Robotic Showerhead (SoRoSh) concepts – elongation, swing, and two–showerhead designs. Our goal was to identify preferred interaction modes (user–guided, voice–controlled, gesture–controlled), desired design features, and perceptions of how such technologies could enhance independence, safety, and usability during showering.

**Method** We conducted semi–structured interviews with 12 participants, including 6 older adults, aged 63–77 (M=72.83; SD=5.03), with long–term (at least 10 years) lower–body mobility disabilities and 6 subject matter experts (SMEs), aged 30–78 (M=60.83; SD=16.82), who were either professional caregivers or family care partners, with at least 1 year of caregiving experience. Participants discussed their current showering routines, unmet needs, barriers to independence, and their feedback on the three showerhead concepts and associated interaction modes. We explored desired improvements, concerns around privacy and technology use, and perceived potential for adaptive showering technologies to support autonomy. Data were thematically analyzed to identify recurring patterns and design–relevant insights.

**Results and Discussion** Participants reported significant physical challenges with showering, including difficulty lifting their arms, reaching all body areas, manipulating handheld showerheads, maintaining balance, and relying on unstable or poorly fitted shower chairs. Participants were positive about the potential of the showerhead concepts. They strongly preferred voice control, citing its low physical effort and ease of access, whereas gesture control was consistently viewed as impractical due to tremors, limited range of motion, spasticity, and environmental interference (e.g., steam, reflections). User-guided manual control was appreciated for its familiarity, and many suggested hybrid modes that combine manual and voice operation to accommodate day-to-day variability in strength and mobility. Participants identified key features they would find beneficial, including integrated water-flow controls, joystick-style input, adjustable spray modes, wake-word activation, and aesthetically streamlined designs. Most believed these technologies could meaningfully extend their ability to shower independently, reduce fear of falling, enhance safety, and improve emotional well–being by reinforcing dignity and control. Participants expressed strong discomfort with cameras due to privacy and security concerns, but sensors were viewed positively for supporting safety functions, showing a preference towards non-visual or privacy-protected sensing approaches. Overall, findings indicate that adaptive showering technologies must prioritize physical accessibility, intuitive multimodal control, customizable features, safety, and privacy. Both older adults and SMEs underscored the potential for such systems to improve independence and quality of life, while highlighting critical design considerations for future development.

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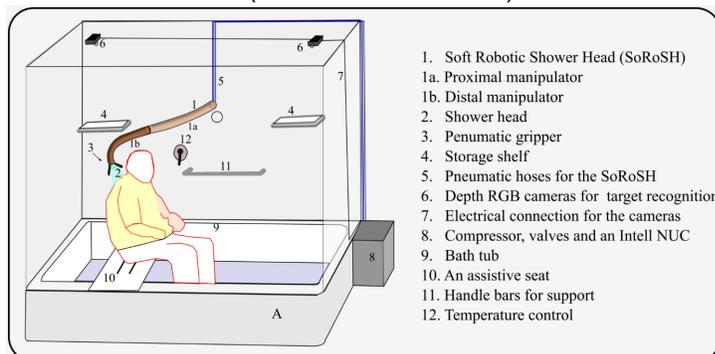
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**Keywords:** mobility impairment, older adults, caregiving and independence, assistive showering technology, robotics

**Main Affiliation and Country of First Author** College of Applied Health Sciences, Department of Health & Kinesiology, University of Illinois Urbana–Champaign, United States

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**ORCID:** P. Bhowmick (0000-0002-3692-0197)



**Fig. 1.** Schematic and labeled representation of SoRoSh