Enhancing Well-being through Socially Assistive Robot.

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Abstract

This research investigates how social assistive robots can contribute to individual well-being through user-centred design. Through a mixed-methods approach including field studies and participatory design, the research explores the effectiveness of robot-mediated interventions on mental and physical health, user acceptance, and interaction quality. Preliminary results include the deployment of AI-enhanced humanoid systems and wearable-integrated architectures for health monitoring, as well as experimental investigations into how robot interaction modalities influence user perception and engagement. Future work aims to assess the long-term impact of these systems, to inform evidence-based guidelines for safe, ethical, and meaningful deployment of social robots in real-world contexts.

Keywords

Human Robot Interaction, Human Robot Collaboration, social robots, social assistive robots, Situation Awareness

1. Introduction

The term *robot* was invented in 1920 by Czech writer Karel Čapek in his play *Rossum's Universal Robots*. Čapek used the word 'robot' to describe machines created to help humans with their work, a concept that later became central to modern robotics. From that first invention, the term robot and the entire field of robotics have faced rapid growth and are now reaching the advanced domain of social robotics [1][2]. This specialization represents a shift from mechanical and automated functions to a more human-centred approach. social robots can provide emotional, social, and practical support, enhancing people's quality of life, using artificial intelligence and sensory systems to create more understanding, adaptive, and intelligent machines. A subset of social robots, known as socially assistive robots, is specifically designed to facilitate social interactions rather than physical ones. These robots are particularly relevant in therapeutic and healthcare contexts, where emotional engagement and personalized interaction are central to the user's experience [3]. A critical driver for effective interaction is Situational Awareness (SA). Originally formulated by Endsley in 1995 [4], SA is defined as "*the perception of elements in the environment, the comprehension of their meaning, and the projection of their status in the immediate future.*" In human-robot interaction terms, SA refers to the robot's ability to perceive user actions and environmental cues to adapt its "behaviour".

The field of social robots can be applied to many fields. For children, it represents a promising frontier in promoting learning and development in young age groups [5]. By engaging in collaborative or competitive games, they can take on active roles, fostering interaction and engagement [6]. It is evident in the literature that research on the adoption of social assistive robots for children must address several challenges. These include assessing the impact of robots on children's learning and well-being through long-term field studies with standardized evaluation tools [7].

Also, the application on social robot among older adults is equally compelling, particularly given the growing older people population and their vulnerabilities spanning the dimensions of chronic diseases, physical limitations, mental disorders, and similar pathology [8][9][10][11][12] . The departure of children from the household for work or personal reasons often leads to increased isolation, which in turn may exacerbate emotional fragility and contribute to the deterioration of psychological well-being in older adults [13][14][15][16][17].

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2. Background literature

In recent years, a growing body of research has investigated the use of robots to support the mental health of older adults. Social robots are now being designed not only to provide assistance with daily tasks, safety, and entertainment, but also to offer cognitive stimulation and emotional engagement. A significant example comes from Salichs et al. [18], who introduced Mini, a social robot developed through expert consultation to ensure relevance to the needs of older adults and their caregivers. Along similar lines, Yvanoff-Frenchin et al [19] focused on a voice-interactive robot designed for mental health assessments. This system allowed specialists to create customized question sets in multiple languages and collect responses from users through a natural interface. While it leveraged tools like Tone Analysis to support emotional interpretation, the authors emphasized the importance of tailoring content to the user's linguistic and medical profile. Hurtado et al [20] use the Pepper robot platform to offer a broad range of physical and cognitive activities, from memory games to guided exercises, all controlled via voice or touchscreen. This approach was particularly valuable during the COVID-19 pandemic, when social isolation had a major psychological impact on the older people. The authors highlighted challenges related to digital literacy and accessibility. Lin et al. [21] reviewed the role of healthcare robots in delivering psychosocial care to older adults during this period, emphasizing the benefits of robot-mediated interventions in mitigating loneliness and stress.

Building on these earlier efforts, recent research has moved toward more nuanced interaction models. For instance, Khoo et al. [22] explored how QTrobot could facilitate meaningful conversations about well-being through short autonomous interactions. Their study revealed a need for improvements in conversation flow, emotional responsiveness, and topic detection to better engage older adults. In a larger-scale deployment, Jeong et al. [23] compared three types of robot interactions and found that a companion-like robot offers more effective support in building therapeutic alliance and enhancing users' enthusiasm than coach or assistant-style robots.

Other studies have examined specific health outcomes. Hsieh et al. [24] found that socially assistive robots were effective in reducing depression and anxiety in individuals with dementia, although the improvements were not sustained in follow-up assessments and did not extend to agitation or overall quality of life. Similarly, Shao et al. [25] highlighted the ability of robots to support exercise routines, monitor health metrics, and provide cognitive stimulation tailored to users' profiles.

Taken together, these studies demonstrate a growing consensus around the potential of interactive robots to enhance both physical and mental health in older adults. However, they also highlight the need for more inclusive, long-term, and ethically grounded research to ensure these technologies are accessible, effective, and safe for diverse users.

3. Research Motivations

The objectives of the research focus on the use of social assistive robots to enhance the well-being and quality of life of individuals. Specifically, it aims to explore how these technologies can provide physical and emotional support, facilitate social interaction, and assist with daily activities. Mental healthcare needs to consider the broad range of users, such as children, adults, and the aged, who have their unique psychological behaviour, communication patterns, and requirements. This heterogeneity requires adaptive systems to understand context and personal preference to provide meaningful and relevant interventions.

The current literature on social robots highlights several significant gaps. First, there is a lack of long-term studies that assess the sustainability and ongoing impacts of social robots. Moreover, successfully implementing these technologies requires a strong interdisciplinary collaboration between healthcare professionals and computer scientists, an area that remains not fully explored. Ethical concerns, particularly around privacy and the handling of sensitive data, are also prominent, with a clear need for standardized global guidelines. Furthermore, while user-centred design is identified as essential, there is a need for more empirical testing to optimize robot interaction with different users.

The social and psychological effects on individuals need further investigation to fully understand how these technologies can help. The exploration of how to achieve inclusive design for social robots has not been thoroughly addressed. Questions remain regarding whether one-on-one interactions with a robot produce better outcomes compared to interactions involving multiple people or even multiple robots. Additionally, an in-depth study is needed to understand how and why familiarity influences interactions with robots, focusing particularly on the motivations behind this influence. Furthermore, there is a lack of research demonstrating whether a social robot can be fully aware of its surroundings and how this awareness impacts its interactions with humans.

4. Objectives and Research Questions

The research questions outlined below were selected to address the role of social robots in enhancing well-being, understanding user interactions, and establishing ethical standards. Each main research question is composed of more specific sub-questions: this hierarchical structure allows for a more focused and detailed exploration of each topic.

RQ_1 What measurable impacts do social robots have on individuals' well-being?

- $RQ_{1.1}$ How do social robots improve physical well-being of individuals?
- $RQ_{1.2}$ How do social robots improve mental well-being of individuals?
- $RQ_{1.3}$ What could be the risks of long-term use of social robots?

RQ_2 How do different populations' backgrounds influence social robots' acceptance and/or effectiveness?

- $RQ_{2.1}$ How does varying technological familiarity affect how individuals interact with social robots?
- $RQ_{2.2}$ How can social robots be designed with inclusive programming to reduce the impact of technological disparities?
- $RQ_{2.3}$ Does individual interaction with a social robot enhance performance and user satisfaction compared to group interactions with a social robot, and what are the potential benefits of one-to-one versus group dynamics in human-robot interactions?

RQ_3 How does situational awareness in social robots enhance human-robot interaction, and to what extent does it contribute to improved user engagement, comfort, and overall well-being?

RQ_4 What ethical guidelines should be formulated to manage the development and implementation of social robots in private and healthcare settings to ensure user safety and dignity?

RQ_1 focuses on the potential impacts of social robots on individuals' well-being. This main question is broken down into sub-questions: $RQ_{1.1}$ and $RQ_{1.2}$ investigate how social robots enhance physical and mental well-being, respectively. These distinctions are crucial because they allow for targeted assessments of the robots' effects on different dimensions of health, with the possibility to explore whether and how these effects differ. Furthermore, $RQ_{1.3}$ considers potential negative effects, acknowledging that while social robots can be beneficial, there may be thresholds beyond which their use could be ineffective. This balanced perspective is critical in understanding the comprehensive role of social robots in health contexts. RQ_2 addresses the acceptance and effectiveness of social robots across different populations. RQ_2 aim is to understand if user backgrounds, experiences, and technological familiarity can influence human-robot interactions. The sub-questions explore several dimensions of this variability in depth: $RQ_{2.1}$ explores how differing levels of technological familiarity impact user interactions, which is vital for designing user-friendly robots. $RQ_{2.2}$ emphasizes the importance of inclusive programming, promoting the design of robots that can adapt to the diverse needs of users, thereby reducing technological disparities. In the end, $RQ_{2.3}$ investigates the differences among individual and group interactions with a robot. The objective is to examine how these contexts affect the performance and the satisfaction of the interaction. RQ_3 examines situational awareness in social robots, specifically exploring whether interactions with robots that can perceive and respond to their environment are more effective than those with robots lacking this capability. Finally, RQ_4 emphasizes the need for ethical guidelines in the development and implementation of social robots, particularly in settings like healthcare. This question addresses the ethical implications of using robots with people.

5. Preliminary Results

This section presents the results of the research activity conducted during the initial phase of the doctoral program. Several publications have contributed to the development of the research trajectory.

The study "*Enhancing older people Health Monitoring: Achieving Autonomous and Secure Living through the Integration of Artificial Intelligence, Autonomous Robots, and Sensors*" [26] investigates the use of robots in older people care, focusing on the integration of robotics, sensors, and Artificial Intelligence (AI). The research introduced a four-actor system involving a stationary humanoid robot, older people, medical personnel, and caregivers, enabling continuous monitoring of physical and emotional well-being through vital sign sensors. This approach aims to enhance home-based care, reducing reliance on institutionalization. Key results include the development of a humanoid robot designed for close interaction with older people, capable of monitoring vital signs and emotional states while assisting with daily activities. A machine learning model, based on the Modified Early Warning Score (MEWS), was also created to predict health status. The findings highlighted the benefits of using IoT technology for continuous health monitoring, emotional support, and personalized care, ultimately promoting the independence of older people and reducing hospital admissions. Looking ahead, the research emphasizes the need for a longitudinal study to evaluate system acceptance and usability among older people users and caregivers. There is potential to improve the medication intake process and vital sign measurement using advanced technologies, while expanding the monitoring framework to assess multiple older individuals within a household. Additionally, the introduction of a prioritization system for health alerts could enhance response times in critical situations. Overall, the study supports a comprehensive and integrated approach to older care that fosters independence and proactive health management.

Building upon this foundation, the study "*Enhanced Home Elderly Care: Integrating Fitbit Technology within Android Studio Evolutionary Prototypes*" [27] advances a self-care architecture that emphasizes passive health monitoring and cognitive engagement through wearable technology. The system employs Fitbit Versa 4 to collect physiological data (e.g., heart rate, sleep, blood oxygen) and supports real-time anomaly detection. It incorporates a mobile application offering role-specific interfaces for older people users, caregivers, and medical personnel to enhance data accessibility and interaction. Furthermore, the architecture includes a memory game designed to counteract cognitive decline, encouraging mental stimulation. The deployment of evolutionary prototypes enables iterative refinement based on user feedback. This work responds directly to literature suggesting that outputs should be tailored to stakeholder roles [28], thereby improving system usability.

While the first studies primarily address physical health, the study "*Social robot in service of the cognitive therapy of elderly people: Exploring robot acceptance in a real-world scenario*" [29] shifts the focus exclusively to cognitive well-being. A key aspect of the first paper in this field of research is the active involvement of doctors, ensuring a user-centred approach. Furthermore, this paper highlights a field experiment that engages the stakeholders of the project, emphasizing the importance of collaboration in addressing the mental well-being of older people.

Ongoing research is currently exploring the role of robot appearance by investigating how different facial configurations of a social robot could influence user perception. Another active line of investigation involves the use of telepresence robots to examine how users interact socially with the robotic embodiment. The goal is to better understand the relational and interactional dynamics that emerge, which may inform future approaches to designing and deploying socially assistive robots. These ongoing studies aim to examine how different robotic modalities can contribute to the development of socially meaningful interactions.

Declaration on Generative AI

During the preparation of this work, the author(s) used ChatGPT, Grammarly in order to: Grammar and spelling check, Paraphrase and reword. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

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