

Katerina Mavrou
Pedro Encarnação *Editors*

Technology for Inclusion and Participation for All: Recent Achievements and Future Directions

18th International Conference, AAATE
2025, Nicosia, Cyprus, September 10–12,
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Katerina Mavrou · Pedro Encarnação
Editors

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Proceedings, Part II

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Preface

The year 2025 heralds a pivotal moment for the assistive technology (AT) field. The United Nations Office of the High Commissioner for Human Rights issued the report “Rights of persons with disabilities and digital technologies and devices, including assistive technologies”¹, clearly affirming that “Access to assistive technologies is a human right and is essential for persons with disabilities, enabling independence, greater participation and improved quality of life.” In parallel, 2025 marks the entry into force of the European Accessibility Act². Assistive technology and accessibility are two faces of the same coin: while accessibility reduces environmental barriers, assistive technology empowers individuals to overcome remaining obstacles.

The year also marks the 30th anniversary of the Association for the Advancement of Assistive Technology in Europe (AAATE). Its foundation in 1995 was the outcome of a growing European network of experts who collaborated through the COST Actions 219 “Future Telecommunications and Teleinformatics Facilities for Disabled People” (1987–1996) and the “Technology initiative for disabled and elderly people” (TIDE) programme (1991–1994) and who recognized the need to establish a permanent forum for advancing the field. Since then, AAATE has pursued its mission of promoting assistive technology and inclusive design as enablers of human rights and full societal participation for all.

Within this context, the 18th AAATE biennial conference³ convenes under the theme “Technology for Inclusion and Participation for All: Recent Achievements and Future Directions.” This reflects a focus on technology with a purpose—*supporting inclusion and participation*; on universal access as a human right—ensuring technology serves all; and on harnessing recent technological advances in the field of Assistive Technology. The conference was held in Nicosia, Cyprus, from September 10 to 12, 2025, and was co-organized by the European University Cyprus and the AAATE.

We received 224 contributions, out of which 107 were accepted to be included in this volume. Each submission was reviewed by at least three members of the international scientific committee. We extend our sincere thanks to all reviewers for their time, expertise, and dedication throughout the evaluation process. The accepted papers mirror the wide spectrum of the field, reflecting the richness and diversity of assistive technology research, development, policy, and practice. The volume comprises 20 chapters, which are briefly described below.

- *Advanced technologies for inclusion and participation in education and labour* present innovations using AI and digital tools to support neurodiverse individuals, autistic students, and people with learning disabilities across educational and vocational settings, while addressing employment challenges and media accessibility.
- *Accessibility in digital spaces* addresses the accessibility of digital content for blind and low-vision users, including adaptive eBook illustrations, accessible email applications, and guidelines for 360-degree media platforms.

- *Accessible indoor navigation systems* focus on indoor navigation and wayfinding technologies for visually impaired and mobility-impaired individuals, with contributions on smartphone-based systems, digital guidance design, and user-centered requirements analysis.
- *Advancing diagnosis and rehabilitation of neurodevelopmental disorders: The role of virtual reality, eye-tracking, and serious games* showcases VR-based interventions and smart wearables for supporting neurodiversity, including children with autism, neurological rehabilitation, and motor and cognitive development in older adults.
- *Artificial intelligence in care and support ecosystems* presents artificial intelligence solutions for residential care, caregiver support, and sensor-based systems promoting active aging, emphasizing personalization and real-time monitoring.
- *Artificial intelligence in higher education: Advancing inclusive environments, pedagogical approaches, and assistive technologies* examines the opportunities and risks of AI-driven educational technologies, accessibility solutions in publishing, and inclusive AI research, with particular attention to dyslexia, dyscalculia, and the role of disabled researchers.
- *Assistive technologies outcomes and impact measurement* addresses systemic challenges in assistive technology provision, access, and evaluation, presenting outcome frameworks, policy analyses, ethical discussions on AI, and studies on customized mobility devices and digital inclusion.
- *Assistive technology and accessibility for cognitive disabilities* investigates inclusive solutions for neurodiversity, including dyslexia, ADHD, cognitive accessibility, and simplified accessibility auditing, including AI-based Easy-to-Read adaptations and user-centered task management tools.
- *Assistive technology and accessibility training* focuses on inclusive education, curriculum development, and teacher training, featuring contributions on digital accessibility in higher education, disability simulation games, inclusive music education, and co-design approaches.
- *Assistive technology for sensory impairments* presents advances in tactile displays, multimodal interfaces, sign language translation, and XR-based subtitle systems for deaf, blind, and partially sighted users.
- *Assistive technology in the healthcare sector* discusses user-centered design for care robots, participatory digital health governance, safety innovations such as intelligent wheelchairs, and AI-assisted governance frameworks in healthcare delivery.
- *Assistive technology provision* highlights contextually appropriate assistive technology design and family-centered care frameworks, showcasing the AT4ALL program and the lived experiences of families caring for children with profound disabilities.
- *Augmentative and alternative communication* explores AAC strategies, AI-powered communication apps, teacher training platforms, professionals' awareness, and the evolving landscape of child-specific text-to-speech and neural speech synthesis systems.
- *Embracing change: Aging, digitalisation, and the future of care* addresses the intersection of aging, care innovation, and digitalization, presenting research on smart homes, digital home care, AI literacy, rights-based approaches, and care ethics.

- *Human-assistive technology interface* focuses on AI-powered solutions for speech recognition, gesture-based interfaces, and adaptive accessibility tools for individuals with complex mobility and communication impairments.
- *ICT to support inclusive education—Universal Design for Learning (UDL)*—examines inclusive educational technology for neurodiverse learners, digital accessibility for blind and visually impaired students, adaptive gaming, and teacher support tools for differentiated instruction.
- *Innovations in assistive technology to support mobility and participation* presents developments in wheelchair technologies, hand rehabilitation, transportation accessibility, mixed reality rehabilitation, paratransit, and urban mobility solutions for individuals with disabilities.
- *Museums for all: Co-design, inclusion and emerging technologies* explores how co-design, AI, and emerging technologies can promote inclusive access to museums and cultural heritage for individuals with intellectual disabilities.
- *Robotic assistive technology for children* examines the role of robots in inclusive education, play, therapy, and communication for children with disabilities, highlighting developments in educational robotics, inclusive play environments, and speech therapy interventions using robotics and virtual reality.
- *User-centered assistive technology co-design* explores participatory approaches in assistive technology development, highlighting co-design experiences with people with intellectual disabilities, AI-powered accessibility solutions in publishing, recommender systems for blind, partially sighted, and autistic users, tools for user-driven audio description, and clinical evaluation practices in industry.

Artificial intelligence is transforming many aspects of today's world, and the assistive technology field is no exception. Of the 107 accepted papers, approximately 60 explicitly address AI applications, ranging from machine learning and speech recognition to large language models, generative AI, and adaptive interaction systems. These contributions demonstrate AI's potential to develop assistive technologies capable of dynamically adapting to the person's varying needs and changing contexts, while also raising important questions related to reliability, transparency, bias, privacy, and equitable access. By actively involving people with disabilities as co-designers and decision-makers, AI-enabled assistive technologies can evolve into truly transformative tools that promote autonomy, inclusion, and participation for all.

We trust that the papers collected in this volume offer a comprehensive overview of the state of the art and valuable insights into how the field will continue to evolve in the years ahead.

Katerina Mavrou
Pedro Encarnação

Notes

1. United Nations Office of the High Commissioner for Human Rights (2024). Rights of persons with disabilities and digital technologies and devices, including assistive technologies. <https://digitallibrary.un.org/record/4073939?ln=en&v=pdf>

2. European Parliament & Council (2019). Directive (EU) 2019/882 on the accessibility requirements for products and services (European Accessibility Act). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L0882>

3. This is the 18th edition because the AAATE conferences were preceded by three ECART (European Conference for the Advancement of Rehabilitation Technology) conferences.

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Enhancing Safety and Navigation in Intelligent Nursing Wheelchairs Using 3D LiDAR Technology

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Abstract. The safety of intelligent wheelchairs with navigation functionality is crucial during operation. Traditional 2D LiDAR sensors are unable to identify three-dimensional obstacles. Even with the addition of RGB-D cameras theoretically capable of reconstructing 3D scenes, the uneven lighting in complex indoor environments prevents the effective reconstruction of indoor scenes using depth-dependent uniform light sources. This limitation poses significant safety risks for traditional wheelchairs operating in complex indoor environments. This paper proposes an intelligent nursing wheelchair based on 3D LiDAR technology. The 3D LiDAR sensor can effectively detect irregular obstacles with height differences in scanning complex indoor environments without relying on uniform indoor lighting. Experimental mapping of indoor environments demonstrates that 3D LiDAR technology enables the wheelchair to identify irregular three-dimensional obstacles during indoor operation, thereby enhancing safety for elderly users.

Keywords: Nursing Wheelchair · 3D LIDAR · Navigation

1 Introduction

Amidst the deepening crisis of the aging population, a significant proportion of seniors grapple with a diverse range of health conditions, culminating in an increased reliance on extended care. Through meticulous examination of the needs of older adults [1], it becomes evident that tasks such as bathing and using the restroom often necessitate considerable assistance from caregivers. However, facilitating these activities invariably entails the physical support of caregivers to ensure the elderly can navigate indoor environments safely and reach their destinations without incident. This process imposes a notable burden on caregivers, both in terms of physical exertion and emotional strain. In response to these challenges, innovative solutions have emerged, seeking to revolutionize the landscape of elderly care. Smart wheelchairs, equipped with state-of-the-art navigation systems, represent a groundbreaking advancement in this field [2, 3]. These technologically advanced mobility aids are designed to enhance the quality of life for disabled elderly individuals by providing autonomous assistance in navigating indoor environments. By leveraging cutting-edge navigation technology, these intelligent

wheelchairs offer caregivers invaluable support, enabling them to fulfill their caregiving responsibilities more effectively while promoting the autonomy and well-being of their elderly charges. Furthermore, the integration of advanced navigation features into these smart wheelchairs holds immense promise for addressing the evolving needs of an aging population. As demographic trends continue to shift towards an increasingly elderly population, the demand for innovative caregiving solutions will only intensify. Thus, smart wheelchairs represent a pivotal step towards meeting the complex challenges associated with elderly care in the modern era.

Traditional navigation wheelchairs typically employ two-dimensional lidar. However, two-dimensional lidar cannot identify obstacles beyond the horizontal plane of the lidar installation, making wheelchairs with two-dimensional navigation functionality unsuitable for indoor environments with complex three-dimensional obstacles. Some research teams have attempted three-dimensional obstacle avoidance for wheelchairs by combining two-dimensional lidar with RGB-D cameras to reconstruct three-dimensional environments [7, 8]. However, RGB-D cameras have high requirements for ambient lighting conditions, limiting their applicability in indoor environments with uneven lighting distribution. Currently, three-dimensional lidar is primarily used for road condition recognition in car navigation systems [9, 10]. The high cost of three-dimensional lidar restricts its application in indoor mapping and navigation. However, some research teams have applied it to AGV (Automated Guided Vehicle) systems, as demonstrated in [11], where three-dimensional lidar was used for indoor environment modeling with promising mapping results. This also highlights the importance of irregular three-dimensional obstacle recognition in navigation processes within complex indoor environments. To address these issues, this paper proposes an indoor navigation wheelchair based on three-dimensional lidar. It assists elderly or disabled individuals with visual or physical impairments in indoor mobility. The wheelchair is equipped with a three-dimensional lidar sensor mounted above, enabling it to effectively identify obstacles of different heights and shapes, and navigate indoors by mapping the environment safely and efficiently.

In response to these challenges, this study proposes the development of an indoor navigation wheelchair leveraging advanced three-dimensional lidar technology. This wheelchair aims to provide enhanced mobility support for elderly or disabled individuals facing difficulties in navigating indoor environments. Equipped with cutting-edge three-dimensional lidar sensors positioned above the wheelchair, it enables precise detection and mapping of obstacles with varying heights and shapes. By utilizing lidar technology, the wheelchair can efficiently navigate through indoor spaces while ensuring safety and reliability. This innovative solution represents a significant advancement in assistive technology, offering improved independence and mobility for users in complex indoor settings. Additionally, it alleviates the workload of caregivers by providing a more efficient and autonomous mobility solution for those in need. The structure of this paper is as follows: In Sect. 2, we introduce the composition of the wheelchair. Section 3 presents the mapping method using three-dimensional lidar. In Sect. 4, we analyze and validate the experimental results of mapping the wheelchair in real environments. Finally, in Sect. 5, we summarize the conclusions and outline prospects for future work.

2 The Wheelchair's Structural Framework

The intelligent wheelchair mentioned in this paper is a multifunctional nursing wheelchair, as shown in Fig. 1, primarily designed for indoor environments. It features functions such as changing posture, standing up, shifting, assisting with toileting, and assisting with bathing. The premise for implementing these functions is the wheelchair's accurate recognition of three-dimensional obstacles in the environment. Therefore, we installed a three-dimensional laser radar above the wheelchair. The radar is positioned at a 160° angle with respect to the wheelchair backrest, and its scanning range is set to 150° , ensuring that the radar can detect obstacles in front of the wheelchair as much as possible.

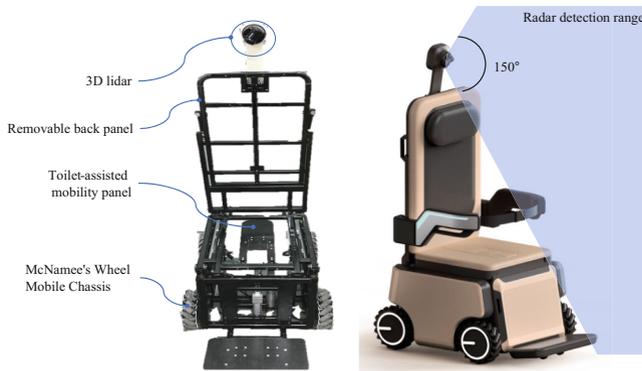


Fig. 1. The wheelchair's structural framework.

Traditional electric wheelchairs typically utilize differential drive systems [12, 13], requiring a larger turning radius during movement, which imposes certain limitations on wheelchair mobility in narrow indoor environments. The intelligent wheelchair mentioned in this paper, however, employs a four-wheel drive (4WD) Mecanum wheel mobile platform, allowing the wheelchair to move in any direction and enhancing its maneuverability. The dimensions of the wheelchair are 110 cm in length, 90 cm in width, and 105 cm in height. Mounted above the wheelchair is the 4D solid-state laser radar L1 from Yushu Technology, with a scanning range of 150° . It is equipped with an industrial computer (Linux, Intel Core2 Duo 2.0 GHz CPU) for managing interactive information and real-time processing of three-dimensional point clouds.

3 Experimental Methodology

The aim of this study is to utilize LiDAR (Light Detection and Ranging) data to construct a three-dimensional map of indoor environments. This section will provide a detailed overview of the methods employed in this study, including data preprocessing, feature extraction, map construction, map optimization, and map updating steps (Fig. 2).

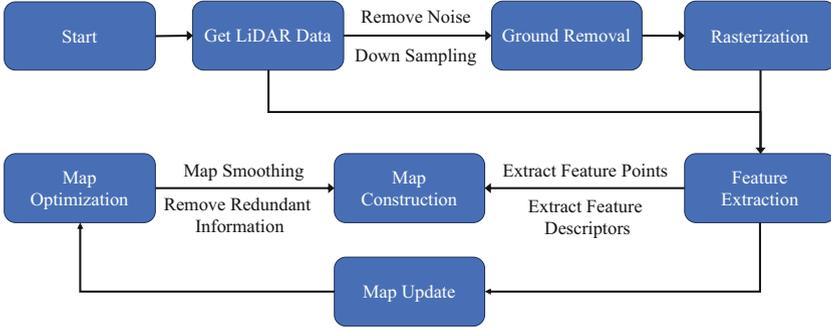


Fig. 2. The process of 3D mapping.

3.1 Data Preprocessing

Data preprocessing is the first step in building a 3D map, aimed at improving data quality and stability. In this study, noise removal and downsampling methods were employed for preprocessing. Gaussian filtering was used to remove noise points and smoothen the 3D point cloud data, while downsampling techniques were applied to reduce the data volume.

3.2 Feature Extraction

Feature extraction is a crucial step in the map construction process, aiming to extract representative features from point cloud data for subsequent mapping and localization. In this study, the Harris corner detection algorithm and Fast Point Feature Histograms (FPFH) descriptor extraction algorithm are employed for feature extraction. The Harris corner detection algorithm effectively identifies corners in point cloud data, which often correspond to prominent features in buildings or environments, such as corners and intersections. Initially, the gradients of each pixel in the image are computed using the Sobel operator or other edge detection methods to obtain the horizontal gradient G_x and vertical gradient G_y . Then, the structure tensor is calculated based on the gradient information, which includes three elements:

$$M_{11} = \sum G_x^2 \quad (1)$$

$$M_{12} = \sum G_x G_y \quad (2)$$

$$M_{22} = \sum G_y^2 \quad (3)$$

Then, the corner response value R is computed based on the structure tensor:

$$R = \det(M) - k \cdot \text{trace}(M)^2 \quad (4)$$

where $\det(M)$ is the determinant of the structure tensor M , $\text{trace}(M)$ is the trace of the tensor, and k is a constant.

The FPFH descriptor extraction algorithm is used to describe the local features around each feature point, i.e., the local shape information in the point cloud data. This algorithm characterizes the surrounding point cloud data of each feature point by computing its FPFH descriptor, which is expressed by the following formula:

$$FPFE(p) = [histogram_1, histogram_2, \dots, histogram_n] \quad (5)$$

where $histogram_i$ represents the histogram around the i th feature point, used to represent its local feature.

The feature extraction algorithm is as follows:

Algorithm 1 Feature Extraction

- 1: **for** each feature point \mathbf{p} in the point cloud data:
 - 2: Compute gradients \mathbf{G}_x and \mathbf{G}_y for point \mathbf{p}
 - 3: Compute elements of the structure tensor \mathbf{M} :

$$M_{11} = \sum \mathbf{G}_x^2$$

$$M_{12} = \sum \mathbf{G}_x \mathbf{G}_y$$

$$M_{22} = \sum \mathbf{G}_y^2$$
 - 4: Compute the corner response R :

$$R = \det(\mathbf{M}) - k \cdot \text{trace}(\mathbf{M})^2$$

$$\det(\mathbf{M}) = M_{11} * M_{22} - M_{12}^2$$

$$\text{trace}(\mathbf{M}) = M_{11} + M_{22}$$
 - 5: **If** R is greater than a threshold:
 - 6: Mark point \mathbf{p} as a corner
 - 7: Find neighboring points within a specified radius around point \mathbf{p} in the point cloud data
 - 8: Initialize an empty histogram for point \mathbf{p}
 - 9: **for** each neighboring point \mathbf{q} :
 - 10: Calculate the difference in position and normals between \mathbf{p} and \mathbf{q}
 - 11: Compute a unique bin index for the pair (\mathbf{p}, \mathbf{q}) based on the difference values
 - 12: Normalize the histogram to obtain the FPFH descriptor for point \mathbf{p}
 - 13: **end**
 - 14: **end**
 - 15: **end**
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3.3 Map Construction

The map construction process involves creating indoor environment maps based on preprocessed point cloud data and extracted feature information. This study employs two representation methods: grid maps and feature-based maps. Grid maps partition space into fixed-size grid cells to represent the structure and layout of buildings, while feature-based maps construct maps by describing the position and feature descriptors of each feature point.

3.4 Map Optimization

Map optimization involves refining the constructed map to enhance its accuracy and consistency. This study employs nonlinear optimization methods to smooth the map and remove redundant information.

3.5 Map Optimization

Map updating involves incorporating new point cloud data into the existing map to maintain its consistency with the environment. This study employs a real-time map updating strategy to promptly integrate new data into the map, reflecting the latest environmental changes.

By employing the integrated application of the aforementioned methods, we are able to effectively utilize lidar data to construct accurate and reliable three-dimensional maps of indoor environments. This capability provides essential data support for later stages of assisting the mobility process of nursing wheelchairs in narrow and complex indoor environments, including tasks such as autonomous navigation and path planning.

4 Experiment on Indoor Mapping Based on 3D LiDAR

After verifying the feasibility of the algorithm in a simulated environment, we proceeded to implement the algorithm on the wheelchair for practical validation. Utilizing the wheelchair to map the indoor environment, Fig. 3 depicts the actual indoor environment, while Fig. 3 showcases partial results of the indoor environment mapping. From the mapping results, it is evident that our approach, utilizing 3D lidar, effectively detects irregular obstacles such as tables and chairs. The processed 3D point cloud distinctly distinguishes the shape characteristics of different obstacles. This lays a solid foundation for achieving autonomous navigation and obstacle avoidance for the wheelchair in subsequent stages.

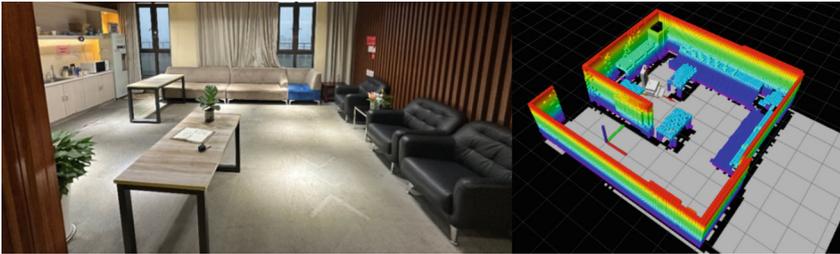


Fig. 3. The actual indoor environment and Effectiveness of indoor 3D LiDAR mapping.

5 Conclusion

In this paper, we propose an intelligent wheelchair based on three-dimensional lidar. By using the lidar sensor to map the indoor environment, irregular obstacles indoors can be effectively identified. Mapping experiments were conducted, and the results showed that the scene restoration rate of the three-dimensional lidar reached 98.2%, with a 100% obstacle recognition rate. This indicates that a navigation wheelchair equipped with a three-dimensional lidar can more effectively and safely assist wheelchair users in indoor navigation and obstacle avoidance. In the future, we will classify the features of three-dimensional point clouds, turning the complexity of indoor environmental obstacles into rich features. Ultimately, this will enable the wheelchair to achieve self-positioning at any location in the room, greatly reducing the manual positioning workload required each time the wheelchair is powered on.

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Co-designing Modular Robots for the Care Sector

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Abstract. This paper presents a structured methodology for the rapid development of modular robots designed to capture and address user requirements in care settings. While co-design is widely applied in robotics, existing approaches often lack detailed, step-by-step frameworks. This study employs a Design Research (DR) methodology to establish a comprehensive process, demonstrated through the development of a modular robot, Robobrico, in collaboration with a users from an Assisted Living Home during the COVID-19 pandemic. The number of participants was limited to five to facilitate the management, structuring, and coordination of user feedback. The proposed methodology follows a seven-step structured process that systematically captures and clusters user requirements while integrating iterative feedback to refine modular robot variations. Design for Additive Manufacturing (DfAM) is used to accelerate prototype production, enabling rapid iterations informed by user input. This approach enhances the adaptability of care and service robots, ensuring they align more effectively with user needs by encouraging active engagement throughout the design process. This research summarize the methodology, the tools developed to capture and assess user requirements, and the evaluation of progress and insights gained. The findings provide a replicable framework for participatory robot design in care environments, contributing to the broader research community.

Keywords: Assistive technology · Modular robotics · Personalisation · Design for Additive manufacturing · Co-design

1 Background

The ageing population in developed nations increasingly strains healthcare and social care systems, a challenge worsened by the COVID-19 pandemic. Robotics presents a potential solution by enhancing patient care and reducing caregivers' workload. Current robotic applications in healthcare include surgical assistance, rehabilitation, and social interaction. However, broader integration

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faces challenges such as costs, market fit, and acceptance, while diverging caregiver and recipient needs further complicate adoption [10]. Socially Assistive Robots (SARs) [13] can address these challenges by supporting physical, cognitive, and social engagement to enhance older adults' well-being and optimise care pathways. However, existing robotic platforms often lack adaptability to evolving care sector needs. Customisation emerges as both a critical design requirement and a practical response to the shortcomings of formal AT provision [7]. Carers, acting as informal engineers and designers, repurpose everyday tools to create tailored care systems. Their role is not only reactive but inventive, highlighting the need for AT design and policy to support co-created, flexible, and customisable solutions rather than imposing top-down, standardised systems. Further more, allowing personalisation, encouraging users to project their identities, enhance symbolic attachment and emotional ownership [2,9]. Understanding user needs is crucial, and User-Centred Design (UCD) [8] and Co-Design methodologies, a collaborative process where stakeholders and end-users jointly create and refine solution, are gaining prominence in Human-Robot Interaction (HRI) research [1], though practical and replicable applications of social robotics platform remain limited. This research introduces a design methodology that integrates DfAM [12], the method of optimising designs for 3D printing, with design thinking for iterative user research, to rapidly prototype a physical robotics platform and develop adaptable solutions for diverse care industry requirements. This work expand upon the limitations of current Co-Design approaches in social robotics, which often lack structured methodologies suited to the iterative development of modular, user-centred systems. In contrast, our detailed design research (DR) framework provides a step-by-step process that explicitly integrates user feedback across design cycles and manufacturing of prototypes. This is particularly relevant for applications involving older adults, where concerns around complexity and adoption are prominent.

2 Method

The DR methodology has been adapted to robotics for this research, as it aims to provide a step-by-step guide through the development of a modular robot while actively engaging users in the process. Unlike the linear Double Diamond [11] framework, which lacks iterative flexibility and systematic evaluation checkpoints, the step-by-step DR approach [5] was chosen because it provides clear definitions of each step with empirical evaluation across the process to test the outcomes with users. The following This method supports iterative ideation and continuous user involvement, which are essential in HRI to address metrics like usability and acceptance. The methodology was implemented over one year, with a group of five participants, part residents, part carers and managers of a Assisted Living home in Edinburgh. Focusing on capturing their functional requirements (FRs), which are then translated by our team into Design Parameters (DPs). This method is integral to the Axiomatic Design method [3], systematically structuring the development process. A combination of online tools, such as Miro