Enabling Homecare With Robotic Technologies

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The home health-care industry is under growing pressure to deliver services more effectively to meet the increasing demand from care recipients, particularly the elderly population. It is estimated that U.S. home health-care expenditures will rise from US$108.8 billion in 2019 to US$186.8 billion in 2027 [1]. A simultaneous ongoing shortage of physicians, registered nurses, certified nursing assistants, and social workers has created a major service delivery gap in the home health-care industry, especially in rural areas where timely access to quality health-care services is very limited [2]. The recent COVID-19 pandemic exacerbated this problem as it isolated many care recipients from their caregivers or friends.

Providing efficient and cost-effective homecare requires major changes in the ways that providers gather information from and deliver care services to homebound care recipients. Robotic technologies are in a unique position to achieve this goal. Research in homecare robots has been attracting great interest in recent years. Robot-based homecare technologies can collect health-related data with advanced sensors, process the data for diagnosis, and provide interventions for health-care delivery, therefore enabling individualized care that promotes independence and safety of the care recipients. For health-care workers, these technologies will improve their productivity and free them to address the more complex aspects of their work.

> “A GAME-BASED ASSESSMENT PLATFORM ENGAGES THE USER AND PERFORMS AUTOMATED EVALUATION OF ARM AND HAND FUNCTION AND THEIR EVOLUTION OVER TIME.”

This special issue aims to present the recent research advances in robot-assisted home health care, identify future research directions, and promote new research endeavors in this emerging field. What follows is an overview of the seven articles accepted in this special issue.

The article by Ankit A. Ravankar et al. [A1] presents a general framework for future welfare facilities with a new concept of the living lab, which is developed to push the health-care 4.0 concept one step closer to reality under the ongoing project “Moonshot R&D” in Japan. The framework integrates an adaptable artificial intelligence (AI) that senses users’ expressions, surroundings and daily conditions and provides the most appropriate support.

With a goal of addressing the specific needs of wheelchair users in their everyday life, Morbidi et al. [A2] have developed innovative assistive robotic technologies within the framework of the “Assistive Devices for Empowering Disabled People Through Robotic Technologies” project. The article focuses on the design, implementation, and experimental validation, via large-scale clinical trials, of two complementary smart wheelchairs and a wheelchair-driving simulator based on virtual reality.

Deng et al. [A3] have provided a new solution to long-term visual simultaneous localization and mapping (SLAM), a fundamental research problem in robotics that enables mobile homecare robots to successfully navigate in complex indoor environments. Their method combines map prediction and dynamics removal, which results in an excellent localization performance for intelligent wheelchairs.

The article by Li et al. [A4] addresses the issue of bandaging using a robotic arm, which has the potential to develop automated home-based daily wound care. A method of force-position decoupling control strategy was developed to achieve the full process of bandage tension control with bandaging trajectory adjustment and following.

Garzo et al. [A5] have developed ArmAssist, a telerehabilitation platform aiming to help poststroke subjects maintain the rehabilitation of the upper limbs at home. ArmAssist consists of robotic modules with multiple sensors to train and measure the users’ voluntary movements. A game-based assessment

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for the Advancement of Artificial Intelligence to beat the world champion in soccer by 2050 [3].

To achieve this ambitious goal, B-Human (https://b-human.de), like any other team, will welcome with open arms anyone who brings motivation and skills to its team. The willingness to improve, enthusiasm, and discipline are the keys to success, not race and gender. Literally anyone who is interested is encouraged to participate, perhaps becoming a role model for currently underrepresented groups and sparking in them an interest in the whole topic of robotics. This is true even if their background may not have fostered that interest so far, which could be for many reasons, such as a nonacademic background in the family and certain expectations due to gender. So basically, everyone has the chance to become a role model and get others excited about this topic through RoboCup, and this chance should be taken!

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[2] J. Müller, T. Laue, and T. Röfer, "Kicking a ball–Modeling complex dynamic motions for humanoid robots," in *Robot Soccer World Cup*, J. Ruiz-del-Solar, E. Chown, and P. G. Plöger, Eds. Berlin, Germany: Springer-Verlag, 2010, pp. 109–120.

[3] H. Kitano, Ed., *RoboCup-97: Robot Soccer World Cup I*, vol. 1395. Berlin, Germany: Springer-Verlag, 1998.

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platform engages the user and performs automated evaluation of arm and hand function and their evolution over time.

The article by Sun et al. [A6] aims to realize a walking-training robot in response to the shortage of rehabilitation physiotherapists. The proposed rehabilitation gait-training robot caters to the characteristics of human omnidirectional walking and allows passive and active training to be directly and gently switched during walking. A control algorithm is realized to accurately follow the exercise programs prescribed by physical therapists and achieve satisfactory practice results.

Finally, Infarinato et al. [A7] developed an augmented and extended a home rehabilitation system that provides neurorehabilitation exercises and assessments to chronic stroke patients with aphasia. Their work analyzes the feasibility, satisfaction, and motivation of patients and the clinical effect of the intervention using their system, which allows the administration of speech and language home therapy.

By presenting the achievements and future opportunities in this multidisciplinary research area, which crosscuts robotics, automation, AI, and health care, we hope this special issue can inform and inspire the researchers in this exciting and important area of robotics and automation. More importantly, we look forward to new research efforts to further robotic technologies for homecare.

APPENDIX: RELATED ARTICLES

[A1] A. A. Ravankar, S. A. Tafrishi, J. V. Salazar Luces, F. Seto, and Y. Hirata, "CARE: Cooperation of AI robot enablers to create a vibrant society," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 9–23, doi: 10.1109/MRA.2022.3223256.

[A2] F. Morbidi et al., "Assistive robotic technologies for next-generation smart wheelchairs: Codesign and modularity to improve users' quality of life," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 24–35, doi: 10.1109/MRA.2022.3178965.

[A3] T. Deng, H. Xie, J. Wang, and W. Chen, "Long-term visual simultaneous localization and mapping: Using a Bayesian persistence filter-based global map prediction," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 36–49, doi: 10.1109/MRA.2022.3228492.

[A4] J. Li et al., "A method for a compliant robot arm to perform a bandaging task on a swaying arm: A proposed approach," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 50–61, doi: 10.1109/MRA.2022.3228501.

[A5] A. Garzo, J. H. Jung, J. Arcas-Ruiz-Ruano, J. C. Perry, and T. Keller, "ArmAssist: A telerehabilitation solution for upper-limb rehabilitation at home," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 62–71, doi: 10.1109/MRA.2022.3225716.

[A6] P. Sun, R. Shan, and S. Wang, "An intelligent rehabilitation robot with passive and active direct switching training: Improving intelligence and security of human–robot interaction systems," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 72–83, doi: 10.1109/MRA.2022.3228490.

[A7] F. Infarinato et al., "A novel telerehabilitation approach for cognitive-language therapy in chronic stroke subjects with aphasia: Neurocognitive intervention through neurorehabilitation exercises and assessments," *IEEE Robot. Autom. Mag.*, vol. 30, no. 1, Mar. 2023, pp. 84–95, doi: 10.1109/MRA.2022.3228503.

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