An Overview of Assistive Robotics and Technologies for Elderly Care

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Abstract. Population ageing is already having an impact on societies. This study briefly reviews associated technologies employed within the framework of elderly care, namely: robotic nursing, ambient assisted living and assistive robotics. Their current status is considered together with their potential and the associated implementation challenges.

Keywords: Assistive robotics · Elderly-care technologies · Nursing robots · Telerobotics · Human factors design

1 Introduction

Population aging is becoming a major concern internationally. An ageing population presents many challenges to labor markets, government tax, government spending and the wider economy. At a personal level, elderly individuals are challenged in different aspects [1]: social (neglect, isolation, fear, loneliness, boredom), financial (low income, fear of being a burden, lack of insurance), psychological (depression, poor memory, dementia, insomnia), and physiological (declining mental abilities, less efficient reflexes, muscle weakness, gait abnormality, fragile bones). Today, the prominent elderly care model involves ageing-in-place and the mission for robotics and modern technologies is to support the elderly both physically and emotionally. Relevant technologies include: robotic nursing, ambient assisted living, and assistive robotics. These technologies are briefly reviewed within the general framework of elderly care, while the primary challenges associated to design and development are discussed.

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2 Nursing Robots

Within hospitals robots may serve as supplemental healthcare workers to ease the burden on nursing staff. They have been considered for distributing food trays, medicines, and laboratory specimens. Robots can be integrated with other hospital technologies effectively supporting continuity of care. It is possible to carry-out laborious physical tasks like patient transfers and lifting to reduce physical stress on nurses, allowing them to focus on their primary duties. Such a commercial system called Robear was developed to lift patients from a bed into a wheelchair (RIKEN and Sumitomo Riko Co. Ltd., Japan). Telehealth robotic service is also among the available options that can be extended to home care. In the latter case, robotic nurses may serve as interfaces for doctors to communicate with elders over distance and facilitate medical routine tasks.

3 Smart Homes and Ambient Assisted Living

Ambient assisted living refers to the use of information and communication technologies (ICT) in the elderly daily living to enable them to stay active, socially connected, and live independently. Implementations typically involve wireless sensor networks for applications including health status monitoring. Sensors used for elderly-care applications can be: (i) wearable, (ii) non-wearable stationary, and (iii) mobile robot-mounted. Restrictions regarding wearable sensors may discourage the elderly people from adopting them. On the other hand, ambient sensors like cameras may be perceived as intrusive and thus rejected. The collection of personal data involved in smart home applications raises a range of privacy management issues that need to be carefully addressed.

Sensors can also be used to monitor everyday living activities including the use of tap water and visits to toilet. The information can be exploited in two ways [2]: (i) Identify emergencies and generate alerts, (ii) Identify long-term variations in health status by analyzing behavioral patterns in daily activities. Enhancements to smart home implementations can be accommodated via internet-of-things (IOT) technologies [1], also leveraging the integration of robots within the setup. Mobile robots may overcome limitations of embedded assistive technologies by ensuring an effective coverage, as well as capture of dynamic activities. Their physical appearance and explicit presence may be easier to accept, while providing for interactions that are more meaningful.

4 Assistive Robotics

The ultimate goal of assistive robotics is to enable elderly/disabled people to pursue healthy, independent, and productive lives. Depending on their main function, assistive robots can be grouped as: (i) Socially assistive, and (ii) Physically assistive.

4.1 Socially Assistive Robots

These robots provide assistance to end-users through social interaction. An example of socially assistive robots is NAO, which is a small-size anthropomorphic robot. Its interactions with autistic children are reported in [3]. Human perceptions towards robots constitute socially assistive robots more effective than a computer program. Companion robots may act as interfaces that enable the elderly to enrich their social lives and connect with their families and friends. Potential uses of robots are also seen in the care of individuals during physical recovery, rehabilitation, and to satisfy their training needs. In the case of post-stroke rehabilitation, the purpose of the robot is to motivate, facilitate, and monitor the process. A movement therapy robot may provide a diagnostic (measurement and assessment) or therapeutic (improvement of function) benefit.

Supporting adults with dementia is another potential role [4]. Symptoms of dementia cause particular stress and pressure on caregivers/families and often become a reason for institutionalization. Various pet-like robots have been developed to stimulate senses and provide motivation through interaction. An example is Paro, which has the appearance of a baby harp seal and interactive behavior [5]. AIBO (Sony Corporation, Japan) is a robotic dog that has been considered for the same purpose [6].

Various robotic systems have also been considered to systematically engage elderly users in physical exercise [7]. A robot may conduct customized exercise sessions, evaluate user performance, and give the user real-time feedback completely autonomously. The first challenge related to this approach is to analyze the coach's gestures automatically, as required for being able to reproduce them adequately. The second challenge is due to the fact that the robot possesses a different physical embodiment than the coach, and hence is inherently an imperfect intermediary interface [8].

4.2 Physically Assistive Robots

A key element of life quality for the ageing population is preservation of mobility. A relevant commercial system is LEA - Lean Empowering Assistant (Robot Care Systems, The Netherlands), which provides autonomous functions to help the elderly when getting out of bed or chair and when walking. Robotic wheelchairs also facilitate mobility and they can be endowed with obstacle avoidance capabilities. Autonomous vehicles is an emerging field within the scope of robotics that is also expected to play a role in elderly transport. Future developments in autonomous vehicles should be appealing and consider the accessibility requirements of the elderly and disabled users.

Specially designed assistive robotic manipulators/devices can support people with motor impairments and help them carry out tasks including eating and drinking, personal care, object manipulation, work and leisure. The manipulators can be divided into: Task-specific and general-purpose. Single-task systems include commercially available robotic feeding devices for people with disabilities [9]. General-purpose assistive robotic manipulators include MANUS and its upgraded version called iARM [9]. Wheelchair mounted arms have the advantage to always accompany the user [10].

A special category of sensory assistive devices is dedicated to the support of mobility and independent travel for blind and partially sighted/older people. Robotic guides exhibit some of the characteristics of a human guide or guide dog (while avoiding the animal care responsibilities). Examples include Guido and GuideCane [9]. Devices may operate in automatic mode (full capability to avoid obstacles) or semi-autonomously.

On a different note, commercially available domestic work robots are often encountered in many modern households and public areas. Indoor uses include robotic vacuum cleaners and floor-washing robots. Outdoor systems include robotic lawn mowers and swimming pool cleaners. Assigning day-to-day needs to technology can effectively increase the quality time the elderly can spend with family and friends.

5 Telemedicine/Telerobotics and Elderly-Care

Teleoperated robots are currently used in medicine [11]. A hospital scenario involves the physician sending a mobile robot out to find the patient in the clinic. The doctor's face comes on the screen of the robot. Using the camera, the doctor can proceed with a diagnosis and also connect to vital signs. An analogous home scenario can be implemented [12] to facilitate social interaction from a distance, support the elderly to remain socially engaged, and allow relatives to make virtual visits. Likewise, contact with doctors and nurses may also be enabled. Compared to video calls, a telepresence robot enhances interaction to a more natural level. Wired and/or wireless communication networks and video compression technologies are involved in such implementations.

6 Ethical, Safety and Legal Issues

Legal and liability issues are associated with the use of the aforementioned elderly-care technologies. They include user safety, and the risk of unauthorized access to health-care databases and sensitive private information. Privacy concerns arise from the use of pervasive technologies for continuous monitoring. In fact, robots may increase the level of privacy by avoiding the need for human assistance for tasks which are potentially embarrassing or private. Although robots are not human, programmed reactions may affect users' sense of privacy. Also, prolonged human-robot interactions may have other psychological effects including the attachment to the robot and deception about its abilities. This may potentially influence interpersonal relationships and raises ethical issues [13].

7 Assistive Robotics and Human Factors Design

Human factors engineering is the study and practice of designing equipment, machines, and environments to accommodate human users. It maximizes performance, safety, comfort, and user satisfaction while minimizing the likelihood of errors, inefficiencies, injuries, and fatigue. User-centered design requires the engagement of end-users as well as the rest of stakeholders (families, physicians, nurses, therapists, psychologists, etc.). The special characteristics of the elderly users can be grouped into: (i) Physical impairments, (ii) Perceptual impairments (sensory limitations), and (iii) Cognitive limitations.

The appearance of assistive robots is important to users [9], even though it doesn't seem to exist a consensus on preferred appearances. Physical appearance also leads to social expectations. For example, a close resemblance to human appearance can be deceiving and may lead to unrealistic expectations about robot's capabilities. Ideally, the system should be able to establish an effective relationship with the user that does not go beyond its intended purpose. Note that considerable design constraints are often imposed on appearance by the required functionality.

8 Conclusions

Elderly care technologies have attracted extensive research interest but few solutions are in common use. This is partly due to high costs, legal and safety issues that need to be resolved. Elderly are also concerned that they will eventually lose personal assistance and companionship. Technologies should be implemented so that the users do not feel that their privacy is violated and retain control, without compromising effectiveness. Human factors are critical towards that direction. Elderly-care technologies are expected to play a key role in future societies. Their full potential is yet to be unleashed!

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