Cooperation of Assistive Robots to Improve Productivity in the Nursing Care Field

Yasuhisa Hirata[1,2], Jose V. Salazar L.[1], Ankit A. Ravankar[1], and Seyed Amir Tafrishi[1]

[1] Department of Robotics, Tohoku University, Sendai 980-8579, Japan
[2] hirata@srd.mech.tohoku.ac.jp
https://srd.mech.tohoku.ac.jp/

Abstract. This paper introduces an overview of the "Adaptable AI-enabled Robots to Create a Vibrant Society" project, which is part of the "Moonshot R&D Program" led by the Cabinet Office of Japan. We also introduce CARE, Cooperation of Ai-Robot Enablers, which are being researched and developed to improve productivity in the nursing care field. The importance of building an educational system for the successful use of advanced technologies will also be presented, and then we propose a nursing care motion guidance system using AR glasses that allows non-expert caregivers to learn appropriate nursing care.

Keywords: Moonshot Program · CARE · Multiple Robots Coordination · Nursing Care Guidance

1 Introduction

The authors are currently working on a project under the "Moonshot R&D Program" led by the Cabinet Office of Japan. The moonshot R&D program is a generally 5-years (maximum 10-years) program in which the government sets ambitious goals (moonshot goals) that attract people and promotes challenging R&D to address important social issues such as a super-aging society and global warming[1]. Moonshot Goal 3 is to "Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings, by 2050", and one of the sub-targets is to develop "AI robots that humans feel comfortable with, have physical abilities equivalent to or greater than humans, and grow in harmony with human life"[2]. To achieve this goal, the authors are working on a project titled "Adaptable AI-enabled Robots to Create a Vibrant Society"[3].

The outline of this project in 2050 is to create a vibrant society with multiple AI robots installed in various public facilities such as commercial, cultural, tourist, sports, nursing, hospital, childcare, etc., and maintained as social infrastructure. The AI robots we are developing can change their shape and form according to the location of use and the user's condition, automatically select the appropriate AI robot from a group of heterogeneous AI robots with various functions, and provide support and services to the user alone or with multiple

AI robots. This will enable anyone to use AI robots anytime, anywhere, and will create a vibrant society in which all people can actively participate in society, in other words, a "Smarter Inclusive Society".

The research results of this project are expected to be used in a wide range of fields, including nursing care, childcare, sports, and education. In the initial phase of the project, we envision the use of AI robots especially in the nursing care field, aiming to solve social issues such as the shortage of nursing care workers. The introduction of AI robots at nursing care facilities will not only reduce the burden on nursing care workers but also improve the quality of care by appropriately combining multiple AI devices and nursing care robots to accommodate the various disabilities of care recipients as shown in Figure 1. In addition, we are collaborating with the "Platform Project for the Development, Demonstration, and Dissemination of Nursing Care Robots" being promoted by the Ministry of Health, Labour and Welfare. In this project, we aim not only to present new and innovative solutions that can be used in the future as a moonshot project but also to propose realistic solutions that can be adapted in the near future by utilizing existing AI devices, sensors, nursing care robots, etc. Through these projects, the authors are developing several AI robots that can improve productivity in the nursing care field. In particular, this paper introduces CARE -Cooperation of Ai-Robot Enablers-, an IoT-based assisted care technology that links existing AI devices, sensors, and nursing care robots via the Internet. In addition, we introduce a nursing care motion guidance system using AR (Augment Reality) glasses to enable anyone to provide appropriate care in the midst of the shortage of caregivers.

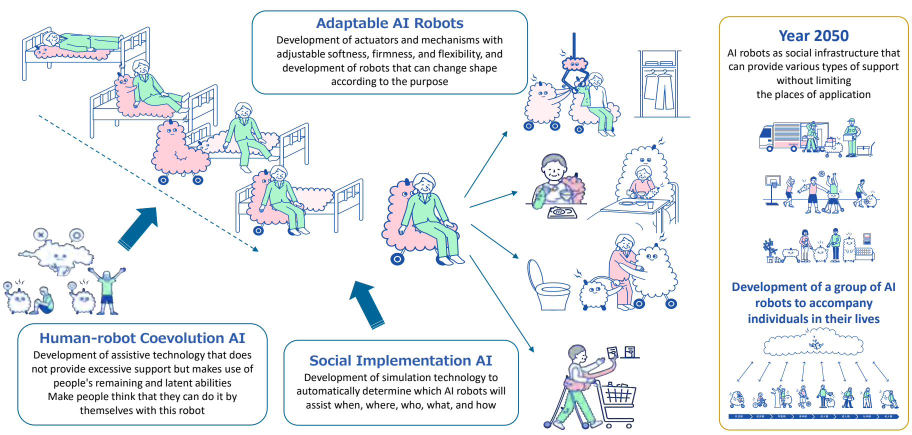

Fig. 1. Project Concept for Nursing Care in 2030

2 CARE -Cooperation of Ai-Robot Enablers-

In the current nursing care field, various robots and monitoring sensors are already in use. However, most of these robots and sensors are used as stand-alone devices. We have also proposed many stand-alone assistive robots such as sit-to-stand assist robot [4], robotic walker[5], cycling wheelchair robot[6], etc. While there are some sites where they can be used successfully, there are many sites where they have been introduced but are not being used. In order to introduce robots and other advanced technologies to nursing care facilities, we believe that (1) various devices must be able to be used in cooperation with each other, and their combinations must be freely changeable according to various forms of support, (2) they must be easy to use without specialized knowledge, and (3) it must be possible to verify whether they can be used in the field before they are actually introduced. To overcome these kinds of issues, other relevant projects that have used socially assistive robots for long-term support in homes or care facilities have been proposed [7], [8]. Our project particularly focuses on providing appropriate support to the user by distributing tasks to an IoT-based multi-robot control system where each robot can do a specific task. Unlike a single robot system, our proposed system is less complex, and task distribution and allotment between the robots can be efficiently handled without hindering the overall task at hand.

In order to solve the above issue (1), the authors have developed a common control framework using ROS, Robot Operating System that connects devices in order to cooperatively use commercially available robots, assistive devices, interfaces, sensors, etc. The ROS is a common operating system that provides software developers with libraries and tools to support the creation of robot applications [9]. In recent years, not only university researchers but also companies have been adopting ROS for robot control and sensor measurement, making it possible to link various robots and sensors. On the other hand, even if engineers can utilize robots and sensors using ROS, there are many people who are not familiar with these devices and ROS programming in the actual nursing care field. Therefore, it is necessary not only to make it easy to use these devices but also to appropriately recombine multiple devices depending on the situation and the target person to solve the above issue (2). The authors have constructed a system that can easily operate in cooperation with existing IoT (Internet of Things) sensors/actuators, AI speakers, and ROS-compatible robots by connecting them to the Internet. These systems also enable the construction of robot and sensor operation interfaces via IFTTT, If This Then That [10]. IFTTT is a web-based service that uses APIs related to web-based services to trigger something actions. It is said that there are more than 700 IFTTT-compatible services, enabling users to choose the interface that best suits their needs.

Furthermore, if there is a system that can verify in advance the cooperative operation of multiple robots and sensors in response to changes in the support scenarios, robot devices, sensors, and environment, it will be possible to confirm the degree to which these systems can be used at the actual nursing care site before introducing them to the site. This is an issue shown above (3). To address

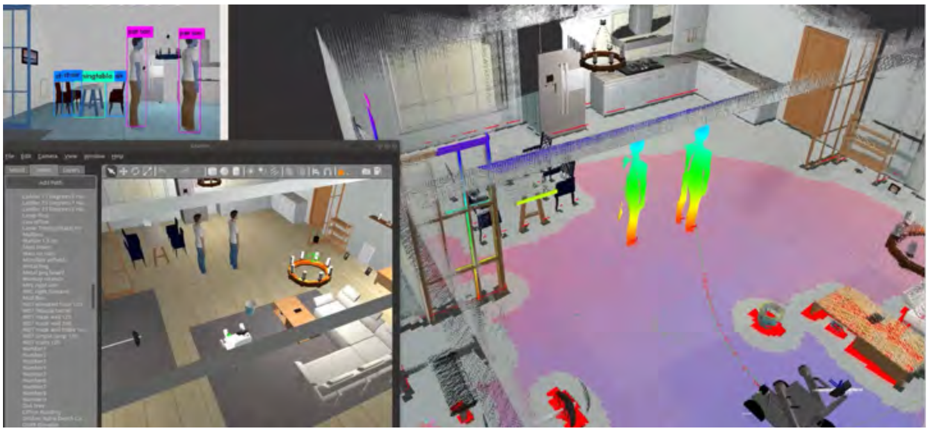

Fig. 2. Living Lab Simulator

this issue, the authors have developed a virtual environment called the living lab simulator as shown in Figure 2, which can verify in advance the cooperative operational configuration of multiple robots and sensors and their operational algorithms in response to changes in support scenarios, robots, sensors, environments, and so on. Using this simulator, it is possible to realize a digital twin of the nursing care field and to study the most suitable operation method of nursing care robots and sensors for each nursing care field. In addition, the living lab simulator can help determine the form of support provided by the multi-robots in real-time. The project is developing a micro-level simulator for human musculoskeletal simulation, a macro-level simulator for determining how an entire group of robots should behave, and so on. By combining these several levels of simulators, the project aims to be able to determine which robot should provide assistance, when, where, to whom, and how.

3 Verification Experiment for CARE in the Living Lab

The authors have established the "Aobayama Living Lab" as shown in Figure 3 at Tohoku University's Aobayama Campus as a center for research and development of nursing care robots, finding both new and innovative solutions for the future in 2050 and realistic solutions that can be applied in the near future. The Aobayama Living Lab is a 250 m^2 space that simulates both nursing home and home care environments and is equipped with various sensors and nursing care robots necessary for research and development. In this section, we show an example of a supported scenario in which multiple robots and sensors are operated in a cooperative manner using IoT sensors/actuators, AI speakers, and

Fig. 3. Aobayama Living Lab at Tohoku University

ROS-enabled robots installed in the Aobayama Living Lab. Although there are many possible scenarios in which robots can be used in a nursing care facility, as the first effort in this study, a scenario was constructed from the perspective of morning activities. In this scenario, the patient gets up from bed, drinks water, then moves to the living room using a walker-type robot, and then goes for a walk outside using a wheelchair-type robot. For example, (1) the back of the bed is raised and adjusted to an appropriate height for standing up by calling "Good morning" to the AI speaker, (2) the object transport robot automatically brings water based on the call "I'm thirsty", (3) a walker-type robot automatically comes to the user when the user calls out "I want to go to the living room", and (4) a wheelchair-type robot picks the user up at the front door when the user calls out "I want to go for a walk". The scenario is shown in Figure 4

The authors' research and development in the Moonshot project aim to realize human-centered support that encourages the user's independent movement rather than providing excessive support or services to the user. Therefore, this project focuses on "self-efficacy," which is the recognition of one's own potential, and aims to improve "self-efficacy" by accumulating users' success experiences between users and AI robots. In other words, we aim to design the behavior of the AI robot so that the user feels that he/she can do it by himself/herself if he/she works with the AI robot. Currently, the above scenarios are created in advance, and the robots operate according to the scenarios. In the future, we intend to develop simulation technology that automatically determines which AI robot will assist when, where, who, what, and how, and technology to improve self-efficacy by making use of a person's remaining and latent abilities without excessive assistance.

Fig. 4. Validation of CARE in Morning Activities Scenario

4 Nursing Care Guidance using AR Glasses

As indicated in the previous section, various cutting-edge technologies will be introduced into the nursing care field in the future. However, for those who have little experience with such technologies, it is not easy to introduce them into nursing care field. This does not simply mean that technicians should enter the nursing care field, but people who understand nursing care well should be able to use these advanced technologies. This will make it possible to respond to individual needs by combining various sensors, actuators, robots, AI speakers, etc., in accordance with the characteristics of the site and the patient being cared for. If we can educate such human resources, we will be able to provide many individualized supports even with current technology, without waiting for the development of high performances robots such as a humanoid robots. In addition, in the future, more and more people, especially in Japan, will want to care for at home, and this will create problems that caregivers not only of young families but also of the elderly have to provide care for the family members. In such cases, family members with little care-giving experience will need to provide various types of support, but it is likely that many situations will arise in which they will not know what type of support is appropriate.

To solve these educational problems, the authors are developing a system using AR glasses, which can project a virtual environment such as people, objects, text, etc. onto the real scene to show what care actions should be performed depending on the situation as shown in Figure 5. For example, when transferring a patient from a bed to a wheelchair, the system can show the caregiver where the patient should lie in bed, what position the arms should be in, how the legs should be bent, etc., according to the actual condition of the person receiving care. Also, in the case of transferring a patient from an end-occupant position to a wheelchair, it is possible to confirm in real-time where and at what angle the wheelchair should be positioned and how to support the transfer operation from there. We believe that this will help to realize nursing care movements that are appropriate for each individual in a place, rather than using instructional books or video materials.

In addition, the system can warn the caregiver if he or she is about to perform an incorrect or inappropriate care-giving action or if the caregiver is in a potentially dangerous position if he or she continues with the action. This allows the caregivers themselves to perform care-giving actions with peace of mind. When caregivers are able to perform care-giving without warnings, they can feel that their own skills have improved, and as a result, their sense of self-efficacy can be improved.

5 Conclusions

This paper introduced the Moonshot project that the authors are currently working on, and presents, in particular, CARE -Cooperation of Ai-Robot Enablers-, which is a cooperative assistance technology that responds to the individuality of care-receivers by cooperatively using multiple AI robots, assistive devices, sensors, interfaces, and other devices. We also focused on the importance of building an educational system for the successful use of advanced technologies. For such education we proposed a nursing care motion guidance system that enables caregivers to provide appropriate nursing care even if they are not skilled caregivers. We hope that the active use of these technologies will help improve the productivity of nursing care facilities in the future.

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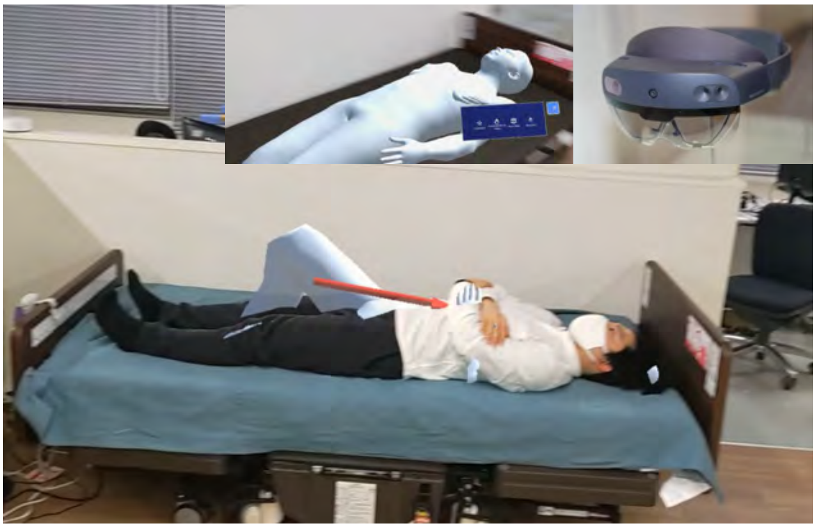

Fig. 5. Guidance using AR Glasses for Novice in the Nursing Care

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