R&D Theme

R&D of AI for human-robot coevolution

Progress until FY2022

1. Outline of the project

The objective of this research theme is to design AI robots that do not provide excessive support but rather encourage people to act on their own, making use of their remaining and latent abilities. The robot will induce independent actions by making a user feel that I can do it by myself if the robots support it, and will eventually make me feel that I can do it by myself even without the robots, thereby creating vitality to challenge various things.

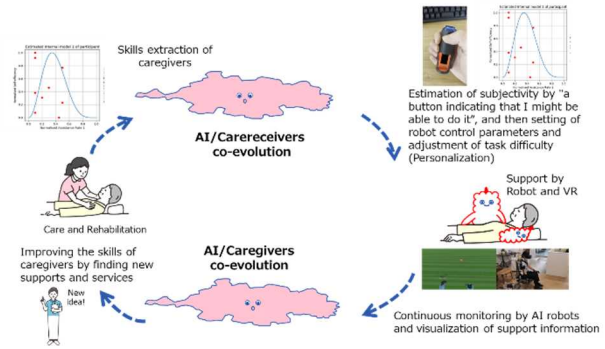
For this purpose, we are conducting research focusing on "self-efficacy," subjective perception of the possibility of one's own actions. We are developing an AI robot that improves an individual's sense of self-efficacy and encourages him or her to challenge various actions and tasks.

2. Outcome so far

In FY2022, we have aimed to develop a training system to improve the self-efficacy of caregivers and challenge them to perform various tasks and rehabilitation for the purpose of utilizing the system in the nursing care field. Support for improving a person's sense of self-efficacy can be effectively achieved by formalizing the tacit knowledge of caregiver skills and realizing it with a robot. In addition, it is necessary to appropriately understand the subjectivity of the individual (e.g., self-efficacy) and adjust the support parameters of the robot and training system.

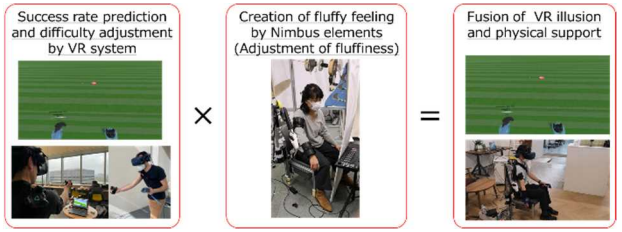
On the other hand, estimating an individual's subjectivity and adapting the support parameters of the system to the individual based on that subjectivity is a very challenging and difficult task. In addition, self-efficacy cannot be improved by simply providing successful experiences in task realization. It is necessary to repeat "good successes," which can be achieved without being too easy, and to generate "good failures," which are just barely short of success, at appropriate times. For this purpose, the realization of a training system that can appropriately adjust success/failure experiences is a very challenging R&D issue.

In this theme, we have developed an "AI/Caregivers co-evolution" framework that first formalizes the tacit knowledge of caregivers' skills, then adapts to individuals based on their subjective estimation, and then provides support by robots. In particular, to estimate a person's subjectivity, we developed a simple interface, "a button indicating that I may be able to do the task," to grasp the user's "confidence in the task. This enables us to estimate individual subjectivity in real time without relying on post-task questionnaires, etc., and to construct a framework for determining AI robot control parameters that can be appropriately adapted to the individual.



In addition, we developed a training system that can create good success/failure experiences by linking physical assistance using the elemental technology of Robotic Nimbus (cloud-like fluffy feeling creation technology) which is being developed under R&D item 2 and Virtual Reality (VR). By adjusting physical support parameters appropriately and providing moderate support without excessive support, we developed a technology to give the user the feeling that he/she is moving his/her own body and to improve the success rate of tasks. In addition, we were able to develop a technique for estimating an individual's task success rate and adjusting the task difficulty freely in a task in a VR system.

Such a training system that combines the visual illusion of VR and the tactile illusion of physical support, and adjusts the control parameters while estimating the person's subjective feelings, is an epoch-making approach that has not yet been realized in current rehabilitation.



3. Future plans

Using the AI/Carereceivers co-evolution framework and the VR/physics-assisted fusion training system constructed in FY2022, the following will be achieved in several tasks.

- Develop assistive technology that improves self-efficacy by adjusting task difficulty appropriately and adjusting success probability according to each user.
- Integrate the developed assistive technology appropriately with the Robotics Nimbus prototype to be developed in R&D item 2.
- We will construct an AI/Caregivers co-evolution framework that improves the skills of caregivers through the discovery of support and services that they had not noticed before by means of continuous monitoring by AI robots and visualization of assistive technologies. And then we will realize a virtuous circle loop with the " AI/Carereceivers co-evolution" proposed in FY2022.

R&D Theme

R&D of Adaptable AI-enabled robots

Progress until FY2022

1. Outline of the project

In this research theme, we are developing robot hardware with actuators and mechanisms that can be soft, firm, or adjustable in flexibility, as well as sensing and control technologies adapted to such hardware, with the aim of freely adapting to humans and the environment.

We are developing an adaptable AI robot that can transform its shape and form according to a person's purpose, physique, degree of disability, and other factors, as well as technology to estimate a person's intentions and actions. A robotic Nimbus is a robot concept that can softly deform like a cloud and extend human motion and function based on human intention, like a Flying Nimbus vehicle.

2. Outcome so far

In order to develop robotic hardware that provides physical support to overcome physical disabilities and poor movement, it is difficult to build a single high-functionality robot that can adapt to all the individual characteristics of the person and the environment and purpose of use. Therefore, in this theme, we have developed an elemental technology for robot hardware called Nimbus Elements, which can provide support tailored to a person's condition (physique, disability, etc.), environment, and purpose, while freely transforming, attaching, and detaching like a cloud.

By freely combining Nimbus Elements to reconfigure their shapes and functions, and by providing support according to the purpose, robots with various shapes and forms can be realized. The cloud-like softness of the Nimbus Elements facilitates cooperative control among Nimbus Elements, and also facilitates the cooperative motion of multiple robots composed of Nimbus Elements.

In FY2022, the following Nimbus Elements were developed to realize movement primitives according to the support configuration (grasping, holding, moving, manipulating, etc.). Comfort Element (temperature and humidity control), Actuation Element (light assistance), Holding Element (holding a human), Grasping Element (grasping an object), Moving Element (moving human/object), Supporting Element (supporting a human or assisting in movement), and Manipulation Element (manipulating object),

The handling of flexible and irregularly shaped objects is more challenging than the handling of rigid and shaped objects. In addition, humans are not only soft, but also delicate, and supported stably, which cannot be achieved with conventional robot hardware. Therefore, it is necessary to develop new robot hardware with actuators and mechanisms that can be soft or firm, and whose flexibility can be adjusted.

In FY2022, the following technologies were developed as new robot hardware elements. Technology to achieve both gentle wrapping along the human body shape and trunk retention, technology to achieve both flexibility and heavy-weight transportation, technology to achieve both lightweight enough to be worn by a person and rigid enough to maintain the posture of the trunk, arms, and legs, technology for temperature-, humidity-, and friction-coefficients changeable skins that adjust to human comfort, a mechanism that can expand and contract freely according to a person's height and posture, etc.

In order to expand humans' capabilities, we have also developed object manipulation technology that senses human intention and allows the robot to feel its own physical expansion. In addition, we have developed a technology that enables a cloud-like robot that provides fluffy support to feel as if it were part of the body, and to perform supportive actions without a sense of discomfort (feeling that it is moving on its own).

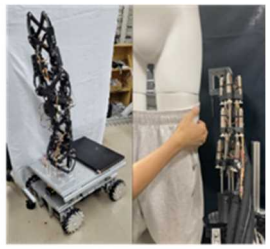

Comfort Element


Actuation Element


Holding Element


Moving Element


Supporting Element


Manipulation Element

3. Future plans

- Develop various Robotics Nimbus prototypes by integrating the developed Nimbus Elements appropriately.
- Extract support actions/tasks to realize the scenarios of care robot support formulated from the viewpoint of social implementation, and realize them by appropriately integrating the developed Robotics Nimbus prototypes.
- Verify the degree of accomplishment of the extracted support actions/tasks in the Living Lab.

R&D Theme

Social implementation of a collective of coevolution AI robots

Progress until FY2022

1. Outline of the project

This research theme aims to develop a self-organizing social AI that adapts to people and the environment and modifies its assistance plan and functions on its own, as a technology necessary for anyone to be able to use AI robots anytime, anywhere with peace of mind. In other words, we will develop simulation technology that automatically determines which AI robots will assist when, where, who, what, and how.

In addition, we will address issues necessary for social implementation, such as the establishment of a demonstration experiment environment (living lab), the creation of social proof scenarios, the design of development concepts for standardization, the establishment of safety evaluation standards and risk assessment methods, protection of personal information, and ELSI.

2. Outcome so far

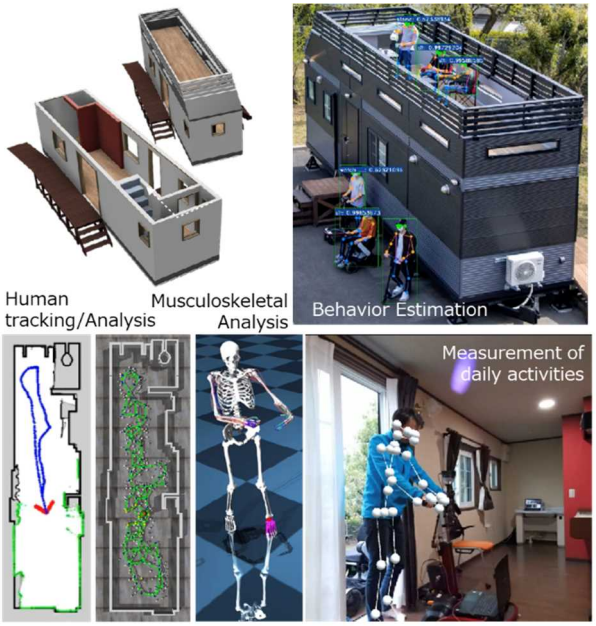
We are working on standardization for the social implementation of new robots, ELSI strategies, development of demonstration sites, construction of technology for the cooperative operation of multiple AI robots, and development of simulators for system integration. In addition, we are working on a framework for sharing the data set developed in R&D item 3 with R&D item 1, as well as on control and operation methods for the adaptable AI robots in R&D item 2, to ensure close collaboration in anticipation of demonstration experiments.

An organizational development framework for ELSI/RRI, which includes concept design, analysis, ethical compliance, and risk assessment of the robot to be developed, was established in accordance with IEEE SA 7000. In addition, to integrate people, robots, and AI, we developed a support tool for developing social implementation scenarios based on the Service Robot Design Matrix (SRDM) by identifying relationships among stakeholders and pain points extracted from them.

Furthermore, as an elemental technology for self-organizing socially implemented AI, we constructed a living laboratory for measuring daily life functions in which various sensors are placed. This living lab is a space where users can understand "what they can do" and "what they cannot do" and "what they want to be able to do" through activities in the lab. In other words, it is a space where they can estimate their cognitive/physical abilities and extract necessary support while having fun through activities in the living lab. It is an epoch-making space that can realize micro-analysis (movement and eye movement measurement, muscle activity estimation), meso-analysis (object manipulation and human behavior analysis), and macro-analysis (task execution evaluation).

Based on the analysis results in the living lab, we also conducted a cooperative planning simulation of AI robots and constructed a IoT based control framework for multiple robots/sensors using a common OS that enables the coordination of robots, sensors, interfaces, and other devices. We conducted demonstration experiments using this framework in the living lab and rehabilitation room at the National Center for Geriatrics and Gerontology.

In addition, to construct a privacy-conscious activity dataset for nursing homes, the actual activities of people are represented by a virtual environment and avatars. In addition, we are developing elemental technologies to measure biometric and physiological information such as eye gaze and heart rate, and to provide the data set together with synthetic voice and daily life sounds.



3. Future plans

- From the viewpoint of social implementation, develop support scenarios using nursing care robots, and specify necessary support actions and tasks derived from the scenarios.
- Development of simulation technology to automatically determine which AI robots should support when, where, who, what, and how.
- Development of operation scenarios for social implementation of Robotic Nimbus, evaluation of functions and ethics, and standardization of AI robots for nursing care.