R&D Item

1. R&D of AI for human-robot coevolution

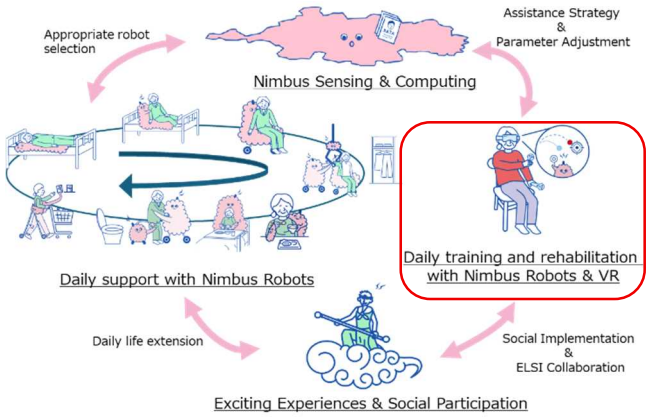
Progress until FY2024

1. Outline of the project

This research theme aims to design AI robot behaviors that encourage humans to act independently, leveraging their remaining and potential abilities without providing excessive assistance. The goal is for users to feel, "With this robot, I can do it myself," thereby initiating proactive behavior. Ultimately, we want them to think, "I can do it myself even without this robot," fostering the vitality to try various new things.

To achieve this, our research focuses on "self-efficacy," which is the subjective perception of one's own capabilities. We are developing an AI robot that improves an individual's self-efficacy and encourages them to attempt diverse actions and tasks.

To accelerate our efforts toward practical implementation in nursing care settings, this research and development theme will concentrate on the "daily training and rehabilitation" domain within the overall integrated vision for research and development shown in the figure below.



2. Outcome so far

This research developed a framework to dynamically adjust the control parameters of adaptive AI robots (Nimbus Robots) based on optimal strategies and support parameters from a social implementation AI simulator. This enables personalized robot behavior that precisely matches an individual's current state and goals. As a result, robots are expected to evolve beyond mere tools, becoming entities that meticulously cater to each user's unique needs.

This technology is particularly transformative in daily training and rehabilitation. We've introduced a "can-do button" for direct feedback on a trainee's subjective feelings and motivation. By integrating cutting-edge VR/AR systems with physical support from Nimbus Robots, we've created a system where trainees can actively generate successful experiences (including valuable learning from failures). This comprehensive approach aims to significantly boost trainees' intrinsic motivation and self-efficacy, not just recover or improve physical function. Users can engage in rehabilitation more actively and consistently, enjoying the process like a game, challenging their limits, and experiencing a sense of accomplishment.

Currently, this system's development is most advanced in upper limb support, with its effectiveness clearly demonstrated in multiple validation experiments. However, our research extends beyond this; we've already completed the development of robots and VR systems for gait support and sit-to-stand assistance, steadily expanding its application scope. These systems integrate several advanced technologies for more effective and efficient training and rehabilitation. These include difficulty adjustment functions (for both robot and VR), the aforementioned subjective evaluation feature (can-do button), and detailed feedback based on motion visualization and analysis. This ensures users always receive the optimal level of support tailored to their physical abilities and goals, allowing them to engage in training proactively and maximize their potential.

Furthermore, these developed systems are now undergoing validation in actual care facilities, where we are assessing their practical utility and identifying challenges in real-world settings.

3. Future plans

In the future, we'll further integrate our core technologies for both upper and lower limb support. This means seamlessly linking features like difficulty adjustment, subjective evaluation feedback, and motion visualization/analysis to enhance the system's versatility.

By doing so, we aim to generalize the system's application beyond limited training environments, extending it to a wide range of daily training and rehabilitation tasks. This broad applicability will allow us to address the diverse needs of more users, significantly expanding the possibilities of support from adaptive AI robots.

R&D Item

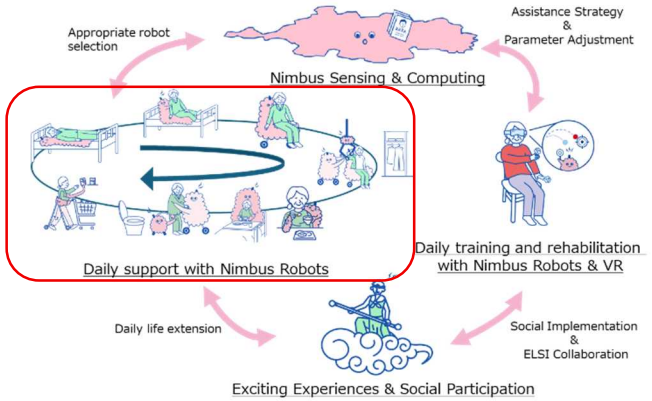
2. R&D of Adaptable AI-enabled robots

1. Outline of the project

This research theme aims to create robot hardware with actuators and mechanisms that can freely adapt their stiffness and flexibility. We're also developing corresponding sensing and control technologies to match this adaptable hardware.

We're advancing the development of adaptive AI robots that can estimate human intent and actions, and transform their shape and form based on a person's purpose, physique, or the degree of their disability. We've proposed the "Robotic Nimbus" concept: robots that can softly deform like a cloud and, like Kintoun (the Flying Nimbus), extend human motor functions based on human intent.

To accelerate real-world validation in elder care settings, this research and development theme envisions using various Robotic Nimbus types to provide daily life support, as outlined in the overall integrated research and development vision shown below.



2. Outcome so far

This research focuses on developing Nimbus Robots designed to assist with a variety of everyday tasks and movements. Under the "like a cloud" concept, we've created the Nimbus Holder, which offers a gentle embrace that conforms to the human body while simultaneously providing robust torso support. We also developed Nimbus Wear, designed to maintain wearer comfort while providing the necessary rigidity to support the trunk, arms, and legs. Furthermore, the Nimbus Sheet combines remarkable flexibility with the ability to transport heavy objects, with the ultimate goal of assisting with human transfer. These innovations serve as foundational technologies for robots that gently conform to users' bodies and provide highly personalized support.

Meanwhile, following the "like Kintoun (Flying Nimbus)" concept, we developed Nimbus Limbs, which are telescopic and can support body weight based on a person's height and posture. We also developed the Flying Nimbus, a soft system capable of achieving complete weightlessness. These advancements enable groundbreaking support that expands user capabilities and opens new possibilities, addressing challenges that were previously difficult for traditional robots to overcome.

We've also made significant progress in developing hardware modules that can attach and detach like clouds. By integrating these modules with commercially available robotic arms or walkers, we've built systems capable of performing complex tasks, such as dressing assistance. This diverse range of developments demonstrates the adaptive AI robot group's remarkable flexibility in handling various tasks. It also embodies the core vision of this project: a robot whose form and function can change freely to match an individual's condition and purpose. Through demonstrations at various events, the exceptionally high expandability of these Nimbus Robots has been proven, marking a significant step toward their social implementation. This breaks through the limitations of fixed functions and forms inherent in conventional robots, which is crucial for realizing truly human-adaptive support.

3. Future plans

In the future, we will further develop our existing elemental technologies and integrate them into a reconfigurable system. This will allow us to evolve into a versatile "Robotic Nimbus Group" capable of adapting to diverse purposes and situations. Specifically, we plan to develop and validate the effectiveness of several prototypes through real-world demonstrations: the human-adaptive Nimbus Holder, the environment-manipulating Nimbus Sheets, the task-specific Nimbus Wear, and the task-specific Nimbus Limbs.

R&D Item

3. Social implementation of a collective of coevolution AI robots

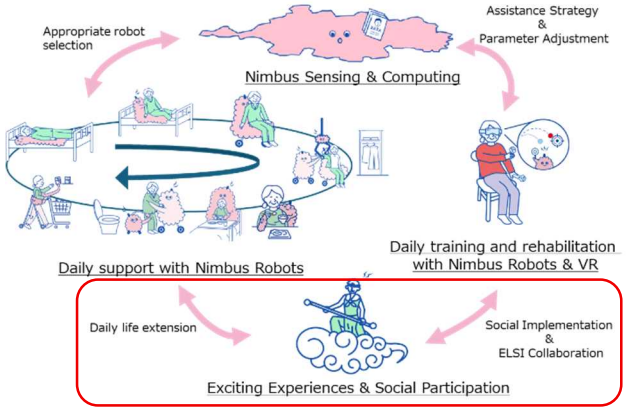
Progress until FY2024

1. Outline of the project

This research theme aims to develop key technologies for AI robots to become a ubiquitous, safe, and reliable part of daily life. Our primary focus is on creating a self-organizing social implementation AI that adapts to people and environments. This AI will autonomously determine which robot provides what support, when, where, and to whom, using advanced simulation technologies.

To ensure successful societal integration, we are also establishing demonstration environments (living labs) and crafting social implementation scenarios. Our efforts include designing development concepts with an eye toward standardization, building robust safety evaluation criteria and risk assessment methods, and addressing critical ELSI (Ethical, Legal, and Social Issues).

To accelerate real-world validation in nursing care, this theme will concentrate on Nimbus Sensing & Computing and fostering exciting social experiences, as shown in our integrated research vision.



2. Outcome so far

This research developed "Nimbus Computing," a social implementation AI simulator for the coordinated operation of our Nimbus Robots. This simulator enables us to determine which robot provides what support to whom, and with what parameters, establishing a framework for seamless collaboration among multiple robots, welfare devices, and caregivers. This significantly contributes to providing seamless services with adaptive AI robots.

We're also vigorously pushing for the social implementation of our rehabilitation systems and Nimbus Robot technologies. We launched the Moonshot Challenge House concept with partners, starting efforts to introduce robots and training systems into homes. Collaborating with a nationwide elder care company, we created a vision for future care facilities. These initiatives are accelerating discussions with care providers, local governments, and robot developers to realize care facilities incorporating Moonshot's achievements.

To speed up AI robot social integration, we're creating new development concepts, formulating application scenarios, setting up verification facilities, and exploring shared data management based on ELSI (Ethical, Legal, and Social Issues). We're also preparing for the international standardization of AI robot ethical evaluations. A significant achievement here is the IEEE Standards Association's approval to establish the AI robot ethical standardization (P7017) working group, initiating global discussions. This is crucial for enhancing AI robot social acceptance and ensuring safe, confident use.

Furthermore, as an exciting initiative involving AI robots, we are promoting Smarter Inclusive Dance, an activity designed for enjoyment by everyone, regardless of disability. This initiative is being advanced through interdisciplinary and international collaboration, and its innovativeness has been highly praised. It has received the Robot Award and has also been featured as a case study for comprehensive knowledge utilization by the Cabinet Office.

3. Future plans

We're driving the development and validation of an AI robot group collaborative operation simulator, designed to automatically determine roles within AI robot groups. This aims to revolutionize eldercare by enabling advanced coordination among care robots.

To further accelerate societal integration, we're also focused on establishing safety evaluation standards for the Robotic Nimbus and developing ethical standardization for AI robots used in healthcare. These combined efforts will expedite the adoption of AI robots in practical care settings.