

R&D Theme

Social and embodied augmentation technology (Cognitive Augmentation Research Group)

Progress until FY2022

1. Outline of the project



Realize cybernetic avatars that can maximize the potential of the user depending on the situation and environment

We are engaged in research to clarify the conditions under which users can leverage cybernetic avatars (CAs) with physical characteristics different from those of the actual body to realize their own potential beyond their intrinsic limitations, or to gain diverse physical experiences and values to enhance their social skills, such as empathy and cooperation with others. Based on this knowledge, we develop cognitive augmentation technology that supports users to freely demonstrate their desired abilities according to the situation and environment by utilizing CA with appropriate physical characteristics, and to enable everyone to be active in society in their own way, thereby contributing to the "freedom from physical limitations" that Goal 1 aims for.



Development of embodied experience control methodology for social augmentation

Takuji NARUMI (The University of Tokyo)



Understanding neurocognitive mechanisms of social and embodied augmentation

Sotaro SHIMADA (Meiji University)



Development of technologies to enable real-world avatar for the transformation of embodiment

Ryoma NIYAMA (Meiji University)

2. Outcome so far

(1) Elucidate and utilize the influence of CA's physical characteristics on users' cognitive abilities and social skills from diverse perspectives

(2) Develop soft wearable CA robots that can be worn

(3) Deploy practical applications of CA-based cognitive augmentation in education, diversity training, remote employment for people with disabilities, etc.

In (1), we verified the effects of CA's physical characteristics on users' cognitive abilities and social skills from various perspectives, and developed methods to support the acquisition of new physical abilities, enhancing memory and promoting inspiration. In addition, we found that contrasting the physical characteristics of one's own CA with those of others further enhances the cognitive augmentation effects (Fig. 1-1). We also showed that the use of CA can change personality traits, for example, by showing that openness improves after the use of a doctor-style CA (Fig. 1-2).

In (2), to make the cognitive augmentation readily available in the real world, we developed a wearable CA robot that is lightweight, easy to wear, and inflates only when needed, utilizing soft materials and soft-robot (Fig. 2).

In (3), we deployed cognitive augmentation technology in real world situations in society. For example, we conducted an online lecture where lecturers used CAs and showed that when lectures were given while changing the appearance of the CAs used by the teacher, the students' performance improved (Fig. 3-1). We also designed a workshop to eliminate unconscious bias related to working parents, and demonstrating that it can support the creation of a workplace where everyone can feel comfortable (Fig. 3-2). We also deployed virtual avatar cafe, which enables people with difficulty accessing employment as a result of disability to engage in customer service with a virtual CA where they can express themselves, demonstrating that the cognitive augmentation effect increases not only ease of work, but also work motivation and well-being (Fig. 3-3).



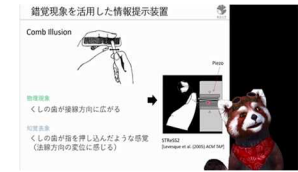
(1-1) Contrast with others' avatars amplifies the cognitive enhancement effect



(1-2) The use of physician avatars can improve openness



(2) Wearable CA that can be worn and appears only when needed



(3-1) Lecturing while teachers change their appearance improves learning



(3-2) Unconscious Bias Workshop Development



(3-3) Self-expression by CA Augmented avatar customer service incorporating

3. Future plans

In (3), it was not clear whether the cognitive augmentation effects are enhanced or attenuated by longer-term use of CA, or to what extent CAs become established as part of the user's own identity. Also, the physical and cognitive load which the continuous use of CA places on users have not yet been clarified. In the future, we will develop cognitive augmentation technology that is easy to use on an ongoing basis in society by clarifying the long-term effects and the effects on the body and brain in more detail.

R&D Theme

Parallelization of experience and integrated cognitive behavioral technology

(Parallel Agency Research Group)

Progress until FY2022

1. Outline of the project



A body that can perceive and act in different spaces at the same time by parallelizing its own physical experiences.

To transcend the one-person-one-body notion when using a cybernetic avatar (CA), we aim to create technology that allows seamless transitions between multiple CAs. This technology will merge perceptions from different bodies, ensuring a consistent sense of self and bodily subjectivity. Additionally, it will preserve and share emotions, movements, and sensations, pushing towards liberation from bodily, spatial, and temporal limitations through the use of CAs.



Development of technologies for integrated agency in parallel embodiment.

Shunichi KASAHARA (Sony CSL)



Understanding the neuroplasticity mechanisms of adaptation to co-creation action technology

Kazuhisa SHIBATA (RIKEN CBS)



Development of emotion digitalization and experience compression technology based on physiological sensing.

Kai KUNZE (Keio Media Design)

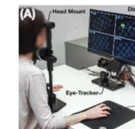
2. Outcome so far

- (1) Development of Parallel Ping-Pong CA System
- (2) Development of a fast-switching method for parallel operation of multiple CA bodies
- (3) Realization of a parallel CA operation learning method that uses multiple CA bodies simultaneously.
- (4) Morphing identity system that continuously changes faces and clarifies the boundaries of facial identity on CA
- (5) Development of Frisson waves to measure and share emotional changes faces to clarify the boundaries of facial identity on CA

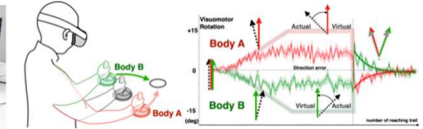
To verify the feasibility of the experience of one user operating multiple bodies simultaneously through the CA, in (1) we designed a parallelized CA focused on table tennis, enabling a single user to control two CAs simultaneously playing on different tables. The viewpoint images from both CAs were merged and presented to the user. In (2) we introduced an interface that rapidly switches between multiple CAs using gaze information, achieving faster outcomes in a task involving four parallel spatial coordinates. As part of (3) we explored parallel motion learning in virtual space using CA bodies, identifying how different motion traits can be simultaneously learned via a third-person perspective. In (4) a machine-learning-driven system was created to enable seamless facial transformations on the CA, ensuring continuity when managing the features of multiple CAs. This was tested in a series of public experiments to define the boundary between one's own identity and others using facial expressions. In (5) we developed emotion estimation and induction technologies, as a way to facilitate shared emotional experiences among multiple individuals during music performances.



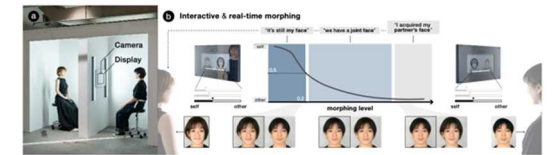
(1) Parallel Ping-Pong using Parallelized CA



(2) Fast switching method for multiple parallel operations



(3) CA motion learning parallelization



(4) Morphing Identity :Continuous Self-Face Transformation



(5) Frisson Waves: measure and share emotions

3. Future plans

We will simultaneously pursue two goals: the development of interface technologies for seamlessly embodying multiple CAs, and foundational neuroscience research to elucidate how the human brain adapts to parallelized bodily sense. We also aim to measure and analyze biometric signals and strive to realize the compression and transmission of experiences based on emotional information.

R&D Theme

Technology that combines the abilities of multiple bodies into one (Collective Ability Research Group)

Progress until FY2022

1. Outline of the project



A body that can integrate its own and others' skills to go beyond individual capabilities

We will develop technologies to share and integrate the diverse physical skills of multiple people simultaneously connect to a single cybernetic avatar (CA). The system allows users to act while sharing each other's senses and capabilities. By realizing CAs that can support sharing and integration of advanced skills and demonstrate beyond individual capabilities, we will contribute to the achievement of "freedom from physical limitations" as stated in Goal 1.



Development of skill co-creation technology that embraces physical diversity

Yoshihiro TANAKA (Nagoya Institute of Technology)



Development of intention mediation and physical response control technology in body fusion

Hiroataka OSAWA (Keio University)



Enabling intrinsic ability activation for frailty treatment by cybernetic avatar technology

Hitoshi HIRATA (Nagoya University)

2. Outcome so far

- (1) Development of a CA platform for skill fusion
- (2) Realization of remote co-creation by people with severe disabilities using skills fusion CA
- (3) Development of a method for remote sharing and learning of skills through the transmission of tactile sensations

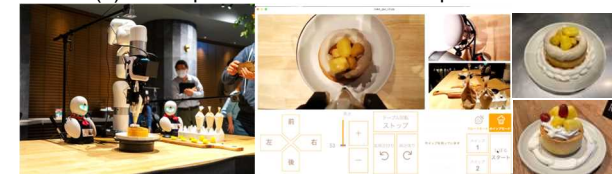
In (1), with the aim of enabling physical co-creation across people with different skills and experiences, we developed "Collaborative Avatar," a CA platform for skill fusion in which two individuals simultaneously operate a single robot to perform collaborative tasks. The two operators can share a single physicality by merging their movements according to a specific ratio or by dividing the roles among themselves.

In (2), the skill fusion CA is used to support employment opportunities for people with disabilities. For one month, two people with severe disabilities (who have limited mobility in upper and lower limbs, and experience difficulties going out) used the CA to handcraft customized pancake decorations in real time for customers at an alter-ego robot café. Through this demonstration experiment, it was shown that the operators felt a sense of agency in working remotely and in fusion through the CA, and that they felt an expansion of their individual abilities and creativity through collaboration with others, clarifying that the skill fusion CA can achieve both smooth cooperation and coordination and support the exercise of individual creativity.

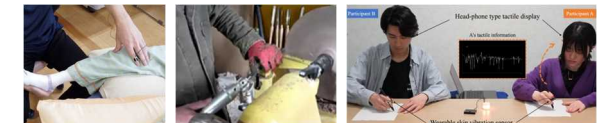
In (3), we are developing an infrastructure for remote sharing of skills based on the sharing of tactile sensation with the aim of realizing direct skill sharing from person to person over a network. By measuring the tactile sensation from fingertips and remotely transmitting and sharing the experience alongside video images, we have developed prototypes of a remote palpation system that enables a physical therapist in a remote location to evaluate contractures in a patient, as well as a system that enables users to experience the skills of a craftworker in a remote



(1) Development of a skill-fusion CA platform



(2) Demonstration experiment of pancake toppings by two people with severe physical disabilities utilizing a skill-fusion CA



(3) Trial of skill sharing (palpation/woodworking) and skill learning by transmission of tactile sensation

location. In addition, we have proposed a method to facilitate learning skills by superimposing the tactile experience of a skilled person on oneself across time and space while performing the target task, aiming for higher efficiency in the transmission of skills.

3. Future plans

We are promoting fusion between human and AI in CA operation models (AI) and skill fusion between three or more people, aiming at social application and advancement of skill fusion in CA. In fusion with AI, we aim not only to provide functional support but also to co-creation. For direct integration of skills between people, in addition to sensory sharing, we will introduce muscle stimulation, etc., and work on sharing by input/output of motor information. We will verify the effectiveness of sensory and motor sharing for the transmission of skills and prevention of frailty in the elderly.

R&D Theme

Building a foundational CA platform for co-creation (CA-Cloud Platform Research Group)

Progress until FY2022

1. Outline of the project



Building a CA Platform for "Digital Twin of the Body" which allows people to freely share experiences and co-create.

By unraveling the interactions between the body, mind, and social abilities, we construct a design theory of cybernetic avatars (CAs) that enables CA users to realize their full potential beyond the single individual, or to gain different experiences and values through bodies different from their own. The creation of a CA platform enabling physical co-creation through the integration and utilization of people's experiences and skills in cyber-physical spaces, contributes to the Goal 1 aim of a society where people are free from bodily limitations.



Construction and application of the CA infrastructure technology for embodied co-creation

Kouta MINAMIZAWA (Keio Media Design)



Construction of next-generation CA cloud and promotion of international standardization

Akira FUKABORI (avatarin Inc.)



Development of digital neural technology for realizing Cybernetic Human-Link

Masaaki SATO (Tokai University)

2. Outcome so far

- (1) "MxN" CA platform to connect multiple people with multiple CAs: Implementation of a system that can be operated by 2 operators x 3 CAs
- (2) Development of bodily sensation and emotion sharing technology through CA
- (3) Establishment and operation of the Cybernetic being consortium
- (4) CA operation experiments in public spaces for social implementation of CA

In (1), a system in which two operators can operate three CAs was developed by integrating the knowledge gained through the collaboration with the Parallel Agency Research Group (1 operator x N CAs) and the Collective Ability Research Group (M operators x 1 CA). We will increase the number of operators and CAs, working to expand the possibility of the body beyond the conventional assumption that links one person with one body.

In (2), we developed technologies for experience-sharing CAs which allow users to incorporate others' experiences into their own bodies by transmitting intrinsic physical sensations through the sense of touch. In addition,, we aim to realize more empathetic communication by measuring users biometric information in the virtual CA environment, estimating emotional changes, which are reflected in the CA.

A key outcome of (3) is the establishment in October 2021 of the Cybernetic being consortium, currently featuring of 32 companies and 6 organizations. The consortium promotes industry-academia collaboration for the development and social implementation of physical co-creation through CA. As part of these collaborations we are working with the Japan Craftsmen's Association toward leveraging the use of CA as a means for sharing craftsmen's skills and experience.



(1) 2x3 CA system: two people control three robots



(2-1) Sharing bodily sensations through the sense of touch



(2-2) Virtual CA reflecting operator's emotion to its appearance



(4) CA operation experiments in public spaces

In (4), we are continuing to conduct demonstration experiments in public spaces to identify various issues in the utilization of CA in the real world and to clarify the requirements for communication and operating environments.

3. Future plans

We are working on the construction of a CA infrastructure that enables people to treat CA as a natural extension of their own bodies, through a network environment with ultra-high speed and low latency, in order to design the communication infrastructure required for the coming CA society. We aim to build a CA infrastructure that enables people to physically incorporate experiences and skills transmitted from other people and other environments with their own experiences and skills.

R&D Theme

Designing a co-created CA society that expands diversity and inclusivity

(Social Co-Creation Research Group)

Progress until FY2022

1. Outline of the project



Creating a well-being lifestyle to overcome disabilities and challenges with CA.

We will co-create practical implementation of cybernetic avatars (CAs) with users to realize a society where individuals can maximize their abilities and work beyond physical, spatial, and social limitations, regardless of individual differences in their natural bodies. Through co-creation with people affected by various social issues such as disabilities and the aging of society, we will contribute to the realization of the "cybernetic avatar lifestyle" as stated in Goal 1 by materializing the future lifestyle, work, learning, and fun that CA will bring.



Practical research on overcoming disabilities through CA

Kentaro YOSHIFUJI (OryLab Inc.)



Industrial implementation and evaluation of physical co-creation

Takeshi ANDO
(Panasonic Holdings Corporation)

2. Outcome so far

- (1) Demonstration experiment applying the core technologies of cognitive augmentation, parallelization, and skill fusion at the avatar robot café DAWN ver.β
- (2) National and international awards, including the Golden Nica at Ars Electronica
- (3) Demonstration experiment of outdoor driving of a mobile cart-type CA with the participation of people with disabilities

At the avatar robot café DAWN ver.β, 77 CA operators, called "pilots," leverage avatar robots from their homes or hospitals to access work. By operating the robots as their "other bodies," they provide café services such as talking with visitors and serving drinks. Pilots include many people with upper and lower limb impairments including ALS, SMA, muscular dystrophy, heart disease, and spinal cord injury.

In (1), a 6-week experiment was conducted to test new ways of working with CA for persons with disabilities at the avatar robot café from May to June 2023. Three CA technologies were deployed to verify the impact of long-term effect using Ca; (I) customer service using virtual characters customized by the pilots themselves, developed by the Cognitive Augmentation Research Group; (II) cafe service in which multiple CAs are operated in parallel, developed by the Parallel Agency Research Group; and (III) cafe service in which two people operate a CA in parallel, developed by the Collective Ability Research Group, in which two people operate one CA and cooperate remotely to make customized pancake topping decorations.

In (2), the avatar robot café received national and international awards, including the Ars Electronica Golden Nica (top prize in the digital community category), the Good Design Award Grand Prize, and a Dubai Zayed Sustainability Award.



(1) Long-term demonstration experiment in the avatar robot café



(2) Ars Electronica Golden Nica prize



(3) Demonstration test of a mobility CA on public roads by persons with disabilities

In (3), a demonstration experiment is being conducted in Fujisawa City, Kanagawa Prefecture, to introduce the city by building an integrated CA that combines an avatar robot operated by a person with disabilities and a mobile cart operated by another operator, traveling outdoors. The operators of the guiding avatar robot and the operator of the mobile cart cooperate smoothly with each other to provide the service, which verifies the effectiveness of the CA as a use case in the real world.

3. Future plans

In order to expand the age range and diversity of people with disabilities who utilize CA, we will implement and verify the effectiveness of a work experience program using CA for students of special-needs schools nationwide as an approach to target younger age groups. We aim to increase the employment rate and expand the scope of social participation of people with physical disabilities, which has been an issue up to now.

Designing the ethics and institutions for a CA society (Social System Research Group)

Progress until FY2022

1. Outline of the project



What kind of social rules and ethical norms do we need in a future where people's bodies are augmented with CA?

We will explore the design of ethics and social institutions in the age of CA by examining social issues such as the rights and responsibilities that should be protected in a society where people use cybernetic avatars (CA) on a daily basis. We will also analyze the distribution and management of experience and skills data from various perspectives, including law, social science, and social theory of science and technology. By supporting a society in which everyone can freely use CA in a safe and ethical environment, we will contribute to the realization of the "cybernetic avatar lifestyle" that are included in Goal 1.



Legal interpretation and policy research of CA
Ryota AKASAKA (Osaka University ELSI Center)



Ethics and social system design in the age of CA
Arisa EMA (The University of Tokyo)



Exploration of Cybernetic Avatar society using design fiction.
Hirotaka OSAWA (Keio University)

2. Outcome so far

- (1) **Holding the Cybernetic Avatar Society (CAS) study group, a study group to examine issues and solutions in a society where CAs are active**
- (2) **Domestic Fieldwork and Promoting cooperation and discussion with international administration on CA**

In order to realize a society in which people use CA in various aspects of their daily lives, and work, learn, and enjoy in new ways on a daily basis, it is necessary to envision specific use cases of CA in the near future, identify what kind of ELSI exist, and design new ethical and social systems to deal with these issues. Therefore in (1), we organized Cybernetic Avatar Society (CAS) study group with lawyers and social scientists and CA users, to understand existing challenges and devise appropriate strategies to address them. As a result, we identified issues related to the legal protection of CA workers, governing law for contracts, and governance that should be addressed by CA platform operators. We have developed guidelines to deal with these issues.

In (2), with the social co-creation group, we are conducting experiments and fieldwork surveys on OriHime use in schools and workplaces. We have started discussions with government officials and practitioners in various countries, sharing insight not only about the technology but also examples of CAs that provide new "options" for employment and the importance of developing frameworks and laws that support flexible work styles through international administrative forums such as the Global Partnership on AI (GPAI) summit.



(1) CAS study group



(2) Presentation using OriHime by CA users at GPAI summit

- **1st CAS Study Group** (June 24, 2021)
"The State of the Cybernetic Avatar Society and the ELSI"
- **The 2nd CAS Study Group** (July 30, 2021)
"CA and ELSI from the Viewpoint of Use Cases"
- **The 3rd CAS Study Group** (September 3, 2021)
"Experience/skill Sharing and Intellectual Property"
- **The 4th CAS Study Group** (December 3, 2021)
"Possibilities and Challenges of VR Avatar for Cognitive Extension of Embodiment and Sociality"
- **Additional The CAS Study Group** (November 8, 2021)
"Issues Concerning the Symbiosis, Co-creation and Co-evolution of Humans and Avatars/robots"
- **The 5th CAS Study Group** (February 16, 2022)
"Multiple 'Bodies' and Legal Liability"
- **Additional CAS Study Group** (March 3, 2022)
"Can VR Promote Awareness of Unconscious Bias? : A Workshop Project on the Work Environment Surrounding Child Care"
- **The 6th CAS Study Group** (June 14, 2022)
"Working Methods and Guidelines Using CA as Seen in the Media"
- **The 7th CAS Study Group** (January 25, 2023)
"Governance of CA Platforms"

3. Future plans

Based on the knowledge gained from the demonstration experiments to date, we will formulate and publish guidelines from an ELSI perspective for both CA users and employers who hire CA users to determine what kind of environment and systems need to be created under the current legal and social systems, what kind of concerns can be anticipated and how they should be addressed.

In addition to predict changes in lifestyles and work styles in a future CA society and reflect them in research and development, we will utilize "SF prototyping," as one of the methods to envision the future with science fiction storytelling and backcasting. This approach has the goal to design CA society scenarios that will be widely accepted by the general public in collaboration with science fiction authors and the research team.