Moonshot Goal 1: PD Guidelines for PM Additional Applications

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1. Overview of R&D program for achieving the Moonshot Goal

Considering our declining birthrate, aging population and concerns over labor shortages, it is important to enable people with various backgrounds and values - including the elderly and those needing nursing care and childcare - to participate in a variety of activities according to their own lifestyles. The key is to realize a society where people are free from the limitations of the human 'body', 'brain', and 'space and time'.

The program promotes research and development of cybernetic avatar (CA) (*) technology that expands our physical, cognitive, and perceptual abilities. We are investigating how cyborg and avatar technology can achieve social acceptance, leading to the "realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050."

* Cybernetic Avatar is a concept that includes not only remote avatars using robots and 3D images as proxies, but also augmentations of human physical/cognitive abilities using ICT and robotics. We aim to make Cybernetic Avatars active in the cyber-physical world of Society 5.0.

2. Portfolio and status of initiatives

(1) Portfolio

The program targets "the construction of a cybernetic avatar infrastructure (CA infrastructure) that enables everyone to participate in a variety of social activities" and "the realization of a cybernetic avatar lifestyle (CA lifestyle) that is socially accepted." In order to liberate people from the constraints of their bodies, brains, space, and time," the various usage scenarios of CA can be classified into three categories: "liberating people from the constraints of space and time," "liberating people from the constraints of their bodies," and "liberating people from the constraints of their brains, especially cognition and perception." We manage a portfolio covering the basic R&D themes of CA including "hospitality-rich and moral dialogue CA," "experience-sharing CA," and "imagination-operated CA ."

The "realization of an avatar-symbiotic society where everyone can perform active

roles without constraint" project, led by PM Hiroshi Ishiguro, is responsible for the R&D of the "hospitality-rich and moral dialogue CA." The R&D of "experience sharing CA" was conducted by the "cybernetic avatar technology and social system design for harmonious co-experience and collective ability" project led by PM Kota Minamizawa. The R&D for "imagination-operated CA" is being conducted under the "liberation from biological limitations via physical, cognitive and perceptual augmentation" project overseen by PM Ryota Kanai. Under the direction of the PD, all R&D projects are collaborating and cooperating to promote the R&D program.

(2) Status of current initiatives

In order to realize the targets of the R&D program, namely "construction of a CA infrastructure that enables everyone to participate in diverse social activities" and "promotion of CA lifestyle based on socially accepted norms," existing R&D projects are focused on CA for individual and group use, and fall into the following areas: "freedom from space and time constraints," "freedom from physical constraints," and "freedom from brain constraints."

The project "realization of an avatar-symbiotic society where everyone can perform active roles without constraint" overseen by Program Manager (PM) Hiroshi Ishiguro, who is in charge of "liberation from the constraints of space and time," has developed hospitality-rich and moral dialogue CAs allowing a variety of remote hospitality-rich and moral dialogues and behaviors for different users with multiple operations. We aim to realize a society in which people can participate in various social activities (work, education, medical care, daily life, etc.) without having to go to the work site, and by 2050, a society in which lifestyles are dramatically transformed in terms of how we choose places and how we use time, as well as in terms of the expansion of human capabilities and a well-balanced avatar symbiotic society.

The "cybernetic avatar technology and social system design for harmonious co-experience and collective ability" project overseen by PM Kouta Minamizawa, who is in charge of the "liberation from physical constraints," has developed an experience-sharing CA that allows people to maximize their abilities and share their skills and experiences. To ensure the sharing of skills and experiences, we will build a social infrastructure allowing distribution of physical skills and experiences in harmony with accepted people and society, considering institutional and ethical issues. By 2050, we aim to realize a society in which this distribution generates new physical co-creation between people, and in which everyone can freely engage in

activities and challenges through CAs.

The “liberation from biological limitations via physical, cognitive and perceptual augmentation” project of PM Ryota Kanai, who is in charge of “liberation from brain limitations,” has developed an imagination-operated CA, that can estimate human intentions and operate according to the user’s imagination. To estimate human intentions, we will develop a CA with brain–machine interface (BMI) functions (BMI-CA) that integrate not only internal brain activity but also brain surface information and interaction information with others using AI technology, while considering ethical issues. By 2050, we aim to realize a trusted BMI-CA that can be operated as the user wishes.

(3) Current research and development issues for achieving the goal

The “PD’s Supplement in FY2020 PM Application” (see “Reference” below), states as follows: (2) “A multidisciplinary research approach that incorporates not only ICT and robotics, but also biotechnology and cognitive science, is welcome.” Existing R&D projects are mainly developing CAs that can be used by individuals and groups. In order to transcend the constraints of body, brain, space and time, we need CAs that can be used inside the body. The combination of CA that can be used by individuals and groups with CA that can be used inside the body will expand the use of human-friendly CA not only in industrial applications but also in various application environments, such as health and medical care. It is expected to revolutionize daily life in terms of health and medical care, not only through medical interviews and external examinations by doctors and nurses in hospitals and clinics, but also by being monitored inside the body by multiple CAs.

Existing R&D projects involve researchers in various fields of ethical, legal, and social issues in order to facilitate social implementation and adjustment. We learn from the recent research work that we need to build a socially accepted CA infrastructure that can solve the cross-cutting technical and institutional issues common to existing R&D projects, ensuring safety, security, and reliability, and social acceptance.

The recent work with field experiments of existing R&D projects shows that CAs may be used for various activities in the lifestyle and work activities of people in society. Meanwhile, as various CAs could be available for use in our daily lives and labor, we have also seen the possibility of rampant unauthorized use, such as hacking of CAs by malicious users, use of CAs by impersonating another person, and illegal copying of expert skills by hacking CAs equipped with such skills. For CAs to be

widely used safely and securely in society, it is essential to research and develop technologies to guarantee CA security to prevent the unauthorized uses. In order to ensure social acceptability, it is necessary not only for existing R&D projects to consider the ethical, legal, and social issues individually, but also to create a cross-sectional organization for R&D projects to appeal to society with the results of research, design systems based on the results of research, and propose policies and strategies for transforming future society to various stakeholders. In addition, existing R&D projects are currently conducting field experiments in the communication environment where actual services are provided, assuming that they will be used in the service industry, mainly in customer service, which is mainly affected by the COVID-19 disaster. However, the CA communication environment is unstable due to the presence of many people as radio wave absorbers and CAs moving around. In order to ensure high real-time performance during surgical remote operations in the medical field and remote control of construction equipment in the construction industry based on beyond 5G communication, the infrastructure for ensuring the reliability of the communication is also one of urgent research and development themes.

3. R&D themes and their requirements in the application

(1) Research and development for CA that can be used inside the body

Aiming to be free from the limitations of body, brain, space and time, this R&D theme calls for R&D projects that will create disruptive innovation for our daily lives in terms of health and medical care, where multiple CAs can be operated and watched over, targeting millimeter-, micro-, or nano-scale CAs that can be utilized inside the body.

Ambitious proposals should include the following (a) through (d).

(a) A vision of a future society in 2050 using multiple millimeter-, micro-, or nano-scale CAs that can be used in the body

(b) Achievement scenarios of multiple millimeter-, micro-, or nanoscale CAs that can be utilized in the body, which can be realized by 2025 in order to realize (a).

(c) Common interface technologies allowing interoperability of CAs to be utilized mainly by individuals and groups in existing R&D projects

(d) Validation of the experimental plans and expected results, and social acceptance of the project considering the ethical, legal, social, and economic (ELSE) issues

Multiple millimeter-, micro-, or nano-scale CAs that can be utilized inside the body without placing a burden on the body or the environment may require the following technologies:

- Technology allowing the CA to move and stay at the intended location in the body (digestive system, circulatory system, etc.), and perform sensing and actuation
- Technology that can remotely control multiple CAs with collaborative and cooperative operations.

(2) Research and development that constructs the social acceptance infrastructure enabling safety, security, and reliability during CA teleoperation

This R&D theme calls for R&D projects that combine either (i) or (ii), or both, in order to build a social acceptance infrastructure consisting of the following two components: (i) an infrastructure enabling the safety and security of CAs and (ii) an infrastructure enabling the reliability of CAs, in line with the goals of existing R&D projects.

(i) Research and development that constructs the social acceptance infrastructure enabling the safety and security of CAs

Research and development projects on the infrastructure for ensuring the safety and security of CAs, including the following (a) through (d), are invited. Advanced CA safety and security technologies for preventing unauthorized use of CAs, such as hijacking, spoofing, and skill imitation, considering the ELSE issues should be considered. They also include scenarios that can realize harmonized social adjustment and regulations (ethics, legislation, etc.), and make recommendations for policy.

Proposals are required to include the following (a) through (d).

(a) Research on advanced security technologies and ELSE issues for CA in collaboration with existing R&D projects and its project organization
(b) Conducting field experiments in collaboration with existing R&D projects
(c) Proposal of the strategies making the policy recommendation on CA technical and institutional issues that come from the latest results obtained from existing R&D projects and should be tackled in the future, and the institution allowing dissemination of the policy recommendation domestically and internationally
(d) Previous work in security technologies that can be flexibly adapted to the technical specifications of CA to be developed by existing R&D projects, and in proposing IT-related institutions and policies.

Note that the proposed R&D project will be adjusted in terms of technical and institutional requirements considering the difference of the existing R&D projects and the R&D project in (ii) within a month after the PM selection.

Regarding the enhancement of advanced CA security, an example is biometric authentication technology that uses brain information, such as electroencephalography, to improve the accuracy of CA teleoperator identification and authentication. The following series of technologies are assumed to comprise a method for identifying and authenticating the CA teleoperator by acquiring and storing the CA teleoperator's actions during remote control as a remote action log via the CA, with the CA teleoperator's consent.

- Technology for acquiring remote control behavior logs
- Technology for modelling individual properties coming from the remote control behavior logs to enable identification and authentication of CA teleoperators
- Technology for realizing safe and secure CA use by automatically detecting unauthorized use of CA through digital twinning of the above

Social adjustment and regulation of CA may include, for example, but are not limited to, the following perspectives:

-Regulations related to health, safety, consumer, and the environment
-Liability of those who manufacture, provide services for, or use CAs
-Intellectual property rights arising from the CA itself or from the use of the CA
-Privacy and data protection
-Capacity on the scope of application of CA regulations
-CA-specific regulations

(ii) Research and development of infrastructure to ensure reliability of CA

Research and development projects are invited to build an infrastructure for ensuring the reliability of CA through the advancement of the following communication functions during CA remote operation by establishing a field experiment environment based on Beyond 5G.

Proposals are required to include the following (a) through (e).

(a) Field test environments with poor radio wave conditions, such as large commercial complexes with large numbers of people (who absorb radio waves)

entering and leaving, as well as construction sites where radio wave absorbers are deployed

(b) Previous work in building communication environments that can flexibly accommodate the technical specifications of CA infrastructure to be developed by existing R&D projects

(c) Project organization and strategy for cooperation with existing R&D projects

(d) The project organization should include companies that research and develop communication equipment, among other areas, participate to establish a field experiment environment based on Beyond 5G

(e) R&D plans and expected results to be socially acceptable considering ELSE issues

Note that the proposed R&D project will be adjusted in terms of technical and institutional requirements considering the difference of the existing R&D projects and the accepted R&D project in (i) within a month after the PM selection.

For example, the following technologies may be considered for the advancement of communication functions during CA remote control:

- Technology that ensures stable communication by using multiple CAs with the functions of mobile communication base stations
- Technology achieving low latency and reduced jitter by significantly reducing the amount of communication that varies depending on the task and usage status of the CA, through distributed processing using base station PCs and adjusting the ratio of upload/download in communication with the base station
- Technology for improving CA reliability and real-time performance through partial predictive control technology on the premise that communication delay and jitter cannot be completely eliminated when multiple CAs are remotely controlled cooperatively

(Reference)

・Moonshot Goal 1 website
https://www.jst.go.jp/moonshot/en/program/goal1/index.html

・Moonshot Goal 1&3 Kickoff Symposium (held March 28, 2021)
https://www.jst.go.jp/moonshot/news/20210328.html

・Moonshot International Symposium for Goal 1 and Goal 3 (held March 27-28, 2021)
https://www.jst.go.jp/moonshot/en/news/20210327.html

(Reference) PD's Supplement in FY2020 PM Application

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1. Policy for Selection and Proposal content

(1) Policy for Selection

Please submit a proposal of a scenario for the set MS Goal, "Realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050." Including both the concept of "forecasting" that predicts the future from current society and technology, and the concept of "backcasting" that suggests what to do now considering 2050 society as a reference point, the proposal should contain an outlook for 3 years, 5 years and 10 years after PM selection, and an outlook for 2050. Please elaborate on feasibility in terms of achieving the MS Goal by 2050, implementing and adapting to society, being challenging and innovative, and integrating ELSI considerations for societal acceptance.

(2) Proposal content

As indicated in the R&D Concept, two targets are set to achieve the Moonshot Goal 1: '1) Cybernetic avatar infrastructure' and '2) Cybernetic avatar life'. The proposal can choose one of the targets or both.

For the selected target(s), please describe the content of the task, the research approach to achieve it, the specific achievement goals of each milestone, and the excellent R&D team that can operate internationally. A multidisciplinary research approach that incorporates not only ICT and robotics, but also biotechnology and cognitive science, is welcome but not mandatory.

Since we expect the development system (connection of core technologies such as hardware, software, and interfaces) to be used in the international Internet community, it is necessary for proposals to include international standardization or activities for that purpose.

R&D of the development system must be promoted not only from the perspective of the supplier, but also by considering acceptability to users in future society. The proposal should state how changes in societal acceptance at each milestone, regarding ELSI and security factors, are being accounted for.

2. Policy for promoting R&D

(1) Portfolio management

Taking into account the relationship between multiple R&D projects, portfolio management requires collaboration and competition between PMs. Therefore, for the period after being selected as a PM, the milestones to be achieved 3, 5 and 10 years from the time of being selected will be made clear, and a review of the progress and budget plan shall be conducted in consultation with the PD.

In addition, different research approaches can be taken during the R&D period.

(2) Collaboration with other MS Goals

Depending on the technology to be researched and developed, it may be desirable to collaborate with other R&D projects. When necessary, the PM should conduct R&D efficiently and effectively while sharing information with other related R&D projects. The PM and their performers (researchers) are expected to undertake groundbreaking synergy initiatives in cooperation with other projects, not only in R&D, but also in effective information transmission and outreach activities both in Japan and overseas.

(3) Industry - academia - government collaboration

We expect the progress of R&D to have beneficial ripple effects on various industries. Therefore, the PM should engage in activities that allow private companies, governmental organizations, and other cooperative organizations to participate in the project.