Communication Robotics

— *Life technologies to catch, communicate and connect* —

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1. Introduction

With the spread of AI and IoT, homes and other living environments are advancing daily, and the government has designated its vision for Japanese society in the future as "Society 5.0." In the government's 2016 5th Science and Technology Basic Plan, Society 5.0 is advocated as, "A human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace (virtual space) and physical (real) space"[1]. In the 2021 6th Science, Technology and Innovation Basic Plan, the image of society for Society 5.0 was revised to reflect rapid changes in Japan and internationally, and to emphasize the diversity in how people pursue happiness, as: "Build sustainability and resilience for the threats faced by society and uncertain conditions yet to come, to ensure safety and security for citizens and a society where people can achieve well-being in their own diverse ways" [2].

To realize this, people must be able to receive meticulous services anywhere in society, accommodating their needs, whatever the situation. This will require technologies that enrich daily life in society, connecting people with systems, with places and with each other. ICT, AI, IoT, virtual reality (VR), and also human interface technologies will play a central role in this. The author is from the Department of Home Electronics, Faculty of Creative Engineering at Kanagawa Institute of Technology, where he conducts R&D in the Life Tech field. This field connects various issues faced by people in life and work with engineering, with three core elements of livelihood, social environment and education. This article describes technologies that the Communication Robotics Laboratory is working on, as examples of research to realize richer lifestyles for people, in three themes: "Catch" technologies that help systems understand people, "Communicate" technologies that help robots show emotion and intentions to people, and "Connect" technologies that help people connect with each other through use of robots. We also include examples of collaboration with enterprise on these technologies. Examples of applications in these three themes, "Catch," "Communicate," and "Connect" are shown in Figure 1.

Figure 1: Catch, Communicate and Connect technologies and applications

2. Life Tech Communication Robotics

As ICT, AI and IoT systems advance and spread, robots are anticipated to serve as interfaces to these systems. In order for such robots will coexist with people in our living spaces, direct communication such as speaking will be important, but so will familiarity and non-verbal behaviors, and as we have with ordinary communication, common rules for these will be needed[3]. Communication Robotics is a field of research on common forms of behavior and expression for robots in contact with humans, so they can convey information to humans. The Communication Robotics Laboratory is developing technologies for robotic movement, representations and systems to convey information to humans in a casual manner, through development of robotic systems focused on expressing emotion and other forms of non-verbal expression.

In this research, we have selected three technical issues discussed below, as elemental technologies for realizing rich lifestyles for people. The first issue is information technology that will enable systems to handle emotion and other human ambiguities. General purpose technology for recognizing an individual's emotions already exists and in the future, frameworks and technologies to determine conditions using data from multiple people will be needed. The second is how to present information to people. Considering the smart-house example, when a system works with a person to control an appliance automatically, the system must present the actions it is planning to the person casually, in a way that does not seem troublesome. The third issue is technology to connect people to others and to spaces through the network. The entire living environment will be connected to the network, providing communication experiences beyond video calling and email, so that new lifestyles and experiences can be provided through the internet.

The following sections of this article present technologies

being developed to solve the problems described above on three themes, which are "Catch" technologies that help systems that can understand people, "Communicate" technologies that help robots show emotion and intention to people and "Connect" technologies that use robots to help people connect with other people. In recent years AI technology has also spread rapidly, and basic technologies that have been accumulating are starting to be implemented in real living spaces, so that cases of trial research with enterprise are increasing. Some of these will also be introduced.

3. "Catch" technologies that help systems understand people

With the spread of IoT, residences are also being converted to smart houses rapidly, with living-space sensors and home appliances being connected to networks, enabling them to use each other. In such an environment, each appliance can be considered as an actuator able to control the living environment, influencing not only superficial physical aspects such as temperature and humidity, but also psychological features such as the moods of people in the space. To do so, information technology to enable systems to handle the ambiguity of people, as well as know-how to apply it in real environments will be essential. This section introduces an "atmosphere" recognition technology that is able to understand people and conditions within a residence.

Technology that recognizes an individual's emotion is already common; utilizing language and also various other approaches, such as speech rhythm, images and bodily information. However, to combine such emotional information from multiple people and quantify the atmosphere in a space requires a different theoretical framework. The method for quantifying atmosphere described in this article uses existing technologies for recognizing emotion and adopts a bottom-up approach to compute the atmosphere of a space from the emotional information of multiple people. To model an individual's emotion, an affinity-pleasure-arousal space[4] is used, and we use a method from Onishi et al.[5] to transform emotional information from several people to an atmosphere space with three axes indicating friendliness, liveliness, and casualness. An overview of the living-room atmosphere-recognition system is shown in Figure 2. When fitting ordinary emotion information into an emotion model, it must be formulated according to the state of the environment, which will be original know-how.

This technology is being applied in development of a smart living room that uses a game device as a sensor and links with home appliances to perform child care[6], in smart appliances that calm the atmosphere when watching a TV program, and in development of smart robots[7][8]. It can also be applied to connect people in distant locations, to develop atmosphere-sharing systems that connect people for telework, online lessons or other applications (Figure 3).

Figure 2: Living-room atmosphere-recognition system using emotion information from individuals

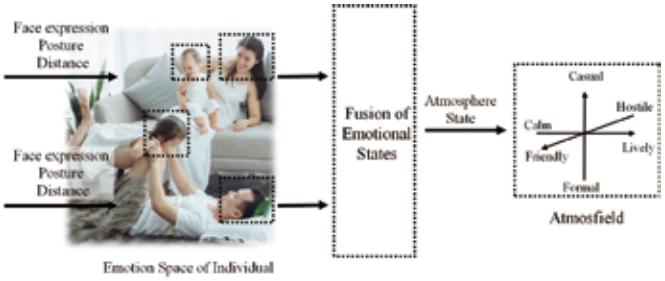
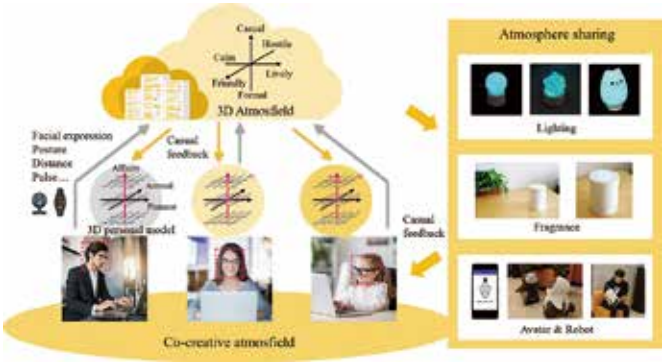


Figure 3: Co-creative atmosfield and remote atmosphere sharing for telework or online learning



4. Casual, non-verbal expression technologies that "Communicate" to people

To implement services suited to people and conditions as required for Society 5.0 will require presentation of detailed information. On the other hand, conveying an excess of information could seem annoying and troublesome to people. To solve this problem requires careful examination and presentation of the minimal necessary information, and the information must be presented in a casual and familiar way so that it does not feel troublesome. This section introduces examples of casual information presentation, focusing on non-verbal expression technology for familiar information presentation.

4.1 Familiar information presentation

Familiarity is an important element in systems that present information to people. This is more than showing the information concisely, and giving it familiarity can have effects including increasing a person's understanding and recall of the information[9]. For familiarity, emotional elements are particularly important. This section introduces a home robot called AHOBO, which provides on-going frailty care to the elderly in their homes for everyday lives (Figure 4)[10].

Frailty refers to various changes in faculties and loss of ability with advancing age, and prevention of frailty in the elderly, or

Figure 4: Recognition training (left) and health support (right) given by AHOBO

frailty care, contributes to preventing illness and accidents in the home. Frailty care requires continuous support in everyday life, and the AHOBO robot was developed to provide such support. AHOBO is a table-top communication robot that shows emotion with its antennas and eyes, and implements two types of system to support daily life of the elderly, for physical health and to prevent dementia. For physical health frailty care, AHOBO supports measurement of blood pressure, and for psychological frailty care, it has a recreational function that provides cognitive training.

4.2 Casual information presentation

When too much information is presented to people at once, they tend to feel it is troublesome, so it is necessary to present the minimal amount of information in a casual way. In particular, while walking, driving or otherwise moving, it can be dangerous to present too much information, so a safe means to convey information is needed. This section introduces a method of presenting information when traveling that is not troublesome, using a device called "FUN'IKI Ambient Glasses."

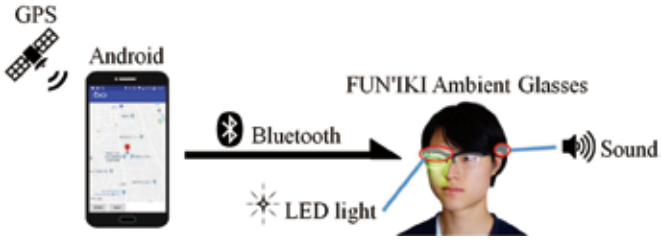
FUN'IKI Ambient Glasses are an information device developed by Namae Megane Inc., that are glasses incorporating full-color LEDs and a compact speaker. They are able to present information linked to a smartphone in an intuitive way, using sounds and LED lights that switch on and off [11]. An example of FUN'IKI Ambient Glasses emitting light is shown in Figure 5. By turning on LEDs in the frame of the glasses, the entire lens glows, and this can be used to convey information.

The benefits of FUN'IKI Ambient Glasses include: (1) information can be checked while working, without looking away from the work, (2) the information presented does not obstruct the field of view, (3) information can be presented intuitively, with

Figure 5: FUN'IKI Ambient Glasses

Figure 6: Presenting bicycle riding conditions using FUN'IKI Ambient Glasses

Figure 7: Navigation system using FUN'IKI Ambient Glasses



low cognitive load, using color and sound, and (4) it is possible to present information to the surroundings at the same time as presenting information to the wearer. This could be suitable for types of mobility that require a certain amount of attention, such as walking or driving, because it requires less cognitive load than smart glasses that display text. The FUN'IKI Ambient Glasses have been used in applications such as visualizing conditions when riding a bicycle[12], or providing map guidance when walking or running[13].

5. Technologies that "Connect" people with people

Entire living environments will become connected to networks, creating environments with communication experiences beyond video calling and email, making new lifestyles and experiences possible through the internet. We are aiming to create disruptive innovation initiated in Japan, and to implement a cybernetic avatar platform that will enable anyone to participate in various social activities, as part of goal 1 of the "Moon-shot research and development program" being promoted: "To realize a society in which people are freed of constraints of body, mind, space and time, by 2050" [14]. More specifically, we aim to expand the opportunities and potential for social activity by remotely operating cybernetic avatars, which includes robots and virtual

avatars, as "additional bodies for the user." This will require technologies that connect people with other people, and people with spaces, as discussed in Section 2. The technology introduced in Section 3 for sharing atmosphere for telework or online learning is an example. This section describes trials of another example of a "Connect" technology, doing remote work and avatar work at the Avatar Robot Café, using avatar robots that OryLab is promoting in collaboration with the authors.

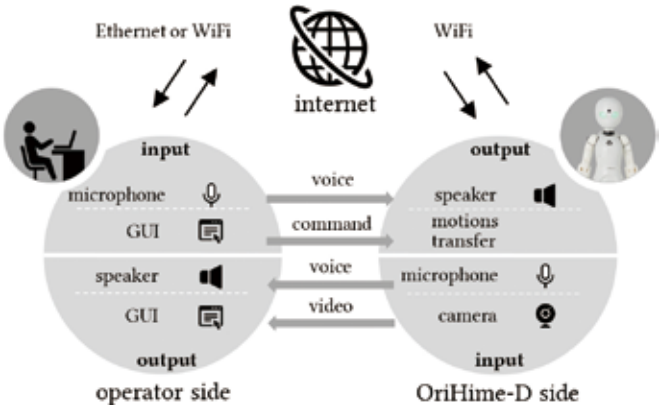
Robots that operate from a remote location through the internet in place of a person are called telepresence robots. Various types of telepresence robot are being developed, such as the newme (avatarin Inc.)[15], which emphasizes communication and combines a mobile robot with a display, and humanoid robots that emphasize a sense of presence.

Telepresence robots enable lifestyles in which people can be transported instantly, overcoming constraints of space, but they also have potential to extend a person's bodily capabilities. This is very significant, particularly for persons with disability. OryLab Inc. has set its mission to eliminate loneliness through technology, and is developing avatar robots that enable people who have given up on communication due to disability, to go out and communicate with people through the internet[16]. There are two types of avatar robot: a table-top model called OriHime (Figure 8) and a mobile model called OriHime-D (Figure 9). Both types of OriHime are equipped with a camera, microphone and speaker and can be operated through the internet using a PC, tablet or smartphone application (Figure 10). In addition to input using a mouse or tablet, line-of-sight input using an intention-communication device (OriHime eye+Switch) is also available. Providing OriHime at schools or companies can enable those with disabilities that make it difficult to go out, to participate in society, attending school or work while they are at home or in the hospital.

OryLab has proposed Avatar work as a system that can enable those with difficulty going out to perform remote work using OriHime from home or hospital, and is operating a café space for

Figure 9: OriHime-D

Figure 10: OriHime-D operating system



avatar work called "Avatar Robot Café DAWN Ver. β," as a trial social implementation[17]. A concept image of Avatar Robot Café DAWN Ver. β is shown in Figure 11.

Avatar Robot Café DAWN Ver. β was opened as a time-limited-trial shop in November 2018, and after trials in various regions, a permanent trial shop was opened in Nihonbashi, Tokyo

Figure 8: OriHime

Figure 11: Avatar Robot Cafe concept image

in June 2021.

To work at Avatar Robot Café, operators (pilots) that have difficulty leaving home provide service by operating OriHime and OriHime-D robots remotely. OriHime are used to provide customer services such as taking orders, and OriHime-D are used to perform service tasks that require physical movement, such as bringing drinks to the table.

One of the important benefits of avatar robots is the ability to share the experience of a place with others using a physical robot. By sharing an experience with the person in front of the avatar robot through the robot, a person can get a real sense of actually being in the place, even from a remote location. In research so far, working at the Avatar Robot Café has been shown to be mentally fulfilling for pilots and has been suitable for many disabled people desiring participation in society[18]. As with Avatar Robot Café, by using avatar robots that expand bodily capabilities of people with disabilities and by creating a society where avatar robots are ubiquitous, we believe we could realize a society in which people can participate in various activities, even if they are bedridden, for example.

6. Conclusion

This article has introduced examples of communication robotics research to enrich the lives of people in the three themes of "Catch" technologies, which help systems understand people; "Communicate" technologies, which help robots express intention to people in familiar and casual ways; and "Connect" technologies, which help people connect with others through use of robots, including examples of collaboration with enterprise. These technologies will contribute to creating the society that Japan is aiming for, in which each and every person can realize their own version of well-being.

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Cover Art

Yōrō Waterfall (Yōrō no taki), Mino Province, from Famous Views of the 60 Provinces

Utagawa Hiroshige (1797-1858)

Source: National Diet Library, NDL Image Bank (https://rnavi.ndl.go.jp/imagebank/)