Implementation and Application of Robot Information Processing Functions

— *Using Communication Robots for Elderly Care Support Services*—

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1. Robots and the cloud robotics platform

Robots are used in industries all over the world, and are proving their worth not only in manufacturing but in a very wide range of other fields too. Applications in the service sector are expected to grow significantly in the future[1] [World Robots, 2012]. Robots will be expected to perform a variety of functions in the service sector, but existing single-function specialized robots may be at a disadvantage with regard to the addition or expansion of functions, and could make it difficult to meet the service requirements. To resolve these drawbacks, it is better to provide mechanisms that allow the expansion and addition of functions whenever necessary, instead of trying to predict the functions that are likely to be needed and incorporating these functions into the robot. In this article, we first discuss a mechanism that is useful for this purpose, with a focus on robots for the service field where demand is expected to grow in the future.

One of the technologies typically required of robots in the service field (referred to as "service robots" in the following) is the ability to communicate with humans. Speech recognition is the most important aspect of this ability, so that robots can understand what people are saying. Also important are dialog generation (understanding what people have said, and generating responses), and speech synthesis (replying with speech generated from the text of these responses). Although these functions rely on advanced information processing, it is already quite possible to incorporate them in service robots due to recent advances in information processing hardware, i.e., higher circuit integration densities and higher-performance CPUs, memory and storage devices. However, when functions such as these need to be extended for new services — e.g., when extending a service that communicates in one language so that it can communicate in another language — it becomes necessary to implement new speech recognition and speech synthesis functions for this language in the service robot. This is straightforward enough if there is sufficient capacity in the service robot's information processing system hardware, but from a cost point of view, it is not realistic to design this sort of extra capacity into service robots.

It was therefore suggested that the information processing

Figure 1: Schematic view of the cloud robotics platform

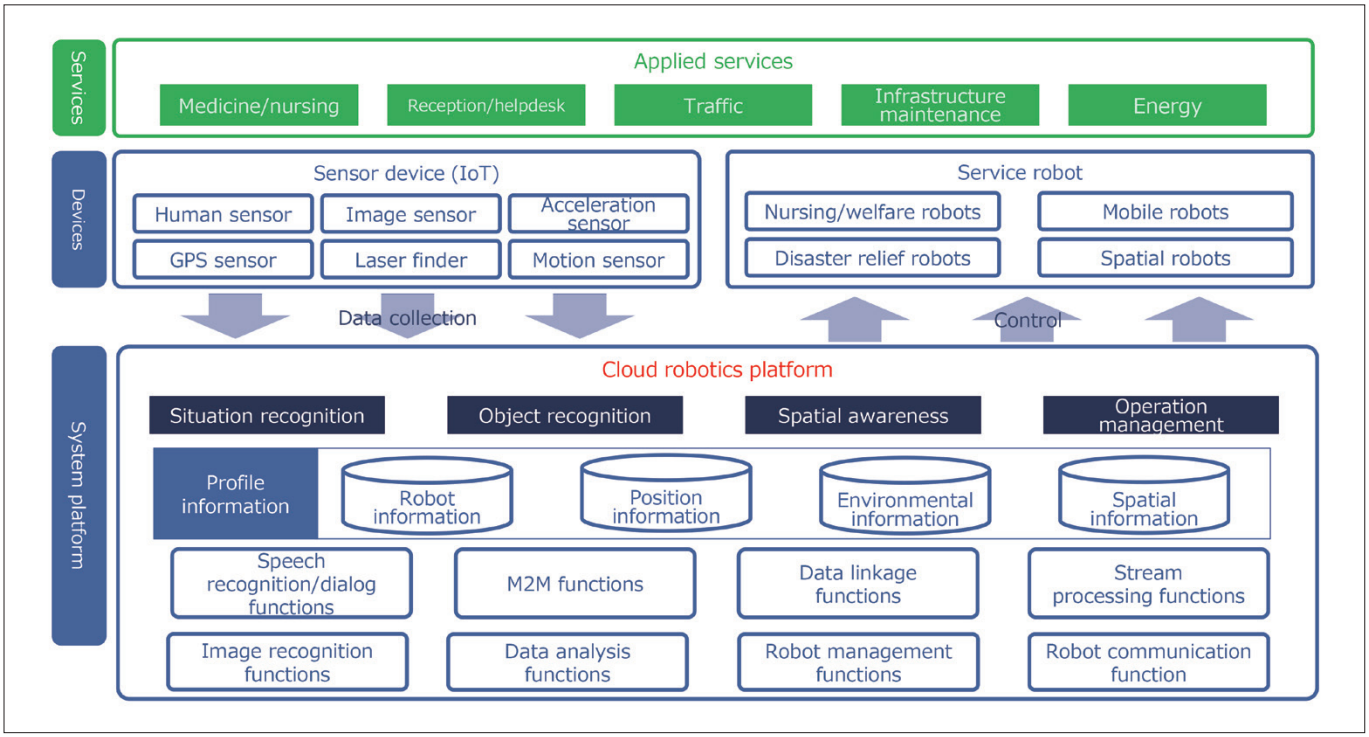
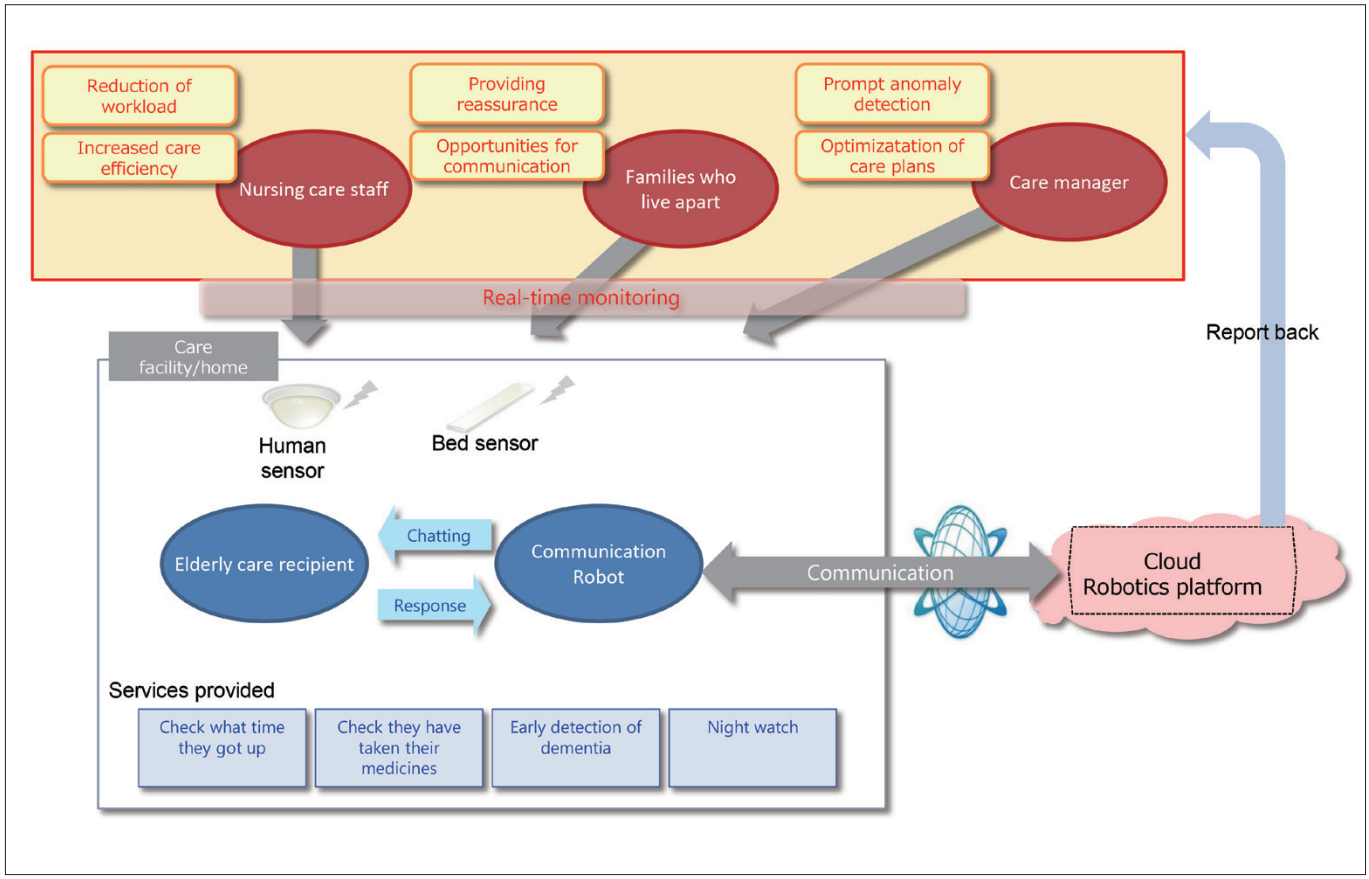


Figure 2: Functional overview of elderly care support



functions of robots could be provided separately. A cloud robotics platform is a mechanism that implements this idea (Figure 1). Currently, nearly all service robots are equipped with network connection functions, and can be considered as a kind of IoT device. The cloud robotics platform plays the pivotal role of processing the sensing data received from IoT devices connected via the network. Specifically, it collects and analyzes this information to make decisions and actuate IoT devices based on the results. Not only does this cloud robotics platform keep down the cost of the robots themselves, but if it is incorporated as a central part of the service system architecture, then it can also allow IoT devices to cooperate with one another. In other words, it facilitates the creation of new services and services with high added value by complementing the capabilities of other IoT devices to implement services that cannot be formed by individual IoT devices.

This idea of a cloud robotics platform is nothing new. Cloud computing was already known about in roughly 2006, and then from about 2009 research and development was performed on specific instances such as UNR-PF (Ubiquitous Network Robot Platform)[2] [Koji Kamei, 2012]. Today, cloud robotics platforms are evolving into practical "mechanisms" together with technical advances in IT. In the future, we expect that the development of cloud robotics platforms, service robots, and services that use IoT devices will lead to further advances by allowing these devices to cooperate in various different ways.

2. The application of robots to elderly care support

Robots are certainly making inroads into our daily lives, and can be seen in all sorts of everyday situations. For example, robots are busy making people's lives more convenient and comfortable in various forms such as autonomous vacuum cleaners, beds and wheelchairs incorporating robotics technology. Furthermore, the robots that make our lives more convenient are not just limited to the ones that users experience in this way. In a smart home, for example, robotics technology is applied to the home environment itself, and the user is able to combine energy savings with comfortable living by using a home energy management system (HEMS) without having to being aware of the robotics technology that makes it happen. Either way, the spread of robots and the convenience they bring to our lives are definitely on the increase, and it is hoped that various social issues will be solved with further developments in robots.

In the future, ageing society is an issue that will affect countries all over the world, and it is of course expected that the introduction of service robots will play a key role in dealing with such issues. For example, the number of elderly people who are dependent on care in Japan is currently continuing to increase, leading to issues such as a shortfall of care workers to meet the needs of elderly people living alone or in care facilities, the heavy workload on care workers, and the likelihood of them being overworked. The introduction of

Table 1: Experimental conditions for elderly care support services

Test period	2 weeks
Test site	Special nursing home for the elderly
Test subjects	2 residentical care recipients, 4 nursing staff, 2 care managers, 1 doctor, 1 nurse — approx. 10 people in total
Number of robots deployed	1 for each elderly care recipient
Number of sensors installed	1 for each elderly care recipient

service robots should help to resolve these issues. Based on the daily work of nursing care staff, there is a strong need for elderly care support services such as chatting with them and keeping an eye on them. The introduction of service robots (communication robots) to perform such tasks is highly feasible with modern technology, and is expected to be an effective way of alleviating the workload of nursing care staff. Figure 2 summarizes the functions and features of this service.

It is important to point out that this cannot be created by individual communication robots. Chatting with the elderly is something that a communication robot can do, while keeping an eye on them can be implemented by using other IoT devices. Specifically, bed sensors can detect everyday events such as what time a person gets up, or their physical state while sleeping, and human sensors can detect the general situation indoors, including emergencies such as when a person has fallen over. It is, of course, essential to allow the communication robot and sensors to cooperate and interconnect via the cloud robotics platform. For example, when a bed sensor detects the person getting up in the morning, this information could be sent via the cloud robotics platform to the communication robot as a trigger for it to say "good morning". Conversely, if the person is not detected getting up in the morning, then this would be judged as abnormal in the cloud robotics platform, and the communication robot might instead ask how the person is feeling.

In this way, it is possible to implement elderly care support services by having the communication robot cooperate and interconnect with other sensors via the cloud robotics platform. However, communication robots are not currently able to fully replace humans no matter how much they cooperate and interconnect with other IoT devices on the cloud robotics platform, and are only capable of shouldering part of the workload of nursing care staff. On the other hand, advances in robots and IoT device technology are being made every day, and it is essential to verify not only the services to which they are applied, but also how these services can be continued as circumstances change over time.

3. Case study to verify the application of robots to elderly care support

This section describes a verification case study where a communication robot that made use of the cloud robotics platform as discussed in the previous section was introduced into an elderly care facility where it was used for elderly care support services. In this verification, we evaluated the following two main points with the aim of grasping how this service can be implemented.

- Effectiveness of conversation with a communication robot for elderly people
- Adequacy of functions implemented on the cloud robotics platform for communicating with elderly people

Table 1 shows the experimental conditions, and Figure 3 shows the functional configuration.

This verification experiment involve watching over elderly care recipients and preparing communication scenarios based on the events of an ordinary day — i.e., checking what time they rose in the morning, checking they had taken their medicine, managing their dietary intake and checking for falls and other anomalies. These checks were performed by having the communication robot speak to the care recipients, and were triggered either at specific times or by alert signals generated from human sensors or waking sensors. For each scenario, we prepared a basic set of conversation scripts, and in cases where the conversation departed from these scripts, the nursing care staff or other workers were asked to help out. Communication between the IoT devices and the cloud robotics platform was achieved using standard protocols such as HTTP or MQTT.

During the two-week trial period, the care recipients responded favorably to the communication robot. They enjoyed the daily conversations and found its presence reassuring. The robot was also popular with the nursing care staff, because it allowed them to constantly watch over their elderly residents. Although the robot's communication functions (speech recognition and speech synthesis) needed to be tuned for elderly users, we confirmed that satisfactory results are achievable with current technology. We were therefore able to confirm the possibility of using a communication robot to provide basic conversational support to elderly care recipients, although there is still a need for further verification with more test subjects. In this study, we only prepared for a minimal range of scenarios and conversation dialogs, so for commercial services it would be necessary to conduct a detailed study of scenarios that can reduce the workload on nursing care staff, and to perform further verification trials.

4. Challenges and future prospects of robots for elderly care support

In this article, we have discussed the implementation of elderly care support services that use a cloud robotics platform to facilitate cooperation between IoT devices, focusing on communication robots in particular. Broadly speaking, there are two issues affecting this elderly care support service — technical issues relating to the cloud robotics platform, and issues with the operation of such services. These can be organized as shown in Table 2.

Figure 3: Functional configuration of elderly care support services

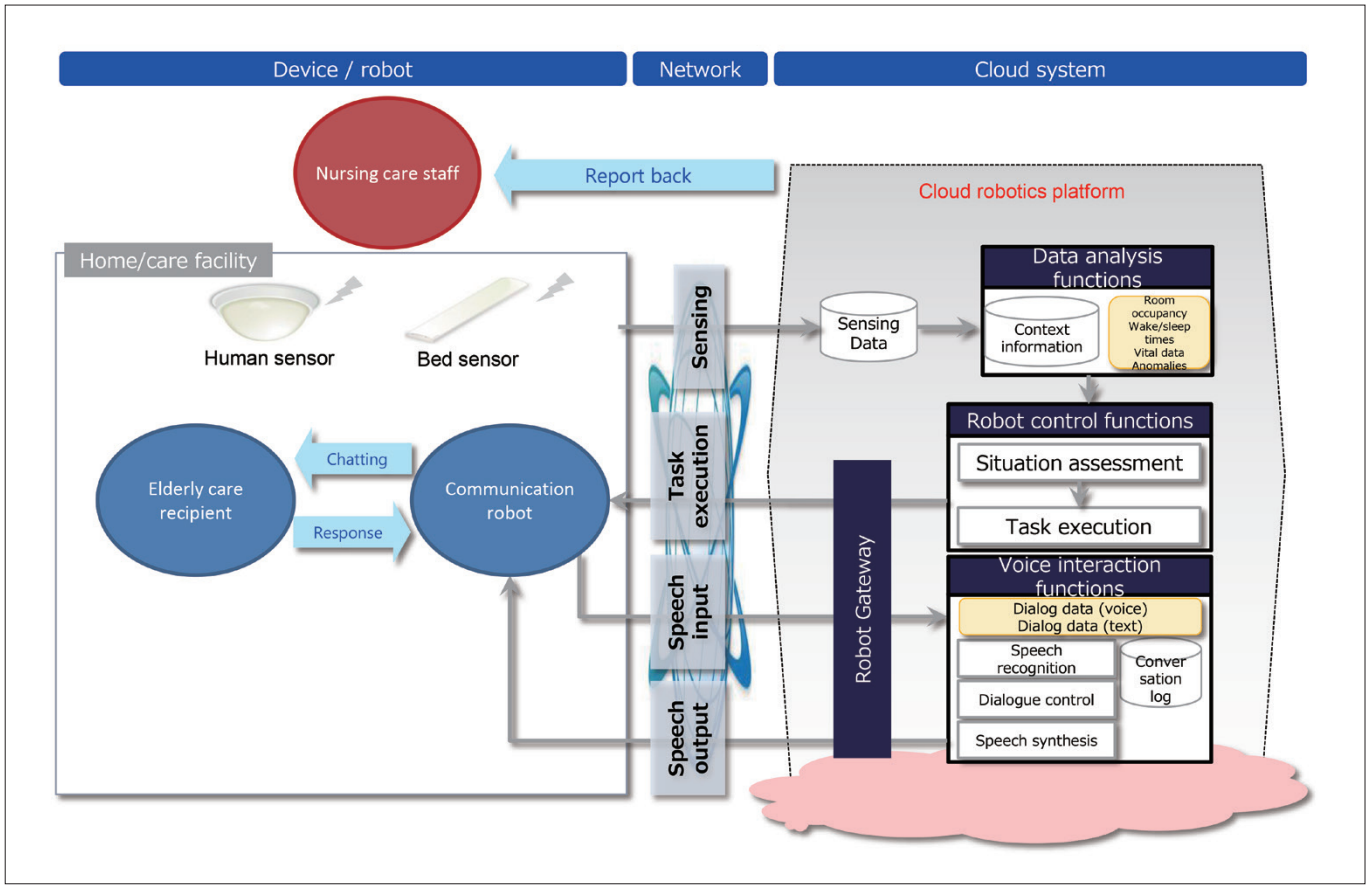


Table 2: Issues affecting elderly support services

Technical aspects	• Secure handling of sensing data • Improvement of speech recognition accuracy • Fine-tuning of dialog scenarios • Improvement of sensor data analysis algorithms
Operational aspects	• Privacy protection • Design of services tailored to the care industry • Establishing methods to verify effectiveness by analyzing care provision

Currently, when considering the deployment of commercial services, the most important issue in Table 2 is ensuring that speech data and the data obtained from sensors is kept secure. This is the sort of data that is subject to privacy protection, and it is necessary to study the technical and operational aspects of how to ensure its security. On the technical side, it is essential to include data encryption and prevent eavesdropping. In some cases, it may even be necessary to process data to mask out any parts that should remain private. Meanwhile, on the operational side, the communication scenarios must be fully examined to find safe locations for the storage of data and ways of ensuring that only limited data is sent to the cloud robotics platform.

If these various issues can be reliably resolved, then the future prospects of the cloud robotics platform in elderly care support services will become clearer. In particular, to match the individual characteristics of users, we should continue to expand the functions of the cloud robotics platform, such as adjusting the pitch, tempo and volume of speech produced by the communication robot to make it easier to hear, and changing the content of communication by using machine learning to ascertain the user's preferences from the content of everyday conversations so that the conversations do not become dull. If these functions can be enhanced, then it might even be possible to implement reminiscence therapy, which is said to be an effective way of preventing dementia or inhibiting its progress.

Since the ageing situation in Japan is more advanced than in any other country, the deployment of elderly care support services in Japan is also worth studying as a precursor for other countries. If the cloud robotics platform can be made compatible with other languages as discussed in section 1, then it can be rapidly deployed at low cost, and if the communication scenarios can be modified based on the culture and customs of each country, then it will be possible to use communication robots to provide elderly care support services all over the world. By designing service systems that take advantage of the merits of the cloud robotics platform, it will be possible to implement advanced services that make our lives more convenient and comfortable through the appropriate use of diverse robots and IoT devices. We hope to make further advances in robotics technology and the cloud robotics platform in the future.

References
[1] "World Robots", 2012, Freedonia
[2] Koji Kamei, Shuichi Nishio, Norihiro Hagita, Miki Sato, "Cloud Networked Robotics", 2012, IEEE Network Magazine