Research Report of Jpn. Soc. Promot. Mach. Ind. Econ. Res. Inst. (JSPMI-ERI 20 -2)

Research Project on Market Development and Industrial Growth of Service Robots <Interim Report>

Executive Summary

1. Purpose of the Project

The Project examines the market formation and industrial development and growth of “service robots,” which have been introduced to many sectors in recent years along with the AI revolution.
It goes without saying that the exploitation of service robots is indispensable for resolving social problems, such as the decrease in population and aging society with a declining birthrate. However, even if diverse prototypes of service robots are released and their industrialization begins, they do not form a any significant scale market, except in some sectors, and many launched businesses come to an end halfway.
The Project will focus mainly on identifying the factors that prevent the service robot market from expanding, and building business models. The Project will examine the trend in technology development in terms of whether there are any problems with the development of robot drive technology itself, and whether there are any problems or issues concerning needs-seeds matching that has been conducted many times to date, while AI technology is dramatically advancing and networking is evolving in various forms.
Because service robots can be exploited in a wide range of sectors, the Project is going to organize and study information about the building of specific business models in limited sectors. In FY2020, which was the first year of the Project, it focused on the nursing care sector and identified issues. This Interim Report covers the activities of the Project in FY 2020 and presents the outlook for FY 2021.

2. “Robots” and “Service Robots” Targeted by the Project

The Project determined how to deal with "robots" and "service robots," which are the subjects of discussion. The Project did not set a strict concept definition and decided to focus on robots having the following characteristics:

<Robots>

- ✓ **Robots that substitute for the “physical elements” of human beings and have mass and velocity**
- ✓ **Robots substituting for the functions of the “hands” in particular are targeted, not robots substituting for the functions of the “feet.”**
- ✓ **Semi autonomy robots (including maneuvering types) are also targeted**

<Service robots>

- ✓ **The target is robots used in non-manufacturing sectors, mainly the (interpersonal) service sector.**

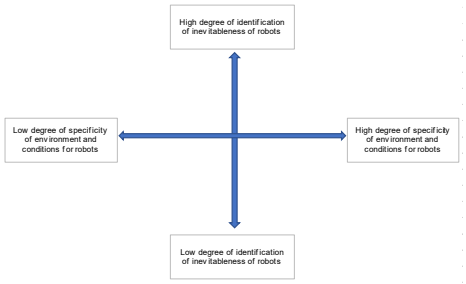
Conventional industrial robots have been operated in an environment separated from workers in production plants and handled only “things.” Thus, the Project made the point of the argument clear by taking up discussions about the robots operated under extremely opposite conditions. The Project thus set robots used in the "interpersonal service industry" at the center of the discussion, and tried to further clarify the future exploitation of robots.

In addition, the Project does not intend to draw a strict line between “robots” and "machines," "devices," "equipment," "systems" and so on, which are used around robots and partially incorporate an automation function, while keeping aware of the differences between them. The Project also considered the roles of robots in the "integrated services" created jointly by robots, machines and mechanisms around them, and service providers.

3. Two “Approaches of Discussion” in the Project

In the process of discussing which market area should be set for “service robots” to be handled, the Project decided to set its original “approaches of discussion.”
The approaches are:

“Degree of specificity of environment and conditions for robots”
“Degree of identification of inevitableness of robots”



The Project set these two approaches.
The Project considered that the question “What situation must inevitably use a robot?” is very important when contemplating a breakthrough in introducing a service robot. This is intended to avoid product development by undue “technology push” and “product-out,” which frequently cause criticism to the manufacturing industry of Japan.
Furthermore, currently realized robots are not general-purpose machines adaptable to any environment but are developed to operate under specific environment and conditions. In other words, if the environment and conditions under which these robots can operate are specified first and the environment and conditions can be adjusted to ensure better operation in some cases, it will be easier to introduce the robots. On the other hand, it is not easy to identify the "environment and conditions" under which robots can operate in personal services, because personal services are provided in diverse situations in favor for service receivers. But discussion itself is unmatured on this topic. By distinguishing the environment and conditions under which robots appropriately operate and those under which they do not operate, it will be possible to clarify areas to which robots can be introduced relatively easily, that is, areas where a market can be formed.

4. How to Conduct a Discussion Using the "Two Approaches of Discussion" in the Project

The Project applies a four-quadrant chart　using the two set criteria of the "degree of identification of inevitableness of robots" and the "degree of specificity of environment and conditions for robots.” First, focus attention on the quadrant 1 and quadrant 2 with a high “degree of identification of inevitableness of robots,” and then examine those robot segments fall on those two quadrants based on whether the “degree of specificity of environment and conditions” is high or low.

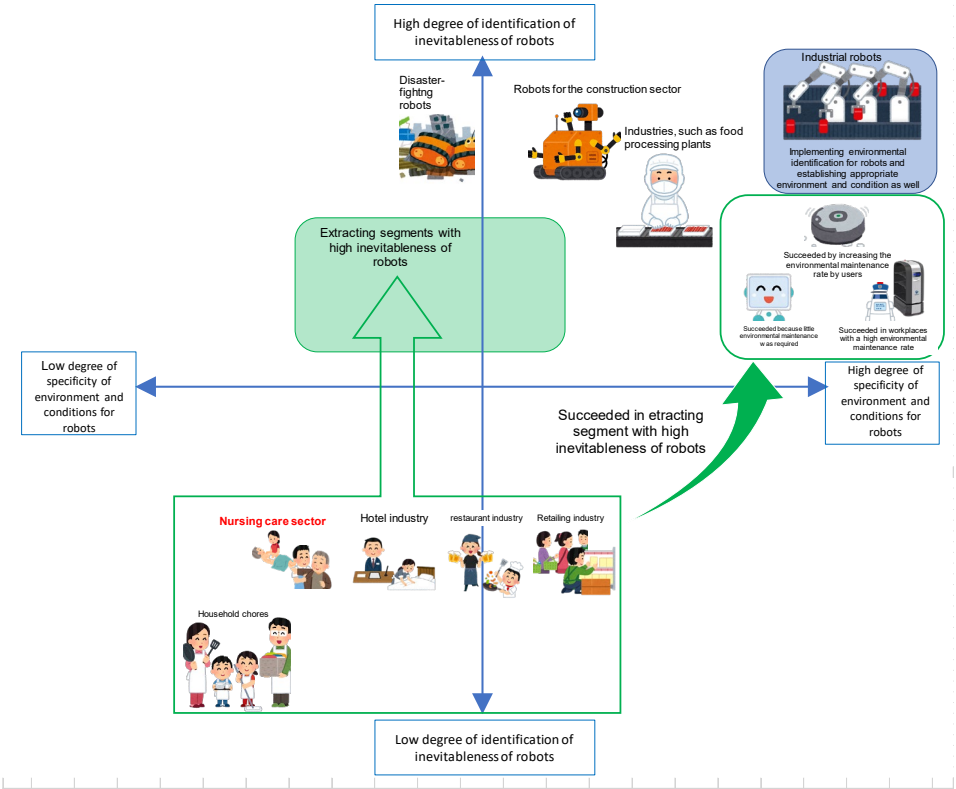
(1) With regard to the robot segments plotted on quadrant with the higher “degree of specificity of environmental conditions” (quadrant 1), dig deeper into the conditions for further promoting commercialization and monetization.
(2) With regard to the robot segments fall on quadrant with the lower “degree of specificity of environmental conditions” (quadrant 2), discuss how commercialization and monetization can be achieved.

In examining commercialization and monetization of service robots, the Project studies a prospect for market formation for robots by considering "constraints," such as space used, the environment, and technology, as well as the levels of the "boundary conditions" (price etc.) set by the party who will introduce robots.
When the sectors in the service industry expected to introduce robots are plotted to the four quadrants, it

becomes clear that the “inevitableness of robots” is not well defined in the nursing care, hotel, food service, retailing, and other sectors. It is also essential to examine whether there are specific segments extracted which could be extracted as a high degree of inevitableness of robots, such as robot vacuums, within each sectors of service industries, while looking into overall inevitableness of robots in the relevant sector.

The Project is going to use this method to identify sectors in the service industry that have a high degree of identification of inevitableness of robots, scrutinize their environment and conditions, and examine whether it is possible to bring them closer to the conditions suitable for introducing robots or whether robot developers can deal with it. The Project hypothesized that the exploitation of robots in the service industry would be accelerated by gradually expanding the market from segments with a high degree of inevitableness of robots.

Figure 1-3 Four quadrants based on the “degree of identification of inevitableness of robots” and the “degree of specificity of environment and conditions for robots”



Source) Interim Report for Research Project on Market Development and Industrial Growth of Service Robots, p.12

5. Coverage and Structure of the Service Robot Project in FY2020

In FY2020, which was the first year of the Service Robot Project, it focused on the nursing care sector and identified issues. The nursing care sector is a typical area in which the active exploitation of robots is called for due to a serious shortage of manpower at workplaces, while the actual introduction of robots does not move forward. Nursing care sector is also one of ultimate interpersonal services. In addition, preparations will be made to handle the retailing sector from FY2021 onward. The handling of other sectors will be determined in the course of the Project.

In FY2020, the Project conducted (1) a questionnaire survey to robot developers and (2) interviewing to nursing care facilities regarding the exploitation of robots in the nursing care sector, in order to obtain a analysis basis from the scratch about the "inevitableness of robots" in the nursing care sector.

For the FY2020 (pre-survey) interviews with nursing care facilities in (1), the coverage was limited to residential type nursing care facilities, and interviewees were selected among employees in managerial positions of those facilities, such as directors and office managers. These interviews must provide understandings of the level of “inevitableness of robots” to some extent in nursing care workplaces through.

The original intention of the questionnaire survey of robot developers of (2) was to ask robot developers, especially engineers currently not engaged in the development of robots for the nursing care sector, to present “what robot technology can do,” and show the results to employees of nursing care facilities to elicit their reactions.

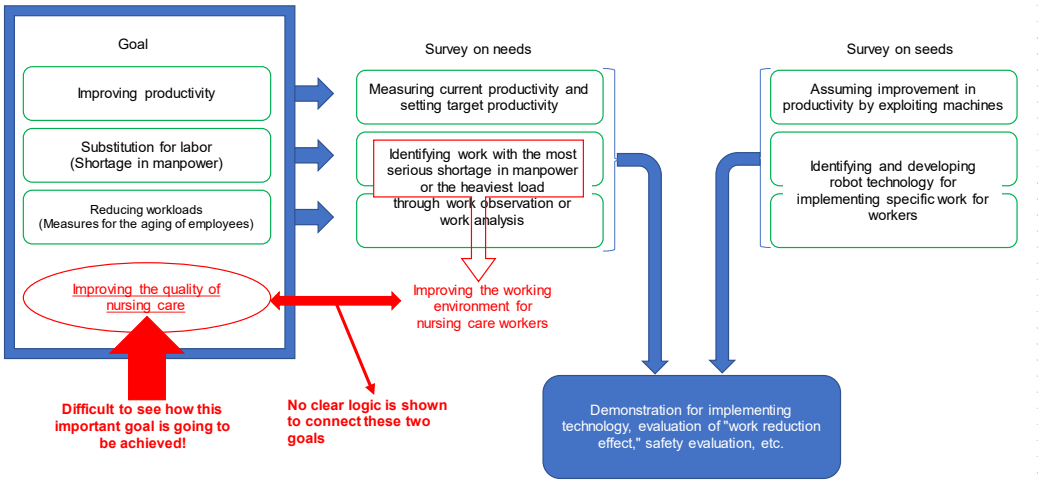
6. Summary of the Research in FY2020 (1)

In FY2020, the Project held interviews with nursing care facilities, mainly through the introduction of the members of the Project. Due to the impact of the spread of the COVID-19 pandemic, the number of interviews actually held was significantly reduced from the originally planned number. Thus, the results of the interviews were summarized by referring to the contents of various seminars, etc. participated mainly by the secretariat in addition to the discussions in the Project.

◆**In contrast to the idea of using robots to cover "shortages in manpower" in the nursing care sector, the perceived "inevitableness of robots" in workplaces seems to be low.**

As the current situation of the exploitation and introduction of robots in the nursing care sector, it turned out from the interviews that the perception that nursing care robots cover shortages in manpower in workplaces of nursing care facilities was weak. The currently realized role of nursing care robots is to “reduce burdens on caregivers,” and they are thus expected to be useful to prevent the turnover of nursing care workers and promote the attraction of nursing care workers. On the other hand, it became also clear that the more knowledgeable about and aggressive in introduction of cutting-edge ICT technology managers at nursing care facilities are, the less they expect that nursing care itself can be substituted by “robots.” It has also been found out that they think few robots introduced contribute to improvement of the “quality” of nursing care at present. Existing reports on the progress of the development of “nursing care robots” demonstrate that this problem of the “quality” of nursing care has not been covered by surveys on needs and seeds of robots, and, in consequence, developed robots do not directly contribute to improving the quality of nursing care. It is highly possible that the fact that the contribution of robots to improving the "quality" of nursing care is unknown is directly related to the low exploitation of robots.

Figure 3-1 Progress of the development of robots for the nursing care sector and problems



Source) Interim Report for Research Project on Market Development and Industrial Growth of Service Robots, p.21.

◆ **Monitoring support sensors and devices for the automatic creation and centralized management of work and nursing care records are exploited because they are expected to contribute to improving the "quality" of nursing care.**

The introduction of monitoring support robots and sensors is in progress not only because of institutional and public support but also because of awareness of the "inevitableness of them" in nursing care workplaces. Monitoring support robots and sensors are often described as equipment or devices that can relieve caregivers from the heavy burdens of patrolling (especially at night) and reduce their workloads, and, what is more, more robots are introduced probably because they actually improve the quality of nursing care.

◆ **By reducing the manpower involved in peripheral and indirect work, or "invisible nursing care," care workers can concentrate on direct nursing care, and high-quality nursing care can be realized. Thus, nursing care workplaces strongly feel the "inevitableness of robots."**

Even when robots are used in the nursing care sector to replace only visible nursing care (direct nursing care), setups and arrangements through "invisible nursing care" (although it is not direct nursing care but peripheral work and indirect work, it is necessary work and/or work connecting main nursing care work) will eventually be necessary. In the end, caregivers will be forced to perform tasks before and after work to be performed by robots, and the effect of work substitution by robots will be very limited. If visible nursing care and invisible nursing care are properly sorted out and robots undertake peripheral work, or "invisible nursing care," in a way acceptable to workplaces, a great effect will be expected because workers can concentrate on the improvement of the quality of nursing care. The segment of replacing "invisible nursing care" by robots/equipment has potential great demand, and efforts should therefore be made to explore needs more aggressively.

In this process, due consideration must be given to introduction of robots, but at the same time, when introducing any new equipment/systems, it is essential to reorganize the work flow with necessity of those new equipment/systems in terms of the work flow and setups taken into account. In other words, it is necessary to understand the needs of robots by considering how to position robots as one of "integrated services" and how to coordinate not only with caregivers, or people, but also with other robots, equipment and devices.

Another probable task with a high inevitableness of robots is that robots serve as "assistants" to caregivers in direct nursing care. The development of robots in this field is still immature, and it is necessary to concentrate efforts on the development of necessary elemental technologies.

◆ **The inevitableness of promoting the application of cutting-edge technologies, such as simulator robots and AR (augmented reality), to education and training (especially sensibility education) of nursing care workers seems to be high.**

◆ **In the case of a nursing care business in a sound management state, it is more important to consider "to what extent work hours can be reduced" rather than the size of "budget for the introduction of robots and other advanced technologies."**

There is no doubt that pricing is an important factor in the nursing care sector, too. Nevertheless, it is an important finding that nursing care providers in a sound management state actively adopt cutting-edge technologies evaluating by "relative price" with the aim of enriching nursing care services and improving the "quality" of nursing care, and rarely decide whether to introduce these technologies based on their absolute prices.

7. Summary of the Research in FY2020 (2)

When considering the introduction and development of robots for the nursing care sector, it is frequently

common practice to identify work with the highest needs as "work with the longest work time or the heaviest workload," search for seeds that meet those needs, and perform “needs-seeds matching.” However, making an attempt to confirm whether it was possible to open up a new perspective by drastically changing this ordinary approach was another aim of the questionnaire of robot developers conducted. Thus, the Project planned to ask robot developers, especially engineers currently not engaged in the development of robots for the nursing care sector, to present "what robot technology can do." This is a "seeds" survey with "virtual voluntary problem solving" approach from the robot engineering aspect. Then, we planned to show the results to employees of nursing care facilities to elicit their reactions.

This time, the questionnaire was sent mainly to universities and private companies through connections of the members of the Project, and the result showed that the number of responses was much smaller than expected. For this reason, instead of conducting a statistical analysis, etc. as a "questionnaire," the Project decided to treat the survey as a "paper interview" and extract important points from the responses.

The details of the responses are presented in the main text of the Interim Report, and the issues that have come to light can be summarized into the teaching that “knowing workplaces” is important in robot development, which is not the only case with the nursing care sector. This means that it is difficult to confirm how to identify the needs of workplaces and how to link the issues grasped as “needs” to “seeds” to derive solutions only through superficial work analyses of workplaces. It was pointed out that as one of the reasons why the exploitation of robots in the nursing care sector is tardy, the poor technological literacy of nursing care providers, who are robot users, is frequently a problem. However, it is also necessary for robot developers to grasp the real needs of workplaces and have a high level of literacy in understanding workplaces for deriving necessary solutions.

In addition, there is no doubt that the securing of safety and security and the fostering of a feeling convicted are the important factors that should be realized in advance when considering the promotion of exploiting robots in the nursing care sector and market formation. However, it is also certain that "security" will not be acquired without actual experience in use. Mechanisms should be contemplated and realized to promote the use of robots and secure safety and security simultaneously, including the quantification of security.

8. Findings from the Discussion of the Project in FY2020

(1) Robots “people cannot resist using” should be pursued

In the nursing care sector, the development of higher-performance equipment and tools is expected by aiming for "intelligent and smart welfare equipment" with the evolution of robot and AI technologies. However, it will be necessary to deal with many needs existing in the nursing care sector more actively, which cannot be fulfilled by up-grading of “welfare equipment and tools” but are important. In addition, it should be seriously discussed that the addition of robot and AI technologies to conventional welfare equipment will create robots and equipment with excessive functions that “will do something unnecessary,” or products that will not be introduced or used due to unnecessarily high prices. The importance of developing technologies to be devised and improved as devices and tools without forcibly promoting "robotization" and "intellectualization” should not be overlooked.

Furthermore, efforts should be made to create **robots “people cannot resist using**” by picking scenes where robot and AI technologies “must be” used and grasping real needs for robots. Creating a situation where a user is forced to use a robot should be avoided wherever possible.

(2) Consider the exploitation of robots as “integrated services” in a network

Also in the nursing care sector, it is necessary to consider the exploitation of robots in networks in order to promote the introduction of robots. There are some companies that provide systems in which the

controllers set and prepared separately for respective devices installed in a nursing care facility into one and the single controller, including the exploitation of a smartphone, can give instructions and operate the devices. However, that alone does not resolve the fundamental complexity. In the development stage of robots, it is necessary to consider the use of multiple robots or the use of these robots based on linkage with peripheral devices or equipment. And considering linkage between robots or between robots and peripheral devices or equipment through a network will lead the exploitation of robots to be regarded as part of “integrated services.” One of the current concerns in the nursing care sector is the vulnerability of information communication infrastructure in many nursing care facilities. It should be carefully noted that the maintenance of such basic infrastructure is indispensable for the use of robots in a network in the nursing care sector.

(3) Support for the development of robot technology, which motivates robot engineers, should be contemplated.

In the development of humanoid-like robots that "carry out” direct nursing care work for nursing care workers, holding-up type of transfer assisting robots, for example, have been developed and commercialized. These robots adopt “human-friendly” technologies, such as sensors and special control mechanisms. However, they alone are insufficient to realize comfortable, high-quality nursing care for care recipients. This problem is caused by the fact that the human body is articulated and soft, and cannot be resolved unless technology for appropriately supporting the human body by controlling the distributed force is realized after considering the different physiques and skeletons of each person. However, robots that can cope with this articulated and soft human body have not been developed yet. It is absolutely necessary to incorporate knowledge from other fields, such as welfare engineering and sports medicine, and to scientifically elucidate the action of robots on the human body itself in order to promote the exploitation of robots not only in the nursing care sector but also in various interpersonal services. We expect that robot engineers will be motivated in this field. Unfortunately, however, policy support to such research and development is weak in reality. Even if a research and development project in which a robot detects appropriate points and acts on the articulated and soft human body is proposed, it is unlikely to receive a research fund. It will be also necessary to change this reality and take measures to help motivate robot engineers.

It is also important to develop or improve the materials that make up robots. For example, in the automobile sector, the development of materials that are lightweight, highly durable, and relatively inexpensive is in progress. In addition, to exploit materials developed in other sectors, it would be necessary to build a mechanism like a development information platform a little more systematically without relying on the ideas of individual robot developers and information networks.

9. Remaining Issues in the Project in 2020 and Prospects for the Next Fiscal year

Since the interviews held in FY2020 were limited to residential type nursing care facilities, it is necessary to consider not only outpatient type nursing care services but also the exploitation of robots by home nursing care service providers and for home nursing care by families in the next fiscal year onward. In addition, although various points were extracted from the "paper interview" of robot developers, it is necessary to continue collecting wider opinions.

In the next fiscal year, the Project is planning to expand the collection of such data, and proceed the discussion to the "degree of specificity of environmental conditions" of the two approaches of discussion prepared by the Project, and then attempt to build a business model that will lead to the formation of a market for robots in the nursing care sector, which is the objective of the Project. The Project is also considering deepening the discussion from the standpoint of exploiting service robots in networks and using and exploiting robots as “integrated services” to elicit teaching for the exploitation of robots in other service sectors.