# A pilot and feasibility study on 'elderly support services' using a communication robot and monitoring sensors integrated with cloud robotics

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Abstract

Aim: This paper describes a pilot and feasibility study on the effect of communication robots cooperated with sensing system combined by cloud robotics on the elderly people care at nursing home.

Method: Two elderly women in nursing home as well as four care workers participated in the study. After examination of overnight process of the elderly and the work stress of the care workers, communication robot SOTA and bio-sensing devices as well as their intervention scenario to the elderly were tuned up to adjust cloud robotics platform.

Results: Analysis of overnight process at nursing home gave us insight when and how communication robot intervened to the elderly. It took three hours for care workers to keep vital notes at most stressful period just before catnapping or at wee hours of the morning, which taught us performance level of sensing devices needed to attach. Care workers stress was maximized when responding to nurse calls, which taught importance of the first response to it by a robot inspired by sensing devices. Tuned up robots triggered by the sensors which has been educated by cloud based intelligence made well-timed verbal note such as a caution "Are you going to toilet?" responding to irregular wakeup motion during sleep. Conversation with robots evoked marked dialogue effect in the elderly, who loved their robots and were pleased with the robots' growth.

Conclusions: The day comes soon when communication robots cooperated with sensing system combined by cloud robotics works in the elderly's living or at nursing home.

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Key words: communication robot, robotics, cloud computing, elderly care, nursing home

## Introduction

The realization of power-assisted robots that can provide elderly care is just around the corner[1]. On the other hand, preliminary studies on socially assisted communication robots for the elderly have been started only a decade ago. Although there have been some reports showing that such type robots had positive psychosocial effects[2,3] and that their deployment worked as a measure to help patients with dementia[4], there are apparently few reports with a satisfactory level of evidence[5]. Moreover, there seems to be few substantial reports whether or not the robots can reduce the labor burden at a care site[6].

What are communication robots? They are not only alternatives to animal pets, of which they were initially considered[7]. New concepts of socially assisted communication started appearing one after another[8]. The introduction of communication robots that provides support to elderly people is at the beginning stage[9].

The present time is considered as the era of cloud computing[10]. As for the desired areas of improvement, next-generation robots are going to be required to have their own intelligence, interact with artificial intelligence (AI) in the cloud, and have a smiling and talking interface in an integrated system which monitors elderly people[11].

This pilot study aims to assess the feasibility of providing care support services using communication robots equipped with monitoring sensors supported by cloud robotics, which has been initiated but not yet fully developed nor commercialized in the elderly care field.

## Methods

This research has been evaluated by the Social Welfare Corporation Tokyo Seishin-kai Ethics Committee and approved as of March 2015.

The subjects consisted of two people who resided in the Social Welfare Corporation Tokyo Seishin-kai Flora Tanashi in whom informed consent was obtained before participating in the study. One was a 104-year-old female subject and the other was an 87-year-old female subject, both of whom had a nursing care level of 4 and a degree of independence in daily life of A2. Four nursing staff members were also surveyed.

We performed validation experiments in 2015. From April to May 2015, we conducted a preliminary survey. We used a resident life rhythm sheet to check the living conditions of the two elderly subjects, and also analyzed the state of the staff member's work using a record sheet to observe the contents of their work. In addition, we quantitatively investigated different types of psychological stress, such as feelings of tension, depression, anger, vigor, fatigue, and confusion, using the Visual Analogue Scale for the Profile of Mood States (POMS-VAS)[12]. We also investigated feelings of sleepiness, anxiety, discomfort, fatigue, and vagueness using the 'Method for checking subjective symptoms'[13] of the Japan Study Organization for Researching Occupational Fatigue. We also investigated the frequency of nurse calls (NC), which is regarded as one of the major factors causing stress to care workers.

In May 2015, we selected ‘use cases’ based on these preliminary studies, and we also started arranging the program, including adjusting the interactive functions and sensing techniques. Between May and June 2015, we introduced the robot and sensors into an actual care of the 87-year-old subject to evaluate their effects for four nights. This system was supported by cloud robotics.

Figure 1 shows a cloud robotics diagrammatic illustration of our elderly monitoring sensor and communication robot system[14]. Real-time sensing data obtained by vital and bed sensors are sent to the cloud robotics platform through the data I/O devices, and conversations between the subject and the robot are also sent to the cloud platform through the robot I/O device, and they are then analyzed and controlled. While referring to the data context information that was previously integrated, the robot analyzes the state of the subject using the sensing data. For example, it determines whether the subject is standing, sitting or lying down, or is sleeping or awake, as well as the subject’s vital state and whether or not the subject is having any difficulties. Dialogue sound data obtained from the robot’s input and output are analyzed by referring to prior speech log analysis, and are then followed by the dialogue control process, resulting in the preparation of speech synthesis. The control mechanism performs assessment of the subject’s state by comprehensively considering the above data and sound control results, and delivers speech along with the execution of any necessary tasks. The final output is also sent to the facility staff.

Fig.1

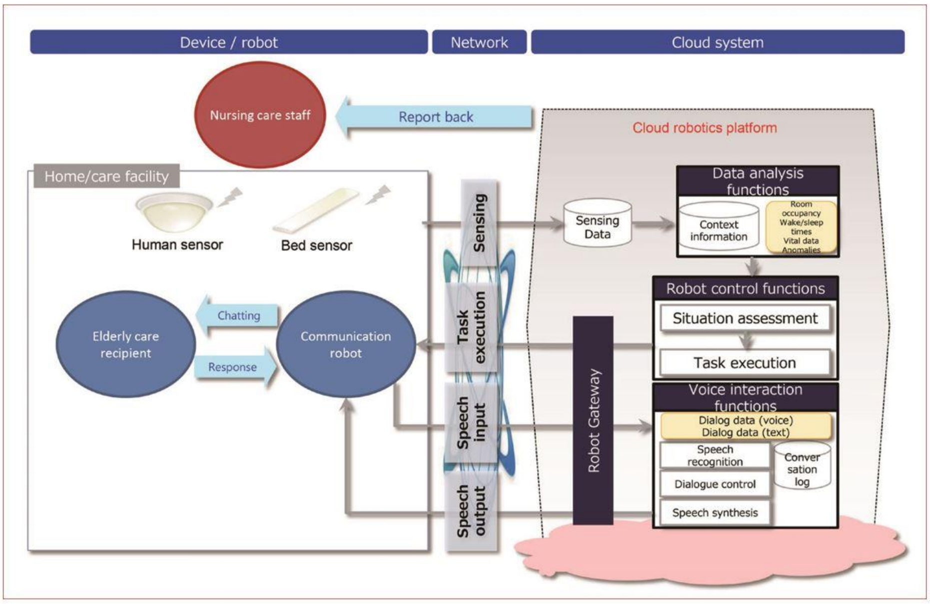


*Fig.1 A cloud robotics diagrammatic illustration of the elderly monitoring sensor and communication robot system. Real-time sensing data obtained by vital and bed sensors are sent to the cloud robotics platform through the data I/O devices, and the conversations between the subject and the robot are also sent to the cloud platform through the robot I/O device, and*

*they are subsequently analyzed and controlled. While referring to the data context information that has been integrated, it analyzes the state of the subject using the sensing data. Dialogue sound data obtained from the robot's input and output are analyzed by referring to prior speech log analysis, and is then followed by the dialogue control process, resulting in speech synthesis being prepared. The final output is also sent to the facility staff.*

The robot system used in this study was configured as follows: the conversational robot was manufactured by Vstone Co. Sota. The external dimensions of the Robot Sota were 280 (H) × 140 (W) × 160 (D) mm, and its weight was 763 g. It had a total of eight degrees of freedom (trunk: 1 axis, arms: 2 axes each, neck: 3 axes). An Intel (R) Edison was mounted on the CPU. For input/output devices, a camera, a monaural microphone, a speaker, and LEDs (both eyes: 2, mouth: 1) were attached. Wi-Fi, Bluetooth, and 2 USBs were available for the interface.

The sensors were non-contact type human vital sensors manufactured by Mio Corporation. The NEMURI SCAN [15] was manufactured by PARAMOUNT BED CO., LTD. The information transmission platform was set up by building an intrafacility Wi-Fi network using 3 servers.

## Results

### Survey of nursing care work

1) Our survey checked for the level of psychological burden and fatigue every hour. The sample case (Fig.2) showed that the time just before their nap (01:00 to 03:00) and the time between the first light and the early morning were the peak times for psychological burden and fatigue.

Fig.2

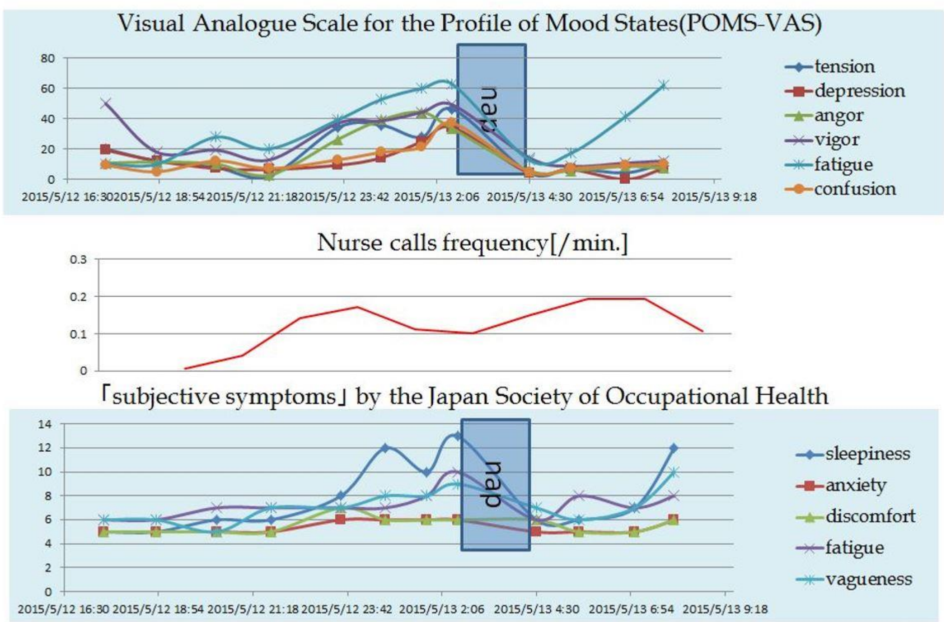

*Fig.2 A sample of our survey checked for the level of psychological burden and fatigue every hour. Data in the upper figure were obtained using POMS-VAS and data in the lower figure were obtained by the 'Method for checking subjective symptoms'. The results showed that the time just before their nap (01:00 to 03:00) and the time between the first light and the early morning were the peak times for psychological burden and fatigue. The middle figure shows the frequency of nurse calls.*

2) Out of 15 hours and half of the total midnight work performed by the staff, the required amount of recording task was 3 hours. The lead staff members performed most of the recording work during the peak fatigue time. When a NC was added during that period, their psychological burden reached its maximum. In response to these sensor signals, the robot was tuned up to be able to make an appropriate conversation.

3) It appeared that there were some correlations between the frequency of NCs and the psychological burden of the staff members. We calculated the correlation coefficient R between the 11 items of psychological burden and subjective fatigue and the frequency of NCs for all 4 staff members (Fig.3a). Some of the items (e.g., anger, fatigue, and confusion) showed good correlations. In particular, the POMS-VAS (average) was relatively well correlated with the frequency of NCs (r = 0.45) (Fig.3b).

Fig.3a

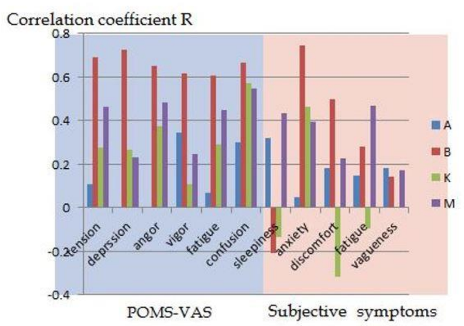


Fig.3b

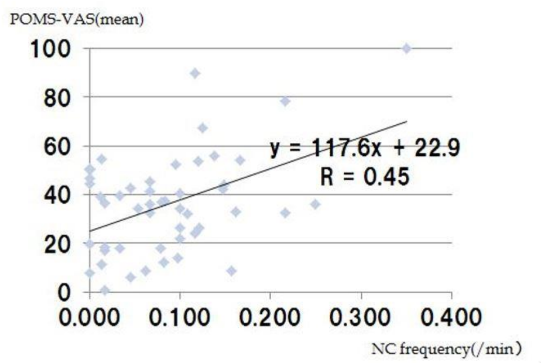


*Fig. 3a (left) shows the correlation coefficient R between the 11 items of subjective burden and the frequency of NCs for all 4 staff members. Some of the items (e.g., anger, fatigue, and confusion) showed a high correlation coefficient.*

*Fig. 3b (right) shows the well correlation of POMS-VAS (average) with the frequency of NCs (r = 0.45).*

**Sensors and Robot**

4) The use of non-contact-type human vital sensors and NEMURI Scan made it possible to automatically record the following events: the length of time the subject was in bed, what time she slept, what time she woke up in the morning, the number of times they got up during the

night, how long she slept, the number of breaths she took, and the reasons she woke up.

5) A well-tuned conversation scenario made it possible for the robot to speak to the subject when triggered by these sensors (Fig.4). Morning call and conversation could confirm the safety of the elderly. Conversation to confirm drug compliance prevented her from making intake mistakes. Conversation in the living room made it possible to record the hidden daily life behind closed doors. Midnight watching and calling by the robot detected the risk of falling or wandering.

Fig.4

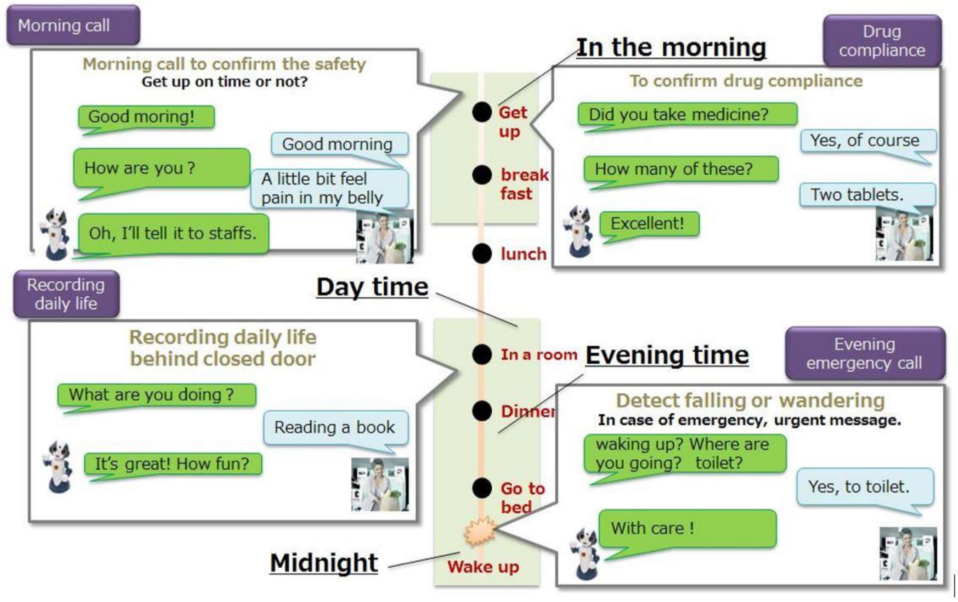


*Fig.4 A well-tuned conversation scenario made the robot possible to speak to the subjects when triggered by these sensors. Morning call could confirm the safety of the elderly. Conversation to confirm drug compliance prevented the elderly from making intake mistakes. Conversation in the living room made it possible to record the daily life of the elderly behind closed doors. Midnight watching and calling by the communication robot detected the risk of falling or wandering.*

6) Prompt calling to the subject at their arousal during sleep by caregivers had been impossible before the trial, whereas the numbers of calling increased to 5 on average by the robot intervention for four days, which provided a sense of security to the subject. The number of times that the subject spoke to the robot also increased to 8; thus, we observed a significant effect on the ability to induce speech from the subject.

7) Generally speaking, the subject could communicate with the robot without any psychological burden. The frequency of conversation increased day by day, and the subject was happy with the 'growth' of the communication robots.

### Points indicated by the results

1) Analyzing the labor characteristics of long-term care workers is essentially important before any robot intervention is introduced to the care facilities. Otherwise, the robot's ability to temporarily respond to a NC to reduce the burden of the night shift staff would not be realized.

2) The use of the sensors to automatically record events and characteristics such as the patient's vitals might also improve the quality of care provided by late-night caregivers.

3) The sensors could detect the situation and allow the robot to provide appropriate responses, which resulted in the establishment of a dialogue. This may enhance the willingness of the elderly to participate in activities, which might help them to realize their own potential.

### Problems

**Operational problems at nursing care sites**

1) The privacy protection of care receivers is very important. Depending on what exactly is being detected, the use of the current cloud system could have serious problems.

2) When introduced into an actual care facility, it is necessary to provide an appropriate scenario in line with the conditions of each facility and to establish a genuinely effective interventional method by analyzing the care being provided.

3) The goals are to improve the activities and increase the level of participation of the care receivers. Using these goals as endpoints, additional scientific trials need to be conducted.

**Optimizing the communication robots and other technical aspects**

1) If safe handling of the sensing data is not guaranteed, this system will not be applicable on a widespread scale.

2) The conversation engine of the communication robots needs to be improved. Specifically, it is essential to improve the robot's speech analysis ability and its accuracy of understanding language. More sophisticated speech and dialogue are desired.

## Discussion

Conversation between the robot and the elderly subject was performed in this study without any serious problems. Some signs of 'active participation in social activities and the realization of self-potential in the elderly' were observed from the viewpoint of the ICF (International Classification of Functioning, Disability and Health）[16,17].

The sensing equipment also assisted us in learning more about the living conditions of the elderly subjects, which in turn can effectively help the caregivers in providing the appropriate support. Owing to these effects, professional caregivers will be able to have more personal face-to-face hours with care receivers, which has been thought to be the most essential factor for achieving optimal care and has been desperately awaited for at actual working sites.

However, the completion level of the system is presently far from satisfactory. Through this trial, we were able to discover technical or operational problems that need to be addressed. In terms of the cloud robotics supported by AI, there are a number of tasks to be solved in the fields of verification, validity, and security. We believe that the challenges that have been identified in this trial could be addressed and handled by our current level of technology.

The role of socially assisted and communication robots in the nursing care field has been considered to give care receivers emotional security[18] primarily to reduce their stress[19], relieve their loneliness, and facilitate communication. This idealistic concept will not have been accepted in the 2040s in Japan, when 38 million elderly people aged over 65 years old (36% of the total population) will be taken care of by 54 million working-age people (20 to 64 years old)[20]. The robots are also expected to contribute in overcoming a hard social and economic battle against the aging society.

In addition to the idea that the robot can help the elderly to participate in more activities through conversation, the communication robots should also act as a mobile frontal device of a comprehensive safety system, led by a cloud that runs on a strong AI[21], which can perceive and reduce survival risks in the daily life of the elderly, such as falling or wandering[22].

To achieve this, a revolutionary leap is necessary both in terms of hardware and software, including the improvement of input/output performance, mobile activity, and automatic tracking capabilities[23] of the robot itself, the rapid growth of its intelligence level, the design of cloud robotics that are integrated with sensors and other robots, and the development of an interactive management system in which crisis management algorithms are supported by learned AI.

In summary, we successfully conducted a pilot study to assess the feasibility of providing care support services to the elderly using a communication robot equipped with monitoring sensors and supported by cloud technology, which would be the first report in this field. Even if the subjects were elderly or have problems with their cognitive function, they appeared to be able to accept the communication robots willingly. Some operational problems that may occur in the nursing field if the robots are installed have been identified. Some technical tasks of the robots that can be solved were also discovered.

The aging population problem is sure to develop not only in Japan but also in other countries[24]. The United States and many European as well as Asian countries are catching up with this problem[25]. Indeed, this aging population problem is a growing concern that entails a worldwide task. At this point, we need the active cooperation of researchers, engineers, nursing care workers, and elderly care receivers to be able to conduct full-fledged research, with the aim of showing a satisfactory level of evidence regarding the benefits of 'Developing the communication robots together'.

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