Developing a Platform of Personalized Conversation Scenarios for In-home Care Assistance

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***Abstract*—The burden on family caregivers for in-home care is increasing in a super-aging society. Realizing conversational agents adapted to individual situations for in-home care assistance is a hard technical issue. The purpose of this paper is to realize a method that can create a personalized conversational agent by the end-user. The challenging points of this paper include two aspects: (1) Editing conversation scenarios easier for end-users. (2) Sharing edited conversation scenarios with others. As the approach, we first present a platform of personalized conversation scenario (PoPCS). Then, we create a logs-as-scenarios concept to improve the personalized contents and the edited efficiency. By selectively sharing the conversation logs, we build a connection between the local conversational agent and the remote that seems like telemedicine. Since different family caregivers and healthcare specialists join in it, continuing to improve the conversation scenarios for in-home care assistance is promising.**

***Index Terms*—in-home care assistance, conversational agents, scenarios, end-user, web service**

I. Introduction

With the global aging of the population, the number of people requiring nursing care is increasing year by year. At the same time, as the demand for nursing care in a super-aging society is increasing, the population, social, and disease structure are changing. A shortage of medical, institutions and the staff of nursing care is becoming a social situation. Though policies in Japan [1] have been formulated to switch from institutional care to **in-home care**, the burden on family caregivers has been increasing. Our research group has been studying various conversational agents for in-home care assistance in a super-aging society, including operation assistance for the home appliance [1], memory assistance for the elderly people [2], and daily counseling for people with dementia [3]. However, a hard part of the current technical issues is how to realize conversational agents adapted to individual situations for in-home care assistance. Due to a huge difference among users' needs exist, it is unrealistic to build a unique conversational agent by developers from one household to another.

The goal of this paper is to realize a method that can create a personalized conversational agent by the end-user for in-home care assistance. To achieve the goal, we are currently developing a **platform of personal conversation scenarios (PoPCS)**. More specifically, the PoPCS is a web-based platform that can not only edit and share conversation scenarios by family caregivers but also execute edited conversation scenarios as a **virtual caregiver** for the individual in-home care assistance. As the approach, we first define three roles: care recipients, family caregivers, and healthcare specialists. Next, we focus on the conversation logs and scenarios, to design three main function modules for the local and remote conversation agent, including conversation logs, scenario editors, and conversation models. Then, we produce a complete description for each function module. Our key idea is a **logs-as-scenarios** concept that not only uses conversation logs as references of scenarios by family caregivers but also selectively shared to the healthcare specialists and others for checking and referring. Compared with traditional ways (e.g., going to the institution or making a call respectively), it can save time, money, and manpower, when some of the care nursing problems are encountered at home.

As a case study, we discuss the three directions for in-home care assistance using the PoPCS, including mental healthcare, medication reminder, and worries or problems response. Moreover, the advantages and the limitations of the PoPCS are also discussed by us, to determine the directions in future work.

II. Preliminaries

A. Problems in Super-aging Society

In recent years, population aging is increasing worldwide, especially problems in **super-aging society**. A super-aging society refers to a society in which the proportion of the population aged 65 and over (aging rate) accounts for 21% of the total population [4]. Looking at the ranking of the world's aging rate [2], developed countries tend to be higher, and developing countries tend to be lower. Regarding the

[1]https://www.mhlw.go.jp/seisakunitsuite/bunya/kenkou_iryou/iryou/zaitaku/dl/zaitakuiryou_all.pdf (in Japanese)

[2]https://population.un.org/wpp/Download/Standard/Population/

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top three countries with aging rates, Japan is 28.7%, Italy is 23.3%, and Germany is 21.7%. In addition, when viewed from the whole, one in 11 of the world's population at the time of 2019 (9%) is greater than or equal to 65 years of age. There is a prediction that the proportion will increase to one in six people in 2050 (16%). Against this background, the population, society, and disease structure are changing in various countries around the world, and the number of people requiring nursing care is increasing year by year.

B. Burden on Family Caregivers for In-home Care

With the demand for nursing care increasing in a super-aging society, the related problems have to be faced, such as a shortage of medical and welfare institutions, a staff shortage in the nursing care industry. In order to improve these problems, and realize people their own lives who require nursing care, policies in Japan have been formulated to promote cooperation between nursing care facilities and switch from institutional care to **in-home care**. As the case of in-home care, while people who require nursing care are possible to continue living in a familiar home, a mental and physical burden on family caregivers has been increasing. A variety of problems related to in-home care, like full-time care for 24 hours due to serious illness, an older adult caring for even older parents, an elderly couple with dementia but nursing care of each other, and the elderly living alone are becoming prevalent. Research on **assistive technology** is progressing all over the world, which attempts to solve these problems of home care through cooperation between machines and humans.

C. In-home Monitoring System Using an Agent Concept

The typical system for in-home care assistance is an "in-home monitoring system" for people requiring nursing care, using ICT, Internet of Things (IoT), Artificial Intelligence (AI), cloud technologies, robots, and so on. The key idea of it is an **agent concept** that uses the machine to replace family caregivers, to make an interaction with people requiring nursing care at home. One way by introducing sensors into the home, to achieve a variety of effects like recording the status of sleeping [5], estimating the excretion [6], and fall prevention [7]. Other ways have been actively developing, such as using a camera device, the research [8] on the measurement of physical activity for long-term in-home nursing care is proposed by us. Moreover, at any time of day or night, the machine will let family caregivers know promptly when all kinds of timing or signals requiring nursing care are coming, like toilet assistance, medication reminder, and assistance in changing physical postures. Using this approach, reducing the burden of family caregivers and improving the Quality of Life (QoL) of people requiring nursing care is promising.

D. Existing Conversational Agents and Related Work

Using the form of conversation to interact between people requiring nursing care at home and the machine that is called a **conversational agent** is one of the topic issues for in-home care assistance. The interaction approach of conversational agents often includes two ways: text-based and speech-based. Regarding text-based conversational agents, they rely on text input from users, where the related work includes mobile-based "chatbot" service using Line Application Programing Interface (API) [9] and a rule-based "mind" sensing service integrating with MPAgent [10] have been widely deploying. However, there are also some elderly people who do not understand the method of text input and feel inconvenient. By contrast, speech-based conversational agents with two types including robot and virtual User Interface (UI) have been more popular among the elderly. A variety of speech-based nursing robot products have been introduced into general households that functions include information presentation [3], medication reminder [4], safety confirmation [5], and so on. Our research group has been studying speech-based conversational agents with virtual UI, like specific software or web applications. In previous studies, operation assistance for the home appliance [1], memory assistance for the elderly people [2], and daily counseling for people with dementia [3] have been proposed.

E. Existing Cloud Platforms and Challenging Points

Rapid progress in cloud technology has made many cloud platforms for conversational agent services continue to appear, such as Google Cloud Dialogflow [6], Microsoft Bot Framework [7], Amazon Alexa Skills Kit [8], and IBM Watson Assistant [9]. Using cloud computing and resources, high-performance processing (e.g., Natural Language Processing (NLP), etc.) can be moved from edge devices to the cloud, to achieve high-quality conversational agent services. On the one hand, cloud platforms can be associated with their smart products (e.g., smart speakers, smart watches, etc.) that allow users to edit scenarios of conversational agents for a special purpose. On the other hand, the various functions of cloud platforms are open to developers as cloud services, which can be used to associate other devices and services, so as to achieve more effects through more flexible utilization. However, we consider that challenging points of these platforms are how to be conveniently used by end-users rather than developers. For special purposes like in-home care assistance, a huge difference among users' needs exists. It is unrealistic to require all users to use smart products, or build a unique agent by developers from one household to another.

F. Requirements of Conversation Scenarios for End-users

Realizing conversational agents adapted to individual situations for in-home care assistance is a hard part of the current technical issues. Except for some specific smart products, in the conversational agent systems for in-home care assistance, most of the conversation scenarios and services are based

[3]https://www.vstone.co.jp/products/sota/ (in Japanese)
[4]https://www.medical-switch.com/ (in Japanese)
[5]https://www.necplatforms.co.jp/solution/papero_i/index.html (in Japanese)
[6]https://cloud.google.com/dialogflow?hl=en
[7]https://dev.botframework.com/
[8]https://developer.amazon.com/en-US/alexa/alexa-skills-kit
[9]https://www.ibm.com/cloud/watson-assistant

TABLE I
END-USERS AND APPLICABLE CONDITIONS IN THE POPCS

End-users	Applicable Conditions
Healthcare specialists	(1) Have professional knowledge to solve problems of home care. (2) Have the basic ability of the web operations of PC or mobile.
Family caregivers	(1) Have worries or problems in the process of performing care. (2) Have the basic ability of the web operations of PC or mobile.
Care recipients	(1) Have worries or problems in the process of requiring care. (2) Have the basic ability to communicate in any language.

on the definition of the developer rather than the end-user. Hence, we consider that there are two potential requirements for end-users as follows:

R1: Editing Conversation Scenarios Easier for End-users End-users can edit conversation scenarios to suit the conditions of people requiring nursing care, like habits and interests.

R2: Sharing Edited Conversation Scenarios with Others End-users can share edited conversation scenarios with the other communities and regions, as references for others.

The long-term vision of our study is to realize a platform of conversational agents for in-home care assistance that end-users can edit, perform, and share the conversation scenarios.

III. POPCS: PLATFORM OF PERSONALIZED CONVERSATION SCENARIOS

A. Outline

To improve the requirements described in Section II-F, we are currently developing a **platform of personalized conversation scenarios (PoPCS)** for in-home care assistance. The ideal image of the PoPCS includes the following two aspects: (1) Can edit and share conversation scenarios from the web browser of various devices, like computers, tablets, and smart phones. (2) Can execute edited conversation scenarios as a **virtual caregiver** by the web browser for the individual in-home care assistance. For this, as the approach, we first identify the required function modules in the PoPCS. Then, we produce a complete description for each function module. End-users and applicable conditions are shown in Table I.

B. Function Modules

To determine end-users in the PoPCS, we define three roles: care recipients, family caregivers, and healthcare specialists. Figure 1 and 2 respectively depict the use case

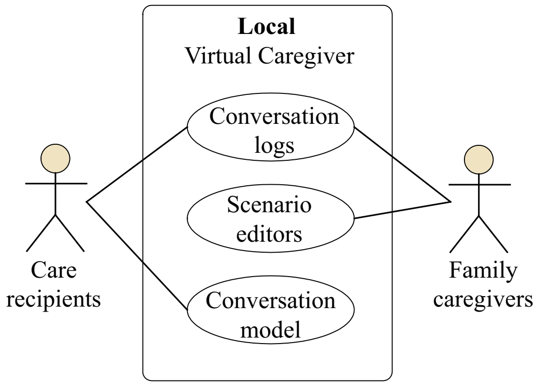

Fig. 1. Use case diagram for a local virtual caregiver.

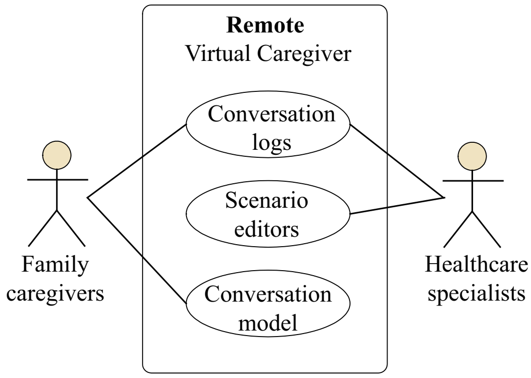

Fig. 2. Use case diagram for a remote virtual caregiver.

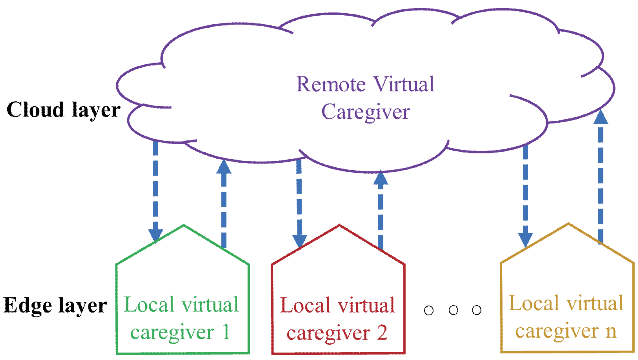

Fig. 3. Conceptual diagram of overall architecture in the PoPCS.

diagram for a virtual caregiver in the local and remote environment. The virtual caregiver here means a speech-based conversational agent using the web browser, which can realize a variety of in-home care assistance, such as mental healthcare, medication reminder, as well as worries or problems response. For each virtual caregiver, we define three main function modules: conversation logs, scenario editors, and conversation models. The conceptual diagram of overall architecture is shown in Figure 3. The key idea of the PoPCS is a **logs-as-scenarios** concept. The conversation logs are not only re-used as scenarios by family caregivers in the edge device, but also selectively shared to the cloud database, for checking by healthcare specialists and referring with others.

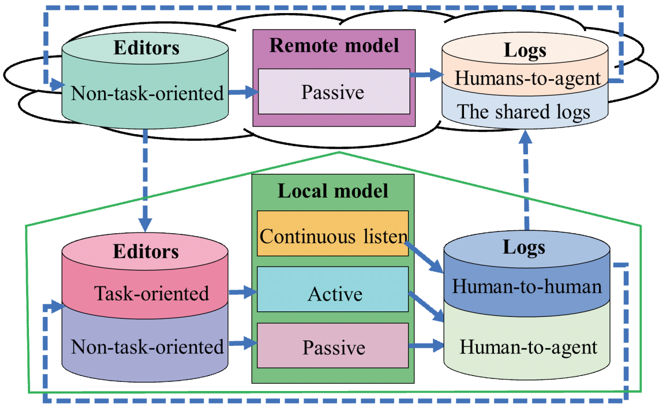

Fig. 4. Internal structure diagram of the function modules.

Figure 4 shows a internal structure diagram of the function modules. More specifically, the description of each function module consists as follows.

C. Module 1: Conversation Logs

Module 1-1: Local Conversation Logs

Using the web speech API [11], automatic speech recognition and synthesis can be easily realized in the web browser. We design two kinds of location conversation logs in the PoPCS: **human-to-human** conversation logs, **human-to-agent** conversation logs. In the human-to-human conversation logs, conversation voices around the local virtual caregiver are automatically converted to text and saved in the edge device. In the human-to-agent conversation logs, the agent here equals a virtual caregiver. To distinguish it from human-to-human conversation logs, end-users can create a name of the agent that is regarded as a keyword for waking the virtual caregiver to talk with the person. In this way, the human-to-agent conversation can be realized and recorded by calling the name of the agent every time. The methods of generating local databases in the web browser include Appcache [12], IndexedDB [13], WebSQL [14], and File System API [15].

Module 1-2: Remote Conversation Logs

The remote conversation here means the **humans-to-agent** conversation using the web browser connected to the internet. We design two kinds of remote conversation logs in the PoPCS: humans-to-agent conversation logs, the shared local conversation logs. In humans-to-agent conversation logs, a public virtual caregiver talks with family caregivers from different households that the conversation logs in the text are automatically saved in the cloud database. As for the shared local conversation logs, family caregivers can selectively share the local conversation logs to the cloud database, for checking by healthcare specialists or referring with others. Remote conversation logs are not only public to each family caregiver, but also re-used as public scenarios by healthcare specialists. The methods for building remote databases in the cloud server include MongoDB [16], MySQL [17], PostgreSQL [18], and Microsoft Access [19].

Date Time	Event
2021-01-21 13:30	Hand massages
2021-03-02 18:00	Card making
2021-04-26 9:00	Read aloud

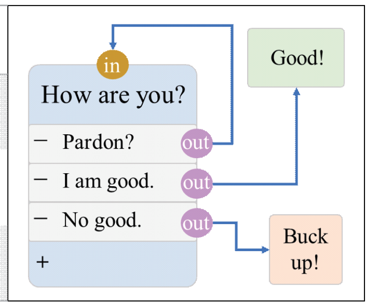

Fig. 5. Examples of form-based and flow-based scenarios.

D. Module 2: Scenario Editors

Module 2-1: Task-oriented Scenario Editor

The key step for executing conversation models is to edit scenarios, which directly affect the quality, sustainability, and purpose of the human-to-agent conversation. The task-oriented scenario editor means editing the required scenarios for a special purpose, like event reminders and personal concerns extraction, where the conversation initiator is the agent. Specifically, it often can edit two kinds of conversation scenarios: form-based scenarios, flow-based scenarios. Figure 5 shows examples of form-based and flow-based scenarios. Using the task-oriented scenario editor, family caregivers can freely edit and update for building conversation models. However, it is not fully convenient because it needs huge manual input for many complex scenarios. For this, we consider that a variety of conversation logs can be used as references to scenarios. In a word, a **logs-as-scenarios** concept is produced by us. Compared with the task-oriented scenarios, the advantage of the concept further concentrates on the non-task-oriented.

Module 2-2: Non-task-oriented Scenario Editor

The non-task-oriented scenario editor means editing conversation scenarios that possibly appear on the care recipient. Unlike the task-oriented scenarios, it is full of uncertainty and randomness, because the conversation initiator is the human rather than the agent. Hence, for editing non-task-oriented scenarios that can fit the personality, the logs-as-scenarios concept is of great significance. Specifically, we first define attributes for each kind of conversation scenario. Referring to Figure 5, attributes in form-based scenarios often include keys (in the left column) and values (in the right column). And attributes in flow-based scenarios often include questions, options, as well as answers. The approach for building classifiers includes document similarity measures [20] and morphological analysis [21]. Family caregivers can manually select the related logs from different attribute groups, to build relationships for the non-task-oriented scenarios.

Module 2-3: Remote Scenario Editors

Remote scenario editors mean deploying the above two kinds of scenario editors to the cloud server. Unlike the local scenario editors, the remote scenario editor corresponds to the above Module 1-2, in order to find problems and create answers in scenarios by healthcare specialists from remote conversation logs. As a part of the remote virtual caregiver, the remote scenarios are public for every local family caregiver. Compared with traditional ways (e.g., going to the institution or making a call respectively), it can save time, money, and manpower, when some of the care nursing problems are encountered at home. Moreover, for the same problem included in the conversation logs, the corresponding answers can be made by multiple healthcare specialists from different views at the same time. The popularity of every remote conversation scenario can also be public and referring to others. In this way, continuing to improve the shared database for in-home care assistance in the form of virtual conversation is promising.

E. Module 3: Conversation Models

Module 3-1: Local Conversation Model

The local conversation model means a virtual caregiver at home, by executing the edited conversation scenarios that directly face the care recipient. It includes three modes: continuous listen mode, active conversation mode, and passive conversation mode. The continuous listen mode aims to collect human-to-human conversation logs (refer to Module 1-1). In the active conversation mode, the agent is a conversation initiator that aims to remind events or extract personal concerns of the care recipient in the form of conversation (refer to Module 2-1). As for the passive mode, the care recipient is a conversation initiator where the answer by the agent will use the non-task-oriented scenarios (refer to Module 2-2). Of course, the contents of exceptional conversation exist. For this, they require adding the answer by family caregivers, or sharing to the remote layer to wait for the answer from healthcare specialists. The method of the above modes switching is calling the keyword created by family caregivers, which is similar to the description of naming the agent in Module 1-1.

Module 3-2: Remote Conversation Model

The remote conversation model means a virtual caregiver deployed in the cloud server, by executing the edited scenarios that face all family caregivers when any required. Corresponding to the above Module 1-2 and 2-3, the remote conversation model offers a humans-to-agent conversation in the cloud layer. It just has a passive conversation mode but can talk with multiple family caregivers in turns. Moreover, unlike the local conversation model, due to a part of the remote scenarios based on the shared conversation logs and the answers from healthcare specialists, the common problems in the process of in-home care will be collected and answered more intensively by the remote conversation model. In this way, building the connection between different family caregivers and institutions, we believe that it can not only reduce the stress of family caregivers but also improve the quality of life (QOL) of the care recipient at home.

IV. Case Study

In this section, as a case study, we explore using the PoPCS to realize personalized in-home care assistance in more detail. Specifically, we discuss the three directions of in-home care assistance: mental healthcare, medication reminder, and worries or problems response.

A. Mental Healthcare

In order to reduce the mental fatigue and stress of family caregivers, the psychological state of the caregiver is common to be grasped from the questionnaire survey of depressive symptoms [22] and care burden [23] in the mental health index. However, there is a troublesome aspect of reading and choosing questionnaires on a regular basis. This may add a feeling of further fatigue for family caregivers. Therefore, we consider that can regard the contents of questionnaires as task-oriented scenarios in the PoPCS. In this way, the psychological state can be expected to be measured in a relaxing process, through speech-based conversation between the family caregiver and the agent. Compared to the written language, the interview questionnaire [24] is easier to use for conversation scenarios. Hence, in order to achieve the expression of daily conversation, it is a challenging point to devise the oral language of the questionnaire.

B. Medication Reminder

In order to prevent care recipients from forgetting to take medication, applications, software, and nursing care robots have been used to improve medication management for the care recipients. However, there are usability and cost problems, due to requiring installing applications or purchasing robot equipment. Therefore, we consider that can regard the contents of the medication time and information as task-oriented scenarios in the PoPCS. In this way, family caregivers can grasp the status of the medication reminder by checking the conversation logs of the care recipient. Moreover, using human-to-agent conversation logs, the experience of taking the medicine can also be shared with healthcare specialists and others, which is significance for long-term nursing care.

C. Worries or Problems Response

There are often different worries or problems for every in-home care site, such as a decrease in the quality of life (QoL) at home, unknown nursing care measures. Generally, family caregivers take measures by referring to the opinions of experts through the care consultation desk or home-visit care services. However, the sharing of related problems among households is finite, and the information obtained from the web is not concentrated. For this, we consider that can regard worries or problems as non-task-oriented scenarios to be shared in the PoPCS. Healthcare specialists will respond in a unified manner to similar problems that the local virtual caregiver in each household cannot answer. In this way, worries or problems will efficiently respond by the remote virtual caregiver.

V. Discussion

A. Advantage

In this paper, we consider that the advantage of the PoPCS includes the following two points:

- **Improvement of equipment and software used:** It does not require mechanical robots or software installation, and can be easily used with the web browser.

- **Improvement of flexibility in editing scenarios:** A variety of conversation scenarios for end-users can be developed on the web UI and personally adapted.

In this way, it can be expected that the editing and operation of conversational agents will become easier and more diversified to in-home care assistance.

B. Limitation

As for the limitation of the PoPS in this paper, we consider that it includes two points as follows:

- **Scalability issue:** In some cases, just a speech-based conversational agent is not sufficient to support long-term nursing care at home. For example, the scalability for using environmental data and image data together is indispensable for special needs such as fall prevention for the elderly.
- **Privacy and security issues:** Traditionally, privacy and security issues have been technology development and service application. In many cases, there was a trade-off relationship. The privacy and security protection of the shared text data in this proposal also requires to be considered.

VI. Conclusion

In this paper, a method that can create a personalized conversational agent for in-home care assistance has been presented by us. To achieve the method for end-users, we described a platform of personalized conversation scenarios (PoPCS) and analyzed the function modules. We also discussed the case study in three directions of in-home care assistance using the PoPCS. As future work, we should develop an automatic algorithm for the logs-as-scenarios concept in the PoPCS. Also, we are planning to evaluate the function module limitations in practical scenes (e.g., emotion estimation from conversation logs [25]). Investigating the characteristics of personality to improve the fluency of human-to-agent conversation is also an interesting challenge.

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