VirtualCareGiver: Personalized Smart Elderly Care

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ABSTRACT

Many care robots have received a lot of attention to help elderly people, however existing care robots have difficult to adapt personalization. For instance, some programmers have to customize robot program to meet needs of individual. In this paper, the authors’ goal is design and develop care robot which provides personalization for an individual elderly people with an efficient and reasonable way. Their proposed service consists of three essential components: VirtualCareGiver (VCG), VirtualCarePersonalizer (VCP) and CareTemplate. VCG is a robot agent, which provides a personalization and integration for each elderly people. The VCG is offered care tasks based on care template which VCP generates. VCP provides adaptation for individual elderly on the cloud. The authors also conduct an experimental evaluation to demonstrate the feasibility with actual 11 subjects in a day care center. As a result, both font size and voice volume are especially contributed for the subjects.

KEYWORDS
Care Robot, CareTemplate, Cloud, Elderly Care, Home Care, Personalization, VirtualCareGiver

INTRODUCTION

We are facing a hyper-aging society, and Japan is forecast to become a society with 39.9% of aged people in 2060. In addition to this, many facilities of welfare and nursing care suffer from a chronic shortage of workers. The job opening ratio is as high as 2.68 (as of Dec. 2014). The number of a nursing home is not sufficient for the number of applicants, who are over 524,000 elderly people. Japanese government starts to support and encourage home care rather than building new facilities. To provide the home care, it is important that each family executes the care based on elderly’s personality. However, caregivers’ burden is still too heavy to provide the personalized care at home. Under these circumstances, the assistive technologies, which support elderly people using technologies, attract great attention.

Care robot is one of the hot assistive technologies to help the independent living for elderly people. Care robot is a robot which aims to support or assist elderly people in his/her daily life. Our research group has also tried to adapt a Virtual Agent (VA) for a care robot. Virtual agent is an animated, human-like graphical chat bot robot program. Using VA would support some simple cares such as greeting with elderly; remind schedules to provide instead of human caregivers.
human caregivers can do tasks, which the caregivers cannot do ever because of the lack of human resources. To provide the care by robots including VA, the robots have to execute tasks based on every elderly’s preference. Because the requirement for cares has variety for each elderly people. Hence, using care robot may ease the burden of caregivers, as a result, that provides personalized care for individual elderly at home.

Although, we think that the existing care robots have three problems to adapt for personalization:

- **Problem P1:** Development cost for personalization becomes larger
- **Problem P2:** Adapting the care robot to individual lifestyle is challenging
- **Problem P3:** Deploying a care robot at general home is quite expensive

The problem P1 means that the developer has to develop the personalized care robot in order to adapt for personalization. To adapt to the growing number of elderly people, we have to develop care robots with an efficient way.

Secondly, the P2 reflects that the care robot automatically learns the individual lifestyle is also challenging topic. Moreover, it requires long-term machine learning as well as costly robot operation and maintenance.

The problem P3 represents that the deploying care robot at general home is quite expensive. We think P3 reduces the motivation to use for elderly people.

The above three problems motivated us to develop a next-generation care system, which considers elderly’s preference with sympathetic interactions, and flexible personalization.

To actualize the above goal, we consider the personalized care architecture that provides automatically personalization for individual elderly people. Our architecture consists of three components; CareTemplate, VirtualCareGiver, and VirtualCarePersonalizer. CareTemplate is a skeleton of care program that defines what should be executed by the virtual agent. For example, when a care program plays a music, CareTemplate just involves an operation playMusic(). If a program greets to elderly, CareTemplate involves greet(). Then, VirtualCarePersonalizer (VCP) implements an actual care by customizing the CareTemplate based on personal profile and contexts of elderly. For instance, if an elderly likes folk songs, VCP chooses a famous folk song for playMusic(). If the elderly has hard of hearing, VCP produces loud and slow voice for greet(). We assume that such personal information is provided by a care manager, family or the elderly himself. The implemented care is finally instructed to VirtualCareGiver (VCG) deployed in an individual home. VCG works as a (virtual) care robot executing given personalized care, using the virtual agent, as well as other smart devices at home. To confirm the effectiveness of the proposed service, we conduct an experimental evaluation with actual 11 subjects. We have found that the proposed care robot is effective both displaying valid font size and speaking with valid volume. It is also useful for music care which plays his/her favorite song. Moreover, we discuss the limitation and future work of our care robot based on the result of the evaluation.

**PRELIMINARIES**

**Person Centered Care**

Person Centered Care (PCC) is a holistic (bio-psychosocial-spiritual) approach to delivering care that is respectful and individualized, allowing negotiation of care, and offering choice through a therapeutic relationship where persons are empowered to be involved in health decisions at whatever
level is desired by that individual who is receiving the care. The concept is based on various sources, including Kitwood (1997) and Epp (2003).

In addition to this, Dementia Care mapping is a practical method to provide the PCC which is developed in the field of dementia care with the long term Research & Center (Japan). Care mapping consists of four processes, mapping, feedback, planning and executing care. The mapping is a process to monitor and logging the elderly’s lifestyle (i.e., walking, eating, and having a chat) during a long time in a day. Currently, the mapping process is executed by a human caregiver, hence the burden is too heavy to do for them. Secondly, the feedback aims to improve the current quality of care by analyzing the individual lifestyle data which we obtain in the mapping process. The planning is the process to improve the current care based on the mapping and feedback. Finally, in the executing care process, the caregiver executes care based on the plan which is made in the previous process. The repetition of four process improves the care which will be person-centered, responsive to individual needs. However, because of the shortage and situation which we said in the previous section of caregivers, it is hardly difficult to execute the person centered care for each elderly people. Hence, it is also quite difficult to provide the person centered care at home. For this situation, the assistive technology is one of the promising solutions, where technologies are introduced to assist the elderly people.

Virtual Agent System

The virtual agent (VA) is a human-looking animated chatbot program that can communicate with a human user via voice (Magalie, Pelachaud & David, 2008). There are a few studies that are adapted the VA for elderly care. Yasuda, Fuketa, and Aoe (2014) developed a system where a VA serves as a conversation partner of people with dementia. Our research group has also developed a system which exploits a VA as a user interface of the home network system (called HNS) (Horiuchi, Saiki, Matsumoto et al., 2014). When a user says “Turn on a TV”, the system interprets the voice as a command TV.on(). Then the system sends the command to the HNS to turn on the TV. Also, the VA autonomously speaks various information obtained from the HNS and the Internet. VA is a promising technology for elderly people, since it can assist an elderly people based on less-mechanical and (simulated) human-to-human conversation. Using the VA, our research group has proposed a new concept of reminder service using virtual agent (Tokunaga, Horiuchi, Takatsuka et al., 2016b; Tokunaga, Horiuchi, Saiki, 2016a). In this research, we re-engineer the VA in order to adapt for wide variety of elderly people.

Goal and Scope of Paper

In this research, our goal is to develop a deploying personalized care service for elderly people which integrates smart services. Figure 1 represents the difference of deploying care robot with conventional method (See upper Figure 1) and our proposed method (See the bottom Figure 1).

The conventional approach is to deploy the different care robot at each home. Hence, it requires much cost to deploy and it also takes learning cost. On the other hand, our proposed method is to deploy identical care robot. Moreover, the care for elderly people is personalized on the cloud that aims to help elderly people in a reasonable and scalable way.

This paper has constructed with following sections. At first, we propose a key idea and system architecture to develop the integration agent. Then, we show some use case to confirm how to provide the personalized care for elderly people using proposed method. Finally, we show a result of experimental evaluation with actual subjects.
CLOUD-BASED PERSONALIZED HOME ELDERLY CARE USING SMART AGENT

System Architecture

In order to achieve the research goal, we develop a service integration agent which consists of three components: VirtualCareGiver (VCG), CareTemplate and VirtualCarePersonalizer (VCP). Figure 2 shows the architecture that we propose. The key idea is a detachment of logic of care and execution part of the cloud. The logic of cares is developed as the skeleton care template in order to adapt for a wide variety of elderly people. In addition to this, the logic of care is deployed on the cloud and personalized with a personalized engine (VCP) and personal information. In addition to this, the VCG also integrates with public web services (e.g. Google Calendar, Skype, some physical sensors).
and robots) in order to execute more useful care. For example, integrating with Google Calendar provides schedule reminder service for elderly people. Integrating YouTube enables to provide the play some video or music to provide the recreation for elderly people.

Figure 3 shows a whole sequence of providing personalized care for elderly “Tokunaga.” At first, the VCP gets personal information with API getElderlyInfo(). Then VCP generates concrete care with GreetCare using personalized(). The GreetCare is the skeleton logic which aims to greet for a user. After creating care, the

VCP offers the care to VCG with invokeCare() with given concrete care information. Finally, the VCG executes cares “greetCareForTokunaga” which aims to greet for the user. In the following section, we explain each component in detail.

**Personal Information**

We have to consider what information should be collected in order to actualize the personalized care. The following list shows the data to provide the personalized care in our proposed architecture such as name, nickname, birthday, sex, address, contact member, family member, hobby, favorite movie, and favorite song.

Using the above personal information, the system could provide the personalized care. For example, using the user’s name, the system can greet with his/her name. In another example, the VCG could play music based on user’s favorite song which is expected to improve the care. For example, user “Tokunaga” who likes Japanese traditional song “Enka”, then the VA should play the music “Enka” based on the user’s preference. The physicality challenged personality seems important to provide care. Because if the user has some physical difficulty (e.g., hard of hearing, aged eyes), the VCG should behave in order to meet the personality needs. For example, if the user “Tokunaga” has hard of hearing, then the VA should speak loudly and play some video with high volume. In another instance, if the user “Nakamura” has aged eye, then the VCG should display the contents bigger so as to confirm clearly. We assume that the caregivers or family would register the above personal information.

**VirtualCareGiver**

VirtualCareGiver (VCG) is a care robot that provides the actual care for a user at home. Figure 4 shows the interface of VirtualCareGiver which we have developed. The left of Figure 4 represents the

![Sequence of GreetingCare](image)
VirtualAgent which performs motions (e.g. smile, bow, shaking hands) to act like human beings. The right of Figure 4 is called MAClient that displays some useful information (e.g. checklist, sentence, and video) for elderly people. Using the different screen VA and MAClient, VCG can display some messages on screen and say something using text to speech technology.

VCG executes cares by VCP. We also design that the VCG has Web-APIs which aims to integrate with another system such as smart home, a physical sensor with HTTP protocol (see the left of Figure 2). The offered care tasks are defined in CareTemplate. Also, the VCG has setAnswer() and getAnswer() APIs which enables to interact with users. Using these APIs would provide an interaction between elderly people and the VCG. For example, the VCG generates a question using displayCheckList([“yes”, “no”], “normal”), then the VCG returns some questionId (e.g. 1234) which identifies each question as following API lists. Then, the user answered “yes” for the id: 1234. After that we can obtain the users’ answer through the getAnswer(). In addition to this, we design the APIs have a feature to meet the needs of individual elderly. For example, if a user has hard of hearing, then we assume VCG says sentence loudly or plays music with high volume. Specifically, the † represents the voice parameter which the API can control, †† is a font parameter which controls the font size which displays on the screen. Hence, using these parameters efficiently, we achieve the personalization in order to meet the user’s physical needs. Moreover, we design to integrate other web interfaces such as Skype, Google Calendar, YouTube and so on. The integration enables to provide more practical cares for an elderly people.

- **getAnswer(questionId)**: Obtain an answer from a specific questionId. The questionId identifies each question which the VCG issues.
- **setAnswer(questionId)**: Set an answer for a specific question which belongs to questionId
- **playVideo(videoId, †volume)**: Play the video with given videoId and volume. The volume parameter controls the sound volume in order to adapt to the individual.
- **displaySentence(sentence, ††fontSize)**: Display sentence on the screen. The API could control the font size in order to meet elderly people’s needs.
- **displayCheckList(list, ††fontSize)**: Display list with given list and font size, whose parameters are same with displaySentence()
- **doMotion(motion)**: Behaves some motions (greeting, bye, bowing and so on)
- **say(sentence, †voiceLevel, †voiceSpeed)**: VCG says some sentence with given sentence.
The API could control the both size and speed of voice using `voiceLevel` and `voiceSpeed`.

**CareTemplate**

CareTemplate is a skeleton of care program that defines what should be executed by the virtual agent. CareTemplate consists of combination of simple VCG’s APIs (greeting(), say(), doMotion()). In addition to this, the skeleton variable is converted with personal information. For example, `#{elderly.name}` is expected to be replaced with elderly’s name. In addition to this, the care template is managed on the cloud. Hence caregivers could update and create care tasks to adapt for an elderly people. We suppose that CareTemplate is shared among caregivers who uses the proposed system. Above design enables to start for the new user with less cost. In the following, we specifically show the three examples of CareTemplate as follows (see Figure 5, 6).

- `greet()`: Greeting with his/her name
- `playMusic()`: Playing his/her favorite song

Developers are able to develop the care efficiently using CareTemplate. Users also have the merit that if the care which user wants has already registered, the user can quickly start the care service using the given CareTemplate.

Figure 5 shows `greet()` which is a kind of logic of CareTemplate. The `greet()` aims to provide greeting instead of human caregivers. The `#{}` represents the template which is replaced with personal information. In this case, `elderly.name` is converted into the name of elderly people. Let us consider an example, a user “Tokunaga” who is a man whose age is 70 years old. Then, the `#{elderly.name}` is expected to be converted as “Tokunaga” with personal information. Finally, the logic of `say()` invokes with sentence “Good morning Tokunaga.” Hence, the `greet()` logic is able to adapt individual elderly people only have to set the personal information. Figure 6 is a `playMusic()` is also CareTemplate which aims to plays music. The `playMusic()` plays his/her favorite music which also adapts the individual needs. For example, a user who likes folk song. If the `playMusic()` is personalized for the user, then the API plays folk song based on the user’s preference.

**VirtualCarePersonalizer**

The VirtualCarePersonalizer (VCP) is a component which generates and adapts personalization the cares on the cloud. VCP’s main work is to convert template partition into personal information.
Specifically, the VCP replaces the APIs which are appeared in the CareTemplate in order to meet individual people’s preference. For instance, let us consider the example of playMusicCare for the user “Tokunaga” whose favorite song is “Enka.” The VCP converts the APIs playMusic(#elderly. favoriteMusic) into playMusic("Enka") based on the user’s preference. Not only considering the preference of the user, also VCP converts care based on the physical difficulty of individual elderly people. For example, when the user has a hard of hearing, then the VCP control turning up the volume and delays the speed of talking that

Use Case Scenario

We describe two kinds of use case. One is called use case scenarios (greeting care, plying music care), and the other is sequence diagram whom we confirm the flow of the proposed architecture. Moreover, we also consider two kinds of persona in order to provide adapt our personalized system. One is user “Tokunaga” is a 70 years old man who has hard of hearing. Tokunaga’s favorite song is “Enka.” The other is a user “Nakamura” who is a 80s woman and she likes folk song. In the following, we confirm that the templates are changed based on his/her personal information. We assume VCP generates care based on the personal information.

Figure 7 represents the use cases of greet() where adapts individual persona users. Based on the personal information the care template greetCareForTokunaga(), greetCareForNakamura() are generated with VirtualCarePersonalizer and CareTemplate. The difference between template greetCareForTokunaga() and greetCareForNakamura() are contents of messages. This difference comes from the personal information. So, the developers are able to develop the GreetingCare which they just only use the API greet(). We also represent the examples of music care. See the template playMusic() which plays his favorite song using Youtube. The playMusic() is also personalized for the individual user both Tokunaga and Nakamura. The VCP replaces the music in order to using personal information. Hence, we can confirm that the CareTemplate is enough simple to develop for the developers, which copes P1 and P2.

EXPERIMENTAL EVALUATION

Experiment Overview

We conduct an experiment in order to confirm how elderly people feel when they receive a personalized care. We preliminary make a scenario care to interact for the subjects as the CareTemplate. The
The detail of scenario is explained in the following section. The subject has participated the experiment one at a time.

We conduct the experiment at day care center in Japan. Subjects are 11 elderly people who belong to the day care center. 2 are men and the others are women.

Figure 9 shows the experimental scene. A PC on the table which displays VCG. The system supporter sits next to the subject who supports the system trouble and explains the subjects that how to interact with VCG. The VCP, CareTemplate and personal information are deployed on the Cloud-Server.

**Experimental Procedure Steps**

We explain a procedure of the experiment where consists of 4 steps as follows.

**Step 1:** Before the experiment, we collect personal information from subjects via a questionnaire (See the left of Figure 10).

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Figure 8. Personalized Music Care (Adapted from Copyright 2009-2013 Nagoya Institute of Technology, Used with permission)

Figure 9. Experimental Scene (This picture was obtained in accordance with the guidelines of the ethical committees of Kobe University (No: 28-02))
Step 2: On the day, we deploy the experimental environment (i.e. VCP, VCG, and CareTemplate) in the day care center.

Step 3: Each subject interacts with VCG using the scenario which we preliminary developed.

Step 4: After the experiment, we also conduct an interview (See the right of Figure 10) to confirm how they feel after the Step2. The questionnaire has four scores where the 4 is the highest score and 1 is the lowest score.

Scenario Care

The ScenarioCare where we develop for the experiment consists of four parts; greeting, confirmation of basic personal information, quiz and playing music.

The contents of ScenarioCare consists of some CareTemplate as follows.

greet(): Greets with his/her name. The VCG also introduce itself (e.g. “How are you. My name is Mei (The agent name)”).
confirmPersonalInfo(): Confirms basic personal information such as “How is your health?”, “Would you already take a medicine?”
quiz(): Quiz about his/her hobby (e.g. sports, picture, TV program, dancing).
playMusic(): Plays his/her favorite music based on his/her personal information.

Experimental Results

Figure 11 shows the result of the experiment. The average result of a score is 3.58. The highest score is 4.00 for the Q7 and the lowest score is 2.90 for Q8. We have confirmed that most subjects showed positive comments for the VCG. In questionnaire some subjects answered that “I was very surprised that the VCG played my favorite song.” Another subject said that “I was very glad both talking about my past job and listening to my favorite song.”

We have confirmed that the playing personalized music is especially useful for the subjects. And as shown the Figure 11, the score of Q7 (about font size) and Q9 (about sound) are much higher than
other results. Hence, the proposed system contributes well to the visibility and the listening. On the other hands, we also have collected some comments for improvements and requirements from subjects. “I would like to talk about my hobby in detail.” We thought this comments derived from the topics of the hobby which VCG spoken was too simple for the subjects. Another subject said that “I would like to talk about my husband who has already died. A subject said that “I got nervous because this was the first time when I talked with a robot.” The former comment represents the specific conversation topic should be personalized deeply. The latter comment shows that subject becomes nervous when he talks with the VCG because of the lack of the habituation for the robot.

We have confirmed that the score of Q10 (acceptable of agent) is also high, hence this score shows that the subjects are acceptable for the subjects. Some subjects said that “the agent looked so beautiful” and “she looked tender.” In addition to this, we also have collected the interesting comment from a subject that “I feel sad that I have to interact with a machine instead of a human in near future.” This comment reflects that the elderly people may feel loneliness talking with human caregivers instead of robots.

Discussion
We have confirmed that most subjects feel positive for the VCG. From the Q7 and Q9 which asks about the visibility of font size and whether the spoken sentence is clear or not. The result seems that the VCP’s personalization for the contents works well for the elderly people. On the other hand, the Q8 seems worse score than others. This score derives from the limitation of topic’s contents which VCG talks. VCG currently supports to ask that do you have anyone who wants to meet. Thus, the above interaction does not attract for the elderly people to talk. In order to cope the problem, the system has to learn personal information to talk with them.

We have confirmed that the when VCG asks about his/her previous work, then many subjects tend to speak about their work actively. After the questionnaire, we also have interviewed them that
how do you feel about the VCG asks you about previous work? Some subjects responded that they felt good because no one listened to their previous work. The result of Q3 (playing music) seems good for the most elderly because in the experiment we have confirmed that some subjects sang the song during the VCG plays favorite song.

However, we also have confirmed the problem that current VCG has simple topics for individual elderly people. This is because current VCG speaks the topic which strongly depends on the CareTemplate. Thus, our proposed method could only cover the preliminary questions which we have made. Hence, it is difficult to learn new topics or automatically generates conversation. Hence, sometimes the elderly people seem boring for the topic because of the duplication of the topics which VCG talk. In order to cope the problem, we have to consider some reasonable learning feature to learn the topic during a conversation.

We have also confirmed the feasibility of proposed service. Although a subject has participated as a walk-in, the proposed service could generate the personalized care based on her personal information. This result has shown the VirtualCareGiver has a potential to deploy with a reasonable way which has coped P3.

**Related Works**

In this section, we analyze and compare the difference between the existing systems and our care robot. SenseCare has proposed the semi-automatic lifelog summarization system using a smart phone (Wu, Peng, Zhu et al., 2011). Above research focus on collecting and analyzing the summarization data to improve the elderly’s life. On the other hands, our proposed method focuses on executing cares directly instead of real human caregivers. Kosugi, Nishiguchi, Izumi et al. (2016) have proposed live communication platform which aims to improve the communication for seniors. Above research has similarity with our proposed method that is consists of a plug-in framework that enables to be extended dynamically on the basis of a common interface. The above research has a different goal from ours the above research aims to improve the human to human communication. On the other hand, our research goal is to provide the VirtualCareGiver which semi-automatically works in each home in order to improve the QoL for individual elderly people.

The therapeutic seal robot “Paro” has been for the mental healthcare and mental conflict at the elderly filed (e.g. day care center, hospital). Tamura et al. (2004) have researched the pet-type robot AIBO is useful for instead of animal assisted therapy to avoid any danger or injury. Looije, Neerincx, and Cnossen (2010) have shown that the Computer-based robot agent can aid healthy behavior by persuading and guide for older elderly people. The above researches aim to improve the elderly’s daily life using pet robot, although our care robot focuses on the improving the quality of life using the agent on the PC’s screen. Hence, the difference between those researches and ours is completely different from the research scope and methods.

Mukai, Hirano, Nakashima et al. (2011) have developed RIBA-II which aims to free caregivers from such heavy physical work and to compensate for the lack of nursing care staff. Therefore, these researches have different goal from ours that focus on how to complement the elderly’s impaired body

**CONCLUSION**

In this paper, we have proposed a smart care service integration agent that provides a personalization and integration for each elderly people. Our proposed service consists of three components; CareTemplate, VirtualCareGiver (VCG) and VirtualCarePersonalizer (VCP). CareTemplate is a skeleton of care program that defines what should be executed by the virtual agent. VCG is a robot agent, where executes care tasks in each home. The VCG executes a care instead of human caregivers. VCP manages and generates personalized care in order to meet individual needs on the cloud. To demonstrate the feasibility, we have considered experimental evaluation where the subjects use the
proposed system. The result has shown that personalization for the static contents (music, font-size) have especially contributed well to adapt to the individual. Our future work is to cover the variety of personalized topics based on the individual hobby, and we also would like to conduct long-term experiment for the wide variety of elderly people.

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