Implementation and Evaluation of Interactive Memory-Aid Agent Service for People with Dementia

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Abstract. In recent years, a number of reminder systems have been developed to help elderly people with dementia. However, the existing reminder systems lack the sympathetic human-machine interaction.

In this paper, we propose a new reminder service which aims to assist elderly people with dementia using Human Computer Interaction technology. Proposed agent service consists of four components called CareModule, Virtual Agent user interface (VA), ControllService and Memory Aid Client (MAClient). VA is a promising technology for people with dementia since it can assist a patient based on less-mechanical and (simulated) human-to-human conversation. CareModule is consists of functions that provides the generating the user interface and operation for the VA. The ControllService manages the state of transition and that enables to provide the loosely coupled component among the agent services. Memory-Aid Client (MAClient) visualizes reminder information in a screen, and which provides graphical user interface (e.g., button, list, etc.) to collect responses from a user.

In order to evaluate the feasibility and usability of the proposed agent service, we also conduct the experiment evaluation with actual subjects. Based on the experiment evaluation, we also show the validity of proposed agent service.

1 Introduction

Dementia is a general term to describe a group of symptoms that impairment human memory, communication, and thinking. According to a report in 2015 [6], 46.8 million people are now suffering from dementia in all over the world.

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Thus, the *home care* for people with dementia becomes more essential, in order to assure the quality of life of the patient. However, sometimes the home care could be a burden to the family or caregivers in a specific context [1].

Moreover, the number of a nursing home is not sufficient for the number of applicants. The labor shortage for the caregivers has occurred based on the social background [9]. Nowadays, some systems have the potential to cover the subset of tasks which caregivers have, in order to complement the lack of human resources [8]. However, to take a proper care of dignity, there are strong needs the Human Computer Interaction (HCI) technology. Because, the mechanical reactions would sometimes impair the dignity of the patient, and decrease the motivation to use the system. If the system could cover the subset of tasks, then the caregivers could focus entirely on making one's own unique contribution.

In this paper, we propose an agent service that provides the voice dialogue and graphical user interface. Our proposed agent service consists of four components called CareModule, Virtual Agent user interface (VA), ControllService and Memory Aid Client(MAClient). VA is a promising technology for people with dementia since it can assist a patient based on less-mechanical and (simulated) human-to-human conversation. CareModule is consists of functions that provides the generating the user interface and operation for the VA. The ControllService provides the loosely coupled component among the agent services. Memory-Aid Client (MAClient) visualizes reminder information in a screen, and provides graphical user interface (e.g., button, list, etc.) to collect responses from a user. VA is a promising technology for people with dementia since it can assist a patient based on less-mechanical and (simulated) human-to-human conversation.

We also implement the agent service based on the proposed architecture. In order to show the validity and feasibility of proposed service, we also conduct the experimental evaluation with actual subjects. The result shows that the both voice dialog with VA and display on the screen (e.g. checklist, images of belongings) are useful for the patients.

2 Preliminary

2.1 Memory Impairment and Memory Aid

The progression of dementia usually begins with mild anterograde amnesia and often involves a variety of behavioral disturbances such as wandering and agitation [2]. People with dementia typically have the following symptoms:

- A decline in memory to an extent that it interferes with everyday activities, or makes an independent living either difficult or impossible.
- A decline in thinking, planning and organizing day-to-day things.
- Initially, preserved awareness of the environment, including orientation in space and time.

To maintain the quality of life of the people with dementia, the care by caregivers or families would become more important. In reality, however, the care is often

a burden because of specific features of dementia, including BPSD (behavioral and psychological symptoms of dementia), aggressiveness, wandering, and sleep disturbance [7]. Indeed, it is not easy for general families to always delegate professional caregivers. Hence, there are many cases observed where the families have been *burned out* by the home care.

For this situation, the *assistive technology* is one of the promising solutions, where technologies are introduced to assist the people with dementia and surrounding people.

2.2 Virtual Agent System

The *virtual agent* (VA) is a human-looking animated chatbot program that can communicate with a human user via voice [5]. There are a few studies that adopt the VA for dementia care. Yasuda et al. developed a system where a VA serves as a conversation partner of people with dementia [10].

Our research group has developed a system which exploits a VA as the user interface of the home network system (HNS) [4]. In order to integrate other systems, VA has developed as the Web interface such as say(), smile(), and so on. Hence, the developer could effectively invoke and integrate with other systems. For instance, when some HTTP client invokes http://xxx/agent?say="How are you?", then the VA says "How are you" with text-to-speech technology. Also, VA has the feature of voice recognition to understand what the patients say. Hence, the patient could interact with using voice dialogue. So, we extensively reuse it for the dementia care. The developed VA is internally defined as a finite state machine. The actions include say(), motion(), recognize(), execWebService(). The detailed information can be seen in [4]. VA is a promising technology for people with dementia since it can assist a patient based on less-mechanical and (simulated) human-to-human conversation.

2.3 Goal and Scope of Paper

In this paper, we propose an agent service that provides the voice dialogue and graphical user interface. To achieve the above goal, we try to develop a new agent service that has the potential to provide the heartwarming and intuitive interface. Our proposed agent service consists of four components called CareModule, Virtual Agent user interface (VA), ControllService and Memory Aid Client(MAClient). VA is a promising technology for people with dementia since it can assist a patient based on less-mechanical and (simulated) human-to-human conversation. CareModule is consists of functions that provides the generating the user interface and operation for the VA. ControllService provides the loosely coupled component among the agent services. Memory-Aid Client (MAClient) visualizes reminder information in a screen, and provides graphical user interface (e.g., button, list, etc.) to collect responses from a user.

We also conduct the experimental evaluation in order to confirm that the people with dementia could interact with proposed agent service.

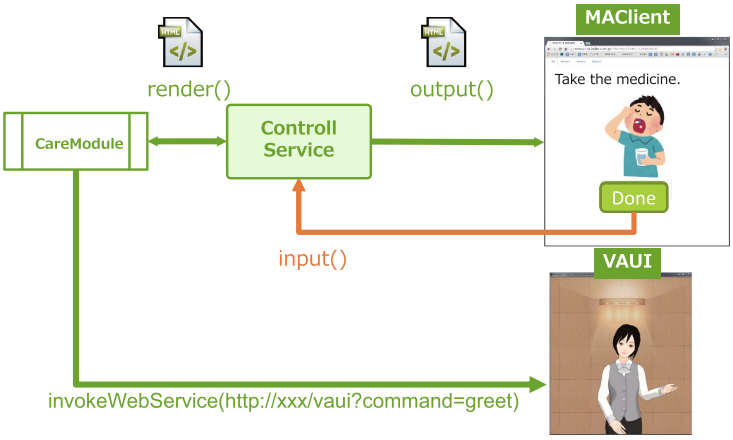

Fig. 1. System overview of agent service

3 Agent Service

3.1 System Architecture

Figure 1 shows the system architecture of agent service. The left of the figure represents CareModule which has the sequence of program execution. In addition to this, CareModule generates HTML data that is rendered on the graphical interface for the patients. We design the CareModule as the tiny program, hence that would apply for the various scenes to care. In order to apply for the various secens to care, we separate CareModule as the tiny program (e.g. greeting cgi, care cgi). The upper center of the Fig. 1 shows the ControllService service which provides the control data transfer between the graphical interface and CareModule. The right of the figure shows the Memory Aid Client (called MAClient) which is the useful interface for the patients. The bottom right of the Fig. 1 represents VA we explained in Sect. 2.2. The MAClient is supposed to be displayed on a touch interface, so that the patient can intuitively interact with the agent service. Moreover, the MAClient can display the images or movies that are quite helpful for the reminder. The MAClient exposes two kinds of API: `input()` and `output()`. The `input()` API displays input GUI components (e.g., list, button, etc.), with which the user can input commands to Agent Service. The `output()` API displays output GUI components (e.g., text, label, etc.)

The developer could develop the system efficiently because the ControllService provides the independence on each system.

MAClient visualizes reminder information in a screen and provides graphical user interface (e.g., button, list, etc.) to collect responses from a user. The MAClient is supposed to be displayed on a touch interface, so that the patient can intuitively interact with the agent service. Moreover, the MAClient can display

the images or movies that are quite helpful for the reminder. When the ControllService. Integrating VA and MAClient, Agent Service provides API that can execute some care using the virtual agent with visualized information. Figure 2 shows the sequence diagram that is the sequence of the agent service. In the following, we show an example of sequence diagram that represents how to remind the patients of taking the medicine with proposed architecture. At first, we have preliminary set the functions to provide the care for the people with dementia. The CareModule invokes the WebAPI which is belongs to the VA. After the invocation of WebAPI, then the VA says the message that "Please take a medicine" (Fig. 3).

Also CareModule generates the HTML to display the button and appropriate message. Then CareModule gives the ControllService service to display the generated HTML. In addition to this, CareModule invokes the render() method to display something. Finally, the MAClient displays the HTML to interact with the patient based on the commands from ControllService.

3.2 Implementation

We implemented the ControllService and agent service as the RESTful Web service. Hence, the developer could develop the software integrated with another web service or system and our proposed service. For example, the ControllService has the above web interface to interact with another system. These WebAPIs enable developers to integrate and manage the UI. Integrating with agent service, the ControllService service could be integrated using render(). The render() methods consumes the HTML format and directly commands to output for the MAClient. The agent service has provided the simple invocation interface such as render() and VA also has each method to behave. We have implemented the proposed service as the following environment.

CareModule Ruby: 2.3.0p0
ControllService Java, Apache Tomcat: 7.0.65, Jersey
VA Java, Apache Tomcat: 7.0.65, Apache Axis2: 1.6.2
MAClient Bootstrap: v3.2.0, jQuery: 2.1.1

4 Evaluation of Agent Service

4.1 Abstract of Evaluation

In this section, we explain the experiment evaluation in order to confirm the system feasibility and usability. We have conducted the experiment at Chiba Rosai Hospital. The goal of the evaluation is to confirm that the patients could interact with the agent service using some interactions (e.g. voice, touch). Especially, we have confirmed the interaction and reactions after the patient used the agent service. Moreover, we show the validity of the possibilities of the adoption of with considering the result of each interface. Seventeen patients participated in the experiment. The age range among the subjects is from forty-six to eighty-four. In the experiment five men were participated and the others were women. And the average score of MMSE [3] among participants is 22.9.

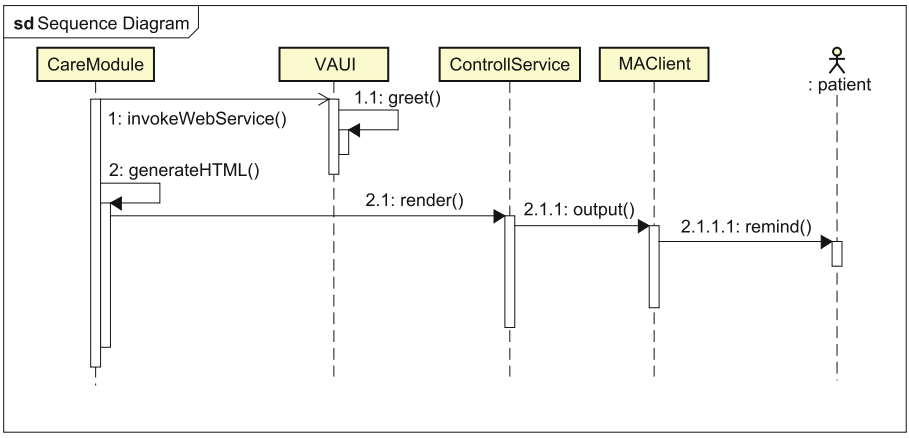

Fig. 2. Sequence diagram of agent service

4.2 Experimental Environment

In the experiment, we have conducted the experiment with five people team. The breakdown of the member is a patient, a caregiver, a recorder, an adjuvant and a system administrator. Figure 4 shows the experimental scene. We deployed the agent service to the Surface Pro 3 which touch panel and a built-in mic. The tablet has connected to the system administrator's device using Wireless LAN. The system administrator controls the agent service and he controls that the operation agent service has started. The subjects interact with agent service in front of the tablet. Among the interaction, the observer conducts the help for the operation and instruction of the subjects. The recorder records the each experimental scene with a video camera.

4.3 Experiment Description

We have explained the feature of agent service, that provides 4 components for the VA and MAClient. Using agent service, we expect the subjects would be feel useful for the people with dementia. However, we have not confirmed that the people with dementia could interact with agent service. In order to validate the evidence, we conduct the experimental evaluation. In the experiment, we focus on the following five points to confirm the feasibility and usability of agent service for patients.

Q1: Can the subjects listen to the speech of what the VA say?
Q1 aims to evaluate that the both voice volume and quality have the feasibility to dialogue for the subjects. In particular, we confirm that the subjects can listen to the speech what the agent says.

Q2: Can the VA system recognize what the subject says? This question aims to validate that the VA system could recognize the speech what the subjects

Fig. 3. User interface of agent service

say. We have judged that the voice recognize system have the feasibility for the what the dementia says.

Q3: Does the interface of agent service have an appropriate design? Q3 aims to judge that the agent service has the appropriate design to display the contents to remind (e.g. display his/her schedules, belongings).

Q4: Can the subjects control the MAClient using touch panel? Q4 aims to confirm that the subjects could control the MAClient using touch screen.

Q5: Does the contents of MAClient have effectiveness for the memory aids? Q5 aims that verify whether the contents of MAClient helps to understand what the agent says and input assistance. Concretely speaking, the MAClient displays the contents which are expected to remind for the subjects (such as Registration Cards, house key). And we have records that showing above items with image would have effective to understand for the subjects.

4.4 Settings of Experiment

The subjects has conducted the interaction with dementia agent based on the some scenario. In the following, we show the concretely scenario that we have conduced. These scenarios are aimed to verify from the Q1 to Q5.

Preliminary scenario This scenario aims to evaluate Q1 and Q2 through the simple dialogue with agent. We confirm that the subjects could have a voice dialogue with agent after the dialogue.

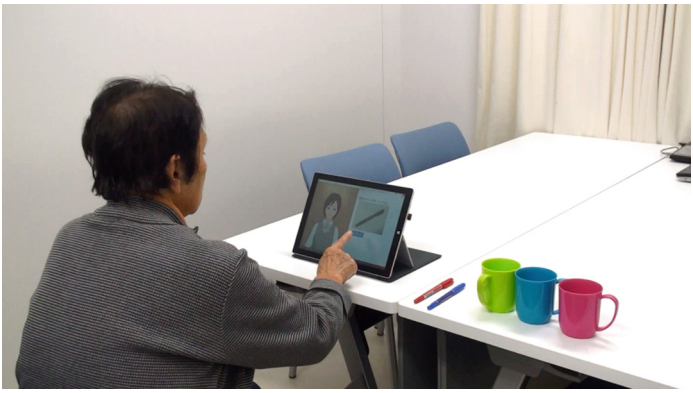

Fig. 4. Scene of experiment

Screen Touch scenario This scenario aims to evaluate that Q3 and Q4 using simple interaction with the agent. After the subjects have dialogue with touch screen of MAClient, we confirm that the subjects could recognize and touch the button.

Check belongings scenario This scenario aims to evaluate the Q5 that has evaluated as the interaction with check list. We suppose this scenario is to confirm the following scene that the subjects go out, then the MAClient displays his/her belongings based on the destination.
(a) represents the checkbox that the user have to have.

Understanding instruction scenario
This scenario aims to evaluate the Q5 that shows the instruction. Specifically, we confirm that whether showing some images on the screen of MAClient was helpful to understand the instruction of what the agent says. In the experiment, we have subjects moves cup or pen with instruction of agent. And then we have compared the case that displays images on the screen or not.

Moreover we have collected the questionnaire from his/her caregiver who has observed the experiment. And we have scored the each evaluation item.

- Q.1 Could the subject recognize the agent? Can he/her talk to the agent?
- Q.2 Could the subject could control the MAClient with a touch screen?
- Q.3 Could the subject understand what the agent says?
- Q.4 Could the subject understand the instruction of agent?
- Q.5 Could the subject offer a response to the instruction of agent?

4.5 Result of Experiment and Discussion

All the subjects[1] have completed the scenario which we have given.

[1] We have supported some subjects when they could not recognize the instruction of agent.

Table 1. Result of experiment

No	Sex	Age	MMSE	Q.1	Q.2	Q.3	Q.4	Q.5
1	F	79	20	5	5	5	3	5
2	F	83	16	2	3	3	3	3
3	F	81	25	3	5	5	5	5
4	F	79	16	3	1	2	2	3
5	F	80	25	4	4	5	4	4
6	F	84	27	3	4	4	4	4
7	M	68	29	4	4	5	4	4
8	F	77	26	3	5	5	5	4
9	M	83	26	3	3	3	3	3
10	F	71	24	4	4	5	4	4
11	F	80	15	5	3	5	4	5
12	F	71	24	5	3	5	4	4
13	M	80	16	4	3	4	4	3
14	M	60	25	3	4	5	5	4
15	M	46	27	4	4	5	5	5
16	F	78	29	3	3	3	2	3
17	F	75	19	3	3	3	3	3

Table 1 shows the experiment result. The head of table Q.x corresponds to the above evaluation items. We also figure the coefficient of correlation for the each result of the score. In this experiment, we use Spearman rank correlation because we could not assumption that the result of scores would follow a normal distribution Table 2. * and ** represent the significant level, hence * is the 5 % significant level.

Table 2. Result of experiment: spearman rank correlation matrix

	Age	MMSE	Q.1	Q.2	Q.3	Q.4
MMSE	−0.29					
Q1	−0.32	−0.07				
Q2	−0.22	0.39	0.25			
Q3	−0.42	0.19	0.62**	0.79**		
Q4	−0.43	0.29	0.22	0.66**	0.79**	
Q5	−0.21	0.12	0.56*	0.73**	0.85**	0.60*

Result of Q1: We have some receive the feedback that the speed of speaking is fast. The Table 2 shows that the result of Q.3 is about 4.2 point. We

have concluded that the most subjects understand what the agent says. We have thought that this result comes from MAClient performs complementary when the subjects missing what the agent says. The Table 2 shows that correlation of Q.3 and MMSE is 0.19. Next, we have found that there is almost no correlation between understanding of dialogue with Agent and MMSE. This is because the understanding of dialogue relates on the individual body condition, that means some subjects have a weak hearing. Hence, we have to adjust the agent's voice based on the individual body condition.

Result of Q2: All of the subjects could recognize the agent and they could dialogue with agent during the experiment. However, voice recognition system can recognize some subjects speech input voice only. Also, the voice recognize system could not recognize the voice input on the first time. The system could recognize the voice input when the subjects speak twice or more. After the preliminary scenario, subjects alternatively used touch interface as the dialogue interface. Although they speak of the system when the fail of recognition causes no response, they look uneasy. The main reason for the low accuracy of recognition is that a built-in microphone could not pick up the subject's voice. To improve the accuracy of voice recognition, we have to use the directional microphone instead of the built-in microphone.

Result of Q3: All the subjects could recognize the message and button on the screen of agent service. But we gathered feedback from some subjects that they felt the contents on the screen were small. We think that above problems are capable of being coped with resizing the contents on the screen. We also have to adopt the personalized contents size on the screen for the individual. Some subjects could not recognize the button on the screen, and they tend to look for the out of the screen. This is because they are unfamiliar with software button on the screen. Hence, we would like to design the button so as to look like the actual physical button. Moreover, we gathered the comments from a caregiver that if the button has a sound effect, then it would feel better.

Result of Q4: The Table 1, Q2 represents the major of subjects have a lot of trouble to push the button on the screen. Sometimes they push the button too strong, That causes the fail to recognize as the touch event on the device. But most subjects could become familiar with touch sense during the experiment. So they could touch the button on the screen to dialogue with the agent. Table 2 shows that the correlation coefficient between Q.2 and MMSE is 0.39. Above result shows that we could not indicate a significant correlation between them. In addition to this, some subjects who usually use smartphone touched the button on the screen without difficulty. Hence, we have confirmed that whether the subjects could use the contents on the screen strongly depends on that they are familiar with smartphone or tablet.

Result of Q5: We have confirmed that showing the images of objects are effect to the instruction of agent. Concretely speaking, in one case the agent instruct subjects to move the objects with showing the pictures. And another case, the agent instruct subjects to move the objects without showing the pictures. As the result of the experiment, we have confirmed that the almost sub-

jects could move the object accurately. One subject fails to move the object because he becomes distracted by VA. He moves objects without making sure of what it is. In order to prevent the above case, the VA have to behave so as to point to guide the target of the picture on the screen. Moreover, we have confirmed that three subjects look being baffled that the agent only instructs without showing pictures of objects. We also gathered the comments that instruction with the pictures felt easy to understand than without pictures. Based on the results, we have concluded that the instruction with images are useful to understand for the subjects. Next we also have conducted the showing checking list scenario that assumes the subjects go out. In this scenario, the subjects could understand the experiment situation, but they could not touch the checking list. This result comes from two reasons one is the lack of instruction of agent and another reason is unfamiliar with UI for the subjects. The lack of instruction represents that the agent only says "please confirm the belongings", hence, the subjects could not know what to do next. So to cope the above problem, the agent behave to say "please confirm the belongings and also check the buttons". The latter means that the subjects are not familiar with general Web UI checklist. To cope the problem, we have to design the UI so as to understand easily for the subjects.

5 Conclusion

In this paper, we have implemented and evaluated the agent service that provides the heartwarming and careful user interface. We also show the feasibility of the agent service based on the experimental evaluation. Proposed agent service consists of the Virtual agent that provides the rich interface and MAClient provides the flexible interface to display the information to remember. Moreover, we have conducted the evaluation to valid the feasibility of proposed service. The experiment result shows that the VA speaking with voice, touch interaction, and display of captions and images are valid for the people with dementia. Our future work is to improve voice recognition accuracy and to improve the interface based on the questionnaire. Moreover, we have to conduct the long-term evaluation to confirm that the proposed agent service is valid to remind.

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