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Social Media Intermediation Robot for Elderly People using External Cloud-based Services

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***Abstract*— Most of the existing elderly people watching services are belonging to the service category of a confirmation of elderly people's safety based on one-way communication from elderly people. Therefore, we propose a Social Media Intermediation Robot used for the interactive communication between elderly people and younger generation via existing social media. This robot system has been implemented on a single board computer embedded in a human-type robot, which is equipped with a microphone, camera, speaker, sensors, and network access function, so that elderly people can retrieve and transmit information by voice via social media without using smart phones. We made clear a human interaction-type user interface, which enables elderly people to have communication just like talking with a receptionist. We also designed the Social Media Intermediation Robot based on the service-oriented architecture that enables us easily to use open innovation like external cloud-based services. We developed the prototype system. Then, we confirmed the effectiveness of the prototype system in the viewpoints of user interface and system availability from the perspective of the total system performance including external cloud-based services.**

***Keywords*— Social media; Elderly people watching services; MVC; Service-oriented architecture; User interface**

I. INTRODUCTION

Current state and trends on the elderly and their environment in Japan is really serious. According to Annual Report on the Aging Society (2014) issued by Cabinet Office [1], the number of households with elderly people aged 65 and over is increasing. As of 2012, the number was 20.93 million, making up 43.4% of all households (48.17 million). The number of elderly people living alone is on the rise. The increase in elderly people living alone is remarkable among both males and females. The percentage of elderly people living alone against the total population of elderly people was 4.3% for males and 11.2% for females in 1980. However, in 2010, these numbers were 11.1% for males and 20.3% for females.

According to this current situation, elderly people watching system has become important. However, most of the existing elderly people watching services are belonging to the service category of a confirmation of elderly people's safety based on one-way communication from elderly people [2][3][4]. Therefore, current services are not enough for elderly people who want to have more tight connection with society. On the other hand, social media like Twitter has already become popular. However, people need to use smart devices like smart phones efficiently to access social media. This matter might be obstacles for elderly people to use social media.

Therefore, we propose a Social Media Intermediation Robot which can be used for the interactive communication between elderly people and younger generation via existing social media like Twitter or Google Calendar [5][6]. We implemented this proposed system on a single board computer embedded in a human-type robot, which is equipped with a microphone, camera, speaker, sensors and network access function. Elderly people can retrieve and transmit information by voice via social media only by simple finger operation like touching a part of the robot body. At the younger generation side, they can communicate with elderly people at any time through their accustomed social media using smart phones without special manner.

In order to realize this use case, we made clear a human interaction-type user interface including a state transition definition that defines the interaction between elderly people and a robot. These features enable elderly people to have communication just like talking with a receptionist. We also designed the Social Media Intermediation Robot based on the service-oriented architecture that enables us easily to use open innovation like external cloud-based services. For example, we used Twitter and YouTube, and Google Calendar as social media of external cloud-based services. We also used Google Cloud Speech API as voice recognition of external cloud-based services. We could expect that this feature allows us to provide the new communication system quickly at low cost.

We developed the prototype system. Then, we evaluated the user operation simplicity in the viewpoint of user interface and the system availability from the perspective of the total system performance including external cloud-based services. In order to evaluate the user operation simplicity, we asked 5 examinees who are from 65 to 86 years old to use the prototype system at a hospital private room in Nagasaki. Through these experiments, we confirmed the effectiveness of the proposed robot system in the viewpoints of user interface and system availability.

We show related work in section II. In section III and IV, we explain the Social Media Intermediation Robot in detail such as use case, user interface, system architecture, system

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configuration, and prototype system. We show evaluation results and discussion in section V. Then, we show conclusion in section VI.

II. Related Work

Recently, we can see many elderly people watching services or systems. We could extract 32 relating services or systems through Web search investigating among Japanese internal commercial services and international research systems. We show the research results in terms of the relationship between elderly people and watchers in Fig.1. For example, Zojirushi I-Pot [7] that is a water heater can send an e-mail message to relatives when a single-living old man turns on the I-Pot in the morning. In this service, the relationship between elderly people and watchers is one-to-one. The information sending direction is one-way that is from elderly people to watchers. We found out that one-way communication like Zojirushi I-Pot was 26 of 32 (81%). This means that existing relating services are focusing on a confirmation of elderly people's safety. Murase proposed distance communication environment using activities in daily life like a setting action of an alarm clock as a trigger [8]. This research has involved in the category of interactive and many-to-many communication. However, he implemented this proposed system as an original communication application. Therefore, in order to use this system, watchers need to install the original application and learn how to use it.

We also show the research results concerning to implementation methods for elderly people watching system in Fig.2. Using social media as an implementation method was only 5%. AWARE–Ageing Workforce towards an Active Retirement [9] is the social media for retired people to keep in touch with younger generation. This is using the original social media platform, so that younger generation cannot communicate with elderly people by using accustomed social media like Twitter or Facebook. Concerning to the implementation device, there is no relevant work based on a single board computer. We are focusing on the interactive communication between elderly people and younger generation via existing social media through the robot system implemented based on a single board computer embedded in a human- type robot. In a viewpoint of purpose and implementation method, our approach is completely different from the related work.

On the other hand, there are some communication robot studies for elderly people. Inoue proposed communication robots for elderly people and their families to support their daily lives [10]. He tried to analyze how families living with seniors feel about using the human-type communication robot. Sasama reported an experiment for motivating elderly people with robot-guided interaction [11]. He built a framework for encouraging elderly people to participate in more activities by providing local news. Kanoh executed examination of practicability of communication robot-assisted activity program for elderly people [12]. He has developed a Robot Assisted Activity (RAA) program for recreational use in health care facilities for elderly people. These relating studies are focusing on encouraging elderly people to have more communication with closed people, so that remote

Target / Direction	One-to-one	One-to-many	Many-to-one	Many-to-many
One-way [Elderly people ↓ Watchers]	16	9	0	1
Interactive way [Elderly people ↕ Watchers]	3	2	0	1

Fig. 1. Relationship between elderly people and watchers (number of relevant work)

Method / Device	Original	Phone	E-mail	Web	SNS
Original devices (robot, sensor)	6	4	0	5	1
Smart Phones	3	1	1	6	1
Consumer devices	1	3	3	2	0
Single board computers	0	0	0	0	0

Fig. 2. Relationship between elderly people and watchers (number of relevant work, double count allowed)

communication functionality is not enough. We are focusing on the remote communication using social media. This point is the different point.

We have also voice operation robots such as Amazon Echo [13], Google Home [14], and Pepper [15]. They are the robots with the artificial intelligence, so that people can operate them by voice to search information or control house appliances. However, we cannot communicate with the other persons via social media by using them. The different point is that our proposed robot enables us to communicate with the other persons via social media.

III. Use Case and User Interface

A. Use Case

Fig. 3 shows the use case of the Social Media Intermediation Robot. After setting the Social Media Intermediation Robot at an elderly person's house, for example, a local care manager can inform an elderly person about a visiting schedule by voice just after inputting a visiting schedule into Google Calendar as her usual work like "We will get there at three o'clock". The reply from the elderly person can be done just by talking in front of the Social Media Intermediation Robot like "Yes, I am waiting". Text information through voice recognition and video information via YouTube will be contributed to Twitter automatically. A local care manager can confirm the reply from an elderly person via her smart phone during her spare time.

In the same way, relatives can send elderly people messages by voice via Twitter on their smart phones. The reply from elderly people can be done just by talking in front of the proposed robot system. Text information through voice recognition and video information via YouTube will be

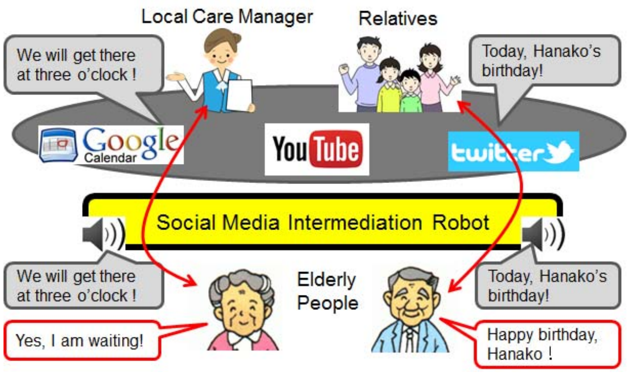


Fig. 3. Use case of Social Media Intermediation Robot

Fig. 4. Rapiro external appearance

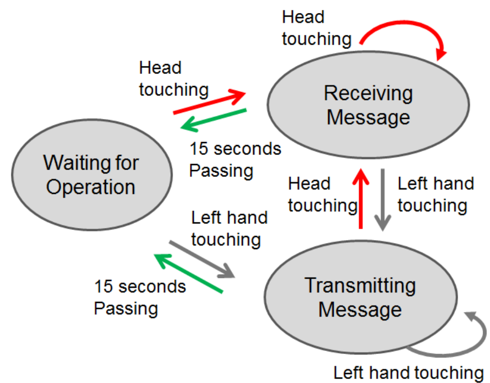


Fig. 5. State transition diagram of Social Media Intermediation Robot

contributed to Twitter automatically. Relatives can see the reply from elderly people via their smart phones at any time.

Using the Social Media Intermediation Robot, elderly people can communicate with younger generation interactively via social media using neither smart phones nor personal computers. Younger generation can also communicate with elderly people interactively using their accustomed social media and smart phones during their spare time.

B. Human Interaction-type User Interface

We need to design a friendly user interface for elderly people, so that we designed a human interaction-type user interface just like talking with a receptionist. The important points based on this concept are listed in the below.

- Realizing a human-type robot that could give friendliness to elderly people.
- Finding a person to execute first action that could announce utilization to elderly people.
- Offering the operation of the system leadership that could avoid elderly people to know how to use the robot system.

In terms of the first point, we selected Rapiro (Fig. 4)) as a human-type robot which could have a single board computer like Raspberry Pi. Raspberry Pi is a hobby robot kit, so that we could customize it easily such as adding new sensors or programing robot motion using servo motors in it. This feature allows us to give friendliness to elderly people. Regarding the second point, we introduced a face recognition algorism to find a person in front of the robot. We used Open Source Computer Vision Library (OpenCV). When the robot recognizes a person, the robot starts to speak a robot utilization explanation. In terms of the third point, we offered the operation of the system leadership based on a state transition diagram we defined (Fig.5). We defined three states that are the operation waiting state (Waiting for Operation), the message receiving sate (Receiving Message) and the message transmitting state (Transmitting Message). We defined the transactions among states such as touching the sensor attached on the head of the robot (Head touching), touching the sensor attached on the left hand of the robot (Left hand touching), and letting the robot alone more than 15 seconds (15 seconds passing) described in Fig.5.

IV. Social Media Intermediation Robot

A. System Architecture

We designed the Social Media Intermediation Robot based on the service-oriented architecture. Fig.6 shows the Social Media Intermediation Robot architecture. The main feature is that this architecture is according to MVC (Model View Controller) model composed of three parts that are a user interface part (View), control part (Controller), and application interface part (Model). The user interface part as View covers information input/output functions between elderly people and the Social Media Intermediation Robot described in section III.B. The control part as Controller handles main functions that are information receiving and transmitting. The application interface part as Model contributes to access social media and voice recognition as external cloud-based services directly. Thanks to this architecture, external cloud-based service using is very easy because it is OK for us to modify only the application interface part. User interface device adapting is also

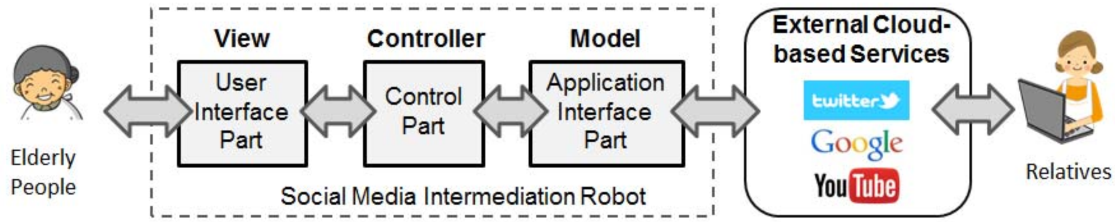


Fig. 6. Social Media Intermediation Robot architecture

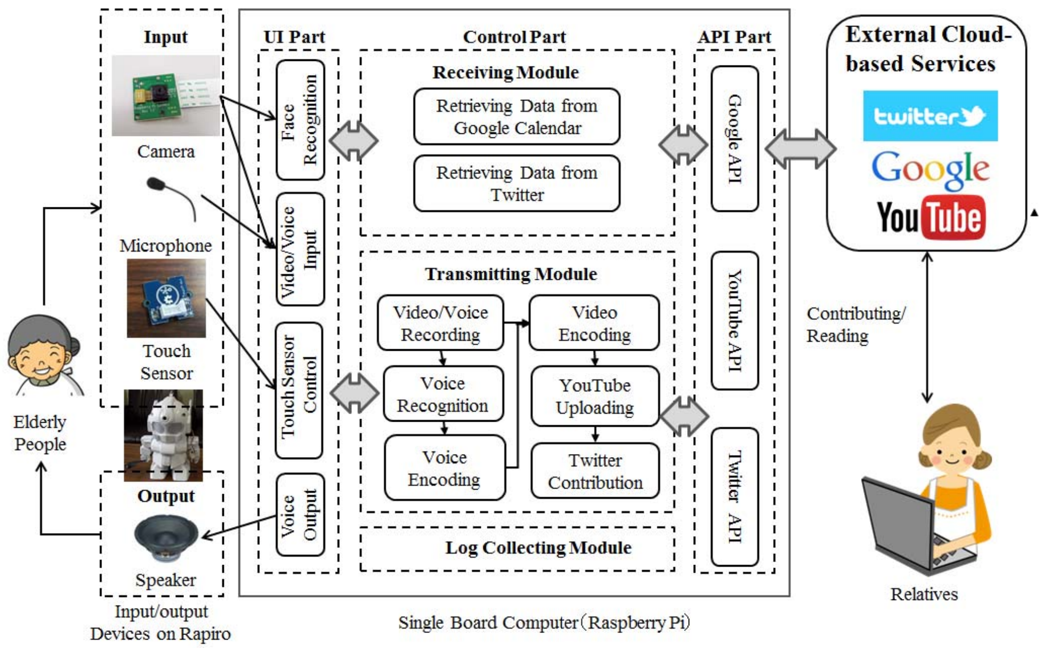


Fig. 7. Social Media Intermediation Robot configuration

easy because it is OK for us to modify only the user interface part. We could expect that these features allow us to provide the new communication system quickly at low cost.

We implemented this robot system on a single board computer, Raspberry Pi. Raspberry Pi is equipped with ARM processor, which has almost same performance of Smartphones. We show the proposed robot system configuration according to the system architecture implemented on Raspberry Pi in Fig. 7.

B. System Configuration: User Interface Part (UI Part)

This part has four functionalities, such as Face Recognition, Video\Voice Input, Touch Sensor Control, and Voice Output. Face Recognition is sensing a face image coming from Video\Voice Input which makes it possible to get an image and voice from elderly people through a camera and a microphone equipped with Rapiro. When this function senses a human face, Rapiro starts to speak how to use this robot system through Voice Output. Voice Output has been implemented using AquesTalk Pi [16] to read aloud not only the robot system usage instruction, but also Goggle Calendar or Twitter. AquesTalk is the special software for Raspberry Pi, so that it is lightweight and high performance software. Touch sensor control checks whether a person touched Rapiro (head or left hand). All these functionalities will be controlled according to the state transition diagram (Fig. 5). This part has been separated with the other parts, so that if new input/output devices would be attached to this robot system, the affected part would be limited only to this UI part.

C. System Configuration: Control Part:

This part has three modules, Receiving Module, Transmitting Module, and Log Collecting Module. Receiving Module is for retrieving data from Google Calendar and Twitter. We show the Receiving Module sequence chart in Fig. 8. We get data as XML format from Google Calendar and JSON format from Twitter API [17] after application relationship authentication. In terms of retrieving data from Google Calendar, only schedule information after executing this function will be extracted and informed to UI part to be announced. Announce example is “Today is 5th March, Wednesday. Today’s schedule is the detailed examination in a hospital from 13:00 to 14:00.” In terms of retrieving data from Twitter, only messages of the day executing this function will be extracted and informed to UI part to be announced.

Announce example is “Message from Mr. Tanaka, How are you today?”

Transmitting Module controls Video/Voice Recording, Voice Recognition, Video/Voice Encoding, YouTube Uploading, and Twitter Contribution. We show Transmitting Module sequence chart in Fig. 9. As for Video/Voice Recording, Raspberry Pi cannot record the video with voice. Therefore, we record video and voice separately as different format files simultaneously such as H.264 and WAV. Regarding Voice Recognition, we chose Google Cloud Speech API [18]. Google Cloud Speech API could send back voice recognition results as JSON format, if we would send 16 kbps FLAC format voice file to Google Cloud Speech API. Therefore, we implemented the format exchanging function from WAV to FLAC into Transmitting Module. By using Google Cloud Speech API, we do not have to have a high spec client computer because all voice recognition functionalities have been assigned to Google Cloud side. That is why we chose Google Cloud Speech API.

In terms of Video/Voice Encoding, in order to upload the video with voice to YouTube, we need to make a MP4 format video file. At first, we exchange WAV format file into AAC format file as a voice file. Then, we encode H.264 video file and AAC voice file to make a MP4 video file. We used the free software FFmpeg [19] operated by command line interface for encoding H.264 video file and AAC voice file. Then, a MP4 video file will be uploaded to YouTube. We used youtube-upload [20] which is the open source software implemented by Python. We can upload the video to YouTube using this software by command line interface. Finally, the secret video viewing URL information will be replied. This information will be used at the next step, Twitter Contribution.

In the step of Twitter Contribution, we used TTYtter [21], which can be used for tweeting from Twitter client by command line interface. JSON format text information as voice recognition results and the secret video viewing URL will be mixed and contributed using TTYtter as Twitter client. After that, we can see the text and video information coming from elderly people through Twitter application on smart phones.

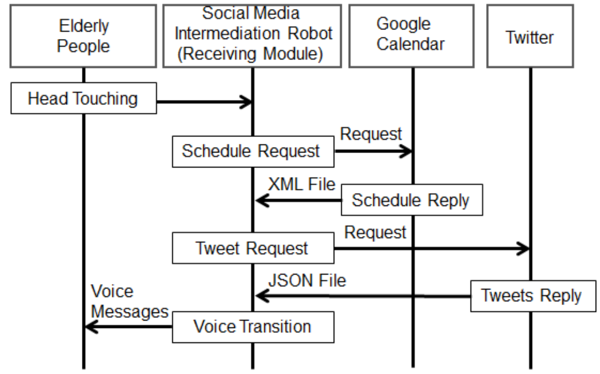


Fig. 8. Receiving module sequence chart

Log Collecting Module is sending us an e-mail message regularly, which contains usage history of this proposed robot system.

D. System Configuration: Application Interface Part (API Part):

This part supports the interface between our robot system and the external cloud-based services, such as Google, YouTube, and Twitter. Authentication against the external cloud-based services to retrieve or send information is the main functionality of this part. Cloud-based service API may change

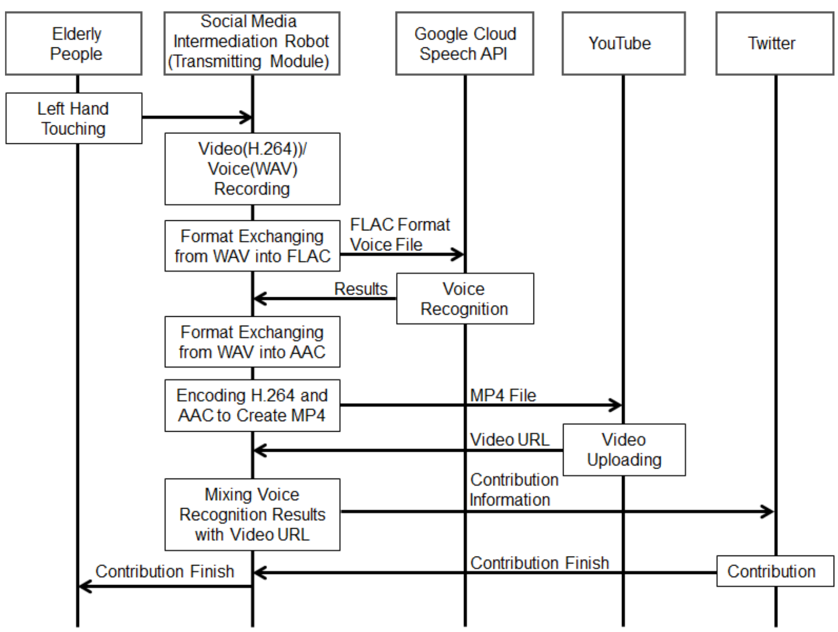


Fig. 9. Transmitting module sequence chart

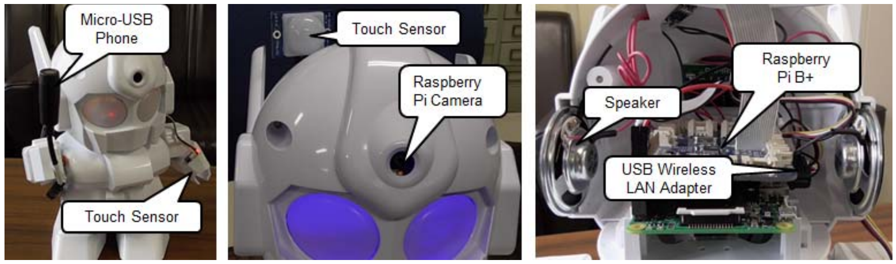


Fig. 10. Rapiro based prototype system

frequently. However, we separated this API part from the other parts, so that if a cloud-based service API might change, an affected part would be limited only to this API part.

E. Prototype System

Fig.10 shows the Rapiro based prototype system which consists of Raspberry Pi B+, USB Microphone, Raspberry Pi Camera, Speaker, Touch Sensors, and USB Wireless LAN Adapter. Fig.11 shows each assembly part detail information. We used the power source from GPIO (General Purpose Input/Output) for a speaker. We also implemented an amplifier to increase voice volume, which makes it possible for elderly people to hear. This prototype system enables us three kinds of operation according to the state transition diagram (Fig. 5).

- Waiting for Operation: In the case of sitting a person in front of Rapiro, the prototype system starts to announce messages which are “If you want to receive messages, please touch the head of the robot” and “If you want to transmit messages, please touch the left hand”.
- Receiving Message: In the case of touching the head of Rapiro, the prototype system collects information from Google Calendar and Twitter. Then, the retrieved information will be informed after translating to voice messages.
- Transmitting Message: In the case of touching the left hand of Rapiro, the prototype system records video/voice in 10 seconds. Then, the recorded information will be contributed to Twitter through YouTube and voice recognition process.

V. Experiments and Discussion

A. Pre-experiments for Face Recognition

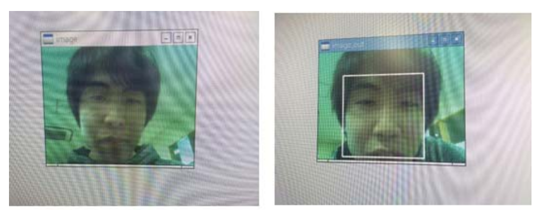
OpenCV library we used for face recognition has some kinds of sorter such as whole face, eyes, nose, and mouth. In order to select the suitable sorter, we did pre-experiment after making the checking program. If this checking program could detect a human face, it could indicate white square on the screen and count number (Fig. 12). In this pre-experiment, we counted misdetection numbers while setting this robot system at the space where no one stays for 12 hours. From the result (Fig. 13), we found out that the sorter focusing on eyes should be used, so that we decided to use the sorter focusing on eyes in the rest experiments.

B. Experiments for User Interface

At a small private room at Isaki neurosurgery hospital in Nagasaki in March 2016, we asked 5 examinees who are 67 years old man, 65, 74, 83, and 86 years old women to use the prototype system. They are all patients who come to Isaki neurosurgery regularly to have some physical care. We needed to prepare the Internet connection and account registrations for social media such as Google, YouTube and Twitter to start evaluation. We asked two hospital staff members who are man and woman. They prepared Twitter messages using personal

Assembly Parts	Product Name	Manufacturer Name
Rapiro	RAPIRO	Switch Science
Raspberry Pi B+	Raspberry Pi Model B+	Raspberry Pi
USB Micro-Phone	MM-MCUSB16	SANWA
Raspberry Pi Camera	Camera Module for Raspberry Pi	Raspberry Pi
Speaker	8Ω 10W Broadband Speaker	Tokyo Cone Paper MFG.CO.,LTD.
Touch Sensor	GROVE – Touch Sensor(SEEED-101020037)	SeeedStudio
USB Wireless LAN Adapter	WLI-UC-GNM2	BUFFALO

Fig. 11. Assembly part detail information



(a) Before face recognition (b) After face recognition

Fig. 12. Face recognition checking program results

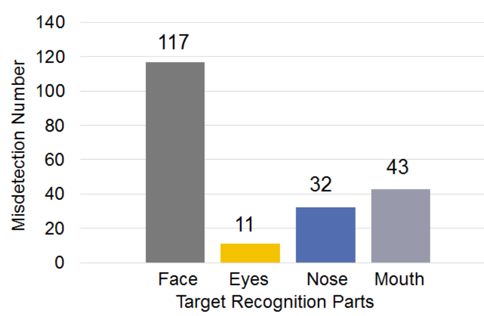


Fig. 13. Misdetection number against target recognition parts

computers or tablet computers in a hospital staff room in advance. In this experiment, we observed the elderly people usage of this prototype system, and asked them some questions after the usage. The experiment sequence is the listed in the bellow.

- We asked the hospital staff to tweet "your taking medicine time is 3:00 pm" using a tablet computer as experiment preparation.
- We give the examinees the purpose of the prototype system.
- We observe how the examinees could hear the tweet message or transmit messages against the tweet message using the prototype system.

We show the evaluation factors.

- Face recognition accuracy
- Understanding of tweet contents, "your taking medicine time is 3:00 pm"
- System operation understanding
- Message transmitting operation

We also show the evaluation result in Fig. 14. In terms of face recognition, we did not observe the misdetection within 5 examinees. However, we had some misdetection in preliminary experiment, so that we need to do more experiments to increase accuracy. For example, if we could gather many old people's pictures and make the special sorter for old people, the detection accuracy might be more increased. We confirmed that understanding of tweet contents was good. However, we found that the operation understanding was not so good due to the low quality of the synthetic sound we implemented. If we could increase the synthetic sound quality like using relative's voice of the target old person, the operation understanding would be more increased. In regard to message transmitting operation, we did not find big problems. We show tweet example (Fig. 15) which we corrected image due to privacy for an examinee. In the case of Figure 15, voice had been recorded clearly, and voice recognition had been good. Of course, we

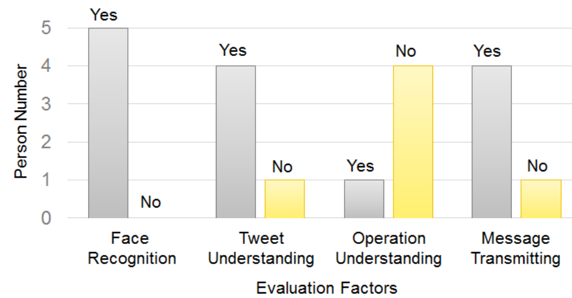


Fig. 14. Results of user interface experiments

Fig. 15. Tweet example

found some miss voice recognition cases due to low level volume voice or a dialect word. However, in those cases, we could understand what they said via video.

C. Experiments for System Availability

In these experiments, we try to confirm whether each response time of the prototype system functionalities can be in a permissible range or not, because the response time could be important factors in terms of system availability. TABLE I shows the response time results. We used "time" command to measure the response time in our laboratories.

In the case of receiving operation, we could hear Google

TABLE I. Response Time Results (second)

Function \ Times	1st	2nd	3rd	4th	5th	Average
Voice Recognition	10.071	10.052	9.745	9.113	10.138	9.824
Voice Encoding	1.788	1.473	1.484	1.487	1.480	1.542
Video Encoding	70.575	70.656	71.141	70.194	70.004	70.514
YouTube Uploading	7.385	6.660	6.638	6.565	11.601	7.770
Twitter Contribution	12.132	5.846	5.435	5.236	5.462	6.822
Retrieving Data from Google Calendar	0.649	0.671	0.868	0.843	0.650	0.736
Retrieving Data from Twitter	1.357	2.260	1.330	1.333	1.278	1.512

Calendar information at 0.736 seconds on an average after touching the head of the robot. After that, we needed to wait 1.512 seconds on an average until we could hear Twitter messages. The total of these response times including external cloud-based service process was within 3 seconds that were allowed by users generally as response time, so that we considered there was no problem in the sense of receiving operation process response time.

In the case of transmitting operation, the robot system starts to record video and voice in ten seconds just after touching the left hand. After that, we needed 9.824 seconds for voice recognition, 1.542 seconds for voice encoding, 70.514 seconds for video encoding, 7.77 seconds for YouTube uploading, then 6.822 seconds for Twitter contribution. Transmitting operation process needs relatively long time rather than receiving operation process. However, if we focused on elderly people's operation, only first ten seconds to record video and voice occupied elderly people's time. After that, we could run long time process like video encoding as a background process. Therefore, this long response time was not negative result.

VI. Conclusion

We proposed the Social Media Intermediation Robot which can be used for the interactive communication between elderly people and younger generation via existing social media. We developed the prototype system implemented on a single board computer embedded in a human-type robot, which is equipped with a microphone, camera, speaker, sensors, and network access function, so that elderly people can retrieve and transmit information by voice via social media without using smart phones. In this study, we made clear a human interaction-type user interface, which enables elderly people to have communication just like talking with a receptionist. We also designed this robot system based on the service-oriented architecture according to MVC model to combine external cloud-based services efficiently.

We confirmed the effectiveness of the proposed robot system in the viewpoints of user interface and system availability from the perspective of the total system performance including external cloud-based services. We checked that elderly people could retrieve and transmit information by voice via social media only by simple finger operation within reasonable response time. However, we found that the operation understanding was not so good due to the low quality of the synthetic sound we implemented. In the future work, we will increase the synthetic sound quality by using relative's voice of the target old person for increasing the operation understanding.

In this study, we implemented all functionalities on the single board computer embedded in Rapiro. However, if we would consider about system maintainability, it would be better for us to implement all functionalities on cloud environment. On the other hand, here in Japan, LINE as a communication application for smartphones is very popular. Therefore, we will change API part of our system to adapt LINE, and construct all functionalities on cloud environment.

Acknowledgment

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