Industrial Paper

Development of a Life Watching Service for Elderly People by using Interactive Home Robot

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Abstract - Since the life watching system using the existing voice interactive robot uses a camera, there is a problem that some users feel mental stress from the constant monitoring by the camera. Therefore, in this research, we propose a service to watch the life of a target person without using any camera by using a voice interactive home robot for the life watching target including the elderly living away from their families. Specifically, by recording and analyzing information such as conversations between the watching target and the home robot as a log, we examined whether it could be applied as a life watching service equivalent to a camera. We developed a trial system of the life watching service using an interactive home robot proposed in this paper and evaluated by comparing it with a camera.
Keywords: Communication Robot, Life Watching Service, ECHONET-Lite.

1 INTRODUCTION

In Japan, the number of elderly people living alone is increasing with the declining birthrate and aging population. Under such circumstances, life watching services for the elderly [1]-[2] are attracting public attention. There are many services [3]-[4] that use robots for the watching. The basic functions of the existing watch robots are communication, and various functions such as telephone functions and schedule functions are implemented. Many of these robots use cameras for the watching. A robot equipped with a camera [3]-[4] can watch the life of the target person with video, but it cannot watch the target person when he/she is in a room where the robot is not installed or within a blind spot of the camera. There is also a possibility that the image may be diffused on the net by being hacked. Also, the subjects may have multiple problems such as the mental stress due to the constant monitoring with a camera [5].

Therefore, in this study, we propose a service to watch the life of a target person without using any camera by using a voice interactive home robot for the life watching target including the elderly living away from their families. Specifically, we examined whether it could be applied as a new life watching service by analyzing a log recording the talks between the watching target and the home robot. What is essential for such a system is how to increase the chances of conversation with the subjects of the life watching including the elderly. Therefore, the dialogue type home robot for life watching that we developed this time starts talking when someone is detected by the human sensor etc. The robot also produces facial expressions and movements such as "nodding" and "swinging" when talking. We will describe how such a method helps to increase the chances of conversation in an easy-to-talk manner. The prototype development and verification evaluation of the interactive home robot proposed by this research is carried out, so the details will be described. In this paper, Chapter 2 describes related works and issues, Chapter 3 is an outline of the life watching service using the interactive home robot proposed by this research, Chapter 4 relates to prototype development, Chapter 5 is evaluation by demonstration experiment of prototype, Chapter 6 is questionnaire evaluation on comparing prototype and AI speaker, Chapter 7 presents the conclusion, and Chapter 8 is concerned with future works.

2 RELATED WORKS AND ISSUES

Existing technologies for home robots can be divided into two types: interactive and non-interactive. Examples of interactive home robots include Pepper [6] and RoBoHoN [7]. In addition, there is LAVOT [8] developed by GROOVE X as a non-interactive home robot. LAVOT is a robot that cannot communicate with the user, but can express a warm feel and cute gestures like a pet. On the other hand, in the case of interactive home robots such as Pepper and RoBoHoN, their appearance is designed to be familiar to general users. In addition, by adding a dedicated application and developing an original application, it is possible to enter a loving nod or gesture, recognize a person with a camera, etc., and have a voice conversation with a specific person. These home robots such as Pepper [6], RoBoHoN [7], and LAVOT [8] are all equipped with cameras, so they can identify the target person or monitor the situation in the house with the cameras. It is possible to perform advanced monitoring, such as sending the captured images by e-mail to the users. However, when using a camera-equipped robot, some target persons feel mental stress due to the constant monitoring by a camera. Also, if the system is hacked, there is a possibility that the life situation of the target person will be completely viewable, and there are security and privacy issues with the camera-mounted type. In this study, we propose a service that uses an interactive home robot to monitor the user's life only by analyzing log data without using any camera.

3 LIFE WATCHING SERVICE USING INTERACTIVE HOME ROBOT

Chapter 3 gives an overview of a life watching service

Figure 1: Overview of life watching service using IHR

using the interactive home robot (hereinafter referred to as "IHR") proposed by this paper and details of the prototype IHR developed this time.

3.1 Outline of life watching service using IHR

Fig. 1 shows the outline of the life watching service using IHR proposed by this paper. This service has an implemented function to record the contents of the conversations between IHR and target person as a log. Log data is saved as a file in CSV format and analyzed by a control program of the interactive home robot and used for the life watching. IHR's natural conversation is realized by combining Google Speech API of speech recognition service and chat conversation API of NTT docomo [9]. Classification numbers are provided according to the contents of the log data acquired by IHR (conversation, home appliance operation, etc.), and IHR estimates the life behavior of elderly people living alone by graphing the data in time series etc. Using those functions, we devised a system service to monitor life by comparing the living condition data with those acquired in the past. The final analysis results of life surveillance are transmitted to the families and relatives living in remote areas by e-mail. The IHR is designed for use in a smart house [10] where home appliances and sensors compatible with ECHONET-Lite are connected to the home network.

4 PROTOTYPE DEVELOPMENT OF IHR

4.1 Hardware of IHR

In developing the IHR, we referred to the Magbot [11] devised by Professor Koike and modified it to enable natural conversation with the user freely. Fig. 2 shows the system configuration of the IHR developed this time. As shown in Fig. 2, RaspberryPi3 B + (hereinafter referred to as RPI) is used as the main MCU (Micro Control Unit) of IHR, and distributed processing is performed using the Arduino microcomputer as the sub MCU. RPI is in charge of the IHR main processing, performs communication processing with ECHONET-Lite compatible home appliances, etc., performs speech synthesis processing and communicates with various

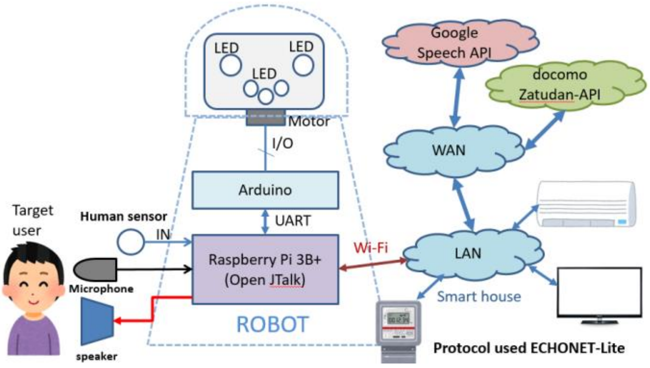


Figure 2: System of IHR

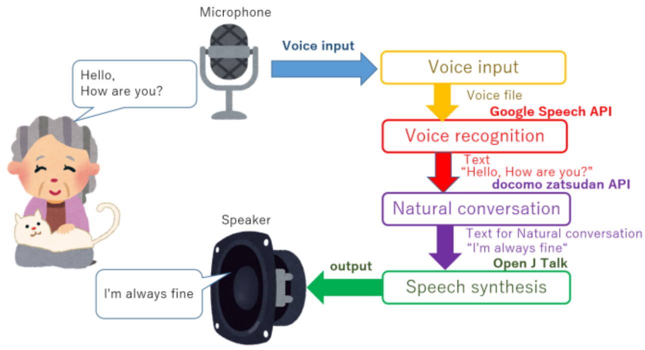


Figure 3: Flowchart of natural conversation processing of IHR

network services (Google Speech API and docomo's chat conversation API), etc.The Arduino microcontroller performs sub-controls such as the light emission of five LEDs that appear to be the face of the IHR and the swing motion of the robot by a servomotor. Therefore, the Ardunio microcontroller controls the part of the IHR facial expression and movement. In addition, a human sensor (Model Type EKMB1301111K / Panasonic) is installed on the body of the IHR to enable the IHR to actively talk to a user near the IHR. The sensor circuit is designed to react to a person within 300 mm of detection distance. Therefore, the proposed IHR operates only when a human movement is detected, and a program that can record the result as a log in the IHR file is implemented in the RPI. The main program of this IHR RPI was developed in Python 2.7 language, and the processing program on the Arudino microcomputer side was developed in C language.

4.2 Mechanism of natural conversation

In order to allow the target person to talk naturally with the IHR, we have used Google Speech API for speech recognition service and docomo's chat conversation API for natural conversation service for our IHR. Fig. 3 shows the flow of the natural conversation processing implemented in the IHR [9]. The IHR acquires the user's voice information with the microphone connected to the RPI, and first creates a voice input file. It performs speech recognition processing that converts speech input files into text information using the Google Speech API. The converted speech text information is sent to docomo's Zatudan-API, which creates text information containing natural speech information. This text information is speech-synthesized using Open JTalk prepared in the IHR, and the obtained voice conversation is outputted from the speaker connected to RPI. In this manner, the natural conversation between human and the IHR has been realized.

4.3 IHR facial expression

Fig. 4 shows the face of the IHR developed this time. The robot's face was made of a breadboard, five LEDs, and five resistors. We arranged two large-size LEDs side by side, protruding as the eyes, and three LEDs located below the center as the mouth. Various expressions were created by lighting and blinking each LED as shown in Fig. 4 as needed in the conversation. In practice, a translucent plastic mug was placed over the breadboard to prevent the circuit from being exposed. When talking with people, IHR lights its eyes and mouth, and produces a swinging motion with the DC servomotor so that it looks friendly and is easy to talk to.

4.4 Conversation log recording function

IHR has a function to keep a log of the talks of the IHR with the target person of the life watching. In order to distinguish between daily conversations and household appliance operation requests as the conversation content, classification numbers are provided to make it easy to extract necessary data using computer programs. The classification number is 1 for daily conversation, 2 for household appliance operation request, and 10 for no conversation. This "no conversation" is written as a log to a file inside the IHR when nobody is detected by the human sensor and there is no conversation.

4.5 Life watching method by conversation log analysis

By analyzing the log data acquired by the IHR using a program or application, the life rhythm and behavior of the watched person can be estimated to some extent. For example, a set of log collected over a long period can be treated as reference data of the living behavior of the target person. Comparing the latest data with this reference data makes it possible to detect a continuation of an abnormal situation and notify relatives and families living in remote areas of the situation by e-mail etc. For example, if the state without conversation has continued for half a day or more during the time when such conversations are normally expected, it is possible to determine that the life behavior is different from usual, so the IHR notifies the family and relatives of the situation by e-mail etc. with a message such as "Please call Mr. OO/Mrs. OO," to prompt them to contact the watching target. The e-mail transmission is performed by the main program of RPI, and realized by the standard library of python.

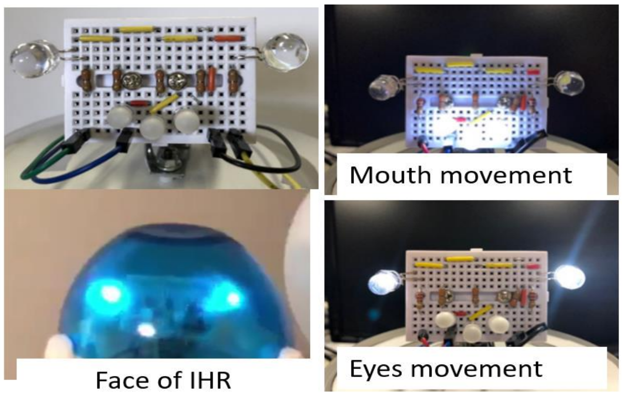


Figure 4: Facial expression of IHR

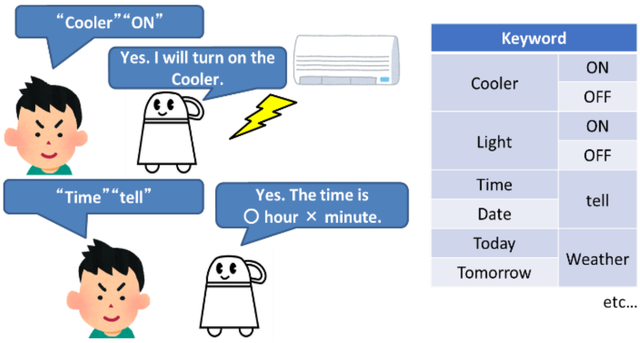


Figure 5: Appliance operation and information service by keyword of 2 words

4.6 Acquisition of living information and appliance operation in the smart house

The IHR developed this time uses ECHONET-Lite [12] as a communication protocol for acquiring living information and operating home appliances in the smart house. By communicating with smart meters and home appliances in the smart house, the IHR is able to acquire the power consumption of the entire home, acquire the ON / OFF status of various home appliances, and remotely operate home appliances. Also, when the user asks time, weather, etc., the IHR acquires necessary data in JSON format from the time [13] or weather web service site [14], and outputs it as voice from IHR. The IHR developed this time was designed to remotely turn on / off a home appliance with the words corresponding to the keyword or to provide the weather and time information when the corresponding keywords are included in the conversation. Fig. 5 shows an example of the remote control of the home appliances and information provision of the weather and time by keywords. For example, if you ask the IHR to turn on the Cooler in the room, there is a possibility that the word “Cooler” may be misrecognized.

Therefore, the IHR is programmed to remotely turn on the “Cooler” only when the two words "Cooler" and "ON" have been recognized found. If you want to hear the weather information, the IHR provides today's weather information by voice only when the two words "Today" and "Weather" have been recognized.

4.7 Software of IHR

Fig. 6 shows the flow chart of the main software implemented in the prototype IHR. A pyroelectric infrared sensor is used as the human sensor. When the motion of a person is detected by the human sensor, the robot starts talking, and when the person is absent, the IHR does not speak. Upon receiving an input of human voice through the microphone, the IHR creates a voice file and sends it to Google Speech API to convert the audio information into text information. If there is no keyword related to home appliance operations in this text information, the IHR checks whether there is a keyword related to time or weather. If there are no keywords related to time or weather, the text information is passed to docomo's chat service and converted to text information for natural conversation. The text information is converted to speech information using the speech synthesis software Open JTalk, and speech is output from the speaker to realize natural daily conversation between a human and a robot [9]. Also, if the 2-word keyword of the home appliance has been recognized in the acquired voice information, the target home appliance compatible with ECHONET-Lite connected to the network is remotely operated and the result of the operation is presented to the user. Also, if there is a keyword related to time or weather, the IHR acquires information from the dedicated site and provides it to the user by voice.

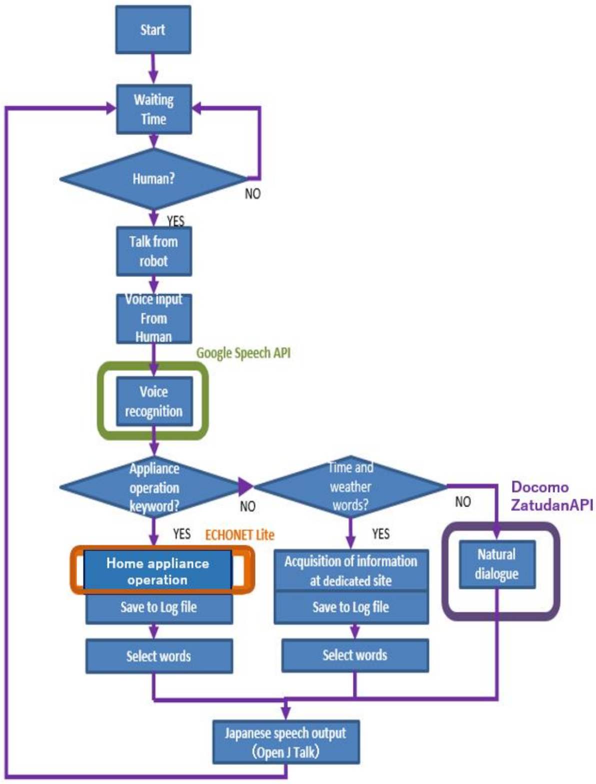


Figure 6: Main software flow chart of IHR

5 EXPERIMENT

An experiment using the IHR prototype developed this time was conducted to demonstrate how accurately the living behavior of a subject can be analyzed from the log data acquired by the IHR.

5.1 Experimental method

This demonstration experiment was conducted at E602 on the 6th floor of Kanagawa Institute of Technology C2. The subject was a 20-year-old male, and the experiment period was from May 14, 2019 to May 20 except Saturday and Sunday. Fig. 7 shows the system of the demonstration experiment, and Fig. 8 shows the layout of the demonstration experiment.

Using the IHR prototype developed this time, we asked the subject to behave as usual, and recorded information such as the subject talking with the IHR or remotely operating home appliances via the robot as log data. The recorded information was analyzed to evaluate the accuracy of human behavior estimation. A camera was installed to acquire correct data in the demonstration experiment. Fig. 9 shows a picture of the IHR and the subject during the demonstration experiment taken with the camera. Table 1 shows the equipment used in the demonstration experiment. As shown in Fig. 8, the two appliances used this time were an ECHONET-Lite compatible Cooler and lighting. The subject entered the room and had a conversation with the IHR at any time. During the demonstration experiment, the camera captured moving images of the IHR and the user's conversation situation along the time display. The correct data was created manually while recognizing the content and time of the action of the subject from the moving image of this camera. After the demonstration experiment, the reliability of the IHR log data was evaluated by comparing the log data recorded by the IHR with the correct data obtained from the camera's moving image. Also, as shown in Fig. 9, the subject sat at his desk and talked to the IHR only when necessary. The subject was asked to take action with a natural feeling, such as requesting the IHR to turn on the Cooler when it is hot, or to turn on the lighting when the room is dark. As shown in Fig. 8, the distance between the IHR and

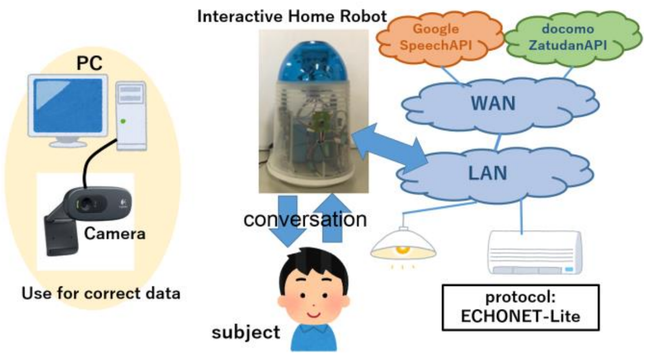


Figure 7: Experimental system

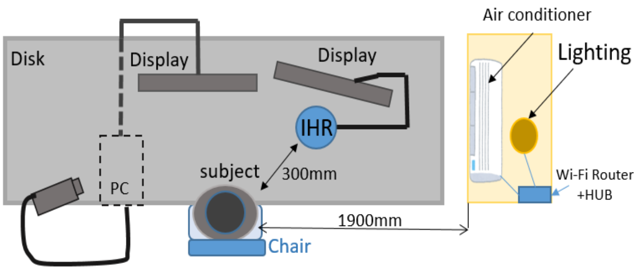


Figure 8: Layout of Experimental (Top View)

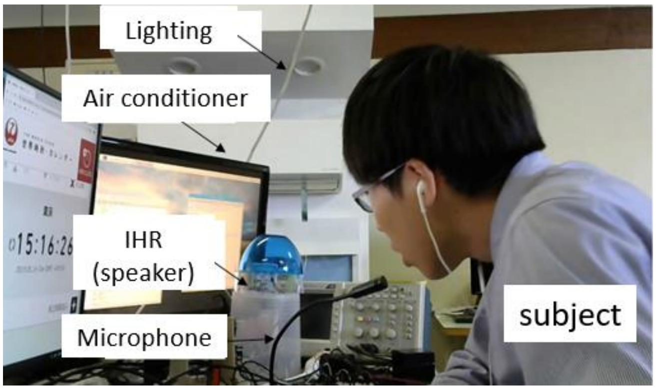
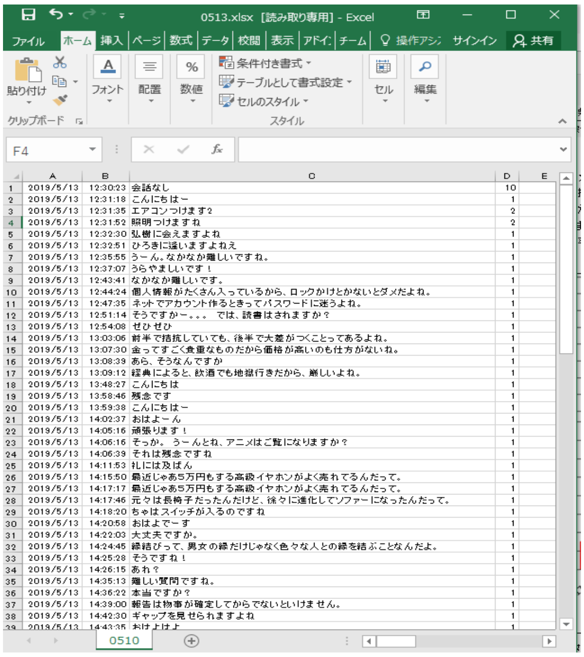


Figure 9: Demonstration experiment state from camera

Tabel.1 Equipment used

Name	Type	Manufacturer
Microphone	MM-MCUSB25	SANWA-SUPPLY
Camera	C270	Logicool
Air conditioner	LDF7N-GX53/D2	TOSHIBA
Lighting	LDF7N-GX53/D2	TOSHIBA
speaker	SP-05	ALPEX



	A	B	C	D
1	2019/5/13	12:30:23	会話なし	10
2	2019/5/13	12:31:18	こんにちはー	1
3	2019/5/13	12:31:35	エアコンつけます?	2
4	2019/5/13	12:31:52	照明つけますね	2
5	2019/5/13	12:32:30	弘樹に会えますよね	1
6	2019/5/13	12:32:51	ひろきに逢いますよねえ	1
7	2019/5/13	12:35:55	うーん。なかなか難しいですね。	1
8	2019/5/13	12:37:07	うらやましいです！	1
9	2019/5/13	12:43:41	なかなか難しいです。	1
10	2019/5/13	12:44:24	個人情報がたくさん入っているから、ロックかけとかないとダメだよね。	1
11	2019/5/13	12:47:35	ネットでアカウント作るときってパスワードに迷うよね。	1
12	2019/5/13	12:51:14	そうですかー。。。 では、読書はされますか？	1
13	2019/5/13	12:54:08	ぜひぜひ	1
14	2019/5/13	13:03:06	前半で拮抗していても、後半で大差がつくことってあるよね。	1
15	2019/5/13	13:07:30	金ってすごく貴重なものだから価格が高いのも仕方がないね。	1
16	2019/5/13	13:08:39	あら、そうなんですか	1
17	2019/5/13	13:09:12	経典によると、飲酒でも地獄行きだから、厳しいよね。	1
18	2019/5/13	13:48:27	こんにちは	1
19	2019/5/13	13:58:46	残念です	1
20	2019/5/13	13:59:38	こんにちはー	1
21	2019/5/13	14:02:37	おはよーん	1
22	2019/5/13	14:05:16	頑張ります！	1
23	2019/5/13	14:06:16	そっか。 うーんとね、アニメはご覧になりますか？	1
24	2019/5/13	14:06:39	それは残念ですね	1
25	2019/5/13	14:11:53	礼には及ばん	1
26	2019/5/13	14:15:50	最近じゃあ5万円もする高級イヤホンがよく売れてるんだって。	1
27	2019/5/13	14:17:17	最近じゃあ5万円もする高級イヤホンがよく売れてるんだって。	1
28	2019/5/13	14:17:46	元々は長椅子だったんだけど、徐々に進化してソファーになったんだって。	1
29	2019/5/13	14:18:20	ちゃはスイッチが入るのですね	1
30	2019/5/13	14:20:58	おはよでーす	1
31	2019/5/13	14:22:03	大丈夫ですか。	1
32	2019/5/13	14:24:45	縁結びって、男女の縁だけじゃなく色々な人との縁を結ぶことなんだよ。	1
33	2019/5/13	14:25:28	そうですね！	1
34	2019/5/13	14:26:15	あれ？	1
35	2019/5/13	14:35:13	難しい質問ですね。	1
36	2019/5/13	14:36:22	本当ですか？	1
37	2019/5/13	14:39:00	報告は物事が確定してからでないといけません。	1
38	2019/5/13	14:42:30	ギャップを見せられますよね	1

Figure10: Log data acquired by IHR (CSV format data)

the subject was 300 mm, while the distance between the Cooler or lighting and the subject was 1900 mm.

Fig. 10 shows log data acquired by the IHR. The log data was saved in CSV format in order of date, time, conversation content, and classification number. This classification number is an optional item provided so that information can be easily extracted later by a database or Excel.

The classification number is 1 for conversation and 2 for home appliance operation and 10 for no conversation. In addition, the number of conversations of the subjects and the number of times the home appliances were operated were obtained from the log data obtained by the IHR every 30 minutes. In addition, the number of conversations and the number of home appliance operations performed by the subject in 30-minute units from the images taken by the camera were used as the correct answer values. The error and error rate were obtained by equations (4.1) and (4.2) from the log data obtained by the IHR and the correct answer values obtained by the camera.

$$\text{Error} = NC_{log} - NC_{cam} \tag{4.1}$$

$$\text{Relative error} = \frac{NC_{log} - NC_{cam}}{NC_{cam}} \times 100[\%] \tag{4.2}$$

NC_{log} is the number of conversations captured in the log or number of appliance operations captured in the log. **NC_{cam}** is the number of conversations acquired by the camera or number of appliance operations acquired by the camera.

5.2 Results and discussion

Fig. 11 is a graph in which the log data obtained in the demonstration experiment from 14 May to 20 May, 2019 excluding Saturday and Sunday and the correct answer data acquired by the camera are summarized as the number of appliance operations and the number of conversations in 30 minutes.

The horizontal axis is the time axis, and the vertical axis is the number of conversations and home appliance operations. The upper graph is the graph acquired by the IHR, and the lower graph is the correct data obtained by the camera. In addition, Table 2 shows the correct answer rate of the number of conversations and the correct answer rate of the number of operations of the home appliance. As shown in Fig. 11, the number of conversations in the log acquired by the IHR is larger than in the correct answer data acquired by the camera. Next, Table 2 shows the error and error rate of the number of conversations with the user and the number of times the home appliances were operated. The number of conversations acquired by the IHR has an error of 2 to 25 times compared with the camera, and it can be seen that when converted to the error rate, it is up to 82%. A possible reason for this was that the IHR unnecessarily responded to the voices of individuals who were there other than the subject during the demonstration experiment, which led to an increase in the number of conversations. Therefore, the error in the number of conversations in Table 2 can be considered as the number of conversations other than the subject. On the other hand, the error rate of the number of home appli-

Figure 11: Number of conversations and appliance operations from 14-May-2019 to 20-May-2019 (The upper graph shows IHR log data. The lower graph shows camera data)

ance operations was zero except for the data on May 15th, indicating that log information was obtained accurately.

Next, referring to the 5-day data in Fig. 11 in chronological order, the time zone for conversation, the type of conversation, etc. are almost synchronized with the correct data taken with the camera. Therefore, IHR's log data can be used to estimate the subject's behavior as well as the camera's correct data. The working hours of the subject this time are 11:00 to 16:00, but it is possible to estimate the early departure and overtime hours etc. depending on the day of the week by combining with the subjects' action memos in Fig. 11. It will be also possible to accurately estimate the time when the subject left for lunch. With 14-May and 16-May data, it is possible to clearly read the time spent leaving for lunch because there is no conversation with the IHR or the operation of home appliances, but with 15-May data it cannot be judged whether the subjected was absent, because there is a conversation recorded. As we summarized the data in units of 30 minutes this time, an error of ± 30 minutes may occur depending on the time zone as compared with the correct data as shown in the graph of 17-May in Fig. 11. For this reason, it is difficult to estimate the exact leaving time etc. when the subject leaves for a short time at lunch etc. in the analysis in units of 30 minutes. Table 3 compares the actual working hours with the working hours estimated from the log data acquired by the IHR. In this result, it is within about ± 15 minutes, but it can be expected that the error will deviate by about 30 minutes if the room entry time is before 11:00, for example. Therefore, the accuracy of the living activity estimation using the proposed IHR depends on the aggregation interval of logs. In other words, if the log data is aggregated every 30 minutes, it is thought that the daily activities such as entering, leaving and working hours will have an error of about ± 30 minutes. Also, since it is possible to determine whether the conversation content with the IHR is a daily conversation or an operation of a home appliance, it is considered that it is possible to extract a subject-specific life behavior pattern from these kinds of information. Next, in order to analyze the subject's specific behavior, Fig. 12 shows the number of conversations with the IHR and the number of home appliance operations in each time zone from 5/14 to 5/20. From this graph, it seems to be possible to find out the time zone where there are many conversations with the IHR and the time zone where there are many times to operate home appliances. However, it is actually difficult to locate such time zones at a glance in those graphs. Therefore, as shown in Fig. 13, we tried the average value of the number of conversations with the IHR and the number of operations of home appliances for each time slot from 5/14 to 5/20. The red line in Fig. 13 shows the average value of the number of conversations and the number of operations of home appliances from 11:00 to 16:00. The time zone where the bar exceeded the red line indicating the average value in Fig. 13 was considered to be the time zone where the subject talked with the IHR and operated the home appliance frequently.

As shown in Fig. 13, when the time zone exceeding the red line is extracted, the time zone in which the subject talks frequently with the IHR is 11:30, 12:30, 14:00, 15:00, 15:30. By comparing this extraction result with that in Fig. 12, it is possible to extract a high frequency time zone as a whole, although it includes a day without conversation and home appliance operation. In this way, subject-specific behavior can be analyzed from log data analysis acquired by the IHR. Moreover, it can be used as a judgment standard of the life watching for determining whether the life is ongoing as usual by comparing the data obtained through this behavior analysis and the log data of the latest value.

Table.2 Comparison of Error of log data vs camera (correct data)

Date	Number of conversation				Number of appliance operation			
	Camera	Log data	Error	Relative error	Camera	Log data	Error	Relative error (%)
14-May-19	51	62	11	22%	18	18	0	0%
15-May-19	58	80	2	51%	14	13	-1	-7%
16-May-19	58	76	18	31%	12	12	0	0%
17-May-19	11	20	9	82%	12	12	0	0%
20-May-19	41	66	25	61%	10	10	0	0%

Table.3 Comparison of actual working time vs working time obtained from log data

Date	Actual working time	Working time obtained from log data
14-May-19	11:12～15:38	11:00～15:59
15-May-19	11:12～16:16	11:00～16:29
16-May-19	11:06～15:53	11:00～15:59
17-May-19	11:10～15:20	11:00～15:29
20-May-19	11:08～15:41	11:00～15:59

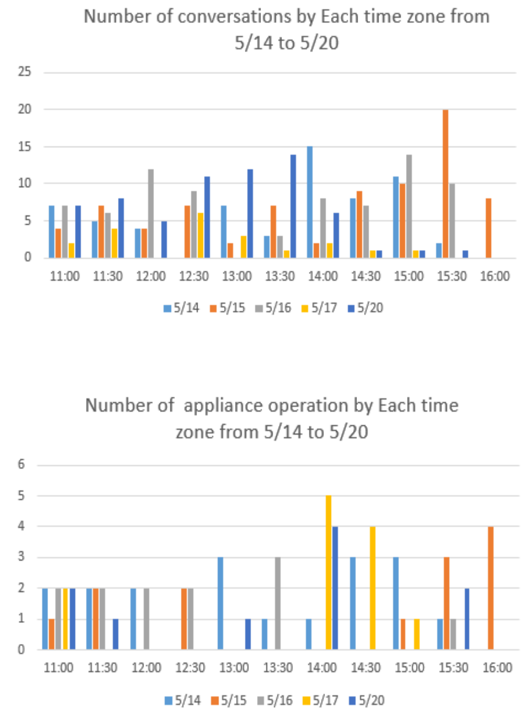


Figure 12: Number of conversations and appliance operations by each time zone from 14-May-2019 to 20-May-2019

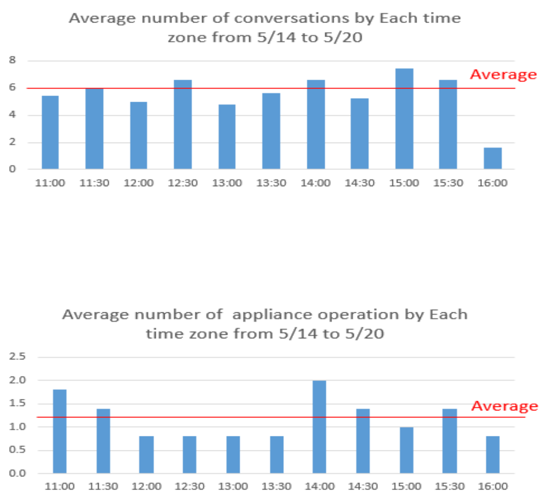


Figure 13: Average number of conversations and appliance operations by each time zone from 14-May-2019 to 20-May-2019

6 QUESTIONNAIRE EVALUATION

The IHR proposed by this study is a technology that does not have a camera at all, but performs natural conversation based on voice information from users, voice control of home appliances, and watching life by collecting log data. There is also a technique using AI speakers [15]-[16] as a related technology for voice interactive system without cameras. Most of the commercially available AI speakers have an inorganic design, so it seems that there are a certain number of people who find it difficult to talk to. Therefore, we aimed to develop an IHR without cameras that is not a simple AI speaker but can also express non-verbal information such as facial expressions and movements [17] like human beings in a rich manner and that can perform dialogue by voice.

We thought that IHR would be useful in a life watching service if it could increase the opportunity of conversation with the user. Therefore, in order to evaluate whether the design of the IHR proposed in this study makes conversation easier than AI speakers, we conducted a comparative evaluation questionnaire using the IHR vs AI speaker. As for the implementation method, we asked the public to see a demonstration of the IHR prototype we developed and an AI speaker. A questionnaire was conducted on 29 men and women in their teens and 60s. Fig. 14 shows the age and gender of the questionnaire respondents. By age group, 20s and less than 20s occupy 60% of the whole. Fig. 15 shows the answer to the question, “Which of the IHR or AI speakers did you think is easier to talk to?” As a result, about 80% of the respondents answered that the IHR we developed was easier to talk to than AI speakers.

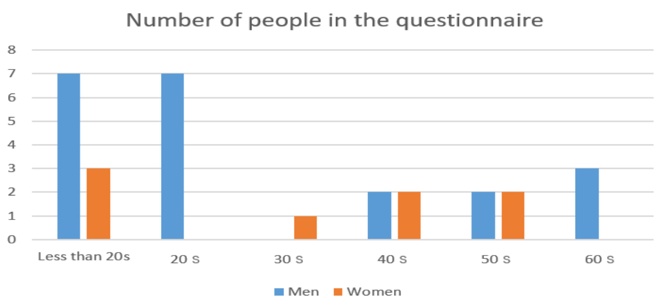


Figure 14: Age and gender of questionnaire respondents

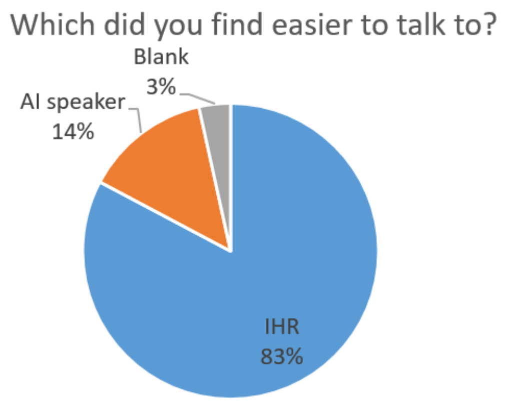


Figure 15: Questionnaire on comparing IHR and AI speaker

7 CONCLUSION

In this paper, we proposed a service that uses an IHR to monitor the life of a target person without using a camera at all for those who want to monitor the lives of their target persons including the elderly, who live away from their families. Specifically, by increasing the chances of conversation between the IHR and the target person, it was possible to collect a large amount of log information, so that the accuracy of the target person's behavior estimation was improved, and as a result, we thought that it could be used as a life watching service. The prototype of the IHR was developed, and the reliability of the data acquired by the log file was evaluated by comparing the log file acquired by the IHR with the result of the moving image acquired by the camera. As a result, it became clear that when there were multiple people other than the subjects, the voices of those other people were picked up, and the number of conversations counted in the log data of the IHR was larger than the actual number. However, it was found that it was possible to estimate the behavior at which time the subject talks with the IHR well and operates home appliances. In addition, it was found that the estimation accuracy of the living activities such as entering, leaving, and working hours depends on the aggregation interval of IHR log data. In addition to this, it is possible to determine whether the contents of the log information acquired by the IHR is a daily conversation or an operation of a home appliance, so it is possible to extract a subject-specific life pattern from these kinds of information.

By the way, there is AI speakers as a related technology of the voice interactive system without a camera. Most of the commercially available AI speakers have an inorganic design, so it seems that a certain number of people will find it difficult to talk to. Therefore, as a means for increasing opportunities for conversations with users, we developed an IHR that can express richly non-verbal information such as facial expressions and movements, but also human speech. This time, we conducted a questionnaire on comparative evaluation of the IHR and the AI speaker to evaluate whether the design of the IHR we developed was easier to talk to than an AI speaker. As a result, according to the answer to the question, “Which of the IHR and AI speakers did you think is easier to talk to?”, approximately 80% of the respondents answered that the IHR was easier to talk to. Therefore, the proposed IHR is more effective as a life watching service for acquiring conversation log data than commercially available AI speakers because the IHR can more easily induce users to talk to.

8 FUTURE WORKS

It is thought that human conversations can be made to go smoothly and useful information can be easily extracted from users by a robot that makes appropriate gestures such as agreeable responses and nodding in the conversation [18]. In the future, we would like to study how to control the timing of the swinging, nodding and other motions of the IHR when talking with users, and to conduct smooth conversations with the users. In addition, we would like to consider the use of displays etc. in order to increase variations in the IHR expressions.

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(Received November 6, 2019)
(Revised February 5, 2020)

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