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Prototype Development and Evaluation of an Avatar Remote Communication System for ALS Patients Using Eye-tracking Interface

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Abstract -ALS patients with severe disease have difficulty in walking, going out, and talking with people. The authors believe that there is a need for a system that enables people with severe ALS to communicate with many people at home while maintaining contact with society. A typical example of a solution to this problem is an alter-ego robot. This robot is placed in a place where ALS patients cannot go, and it can communicate with the other person remotely by gestures. However, the robot needs to be set up at the place where the patient is going to talk with the other person, and the robot needs to be removed from the place after the conversation. In this study, we propose a system that enables ALS patients with severe symptoms who have difficulty in going out to talk with many people through avatars such as computer graphics (CG), which are alter ego characters, easily and remotely by the patients themselves. We also describe in detail the development and evaluation of a prototype of our proposed system.

Keywords: Remote Communication, ALS, online conferencing tool.

1 INTRODUCTION

Amyotrophic lateral sclerosis (ALS) is a disease in which the nerves that control voluntary movements (motor neurons) are damaged, resulting in the loss of muscles throughout the body and those necessary for conversation. In severe cases, the patient becomes bedridden and isolated, with no contact with other people, and it is difficult for the patient to move his/her body, although he/she is conscious. A previous study aiming to solve this problem is an avatar robot [1]. This avatar robot is placed in a place where ALS patients cannot go, and it can communicate with a person remotely by gestures. However, it is necessary to set up the avatar robot and remove it after the conversation. Therefore, the system requires help from other people besides the ALS patient.

In this study, we propose a system that enables ALS patients to communicate with many people by themselves in order to keep contact with society and enjoy communication with various people. In this study, we propose a system that enables ALS patients to talk with many people at their own will by using eye control technology, avatar technology, and online conferencing tools [2]. Furthermore, the system allows ALS patients to choose their favorite avatar character during the conversation. We developed and evaluated a prototype of the proposed system. In order to evaluate the effectiveness of the proposed system from various viewpoints, we performed three questionnaires: one is a questionnaire for ALS patients, two is a questionnaire for medical professionals who actually work with ALS patients. and the other is a questionnaire for able-bodied persons. The details are described below.

2 RELARED WORKS

When ALS patients become severely ill, it becomes difficult for them to move their bodies and to speak. Conversation aids are an existing technology to help severely ill ALS patients communicate their intentions. The first representative product of portable conversational aids is a keyboard input type conversational aid [3]. This keyboard-input type conversation aid uses the keyboard to create sentences, which are then spoken by a voice synthesizer. It also has functions for registering frequently used words in categories and communicating using images. However, this keyboard input type conversation aid is difficult to use for severely ill ALS patients who have quadriplegia and have difficulty moving their bodies because the device requires the user to input data by hand. On the other hand, there is a gaze-input conversation aid [4]. Gaze input type conversation aids are devices that use a gaze input instead of a keyboard to create sentences and have them spoken by speech synthesis. Gaze-input conversation aids use a special gaze-input interface which is expensive and increases the system introduction cost. Common to these two products is the issue of not being able to converse with many people at once because they are face-to-face conversational types. As a previous study to solve these problems, there is an avatar robot developed by Oly Research Institute. This robot is installed in a place where ALS patients cannot go, and it can talk with a person whom the patient wants to talk with remotely by gestures. However, the robot needs to be set up at the place where there is the person whom the ALS patient wants to talk to, and the robot needs to be removed after the conversation is over, which requires the help of others besides the ALS patient. Another avatar technology other than robots is the Metaverse [6]. The avatars used in the metaverse are computer graphics, and users can select various characters of their choice. This technology allows people who have difficulty communicating in the real world to freely enjoy conversations and other activities in the virtual space through their favorite avatars. In this metaverse, there is no need to set up an avatar robot in advance at the place where you want to have a conversation, nor is it necessary to remove the avatar after the conversation is over. However, the interface currently used in the metaverse is a technology for able-bodied people, and it is difficult for people with physical disabilities, such as ALS patients, who cannot speak. On the other hand, a prior study of CG avatars is the Avatar Customer Service [5], which has begun to be introduced in convenience stores. This technology was developed to realize a new way of working that is not restricted by time, place, age, gender, or various other obstacles, and has been installed in actual convenience stores. The system displays a CG avatar on the display screen and uses gestures and hand gestures to converse with the customer. This technology does not burden others as avatar robots do because it is operated remotely using a personal computer, and it allows users to communicate remotely via avatars without questioning the location of the user. However, these prior technologies have issues that make it difficult to use in cases such as ALS patients with physical disabilities, because they are only for able-bodied people.

Therefore, in related work on the past, to the best of our knowledge, remote video communication for ALS patients with the help of eye-tracking does not exist. To solve this problem, we propose a remote video communication using eye- tracking for ALS patients who have difficulty going out. additionally, we propose a system that allows you to have a pleasant conversation with many people remotely using avatars, which are your favorite spoken dialogue agents.

3 PROPOSED SYSTEM

Section 3 provides a detailed overview of the avatar remote communication system for ALS patients using video conferencing tools proposed in this paper.

3.1 Outline of the Proposed System

Figure 1 shows a schematic diagram of the proposed system. The proposed system uses an online conferencing tool [2] as a telecommunication tool for the patient and the other party to have a conversation. There are two reasons for using an online conferencing tool in this paper. One is that ZOOM is widely used around the world as an online conferencing tool and is compatible with various platforms. The second reason is that ALS patients can easily communicate with their counterparts at home or in the hospital, regardless of their location, as long as the other party has an information terminal that can use the online conferencing tool and a network connection is available. We also thought that if the other party to the conversation used a smartphone or similar device, there would be no burden of removing the device after the conversation, and both parties could talk without burdening the other. Next, the proposed system uses an eye tracking interface [7] for the ALS patient's side. We adopted the Eye Tracking interface because it is less physically demanding than keyboard

Figure 1: ARCS-ALS overview

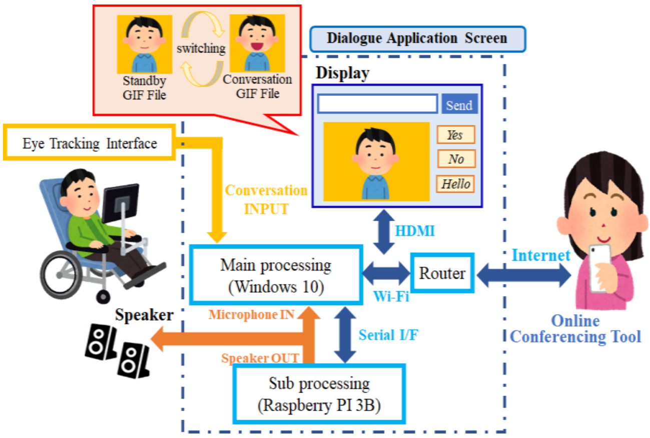

Figure 2: ARCS-ALS Prototype System Overview

operation, since severely ill ALS patients have significantly reduced physical abilities. In this system, the characters input by the eye tracking interface are directly output by text-to-speech to realize conversation. In addition, the system allows the user to freely add and select a character for the spoken dialogue agent that serves as the alter ego of the ALS patient by utilizing the function of adding and selecting spoken dialogue agents of a previous study [8]. As in the previous study, the ALS patient's favorite voice interaction agent can be used as an avatar by adding GIF (Graphics Interchange Format) files of his/her favorite cartoon character in conversation and in standby mode to the system, using FaceRig [9] or other software. The system allows users to use their favorite characters as avatars. By adding these two files to the system, a live-action video of the ALS patient himself can be used as a voice interaction agent. By adding a voice model for each character and configuring detailed settings such as voice, speed of speech, and endings, the system can output different voices for each character. The system allows users to remotely communicate with their conversation partners via the spoken dialogue agent by transmitting the display screen of the spoken dialogue agent selected by the user on the shared screen of an online conference tool. The system also has a branch speaker output so that the user can talk not only remotely but also with a person nearby. In this paper, we call the proposed system Avatar Remote Communication System for ALS Patients (ARCS-ALS).

4 PROTOTYPE DEVELOPMENT

Section 4 details the development of the ARCS-ALS prototype system proposed in Section 3.

4.1 Outline of Prototype System

Figure 2 shows an overview of the prototype system. In this prototype, distributed processing is performed by a Windows PC and a Raspberry PI3B+ (hereafter referred to as "RPI"). The Windows PC is in charge of the main processing, and the RPI is in charge of the sub-processing. The main processing on the Windows PC is the input processing of the Eye Tracking interface (model EyeTracke4C/Tobii) [7] used by the ALS patient to operate the ARCS-ALS, the switching processing of the video in standby and conversational mode according to the speech synthesis of the spoken dialogue agent that talks on behalf of the ALS patient, the input processing of the video in standby and conversational mode according to the speech synthesis of the spoken dialogue agent that talks on behalf of the ALS patient. The RPI is in charge of the sub-processing, and is in charge of the video switching between standby and conversation, as well as the remote communication with the other party via ZOOM. On the other hand, RPI, which is in charge of sub-processing, outputs the input from the Windows PC to the voice of the spoken dialogue agent and instructs the Windows PC when to switch between the live-action video in standby mode and the live-action video during conversation. The text-to-speech output from the sub-processing (RPI) was input to the microphone on the Windows PC side of the main processing via the speaker output of the RPI. This allows the synthesized voice to be output to the other party via ZOOM. In addition, the system is designed to output the synthesized voice from the sub-processing (RPI) to the speaker on the ALS patient's side through a branch. This enables the patient to talk not only online but also with people in the vicinity. Open JTalk [10] was used for the speech synthesis of the spoken dialogue agent.

4.2 Application Screen

In the prototype of the proposed system, ARCS-ALS, we developed a voice dialogue application to be used by ALS patients when conversing with each other. Figure 3 is a general view of the prototype system developed for this project, and Fig. 4 shows the screen of the application developed this time. As shown in Fig. 4, the large character in the middle of the screen is the selected character. In other words, it will be a voice dialogue agent that will carry out conversations on behalf of the ALS patient. When the patient wants to change the selected agent to suit his/her preference, he/she can click on the character display on the right side of the screen to change the character automatically.

In this prototype, we prepared four characters: the user's own image, a child character, and animal characters of a dog and a cat. Two methods were prepared for the input of

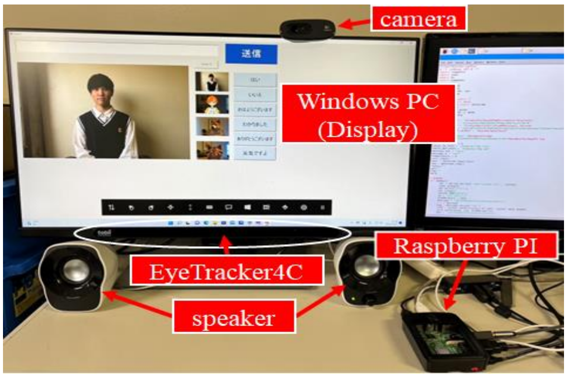

Figure 3: Prototype system developed for this project

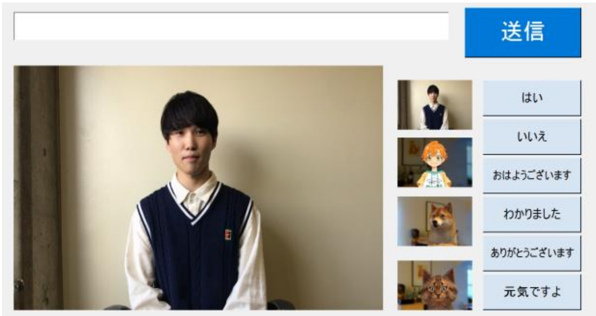

Figure 4: Application screen for ARCS-ALS

the conversation. In the first method, frequently used conversations such as replies, and greetings are registered in advance and can be spoken at the touch of a button. The second method is to use the keyboard, which is one of the functions of the eye control input interface, to input text. In this method, the ALS patient inputs what he/she wants to say using the keyboard and presses the "send" button to speak. Although it takes some time to input the content of the conversation, any kind of conversation can be sent.

4.3 Eye Tracking Interface

ARCS-ALS uses the Eye Tracking interface [7] as a method for ALS patients to talk. The reason for using this interface is that even ALS patients who have limb disabilities and have difficulty moving their bodies can use the Eye Tracking interface for eye control if they do not have eye problems. In our proposed system, we used an off-the-shelf eye tracking interface and the eye tracking function [7] that comes standard in Windows 10. To use the system, the Eye Tracking interface is connected to a Windows PC via a USB interface, and the main unit of the Eye Tracking interface is attached to the bottom of the monitor. After installing the driver, adjusting the position of the Eye Tracker 4C, and performing simple setups such as a visibility test, the system is able to detect the user's line of sight on the Windows PC screen. Next, by activating the eye control function that comes standard with Windows 10 and later, the user can click, use the mouse, and perform keyboard input, so even the physically challenged can operate the PC using only their line of sight. The Eye Tracking interface should be installed at an appropriate distance from the user, which is approximately 90 cm. If the

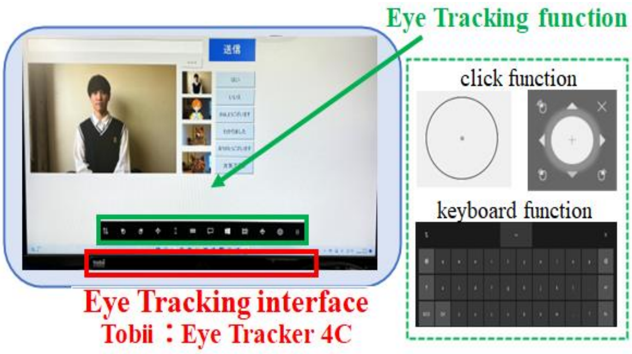

Figure 5: Overview of Eye Tracking interface

distance is too close or too far, the camera cannot be calibrated accurately and may not operate properly.

Figure 5 shows the eye tracking interface used in the prototype and the eye control function. The eye tracking interface attached to the lower part of the monitor (circled in red) recognizes the user's line of sight, and the eye control function (circled in green) is used to control the operation. By looking at the desired function for a certain period of time, the user can instruct the eye tracking function to display icons to select the desired location for clicking and a keyboard for inputting text, as shown in Fig. 5. At first, it may be a little difficult to operate the function you want to use, but as you gradually become accustomed to it, you will be able to operate it at will.

4.4 Voice Dialogue Agent

In the ARCS-ALS system, a voice dialogue agent is used which talks to the other party instead of the patient. The voice dialogue agent was created by applying our previous studies. In this prototype, we prepared four characters: a character created from the ALS patient's own image, a child character, and animal characters (a dog and a cat). This allows the user to choose one of the characters according to his or her preference and environment, such as those who want to show their healthy self when talking to other persons or those who want to appear to be a substitute cartoon character instead of their own image. The voice dialogue agent can be created in two main ways: as a CG character or as a live-action character. Figure 6 shows a summary of each method. First, CG characters were created using FaceRig [9] software, which allows the user to become any character using a webcam, and two GIF images were created: one in the standby mode (as if the user is listening to a conversation) and one in the conversational mode (as if the user is talking). By displaying the two GIF images in accordance with the speech state of the voice dialogue agent using text-to-speech output and switching the character, the mouth movements are synchronized with the video as if the character is actually speaking. The live-action character is an application of our previous work on creating CG characters. To create a live-action character, two live-action videos were actually shot using video equipment, one in the standby mode and the other in the conversational mode.

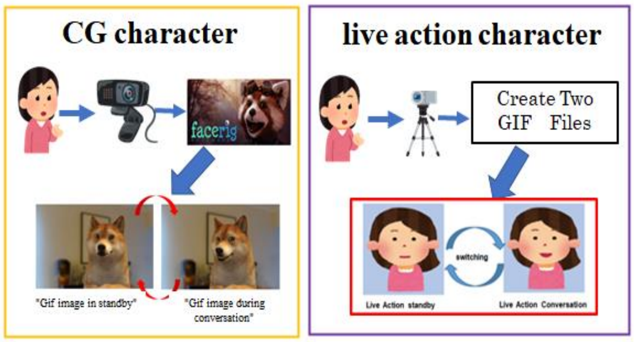

Figure 6 : How to Create Voice Dialogue Agents

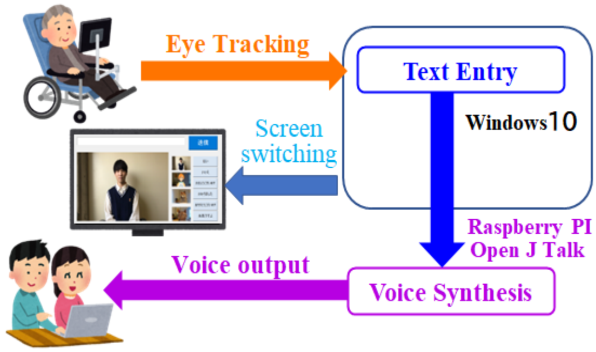

Figure 7: Speech synthesis output mechanism

As in the previous study, a live-action character is easily created by switching between the two GIF images in accordance with the speech state. In this case, it is necessary to shoot a short movie of 3 to 5 seconds and change the movie file to a GIF file. This makes it possible to repeat and play back the short video, which allows for longer text conversations. This method has the advantage that, once the user becomes accustomed to it, a live-action character can be created in about 10 minutes, making it possible to create a character of the person to be reproduced at a low cost. In addition, it is considered to be better to create the image of the ALS patient before the disease becomes severe, because it is considered to be practically difficult for the ALS patient to film himself after the disease has become severe Voice synthesis output.

The voice of the voice dialogue agent, which is the avatar of the ALS patient, is synthesized by Open J Talk [10], and its output is shown in Fig. 7. In this system, the ALS patient uses the eye control input interface to input the content of the conversation in text using the application developed in this study. The input conversation content is output as text-to-speech by Open J Talk [10], and the voice dialogue agent speaks the content. Acoustic models are prepared for each of the voice dialogue agents selected by the user, and the voice, speech style, and endings are changed for each character to speak. The dog CG character would end with "bow-wow" and the cat CG character would say "meow". On the other hand, when using a live-action character created from the ALS patient's own video, we prepared an acoustic model that closely resembled the patient's own voice, and then manually adjusted the parameters using Open J Talk to make the voice sound similar to the patient's own voice.

Specifically, the voice quality, which can be changed to feminine or masculine by changing related parameter values, the pitch shift, which changes the tone of the voice, and the speech speed, which changes the speed of speech, were adjusted to match the patient's voice. The values of these voice parameters were used because they can be fine-tuned, which actually takes time but produces highly reproducible voice. Other speech synthesis technologies include those that utilize AI technology to learn voices. Coestation [11] and LYREBIRD [12] are representative of these technologies. With these technologies, it is easy to produce a voice synthesizer that is close to the user's own voice by reading a few examples of sentences and having the AI learn those sentences. However, since the example sentences need to be learned repeatedly, it is not possible to train the AI for ALS patients who have difficulty in speech. Therefore, this system uses Open J Talk, which allows the user to manually adjust the parameters of the acoustic model based on the original voice.

5 EVALUATION

In this Section 5, a questionnaire evaluation was conducted to evaluate the prototype of the proposed system. This time, in addition to the questionnaire evaluation targeting ALS patients, the evaluation was conducted from three viewpoints targeting medical professionals who have knowledge about ALS patients, able-bodied persons. From the questionnaire evaluation, we investigated the effectiveness of the proposed system ARCS-ALS as a communication tool that enables ALS patients to enjoy talking with many people by their own power, and the functions and improvements that are required for this system.

5.1 Method of Evaluation

First, we conducted a questionnaire evaluation of one ALS patient through an acquaintance who had a close relationship with the patient. Face-to-face evaluation was difficult this time because of the coronary disaster. Although it was difficult to have the participants actually use the prototype, we asked them to understand the proposed system and to answer a questionnaire based on the assumption that they had used the prototype. This time, we evaluated the questionnaire on the assumption that the prototype was actually used, but we asked ALS patients who cooperated in this survey to fill out the questionnaire because they had experience using eye tracking interfaces in the past, and we thought they would give us their opinions. In the second evaluation, a questionnaire was sent to medical personnel involved with ALS patients. This time, a questionnaire evaluation was conducted on 26 medical personnel at several home health care nursing stations in Kanagawa Prefecture. In this survey, we created a video (about 9 minutes long) explaining the proposed system and showing an actual conversation using the prototype, so that the medical personnel could answer the questionnaire at any time according to their work schedule. The video was watched during breaks, etc., and the participants were asked to answer a questionnaire afterward. The Third evaluation was conducted with able-bodied persons. The questionnaire evaluation of able-bodied persons was conducted on 20 male subjects in their 20s. The survey method consisted of explaining the outline of the proposed system and the prototype to the subjects, having them watch a demonstration video of the actual use of the prototype (about 5 minutes), and then asking them for answering the questionnaire. The survey consisted of five major questions. These of evaluation procedure will be basically the same, just with different subjects.

5.2 Evaluation Results of ALS Patients

Table 1 shows the results of the questionnaire for ALS patients. The answer was "Yes" to the question 1 "Would you like to use the system you saw in the video? Yes" to the question "Would you like to use the system shown in the video? This indicates that the proposed system is useful from the viewpoint of ALS patients. In response to question 2, "In what ways would you like to use the system? The answers to all the questions were "I can use it by myself," "I can communicate easily," "I can communicate with others as my favorite character," and "I can talk with many people even if I cannot go out. In addition, "It is easy to listen to because of the voice synthesis and pronunciation intonation" and "Predictive text conversion is easy to use. These results indicate that the proposed system has achieved the objectives of the proposed system. Next, to question 3, "What would you like to use as a character for the spoken dialogue agent in this system? the answers were "My current live-action video," "My favorite animal (dog, cat, etc.) character," "My favorite animation," and so on. This suggests that the respondents would like to use not only their current live-action video, but also their favorite animals and favorite animation characters for conversation. In response to question 4, "What would you like to use as the voice of this system? the respondents answered "my voice","favorite star's voice", "favorite anime", etc., suggesting that they would like to select a voice that matches the avatar character they are using. Next, There were no responses to the question 5, "What improvements do you think are needed in the layout of the application screen of the system? In response to question 6, "In addition to the remote conversation function, what other service functions would you like to see in this system? was "more types of keyboards" as other opinions. Next, There was no answer to the question 7, "What do you think needs to be improved in the future? Finally, to the question 8, "Please feel free to give us any other comments or requests you may have. The last question was "Please feel free to give us any other comments or requests. I use the internet, YouTube, Facebook, LINE, and recently google spreadsheets instead of Excel. The rest I rarely use, so I thought it would be better to create a well-balanced system. Please let me make a decision after actually using the system. In summary, for ALS patients who responded to this survey, in addition to the avatar remote communication function, it would be useful to have various functions that would help them in their daily lives, such as remote control of home appliances, health management, and a doorbell.

Table1:Results of Questionnaire Evaluation of ALS Patient.

question	choice	Answer
Q1: Would you like to actually use the system you have seen in this video? (Or would you like to use the system you saw in the video?)	1. yes 2. no	1
Q2. If you answered "yes" to Q1. In what ways would you like to use it?	1. because I can use it by myself 2. because it is easy to communicate 3. because I can communicate with others as my favorite character 4. because I can communicate with many people even if I cannot go out 5. other	1 2 3 4 5 [It is easy to listen to the voice synthesizer, and the pronunciation can be inflected. Predictive conversion is also easy to use.]
Q3. What would you like to use as a character for the spoken dialogue agent in this system? Please select more than one.	1. past live-action videos of yourself when you were healthy 2. live-action video of yourself in the present 3. favorite animal (dog, cat, etc.) character 4. favorite cartoon or other character 5. other	2 3 4 5 [Furniture, musical instruments, and food]
Q4. what would you like to use as the voice of this system? Please select more than one.	1. your own voice 2. voice of your favorite star 3. voice of your favorite cartoon character 4. other	1 2 3
Q5. What improvements do you think are needed in the layout of the application screen of the system? Please select more than one that apply.	1. difficult to select canned text 2. the text box is too small and it is hard to input characters 3. difficult to select characters 4. small screen size 5. small character size 6. other	
Q6. In addition to the remote conversation function, what other service functions would you like to see in this system? Please select more than one that apply.	1. subtitling of conversations 2. function to remotely control home appliances 3. function to measure and manage the user's health (body temperature, pulse wave, Spo2, etc.) 4. function to provide daily life information such as weather, time, etc. 5. other 5. other	1 2 3 4 5 [More doorbells, zoom function, and keyboard types]
Q7. What do you think needs to be improved in the future? Please select more than one.	1. speed of conversation 2. awkwardness of response 3. gaze input 4. application 5. screen size 6. audio quality 7. other	
Q8. Please feel free to give us any other comments or requests.	I think it is better to start with less, as more features will cost more. I use the internet, YouTube, Facebook, LINE, and recently google spreadsheets instead of Excel. I rarely use the rest, so I thought it would be better to create a well-balanced system. Please let me judge the rest by actually using it.	

but however, considering the cost at the time of installation, we feel that a minimal number of functions is sufficient. In other words, in addition to the proposed remote communication function, it would be good if the user could watch YouTube videos on the Internet or send messages via SNS.

5.3 Evaluation Results of Medical Personnel

Figure 8 shows the results of the questionnaire for healthcare professionals involved with ALS patients. This time, the questionnaire was sent to 26 medical professionals involved with ALS patients. The gender of the respondents was 22 females and 4 males, and the age breakdown was as follows: 1 respondent was in her 20s, 8 were in their 30s, 10 were in their 40s, 5 were in their 50s, and 2 were in their 60s or older. To the question 1, "Do you feel that the system you saw in the demo video is a system that you would recommend to ALS patients? 96% of all respondents answered "Yes" and 4% answered "No". This indicates that more than 90% of the medical professionals highly evaluated the proposed system.

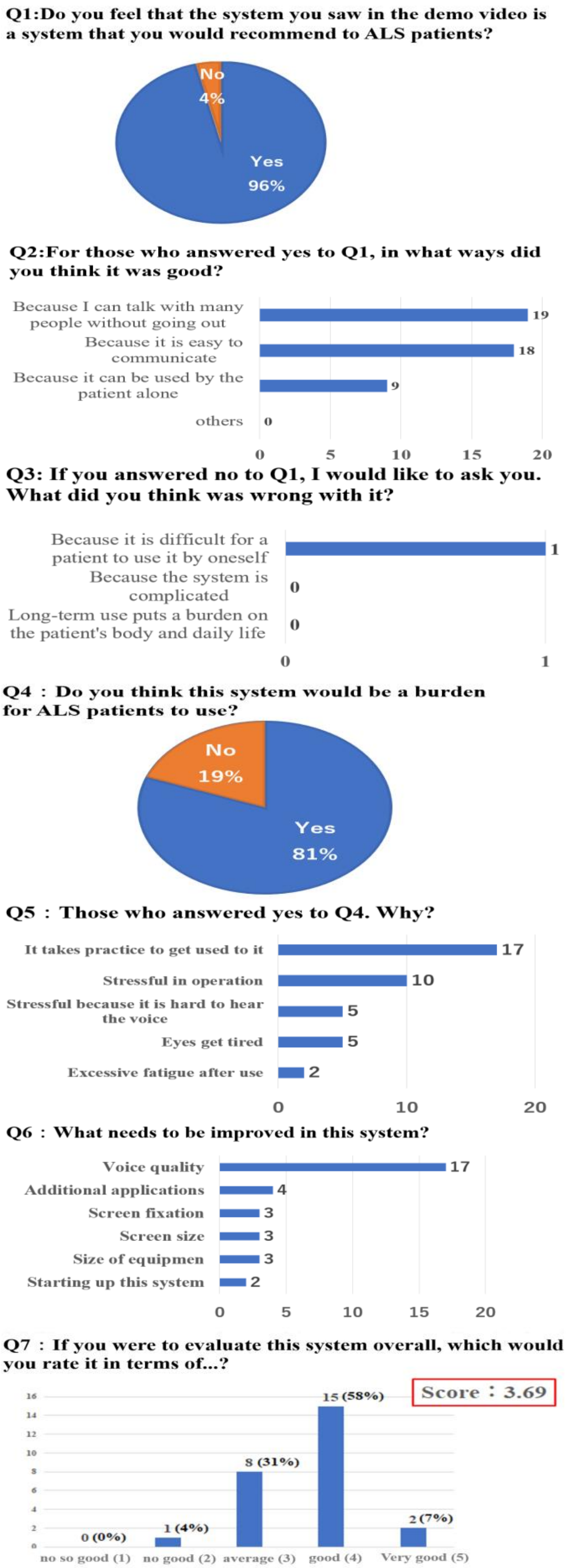

Figure 8: Questionnaire evaluation results for medical professionals.

Next, in response to question 2, "For those who answered yes to question 1, in what ways did you think it was good? " The most common answer was "Because I can talk with many people without going out" was 19 responses, followed by "Because it is easy to communicate" was 18 responses, and then "Because it can be used by the patient alone" was 9 responses. These results indicate that the proposed system's purpose of communicating with many people without having to go outside and its ease of use were well understood and appreciated by many medical professionals. Next, in response to question 3 of "If you answered no to question 1, I would like to ask you. What did you think was wrong with it?" one respondent answered "Because it is difficult for one patient to use it alone. Next, in response to question 4 of "Do you think this system would be a burden for ALS patients to use?" about 81% of all respondents answered "Yes," and about 19% of all respondents answered "No". In response to Question 5 of " Those who answered yes to question 4. Why?" , the most common answer was "It takes practice to get used to it" was 17 responses, "Stressful in operation" was the second most common was 10 responses, and "Stressful because it is hard to hear the voice" and "Eyes get tired" were the third most common was 5 responses. This indicates that many respondents thought that the system requires practice before they get used to it, and that many healthcare professionals thought that the system would be stressful to operate. Next, in response to question 6, "What needs to be improved in this system?" the most common response was "voice quality" with 17 responses.

Other responses were "additional applications" was 4 responses, "screen fixation," "size of equipment," and "screen size" was 3 responses, and "starting up this system" was 2 responses. This suggests that the current system is difficult for ALS patients to listen to due to the poor voice quality of the avatar character speaking. Finally, to question 7, "If you were to evaluate this system overall, which would you rate it in terms of...?" 7% of all respondents answered "very good (5)," 58% answered "good (4)," 31% answered "average (3)," 4% answered "not good (2)," and 0% answered "not so good (1)." The total of "very good" and "good" responses amounted to 65% overall. The average score on a 5-point scale from "very good: 5" to "not so good: 1" was about 3.69, which is a reasonably high rating. Therefore, although the proposed system needs to be improved in terms of "voice quality" and "requires practice until the user becomes familiar with the operation," the system is considered to be reasonably useful for ALS patients from the viewpoint of medical professionals who are usually involved with ALS patients.

5.4 Evaluation Results of Able-bodied Persons

Figure 9 shows the results of the questionnaire with able-bodied persons. All respondents answered "Yes" to the first question, "Do you feel that you would recommend this system to ALS patients?" For those who answered "yes," the second question was asked: "In what ways do you think this system is recommended for ALS patients?"

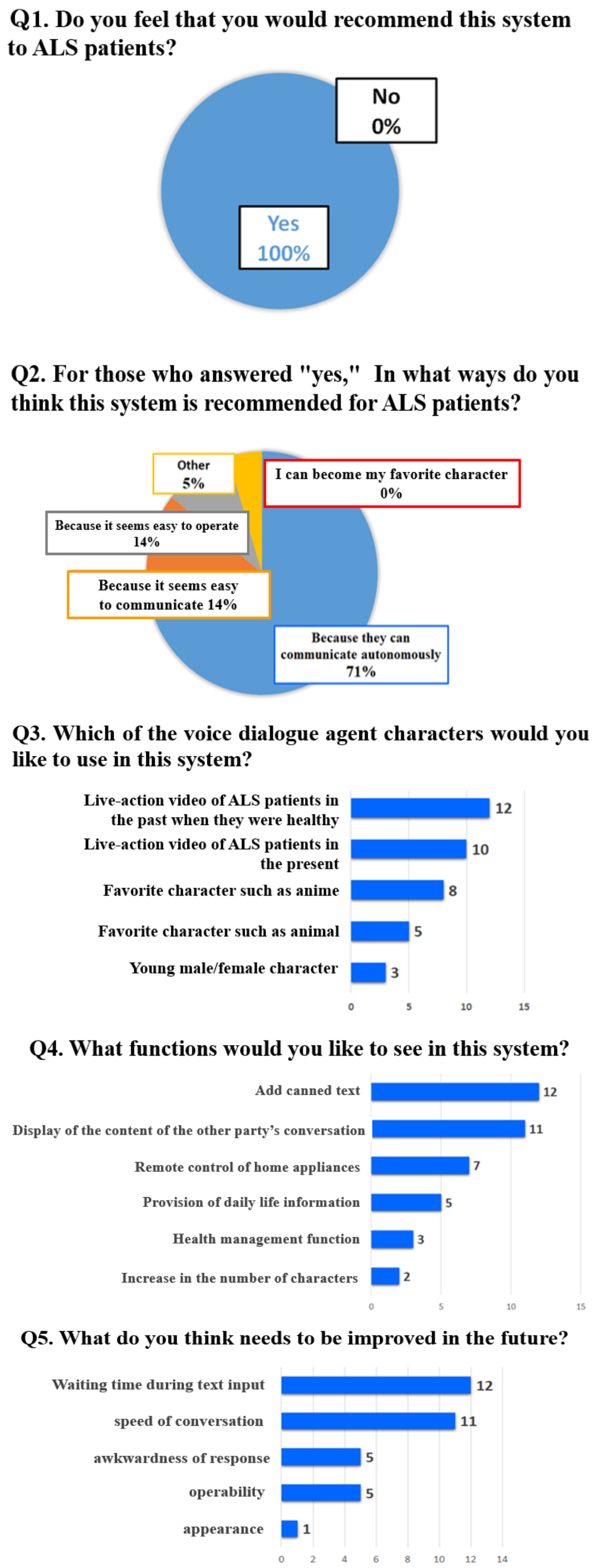

Figure 9: Questionnaire evaluation results for able-bodied persons.

The most popular answer was “Because they can communicate autonomously (71%)”. The next most common answer was "Because it seems easy to communicate" (14%), followed by "Because it seems easy to operate" (10%), and "Because I can become my favorite character" (0%). The other responses were "the cost of introduction is low" and "it is easy to use”. Next, Question 3 was asked: "Which of the voice dialogue agent characters would you like to use in this system?” The most common answer was "Live-action video of ALS patients in the past when they were healthy" (12 responses), and "Live-action video of ALS patients in the present" (10 responses), both of which were answered by more than one half of all the respondents. Among the other responses, "Favorite character such as anime" was selected by 8 respondents, "Favorite character such as animal" by 5 respondents, and "Young male/female character" by 3 respondents, indicating that "Favorite character such as anime" was the most sought-after character for ALS patients other than live-action videos. As for Question 4, "What functions would you like to see in this system?”, the two most popular responses were “add canned text” (12) and “display of the content of the other party’s conversation” (11). The next most common responses were "remote control of home appliances" (7), "provision of daily life information" (5), "health management function" (3), and "increase in the number of characters" (2). Finally, to Question 5, “What do you think needs to be improved in the future?”, the most common response was "waiting time during text input" (12 responses), followed by "speed of conversation" (11 responses), both of which were cited by more than one half of the respondents as an area that needs improvement. Next were "awkwardness of response" and "operability" (5 responses each), and "appearance" (1 response).

5.5 Summary of Evaluation Results

In this prototype evaluation, the proposed system was evaluated from various perspectives by ALS patients, medical professionals working with ALS patients and able-bodied persons. As a result, more than 90% of the respondents answered that they would recommend the proposed system to ALS patients, and the system was highly evaluated. The reasons for this are as follows: "I can use the system by myself," "I can communicate easily," "I can communicate with others as my favorite character," and "I can talk with many people even if I cannot go out," according to the questionnaire results from the ALS patients' side.

On the other hand, the most common response from medical professionals involved with ALS patients in the questionnaire was "I like the fact that I can talk with many people without going out", followed by "I can communicate easily" and "The patient can use the system alone". This indicates that the medical professionals involved with ALS patients understood and highly evaluated the features of the proposed system. On the other hand, however, when medical professionals were asked, "Do you think this system will be a burden for ALS patients? 81% of the respondents answered that the system would be a burden for ALS patients. The reason for this is that it requires practice until they become accustomed to its operation. Also, some respondents felt that the proposed system is burdensome in terms of operation. This point is considered to be an issue for the future of this system. Next, we asked, "Are there any functions you would like to see in the proposed system? The ALS patient's answers were "a function to display conversations," "a function to remotely operate home appliances," "a function to measure and manage the user's health (temperature, pulse, SpO2)," "a function to provide daily life information such as weather and time," etc., as well as "a doorbell and zoom function.

However, in consideration of the cost at the time of installation, ALS patients' opinions indicated that, as a minimum, in addition to the proposed remote avatar communication function, they would like to be able to watch YouTube videos on the Internet and send messages via SNS. Furthermore, when asked, "What do you think needs to be improved in the future?" the ALS patients answered that there were no areas that needed improvement, while the medical professionals most frequently asked for improvement in "voice quality. This indicates that the quality of the voice output from the avatar is something that needs to be improved in the future. In addition, the medical professionals who responded to the questionnaire gave the proposed system a five-point overall rating, with an average score of 3.69, indicating that they gave the system a reasonably high rating.

6 CONCLUSION

In this paper, we proposed a remote video communication using eye-tracking for ALS patients who have difficulty going out. additionally, we proposed a system that allows you to have a pleasant conversation with many people remotely using avatars, which are your favorite spoken dialogue agents. The proposed system utilizes an online conferencing tool as a method of conversation with other parties, and uses an interface that can be operated by the ALS patient himself/herself by using an eye tracking interface. In addition, we have developed a new dedicated application for ALS patients to conduct a conversation. This enables ALS patients to easily converse with many people at their own will without the help of others. In addition, we developed an actual prototype of the proposed system and evaluated the prototype. In the evaluation, the prototype was evaluated from two perspectives: a questionnaire evaluation for ALS patients themselves and a questionnaire evaluation for medical professionals involved with ALS patients. The evaluation results confirmed the effectiveness of the proposed system, ARCS-ALS. We were also able to confirm the required functions of the system and points to be improved.

7 FUTURE WORK

Through the development and evaluation of the prototype of the proposed system, we have learned some details that need to be improved, and we plan to improve this prototype for practical use in the future.

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