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Dialogue Generation for Robot Family Using ROS and Generative AI: Initial Implementation of Centralized and Distributed Systems

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Abstract— **The problem of human isolation and loneliness is growing worldwide. Although there are ways to provide human support, there are sustainability issues, so support using conversational physical partners, such as robots, is attracting attention as an alternative solution. Most previous attempts have been based on a single robot, and there are few attempts that use multiple robots, especially those that form a family and try to save the user from isolation and loneliness. This study aims to develop a basic infrastructure system to realize such a family consisting of multiple robots and a single human. More specifically, in this paper we report on the implementation and preliminary verification of two types of dialogue generation for robots using ROS (Robot Operating System) and GPT-4o-mini: one is a centralized system (in which the command center generates conversation scenarios for each robot in batches) and the other is a distributed system (in which each robot generates conversations individually).**

I. INTRODUCTION

Isolation and loneliness are serious problems in society. Loneliness is a subjective mental state of feeling alone, and isolation is considered a state of objective lack of social connection [1]. The Office of the Surgeon General (OSG) in the United States reports that lack of social connection has a health risk equivalent to smoking up to 15 cigarettes a day [2], indicating that the problem of loneliness and isolation is a major health risk. In Japan, the government has been promoting measures to combat loneliness and isolation, and surveys have shown that not only the elderly, but also people in their 20s to 50s feel lonely [3]. It has also been reported that loneliness is not necessarily caused by social isolation alone, but is influenced by the relationship with one's spouse, such as feeling lonely due to dissatisfaction with affection, even if one has a spouse [4]. In other words, not only physical connection with people, but also psychological and emotional connection are considered important in alleviating isolation and loneliness.

Robotics solutions include a telepresence robot with mobile videoconferencing capabilities [5] and a non-humanoid robot that presents a sense of "being-watched" [6]. Devices to support isolation and loneliness include virtual tour using VR [7] and the smartphone-based app "Nod" [8]. However, these existing studies use a single robot or device, and the effectiveness of multiple robots working together to support isolation and loneliness has not been fully tested. There are also studies that use multiple robots, such as three robots interacting with each other at a real event [9], but they have not yet been applied in the context of alleviating loneliness and isolation.

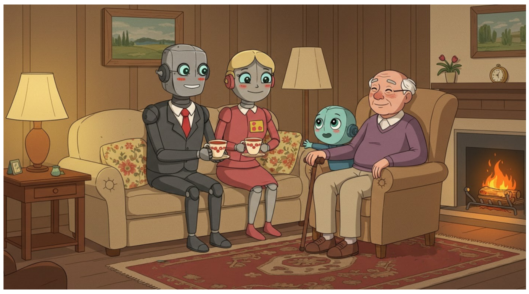

Fig. 1. A concept diagram of a family composed of multiple robots and an elderly person living alone. (Generated by ChatGPT)

Therefore, we will explore the use of multiple robots to alleviate the isolation and loneliness of people who live alone. The ultimate goal is to alleviate the isolation and loneliness of people living alone by forming a small society between multiple robots and the person, similar to a human family, and providing the psychological security that a family provides (Fig. 1). In a previous attempt, the use of robots in human families was discussed [10], but in this study our goal is to form a family with multiple robots added to a person. With this ultimate goal in mind, this paper reports on the initial implementation of two types of dialogue generation for robots using ROS (Robot Operating System) [11] and the GPT-4o-mini API [12]: one is a centralized system (in which the command center generates conversation scenarios for all robots at once), and the other is a distributed system (in which each robot generates conversations individually). An initial pilot study was also conducted to compare and analyze the characteristics of these systems, and to identify factors that promote more family-like interactions.

II. RELATED WORKS

A. Human Support to Alleviate Isolation And Loneliness

An example of human support to alleviate isolation and loneliness is community activities in which local people interact with each other. Children's cafeterias in Japan provide a place for diverse generations in the community, from the elderly to children, to enjoy meals and social interaction together [13]. However, children's cafeterias are generally held once or twice a month, which is difficult to support on a continuous basis [14].

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Another international example is the Men's Shed in Australia [15]. The Men's Shed is mainly for elderly men to build community connection, alleviate loneliness, and promote physical and mental health through woodworking activities and furniture making, etc. However, this activity is also limited in frequency (2, 3 times a week), and it remains a challenge to provide continuous and routine support.

B. Robotic Support to Alleviate Isolation And Loneliness

Robotic support for isolation and loneliness differs from human support in that it offers the advantage of continuous and routine support. For example, Rheman et al. conducted a long-term study that placed mobile telepresence robots with videoconferencing capabilities in the homes of elderly people in New Mexico, USA, over a 7-month period. The results suggest that robots can improve social connectivity and alleviate loneliness among the elderly [5]. Zuckerman et al. also developed a robot with a non-humanoid abstract design that presented nonverbal gestures to the elderly. By doing so, the robot gave the elderly a sense of "being-seen" and evoked positive emotions [6]. However, most of these studies were conducted using a single robot, and there are no studies using multiple robots to help people with isolation and loneliness.

On the other hand, there are also studies on the effects of interaction with multiple robots. For example, Iio et al. compared single and multiple robot conversations and reported that conversations with multiple robots lasted longer and made better impressions [9]. Okada et al. showed that cooperative apologies of two robots were preferred and made more favorable impressions than the apology of a single robot, suggesting that multiple robots' interaction may have a positive impact on users [16]. Thus, cooperative interaction among multiple robots may be effective in alleviating isolation and loneliness, but direct adaptation of such an interaction has not yet been made. In addition, a study by Sakamoto et al. on LOVOT [17] reported that people have family-like feelings through interaction with robots [18]. Therefore, family-like interactions using multiple robots may be effective in alleviating isolation and loneliness. However, there is currently no research on robots that perform such family-like interactions.

C. Device Support to Alleviate Isolation And Loneliness

Technology-based approaches, such as virtual reality (VR) and mobile applications, are also gaining attention for alleviating isolation and loneliness. Oppert et al. conducted group and individual VR virtual tours with elderly people and tested the effects on increasing social connection [7]. The results suggested that group virtual tours had the potential to increase social connection, but participants were less likely to perceive the virtual tour as similar to an actual trip and rated it moderately well in terms of promoting social interaction.

In addition, the "Nod" smartphone app is designed to alleviate students' feelings of isolation as they transition from high school to college [8]. Nod includes suggested activities to promote social interaction, emotional reflection, and exercises to promote cognitive restructuring, and the presentation of other students' experiences. The results of the experiment suggested that Nod may prevent the worsening of loneliness and depressive symptoms in students with high loneliness and depressive symptoms, but no significant effect was found in students with low loneliness and depressive symptoms. Unlike device-based approaches, which indirectly promote human-to-human interaction, the proposed robot family system provides a form of human-robot interaction that can occur even when other humans are not present.

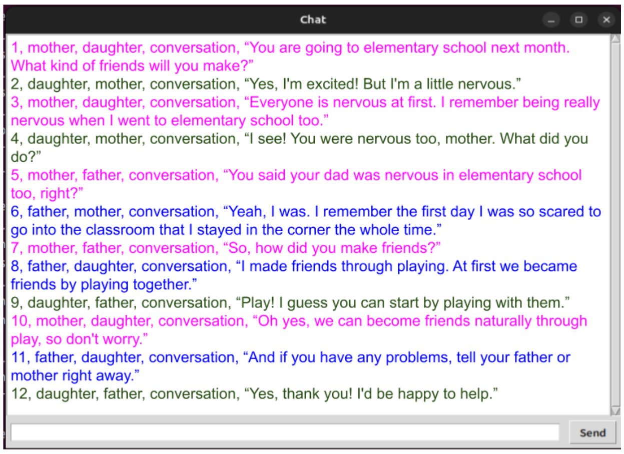

Fig. 2. Chat Screen. The interface is simple, with minimal visual information. Each family robot member is automatically color-coded. Users can intervene in the conversation by asking questions to the family robot members using the input form at the bottom of the screen.

D. Family-Robot Interaction

Cagiltay et al. propose a framework called Family-Robot Interaction [10]. This framework aims to consider the entire family as a single system when designing human family-robot interactions and to examine the overall impact of the robot on the family. Specifically, it consists of three systems: the Contextual System, which considers the characteristics and relationships among family members; the Robot System, which examines the technical features, functions, and design of the robot; and the Family System, which considers the environment in which the interaction takes place. In addition, the interactions between these systems are constrained by four dimensions: roles, goals, processes, and time [10]. However, this framework is designed for the robot to intervene in a human family, and the approach to alleviating isolation and loneliness is not taken by having the human participate in the familial environment formed by robots.

Additionally, research has developed a non-anthropomorphic, non-vocal robot called "Yōkobo" aimed at bridging the loneliness gap between newly retired couples and strengthening a possible link within them [19]. However, Yōkobo is specialized solely to function as an "intermediary" for enhancing the couple's relationship and does not possess the role of a family member.

III. Dialogue Generation for Robot Family

A. System Implementation

We plan to implement this system on real robots, so the actions we deal with will not be limited to dialogue generation, but in this study we will deal with dialogue generation as a first step towards that goal. The overall picture of the system is a multi-agent system, where each robot is considered an agent. Since multi-agent systems are generally divided into two types, centralized and distributed [20], this study also attempts to implement two types of system, a centralized type and a distributed type, to compare their behaviors and obtain guidelines to design an ideal system.

In this study, considering future implementation in real robots, we used ROS (Robot Operating System) [11], which is a robot development middleware that can be used not only in real robots but also in simulation environments. ROS offers the advantage of modularizing multiple processes to enable parallel and distributed processing. ROS2 Jazzy was used to perform parallel and distributed processing of multiple functions. In addition, we implemented the dialogue generation function by calling the GPT-4o-mini API [12], which has excellent response speed and accuracy, from Python. In addition, the ROS communication function was used to enable data communication between each family robot member. Using these features, we developed two types of dialogue systems: a centralized and a distributed system, as described below. As a first prototype, we developed a simple text chat-based interface as shown in Fig. 2 that minimizes visual information as much as possible. By placing a form that users can enter, the system allows the users to talk to each family robot member.

B. Centralized System

The concept of a centralized system is shown in Fig. 3. In this method, the master generates dialogue scenarios in batches using GPT-4o-mini API, and then gives instructions to each family robot member individually. Therefore, there is no direct communication between each robot in reality, and the dialogue proceeds in a way that the system indirectly makes it appear as if each robot is talking to the other. For data communication between the master and each robot, ROS is used. The centralized system has the advantage that scenarios are generated in batches, so the overall system is highly consistent and the dialogue rarely deviates, but it has the disadvantage of being vulnerable to external disturbances such as sudden intervention by the user.

An example prompt for GPT-4o-mini used in a centralized system is shown in Fig. 4. The Temperature parameter related to output randomness was set to 0.8 (default is 1.0) that was obtained after an exploratory study of the balance between randomness and robustness of the output when generating it to ensure a little consistency. The output format is of the form *"number, subject of action, object of action, action, content of action,"* for example, *"2, father, daughter, conversation, How was your day?"* The user can intervene in the conversation at any time. Although the type of action

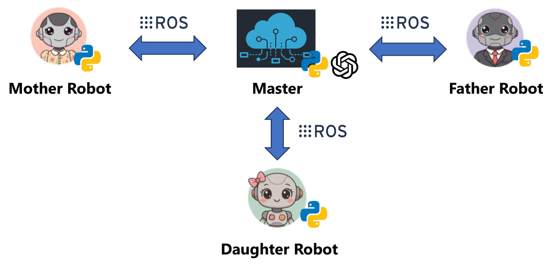

Fig. 3. Conceptual Diagram of a Centralized System. The master generates family robot dialogue scenarios in batches using GPT-4o-mini API, and gives instructions to each family robot member. By doing so, it appears that each robot member is indirectly talking to each other. The master and each robot member send and receive data through the ROS communication.

A family robot consisting of the **# Family Structure** has come to the **# Target User**. You are a professional writer. Create a "daily life scenario of the family robot" based on the **# Requirement Specification**, **# Conversation History** and **# Theme**, and output it in the **# Output Format**. If the target user intervened (with "User Intervention:"), choose one family member from the **# Conversation History** who is best suited to answer based on the previous conversation, and set that family member as {{action_subject}}.

 # Requirement Specification
- The family member's daily conversation will be developed and the topic will be discussed in depth. However, if there are many "~?" questions in the **# Conversation History**, the family member should be able to express his/her opinion or thoughts without asking questions.
- If the **# Conversation History** shows that {{action_subject}} becomes {{action_object}}, and {{action_object}} becomes {{action_subject}} more than 5 times, encourage other non-participating family members to join the conversation.
- The {{action_subject}} is limited to the family members in the **# Family Structure**.
- Each family member should have the characteristics of his/her assigned role (tone of voice, how to address other family members, etc.) and use a casual tone in family conversations.
- If there are pets in the **# Family Structure**, they will only make noises and not speak, just like in the real world.

 # Conversation History
{chat_history}

 # Theme
{theme}

 # Family Structure
{family_structure}

 # Target User
{target_user}

 # Action List
- Conversation

 # Output Format
{{number}}, {{action_subject}}, {{action_object}}, {{action}}, {{action_content}}
Ex:1, father, mother, conversation, "You left your socks on again."

Fig. 4. Prompt for Centralized System.

is limited to "conversation" in this study, we believe that adding different types of actions. For example, in the future, we plan to add a "move" command. In advance, we will prepare basic action functions such as moving forward and rotating. By using an LLM to call these functions, we aim to enable movement.

C. Distributed System

On the other hand, the concept of a distributed system is shown in Fig. 5. In this system, each family robot member uses GPT-4o-mini API to generate a one-line dialogue scenario in each case, in which he/she is the main subject, and the robots interact with each other in real time. This mechanism allows direct interaction between robots and

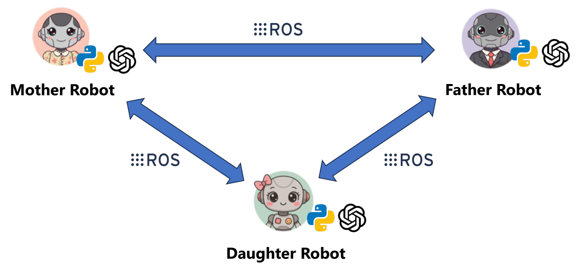

Fig. 5. Conceptual Diagram of a Distributed System. Unlike the centralized system, each family robot member interacts directly with each other. Each robot uses the GPT-4o-mini API to generate a one-line dialogue scenario that makes itself the subject of the action.

makes it possible to build a system that is resistant to sudden user intervention and other disturbances, but it is more difficult to maintain the consistency of the entire conversation compared to a centralized system. The distributed system also uses ROS for data communication processing. Even when using actual robots in the future, it will be possible to exchange data with each robot via Wi-Fi.

An example prompt for GPT-4o-mini used in a distributed system is shown in Fig. 6. The temperature parameter and output format are the same as the centralized system, but only one line of scenario is generated.

D. System Functions

1) Setting Family Composition and Theme: In the system proposed in this research, family composition (number of members and roles) and family theme (family motto, goals, etc.) can be set interactively via the terminal. For example, a family of three members, including a father robot, a mother robot, and a daughter robot, can be set up, and the family theme can be set to something like *"daughter robot starting elementary school."* This theme setting enables interaction based on the theme. For example, the cleaning robot iRobot Roomba [21] generally tries to optimize cleaning efficiency, but if the theme is *"family love,"* it can be expected to behave in a more human-like and natural way to fit in with the human living environment, such as avoiding cleaning family memorabilia. The settings are saved in a file in json format and are automatically loaded when the program is executed.

2) Dialogue Generation: Based on the set family theme, GPT-4o-mini generates dialogue scenarios according to the requirement specifications.

3) User Intervention: Users can freely send messages to specific robot members through the input form at the bottom of the screen. For example, the user can ask a question to the daughter robot, such as, "What is your favorite food?" The user's intervention is detected via ROS communication, and GPT-4o-mini determines which robot should respond.

4) Chat Screen: The generated dialogue is displayed on the chat screen, with different colors for different family members and users to increase visibility. The chat screen is shown in the following format: the left side of the colon is the talker and the right side is the content of the dialogue.

A family robot consisting of the **# Family Structure** has come to the **# Target User**. You are a {role}. Be sure to fix the subject of the action to yourself ({role}). Create a single line of "daily life scenario of the family robot" based on the **# Requirement Specification**, **# Conversation History** and **# Theme**, and output a single line in the **# Output Format**. If the target user intervened (with "User Intervention:"), choose one family member from the **# Conversation History** who is best suited to answer based on the previous conversation, and set that family member as {{action_subject}}.

 # Requirement Specification
・The family member's daily conversation will be developed and the topic will be discussed in depth. However, if there are many "~?" questions in the **# Conversation History**, the family member should be able to express his/her opinion or thoughts without asking questions.
・If the **# Conversation History** shows that {{action_subject}} becomes {{action_object}}, and {{action_object}} becomes {{action_subject}} more than 5 times, encourage other non-participating family members to join the conversation.
・The {{action_subject}} is limited to the family members in the **# Family Structure**.
・Each family member should have the characteristics of his/her assigned role (tone of voice, how to address other family members, etc.) and use a casual tone in family conversations.
・If there are pets in the **# Family Structure**, they will only make noises and not speak, just like in the real world.

 # Conversation History
{chat_history}

 # Theme
{theme}

 # Family Structure
{family_structure}

 # Target User
{target_user}

 # Action List
・Conversation

 # Output Format (single line only)
{{number}}, {{action_subject}}, {{action_object}}, {{action}}, {{action_content}}
Ex:1, father, mother, conversation, "You left your socks on again."

Fig. 6. Prompt for Distributed System.

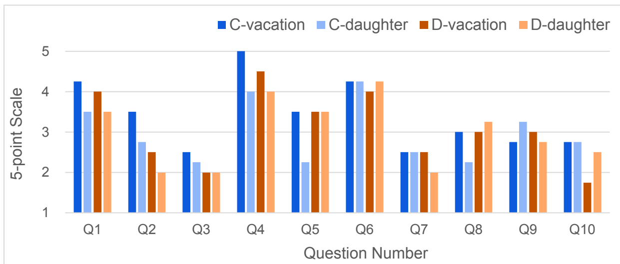

Fig. 7. Results of 5-point Evaluation of Pilot Study. We denote the centralized system as "C," the distributed system as "D," Theme 1 (Planning a family vacation next month) as "vacation," and Theme 2 (Daughter to start elementary school next month) as "daughter."

5) Dialogue History: A dialogue log is automatically saved to a text file each time a dialogue is generated, and included in the prompts to the GPT-4o-mini in the next session, thereby enabling continuous interaction that maintains the context of the dialogue.

IV. Pilot Study

The objective of the pilot study is to compare a centralized system with a distributed system, and to gain insight into the ideal system design for future implementation on real robots.

A. Settings

Participants were four laboratory members (Age_Mean = 23.250, Age_SD=0.433, Male=2, Female=2).

In the pilot study, two themes were set up to facilitate user intervention: “discussing together” and “advising someone.” The family composition and target users were as follows.

Theme1: Planning a family vacation next month

Theme2: Daughter to start elementary school next month

Family Structure: Father, Mother, Daughter

Target Users (played by participants): Elderly living alone

The participants participated in the family robot dialogues as the target user. The order in which the themes were presented were randomly determined for each participant.

B. Methods

The participants were given the opportunity to experience both centralized and distributed systems. First, after a short tutorial on how to use the chat screen and how to chat, the participants were free to experience each system for five minutes, respectively.

The dialogue among the robots started automatically when the author executed the program. Whether and when the user intervened in the robot’s dialogue was left to the participant’s own decision.

After the experience with each system, a questionnaire containing a 5-point scale and open-ended questions and a short verbal interview were conducted for each of the systems. The questionnaire items were given four times in total for a combination of system type (centralized or distributed) and themes (two themes). The order of the system experiences was randomly determined for each participant. The questions in the questionnaire were as follows.

Q1. Was the flow of the dialogue consistent throughout the entire dialogue with the family robot? (5-point scale)

Q2. Did you feel that the robot’s dialogues were similar to actual human family dialogues? (5-point scale)

Q3. Was the content of the dialogue consistent with the theme? (5-point scale)

Q4. Did you feel that the family robot responded smoothly to your intervention? (5-point scale)

Q5. When you intervened, did the response of the family member correspond to what you intervened in? (5-point scale)

Q6. Were you satisfied with your dialogue with the family robot? (5-point scale)

Q7. Did you feel like you were part of the family through your dialogues with family members? (5-point scale)

Q8. Did you feel lonely while talking to the family robot? (5-point scale)

Q9. How did you feel when you had dialogues with the family robot? (open-ended)

Q10. What is your impression of the robot? (open-ended)

V. Results and Discussions

The purpose of this pilot exploratory study was to gain insight for future applications to real robots. Due to the limited number of participants, no statistical analysis was conducted. The results of the 5-point evaluation of the pilot study are shown in Fig. 7.

A. Consistency of Dialogue (Q1)

The centralized system was rated slightly more consistent in dialogue than the distributed system. In addition, the vacation theme was rated as more consistent in dialogue than the daughter theme. This is thought to be because the centralized system generates the entire scenario at once, making it easier to maintain the consistency of the context.

However, a participant commented that the same message was continuously displayed after the user intervened. We investigated and found that this was due to a conflict between the signals for the process of continuing the dialogue before the user’s intervention and the signals for the process of responding to the user’s intervention, which needs to be improved. Also, with regard to the theme of family travel, comments such as *“I felt that the system was listening to me carefully because it proposed other opinions in relation to my own opinion”* indicated that the experience of having one’s own opinion accepted by the system may have enhanced the evaluation of the consistency of the dialogue.

B. Humanity of Robot Dialogue (Q2)

The centralized system was rated as more human-like dialogue than the distributed system. In addition, in a thematic comparison, the vacation theme was rated as a more human-like dialogue than the daughter theme. This result may be related to the consistency of the dialogue identified in the previous question (Q1). The participants commented that *“I felt like this is how I talk to my grandparents that I haven’t seen in a long time, so in a way I felt like it might be real.”* and *“This is the first time I had a conversation with multiple AI at the same time, but it felt more human-like than I had imagined.”* This response suggests that the generated dialogues are similar to actual family conversations.

C. Consistency with Theme (Q3)

The centralized system was rated slightly more consistent with the theme than the distributed system, and by theme, the vacation theme was rated as a more consistent dialogue with the theme than the daughter theme. Overall, the evaluation values were high, with one participant commenting positively that *“I could see how much the parents cared about their daughter.”* This suggests that setting a clear theme may be important in designing a family robot system.

D. Smoothness of Response to User Intervention (Q4)

There were no large differences in overall evaluations between centralized and distributed systems. However, in the daughter theme of the centralized system, the response to user intervention was rated as not smooth. The participants commented that *“I felt like I was being intentionally ignored because of the delay in reflecting the results of my intervention.”* and *“The delay during the intervention makes me anxious.”* This suggests that if the user’s response to intervention is delayed, the tempo of the conversation may be interrupted, giving a negative impression of anxiety.

E. Adequacy of Response to User Intervention (Q5)

While there were no major differences between the centralized and distributed systems, overall the evaluations were high. The participants commented that *"I felt a little warmth from the family because they reflected well when I intervened in the dialogues."* and *"It is good that they always respond positively to my interventions."* These results suggest that the user's interventions are appropriately reflected in the system's conversations, leading to positive evaluations.

F. Satisfaction with Robot Dialogue (Q6)

No major differences were found between the centralized and distributed systems. Satisfaction with the daughter theme in the distributed system was particularly low, but overall satisfaction was not very high either. This may be due to the unfinished elements of the system, such as the lack of naturalness of the dialogue and the lag after user intervention, as mentioned previously, which reduced the user experience.

G. Oneness with Family Robot (Q7)

Although there was no major difference between the centralized and distributed systems on the theme of family vacation, the distributed system was rated slightly more integrated with the robot on the theme of the daughter. The participants commented that *"I felt like I was part of the family." "I felt like I was a member of the family and had a conversation with them."* and *"I get the feeling that I am talking to my family."* This suggested that the users could get the feeling of being part of the family robot.

On the other hand, one participant pointed out that *"The speed of the conversation was so fast, it went so fast without the user's intervention that I didn't feel like I was part of the family"*, suggesting that too fast a conversational tempo could undermine the user's sense of unity with the family.

H. Feeling of Loneliness (Q8)

The centralized system was rated less lonely than the distributed system on family vacation. One participant felt that *"I felt that if you limit the number of interventions, the impression would change quite a bit, because it depends on whether or not the user actively intervenes to fit in,"* which suggests that the number of user interventions may have an impact on the decrease feeling of loneliness.

I. Comments on Talking to the Family Robot (Q9)

One participant commented, *"There was a moment in the middle when the daughter imitated my tone of speech, which was rather likable."* In fact, there was a scene in which the daughter robot happened to imitate the grandfather tone of speech that the participant typed in, and the participant laughed at the scene. In this way, the action of the robot imitating the user's speech can be an element that gives the feeling of a real family conversation.

Also, *"I felt a sense of closeness with some of the situations where family robot was asking questions of me as well."* while others commented, *"I was sad that it was displayed as if someone from my family was speaking for me, as I felt like my comments were being rephrased."* These suggest that questioning the user is an important part of the conversation with the family robot, and that uneven frequency and timing of questioning may have affected the impression.

Furthermore, *"Even when I responded badly to the robots, they always responded like a Buddha, so I didn't feel much humanity."* was also pointed out, and the participants sometimes asked for negative responses. From this, it is believed that incorporating a variety of responses, such as scolding or cautioning depending on the situation, like an actual family member, rather than always responding positively, will lead to more realistic and human-like dialogues.

J. Impressions of the Family Robot (Q10)

The comments such as *"Image of a very common family" and "I get the impression that the family is kind and acts kindly even to me, a non-family member"* suggested that the participants perceived the family robot as a warm and friendly family member and were willing to join in the center of the conversation.

On the other hand, some pointed out that *"the impression was of a family whose opinions were too extreme and too honest,"* and indeed, in some cases, the impression was that each family member expressed his or her own opinion unilaterally without fully discussing it with the other. This suggests the need to improve the conversation design in the future to incorporate more diverse viewpoints and to encourage cooperation with the other party's opinions.

K. Gained Findings

The main findings from the above results are as follows.

- To generate consistent and human family-like conversations, a centralized system is better suited than a distributed system. This is thought to stem from the fact that enhancing the autonomy of individual agents does not necessarily strengthen the sense of unity as a family. Even when each individual acts optimally, the system as a whole may still produce undesirable outcomes.
- It is important in the design of family robots to pre-set the theme and follow it through the dialogue.
- The implementation of functions that mimic the user's tone of speech, express opposite opinions, or ask questions of the user will allow for more realistic and family-like conversations.

L. Limitations and Future Works

In this study, there are several limitations.

1) Issues with the Pilot Study: This pilot study involved only four participants, a very small number. Furthermore, recruiting elderly participants proved difficult, so no actual seniors participated. Therefore, the content and pace of young people's conversations may differ from those of older adults in reality. To approximate an experimental setting targeting the elderly as much as possible, participants were asked to talk as if they were elderly individuals. However, conducting deeper analysis is challenging under these conditions. Therefore, future studies must increase the number of participants and recruit actual elderly individuals to conduct the experiment. In addition, since the experimental time is as short as 5 minutes, it is necessary to conduct long-term investigations, such as over several weeks.

2) Issues with the Systems: Because of the fast tempo of the conversation (the next dialogue text will appear in approximately 5 seconds), it is necessary to implement a mechanism that automatically pauses the conversation while the user enters text into the input form. Also, although this was a text chat-based dialogue, it is considered that voice-based dialogue and using real robots would facilitate smoother communication. This is expected to reflect important aspects of natural interaction such as the robot recognizing the user's presence and conversational intent, which were missing in this pilot study.

VI. CONCLUSIONS

In this study, we proposed a new concept to alleviate isolation and loneliness by establishing a family-like relationship between multiple robots together with humans. To realize this concept, we implemented two types of systems using ROS and the GPT-4o-mini API: a centralized system in which all the robots' conversations are generated at once, and a distributed system in which each robot generates conversations individually.

We also conducted an initial evaluation of these two systems through a pilot study. The results suggest that the centralized system is superior in terms of conversational consistency and human-like quality, while the distributed system has strengths in flexibility and real-time performance. Furthermore, theme setting and family-like interactions, such as imitating the user's tone of speech and presenting opposing opinions, were confirmed to contribute to a more realistic experience.

These findings provide valuable suggestions for future applications to real robots and for the design of multi-robot systems that can provide emotional support to people living alone. We plan to develop more practical robots through long-term evaluations in real environments.

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