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Virtual Agent to Absorb the Difference of Impression According with Real-time Emotion by Biometric Information

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Abstract: Communication robots are becoming widespread, in particular partner robots that perform personal services are in demand. However, they can be prohibitively expensive; therefore, we consider that a shared robot with a virtual agent service could satisfy user demands. Several issues need to be solved to achieve this purpose. First, there exists no generally used platform service for such robots. Second, even if we use the shared robot service calling the virtual agent, the physical shape and impression of the shared robot sometimes give a strong impression for users. To solve these problems, we proposed a platform and impression improvement method for a shared robot. This robot can autonomously adjust its position according to each users' biometric information-based emotion in real-time. We present a preliminary evaluation to gauge if the proposed method would be an improvement regarding user experience of the robot, even for users who are not familiar with robots.

Keywords: **Virtual Agent, Biometric information, Personal space**

I. INTRODUCTION

As we move towards a human-robot symbiotic society, communication robots and services mainly aimed at interaction with humans are becoming widely popular. It is estimated that more than 50% of the robot industry will be constituted for the services sector by 2035 [1]. The number of partner robots that provide personal services for individual users is on the rise [2]. Such robots provide user support, such as livelihood support, rehabilitation and social activities. In countries such as Japan, there is a increasing elderly population, many of whom are living alone [3]. Improving the quality of life (QOL) of such elderly people is one of the main goals for robots providing personal support.

Partner robots have not only a purchase cost but also maintenance costs to the individual. Conversely, general-purpose communication robots installed in shared spaces are purchased by corporations and public institutions. They are becoming widespread as they are publicly available and they cover for the shortage of workers. It is important to build a mechanism to realize personal services by classifying multiple users. Research on virtual agents has been hindered by issues such as low versatility and lack of common platform. Therefore, in this research, we first developed a platform for virtual agents. Next, we analyzed the impression evaluation results of robots in different enclosures, which are essential when providing personal service. We show that it is possible to provide a better user experience of robots by estimating emotions using individual biometric information and autonomously adjusting the position to suit. Functionality based on this was designed and implemented in a robot, and showed to significantly improve user experience with of robots.

II. RELEVANT RESEARCH

In robot-human interaction, interaction through an agent is called HAI (Human-Agent Interaction), and several studies have been conducted on this topic [4]. Komatsu et al. conducted a comparative experiment with a robot and a virtual agent displayed on a monitor that looked identical to the robot. The result suggested that having a physical entity as a partner agent for interaction may enable smoother interaction [5].

Several studies have been conducted for virtual agents, and active discussions have continued. However, many of the studies on virtual agents that have been summarized in papers remain restricted to specific conditions due to cost, such as studies using a virtual robot inside a monitor or a single dedicated robot. In Osawa et al.'s study [6], common appliances such as general home appliances and information devices were changed into an agent by the attachment of humanoid parts like arms and eyes. However, no viable common virtual agent to operate multiple devices has been described. Further, there is insufficient information on the generalized method for building personal service using robots shared by multiple users is also not sufficient.

The composition of this paper is as follows: Section 2 describes the relevant research, Section 3 describes the proposal, Section 4 describes the platform development and preliminary research, Section 5 describes the preliminary research on autonomous position adjustment functionality and Section 6 states the conclusion and future topics.

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III. PROPOSAL

A. Study Objective

In the study on robot-human interaction using an agent, robots with various appearances are created using virtual agents to enable smooth communication between robots and humans. However, there are not many studies on a virtual agent platform that could support all robots. Also, methods for enabling personal service have not been sufficiently discussed. In this study, we aim to provide personal service using shared robots.

B. Virtual Agent for Shared Robots

To create a virtual agent, it is necessary to consider important items in human-to-human communication. According to Yamada [4], non-verbal information such as facial expressions, gaze, and gestures, which are called subtle expression, is important in human communication. Moreover, Tsuruta et al. [7] pointed out that in the group of visual elements, elements such as face and expressions have a high correlation with anthropomorphism, animacy, likability, perceived intelligence and that the correlation of face and expressions with virtual elements is particularly high. We propose an easy-to-understand common agent by calling a virtual agent with a face for any shared robot.

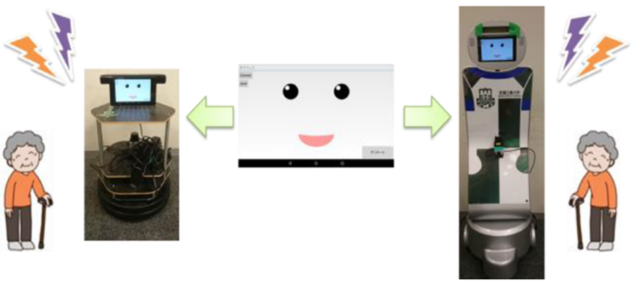

Fig. 1 The idea of a virtual agent in shared robot

C. Virtual Agent

In this study, we assumed that the same user will use two robots of different types and shapes, but share a common face at different locations (Fig. 1). As shown in Fig. 1, agents are called by the robots which have different enclosures for communication. Even if robots differ in shape, a user can use a shared robot as their personalized robot by communicating in the same manner through an agent. Although the robots are different in shape, it is desirable to minimize impression difference in the communication. Therefore, in this study, we evaluated the difference in user experience when a virtual agent with the same face was called for robots with different shapes and designed a method to reduce this difference. To achieve this, we used the emotion estimation method based on biological information to evaluate the impression in real-time. Someya et al. and Kagawa et al. [7 to 9] grasped the changes of an impression which takes place in real-time based on the position and motion of the mobile robot, which cannot be observed in post-implementation questionnaires. By using our emotion evaluation method, the actual emotional response to the robot could be measured.

IV. PLATFORM DEVELOPMENT AND PRELIMINARY RESEARCH

A. Design

The purpose of this work is to achieve personal interaction even with different shape robots that are not familiar. However, there is little to no platform upon which to build the system. Therefore, we designed the virtual agent mechanism platform. The design is illustrated in the Fig.2. In this platform, we set up the database that stores the information of each person (Personal Info DB). The user can call out his/her personal information from a server in file units and enable personal settings on any machine in different locations, and the server stores the personal data. In this system, we built a server-client architecture and enabled file sharing where a client can easily use the files on a server. Fig. 2 shows how to call a virtual agent using data sharing in a virtual file system.

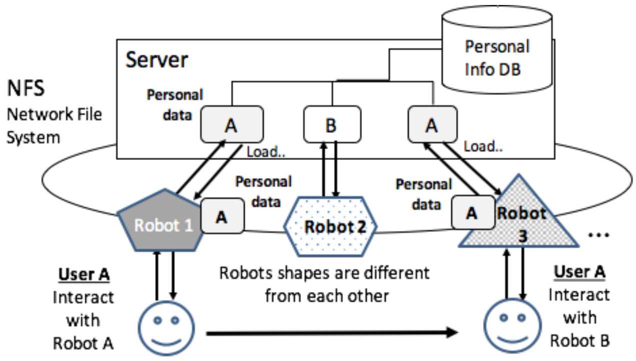

Fig. 2 Personal Information calling by the virtual file system

As a basic system configuration, machines that share robots are the clients and the machine sharing data by connecting these clients is the server. The personal information database that maintains the executable files and individual registration information is recorded in the database, located on the server. Executable files on the server are mounted on each client using NFS (Network File System), and multiple files are made available collectively. With this, we built a mechanism by which a virtual agent based on individual registration information can be called and used from any client.

By preparing a configuration file based on individual differences of enclosures such as the size and running speed of each robot, we implemented a unified virtual agent that is independent of individual differences. In this study, we registered facial data for each user that used the shared file system and implemented file sharing and calling of an agent. Fig. 3 shows the input for calling and the appearance of the screen when calling an agent.

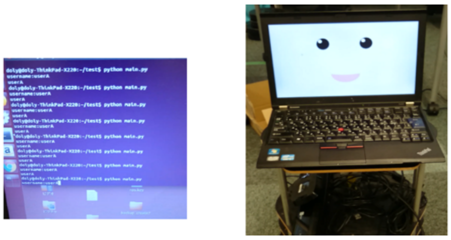

Fig. 3 User name input (left) and appearance of the screen when an agent is called (right).

B. *Impression Evaluation of Robots Using Biological information*

To evaluate different response to approach of different robots, we estimated user's emotion based on his/her biological information. We use the index of biological information. The autonomic nervous information is measured with heart rate analysis, and the brainwaves are measured by the frontal-location of the brain activity, namely AF4, with the 10-20% method. It has been used as a method to evaluate human emotions and state of mind based on the fact that people react unconsciously to external stimuli in a manner different from body sensations [10]. Ikeda et al. classified and estimated emotions by associating the above brainwaves and heart rate with the two axes arousal and valence, respectively, on a coordinate system [9]. In this study, we used the method similar to that of Someya et al. [7], since they showed effective results in emotion evaluation on their robot.

In this study, the arousal level is obtained by the measurement of brainwaves using NeuroSky's Mind Wave Mobile [11], and the valence value is measured using Switch Science's heart rate sensor. Based on the values calculated by each sensor, the two-dimensional coordinate position (XY) is determined based on the emotion classification model, and from that position emotions are classified into 8 types, namely, "Happy", "Excitement", "Surprise", "Tension", "Unhappy", "Bored", "Drowsy" and "Calm" [9, 10]. From the points plotted based on the brainwave and heart rate values in [11], we analyzed the magnitude of emotions using vector decomposition.

C. *Outline of the Experiment*

Following the example of the evaluation experiment by Ikeda et al. [10], in this experiment, we analyzed emotions with values obtained from sensors when robots of two types with differences in appearance (Concierge robot [14] and Kobuki robot [15]) approach and retreat. One male (20-25 years old) participated in this experiment. A man in his twenties collaborated in the experiment.

D. *Experimental Environment*

External factors such as noise could influence the measurement of biological information; the experiment was carried out in a quiet room to eliminate the external variables with only the implementor and experimental collaborator present. The experimental environment is shown in Fig. 4. The experimental collaborator is seated on a chair with the brainwave and heart rate sensor attached to the body. A PC is installed to estimate and record biological information on the desk next to the test subject, and the robot is placed at a distance of 3 m in front of the chair of the experimental collaborator. The distance moved by the robot was determined as the close-range distance (up to 0.45 m), individual distance (0.45 m to 1.20 m), social distance (1.20 m to 3.60 m), public distance (more than 3.60 m) based on the distance of personal space between individuals [15]. The moving distance of the robot was set between 3 m to 40 cm comprising close-range distance, individual distance, and social distance.

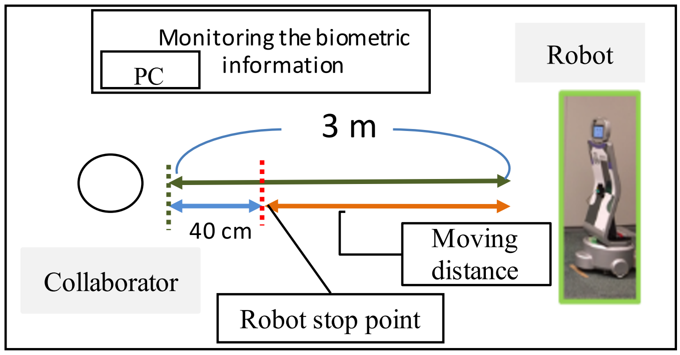

Fig. 4 Experiment environment.

E. *Robots Used and Design and Installation of Robots*

Two robots were used for the experiment. "Concierge" of SOCIAL ROBOTICS [13] (Fig. 5, left), and "Kobuki" of Yujin Robot [14] (Fig. 5, right). The face of the robot was equipped with a tablet (Galaxy) to indicate the face of the virtual agent and display a common face.

Fig. 5 Concierge Robot [13] (left), Kobuki [14] (right).

The ROS (Robot Operating System) is used to control the robots used in the experiment. In this study, we have used ROS Indigo running on Ubuntu 14.04. Implementation of ROS supports C++ and Python, and we have used C++ for robot control in this study. At the front and center of the robot, a range sensor (URG-04LX-UG01) from Hokuyo was set up to measure distance data, and to control the robot.

F. *Experiment Protocol*

In the experiment, two types of robots with the same face displayed on the tablet which was used as the face portion. During the entire experiment, the biological information of the experimental collaborator is measured, and the estimated emotions are recorded. The experiment procedure is as follows.

1. The robot is positioned at a distance of 3 m in front of the collaborator
2. An electroencephalogram and heart rate sensor are attached to the collaborator, then rest for 2 minutes for baseline measurement.
3. The robot approaches the collaborator at a speed of 0.2 m/sec.
4. The robot approaches up to a distance of 30 to 40 cm from the collaborator.
5. The robot stops just in front of the collaborator for 5 secs.
6. The robot retreats from the collaborator at a speed of 0.2 m/sec.
7. The robot retreats to a position 3m in front of the collaborator.
8. The robot stops.

The distance moved by the robot was determined according on the distance of personal space between individuals [15] as follows.

- Close-range distance: up to 0.45m
- Individual distance: 0.45m to 1.20m
- Social distance: 1.20m to 3.60m
- Public distance: more than 3.60m

The moving distance of the robot in this work was set from 3m to 40cm comprising close-range distance, individual distance, and social distance. We measure biological information during 2 minutes of baseline measurement and during 5 secs of remote suspension of close-range distance in front of the experimental collaborator. The above procedure was carried out with two types of robot; Concierge [14] and Kobuki [15].

G. Experimental Results

We show the transition of the estimated emotions using the biological information for the two types of robots, Concierge in Fig. 6, and Kobuki in Fig. 7. Both figures particularly show "Calmness" and "Excitement" where changes are observed. "Excitement" is when high arousal and high valence is observed. In contrary, "Calmness" is the emotion that indicates the low arousal and high valence

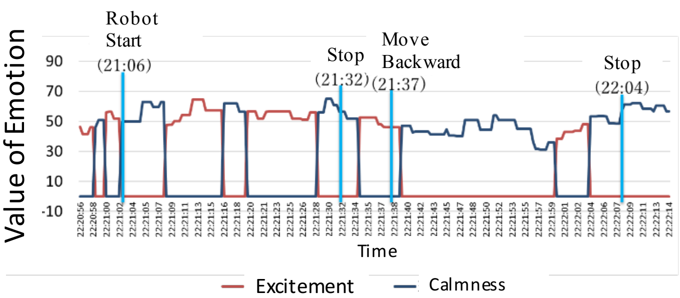

Fig. 6 The measurement result of the movement of a concierge robot.

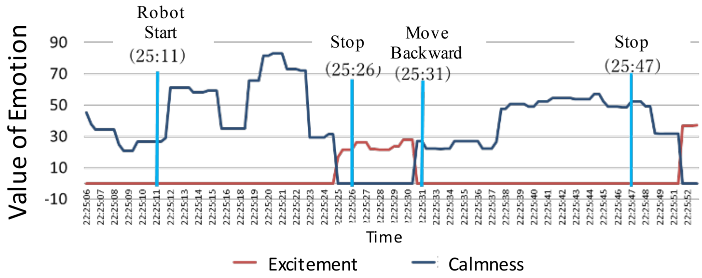

Fig. 7 The measurement result of the movement of the Kobuki robot.

From the results measured from the beginning of robot advance (forward) movement, to when the robot stops in Fig. 6 and 7, it can be seen that the emotion "Calmness" was decreased while "Excitement" was increased with both robots. This suggests that as the robot approaches, the arousal level increases.

Furthermore, on comparing the value of transition of emotion between Concierge and Kobuki robots during the experiment, it was observed that the Concierge robot was more likely to increase the emotional value of "Excitement" and have a higher arousal level between the start of advance (forward) and the start of the retreat (backward). One of the reasons for this is that the enclosure size of Concierge robot is comparatively bigger than the Kobuki robot, and the arousal levels that indicate concentration are higher. By carrying out operations to reduce these values, it is considered that communication can be achived by reducing the user's emotional response towards the robot due to differences in the enclosure.

V. SUMMARY AND FUTURE TOPICS

In this study, we proposed the implementation of personal communication using a shared-type robot that could communicate with users based on their personal information. The proposed method could be used to solve the problem of the high cost of partner robots. A platform was designed and implemented using a virtual agent to achieve personal communication using a shared-type robot. Using the developed platform, we conducted evaluation experiments for the difference in experiences due to differences in the robots enclosure. From the results of the experiment, we conclude that the experience could be improved by adjusting the characteristics of the mobile robot based on biological information and proposed an autonomous position adjustment method to change the position characteristics of the mobile robot based on biological information. We measured heart rate and calculated valence from the heart rate, which was used as biometric information for the evaluation. finally, we found that the autonomous position adjustment method, was able to increase the emotion of happiness when the robot approaches, but the result was that arousal level became high.

The autonomous position adjustment method is carried out using the value of valence calculated from the biometric information taken from the heart rate. The result of adjusting the position by using the autonomous position adjustment method is that arousal level increased due to irregular movements. To suppress the arousal level, including the arousal level for evaluation and examining a method that uses constant movement to travel to an appropriate position can be considered. In addition to acquiring biological information of the users in real-time, examining methods for recording communication data of the past, studying the appropriate positioning through machine learning and suppressing an increase in arousal levels by decreasing irregular movements could also be considered.

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