Ambient Suite: Room-shaped Information Environment for Interpersonal Communication

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Abstract — We propose a room-shaped information environment called Ambient Suite that enhances interpersonal communication. In Ambient Suite, the room itself works as both sensors to estimate the conversation states of participants and displays to present information to stimulate conversation. This paper introduces an implementation assumed standing-party situations as a typical use case of Ambient Suite. From the result of user study using its implementation, we confirmed that our system adequately encouraged participant conversations.

Keywords; ambient interfaces; communication support; information presentation; nonverbal cues

I. INTRODUCTION

Many researchers have studied for the better interpersonal communication. In the field of social psychology, researchers have estimated communication features from verbal or non-verbal cues. In computer science, researchers have explored communication-support systems for various situations such as group collaborations. For example, Proactive Display [4] extracts the personal information of users from RFID tags and displays images of their common interests to enhance the beginning stage of conversation among multiple persons. Other examples support group meetings by sensing the conversational signals and showing real-time visual feedback to help participants improve their social behaviors [2]. They helped participants find or change conversational topics, and the participants were satisfied. However, most existing systems can only be used in a limited number of situations with a small number of participants because they are designed for specific purposes. Furthermore, the stimulus information from the system is usually simple or presented by commonly used displays. This makes it difficult to show such complex information as person-specific or situation-dependent information.

In this study, we propose a novel room-shaped information environment called Ambient Suite that enhances communication among multiple people. One of its main features is that all sensors and displays surrounding the participants in the room cooperatively work to activate conversation to establish the mood. Based on participants’ nonverbal cues detected by sensors, displays present various types of information to stimulate conversation. We expect this system to work well regardless of conversational styles or the number of participants. In this paper we introduce an implementation for a standing-party (social gathering) situation as a typical example, and an evaluation with real conversation tasks.

II. AMBIENT SUITE

A. Concepts

We propose a room-shaped information environment called Ambient Suite that enhances communication among multiple people. In this environment, sensors and displays that fit in the environment cooperatively enhance participant conversations and establish the mood. We design and implement the whole room with I/O devices so that our system can be adapted for a wide range of conversational styles from person-to-person talks to discussions or parties with many persons.

B. System architecture

1) Sensors

First, participants’ voice should be measured because nonverbal cues about their utterances are essential to understand conversation states. In a conversation situation like a group meeting or party, participants usually hold their personal cups. We focused on it and developed a cup-shaped device called Cup-le equipped with a microphone and an accelerometer, as shown in Fig. 2. This device can obtain participant utterances and hand gestures without wearing...
sensors. In addition, we asked participants to hold the cup with their dominant hand and to wear another wireless accelerometer (ATR-Promotions, WAA-006) on their non-dominant hand to precisely recognize their head gestures in the experiment we describe later. The data measured by the cup-shaped device are sent to the server PC using a Wi-Fi network, and the data from the B-Pack are gathered through Bluetooth.

In the case where participants move freely around the room, position tracking is necessary to recognize the conversational states. In addition, participant head directions are often required to estimate conversational states as well. We utilize a 3D tracker system (OptiTrack FLEX:V100R2). For sensing, all participants wear a marker on their heads.

2) Displays

Madan’s system [3], the combination between public displays and private displays, demonstrated the potential of coupling two types of displays. We propose a further advanced environment where participants are surrounded by various displays that cooperatively work. To realize this, we use walls and the floor as screens. Wall displays provide public information. We projected images to at least two walls of all the sides so that all participants can see the information. In our implementation, each size of wall display is about 130 inches. On the floor we project images on 200 inches area on which the participants walk. Two short focus projectors at the head-on position project to the same floor area to avoid occluding the participants’ feet. The floor display is suitable for position-dependent displays, but it is difficult to get complex information including letters, since each participant sees the display from different orientations. Therefore, the floor display must show supplementary information with wall displays. To present private information to specific participants, we use a display on their cup-shaped devices. The server PC controls the displayed information on each device. To present information, we can switch three different types of displays: walls, floors, and cup-shaped devices.

3) Estimation of conversational states

Existing studies that estimate conversational states usually use various nonverbal extracted cues. Although the three sensors that could capture many nonverbal cues was used, we focused on utterances (speaking time), head movements (head-rotation frequency), and hand movements (hand-gesture frequency) to estimate the participants’ conversation activity[1]. The activity, one of most important characteristics in estimating conversational states, is represented by a multi-regression model using a combination of the cues of utterance, hand gestures, and head directions as below:

\[
\text{Activity} = 0.00046 \ ST + 0.000006 \ HA + 0.001 \ HR + 0.565 \\
\text{ST: speaking time (sec), HA: hand acceleration (m/sec}^2\text{), HR: head rotation (times))}
\]

We probatively used this model to represent conversation activity, since this regression model can be simply extended from triadic conversations because these nonverbal cues linearly increase as a conversation becomes more active [1]. Fine-tuning of thresholds to sense the nonverbal cues were determined by preliminary studies.

III. INFORMATION PRESENTATION FOR STANDING-PARTY SITUATIONS

Although Ambient Suite has many applicable situations, we focus on an application of standing-party situations. One of its reasons is that there must be more demands for enhancing communication than other situations since many people meet each other for the first time at parties.

In such standing-parties, people generally walk around freely and want to become friendly with each other by talking about various topics. Although many examples can be thought as the information presentation that activates conversation in such situations, we introduce two types of stimuli: visualization of participant activities, and displaying common interests. We chose these based on existing studies about information-presentation in conversational space.

A. Visualization of Participant Activity

Some existing works enhanced communication by visualizing the amount of nonverbal cues [e.g., 2]. Based on these studies, we explore a visualization technique to better promote participant social interactions using the value of the activity of the conversation space.
Before entering the room, all participants ranked ten items (mentioned above) calculated every 10 seconds (Fig. 3(a)). The activity is illustrated in a line graph whose x-axis represents time and whose y-axis represents the activity. This visualization allows participants to find who or which area participant is indicated by the color based on his/her activity for each person is visualized (Fig. 3(b)) using the same nonverbal cues for all participants, but it is calculated every five seconds for the better appearance. Activity is represented as a heat map. The activity level for each participant is calculated every 10 seconds (Fig. 3(a)) using the same nonverbal cues for all participants, but it is calculated every five seconds for the better appearance. Activity is represented as a heat map. The activity level for each participant is indicated by the color based on his/her position (red means high activity and black means low). This visualization allows participants to find who or which area has high or low activity to support someone who seeks a person with low activity to improve the mood of the whole space. In this way, we use both public and position-dependent information for each participant in an environment with wall and floor displays.

### B. Displaying Participants’ Common Interests

People who meet for the first time often talk about their interests. For example, Proactive Display helps conversations get started [4]. Displaying the common interests of participants is a reasonable way to activate conversations and is worth investigating. Figures 4(a) and (b) show this information-presentation on the wall and the floor. In advance, we chose ten items that participants might be interested in, including sports, music, outdoor activities, etc. We presented to the participants photos from websites related to these ten interests (Fig. 4(a)). Before entering the room, all participants ranked these items. Photos, which are highly ranked by many participants, are more likely to be displayed on the wall displays than other images. On the floor display, the persons who greatly rated the currently displayed item are highlighted (Fig. 4(b)), informing participants of shared interests, which simplifies raising conversation topics. This presentation also utilizes a combination between wall and floor displays.

### IV. USER FEEDBACKS

We conducted an experiment in which participants actually talked using the standing-party implementation of Ambient Suite. The main purpose of the experiment was to observe participants’ impression of the information-presentation. We subjectively evaluated whether our system actually stimulated conversation in the party situations through post-task questionnaires.

#### A. Apparatus and Environment

Seventeen groups consisted of six persons (51 males and 50 females, one female was absent, thus 101 participants) participated in the experiment. Each group had three males and three females who had never met each other before this experiment. All participants were Japanese graduate or undergraduate students whose ages ranged from 18 to 24 (average was 21.7). The conversation was done in a 25 m² area separated by partitions. To capture all participant behaviors, three video cameras were also set around the space. As shown in Fig. 2, participants wore a marker of a 3D tracker and an accelerometer in their non-dominant hand and held a cup-shaped device in their dominant hand.

The participants had two 12-minute conversation sets for each with/without information-presentation condition. During the experiment, participants were allowed to talk freely in a standing position to become friendly in both of the conditions. We explained the meaning of each information presentation to the participants, and they were allowed (not forced) to talk about the displayed information in the information-presentation condition. The order of the conditions of the information-presentation was fixed; the first was without information and the second was with. In the information-presentation condition, we presented the visualization of the participant activities and their common interests for six minutes. The order of the two sets of presented information was counterbalanced. After every 12-minute conversation, the participants filled out questionnaires about their conversations and provided subjective comments.

#### B. Results

Figure 5 shows the five-point scale score of the questionnaire. Each bar indicates the average score of all the participant ratings for each information-presentation condition. Regarding Q1 in Fig. 7(a), the score of the information-presentation condition, 3.92, was significantly higher than that of without information-presentation, 3.60 ($t$(16)=4.42, $p<.01$). In contrast, the Q2 score of the information-presentation condition, 3.19, was significantly lower than that of without information-presentation, 3.41 ($t$(16)=3.03, $p<.01$). Regarding the questions about information presentation, the score of Q3 2.82, was
significantly lower than that of Q4 4.22 (t(16)=6.64, p<.01). That shows that participants preferred the visualization of their common interests to that of participant activities.

C. Discussions

From our observations of the conversation, the information-presentation provided a significant stimulus to the conversation space and also entertained most of the participants. At the moment the task started, they easily understood and enjoyed the collaborations among the wall and floor displays. They also appropriately shared the presented information from their respective standing positions and direction even when they moved around the room. This suggests that a room-shaped system has an affinity with the situation where the position and the direction of each participant change dynamically in the conversation space. In addition, we observe that the presented information triggered participant conversation when beginning a certain talk and also often helped them when they exhausted conversation topics. We think continuous presentation of the information was effective for that.

The results of questionnaires also showed that our system with information-presentation was more capable of stimulating conversations. However, further study is required to precisely measure how much the conversation was activated by the information, since the order of the information-presentation conditions may have affected the results. Nevertheless, note that fewer conversations were led by someone with information presentation. This indicates that our system not only activates but balances participant conversation.

Between two types of stimuli, the displaying of shared interests sparked conversation and produced higher scores than the neutral value of 3.0 in Q3. We believe that such information presentation was preferred because it offered participant self-disclosures, which are quite important processes to become friendly regardless of whether they are strangers. In the current system, the information of their interests is needed in advance. For actual party situations, we will introduce an additional method to automatically select common interests from SNS or RFID tags like Proactive Displays [4].

On the other hand, the visualization of participant activities stimulated the conversations less than the shared interests, and the Q4 score was also less than the neutral score. The primary purpose of this visualization was to explore whether its visual feedback favorably affected their conversation activity. The questionnaire results and observations simply show that the visualization just entertained them without improving social actions. We expect that the visual feedback would more greatly influence the participants’ social behavior in more purposeful tasks such as group discussions. In our follow-up study using such feedback technologies, we will reconsider the visualization way based on the context and also modify the spatial layout and the display usage, including the cup-shaped device’s private display that allows participants to easily access such visual information.

We confirmed the efficiency of the collaborative information-presentation between the wall and floor displays, and we still need to investigate a private information-presentation using the cup-shaped device for the next step. We might present information to the conversation leader to secretly encourage those who are struggling to participate in the current conversation.

V. Conclusions

We proposed a room-shaped information environment called Ambient Suite that enhances communications among multiple persons. We implemented it assuming standing-party situations and experimentally evaluated its performance. The results showed that our system presented various types of information, and that the participants became friendly quicker due to the information that was cooperatively presented by the wall and floor displays.

Future work will explore more variations of information-presentation that will not only visualize participant conversational states but also amplify them.

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