Adaptive Spatial User Interfaces That Activate Us

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ABSTRACT

We have been exploring adaptive spatial user interfaces to make the users more active and productive. This paper presents our proposal based on our recent efforts on realizing the vision of adaptive spatial user interfaces. For example, Ambient Suite enhances communication among multiple participants. With Ambient Suite, the space itself works as both sensors to estimate the conversation states of participants from nonverbal cues and displays to present information to stimulate conversation. Another example is AI-Supported Meeting Space, in which the space itself behaves as "another participant" to make the meeting more productive. The system periodically provides the participants with some information related to their discussion topics on the surface of the table and walls. We believe these adaptive spatial user interfaces fit the recent changes in working style and contribute to the improvement of our quality of life.

1 INTRODUCTION

According to the expansion of Internet of Things (IoT), everything around us is coming online and joining integrated networks. Even everyday items like furniture and space itself are going digital. Our research explores interactions between people, content, systems, and environments in order to build a world that is not only smarter, but also one that is happier, and better integrated. We focus on relationship and interaction in order to achieve greater harmony.

We view all artifacts, physical and digital, as content. Honoring the unique perspectives of people, systems, and the environments they inhabit, we study the interactions between types of content, with the ultimate goal of formulating cohesive, holistic, and intuitive approaches that promote efficiency, ease of use, and effective communication. We focus on content design to enhance living. We are pursuing a vision of reactive interior spaces which are aware of people's actions and transform according to changing needs. We envision furniture and walls that act as interactive displays and that shapeshift to the correct physical form, and the appropriate interactive visual content and modality. This paper presents our proposal based on our recent efforts on realizing the vision of adaptive spatial user interfaces, Ambient Suite [1,2] (shown in Fig. 1) and AI-supported Meeting Space [3] (shown in Fig. 2), and provides a roadmap of our current and near-term efforts on this exciting research challenge.

Fig. 1 Overview of Ambient Suite [1,2]

2 AMBIENT SUITE

Ambient Suite a concept of room-shaped information environment that enhances communication among multiple participants. 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. Such nonverbal cues as utterances, positions, and gestures are measured to sense participant states. The participants are surrounded by displays so that various types of information can be given based on their states. Although this system is adaptable to a wide range of situations where groups talk with each other, our implementation assumed standing-party situations as a typical case. We also implemented two types of information presentation to activating conversation: profile-based information stimulus and feedback visualization. Profile-based information stimulus shows the participants photos on the wall and also highlight the participants who are interested in the photos on the floor (like a spotlight). With feedback visualization, the wall illustrates a line graph of the participants' conversation activity calculated by the system at every one second, and the floor visualizes the conversation activity for each person like a heat map.

Using this implementation, we experimentally evaluated the performance of input, output, and whether our system can actually stimulate conversation. Seventeen groups participated in the experiment. Each group consisted of six persons, and thus 101 participants (51 males and 50 females, one female was absent) took part in the experiment. Each group consisted of 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). They had 12-minute conversation sets for each with / without information presentation condition. During the experiment, they were allowed to talk freely and talk about the displayed information to become friendly with each other. After every 12-minute conversation set, they filled out questionnaires about their conversation and the gave us subjective comments.

Regarding the question of questionnaire “I felt shared interests when talking with each other (8-point Likert scale)”, the average score with information presentation, 6.07, was significantly higher than that of without information 5.61 ($t(16)=3.17$, $p<.01$). Similarly, as for the question “I felt that the atmosphere of the conversation space was active (5-point Likert scale)”, the score with information was 3.92, which was significantly higher than that of without information 3.60 ($t(16)=4.42$, $p<.01$). In contrast, the score of the question “I felt that someone was leading the conversation” with information, 3.19, was significantly lower than that of without information-presentation, 3.41 ($t(16)=3.03$, $p<.01$). The results showed that our system adequately encouraged participant conversations and share their interest with each other.

3 AI-SUPPORTED MEETING SPACE

AI-Supported Meeting Space itself behaves as *another participant* so as to make the meeting more productive. The system periodically provides the participants with some information relevant to their discussion topics on the surface of the table and walls. More specifically, the system first acquires utterances of each participant from microphones, recognizes the speech, and extracts keywords from the speech texts using such morphological analysis. Then the system searches and retrieves specific information using one of the extracted keywords as a query (the search resource is chosen by the system according to the situation of discussion). After that, the system presents the participants the retrieved information on their environment. Based on how the information activated the conversation or not, rewards are given to the system. We chose the walls in front of and behind the participants as surfaces to present such retrieved information. We implemented a proof-of-concept prototype in an actual meeting space (size: 4.00 × 3.45 *m*) in our office. Two short focus projectors (Ricoh PJ-WX4141NI) projected both sides of the existing 46-inch monitor. Each projected area was 2.56 × 0.80 *m* (approximately 106 inches). As information resource for retrieving, we employed the three categories: news (Bing Search), images (Bing Image Search), and difinitions (Wikipedia). The system picked up one of the retrieval results and based on the participants’ topic and displayed it for 30 seconds.

We assessed our information representation method from walls through a user study. Twelve participants (9 males, average age was 39.3) took part in our assessment and we divided them into three groups. Each group (consisting of four people) were instructed to discuss the topic given by us for 30 minutes, and generate valuable ideas as much as possible. We showed the agenda of the topic on the existing 46-inch monitor, and also presented the relevant information (retrieved in advance for the assessment) on the wall at the both sides of the monitor. The participants were allowed to refer to information presented on the wall if necessary.

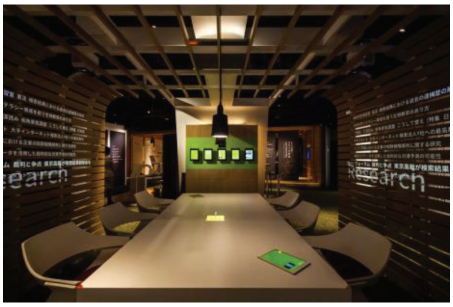

Fig. 2 Overview of AI-supported Meeting Space [3]

From the post-task questionnaire of the assessment, we found that most participants did not regularly use the presented information, but they needed it especially when the conversation temporarily stopped. From the interview, it is also revealed that they preferred image-based information more to character-based one, because they rarely looked at the information on the wall carefully and the image-based information was easy to recognize. In addition, several participants commented that the wall information should be located within the participants’ sight because they could have kept gazing at each other while referring to the information. These results indicate that it would be better for the system to keep the participants focusing on their conversation without disturbing them while presenting the information.

4 CONCLUSION

We presented our research proposal of adaptive spatial user interfaces based on the several examples of our recent efforts. Ambient Suite adequately demonstrated the potential to activate a multi-person conversation using whole room. AI-Supported Meeting Space demonstrated the potential of activating a meeting with retrieved information on their nearby walls. Some of our short-term efforts are now dedicated to implementing an even richer set of our spatial user interfaces. In the future we plan to explore more possibilities of adaptive spatial user interface including even physical shape-shifting that responds to explicit and implicit controls and change their physical layouts to match particular activities.

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