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Personalizing Information in a Conversation Support Environment for Facilitating Collaborative Concept Formation and Information Sharing

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SUMMARY

We spend much time daily in meetings and informal conversation in collaborative work for research, business activities, and so on. The creativity of groups is often enhanced by the effects of collaborative concept formation and information sharing during conversations. This paper proposes a system—Augmented Informative Discussion Environment (AIDE)—that facilitates creative conversation. AIDE is an online chat system seamlessly integrated with techniques for visualizing information structure and information retrieval. Specifically, this paper explains the personalization of shared information when using AIDE and proposes a method of visualizing the relationships between multiple participants' viewpoints acquired from these personalized information spaces. © 1998 Scripta Technica. Syst Comp Jpn, 28(10): 1–8, 1997

Key words: Group creativity, electronic conversation environment; information sharing, personalization; individual viewpoint.

1. Introduction

This paper describes a system which facilitates communications and information sharing in conversation between people sharing common interests. We spend much time daily in meetings and informal conversation in collaborative work for research, business activities, and so on. The creativity of groups is often enhanced by the effects of *collaborative concept formation* and *information sharing* during the conversations.

Our system assumes a conversation environment on networked computers, since we have become accustomed to electronic conversation environments (e.g., e-mail and online news) with the recent spread of the Internet. These media relax temporal and spatial restrictions on communities and raise the possibility of reusing accumulated results from their collaborative work.

Colab [1] is a pioneering system for electronic conferences. Its targets are brainstorming in electronic conversation environments, organizing fragments of ideas extracted there, and sharing information; these are similar to our targets. Colab, however, cannot lead to a novel form of collaboration by making the best use of computers, because this would only reproduce meetings using traditional tools such as pen, paper, and chalkboard in some electronic form. Our purpose is to create a new form of collaboration, with computer-augmented environments which actively offer information that cannot be provided by the traditional passive tools.

Some systems that help coordination in conversation have been proposed [e.g., 2, 3]. Their aim is to support information sharing among groups by processing the relationships among utterances and positions of participants during conversation in collaborative work. However, these systems force their users to converse in accordance with conversation models prepared by their designers before-

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hand. That is, the users must attach their positions or relationships with others to all utterances. Our system does not require the users to specify any extra information during a conversation; in contrast, it offers them hints of relationships among utterances.

The authors have been developing a system—Augmented Informative Discussion Environment (AIDE)—that facilitates our daily conversations. AIDE is an online chat system with conversation spaces to be shared by the users. The spaces are automatically visualized with a method that statistically structures conceptual spaces containing text-objects and their keywords, as proposed in Ref. 4. Also employed is a technique that extracts texts relevant to the conversation spaces from a text-base [5].

In order to flexibly exploit shared information, including adaptation to facing problems to solve, and to accommodate distributed and asynchronous environments of collaboration, *personalizing information* (gathering and organizing information) by each collaborative participant is the key technique. One possible approach is to have all participants improve the quality of information through personalization, acquire the *viewpoints* causing the results, and understand the relationships among them.

This paper describes our system AIDE and, in particular, explains the personalization of shared information when using AIDE. We propose a method of visualizing the relationships between multiple participants' viewpoints acquired from these personalized information spaces.

2. AIDE, System Overview

AIDE is a client-server type of chat system. This system can be both centralized/distributed and synchronous/asynchronous. Figure 1 illustrates the configuration of AIDE, and Fig. 2 shows an example of the use of AIDE. The main window of AIDE shown on the left of Fig. 2 includes a window with which a user can submit his or her utterances and a window that lists all collected utterances. AIDE is characterized by the following three subsystems.

Discussion Viewer: shows discussion spaces that visualize the structures of conversations. These spaces are information spaces shared among all participants in the conversations.

Conversationalist: a virtual participant that automatically extracts texts relevant to the conversation from an external text-base and introduces them into the discussion spaces.

Personal Desktop: a desktop in which users can enter the phase of individual thought. The users can personalize shared information by duplicating and modifying the discussion spaces with it.

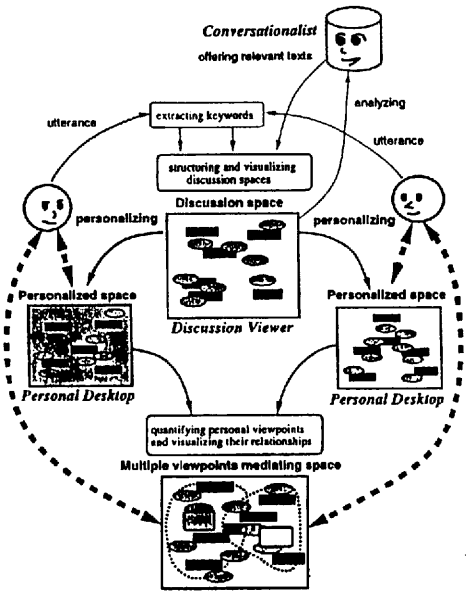

Fig. 1. Configuration of AIDE, and viewpoints sharing among participants using AIDE.

A user participates in conversation with the graphical user interface shown in Fig. 2 on a client machine. The server machine manages information on the users' utterances and discussion spaces which visualize the structures. When a user submits an utterance, the server automatically extracts keywords from the text along with their importance values, and according to updated information, calculates and redisplays discussion spaces on all of the users' client machines.

In the discussion spaces, icons are used to indicate the utterances up to that point, and their keywords (which are automatically extracted) are mapped.* The discussion spaces are two-dimensional spaces which visualize the relationships between utterances and their keywords; a pair of utterances with more common keywords is located closer together and these common keywords are mapped around the pair [4]. All users can participate in conversation and understand the global structure and relationships among multiple topics (clusters of icons in the space) by viewing the shared discussion spaces. The discussion spaces visualize the relationships among the utterances based on such objective and simple information as the co-occurrences of keywords; this has the effect of making users notice new relationships instead of temporal relations. Hence, the Dis-

*Each user can decide whether to show icons of utterances and keywords together or not.

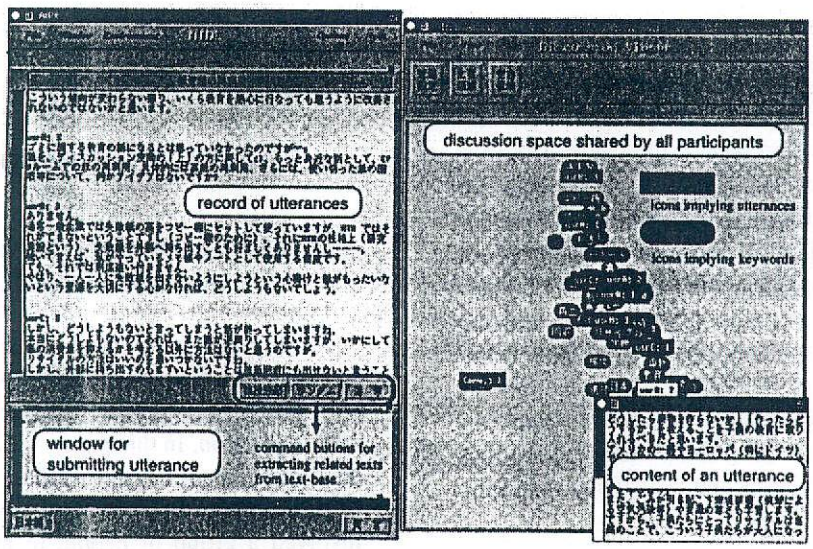

Fig. 2. Usage of AIDE.

cussion Viewer and record of utterances on the main window are complementary.

Next, we explain the information retrieval subsystem. As mentioned above, this subsystem is being implemented as a virtual participant called the Conversationalist. To achieve its purpose, we have implemented abilities such as being able to calculate the timing of utterances and to judge the contents of utterances, perhaps by analyzing other utterances during conversation. In this work, we used the subsystem as an ordinary information retrieval system, which works in response to user requests.

The information retrieval subsystem has a text-base containing texts indexed with keyword vectors beforehand.* We implemented several retrieval strategies, but this paper uses only one method, outputting the text having the largest normalized inner product of its keyword vector with a set of keywords mapped in a discussion space when requested. Texts and their keywords output by the subsystem are also introduced into the discussion spaces, and this causes a reconfiguration of the spaces. These results may be effective in leading human participants to a wider thought space and new ideas.

Lastly, we explain the Personal Desktop. Using it enables each user to enter the phase of individual thought whenever he or she wishes, while participating in the conversation. Although the presentation of information and the method of visualizing this information are the same as those for the Discussion Viewer, users of the Personal Desktop can freely move icons, remove or modify utterances and keywords, and add new texts such as private memos into the personalized space, as with regular utterances. In the next section, we will explain the personalization of discussion spaces in Personal Desktops and a method for mutually understanding participants' personal viewpoints during conversation using the results.

*Currently, this text-base contains articles from a Japanese contemporary encyclopedia. The number of articles is about 10,000 and the number of keywords extracted beforehand is about 40,000.

3. Mutual Understanding in Conversation

3.1. Personalizing discussion spaces

Since emerging clusters of utterances with many common keywords in the discussion spaces display the global structure and local information of the conversation simultaneously, not only the participants themselves but also an outsider can easily browse the conversation. While the discussion spaces visualize the structures of the conversation with an average viewpoint, they consequently may be unsuitable for any one participant's viewpoint.

For that reason, we have prepared the Personal Desktop, where each participant can personalize information from a discussion space by duplicating the discussion space and performing the following operations:

- remove uninteresting utterances and add private texts into the personalized space instead; and
- raise the importance values of keywords of interest and remove uninteresting ones.

These data modifications are reflected in a restructuring of the space.

Restructured spaces in Personal Desktops reveal each participant's individual viewpoints: in the different personalized spaces, even the same pair of utterances from the same conversation can be mapped at relatively different positions. The sharing of such information by all participants can enable all of them to mutually understand each other. However, simply preparing the environment for personalizing information is insufficient for explicitly utilizing the personal viewpoints and their relationships in collaborative work. Accordingly, in the next section, we propose a method that facilitates the mutual understanding of personal viewpoints by quantifying the personal viewpoints revealed in personalized spaces and visualizing their relationships.

3.2. Visualization of individual viewpoints and their relationships

This section describes how to quantify the personal viewpoints revealed in the Personal Desktops and to newly visualize their relationships.

We propose the following procedure, which does not postulate any special operations except personalization of the discussion space of each user and, accordingly, quantifies the users' viewpoints and visualizes their relationships as a by-product of the personalization (refer to the lower part of Fig. 1).

1. Each user freely builds his or her own personalized space on a Personal Desktop as mentioned above.

2. The system newly creates a *viewpoint-object* that quantifies each user's viewpoint from information on the Personal Desktop. This is an object that has all of the keywords existing in the user's personalized space. These keywords have importance values, which are the mean values of those in the personalized space.

3. The system forms a *multiple viewpoint mediating space*, which is a mediated space derived from multiple personalized spaces and visualizes the relationships between the viewpoints. This space is constructed from the sum of sets of utterances (including private texts given by each user) and keywords in the personalized spaces, and the viewpoint-objects generated by the previous process. This space is structured by the same mechanism used with the Discussion Viewer and Personal Desktops.

The multiple viewpoint mediating space has utterances and keywords commonly inherited from the discussion space. The space visually mediates the multiple users' viewpoints and leads them to mutual understanding. The space including private texts contained in the personalized spaces encourages the users to mutually exchange and share private knowledge and ideas.

4. Experiments and Evaluation

4.1. The effects of discussion spaces and the information retrieval function

We have preliminarily experimented on AIDE with sets of articles posted in online news, records of discussions by a group of closely collaborating researchers using e-mail, and so on. In this paper, we describe one example of the experimental usage of AIDE in detail to explain the implementation of the proposed method. This experiment involved a group of people in an organization, namely, usrA, usrB, and usrC. The subject of the conversation was "recycling used paper in our office." This experiment lasted 1 day, and the group participated in the conversation in their spare time using their own desktop machines. The numbers of submitted utterances of usrA, usrB, and usrC were four, three, and four, respectively. The final status of the discussion space is shown in Fig. 3.*

Rectangular icons in the figure represent utterances, showing whose utterance and the submission order. "Conv." seen in the figure refers to an utterance by Conversationalist. However, we handled this as an ordinary information retrieval system instead of a virtual participant autonomously making utterances in this experiment. Oval icons represent keywords automatically extracted from the utterances; there were 208 of these.

We can roughly understand the contents of the conversation by viewing clusters of utterance icons and keyword icons scattered around them, and we intuitively understand their topological relationships. For example, as noted in Fig. 3, we can understand that the topics of the conversation were expanded from "recycling used papers" to "environmental problems related to garbage disposal and recycling," and "educational issues."

The information retrieval function was used twice during the conversation. After each user input one utterance, this presented an utterance Conv.:1 (an article on "garbage tax") in response to a request from one of the users. An utterance given by usrB just after that did not mention this topic, but addressed an educational issue concerned with environmental problems, and a few utterances followed this topic. Since the focus of the conversation was approaching a standstill, the information retrieval function was used, and then Conv. :2 (an article on "recycled paper") was given. This made the focus go back to the original

*This experiment was done in Japanese. Later examples in this paper have been translated by the authors.

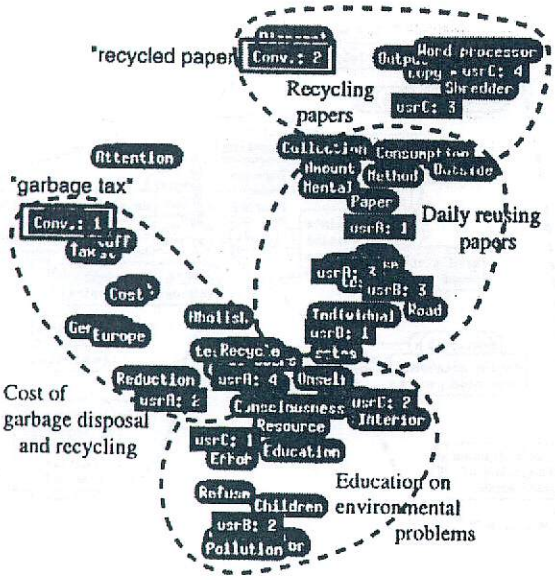

Fig. 3. An example of discussion space on the subject "recycling paper."

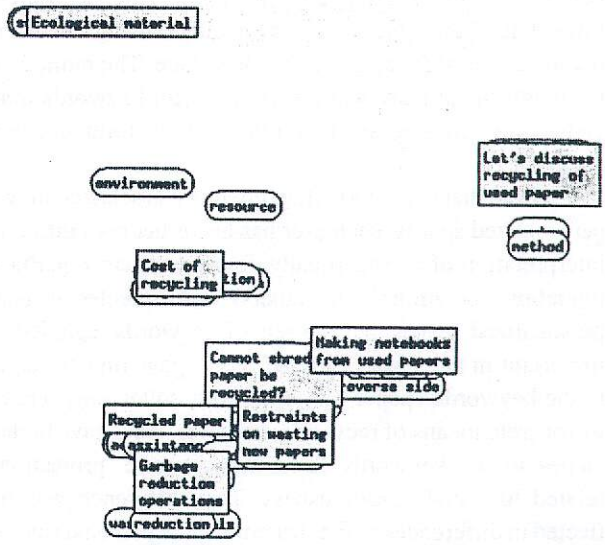

Fig. 4. UsrA's personalized space with the viewpoints of "means of recycling."

subject, that is, effectively reusing papers. Moreover, a description of the "cost of garbage disposal and recycling" in Conv.:1 gave stimuli to usrA and provoked the following further discussion.

4.2. Personalized spaces with different viewpoints

This section describes the building of personalized spaces by two users, namely, usrA and usrC, derived from the discussion space shown in Fig. 3. Figures 4 and 5 show the respective results. The tags of the utterance icons are changed to phrases indicating the utterances by the authors with the function of a Personal Desktop. The same utterance appearing in both Figs. 4 and 5 is given the same tag.

In the case of usrA, the discussion space was personalized with the viewpoint of "means of recycling." As a result, utterances concerned with an educational issue were removed from usrA's personalized space, and, in contrast, a text about "ecological material" (mapped at the upper left of the space) was newly added. This text was obtained as a related text to usrA's personalized space by the information retrieval function of AIDE. But this does not mean that texts added to personalized spaces are always obtained using this function. The number of keywords remaining in usrA's space was 68. The keywords with relatively high importance values were {recycling, waste materials, nature, environment, cost}, which would be keywords of usrA's viewpoint-object afterward.

In the case of usrC, his personalized space was built with the viewpoint of "raising public spirit," and consequently, many utterances were removed, leaving five utterances related to this. In contrast, he selected and added a

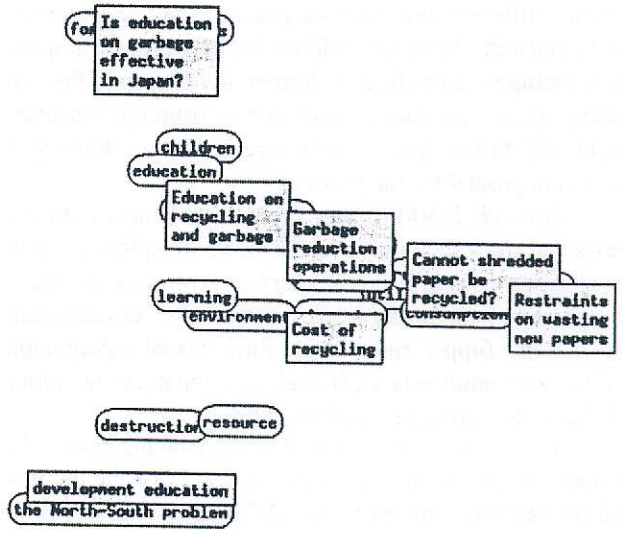

Fig. 5. UsrC's personalized space with the viewpoints of "raising public spirit."

new text about "development education" (mapped on the lower left of the space) that was obtained using the information retrieval function as usrA had done. The number of keywords in his space was 69, and the prior keywords were {education, awareness, children, society, foreign countries}.

Note that even if a certain utterance is selected in two personalized spaces, each user has his or her own different interpretation of it. Specifically, four utterances ("garbage reduction operations," and others) were selected in both personalized spaces, but the sets of keywords regarded as important in the spaces differed: UsrA gave higher values to the keywords {paper, shredder, cost, collection} related to concrete means of recycling; however, usrC gave higher values to the keywords {awareness, nature, protection} related to social consciousness. This difference was reflected in differences of the structure of the personal spaces.

4.3. Mediating multiple viewpoints

Figure 6 shows a multiple viewpoint mediating (MVM) space automatically created from the personalized spaces of usrA and usrC by the method described in section 3.2. The mapped icons of utterances and keywords are the sum of those in the two users' personalized spaces; there are 11 and 111 of them, respectively. The MVM space also includes viewpoint-objects that denote the two users' individual viewpoints.

We can read several effects of MVM spaces by the example shown in Fig. 6. First, we notice that the MVM space is not a simple superposition of the two personalized spaces, and its structure differs distinctly from that of the initial discussion space shown in Fig. 3. This MVM space reveals different and shared aspects of the viewpoints of usrA and usrC. Moreover, while the initial discussion space also includes insignificant information for each of the two users, since it contains all information from the conversations, the MVM space can be regarded as a refined new common ground for the two users.

Second, MVM spaces include each user's private texts that show their interests and viewpoints; for example, the space shown in Fig. 6 has usrA's "ecological material" (upper left icon in the space) and usrC's "development education" (upper right icon). Such visual information helps users intuitively grasp their collaborators' intentions and aids in sharing personal knowledge.

Lastly, we point out the effect of reducing keywords, namely, irrelevant keywords are removed and the number of keywords is reduced in the MVM spaces. This refines the structure of the MVM spaces, which can be a new common ground for users. It is noteworthy that the only requirement for obtaining an MVM space is each individual's operation of personalizing a shared discussion space;

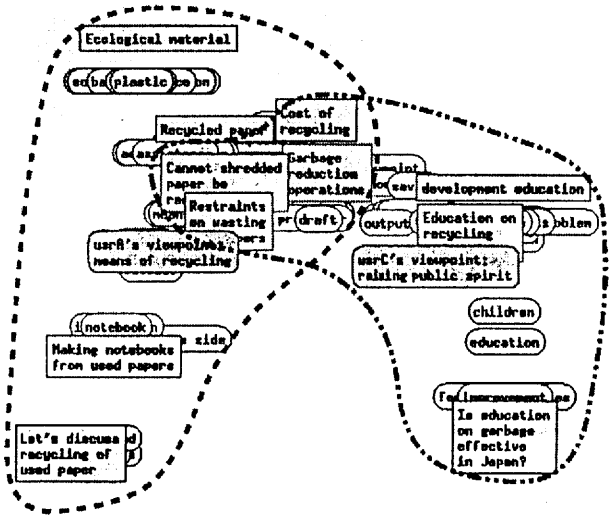

Fig. 6. An example of the space visualizing relationships between two participants' viewpoints.

this method does not require any special operations of negotiation or coordination between users.

5. Conclusions and Future Work

We have proposed a conversation support environment, called AIDE, that facilitates collaborative concept formation and information sharing in conversations. In particular, we have described methods of personalizing the shared information in the conversation and promoting mutual understanding of all participants' personal viewpoints, and have illustrated these effects with experimental results.

Although we have shown only experiments with AIDE used by a closed and localized organization, we are eager to apply AIDE to conversations of loosely organized and spatially distributed communities, via the Internet. For that purpose, we need other technologies, such as information filtering and hierarchical information organizing, since the present AIDE will not provide meaningful discussion spaces if there are too many utterances. It will also be interesting to facilitate new encounters between people accessing the Internet who have similar interests [6], as a means of helping an earlier stage of formation of and collaboration in communities.

The authors' group has proposed the concept of the Meta-Museum [7], which is a new environment for knowledge sharing. The primary goal of the Meta-Museum is to create and facilitate communications between specialists

(providers of information and knowledge) and visitors (receivers of information and knowledge), thereby enabling a better understanding of museum exhibitions. The Meta-Museum can be an example of the *knowledge medium* proposed in Ref. 8, which is an information network with semiautomatic services for the generation, distribution, and consumption of knowledge. Future knowledge media will host creative collaborations not only between human agents but also between any combination of human agents and intelligent machine agents. AIDE's Conversationalist, which we are currently developing, can be an example of the intelligent machine agent. In such knowledge media, communication between agents is a critical ingredient, and can be facilitated by interposing a mediating agent [9]. The multiple viewpoint mediating spaces proposed in this paper can be a mediating agent between the personal viewpoints of participants in collaboration.

From the knowledge engineering viewpoint, we are interested in recording or classifying the emerging concepts and keywords in the spaces provided by AIDE into an ontology. At that time, it will also be interesting to discuss the granularity and usability of the ontology as related to the closeness or scale of the communities.

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