Method for evaluating discussion status in online text discussions using network analysis

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Abstract: We analyze text discussions with the aim of using statement data to assess the status of an in-progress discussion. We assume convergent discussions with three discussion status types: Publication, Active, and Convergent. Then we propose an automatic method for evaluating discussion status by network analysis. Experimental evaluation indicates that the method is useful. We also achieved positive results in comparison with manual analysis.

Keywords: CSCL, Discussion Status, Network Analysis, Time-Series Analysis

Introduction

Analysis of discussion status from text is valuable when designing text-based CSCL. We analyze text discussions with the aim of assessing the status of in-progress discussions. We develop an automatic method for evaluating discussion status using time-series analysis.

There are two main approaches to analyzing statements in discussion: content analysis (CA) and social network analysis (SNA) [1]. CA codes statements according to statement type, focusing on contextual meaning [2]. SNA is a method for determining the relationship structure of components in various objects [3]. Erlin et al. [1] introduced research about CA and SNA, and argued that their integration provides a scientific and systemic way to analyze the quality of discussion. SNA can be applied to evaluate participants' roles by analyzing statement character [4]. In this paper, we apply SNA for such evaluation, and examine the efficacy of our method in comparison with CA-based methods. We also construct a network that indicates statement relativity based on discussion statement data.

Our objective is to propose an automatic analysis method for evaluating discussion status by SNA. We assume convergent discussions that form a conclusion, and that there are at least three status types: *Publication*, *Active*, and *Convergent*. As a preliminary development of the method, we propose a method to detect these status types. We analyze the experimental data by using our method and by manually applying CA, and determine the discussion status. Finally, we quantitatively assess our method by comparing its results.

1. Method for Evaluating Discussion Status Using Statement Data

1.1 Discussion Status

We assume an online discussion in text-based CSCL. Statements are extracted from a chat log along with input time and person. Our target is not divergent discussions that gather various opinions, but rather convergent discussions that form conclusions.

We assume that convergent discussions contain at least three types of discussion status (Figure 1): participants first describe their own ideas (Publication), and then they examine and compile these ideas (Active, and Convergent). We examine relational ties between statements with related content to detect discussion status. Participants disclose their own ideas in the Publication status. Therefore instructions to gather ideas and informative statements are made in this status. Back-channel feedback to these statements is also given in the Publication status, so at this time there are more new ideas than relational ties between statements. Participants examine their own ideas in the Active status, and thus provide questions and answers, as well as statements that connect with other statements. The number of relational ties between statements increases in the Active status. Participants compile their own ideas in the Convergent status, and thus make comments about their interaction and instruction that promote compilation. Thus, statements with many connections to previous ones are added at this time. Our objective is to detect changes in discussion status in progress. We seek alterations in discussion status by analyzing networks consisting of incrementally formed statements.

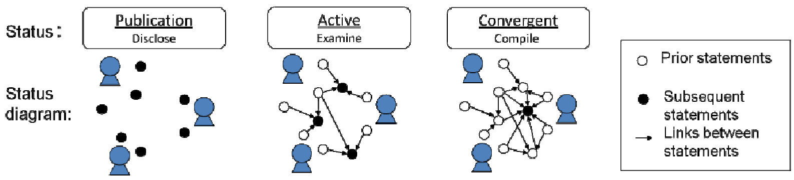

Figure 1 Discussion Status

1.2 Time-Series Analysis

This paper analyzes changes in discussion status by time-series analysis. We adopt statements by increments continuously to construct networks (statement networks), in which the nodes are statements and the links are the relational ties of statements. After making a statement, we adopt a given number of consecutive statements including that statement as a component of statement network, and construct statement network in continuity. Figure 2 shows an example of statement networks consisting six statements. In this manner, we analyze by calculating indexes of statement networks consisting consecutive statements as often as statement is made. We define relational ties according to the co-occurrence of words, adopting links between statements that share same nouns and adjectives. A statement network is digraph in which links are connected from a prior statement to a subsequent statement.

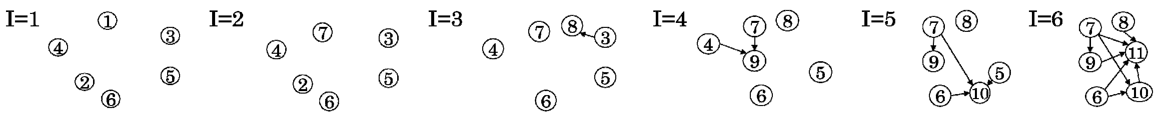

Figure 2 Time-Series Analysis (Number: Statement No., I: Statement Network No.)

To conduct quantitative analysis, we calculate three indexes on statement networks. First, we evaluate the amount of information in statements to detect *Publication*, in which statements present new ideas. Then we count the net number of words in statement networks to evaluate the amount of information in the statements. The net number is counted duplicative words as one word. The more words that statement networks have, the more information they contain. This allows us to detect *Publication*, the status with the most information, by counting the net number of words.

Next we focus on relational ties to detect the *Active* status, in which participants interact to examine their ideas, by calculating network density. Density, the proportion of possible links that are actually present in the network, is an index of the overall network structure [3]. In a statement network, density indicates the number of relational ties between statements, allowing us to detect the *Active* status through the increase in the number of relational ties.

Finally, we search for statements that affect prior statements to detect the *Convergent* status, in which statements concluding prior ones are added. Then we calculate the indegree centrality defined as the number of links directed to the node in the digraph [3]. The more links a node has in a network, the more central the node is [3]. Thus, the value of the indegree centrality of a node in a statement network indicates the amount of influence from the other statements. This allows us to detect *Convergent* status by calculating the indegree centrality of the last node in a statement network. When a statement alters the discussion status from, for example, *Active* to *Convergent*, the network around the statement can be in both statuses. Thus, we assume that statement networks can be in multiple statuses.

1.1 Determining Discussion Status through Social Network Analysis (SNA)

The following describes the method of determining discussion status through SNA. First, we construct statement networks consisting of h statements in a discussion with n statements. A statement network S_k has nodes from the kth statement to the $k + (h - 1)$th statement, and is a member of the statement network set $N = \{S_k \mid k = 1, \cdots, n - h + 1\}$. We use the net number of words, $W(S_k)$, as an index to determine *Publication.* A statement network set *P* whose elements are determined as being in the *Publication* status is defined as

$$P = \{ S_k \in N \mid W(S_k) > \overline{W} \}, \qquad (1)$$

where $\overline{W}$ is the average of $W(S_k)$ of all statement networks. Similarly, a statement network set *A* whose elements are determined as being in the *Active* status is defined as

$$A = \left\{ S_k \in N \mid \frac{D(S_k)}{D(S_{k-1})} > 1 \right\}, \qquad (2)$$

where $D(S_k)$ is the density of S_k. A statement network set *C* whose elements are determined as being in *Convergent* status is defined as

$$C = \{ S_k \in N \mid I(S_k) > \bar{I} \}, \qquad (3)$$

where $I(S_k)$ is the indegree centrality of the last nodes, and $\bar{I}$ is the average of $I(S_k)$ of all statement networks.

2. Experiment

2.1 Outline

In this chapter, we describe the experimental data on which we applied our method, and evaluate our method qualitatively by comparing chat log data. We also evaluate our method quantitatively by comparing the results of applying a CA-based method.

We conducted experiments with the participation of 20 Japanese students. We divided the students into four groups of five participants each. All four groups held a discussion through online text chat for 50 min. The theme of the discussion was the consensus game, the purpose of which is obtaining consensus among group members through discussion [5]. Group members performed an exercise in which they ranked eight items in descending order of importance for survival in a difficult situation [5]. They could use Google Chat as a group chat program and Google Docs Presentation to share information.

2.2 *Results of Proposed Method*

In applying our method to the experimental data, we set the number of nodes *h* as 35 in a statement network for every group. The ‘SNA’ column in Table 1 shows the results of the status determination. The number of status determinations in the group 2 discussion was biased, because that group did not have enough time after an extended discussion of policy, and thus decided to determine conclusions by majority vote. Results are therefore biased towards a *Publication* determination. Here we describe the results of the group 1 discussion analysis in detail. Figure 3 shows the statuses of the group 1 discussion. The horizontal axis shows the statement network number, thus progress of discussion. The painted bars describe that network is in the status. The beginning of the discussion was determined as *Publication*, indicating that they were disclosing their own ideas. After that, the number of *Active* statuses increased. Statement network 55 was determined to be in the *Convergent* status. It showed a full flow of discussion: disclosing, examining, and compiling ideas. The early part of discussion showed the discussion cycle defined in Section 1.1, but the latter part of the discussion became jumbled. This illustrates the difficulty of our method in exactly analyzing status along with discussion progress. The discussion status skipped, for example, from *Convergent* to *Active* status when previous statements were mentioned again. We confirmed those statements by checking pertinent sections of the chat log. As a result, our method is effective for evaluating discussion status.

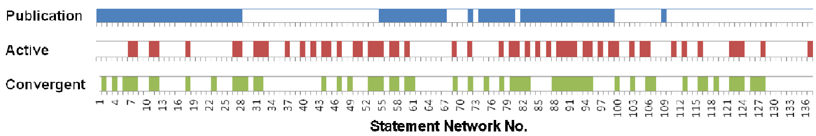

Figure 3 Determinations by our method (Group 1)

2.3 *Comparison of proposed method with CA*

We next compared the results from our SNA-based method with the results from a CA-based method. Following Fujimoto et al. [6], we used six types of statement code for CA: *Information*, *Instruction*, *Reflection*, *Question*, *Answer*, and *Comment*. This code is an adaptation of Verbal Response Mode Coding System [7], modified to accommodate discussions in Japanese. Three collaborators who did not join the discussions manually coded the chat log data. Coding was decided by majority, and data were coded as *non-codable* when all three opinions differed.

We determined the relationship between this code and discussion status based on the assumptions in Section 1.1. A statement S_k is determined to be *Publication* when there are more statements coded *Information*, *Instruction*, or *Reflection* than the average of those in the entire network. Similarly, a statement S_k is determined to be in the *Active* status when there are more statements coded *Question* or *Answer* than the average of those in the entire network. A statement S_k is determined to be in the *Convergent* status when there are more statements coded *Instruction* or *Comment* than the average of those in the entire network. We examine precision and recall to compare the results. As previously noted, each statement network can have multiple statuses. We therefore separately evaluate each status. Equations (4) and (5) define the precision and recall, respectively, for a status *X*.

$$\text{precision} = \frac{|\{\text{Networks are determined to be } X \text{ by SNA}\} \cap \{\text{Networks are determined to be } X \text{ by CA}\}|}{|\{\text{Networks are determined to be } X \text{ by SNA}\}|} \quad (4)$$

$$\text{recall} = \frac{|\{\text{Networks are determined to be} X \text{ by SNA}\} \cap \{\text{Networks are determined to be } X \text{ by CA}\}|}{|\{\text{Networks are determined to be } X \text{ by CA}\}|} \quad (5)$$

Table 1 Comparison of SNA and CA

	Group 1(137)				Group 2(163)				Group 3(105)				Group 4(316)			
	SNA	CA	Precision	Recall	SNA	CA	Precision	Recall	SNA	CA	Precision	Recall	SNA	CA	Precision	Recall
P	68	69	0.735	0.833	103	71	0.592	0.616	51	66	0.608	0.463	101	111	0.287	0.420
A	52	61	0.423	0.458	59	113	0.542	0.364	43	57	0.465	0.317	95	215	0.516	0.310
C	54	84	0.685	0.440	72	86	0.458	0.384	35	57	0.686	0.421	91	200	0.626	0.285

P:*Publication*, A:*Active*, C: *Convergent* ( ): The number of statement networks

Table 1 shows a comparison of the precision and recall of the results of our method and those of the CA-based method. The ‘CA’ column in Table 1 gives the CA-based determinations. With the exception of group 4, determinations of *Publication* status showed relatively good value. Group 4 had many short statements, making automatic determination difficult by our method. Although values there were poor, the proposed method achieved some positive values for *Active* status. With the exception of group 2, the precision of determining *Convergent* status exceeded 60%. Calculating the feature quantity of networks of consecutive statements in our automatic analysis method is corresponded with manual evaluations to some extent. We could get good values for *Publication* and some positive values for *Active* and *Convergent* status determinations.

3. Conclusion

We proposed an automatic method based on SNA for evaluating discussion status in chat log data, assuming convergent-type discussions with three discussion status types: *Publication*, *Active*, and *Convergent.* We applied time-series analysis using indexes to evaluate each status. Furthermore, we developed a method for determination of discussion status using SNA based on those indexes. Experimental verification using the chat log data indicated the possibility of detecting discussion status, and comparison of the results of CA confirmed that our automatic method corresponded with manual analysis to some extent. In future research, we plan to develop a method for evaluating other discussion status from many perspectives. Furthermore, we will consider what constitutes a smooth discussion when this method is established. We expect that we will be able to immediately give suitable support in CSCL for each discussion status through real-time discussion evaluation.

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