Analysis Method for One-to-one Discussion Process for Research Progress Using Transition Probability of Utterance Types

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***Abstract*—People in business companies and academic fields work in cooperation with others rather than working alone. They may discuss their progress with others, like co-workers and supervisors, to help them obtain the best results. Sometimes people may feel that such discussions are not conducted well. However, people do not evaluate the quality of each discussion every time because it is tough work for them; they usually do not have enough time for that. In the process of evaluating discussions, people might look back on their discussions and make a plan to have an improved discussion next time. This paper proposes an evaluation method for one-to-one research discussions. The method makes a model of the discussion process with transitions of utterance types. The labels of utterance types are assigned to each utterance in a discussion text manually. By calculating the transition probabilities between two labels, a matrix of transition probabilities is obtained. The transitions of labels with high probabilities are extracted from high quality discussions and connected to obtain a discussion process model. The model can be used for the evaluation of new discussions. We applied the proposed method to discussion texts and found that the obtained process model from high quality discussions had several loops of transitions which were connected loosely.**

Keywords–One-to-one discussion; Utterance type; Visualization; Process model; Transition probability.

I. INTRODUCTION

People in business companies and academic fields work in cooperation with others rather than working alone. It is important to discuss their working progress with others, like co-workers and supervisors, to help them obtain the best results. Such people can exchange their opinions and advise each other. These discussions make people understand not only what others think, but also ensure that members of the same team are in agreement about their work.

Discussions are sometimes not conducted well. This happens because discussions have a time limit and people often fail to arrive at a common understandings due to the difference in their thinking styles. However, people do not evaluate the quality of each discussion every time because it is tough work for them; they usually do not have enough time for that. In the process of evaluating discussions, people might look back on their discussions and make a plan to have an improved discussion next time.

This paper proposes an evaluation method for one-to-one research discussions between a student and his/her corresponding supervisor. The method makes a model of the discussion process with transitions of utterance types to evaluate future discussions. Note that we define a high quality discussion to be a discussion in which both the student and his/her corresponding supervisor understand their research progress. We believe that a high quality discussion should have characteristic transitions of utterance types.

The rest of this paper is structured as follows. In Section 2, we discuss related work. The proposed method is presented in Section 3, followed by our experiment in Section 4. Finally, we conclude in Section 5.

II. RELATED WORK

Our proposed method is a conversation analysis method. Previous methods cover not only general conversations [1], but also purpose-oriented conversations such as conversations for persuasion [2]. The proposed method targets the analysis of one-to-one discussions for research progress. A discussion on the topic of research progress tends to have loops of divergence and convergence. General conversations should be divergent conversations while purpose-oriented conversations should be convergent. A target discussion should be in the middle of the two types. Our hypothesis is that a loop appears in a model of the discussion process if the discussion is conducted well. Many conversational features are used in the conversation analysis. The number of utterances in a conversation is used for evaluating the quality of conversations [3]. The length of silent time in a conversation is also used for the evaluation of the quality of the conversation [4]. The proposed method uses utterance types in a discussion as the conversational features. While the two previous studies use quantitative features, the proposed method uses qualitative features, i.e., utterance types. If both features are used for conversation analysis, the analysis results will become rich.

There are some sets of utterance types for conversation analysis. The sets such as Switchboard-Dialog Act Markup in Several Layers (SWBD-DAMSL) [5] and Meeting Recorder Dialog Act (MRDA) [6] provide labels of utterance types. Those sets were prepared for analyzing specific conversations and discussions. Therefore, we also design a set of labels of utterance types by referring to our target discussions.

III. PROPOSED METHOD FOR EVALUATION OF DISCUSSION

The outline of the proposed method is described in this section. Firstly, a transcript of a discussion is prepared manually. One line includes a speaker's name and an utterance text.

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Greeting, Confirmation, Question, Answer, Agreement, Repetition, Explanation, Opinion, Admiration, Suggestion, Understanding, Topic Shifting, Report, Degression, Soliloquy, Nodding, Request, Planning, Denial, Filler, Consultation, Response, Comment, Advice, Indication, Correction, Wondering, Surprise, Acknowledgement, Chatting, Additional Comment

Figure 1. Labels of Utterance Types.

Each utterance is assigned one utterance type label. A matrix of the transition of labels (i.e., utterance types) is obtained. Each cell of the matrix has a transition probability between two labels. Transitions with high probabilities are extracted from the matrix. The extracted transitions are connected if the same labels are included, and then a discussion process model is obtained. The model can be used to evaluate future discussions.

A. Preparing Transcripts of Discussions

We suppose that a research discussion should be conducted face-to-face. The research discussion is recorded by a voice recorder. The proposed method uses transcripts of discussion to make a model. One line of the transcript includes a speaker's name and an utterance text; the utterance text includes fillers. The length of sound in a word, the length of silent time, and any laughing time are not included. An utterance text includes several sentences before turn-taking occurs. Table I shows an example of a part of a transcript.

B. Assigning Utterance Type Labels to Utterances

Each utterance in the transcript is labeled with utterance types. Though an automatic labeling method has been proposed [7], the labeling accuracy is not enough. In our case, each utterance is labeled manually to ensure accurate labels. Though sets of labels for utterances have also been proposed [8], most of the sets of labels have their target discussions and conversations. We design a new set of labels for utterances of our target discussions, that is discussions for research progress.

Figure 1 shows labels of utterance types. These labels are designed by referring to the transcripts of discussions that will be described in Section IV. The utterance from a supervisor and the utterance from a student will be distinguished. The labels for the supervisor's utterances and the labels for the student's utterances will also be distinguished by a different ending added to the label. The proposed method uses $31 * 2 = 62$ types of labels in total.

When labeling utterance text, the already appeared utterance texts are also considered. An utterance text may not have enough information for labeling. If a student says "Yes" for a question from a supervisor, it means "Yes, you are right." But if a student says "Yes" for a proposal from a supervisor, it means "Yes, I will do it." The two "Yes"s are different types of utterances.

Multiple labels may be assigned to an utterance text because a single utterance may have several roles. The corresponding ending to distinguish the speaker is also added to each label. In this paper, the ending for an utterance from a supervisor is set to T, while the ending for an utterance from a student is set to S.

C. Matrix of Transition Probabilities of Labels

A matrix of transition probabilities of labels is obtained by using the labels information on utterance texts. The transition probability of labels means a probability between labels. Suppose that the ith utterance text has a vector of labels $L(i)$ and the jth utterance text has a vector of labels $L(j)$ ($j = i+1$). $L(i)$ is described by (1).

$$L(i) = \{l_n | 0 <= n <= 61\}, \tag{1}$$

where n is the label index. l_n is 0 or 1. If the nth label is assigned to an utterance text, l_n = 1. Otherwise, $l_n = 0$. The frequency of transition from the label l_n in $L(i)$ to the label l_m in $L(j)$ is increased if both of l_n and l_p are not equal to zero. Let the frequency be $f_{n,m}$. Let the number of lines of the transcript be NL. $NL - 1$ is the number of turn-taking in a discussion. The transition probability $p_{n,m}$ from the label l_n to the label l_m is calculated by (2).

$$p_{n,m} = \frac{f_{n,m}}{NL - 1}, \tag{2}$$

where n and m are labels indices. By assigning the probability $p_{n,m}$ to each cell, a matrix of transition probabilities is obtained. Table II shows an example of a part of the matrix that is obtained from discussion texts (detailed in Section IV).

D. Discussion Process Model

A discussion process model is obtained by using the matrix of transition probabilities. Transitions of labels with probabilities more than a threshold T are extracted from the matrix. The extracted transitions are connected if the same label is included in two different transitions. The graph of connected transitions is the model to evaluate the discussions proposed in this paper.

IV. Experiment

We made discussion process models for high quality discussions and low quality discussions. We compared the two models and found the differences between the two models. We used eight transcripts of discussion between a supervisor and a student in our laboratory. The number of supervisors was two while eight students (four males and four females) were in the laboratory. Each of the supervisors had for students, respectively. The students were 21 to 22 years old and were enrolled in the College of Information Science and Engineering. The transcripts of the discussion were read by the 1st author and the 2nd author. The two authors divided the transcripts into two classes: a high quality discussion class and a low quality discussion class. Table III shows the details of the eight transcripts; the length of discussion, the number of utterances from a supervisor and the number of utterances from a student are described. The average length of discussion was 26 minutes and 58 seconds. The average number of utterances from a supervisor was 81 while that from a student was 71.5. The transcripts with IDs 1 to 4 were in the high quality discussion class while those with IDs 5 to 8 were in the opposite class.

A. Experimental Results and Discussion

Table IV and Table V show the top five label transitions with high probabilities in each transcript of the discussion. Table IV shows the transitions obtained from transcripts of a high quality discussion class. All of them had the transition $Answer\_S \rightarrow Question\_T$ in the top five transitions with the highest probabilities except in the transcript #4. It means that a supervisor gave a question and a student answered a question

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TABLE I. EXAMPLE OF TRANSCRIPT OF ONE-TO-ONE DISCUSSION.

Speaker	Utterance	Label
T	はい、じゃあ、えっと、よろしくお願いします。(Well, let's start the meeting.)	挨拶 (Greeting)
T	えーっと、書き起こしが、まあ当然まだだと思ってるんですけども、えっと１人もらった？ (I'm sure that you have not made a transcription naturally. Did you get a recording data?)	質問 (Question)
S	はい。(Yes.)	回答 (Answer)
T	それは誰のん？(Who did you get it from?)	質問 (Question)
S	岡村さんから。(From Riko.)	回答 (Answer)
T	岡村さんからもらった、了解、了解。(You got it from Riko, OK.)	理解 (Understanding)
T	それはなん分ぐらいのデータ？(How long was the data?)	質問 (Question)
S	えっと、４５分ぐらいだったと思います。(Well, about 45 minutes)	回答 (Answer)
T	ながっ。(So long.)	感想 (Comment)
S	長かったです。(It's so long.)	反復 (Repetition)

TABLE II. EXAMPLE OF MATRIX OF TRANSITION PROBABILITIES.

/	Greeting_T	Question_T	Understanding_T	Suggestion_T	Confirmation_T	Answer_S	Repetition_S	Agreement_S	Question_S
Greeting_T	0	0	0	0	0	0	0	0	0
Question_T	0	0	0	0	0	0.082	0	3	0
Understanding_T	0	0	0	0	0	0	0	0	0
Suggestion_T	0	0	0	0	0	0	0	0.014	0.014
Confirmation_T	0	0	0	0	0	0.031	0	5	0
Answer_S	0	0.054	0	0.003	0	0	0	0	0
Repetition_S	0	0	0	0	0	0	0	0	0
Agreement_S	0	3	0	0.008	0.007	0	0	0	0
Question_S	0	0	0	0	0	0	0	0	0

TABLE III. USED EIGHT TRANSCRIPTS OF DISCUSSION. THE LENGTH OF DISCUSSION, THE NUMBERS OF UTTERANCES FROM A SUPERVISOR AND A STUDENT ARE SHOWN, RESPECTIVELY.

Discussion ID	Length (minutes : seconds)	# of utterances from a supervisor	# of utterances from a student
1	48:02	139	127
2	24:29	50	43
3	19:20	50	44
4	44:11	151	145
5	20:38	53	50
6	28:55	100	76
7	17:25	67	58
8	12:42	38	29
Average	26:58	81.0	71.5

frequently in a discussion. Table V shows the top five transitions of low quality discussion class. Though all of them had the same transition ($Answer\_S \rightarrow Question\_T$), there were other labels such as $Confirmation\_T$ and $Explanation\_T$. This means that the supervisor needed to confirm and explain to the student frequently in the discussion.

Table VI shows the top nine transitions of labels with high values of summation of probabilities in transcripts of high quality discussion and low quality discussion, respectively. The high quality discussion class has transitions such as $Answer\_S \rightarrow Question\_T$, $Agreement\_S \rightarrow Opinion\_T$ and $Answer\_S \rightarrow Understanding\_T$. The transitions indicated that the discussions were conducted smoothly. In contrast, the low quality discussion class has transitions such as $Question\_S \rightarrow Answer\_T$ and $Agreement\_S \rightarrow Explanation\_T$. The transitions indicated that the discussions were not conducted smoothly and so the supervisor and the student could not come to a common agreement.

Figure 2 shows the obtained model of the high quality discussion process. In the figure, there are loops consisting of some specific labels such as $Question\_T \leftrightarrow Answer\_S$, $Opinion\_T \leftrightarrow Agreement\_S$, and $Suggestion\_T \leftrightarrow Agreement\_S$. The small loops are connected to make a big loose loop.

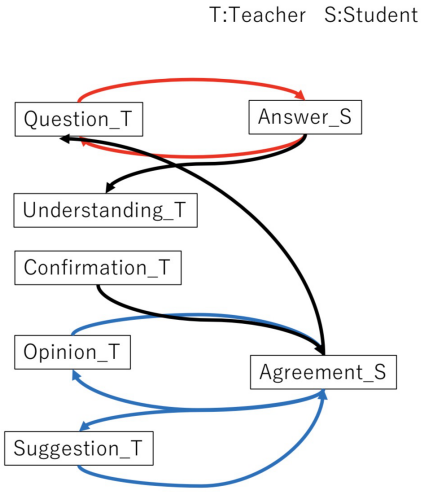

Figure 2. Process model of high quality discussion.

Figure 3 shows the obtained model of the low quality discussion process. In the figure, there are loops of some specific labels such as $Question\_T \leftrightarrow Answer\_S$ and $Suggestion\_T \leftrightarrow Agreement\_S$. Although some of the small loops are connected, all loops are not connected. Some of the transitions have dead-end paths like $Understanding\_S \rightarrow Opinion\_T$.

V. CONCLUSION

This paper proposed an evaluation method for one-to-one research discussions. We used the research discussion between a supervisor and a student who is studying for a graduation thesis at a university. The proposed method makes a discussion process model with transitions of utterance types. Labels of utterance types are originally designed for discussion analysis for research progress.

In this paper, we analyzed eight discussion texts. We

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TABLE IV. TOP FIVE TRANSITIONS OF LABELS IN TRANSCRIPTS OF **HIGH** QUALITY DISCUSSION CLASS.

Discussion 1 Transition(Prob.)	Discussion 2 Transition(Prob.)	Discussion 3 Transition(Prob.)	Discussion 4 Transition(Prob.)
Answer_S → Question_T(0.074)	Answer_S → Question_T(0.098)	Answer_S → Question_T(0.069)	Opinion_T → Agreement_S(0.087)
Indication_T → Agreement_S(0.028)	Answer_S → Suggestion_T(0.036)	Agreement_S → Question_T(0.052)	Agreement_S → Opinion_T(0.084)
Question_S → Answer_T(0.025)	Suggestion_T → Agreement_S(0.036)	Suggestion_T → Agreement_S(0.052)	Suggestion_T → Agreement_S(0.032)
Understanding_S → Advice_T(0.025)	Nodding_S → Opinion_T(0.027)	Agreement_S → Suggestion_T(0.043)	Answer_S → Question_T(0.029)
Understanding_S → Question_T(0.021)	Answer_S → Understanding_T(0.027)	Confirmation_T → Answer_S(0.043)	Confirmation_T → Agreement_S(0.029)
Answer_S → Advice_T(0.021)	Opinion_T → Nodding_S(0.027)		

TABLE V. TOP FIVE TRANSITIONS OF LABELS IN TRANSCRIPTS OF **LOW** QUALITY DISCUSSION CLASS.

Discussion 5 Transition(Prob.)	Discussion 6 Transition(Prob.)	Discussion 7 Transition(Prob.)	Discussion 8 Transition(Prob.)
Understanding_S → Opinion_T(0.074)	Suggestion_T → Agreement_S(0.060)	Question_S → Answer_T(0.049)	Question_S → Answer_T(0.040)
Explanation_T → Understanding_S(0.074)	Agreement_S → Suggestion_T(0.042)	Confirmation_S → Answer_T(0.042)	Answer_S → Question_T(0.040)
Suggestion_T → Agreement_S(0.056)	Answer_S → Question_T(0.036)	Answer_S → Question_T(0.042)	Agreement_S → Suggestion_T(0.040)
Agreement_S → Explanation_T(0.037)	Explanation_T → Understanding_S(0.036)	Agreement_S → Suggestion_T(0.035)	Agreement_S → Confirmation_T(0.030)
Agreement_S → Suggestion_T(0.037)	Answer_S → Suggestion_T(0.030)	Suggestion_T → Agreement_S(0.035)	Confirmation_T → Agreement_S(0.030)
	Agreement_S → Advice_T(0.030)		Suggestion_T → Agreement_S(0.030)
	Advice_T → Agreement_S(0.030)		

TABLE VI. TRANSITIONS OF LABELS USED FOR MAKING DISCUSSION PROCESS MODELS FOR HIGH/LOW QUALITY DISCUSSION.

Transitions from **high** quality (Prob.)	Transitions from **low** quality (Prob.)
Question_T → Answer_S(0.125)	Question_T → Answer_S(0.083)
Answer_S → Question_T(0.058)	Suggestion_T → Agreement_S(0.044)
Opinion_T → Agreement_S(0.038)	Agreement_S → Suggestion_T(0.039)
Agreement_S → Opinion_T(0.037)	Question_S → Answer_T(0.035)
Suggestion_T → Agreement_S(0.027)	Answer_S → Question_T(0.031)
Confirmation_T → Agreement_S(0.022)	Explanation_T → Understanding_S(0.023)
Agreement_S → Question_T(0.020)	Understanding_S → Opinion_T(0.019)
Answer_S → Understanding_T(0.017)	Answer_S → Suggestion_T(0.017)
Agreement_S → Suggestion_T(0.017)	Agreement_S → Explanation_T(0.017)

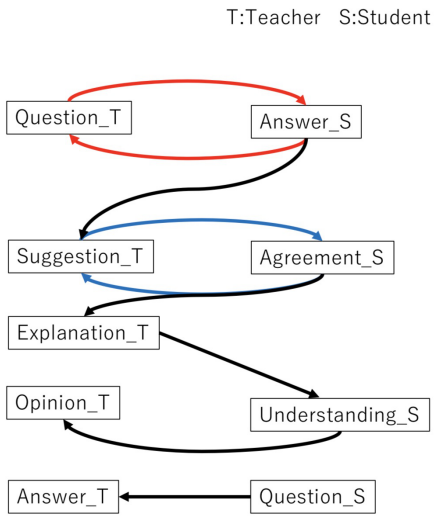

Figure 3. Process model of low quality discussion.

divided the texts into high quality and low quality discussion classes; each class had four texts, respectively. The obtained model from high quality discussions had several loops of transitions, which were connected loosely. In contrast, the obtained model from low quality discussions did not have loops of transitions. In the model for low quality discussions, the transitions between "understood by student" and "explanation by supervisor" were included. The transition in the model might mean that the supervisor and the student did not come to a common understanding.

As future work, we will try to evaluate the growth in the discussion skills of a student by using the proposed method. We will improve our method to conduct automatic labeling of utterances for analyzing many discussions.

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