Design and Implementation of Group Work Monitoring System for Exploring Creativity

Atsuo Yoshitaka
School of Advanced Science and Technology
JAIST
1-1 Asahidai, Nomi, Ishikawa, Japan

Anh Minh Truong*
School of Advanced Science and Technology
JAIST
1-1 Asahidai, Nomi, Ishikawa, Japan

***Abstract*—One of the objectives of group work is to make new idea, method, design, product, etc., which is essential task requiring creativity. When we evaluate or analyze activities in group work, peer and/or self-evaluation by questionnaire is often taken. Such method of evaluation is adequate in order to explore various aspects of quality which is involved in the group work, however, it is not easy to analyze how each member of the group was in active or just to join the discussion, following time transition. In order to analyze the activity with regard to conversation between one member and another, protocol analysis, which tracks conversation between one person and another, is employed as one of the typical method. Protocol analysis basically focuses on direction, frequency, and verbal contents of conversation. Therefore, affective status of members, which is one of the aspects considered to be related to the degree of creativity. In this paper, we describe a system for monitoring emotional status of each members involved in group work by means of the analysis of vocal features. Since vocal features, such as f1 frequency or pitch, are known to be related to affective condition of a person, the proposed system keeps track of such frequencies of multiple persons simultaneously and visualizes the transition of such frequencies on screen. The proposed system can be utilized to analyze the status of affective condition of each member of the group to find when he/she was active to contribute to present the status of higher creativity.**

Keywords—group work; affective information; status of creativity; affective information analysis; vocal features

I. INTRODUCTION

Group work is often carried out when we need to make new idea, design, method, product, services, and so on. Expectations of group work compared with individual based thinking process are exchanging idea, getting different viewpoints with regard to a target issue, cultivate idea inspired by comments by others. One of ideal status of group work is that it contributes to produce quality outcome as expected prior to conduct it, which is often mentioned as a term of 'creativity'. From this point of view, there is an issue of how we should analyze and measure group work from the point of view of creativity.

Though many discussions have been made on the method of analyzing group work, we can consider several criteria or directions to evaluate creativity of group work. First direction is the granularity of analysis; one is to evaluate 'group creativity', which is to assess the degree or quality of creativity of a group without decomposing the reason of creativity into individual based contribution for the outcome. Another is to evaluate individual creativity in a group based on the analysis to figure out the elements of individual activity which are associated with the outcome.

Second direction is temporal granularity. Endpoint evaluation is to evaluate the quality of the activity or the outcome of a group work from the point of view of creativity after the group reached a goal or when the specified term for group work is completed. Continuous evaluation or on the fly evaluation is to evaluate creativity from the beginning until the end of group work. This way of evaluation is chosen if we are more interested in analyzing when crucial event is happened during the process of discussion. In this case we are more interested in temporal transition of the activity which may contributed to creativity rather than the outcome itself.

Third direction is the source of information. Direct evaluation is to evaluate the quality of creativity by the outcome, whereas Indirect evaluation refers to verbal information during group work or other kind of behavioral information which is considered to be related to creativity.

We are motivated to analyze the temporal transition or process of creativity and to explore attributes which are informative to evaluate the creativity of individual at each moment of time in group work. Discussing by following above-mentioned criteria, our motivation follows the directions of individual creativity, continuous evaluation, and indirect evaluation. This is because we are more interested in when or how frequently each of the members in a group was active from creativity point of view.

In this paper, we describe our design and implementation of group work monitoring system, which is aimed at monitoring activity of each member in a group to analyze when he/she is neutral in group discussion or tends to be more creative by measuring a specific frequency of his/her voice. The relationship between emotional condition and creativity as well as the relationship between emotional state and vocal features with respect to frequency have been studied. Our idea is to monitor specific vocal features such as F1 frequency, which are known to be related with emotion of a person, to visualize with

*Currently with Ghent University

respect to time in order to analyze in which moment in a group work he/she was more creative or neutral from emotional state.

In the reminder of this paper, we describe the background of our strategy to evaluate whether a member of group work is more creative or less in section 2. The organization of our system and the method of vocal data processing is described in Section 3, and experimental result of visualizing vocal features are shown in Section4. Concluding remarks with future work are mentioned in Section 5.

II. Group Work and Analysis

A. Conventional Methods for Group Work Analysis

Group work is considered as a learning tool and it is expected to cultivate ideas in a group, stimulated by opinions by other members [1]. Not only to analyze the outcome of group work, but the analysis of dynamics in the process of group work by focusing on both individual creativity and group creativity is also studied [2]. Factors which support creativity are summarized into seven classes, which relate to information, organization, time constraint, and human factors [3]. Methods to analyze group work are studied by researchers. Though main interest for analysis may depend on the area of study, profile of the members, types of outcome, and so on, various methods for collecting or analyzing data are proposed, one of the typical ways of analysis is to observe group work from different levels; individual level and group level [4].

We think one of the important questions with regard to group work is what and how we should analyze group work to measure creativity. Concerning dimensions to measure creativity, [8] proposed three dimensional model that consist of level (individual, team, organization, and culture), facet (trait, process, press, product), and measurement approach (objective, self-rating, and other-ratings). Such studies are surveyed and summarized by four major directions, namely, process, person, product, and press [9]. Since our objective in this study is to develop a system which will be informative to measure creativity in group work by analyzing the behavior of person, we focus on the `person` in above-mentioned directions. We discuss what and how we should observe members in group work for measuring creativity hereafter.

There are two typical and standard methods of analysis; analysis by questionnaire [5] and analysis by communication such as conversation [6]. Analysis by questionnaire is to ask participants of group work to fill in questionnaire for self-evaluation and/or peer evaluation. This way of analysis is adequate if main concern is to explore internally (by oneself) and/or externally (by other members) recognized behaviors. Filling in questionnaire may be carried out multiple times during group work, however, granularity of analysis with regard to time is quite limited. Analysis by communication is also common for analyzing individual and group behavior in group work. This method is further classified into two types; one is oral communication based analysis, and another is mediated communication based analysis. In some studies, both types of communication, i.e., face to face communication as well as communication by e-mail, are monitored for analysis [7].

In addition to these methods, [9] mentioned traits of creative individuals as attraction of complexity, high energy, behavioral flexibility, intuition, emotional variability, and so on.

B. Creativity and emotion

Focusing on emotional variability, there are studies that revealed the relationship between creativity and emotion. It is argued that creative performance is enhanced in positive emotional states in [10], configuring positive, neutral, and negative affective condition in the study. Other studies [11] [12] also mentioned that a person tends to be more creative in positive mood. According to these observations, detecting the transition of emotional or affective condition of each member in a group is considered to give us clue to measure whether he/she is more in the state of higher creativity of lower creativity. The reason why we focus on the relationship between emotion and creativity is that emotional state of person can be detected without explicit declaration by a person but by bio-related information such as facial expression of vocal feature of a person.

III. System Design for Group Work Monitoring

A. Consideration on source of information for emotion detection

As mentioned in the previous section, our objective is to monitor the transition of the degree of creativity of a person involved in group work, from the point of view of detection his/her emotional state in group conversation. As mentioned, there is a relationship between positive emotional state and higher creativity, we aim to detect the transition between neutral and positive state implicitly from bio-information observable. Facial expression and vocal feature are considered as major source of information which can be sensed without disturbing activity of group work, free from attaching sophisticated sensors or conductors which restrict the mobility of a person. When we consider detecting emotional state by facial expression, there is a problem of occlusion in capturing human face. It is obvious that it is not possible to capture face image when a person does not direct toward camera. In order to avoid this problem, multiple cameras can be installed in the environment, however, such solution does not solve to capture a face when he/she looks downward in addition to the issue of increase of the cost of the system.

Another possible solution is to capture the voice of each member independently in order to detect emotional state by vocal feature extraction and evaluation. This method may be a problem if a single microphone is installed in the environment to capture voice of all the members in mixture, since voice separation or voice identification is still a difficult problem to solve. However, this problem can easily be avoided by attaching independent microphone to each of the person, without significant increase of cost and data processing for person identification or source separation. In the following section we discuss system architecture for analyzing transition of emotional state of each member in group work and describe implementation detail and preliminary testing of the proposed system.

B. *System Architecture*

Figure 1 illustrates the architecture of the system. We assume that head-set with microphone is wore by each of the member in a group for better separation of voice of others. The head-set with microphone, FerBuee, is Bluetooth wireless microphone coupled with small receiver, whose output is analog signal served with mini audio plug. Voice output from Bluetooth microphones is then connected to multi-channel audio interface, Live Recorder LR16 by cymatic audio. It accepts analog 8ch stereo simultaneously, i.e., 16 voice input can be captured simultaneously. Multiple channels of voice input is then transferred to laptop PC (Lenovo ThinkPad X220) via USB. Figure 2 show a snapshot of the entire components of the system. Note that the number of microphone can be increased upto 16, as many as the number of member in a group.

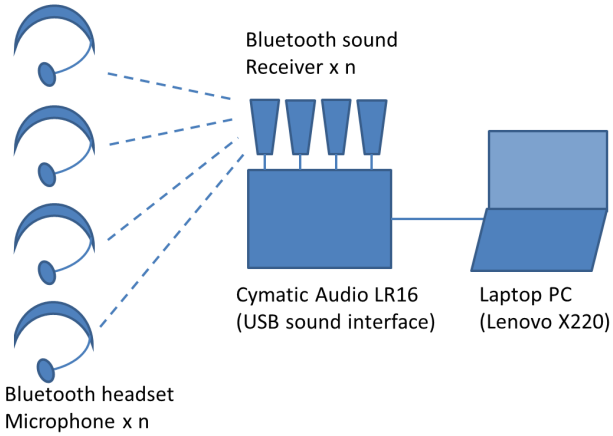

Fig. 1 System Organization

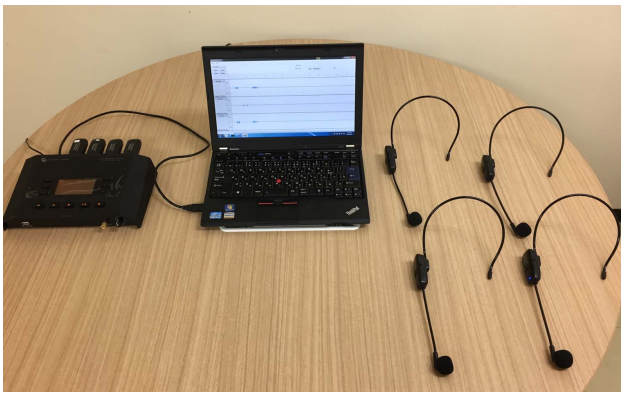

Fig. 2 System Overview

IV. Vocal Feature Extraction and Visualization

A. *Vocal Feature and Emotional State*

There are vocal features which are known to be associated with emotion, mental state, and/or personal identity, namely fundamental frequency, word pitch, formant frequency, relative power strength. They are referred to for detecting the state of emotion. Emotional state of a person is known to be related to the change of fundamental frequency (F0) and formant frequency such as first formant (F1), second formant (F2), and so on. Positive emotional state such as joy is known that the first formant frequency (F1) is higher than neutral of negative emotion such as sad [13], and formant power is highest in happiness emotion [14]. Therefore LPC (linear predictive coding) is applied in order to calculate the first formant frequency. LPC is one of the common way of calculating formant frequencies.

B. *Visualizing Temporal Transition of Formant Frequencies*

Fig. 3 shows the initial screen of the proposed system displaying waveform of voice input. This initial screen is view in order to check gain adjustment of each channel of microphone. As seen in the figure, sound waveform of multiple channels is displayed real time.

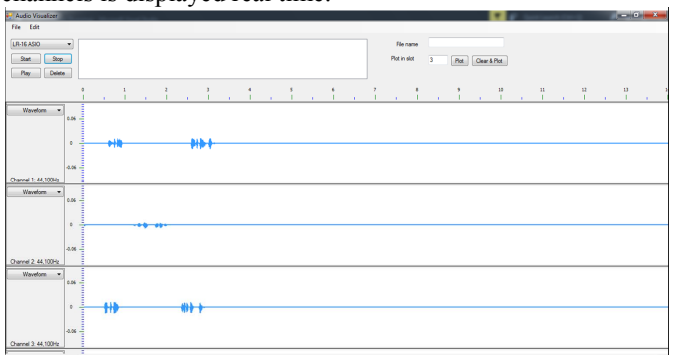

Fig. 3 Initial Screen of the Prototype System

Improper configuration of voice gain prevents the user of the system to observe difference of vocal features. For example, over gain configuration results spectral component to be deformed, which means that the accuracy of the result of LPC is unreliable. On the contrary, if the configuration of the gain configuration is too low, peaks that correspond to formant frequency will be less sharper, which results precision of LPC is lower. Therefore, proper amount of gain should be specified by monitoring the waveform displayed on the screen.

After configuration, the user may specify frequency component in accordance with his/her interest of analysis of group work. Since this system is implemented so that the user can observe not only F1 frequency but power and power envelope of F1 frequency component. Figure 4 shows an example of visualizing F1 frequency, F1 power and power envelope. Horizontal axis corresponds time line and vertical axis corresponds to frequency or power. In some cases it is too busy to display all the three component on screen and it may disturb the user to see the detail of the transition of formant frequency, power, and the shape of power envelope, he/she can choose one or more components by marking check box on the left.

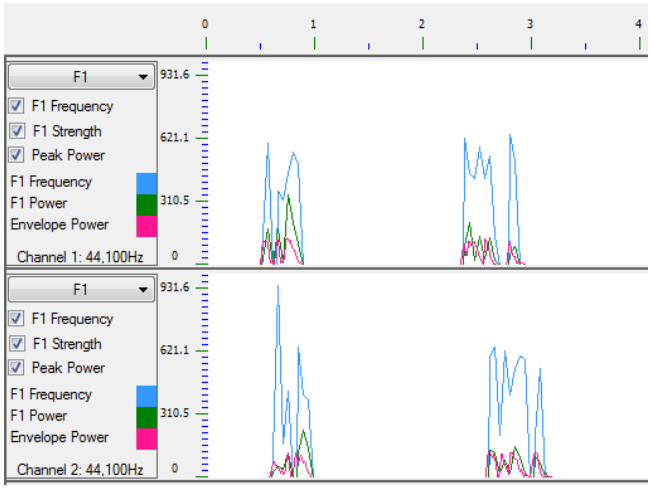

Fig. 4 An example of Visualizing F1 freq., Power and envelope

C. *Preliminary Operation of Formant Visualization*

In this section, we will show preliminary operation of the proposed system. In order to confirm if we can observe the different emotional condition by the difference of F1 frequency, we instructed two mail students to have the same conversation (same verbal contents) in neutral emotion and in another emotional condition of happiness or joy.

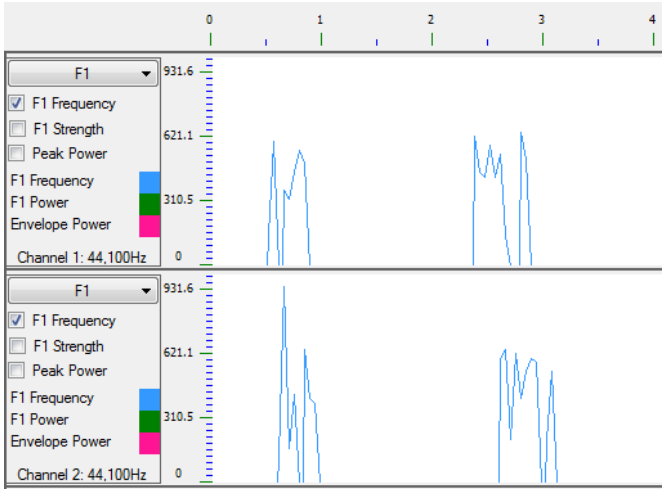

Fig. 5 Visualizing F1 freq. in neutral and joy of student A

Fig. 5 and 6 shows visualized transition of F1 frequency uttering the same verbal contents by student A and student B, respectively. Upper area corresponds to visualization of F1 component of utterance in neutral emotional state, and lower area corresponds to that of joy or happiness state. As seen in both of the examples, F1 frequency in the utterance is higher in the state of joy or happiness emotion.

Note that F1 power is also informative to find the state of happiness of joy, however, we did not tested to see if this feature is observable since gain normalization is needed for precise comparison and such process gives less freedom in operating environment of the system.

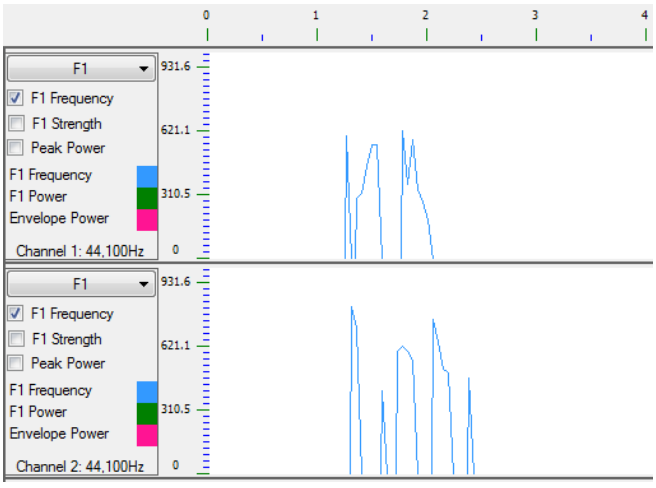

Fig. 6 Visualizing F1 freq. in neutral and joy of student B

V. Conclusion

In this paper, we described our design and implementation for analyze temporal transition whether he/she is in the state of higher or lower creativity based on the studies that explored the relationship between emotional state and creativity. According to the study, a person is more creative in the state of happiness or joy compared with negative emotional state. Therefore, the proposed system monitors the utterance of each member of group work in order to measure first formant frequency for exploring the transition of emotional state in group work.

We observed that even he/she utters the same verbal contents, F1 component tends to be higher in joy or happiness state compared with neutral emotional state. Auto-calibration of formant frequency normalized in neutral emotional state, consideration and design of more effective mode of visualization, and evaluation in real group work environment are our future work.

Acknowledgment

The authors would like to thank Mr. Pho Ngoc Dang Khoa for his help for experimental operation of the prototype system. This work is supported by JSPS KAKENHI Grant Number JP16H03015.

References

[1] C. A. Gorse and A. M. Sansderson, "Exploring group work dynamics", In: Boyd, D (Ed) Procs 23rd Annual ARCOM Conference, pp. 295-304, 2007.

[2] Andrew Pirola-Merlo and Leon Mann, "The Relationship between Individual Creativity and Team Creativity: Aggregating across People and Time", Journal of Organizational Behavior, Vol. 25, No. 2, pp. 235-257, 2004.

[3] Petro K. Poutanen, Pirjo Ståhle, "Creativity in short-term self-directed groups: an analysis using a complexity-based framework," International Journal of Complexity in Leadership and Management, DOI: 10.1504/IJCLM.2014.064455

[4] Salman Amur Alhajri, "Investigating Creativity in Graphic Design Education from Psychological Perspectives," Journal of Arts and Humanities, Vol 6, No. 01, DOI: 10.18533/journal.v6i01.1079

[5] Nancy Falchikov, "Group Process Analysis: Self and Peer Assessment of Working Together in a Group," Educational & Training Technology International, 30:3, 275-284, 1993. DOI: 10.1080/0954730930300308

[6] HERNANDEZ-MARTINEZ, P. and HARTH, H.,"An activity theory analysis of group work in mathematical modelling", IN: Beswick, K., Muir, T. and Wells, J. (eds.) 39th Psychology of Mathematics Education Conference, Hobart, Australia, 13-18th July, pp. 57-64., 2015.

[7] Peter A. Gloor and Adam Almozlino and Orr Inbar and Wei Lo and Shannon M. Provost, "Measuring Team Creativity Through Longitudinal Social Signals",arXiv:1407.0440

[8] Mark Batey, "The Measurement of Creativity: From Definitional Consensus to the Introduction of a New Heuristic Framework," Creativity Research Journal, 24(1), 55–65, 2012.

[9] Sameh Said-Metwaly, Wim Van den Noortgate and Eva Kyndt, "Approaches to Measuring Creativity: A Systematic Literature Review", Creativity. Theories – Research - Applications, Volume 4, Issue 2, pp. 238–275, 2017.

[10] Wei-Lun Lin, Ping-Hsun Tsai, Hung-Yu Lin & Hsueh-Chih Chen, "How does emotion influence different creative performances? The mediating role of cognitive flexibility," Cognition and Emotion, 28:5, 834-844, 2014.

[11] James R. Averill, James R. Averill, James R. Averill, "Emotions and Creativity, East and West", Asian Journal of Social Psychology, Vol. 4, pp. 165-183, 2001.

[12] Zenasni, Franck, Lubart, Todd,"Effects of Mood States on Creativity", Current Psychology Letters: Behaviour, Brain and Cognition, No. 8, pp. 33-50, 2002.

[13] Martijn Goudbeek, Jean Philippe Goldman, Klaus R. Scherer, "Emotion dimensions and formant position", in Proc. Interspeech 2009., pp. 1575-1578, 2009.

[14] Prabal Deep Das, Sharmila Sengupta, "An Emotion Based Speech Analysis", International Journal of Computer Science and Mobile Computing, Vol.4 Issue.10, pp. 295-302, 2015.