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Four-participant group conversation: A facilitation robot controlling engagement density as the fourth participant☆

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Abstract

In this paper, we present a framework for facilitation robots that regulate imbalanced engagement density in a four-participant conversation as the forth participant with proper procedures for obtaining initiatives. Four is the special number in multiparty conversations. In three-participant conversations, the minimum unit for multiparty conversations, social imbalance, in which a participant is left behind in the current conversation, sometimes occurs. In such scenarios, a conversational robot has the potential to objectively observe and control situations as the fourth participant. Consequently, we present model procedures for obtaining conversational initiatives in incremental steps to harmonize such four-participant conversations. During the procedures, a facilitator must be aware of both the presence of dominant participants leading the current conversation and the status of any participant that is left behind. We model and optimize these situations and procedures as a partially observable Markov decision process (POMDP), which is suitable for real-world sequential decision processes. The results of experiments conducted to evaluate the proposed procedures show evidence of their acceptability and feeling of groupness.

Keywords: Multiparty conversation; Facilitation robot; Conversational strategy; Engagement density control; Multimodal processing; Partially observable Markov decision process

1. Introduction

We present a framework for facilitation robots regulating engagement density to maintain a four-participant conversation as the forth participant with procedural steps obtaining initiatives. Four is the special number in multiparty conversations. The three-participant conversation is the minimum unit where the participants autonomously organize a multiparty conversational situation. The fourth participant is the first person who can objectively observe the conversational situation. In three-participant conversations, social imbalance, in which a participant is left behind in the current conversation, sometimes occurs. In such scenarios, a conversational robot has the potential to objectively observe and

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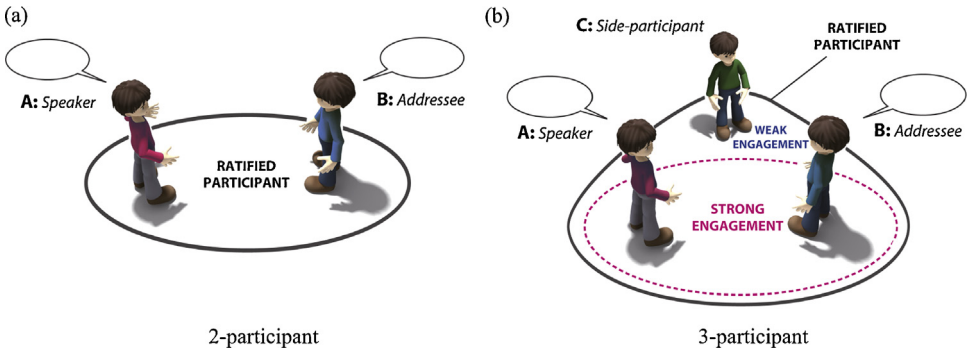

Fig. 1. (a) Two-participant conversation model, which has been focused upon by conventional dialogue systems. (b) Three-participant conversation model; the minimum unit for a multiparty conversation.

control situations as the fourth participant. A four-participant conversational situation, where three participants and a facilitator are participating, is the minimum unit of the facilitation process model.

Fig. 1(a) depicts a two-participant conversation. In such situations, conversational context, including engagement (Sidner et al., 2004) and turn-taking (Sacks et al., 1995), is commonly grounded between two interlocutors. Many dialogue systems have dealt with turn-taking within two-participant engagement (Raux and Eskenazi, 2009; Chao and Thomaz, 2012). However, in three-participant conversations as shown in Fig. 1(b), which is the minimum unit for multiparty conversation, engagement and turn-taking cannot always be identified among the participants. In terms of turn-taking in multiparty conversations, the participation structure model was presented by Clark (1996), drawing on Goffman's work (1981). In the participation structure model, each participant is assigned a participation role considered by the current speaker, where *speaker*, *addressee*, and *side-participant* are "ratified participants" (Goffman, 1981). In such three-participant situations, interactions between two dominant participants primarily occur between participants A and B, and the other participants, who cannot properly get the floor to speak for a long while (can neither be promoted to a speaker nor an addressee), tends to get left behind, even though all participants are ratified.

Such a social imbalance problem cannot be solved easily because participation roles do not always share common ground among the ratified participants. For example, in Fig. 1(b), participant C might not be able to properly take chances to assume the floor to speak for a while, and thus, from his viewpoint, is left out of the dominant conversation, even though floor exchanges may be well maintained among participants from participant A's viewpoint. If situational comprehension of the participation structure is diverged among the participants and participant A cannot recognize the left-behind situation, he may not be motivated to self-initiate control of the situation. In the left-behind situation, the engagement density may be different between dominant participants and the left-behind participant. The dominant participants' engagement is so strong that participant C's engagement with others is relatively weak. In addition, it is also possible that participant C cannot share a common interest topic with the other participants. Consequently, socially imbalanced three-participant situations dictate the need for an additional *facilitator* participant to help the left-behind participant "harmonize" with the other participants. In this context, "harmonize" means maintaining equality of engagement density within the group. A four-participant conversational situation is the minimum unit of the facilitation process model, which has never been discussed substantially in research of both conversational analysis and dialogue systems. Conversational robots have the potential to participate as the fourth participant to facilitate such conversations, as is illustrated in Fig. 2. Kobayashi and Fujie (2013) have discussed the importance of situated human-like conversational robots, which are capable of omitting and understanding conversational protocols. Generally, when a facilitator (robot) steps into the situation to coordinate, it should follow properly established procedures to obtain initiative within situations and give this initiate back to the other participants. To coordinate situations, a facilitator must take the following procedural steps. (1) Be aware of both the presence of dominant participants leading the current conversation and the status of a left-behind participant; (2) obtain an initiative to control the situation and wait for approval from the others, either explicitly or implicitly; and (3) give the floor to a suitable participant (sometimes by initiating a new topic).

Various related research on specially situated facilitation agents in multiparty conversations has been conducted. Matsusaka et al. (2003) pioneered the use of a physical robot participating in multiparty conversations. We have