An Incremental Tripartite Model of Consultation Dialogues and Negotiation Subdialogues

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Program Area
Speech and Natural Language Understanding

Keywords
dialogue, negotiation subdialogues, discourse acts, tripartite model, intention, plan recognition

Project Summary
Natural language systems have been unable to effectively participate in expert consultation dialogues in which one participant has a goal that he wants to achieve and is seeking advice from the other participant about how to construct a plan for achieving this goal. Our research has been investigating collaborative expert consultation dialogues within a plan-based framework, with emphasis on the incremental recognition of problem-solving and communicative intentions and the handling of negotiation subdialogues. The overall goal of the project is to develop a processing model for effective participation in collaboration and negotiation.

In order to effectively participate in expert consultation dialogues, it is necessary to model not only the domain plan that is being constructed but also how the agents are going about constructing it. We have developed a rich tripartite dialogue model that differentiates among domain, problem-solving, and communicative intentions yet captures the relationships among them. One of the most significant advantages of our tripartite model over previous models of task-oriented dialogue is its ability to recognize actions incrementally. By modeling each kind of action (domain, problem-solving, and communicative) as a tree structure that can grow new root nodes as well as new leaves, our tripartite model is able to perform incremental recognition of each kind of intention. Our recognition algorithm can infer a parent intention to which the intentions communicated in two individual utterances are intended to contribute, even though neither utterance alone conveys the parent intention. Thus our model is able to recognize communicative actions comprised of several utterances but which cannot be recognized from the first utterance alone, something that previous models of discourse have been unable to do.

We have also developed a computational framework for handling collaboration that has implications for both response generation and dialogue understanding. For example, previous accounts of dialogue argue that questions must be answered in a cooperative interaction. However, in our model, situations in which a participant fails to answer a question (and instead rejects a proposal or suggests a better alternative) can be accounted for by the collaborative process rather than being viewed as a violation of a maxim of cooperative behavior. In addition, our research on collaborative dialogue has shown the importance of recognizing and taking into account agent preferences, such as a preference for an aisle seat or business class in a travel domain. We have developed two algorithms: one for dynamically recognizing user preferences during the course of a collaborative planning dialogue and the other for exploiting the model of user preferences to detect suboptimal solutions and suggest better alternatives. Our recognition algorithm is the first to recognize preferences during the course of a natural dialogue. It utilizes the semantics of the utterance itself, the conversational situation in which the utterance occurs, patterns in the user's rejection and acceptance of proposals, and a model of stereotypical user preferences. Our algorithm for utilizing preferences in response generation takes into account both the strength of a recognized preference and the closeness of a potential match.

Previous models of discourse could not handle negotiation subdialogues in which the participants attempt to square away disparate beliefs, since this necessitates recognizing when new beliefs are adopted and when communicated propositions are questioned or rejected. We have investigated complex discourse acts such as expressions of doubt that commonly occur in negotiation subdialogues. Our research has shown that to recognize such discourse acts, it is necessary to model the strength of an agent's belief in a proposition, instead of just belief, disbelief, and ignorance about the truth of a proposition. Our work has produced an algorithm that combines linguistic, contextual, and domain knowledge to recognize one kind of expression of doubt.

Our current work is investigating response generation during collaboration. We have developed a computational strategy for detecting conflicts regarding proposed beliefs and for engaging in collaborative negotiation to resolve the conflicts that warrant resolution. Our model is capable of selecting the most effective aspect to address in its pursuit of conflict resolution in cases where multiple conflicts arise, and of selecting appropriate supporting evidence. We are continuing

our work on this aspect of the project, along with developing strategies for engaging in information-sharing when the system cannot make a rational decision about whether to accept or reject a belief proposed by the user.

Project References

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Area Background

Research on collaborative dialogue systems draws from several disciplines: psychological studies of human problem-solving and communication, natural language understanding, natural language generation, and user modeling. Psychologists have studied strategies that humans use in making decisions and have developed a wide range of models which attempt to explain the human decision process. In addition, they have studied how humans communicate and have posited models of the communication process. Researchers working on the design of dialogue systems take these studies into account, along with their own insights gained from analyses of naturally occurring dialogue, in developing computational strategies that account for observed human behavior and that produce system behavior that humans will consider natural and rational.

Dialogue systems for task-oriented collaboration rely heavily on the wealth of work that is being done in natural language understanding and natural language generation. Of particular concern for dialogue systems is the coherence of the discourse. One way in which this coherence manifests itself is in the relationship of utterances to the plan being developed by the participants and the current focus of attention in the plan. This plan includes not only the partially built domain plan that will eventually be executed, but also the problem-solving plan that captures how the participants are going about constructing the domain plan and the communicative plan that captures how the participants are exchanging information in order to achieve their problem-solving intentions. By interpreting utterances with respect to the evolving plan of the participants, the system can better understand the meaning of an utterance and identify how the utterance is intended to contribute to the discourse. By taking the evolving plan into account when responding, the system can generate responses that are coherent and that appropriately address the needs of the other participant. In addition, the system's responses must be tailored to the particular user of the system. This requires that the system take into account the user's beliefs, preferences, abilities, and level of expertise in the domain. Thus plan recognition and user modeling play important roles in the development of a robust system for collaborative dialogue.

Area References

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Related Program Areas

Other Communication Modalities
Adaptive Human Interfaces

Potential Related Projects

Humans use gestures when communicating. Little attention has been given to taking gestures into account in dialogue understanding. This is a project in which I have a great deal of interest and which would mesh nicely with our current work.