Reconstructing Conversational Games in an Obligation-Driven Dialogue Model

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Abstract. Departing from a dialogue model that uses DISCOURSE OBLIGATIONS as basic expressive means we will propose a set of inference rules that assign intentional structures to sequences of dialogue moves. We then can demonstrate that from our point of view CONVERSATIONAL GAMES can be seen as macro-structures which are decomposable into smaller functional units where the coherence between the latter is explained in terms of obligations.

1 Introduction

In the course of the last decade, research in dialogue modelling has come to pay increasing attention to the language-specific aspects of dialogue. This tendency, which has resulted in dialogue being dealt with as a phenomenon of the use of natural language in a social context rather than as just a particular case of rational agency, is underlined by the use of DISCOURSE OBLIGATIONS as expressive means that allow the modelling of the actions of dialogue participants (DPs) in an explanatorily more adequate way than mere intention-based approaches (see [12], [5]).

It is in the context of obligation driven models for dialogue that a concept of INFORMATION STATE (IS) has been developed which has proved to be of considerable influence in dialogue related research (see [9], [13]). Our aim here is to sketch the outlines of a very simple model of IS using discourse obligations, which adheres to the formalisation principles proposed by the TRINDI workgroup that stresses the idea of dialogue being describable in terms of INFORMATION STATE UPDATES (see [13]). We will propose a set of inference rules for the dialogue model outlined by Kreutel & Matheson in [5] that operate on ISs and assign an intentional structure to a sequence of dialogue moves. This way we can show that a 'bottom-up' approach to dialogue modelling yields results at the descriptive level that are equivalent to the ones proposed in intention based explanations while proving to be superior as far as its explanatory power is concerned. In particular, we will show how the structuring aspect of CONVERSATIONAL GAMES can be reconstructed in terms of obligations.

Thus we intend to provide arguments for the strong attractiveness a model using information states and discourse obligations as expressive means has for dialogue related research in the academic field as well as in the area of practically applied language technology.

2 Information States and Intentional Structure

Kreutel & Matheson [5] assume a very basic notion of IS which includes just the DIALOGUE HISTORY (DH) as a sequence of moves, and a representation of the DPs' obligations (OBL). The dialogue acts used are a subset of those proposed by Poesio & Traum [9], where the acts are sub-classified into CORE SPEECH ACTS (`assert`, `ask`, `accept`, etc.) and ARGUMENTATION ACTS (`answer`, `info_request`, etc.). This classification captures the idea that any speech act may appear in a wider discourse context, where argumentation acts characterise the context-dependent actions of core speech acts. Obligations are represented as stacks of `address` and `answer` elements.

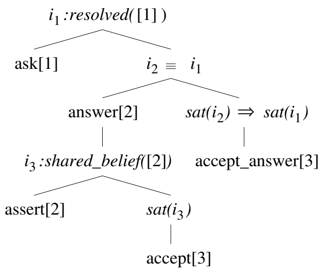
The updating of information states is done based on the notion of INFORMATION STATE UPDATE SCENARIOS. Update scenarios are meant to specify certain 'constellations' of IS, corresponding to situations like the turnholder's replying to an assertion, to a question, or to an assertion that is meant as an answer to a question. Each scenario can be defined based on the information in IS, i.e. on the overall structure of the DPs' obligations and the history of the dialogue.

The intentional structure INT is built up by means of inference rules given the information in DH. Departing from the idea that dialogue acts dispose of an 'expressive' function, which is to convey the mental state of the speaker (see [11]), we assume that from the occurrence of certain dialogue acts in DH the DPs can infer each other's intentions and the way they are related and managed:

- Formally, we represent INT as a quadruple $< I, \gg, sat, drop >$, where I is the set of the DPs' intentions, $\gg$ is the two-place relation of *immediate dominance* in I, which is defined on the base of the *dominance* relation proposed by Grosz & Sidner [4], and *sat* and *drop* are 1-place relations in I that correspond to the sets of satisfied and dropped intentions, respectively.
- After each move, I is updated according to inference rules that associate dialogue acts with intentions, e.g. $i_a : shared\_belief(p)$ and $i_b : resolved(q)$ with an assertion of a that p and a question of b whether q, respectively. In the same way, we infer $i_a : resolved(q)$ from a's performance of an `answer` or an `info_request` argumentation act.
- *sat*, on the other hand, is determined by inferring contents of intentions from dialogue acts, e.g. $shared\_belief(p)$ from the acceptance of an assertion that p or $resolved(q)$ from the acceptance of an assertion as an answer to a question whether q. An intention is said to be satisfied iff its content occurs in DH.
- Finally, for updating $\gg$ we attach a new intention as immediately dominated by the last intention which has neither been satisfied nor dropped.

Given these rules we assume the structure below as the representation of an ordinary question-answer sequence:

(1) A[1]: Did Helen come to the Party?
B[2]: No.
A[3]: Ok.



As the tree shows, we assume that the intentions associated with dialogue acts reformulate the idea that an askee adopts an asker's desire for information when answering a question (see [2]): i_1 and i_2 are identical with respect to their content, but individualised over the two DPs. The tree also captures the notion that the intention i_3 associated with the assertion in [2], which is offered as an answer to the question, is *dominated* by the askee's intention that the question should be resolved, and thus significantly differs from a discourse-initial assertion due to its context. As i_1 and i_2 have the same content, satisfaction of the latter by A's acceptance of B's answer automatically means satisfaction of i_1.[1]

Having thus outlined how the model proposed by Kreutel & Matheson [5] can be extended to allow for an account of the intentional structure of dialogue, the following section will discuss the advantages of the obligation-driven model as opposed to the notion of conversational games.

3 Reconstructing Conversational Games

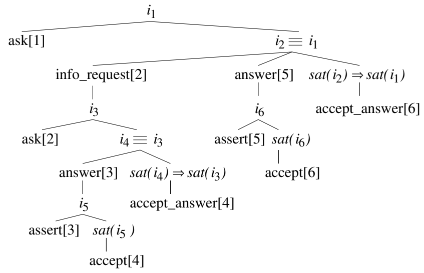
The notion of conversational games has proved to be very useful in dialogue modelling from the descriptive (see [3], [1]) as well as from the computational (see [7], [8]) point of view. However, in terms of explanatory power the games approach runs into similar difficulties as the ones pointed out by Traum & Allen in [12] for intention-based approaches to dialogue in that capturing uncooperative actions is at best very awkward *within* the concept of a game. We argue that our own approach reconstructs the structural aspects of the games model and extends the coverage to include some data for which an approach using games is arguably too rigid.

Following a proposal by Eklundh [3] to associate conversational games with intentions - or 'discourse segment purposes' in Grosz & Sidner's terms (see [4]) - we could associate the games `question-answer`, `answer` and `assert` with i_1, i_2 and i_3 in (1), respectively, thus labelling the discourse segments that correspond

[1] see [5] for the motivation to analyse the evaluation of an assertion that is meant as an answer to a question as a two-fold process involving the dialogue acts `accept` and `accept_answer` in example (1).

to the intentions in our model with types of games. So far, then, on a descriptive level our treatment of INT coincides with the basic structural mechanisms of the games model. However the latter has problems in providing a satisfactory explanation of sequences of moves that deviate significantly from the 'canonical' structure of a game, but which nevertheless can be seen as very common in human interaction. For instance:

(2) A[1]: Did Helen come to the Party?
B[2]: Did Jack come?
A[3]: Yes.
B[4]: Ok.
B[5]: Then Helen didn't come.
A[6]: Ok.



In terms of dialogue processing, either by humans or machines, the idea of a conversational game allows a distinction of the moves that follow the initial one in terms of 'preferred' or 'dispreferred' moves (see [6], [3], [7]) and assumes an increased processing effort for all the cases which are considered to be dispreferred. According to this point of view, for `question-answer` games an assertion which provides an answer will always be considered the preferred follow-up move to a question.

The possibility of the askee replying to a question with a question, as in (2), which can be considered a reasonably common case in information-oriented interaction (see INSERTION SEQUENCES in [6]), will thus have to be treated as an exception along with requests for clarification or utterances that express the askee's inability or unwillingness to answer. Apart from the fact that the latter falls completely outside the scope of the games model (if one does not assume the contradictory notion of an 'uncooperativity game'), this way of prioritising the range of possible follow-up moves in a dialogue must be seen as too strict. The obligation-driven approach, on the other hand, simply assumes that a question obliges the askee to provide an answer which resolves the question, and thus a situation where an askee replies with a question in order ultimately to provide an answer can be seen as just an alternative to the 'canonical' case.

However, in spite of their explanatory weakness conversational games have proved to be of great use in speech and language technology and can still be seen as one of the leading notions in dialogue related research. In particular, the possibility of modelling games as recursive transition networks (see for instance [7]), and thus of determining significant 'states' of a game, has made the games model an attractive candidate for dialogue systems which make use of probabilistic heuristics to influence the behaviour of, for example, modules for speech and speech act recognition (see [14], [10]). However, as we have pointed out above, our model defines a set of update scenarios as the framework for determining or interpreting the DPs' actual actions. In terms of scenarios, the ordinary question-answer sequence in example (1) can be analysed as follows:

(3) A[1]: Did Helen come to the Party?
REPLY_QUESTION
B[2]: No.
REPLY_ANSWER $\supset$ REPLY_ASSERT
A[3]: Ok.

While B's move in [2] takes place in the context of a scenario in which B has to answer a question, [2] itself results in an information state in which DP_1 (A) is obliged to `address` [2] and DP_2 (B) is obliged to `answer` [1]. This constellation of the DPs' obligations characterises a scenario in which DP_1's actions can be interpreted as expressing his evaluation of the answer provided by DP_2 and is identical with the situation after A's move [5] in the more complex example below:

(4) A[1]: Helen did not come to the Party.
B[2]: How do you know that?
A[3]: Her car wasn't there.
B[4]: Ok. But she could have come by bicycle.
A[5]: I stayed there until 4am and she didn't show up.
B[6]: Ok.

With our model assuming the classification of information states in terms of update scenarios as part of the expressive means we propose an alternative to the games approach also in terms of the model's capacity to feed back heuristic analyses to other modules in a dialogue system – in the same way that a games-based account allows follow-up moves to be ranked. So, for each scenario, probabilities can be assigned to each admissible subsequent action thus allowing for the interpretation of ambiguous or 'noisy' responses. This way we are able to introduce a notion of prioritisation, which we have argued is problematic for the games approach in explanatory terms, at a higher level in our model. It should be noted that we have not undertaken such an analysis; however, it seems clear that the scenario-based account can be used to provide the same formal properties as conversational games, and hence similar predictive power can be assumed.

4 Conclusion

Beginning with a dialogue model which uses discourse obligations as basic means to predict the actions of participants in a dialogue, we have proposed a set of inference rules which operate on the information in the dialogue history to determine a representation of the DPs' intentions. We have shown that the structures generated by our rules can be reinterpreted in terms of the notion of conversational games.

We have suggested that the obligation-based approach is able to reconstruct games structures at the descriptive level and also to flexibly integrate probabilities as developed in the games framework. In addition to this, however, taking into account the equivalence between 'states' in a games model and 'scenarios' on the one hand, and the definition of scenarios in terms of the DPs' obligations on the other, we claim that conversational games should be seen as structures that emerge from the DPs' acting according to the obligations imposed on them rather than as primitives in the theory of dialogue modelling.

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