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Combinatorial Dialogue Games in Strategic Argumentation

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We introduce combinatorial dialogue games, an approach to strategizing within argumentative dialogue games where the moves played are interpreted as moves within an edge-addition and/or edge-removal combinatorial game. This enables an agent to reason about which move to make, regardless of the particular dialogue game that is being played. Our aim is to give agents the ability to play dialogue games better and to give researchers a clear framework within which to define new strategies.

KEYWORDS: argumentative dialogue, combinatorics, dialectical games, dialogue games, heuristics, strategy, tactics

1. INTRODUCTION

This paper introduces Combinatorial Dialogue Games (CDG), a formal approach to strategizing within argumentative dialogue games where the moves played within a dialogue game are interpreted as moves within an edge-addition and/or edge-removal combinatorial game played upon a graph.

Dialectical games have been used as interaction protocols to intelligent agents with the ability to engage in argumentative dialogue. As agents become more widespread, and move into the real world, existing in heterogeneous agent societies, it is important that they are able to act effectively to satisfy their, or their owners, goals. Thus effective play of dialectical games is increasingly important. Similarly there are increasing numbers of dialectical games, dialogue games and argument-based interaction protocols. Agents may not be confined to a playing a single game and thus must have the ability to choose an appropriate dialectical game, and subsequently to play it well. Thus a mechanism is required that enables an agent to play arbitrary dialectical

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games but that avoids the approach of identifying specific guidelines for effective play of every possible individual game[1].

The goal of CDG is thus to enable an agent to reason about which move to make, regardless of the particular dialogue game that is being played. Thus the process of defining strategies related to dialogue outcome classes, selecting tactics for realising those strategies, and the definition and interpretation of heuristics for good, ideal, or merely societally responsible play are all abstracted away from the, potentially complex, underlying dialogue game. Such an approach increases the flexibility of the agents concerned, enabling them to better act within heterogeneous societies. However, this approach is not meant to replace existing methods for reasoning about arguments but to compliment them. CDG provides a mechanism for mapping from disparate dialogue game descriptions into a consistent framework for representing the state of the locutors arguments in terms of their commitments. Rather than providing strategies for each and every possible dialogue game, the CDG framework acts both as an interlingua, within which various strategies, tactics, and heuristics can be defined, and as a bridge to further, more specialist and established argument-oriented reasoning and evaluation mechanisms.

2. BACKGROUND

Dialectical games, due to (Hamblin, 1970), are multi-player (but usually two), turn-taking games in which the players take turns to make moves, that correspond to speech acts and locutional content, and the rules of the game regulate when a given move can be legally played.

Whilst many dialectical games have been developed to explore a range of problems in argumentative dialogue, there are a wide range of representational forms which made it difficult to produce computational implementations. This was mitigated by the introduction of the Dialogue Game Description Language (DGDL) (Wells & Reed, 2012). The DGDL is a domain specific language for producing syntactically correct descriptions of the rules and components of dialectical games. Underpinned by an extended Backus-Naur Form (EBNF) grammar, the DGDL supports the description of interpretations of a range of dialectical games from the literature including those from Hamblin (1970), Mackenzie (1979), Woods & Walton (1982), Walton & Krabbe (1995), McBurney & Parsons (2002), Bench-Capon (1998), Lorenzen (1978). Newer games such as those found in the MAgtALO system (Reed & Wells, 2007) and the Argument Blogging protocol

[1] This does not feel like an elegant solution.

(Wells *et al.,* 2009) are also supported. Additional features include support for dialectical shifts and embeddings (Wells, 2006) and Argumentation Schemes (Wells, 2014). A DGDL game description is comprised a composition, in which the game's component such as the participants, their roles, and commitments stores are defined, a set of rules, regulations that indirectly manipulate components, and a set of interactions, regulations that enable direct manipulations of game components by players. A simple example of a DGDL description is as follows:

```
simple{
        {turns,magnitude:single,ordering:strict}
        {players,min:2,max:2}
        {player,id:Player1}
        {player,id:Player2}
        {store,id:CStore,owner:Player1}
        {store,id:CStore,owner:Player2}
        {Assert,{p},"I assert that",
                {store(add, {p}, CStore, Speaker),
                store(add, {p}, CStore, Listener)
                }
        }
}
```

This description for the "simple" game defines a single move per turn, a strict ordering of turns, 2 players named Player1 and Player2 respectively, each with a single commitment store, and with a single "Assert" move that take a single piece of locutional content, is scaffolded with the phrase "I assert that" and which adds the content of the assertion to both the players commitment stores. The advantage of adopting the DGDL, from the perspective of this paper, is that it provides a single, consistent method for describing dialogue games and affords a game engine that enables agents to select the game to play at runtime by merely loading a new game description. Importantly, a DGDL description describes all of the relevant effects of playing a specific move, for example, adding "p" to the commitment store of both Speaker and Listener in the simple dialogue game above, in a way that is machine parseable. A set of DGDL descriptions can therefore be parsed by a, hypothetical, strategic engine to work out what the effects of playing a given move would be which is important in the context of determining which move is the best to make.

Given that reasonably arbitrary, with varying features and characteristics, dialectical games can be defined in the DGDL an issue

arises of deciding what to say. Whilst the rules of a well formed game should always enable the players to determine which moves are permitted or legal it is not the role of either the game engine or rules to determine what members of the set of legal moves are relevant. Furthermore, there is a subset of relevant move that are strategically "good" and a subset of those that are optimal. Whilst determining the optimal set of moves to make at any given time is hard, the determination of good moves is necessary to enable agents to play dialectical games well.

3. COMBINATORIAL DIALOGUE GAMES

Moves within formal dialectical games usually take the form of a set of locutions that the players may utter in combination with content expressed in some knowledge representation language.

This combination of locution plus content constitutes a signature for the move and usually when considering a dialogue strategy we think in terms of sequences of moves that bring about some desirable state of the game's components. However, from the perspective of the arguments that are constructed, exposed, or otherwise elicited during a dialogue, the important aspect of making a move that must be considered is not the locution itself, but the effect upon the game's components of playing that move. If we consider the moves of a dialectical game as described using the DGDL, there are a limited number of identified effects that can occur. These include constraint over the legality of future moves, updates concerning the status of the game (or subgame), assignment of roles to the participants, and operations upon artifact stores, or, in other words *commitment state*[2].

If the entirety of the effect of playing a move is bound up in its effect on the game state then the locution itself can be considered merely to be a convenience, a label that references a set of effects. It follows therefore that locutions can be ignored temporarily and only the sets of effects need be examined and exploited. This approach enables an abstraction to be formulated, away from a game as a heterogeneous set of locutions that define a given "type" of dialogue, and towards a more homogeneous, condensed, intermediate structure that serves as an adjunct to the ongoing dialectical game.

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[2] It should be noted however that the author does not consider this list of effects to be exhaustive but merely sufficient to enable the description of many of the games already introduced in the relevant literature, for a collection of which, (Wells, 2012) should be consulted.

At this point we can begin to sketch the framework of a Combinatorial Dialogue Game, a CDG, in terms of a private, directed-edge, addition/removal combinatorial game. If we ignore locutions and consider only commitment state then a CDG is a game in which incurring commitment adds node(s) and/or edge(s) to the CDG graph and retraction of commitment removes node(s) and/or edge(s) from the graph. Thus each time a player utters a locution the CDG associated with the dialogue is updated in line with the resultant changes to the player's joint public commitment state. Whilst the CDG is constructed based upon the public commitment state of the dialogue's participants, the CDG is not itself a public object but is private to a participant. It is conceived therefore that all players might build their own private representation of the commitment state of the dialogue that they use separately to determine a course of action in line with their own public and private dialogical goals.

Combinatorial games (Albert *et al.*, 2007; Conway, 1976) are traditionally studied as a single play in which there is a single, static graph that forms the board upon which the game is played until a win/loss/draw state is reached. However, because a change of commitment state alters the graph, the single-play assumption must be relaxed. This is because I don't know what my opponent knows, what their private goals are, although I can infer their public goals from the attitude that they have taken during the opening of the dialogue, and I don't know what they will day. Therefore I cannot know how the CDG graph will update after my opponent's turn. Therefore, depending upon whether the dialectical game is single or multiple move per turn and also whether the moves made have a commitment effect, the CDG graph may have to be updated and re-evaluated frequently, possibly after every turn.

One question that might be posed asks which features of extant dialectical games are necessary for a game to be amenable to the CDG approach? To address this we shall construct a characterisation of well formedness that places additional constraints on a dialectical game with the goal of making it more tractable within a computational context. Well-formed dialectical games must include a commitment model so that a CDG graph can be constructed and manipulated during a dialogue. However, a simplified model in which players may only incur commitment would be sufficient and necessite termination conditions based upon inconsistency in the players commitment store. Such an approach would not be amenable to the termination conditions based upon the "retraction of initial thesis" approach of, e.g. PPD_0 (Walton & Krabbe, 1995) but would allow a Socratic style of dialogue. Dialectical games that support an opening stage are useful as a way to force the

establishment of the player's respective initial positions and theses that can define the motivations and respective goals of the participants. The addition of an adequate opening stage in which the player's positions are established also enables games to be played whose commitment models, after the opening stage, only allowed retraction of commitment. This would transform the CDG into a traditional edge removal combinatorial game and enable exploitation of game-playing strategies straight from the combinatorial game literature. In addition to a commitment model, a dialectical game should also incorporate termination conditions. These are useful because they give hard boundaries that help agents to determine when to stop talking and can be formulated in terms of commitment store contents that are, ideally, established during the opening phase. For example, the player who retracts commitment from their initial thesis loses and the other player wins. A game that has a commitment model in which at least one move enables the players to alter the commitment state of the dialogue and at least one termination condition that ascribes a win-loss state to one or another player should be sufficient to build a simple CDG graph on which subsequent moves, and their effects are recorded.

Having a well-formed dialectical game, and an ongoing associated dialogue, from both of which a CDG graph can be constructed, attention must turn to the identification of which commitments, or relations between them, that is which nodes and edges, to target. A simple, bottom-up offensive strategy suggests targeting those edges or nodes whose commitments underpin the opponent's position. Causing the opponent to retract those commitments will leave their thesis exposed. A top-down offensive strategy might target directly the opponent's position by providing a counter-argument position. Alternatively, a player might use their turns to execute a defensive strategy in which their own position is bolstered.

One aspect that has yet to be considered is how to return from a CDG to the locutional level of the associated dialectical game. This would appear to be tricky as locutions were the first element to be discarded in order to work with graphs constructed from pure commitment. Having identified the commitments to target, and whether they must be incurred or removed, there must be reification in terms of locutions, by identifying the things to say next. The simplest approach is to turn this into a search problem; dialogue profiles (Krabbe, 1999) must be generated until their pattern of commitment effects matches those of the CDG. This potentially still yields a large set of potential moves but rather than this set being the merely legal or relevant moves, they should constitute, at least part of the set of good moves. Heuristics may have a role to play in further reducing the size of the set of good moves.

Similarly, argumentation schemes may play a role in further restricting the set of available locutions by exploiting critical questions. As schemes, and the exploitation of critical questions, are supported by a minor DGDL extension (Wells, 2014) this may be a prudent approach

4. FURTHER WORK

The current approach assumes well-formed games, minimally, games that utilise artifact stores to record the various commitments of their players and that incorporate termination conditions.

One direction of future research is to relax these assumptions and to examine the utility of CDGs that are built from games that do not incorporate a commitment model within their rules. It would appear that the obvious route in this case would be to assume a commitment model and provide associate rules that map locutions in the game onto a commitment model that in turn yields a CDG. In (Wells, 2006) it was proposed that even without an explicit commitment model there exists an *essential cumulativeness* in dialogue because what is said cannot be unsaid, and even without commitment stores there is always a transcript of what has been said. This would, at least, extend the approach to those games that fall outside of the canon of games that can be traced back to Hamblin's influence and the genesis of the commitment store and related approaches. A similar solution may also enable adjunct termination conditions to be ascribed to dialectical games that do not define them, enabling support for goal-oriented behaviour.

Another interesting direction for research is to introduce additional graphs. In the CDGs described in this paper, we only consider a CDG that maps directly onto the current commitment state of the players. However, because a CDG is private to a given player, it need not merely model what has been said and how the players are currently positioned in relation to what has been said. It could, for example, be extended to handle my wider knowledge of the domain so as to include in the CDG nodes and edges that represent arguments I haven't yet made and arguments to which I might commit, or definitely not commit to in the future. Similarly, a CDG might be extended to cover what I know of my opponent's knowledge, things that they have not yet said in the current dialogue but that they have committed to in previous dialogues, and which I could therefore infer that they will still believe and will commit to if pressed. Such an approach enables a form of dialogical history to be utilised and recognises that what a rational agent says should remain consistent over time, unless of course, the agent has been persuaded to revise its beliefs at some intermediate

juncture. Additionally, hypothetical or inferred knowledge might be included, to cover those things that I would expect my opponent to commit to based upon stereotype. Obviously, the further we step away from the actual utterances of the opponent, the more likelihood of a misstep, especially if too much reliance is placed upon increasingly tenuous strategizing. However, this would afford the CDG approach a richness of strategizing that accords with how many people choose and use their arguments in the real world.

5. CONCLUSION

In this paper we have introduced Combinatorial Dialogue Games as a means to effect game-agnostic purposive behaviour within dialectical game play. Elements of a mapping from dialectical game and ongoing dialogue to a form of directed-edge removal/addition combinatorial game have been presented together with an exploration of the reification required to transform a CDG into a set of desirable moves that the player should select from to play. It is argued that such an approach enables the specific locutions of a given dialectical game, and the associated game-specific playbook exploration of strategy to be avoided in favour of an approach that ignores locutions and thus enables strategic, tactical, and heuristic behaviours to be expressed within a single, consistent, extensible framework. The results are twofold; some progress has been made towards enabling agents to play dialogue games better without needing extensive prior analysis of a given dialectical game, and researchers have a clear framework within which to define, effect, and explore new strategies for better play.

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