Group Decision Making in Multiagent Systems with Abduction

(Extended Abstract)

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ABSTRACT

In Multiagent Systems (MAS), various activities are related to decisions involving a group of agents such as negotiation, auctions and social choice. Group Decision Making (GDM) specializes in situations where a group of agents need to pick one of possibly many options from a set and commit to it. We intend to provide a new GDM framework in which the agents are able to employ abductive reasoning and discuss the options towards consensus.

Categories and Subject Descriptors

F.4.1 [**Mathematical Logic**]: Logic and Constraint Programming; I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems

General Terms

Theory

Keywords

Group Decision Making, Collective Decision Making, Abductive Logic Programming

1. INTRODUCTION

The problem of accounting preferences of agents in a group decision setting dates from a long time. Various attempts were made to outline the preferences of a group by combining the individual preferences of its members. The first attempt to do so was Social Choice Theory [1]. Social choice is based on preference ordering relations and voting rules, which can lead to a series of known inconsistencies. More recent approaches proposed different structures to represent preferences [2, 9, 13] and to aggregate them [2, 4, 5, 7, 10]. Other work include finding consensus in a set of agent knowledge bases [11] and sharing knowledge to solve problems in groups [14], but these are not directed to GDM. As far as our knowledge goes, no attempt has been made to treat GDM as a process of discussion. Our goal is to create the means for a group of agents to engage discussion in that sense. We believe that this behavior better relates to the paradigm of MAS and that abductive reasoning as in [12] is the key to it. Next, we define GDM problems (Section 2). We then proceed to discuss the existing approaches (Section 3), their issues and our proposed solution (Section 4). Finally, we conclude the paper (Section 5).

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2. GDM PROBLEMS

In order to better understand the approaches discussed next and our own, the reader should first fully understand the characterization of a GDM Problem. These problems are defined as those where a set of agents $A = \{a_1, \ldots, a_n\}$, $n \geq 2$, try to make a common choice out of a set of options $O = \{o_1, \ldots, o_m\}$, with $m \geq 2$. Agents are characterized by their own knowledge, goals, intentions, etc, and are usually addressed in the GDM literature as experts. When a common choice is made, it is said that the agents reached a consensus. The reading of the problem resembles Social Choice Theory [1], but GDM approaches focus in combining the preferences of agents in more sophisticated ways.

3. RELATED WORK

In this section we give a general overview of the existing approaches to GDM and related work. A common argument in the GDM literature is that full consensus is really hard to achieve. Consequently, the existing approaches usually resort to majority voting or judgment aggregation. Most of these are based on preference orderings or relations and use Fuzzy Logics, Modal Logics, Extended Disjunctive Logic Programs or Conditional Preference Networks (CP-Nets) to represent the preferences of agents. Some approaches deal with unknown parameters and flexibility of the agents, but information sharing and learning are hardly addressed.

3.1 Majority Rules

This category relates decision making to Social Choice and is usually addressed by the name of Collective Decision Making [2, 8]. In such approaches, an option elected by majority is taken as consensus and the agents are supposed to commit to the outcome of the election. Some of the work in this sense is related to improve preferences representation [2, 8] and to avoid manipulation of voting rules [3].

3.2 Approaches under Fuzzy Logics

Most of the attempts to avoid voting rules in GDM are based on preference aggregation under a Fuzzy preferences setting [4, 5, 7, 9, 10, 13]. Each agent ranks the given options and provides their preference relations by attributing to each pair of alternatives either a fuzzy value, fuzzy interval or linguistic term [9]. The consensus is measured and interpreted as a degree of general agreement in the group. In such approaches, an option will only be considered as consensual in the group if this degree surpasses a certain predefined fuzzy threshold. Some of the research in the area is also related to find good threshold values. There is also work with fuzzy preferences directed to allow flexibility of the agents in the decision process. In this case, their preferences might change over time [5, 10]. The decision process then occurs in a given number of rounds and a moderator is required to supervise it. The moderator is responsible for keeping track of the time (number of rounds), suggest to some of the experts review their opinions or even revising the weights attributed to each expert in each round. In [10], it is argued about the computational complexity of the process and a human moderator is suggested. These approaches are related to optimization and try to manipulate the agents preferences towards a consensus.

3.3 Other Work Worth Mentioning

A behavioral attempt to make agents choose options as a group is under development by Hoogendoorn [6]. This model is inspired in Social Neuroscience and the agents are able to influence one another by communication and empathy. The result is that the mental state of the group seems to develop in a way that the agents in the group get to think alike. There is also work in Distributed Problem Solving due to Woorldridge [14] where the agents communicate in order to share knowledge in a collaborative scenario and reason together. The agents are then capable of reaching conclusions that none of them would be capable to reach by itself. Finally, a definition of consensus over Logic Programs has been proposed by Sakama in [11] that also allows for agents flexibility. Even though the agents can change their preferences, this framework only considers consensus where all agents should agree to the choices made by having a semantics that supports it.

4. AN ABDUCTION-BASED APPROACH

The approaches in sections 3.1 and 3.2 do not consider direct interaction of the agents or knowledge sharing. At most, all agent interaction is restricted to that with the moderator. It is assumed that the options are all viable and that the agents understand all of them. Also, the cases with options that can not be compared or the group equally agrees over more than one option are not properly addressed. To try to solve most of these problems while avoiding social choice paradoxes, we propose a group decision process where the agents share knowledge and engage in group reasoning.

In the proposed thesis, a group decision process entirely based on group reasoning with abduction is proposed. We consider agents with knowledge bases represented by Abductive Logic Programs (ALP) as intended in [12]. In this scenario, the agents resort to abduction to decide whether to partially support, abstain from or refuse each of the options. In each case, an agent is able to explain its position or specify conditions to change its mind. Our goal is to allow that the group of agents figure their general agreement about each option through discussion and decide for one with maximal support. This model is based on the interaction of humans in a GDM situation. We expect our approach to introduce a more natural process of GDM to MAS.

5. CONCLUSION

The thesis discussed in this paper aims to provide agents with means to engage in group decisions in a way closer to how humans do. We propose a new approach based on the abductive logic programming framework mentioned in [12]. Through abductive reasoning the agents should be able to explain their opinions and conditionally change their minds.

6. REFERENCES

[1] K. J. Arrow. *Social Choice and Individual Values.* John Wiley & Sons, Inc., 1963.

[2] Y. Chevaleyre, U. Endriss, J. Lang, and N. Maudet. Preference handling in combinatorial domains: From ai to social choice. *AI Magazine*, 29(4):37–46, 2008.

[3] E. Ephrati and J. S. Rosenschein. Deriving consensus in multiagent systems. *Artificial Intelligence*, 87(1-2):21–74, 1996.

[4] M. Fedrizzi and G. Pasi. Fuzzy logic approaches to consensus modelling in group decision making. volume 117 of *SCI*, pages 19–37. 2008.

[5] E. Herrera-Viedma, F. Mata, L. Martínez, and L. Pérez. An adaptive module for the consensus reaching process in group decision making problems. In *MDAI*, pages 89–98, 2005.

[6] M. Hoogendoorn, J. Treur, C. van der Wal, and A. van Wissen. Modelling the interplay of emotions, beliefs and intentions within collective decision making based on insights from social neuroscience. In *Neural Information Processing. Theory and Algorithms*, pages 196–206. 2010.

[7] J. Kacprzyk, S. Zadrożny, M. Fedrizzi, and H. Nurmi. On group decision making, consensus reaching, voting and voting paradoxes under fuzzy preferences and a fuzzy majority: A survey and some perspectives. In *Fuzzy Sets and Their Extensions: Representation, Aggregation and Models*, pages 263–295. 2008.

[8] M. Li, Q. B. Vo, and R. Kowalczyk. An efficient majority-rule-based approach for collective decision making with cp-nets. In *KR*, 2010.

[9] F. Mata, L. Martínez, and E. Herrera-Viedma. A consensus support system for group decision making problems with heterogeneous information. volume 97 of *SCI*, pages 229–257. 2008.

[10] R. Parreiras, P. Ekel, J. Martini, and R. Palhares. A flexible consensus scheme for multicriteria group decision making under linguistic assessments. *Information Sciences*, 180(7):1075–1089, 2010.

[11] C. Sakama and K. Inoue. Constructing consensus logic programs. LOPSTR'06, pages 26–42, 2007.

[12] C. Sakama and K. Inoue. Negotiation by abduction and relaxation. In *AAMAS*, pages 1022–1029, 2007.

[13] E. Szmidt and J. Kacprzyk. Atanassov's intuitionistic fuzzy sets as a promising tool for extended fuzzy decision making models. In *Fuzzy Sets and Their Extensions: Representation, Aggregation and Models*, pages 335–355. 2008.

[14] M. Wooldridge. A knowledge-theoretic approach to distributed problem solving. In *Proceedings of ECAI'98*, pages 308–312. John Wiley, 1998.