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Including social factors in an argumentative model for Group Decision Support Systems ☆

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ABSTRACT

In this paper we propose a Decision Support System for groups of people where each user delegates to an agent that represents her preferences and argues with other agents to obtain the best alternative for the whole group. The novelties of our approach are the inclusion of users' social factors, personality and trust, in the argumentation process and the negotiation system, plus a multi-agent architecture that represents the social connections within the group. Therefore, our model simulates the argumentations made by real users to agree on a concrete product in a very accurate way. As a case study, we have tested our theories in the movie recommendation domain with real social networks. We have concluded that distributed models and argumentation techniques including personality and social trust improve the satisfaction of users involved in a group decision making process.

1. Introduction

A decision is a choice among alternatives based on estimated values for these alternatives. Supporting a decision means helping people to work alone or in groups to gather information, generate alternatives and make decisions. A decision making process also involves the estimation, evaluation and comparison of alternatives. Our work presented in this paper consists of providing a new method to evaluate users' estimation of different products and supporting decision making processes by providing a group recommendation for these products.

Our goal is to get an accurate reproduction of the decision making processes run by real groups of people when deciding leisure activities. There are some types of items, like restaurants, movies or trips that people tend to enjoy together. These kinds of items have a very relevant commercial interest, so it is kind of a natural thing to make the most accurate recommendations to groups of people. Existing approaches on *Group Decision Support Systems* (GDSS) are typically based on the aggregation of the preferences of group members, where every person in the group is considered equal to the others [7,18]. Other group decision approaches have solved the conflict by trying to maximize the preferences of the greatest number of group members [20]. But none of these approaches have into account that different groups of people have very different characteristics that strongly affect the decision process: size, social strength and influence between group members, personal preferences, personality of the group members, etc. It is a fact that when we face a situation where people's concerns don't match, conflict arises. Therefore, the general satisfaction of the group is not always the aggregation of the satisfaction of its members, as different people have different expectations and behavior in conflict situations. This fact is taken into account in recent works that agree on the need to adapt the decision making process to the group composition [15,19]. Furthermore, it is also well-known that user preferences can be affected by the rest of the group [6,19].

Our recent work [24] involves the improvement of current group recommendation techniques by introducing two novel factors: the *personality* of each individual and the *trust* among users. We have also presented some experiments where we test our theories for recommending products to groups of people connected through social network structures. In our model, we support the process of decision making by taking into account the group personality composition and the social connections among the individuals of the group. Once the relevance of these factors has been validated, in this paper we propose integrating them into a novel approach for group decision making based on a multi-agent system that accurately reproduces real argumentation processes made by real users. In the network of agents every agent should be able to define the trustworthiness regarding the connected agents [12,14] and to reflect the personality of the user it is representing. Our model is based on the idea of taking into account the social connections of the collaborative agents, including the level of trust of the agent they collaborate with [11,21,32].

Therefore, this paper presents a software architecture where each user delegates to an agent that represents her in the argumentation process.

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This way, users are freed from holding the typical annoying discussions to agree on a common decision for the group [30]. Another relevant advantage of this architecture is its perfect integration into existing social networks like Facebook or Google+.

Finally, we describe a case study for a collaborative movie recommender system and we present the results of an experiment where we measure the accuracy of the system results using argumentation protocols and a network topology based on a real social network.

Summarizing, this paper presents our research on GDSS by reproducing the real social organization of the group and including deliberation capabilities. Our main contribution is to improve group decisions by moving to a distributed model with social network topologies, introducing social factors, like personality and trust, plus an argumentation process that enables users to argue and defend their opinions by means of delegation to agents.

The paper runs as follows: Section 2 presents our approach for distributed GDSS and how to obtain the personality and trust factors to be integrated in this kind of systems. The distributed models and argumentation processes are explained in Section 3. Section 4 describes a case study of our method in the movie recommendation domain using data extracted from real social networks. Section 5 presents the results of our experiments. Finally, the conclusions and main lines of future work are explained in Section 6.

2. Distributed Group Decision Support Systems

Our approach to solving decision support problems is rooted in the Case-Based Reasoning field [1]. Case-Based Reasoning (CBR) is based on the intuition that similar problems tend to recur. It means that new problems are often similar to previously encountered problems and, therefore, that past solutions may be of use in the current situation [17]. When a CBR system faces the resolution of a new problem, it will search in its case base for problems similar to the current one. Once it finds them, these previous cases will be adapted to the current problem in order to provide a valid answer. The analogies between CBR and *Decision Support Systems* (DSS) are manifold. In DSS users manage a memory of preferences that must be similar to the alternative chosen by the group. Once the best alternative is obtained it is proposed directly to the user without requiring adaptation. Moreover, both techniques pay significant attention to the learning processes that improve system performance by taking into account user knowledge (the preferences or experiences of the users).

Brehmer [5] describes a distributed decision making system as an environment that (a) enables cooperation from a number of decision makers, where (b) each decision maker owns part of the resources needed to solve the problem; and (c) no decision maker has a complete overview of the problem as a whole. This schema fits perfectly in several works in distributed CBR that assume multi-case-base architectures involving multiple processing agents differing in their working memory [22]. In this kind of systems, each agent manages its own memory of preferences that make up its partial view of the world. To solve a given problem, this knowledge must be shared to obtain a solution for the whole group. This way we can reuse the existing research on distributed CBR in the GDSS field. CBR literature proposes several ways to combine different experiences to obtain improved solutions in distributed architectures. One important methodology is the *ensemble effect*, explained in [23], which proves that the argumentation of two agents improves the results obtained by one only agent working with the same experiences. This conclusion was the precursor of a research line focused on finding the best argumentation protocols to allow CBR agents to discuss a common problem. In [23] they came up with the AMAL protocol, which enables several CBR agents to argue about a common problem by means of arguments and counterarguments. This protocol and its adaptation to our model are presented in Section 3.

Setting aside the distributed architecture, when moving from individual to GDSS, the main issue that arises is how to find an alternative that satisfies the greatest number of group members, while taking into account the preferences of the decision makers. Several GDSS propose the generation of an aggregated preference built with individual user preferences [4,31]. However, our approach to group decision support is completely different because it simulates the argumentation process of a group of users by using a distributed architecture instead of providing an aggregated estimation. This way, we try to reproduce – in an accurate way – the real argumentation process carried out by decision makers when reaching an agreement. Moreover, to reproduce these argumentations accurately in our model we include two factors that reflect the real (or *human*) behavior of users. These factors – described in following subsections – are personality and social trust.

2.1. Personality estimation for Group Decision Support Systems

Usually, works in GDSS consider the preferences of every member of the group to have the same degree of importance and try to satisfy the preferences of every group member. However, groups of people can have very different characteristics and can be made of people with similar or antagonistic personal preferences. It is a fact that when we face a situation in which the concerns of people appear to be incompatible a *conflict situation* arises.

Our approach determines that the general satisfaction of the group is not always the aggregation of the satisfaction of its members, as different people have different expectations and behavior in conflict situations that should be taken into account. In [24] we presented a method for group decision support where we distinguish between different types of individuals in a group. Our research characterizes people using the Thomas–Kilmann Conflict Mode Instrument (TKI) [29]. From the answers to the TKI test we compute a value $p_u \in [0,1]$ that represents the personality as user u; 0 being the reflection of a very cooperative person and 1 the reflection of a very selfish one. Our method takes this value into account by studying how group personality composition influences the decision making process for the group, and how performance is improved for certain types of groups when compared to different simple group preference aggregation algorithms.

In this paper we present some experiments where we include the impact that personality will have on the argumentation process when two users u and v are arguing. This factor is computed as the personality difference:

$$\Delta p_{u,v} = p_u - p_v$$

where p_u and p_v are the values that reflect the personality of users u and v respectively. Note that $\Delta p_{u,v} \in [-1,1]$.

As we detail in Section 3, we propose to use the personality difference value to configure the behavior of each agent in the distributed architecture. This factor will be integrated into the group decision making process together with another feature: trust among agents. This second factor is detailed next.

2.2. Social trust and network topologies in GDSS

In today's networked worlds, uncertainty and anonymity are important factors that have strong implications in decision-making. Several researchers have therefore proposed to incorporate the concept of interpersonal trust in Group Decision Support Systems [27,28,32]. This factor is even more important when we are performing a group decision making process where users have to agree on an alternative for the whole group. This kind of process usually follows an argumentation schema where each user defends her preferences and rebuts others' opinions. Here, trust among users is the major factor when users must change their mind to reach a common decision.

A promising approach is to collect trust knowledge from existing social networks like Facebook, Twitter, Google+, among others.

The use of social networks and trust when building a DSS system is not new. Generally, trust is employed as a way to give more weight to