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A bipolar consensus approach for group decision making problems

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ABSTRACT

This paper addresses the collaborative group decision making problems considering a consensus processes to achieve a common legitimate solution. The proposed resolution model is based on individual bipolar assessment. Each decision maker evaluates alternatives through selectability and rejectability measures which respectively represent the positive and negative aspects of alternatives considering objectives achievement. The impact of human behavior (influence, individualism, fear, caution, etc.) on decisional capacity has been taken into account. The influence degrees exerted mutually by decision makers are modeled through concordance and discordance measures. The individualistic nature of decision makers has been taken into account from the individualism degree. In order to achieve a common solution(s), models of consensus building are proposed based on the satisficing game theory formalism for collective decision problems. An application example is given to illustrate the proposed concepts.

1. Introduction

Nowadays, the increasing complexity of the socio-economic, engineering and environmental management make less possible decision by a single decision maker considering all aspects of a problem (Yue, 2011a). Therefore, the majority of decision problems are considered currently in the group decision process. This process is generally characterized by the existence of two or more persons (i) who have different perceptions, attitudes, motivations and personality, (ii) who recognize the existence of a common problem, and (iii) attempt to reach a collective decision (Herrera, Herrera-Viedma, & Verdegay, 1996b).

Solving a group decision making (GDM) problem often goes through the following phases: elicitation phase where different characteristics of the problem are defined (objectives, alternatives, attributes, etc.), evaluation phase and a selection and recommendation phase. In the evaluation phase, the way information is managed can leads to two families of aggregation approaches, we speak of input and output aggregation (Leyva Lopez, 2010) or common value tree for all decision makers and a value tree for each decision maker (De Brucker & Macharis, 2010). In the first case, aggregation is performed at the input when the decision group is invited to agree on a common set of attributes, weights and other parameters, which amounts to solving a problem as a single decision making problem. In the second case, the individual evaluations are represented by individual value trees solved using standard process of decision support. The output aggregation is performed at the end. The present paper focuses on this second type of problem dealing with group decision making problem based on individual assessments.

Decision makers' evaluations can be represented by preference order (where the alternatives are ranked from best to worst), a utility function (where the alternatives are represented by real value –physical or monetary value–), or a frequently used preference relation (where alternatives are evaluated by pairwise comparison) (Herrera, Herrera-Viedma, & Chiclana, 2001). Depending on the nature of the data, the certainty of decision-makers, these preferences can be modeled by absolute evaluations when information is known or fuzzy evaluation based on the theory of fuzzy set, introduced by Zadeh (1965) in case of uncertainty in order to manage human subjectivity, imprecision and vagueness. The fuzzy evaluation is used in many areas due to the pressure, lack of knowledge and/or time.

Decision-makers' evaluations are then integrated into decision resolution procedures to reach an agreement on the selection of the best solutions. Traditionally, GDM problems have been solved by applying an alternative selection process in which the preferences of each decision makers over the alternatives are gathered and the best alternative or subset of alternatives is chosen (Roubens, 1997). However, as a group decision members usually come from different horizons with different specialty areas and different levels of knowledge, each group member has distinct

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information and sharing in general a part of the objectives with other decision members (Xu & Wu, 2011). This implies that individual assessments rarely meet (Roselló, Prats, Agell, & Sánchez, 2010; Ben-Arieh, Easton, & Evans, 2009) and the divergence of opinions can generates conflict (disagreement) and/or agreement within the group decision making. The recommendation phase in this case usually requires the establishment of a "consensus" building process in order to lead actors to a common decision (Khorshid, 2010).

To achieve a common accord, a variety of consensus reaching processes have been proposed in recent years (Eklund, Rusinowska, & de. Swart, 2008; Gong, Forrest, & Yang, 2013; Herrera-Viedma, Cabrerizo, Kacprzyk, & Pedrycz, 2014). These approaches going from mechanist models of operational research to more sophisticated and soft computing oriented models that attempt to integrate human attitude (emotion, affect, fear, egoism, altruism, selfishness, etc.). The soft computing oriented models are used increasingly due to their ability to tolerate imprecision, uncertainty and partial truth in order to simulate human behavior with low cost (Pal & Ghosh, 2004), they allow to take into account the ambiguity in human thinking and uncertainty of the real world (Ko, Tiwari, & Mehnen, 2010).

2. Consensus building processes

Basically, group decision making aims at obtaining the consent, not necessarily the agreement of the participants by accommodating views of all parties involved to attain a decision that will yield what will be beneficial to the entire group (Herrera-Viedma et al., 2014). This is why the group consensus is usually considered as a total and final agreement between the decision members (Leyva Lopez, 2010). To reach a consensus, the researchers first proposed consensus approaches with the objective of reaching a full degree of agreement in the group, i.e. unanimity (Kline, 1972). The earliest approaches proposed to use group consensus functions that aggregate decision maker evaluations in a unique value representing the common opinion. Several aggregation methods have been proposed in the literature, simple average (Wheeler, Hora, Cramond, & Unwin, 1989), geometric mean (Cook & Kress, 1985), Bayesian aggregation (Bonano & Apostolakis, 1991), aggregation using the analytic hierarchy process (AHP) (see eg (Bard & Sousk, 1990; Korpela & Tuominen, 1997; Lai, Wong, & Cheung, 2002; Tavana, Kennedy, & Joglekar, 1996)), fuzzy set theory (Hsu & Chen, 1996; Kacprzyk, Fedrizzi, & Nurmi, 1992; Moon & Kang, 1999; Yue & Jia, 2012), multi-criteria decision analysis methods (Hatami-Marbini & Tavana, 2011), etc.

In the best possible way, consensus should refer to unanimity of individuals because the selected solution(s) will be best representative for the entire group. Traditionally way to reach a consensus propose to model process by using matrix calculus or Markov chains to model the time evolution of changes of opinions toward consensus (Coch & French, 1948; French, 1956; Harary, 1959). However, unanimity may be difficult to attain, in particular in large and diversified groups of individuals as is the case in real world settings (Herrera-Viedma et al., 2014).

This resolution scheme does not take into account the agreement level between decision makers and some actors may not accept the final decision because their individual preferences are not taken into account sufficiently (Butler & Rothstein, 1987; Kacprzyk & Fedrizzi, 1988). For this reason, consensus reaching processes based on agreement levels were introduced as an additional phase in the resolution of GDM problems (Saint, 1994), as cited in (Palomares, Estrella, Martínez, & Herrera, 2014).

In this context, the concept of a soft consensus was introduced by Kacprzyk and Fedrizzi (1988) where some researchers assume that unanimity is not required in the real decision problem and employed milder definitions of consensus (Butler & Rothstein, 1987; Verma, 2009) which consider for example a unanimity minus number of persons whose don't support the decision, percentage of actors (%) accepting decision, etc.

Generally, the soft consensus reached process is based on multistage setting where the individuals assumed collaborative, change their opinions until some consensus is reached.

The individual evaluation settings can be realized in discussion phases where the analyst or moderator –who is responsible for running the consensus reaching session– intervenes to guide stakeholders towards a common output solution, recommending them, based on rational arguments, to settle their preferences, and keeping the process within a period of time considered (Butler & Rothstein, 1987).

In some case, the individual settings are modeled by integrating the dynamic discussion phase in the reach consensus process and thus substituting the role of the analyst. (see for example (Choudhury, Shankar, & Tiwari, 2006)). Although the latter method is becoming increasingly popular in recent years, the method where moderator running a consensus reaching process is usually more effective and efficient (Herrera-Viedma et al., 2014).

In the present paper, a new adaptive consensus reached process based on semi-automated feedback mechanism –where analyst can intervenes– is developed. Considering a bipolar framework, initial decision makers' preferences are represented by bipolar measures that express the degree of supportability and rejectability of alternatives avoiding compensations.

To more realistic model, human behavior aspects (positive affect, negative affect, selfish, prudence, etc.) are integrated in the evaluation and recommendation phases of proposed approach. By considering social ties, the mutual influence of positive and negative interactions of the group members are integrated through individualism degree of each one. The weight of the decision makers which was the subject of several studies (Yue, 2011b; Yue, 2012a; Yue, 2012b; Yue & Jia, 2012) is also treated in this paper.

To our knowledge and as underlined in (Herrera-Viedma et al., 2014), although some authors introduce the decision maker importance degrees in the aggregation phase of actors' opinions (Herrera, Herrera-Viedma, & Verdegay, 1996a; Herrera, Herrera-Viedma, & Verdegay, 1997a; Lee, 2002), no one considers them in the recommendation phase when advising to the decision actors how to change their preferences to increase the consensus level. To remedy this, the present contribution integrates importance degrees of actors in proximity and bipolar consensus measures to adjust the actors' preference depending on his/her own knowledge level about the problem.

Considering that local preferences can be represented by a set of satisficing and non-dominated alternatives, developed consensus processes are defined considering two cases: when the local preferences of actors cannot be modified and in the case when modifications are possible. In the first case, consensus achievement is based on setting caution index and consensus measures are used in the second.

The remainder of the paper is organized as follow. Section 2 traces the evolution of consensus approaches in group decision making (GDM) and give a general classification of these process. Section 3 describe global framework of bipolar modeling of decision group problems when considering members interaction. The satisficing game theory used as aggregation tool is briefly described in this section. Section 3 presents proposed consensus and selection processes, an application example is given in Section 4. Eventually, Section 5 provides a conclusion and some perspectives.

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