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Managing incomplete preference relations in decision making: A review and future trends

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ABSTRACT

In decision making, situations where all experts are able to efficiently express their preferences over all the available options are the exception rather than the rule. Indeed, the above scenario requires all experts to possess a precise or sufficient level of knowledge of the whole problem to tackle, including the ability to discriminate the degree up to which some options are better than others. These assumptions can be seen unrealistic in many decision making situations, especially those involving a large number of alternatives to choose from and/or conflicting and dynamic sources of information. Some methodologies widely adopted in these situations are to discard or to rate more negatively those experts that provide preferences with missing values. However, incomplete information is not equivalent to low quality information, and consequently these methodologies could lead to biased or even bad solutions since useful information might not being taken properly into account in the decision process. Therefore, alternative approaches to manage incomplete preference relations that estimates the missing information in decision making are desirable and possible. This paper presents and analyses methods and processes developed on this area towards the estimation of missing preferences in decision making, and highlights some areas for future research.

1. Introduction

Group decision making (GDM) consists of multiple individuals interacting to choose the best option between all the available ones. Each decision maker (DM) or expert may have his/her own opinions and background and, although they might share a common interest in achieving agreement on selecting the most suitable option, it is expected that they would approach the problem in different ways.

The majority of GDM problems comprise the following phases depicted in Fig. 1 [36]: (1) definition of the problem; (2) analysis of the problem; (3) identification of a set of alternatives; (4) identification of the set of criteria and panel of experts; and (5) application of a selection process to derive the solution to the problem.

In GDM systems experts have to express their preferences by means of a set of evaluations over a set of alternatives. To that aim different preference representation formats are available [27]. However, it is common that an expert might not possess a precise or sufficient level of knowledge of part of the problem and, as a consequence, he/she might not provide all the

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information that is required [2,14,24,44]. Actually, situations where all experts are able to efficiently express their preferences over all the available options might be considered the exception rather than the rule. Indeed, the above scenario requires all experts to possess a precise or sufficient level of knowledge of the whole problem to tackle, including the ability to discriminate the degree up to which some options are better than others. These assumptions can be seen as unrealistic in many decision making situations, especially those involving a large number of alternatives to choose from and/or conflicting and dynamic sources of information. Indeed, a study by Deparis et al. [22] corroborates empirically the following hypothesis: "increasing the intensity of conflict in a multicriteria comparison increases the likelihood that DMs consider two alternatives as incomparable," and therefore leading to the expression of incomplete preferences. Their results indicate that a large attribute spread increases the frequency of incomparability statements when allowed, otherwise an increase of indifference statements happens. Therefore, it becomes necessary to develop decision models to address the presence of incomplete information, i.e. information with missing data.

Different approaches have been developed to deal with incomplete information modelled using different representation formats, which can be broadly classified into three main groups:

(i) methods that directly discard the incomplete information and process only pieces of complete information [52];
(ii) methods that penalise or rate negatively the experts who provide incomplete preferences [24]; and
(iii) methods that estimate the missing preference values using the provided ones [39,40].

The first two groups of methods are based on the assumption that a good solution to a decision making problem cannot be achieved from incomplete information, or that the solution would not be as good as the one that would derive using complete information. However, empirical evidence suggests that the incomplete relation derived from the random deletion of as much as 50% of the elements of a complete pairwise preference relation provides good results without compromising accuracy [14]. Therefore, these two groups of methods eliminate or undervalue useful information in the data provided, which could lead to serious biases [43]. Indeed, incomplete information is not equivalent to low quality information, and consequently imposing penalties in the decision making processes to experts providing incomplete information could lead to misleading solution, specially when the incomplete information is consistent and the complete information is not. Thus, alternative approaches to manage incomplete information in decision making are desirable. One of these approaches is based on the selection of an appropriate methodology to 'build' the matrix, and/or to assign importance values to experts based not on the amount of information provided but on how consistent the information provided is.

Some of the existing methods that estimate missing preference values in GDM use the information provided by the rest of experts together with aggregation procedures [44]. The main drawback for this approach is that it requires several experts to estimate the missing values of a particular one, which in conjunction with notable difference between the experts preferences could lead to the estimation of information not naturally compatible with the rest of the expert's information. An alternative approach here is to use methods to estimate an expert's missing values using just his/her own assessments and consistency criteria to avoid incompatibility. This has been a tool extensively applied in decision making contexts under preference relations [1–5,25,29,39,40,46,48,74]. An extreme case of incomplete preferences happens when one or more experts in the group do not provide any preference information on at least one of the feasible alternatives. This situations are called in literature *total ignorance* or simply *ignorance* situations, and several approaches to deal with them have been presented in [4].

This paper presents a review of the foundations and developments in estimating missing preferences in decision making with the following different kinds of preference relations used as the preference representation format: additive, multiplicative, intuitionistic, interval and linguistic preference relations. A comprehensive analysis of the most recent developed applications in the specialised literature is presented. Finally, some of the current trends and potential future research lines of enquiry on this research topic are also outlined.

The remainder of the paper is set out as follows: In Section 2 the principal types of preference relations used in decision making are reviewed, including a description on the characterisation of their consistency. The main strategies developed to tackle the presence of incomplete preferences for the different types of preference relations will be presented in Section 3. Section 4 focuses on those cases that are being called as ignorance situations in GDM. A discussion on the current trends and future work in this research area is covered in Section 5. In Section 6 conclusions are drawn.

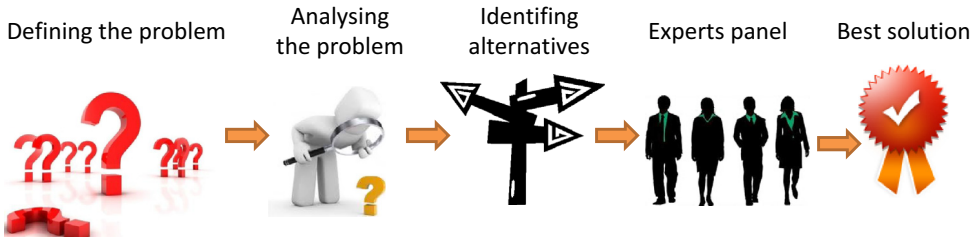

Fig. 1. GDM problem resolution steps.