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On multi-granular fuzzy linguistic modelling in decision making

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Abstract

Nowadays, the human-computer interaction is being a hot topic. In such a way, several methods have been proposed to deal with multi-granularity when people with different knowledge level express their preferences on the same concept using linguistic notation, that is, words instead of numbers. This is a critical problem in group decision making scenarios, but all the existing approaches have their own advantages and drawbacks. Therefore, some work better in certain environments than others. In such a way, choosing the best method in each situation is critical for obtaining good quality results. In this contribution, an analysis on the different fuzzy linguistic multi-granular modelling approaches is presented in order to provide the reader some advice of what method should be chosen depending on the problem and the quality of results that the user expects to obtain.

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Keywords: Computing with words; Group decision making; Fuzzy linguistic modelling; Multi-granular linguistic information.

1. Introduction

Group decision making (GDM) is used to obtain the best solution(s) for a problem according to the information provided by some decision makers. Usually, each decision maker (expert) may approach the decision process from a different angle, but they have a common interest in reaching an agreement on taking the best decision. Concretely, in a GDM problem we have a set of different alternatives to solve the problem and a set of experts which are usually required to provide their preferences about the alternatives by means of a particular preference format.

In an ideal GDM situation, all the experts could express their preferences in a precise way by using numerical values. Unfortunately, in many cases, due to the experts background or the kind of information, experts can not represent their preferences precisely in a quantitative way. In these cases, it seems to be more adequate the use of qualitative concepts instead of numerical values. Several authors have provided interesting results on GDM with the help of fuzzy set theory [1]. Even, some of them have proposed the necessity of a linguistic approach to model that situations [2]. A linguistic approach is an approximate technique which represents qualitative aspects as linguistic values by means of linguistic variables, that is, variables whose values are not numbers but

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words or sentences in a natural or artificial language. In the current literature, it is possible to find two kinds of fuzzy linguistic approaches in order to represent linguistic information [3]: traditional fuzzy linguistic approach and ordinal fuzzy linguistic approach. The former is more classical and is based on the membership functions associated to each label [1], while the latter is based on the symbolic ordinal representation of the labels [2]. The symbolic approximation approach has awakened high interest among the scientific community because of its simplicity and application possibilities.

An important parameter to determine a linguistic approach is the number of linguistic variables, that is, the cardinality of the term set. There are cases where experts are non homogeneous in the sense of they have different background and levels of knowledge about the alternatives, and as consequence, they might use linguistic term sets with different granularity to express their preferences. In such cases, we say that GDM problem is defined in a multigranular fuzzy linguistic context [4].

The multi-granular fuzzy linguistic modelling (FLM) is appropriate in cases where several information providers need different criteria to express their preferences. For example, this could happen when they have different knowledge levels and need different expression linguistic domains with a different granularity and/or semantics. Multi-granular FLM has been applied successfully in areas such as information retrieval, recommender systems, consensus, web quality and decision making.

The aim of this paper is to show a comprehensive presentation of the state of the art of all known multi-granular FLM approaches, with an in-depth analysis of the respective problems and solutions. Methods selected after carrying out a systematic review process have been classified into six different categories:

1. Traditional multi-granular FLM based on fuzzy membership functions.
2. Ordinal multi-granular FLM based on a basic Linguistic Term Set.
3. Ordinal multi-granular FLM based on 2-tuple FLM.
4. Ordinal multi-granular FLM based on hierarchical trees.
5. Multi-granular FLM based on qualitative description spaces.
6. Ordinal multi-granular FLM based on discrete fuzzy numbers.

This paper is organized as follows. Section 2 presents some background information about GDM problems and multi-granular FLM. In Section 3, different multi-granular fuzzy linguistic approaches are described. Finally, some conclusions are pointed out.

2. GDM problems and multi-granular FLM background

A GDM problem is classically defined as a decision situation where a set of experts, $E = \{e_1, e_2, \ldots, e_m\}$ ($m \geq 2$), express their preferences about a set of feasible alternatives, $X = \{x_1, x_2, \ldots, x_n\}$ ($n \geq 2$), and they work to achieve a consensual solution. In many decision situations it is assumed that each expert e_i provides his/her preferences by means of a fuzzy preference relation, $P_{e_i} = [p_i^{lk}]$, $l, k \in \{1, \ldots, n\}$ with $p_i^{lk} = \mu_{P_{e_i}}(x_l, x_k)$ assessed in the unit interval $[0, 1]$ and being interpreted as the preference degree of the alternative x_l over x_k according to the expert e_i. Another possibility is that experts use linguistic preference relations to represent their preferences, i.e., with $p_i^{lk} = \mu_{P_{e_i}}(x_l, x_k)$ assessed in a linguistic term set (LTS) S. The ideal situation for GDM problems defined in linguistic contexts would be that all the experts use the same LTS S to express their preferences about the alternatives. However, in some cases, experts may belong, e.g., to distinct research areas and, therefore, could have different background and levels of knowledge. A consequence of this is that they need to express their preferences by using LTSs with different granularity, $S_i = \{s_0^i, \ldots, s_{g_i}^i\}$, $i \in \{1, 2, \ldots, m\}$. In these cases, we say that the GDM problem is defined in a multi-granular fuzzy linguistic context [4].

Multi-granular FLM was first introduced by Herrera et al. [4]. They designed a GDM method where each expert can use a different ordinal LTS in order to provide his/her preferences. In such a way, they defined a new fuzzy linguistic framework to make decisions that allowed experts to express their preferences using the concept of linguistic variable introduced by Zadeh [1], but in a more flexible way, i.e., using different LTS to express the different assessments of the linguistic variable. This multi-granular fuzzy linguistic approach was introduced assuming that the qualitative information in the GDM problem was modeled using an ordinal fuzzy linguistic approach.