A Multi-granular Linguistic Decision Model for Evaluating the Quality of Network Services

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Summary. The fuzzy linguistic approach has been applied successfully to many problems dealing with qualitative aspects that are assessed by means of linguistic terms. The use of linguistic information implies in most cases the need for using fusion processes to obtain aggregated values that summarize the input information. One important limitation of the fuzzy linguistic approach appears when fusion processes are applied to problems in which the linguistic information is assessed in linguistic term sets with different granularity of uncertainty, i.e., different cardinality; this type of information is denoted as multi-granular linguistic information. This limitation consists of the difficulty in dealing with this type of information in fusion processes due to the fact that there is no standard normalization process for this type of information, as in the numerical domain.

   In this contribution, taking as base the 2-tuple fuzzy linguistic representation model and its computational technique, we shall present a method for easily dealing with multi-granular linguistic information in fusion processes. Afterwards, we shall apply this fusion method to a decision process in a multi-expert decision-making (MEDM) problem with multi-granular linguistic information, that evaluates the quality of network services from different Operative Systems.

1 Introduction

On many occasions we find problems that present several sources of information to qualify their phenomena. When these phenomena present quantitative aspects they can be assessed by means of precise numerical values, however

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when the aspects presented by the phenomena are qualitative may be difficult to qualify using precise values. So, the use of the fuzzy linguistic approach [45] has shown itself as a good choice to model these phenomena, due to the fact that it represents qualitative aspects with qualitative terms by means of linguistic variables, i.e., variables whose values are not numbers but words or sentences in a natural or artificial language.

An important aspect when the fuzzy linguistic approach is used, is to determine the "granularity of uncertainty," i.e., the cardinality of the linguistic term set used to assess the linguistic variables. Depending on the uncertainty degree held by a source of information qualifying a phenomenon, the linguistic term set will have more or less terms. Then, in those problems with several sources of information each one may have a different uncertainty degree on the phenomena to qualify. Therefore, each source could express its knowledge by means of linguistic term sets with a different granularity of uncertainty from the other ones. In these situations we shall denote this type of information as multi-granular linguistic information.

The use of the fuzzy linguistic approach implies processes of "computing with words" (CW), in the specialized literature, three different linguistic computational techniques can be found [2, 10, 11, 20]. The first one is based on the Extension Principle [2, 11] that acts on the linguistic terms through computations on the associated membership functions, the second method or Symbolic one [10] acts by direct computations on the labels and the third method uses the 2-tuple fuzzy linguistic representation model [20] and acts on numerical values associated with the fuzzy linguistic 2-tuple. These computational techniques provide linguistic operators for CW.

When a problem presents multi-granular linguistic information, the fuzzy linguistic approach together with the first two linguistic computational techniques mentioned present an important limitation because in these computational methods, neither a standard normalization process nor fusion operators are defined for this type of information. Therefore, it is highly complex to solve this type of problems using these methods and the results obtained present loss of information during computing processes. Besides, they are expressed by values assessed in domains far removed from the initial expression ones, as occurs in the fusion method for multi-granular linguistic information that we presented in [18] for decision problems, introducing a fuzzy preference relation among the alternatives as a final step because it was not possible to manage the multi-granular information directly.

The aim of this paper is to develop an aggregation process, for multi-granular linguistic information, that overcomes the above limitations, i.e., it will be able to reduce the loss of information and express the final results in an expression domain near the initial one. To do so, we shall use the 2-tuple fuzzy linguistic representation model and its computational technique [20], together with the multi-granular linguistic information fusion ideas presented in [18]. For the development of a practical example of the multi-granular fusion method based on the 2-tuple linguistic representation we shall solve an