Linguistic Preference Modeling: Foundation Models and New Trends

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Extended Abstract

There are decision situations in which the information cannot be assessed precisely in a quantitative form but may be in a qualitative one, and thus, the use of a *linguistic approach* is necessary. For example, when attempting to qualify phenomena related to human perception, we are often led to use words in natural language instead of numerical values. As was pointed out in [2], this may arise for different reasons. There are some situations in which the information may be unquantifiable due to its nature, and thus, it may be stated only in linguistic terms (e.g., when evaluating the "comfort" or "design" of a car, terms like "good", "medium", "bad" can be used). In other cases, precise quantitative information may not be stated because either it is unavailable or the cost of its computation is too high, so an "approximate value" may be tolerated (e.g., when evaluating the speed of a car, linguistic terms like "fast", "very fast", "slow" may be used instead of numerical values).

The linguistic approach is an approximate technique which represents qualitative aspects as linguistic values by means of *linguistic variables* [16], that is, variables whose values are not numbers but words or sentences in a natural or artificial language. Each linguistic value is characterized by a *syntactic value* or *label* and a *semantic value* or *meaning*. Since words are less precise than numbers, the concept of a linguistic variable serves the purpose of providing a measure of an approximate characterization of the phenomena which are too complex or ill-defined to be amenable to their description by conventional quantitative terms.

Linguistic preference modeling consists in the use of the linguistic approach for solving decision making problems assuming that experts' preferences are expressed by means of linguistic preference relations. Its application in the development of the theory and methods in *Decision Analysis* is very beneficial because it introduces a more flexible framework which allows to represent the information in a more direct and adequate way when experts are unable to express it precisely. In this way, the burden of quantifying a qualitative concept is eliminated. In the literature, we may find many applications of linguistic preference modeling to solve real-world decision activities [5], e.g., marketing, software development, education, subjective assessment of car evaluation, vine pruning, material selection, personal management, ...

Usually, in all real world decision making processes there are various actors (experts or decision makers) who are called to express their performance values on a predefined set of options (alternatives) in order to select the best one(s). In a classical fuzzy linguistic decision analysis, the solution scheme basically consists of two phases [8, 4, 12, 13]:

1. *Aggregation phase.* It consists of obtaining a collective linguistic preference relation on the alternatives by aggregating the individual linguistic preference relations provided by all the experts by means of an aggregation operator of linguistic information.

2. *Exploitation phase.* It consists of establishing a rank ordering among the alternatives according to the collective linguistic preference relation for choosing the best alternatives. This usually is done by defining linguistic choice functions based on aggregation operators of linguistic information [7].

To apply the linguistic preference modeling in decision making we have to define two elements:

1. *The linguistic representation model:* It is defined by choosing the linguistic term set used to express linguistic preference relations and its semantics.

2. *The linguistic computational model:* It is defined by designing aggregation operators to develop the *processes of Computing with Words (CW)* that allow to solve decision making problems.

There exist three foundation models of linguistic preference modeling, being the performance of linguistic computational model the main difference among them [11]:

1. Approximate linguistic preference modeling [1, 3, 14, 16].

   (a) *Approximate representation model:* This representation model defines the linguistic term set by means of a context-free grammar, and the semantics of linguistic terms is represented by fuzzy numbers described by membership functions based on parameters and defined in the [0,1] interval, and by a semantic rule.

   (b) *Approximate computational model:* This model uses fuzzy arithmetic based on the Extension Principle to make linguistic computations and the membership functions associated with the linguistic terms. By using extended arithmetic operations to handle fuzzy sets the vagueness of the results increases step by step, and the shape of the membership functions does not hold when the linguistic variables are interactive. Then, the approximate computational model presents the known problem of *linguistic approximation*, i.e., which consists of finding a label whose meaning is the same or the closest (according to some metric) to the meaning of the unlabelled fuzzy set generated by the linguistic computational model based on Extension Principle. There is no general method for associating a label with a fuzzy set, so specific problems may require specifically developed methods.

2. Ordinal linguistic preference modeling [9, 6, 15].

   (a) *Ordinal representation model:* This representation model defines the linguistic term set by means of an ordered structure of linguistic terms distributed on a scale, e.g. the [0,1] internal, with an odd cardinal and the mid term representing an assessment of "approximately 0.5" and with the rest of the terms being placed symmetrically around it. Then, the semantics of the linguistic term set is established from the ordered structure of the term set by considering that each linguistic term for the label pair (s_i, s_{T-i}) (T+1 is the cardinality of linguistic term set) is equally informative.

   (b) *Ordinal computational model:* This is a symbolic computational model that acts by direct computation on labels by taking into account the meaning and features of such linguistic assessments. It works assuming that the linguistic term set is an ordered structure uniformly distributed on a scale. Sometimes, this computational model also presents loss of information as a consequence of the *round operation* developed in the computation of some proposed aggregation operators, e.g. the LOWA and LWA operators [9, 6].

3. 2-Tuple linguistic preference modeling [10].

   (a) *2-Tuple representation model:* This representation model is based on the ordinal representation model, but it defines a representation proposal for the linguistic values more complete in order to avoid the loss of information that appears in the aggregation processes developed by the ordinal computational model, called linguistic 2-Tuple. This representation model represents the linguistic information by means of a pair of values, (s, α), where s is a linguistic label and α is a numerical value that represents the value of the symbolic translation.

   Definition 1.[10] *Let $\beta \in [0, g]$ be the result of an aggregation of the indices of a set of labels assessed in a linguistic term set S, i.e., the result of a symbolic aggregation operation, with $g + 1$ the cardinality of S. Let $i = round(\beta)$ and $\alpha = \beta - i$ be two values, such that, $i \in [0, g]$ and $\alpha \in [-.5, .5)$ then α is called a Symbolic Translation.*

   (b) *2-Tuple computational model:* This computational model is an extension of the ordinal computational model that avoids the loss of information by means of the 2-tuple linguistic representation model.

However, there exist problems that need to assess their variables in linguistic term sets that are not uniformly and symmetrically distributed. We call this type of linguistic term sets, *unbalanced linguistic term sets*. In some cases, the unbalanced linguistic information appears due to the nature of the linguistic variables that participate in the problem, as for example it happens in the grading system, Fig. 1, and in other cases, it appears in problems dealing with scales for assessing preferences where the experts need to assess a higher number of terms in a part of reference domain than in other Fig. 2.

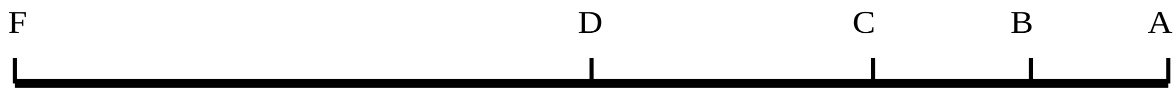

Figure 1: Grading system evaluations

Figure 2: Scale with more values on the right of the mid term.

Then, to develop methodologies to manage unbalanced linguistic term sets that operates without loss of information is an important future research field.

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