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FLINTSTONES: A fuzzy linguistic decision tools enhancement suite based on the 2-tuple linguistic model and extensions

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ABSTRACT

Uncertainty in real world decision making problems not always has probabilistic nature, in such cases the use of linguistic information to model and manage such an uncertainty has given good results. The adoption of linguistic information implies the accomplishment of processes of computing with words to solve linguistic decision making problems. In the specialized literature, several computational models can be found to carry out such processes. However, there is a shortage of software tools that develop and implement these computational models. The 2-tuple linguistic model has been widely used to operate with linguistic information in decision problems due to the fact that provides linguistic results that are accurate and easy to understand for human beings. Furthermore, another advantage of the 2-tuple linguistic model is the existence of different extensions to accomplish processes of computing with words in complex decision frameworks. Due to these reasons, in this paper a fuzzy linguistic decision tools enhancement suite so-called *Flintstones* is proposed to solve linguistic decision making problems based on the 2-tuple linguistic model and its extensions. Additionally, the *Flintstones* website is also presented, this website has been deployed and includes a repository of case studies and datasets for different linguistic decision making problems. Finally, a case study solved by *Flintstones* is illustrated in order to show its performance, usefulness and effectiveness.

1. Introduction

Decision making processes are one of the most frequent mankind activities in daily life. In order to solve decision making problems, usually, human beings, experts, provide either their knowledge about a set of different alternatives in a given activity to make a decision by means of reasoning processes [2,14,29,34,48,49,58]. Generally, the modeling of such knowledge by linguistic information in decision making is motivated because these situations are defined under uncertainty that has a non-probabilistic nature. In such cases, experts feel more comfortable providing their knowledge by using terms close to human beings cognitive model. Fuzzy logic and fuzzy linguistic approach provide tools to model and manage such a uncertainty by means of linguistic variables [67], improving the flexibility and offering reliability of the decision models in different fields [12,16,33,61].

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Fig. 1. CWW paradigm.

The use of linguistic information involves the need to operate with linguistic variables. Computing with Words (CWW) is a paradigm based on a procedure that emulates human cognitive processes to make reasoning processes and decisions in environments of uncertainty and imprecision [68]. In this paradigm the objects of computation are words or sentences from a natural language and results are also expressed in a linguistic expression domain that, usually, corresponds to the initial linguistic domain. To do so, a computational scheme (see Fig. 1), which includes a translation phase and a retranslation phase, has been defined in such paradigm [18,40,42,64].

The linguistic preference modeling in decision making can be managed by means of CWW processes. However, there are some decision situations that define complex frameworks in which to carry out CWW processes could be not enough. These complex frameworks are briefly detailed below:

- *Heterogeneous frameworks*: Decision problems where each expert may express his/her assessments in different expression domains, depending on the level of knowledge, experience or the nature of criteria that characterized the set of alternatives. Therefore, the assessments are expressed with non-homogeneous information such as, numerical, interval or linguistic [26,32,46,50].
- *Multi-granular linguistic frameworks*: Decision problems with multiple experts or multiple criteria in which appear linguistic information assessed in multiple linguistic term sets with different granularity. Therefore, the assessments of the problem are represented in multiple linguistic scales [5,13,21,25,28].
- *Unbalanced linguistic frameworks*: Decision problems in which it is necessary to assess preferences with a greater granularity on one side of the linguistic scale regarding the another one. Hence, linguistic terms of the scale are neither uniformly nor symmetrically distributed. Therefore, experts express their assessments in an unbalanced linguistic scale [1,4,22,57].

Different linguistic computational models for decision making have been introduced in the literature [8–10,59,63]. However, the 2-tuple linguistic model [23,24] has been compared with them and it has been showed as the most appropriate model in linguistic decision making, considering the computing with words paradigm [24,52]. The main advantage of the 2-tuple linguistic model is its computational model that offers linguistic results in the original linguistic domain in a precise way.

Furthermore, the 2-tuple linguistic model has been extended to perform processes of CWW in complex decision frameworks [13,21,22,25,26,39] and have been successfully applied in different fields such as sustainable energy [15], recommender systems [51], sensory evaluation [16,38], personnel selection [30], quality of service [17], performance appraisal [12], vendor selection problem [3], soft consensus [27,47,69] or software project selection [71]. Given that the 2-tuple linguistic model and its extensions keep the CWW scheme showed in Fig. 1, together with its own features and extensions make of it a flexible and adaptable model to solve decision making problems in all type of decision frameworks.

Notwithstanding there are many linguistic computational models and a lot of applications solved by using them, there is a lack of software tools to solve linguistic decision problems carrying out CWW processes. In [36] was proposed *Decider*, a linguistic decision support system that develops and implements a fuzzy multicriteria group decision making method. *Decider* can deal with complex decision frameworks and has been applied to different evaluation problems [33,35,55,70]. To do so, *Decider* uses a method that unifies the information into triangular fuzzy numbers, which are aggregated to obtain a closeness coefficient for each alternative. This method considers the distance measure between the fuzzy group assessment of each alternative and both a group ideal solution and a group negative ideal solution. The weakness of *Decider* is that the proposed method provides closeness coefficients expressed in the unit interval and, therefore, cannot be considered inside of the CWW paradigm (see Fig. 1). Due to this fact, the proposed method lacks the retranslation phase and computed closeness coefficients cannot be easily interpreted.

In [6] was proposed *jFuzzyLogic*[1] that is an open source Java library which offers a fuzzy inference system. Although the library has been extended to handle decision problems with linguistic information by means the linguistic 2-tuple model and some extensions, this library is far from being a complete tool focused on solving decision problems with linguistic and complex frameworks.

Beyond the scope of linguistic decision making, three interesting software tools can be found. First, *DECERNS* (Decision Evaluation in Complex Risk Network Systems) [66] that is a web-based spatial decision support system for multi-criteria analysis of a wide range of spatially-distributed alternatives. Second, the *decision deck project* [41] that offers open source software tools which develops multicriteria decision aid techniques to support complex decision aid processes.

[1] https://salty.unice.fr/wiki/salty-public/Deliverables.