# A FUZZY LINGUISTIC DECISION TOOLS ENHANCEMENT SUITE TO SOLVE LINGUISTIC DECISION MAKING PROBLEMS

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In linguistic decision making problems, the set of alternatives are assessed by means of linguistic terms, implying processes of Computing with Words (CWW). The 2-tuple linguistic model provides a computational model that offers linguistic results in the original linguistic domain in a precise way. Furthermore, this model has been extended to carry out processes of CWW in complex decision frameworks. Despite these advantages, this model and its extensions have not been developed in a software tool suite to facilitate the resolution of linguistic decision making problems. In this contribution, we present FLINTSTONES, a fuzzy linguistic decision tools enhancement suite to solve linguistic decision making problems based on the 2-tuple linguistic model and its extensions as well as the FLINTSTONES website.

*Keywords:* Decision Making; Linguistic Information.

## 1. Introduction

A decision making process is used to select the best alternative from a set of alternatives. This process can be decomposed into several steps (see Figure 1):
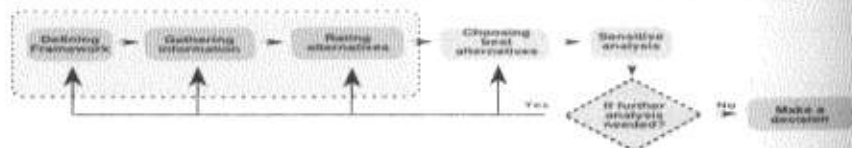


Figure 1: Decision resolution scheme

Generally, decision making problems are defined under uncertainty, which has a non-probabilistic nature, due to the fact that experts feel more comfortable providing their knowledge by using terms closer to human beings cognitive

model. Fuzzy logic and fuzzy linguistic approach [10] provide tools to model and manage such an uncertainty by means of linguistic variables, improving the flexibility and offering reliability of the decision models in different fields [8,9].

The use of linguistic information involves processes of Computing with Words (CWW) in which the objects of computation are words or sentences from a natural language and results are also expressed in a linguistic expression domain. A computational scheme for CWW has been defined which includes a translation phase and a retranslation phase (see Figure 2).



Figure 2: CWW scheme

Usually, a lot of real world decision making problems are defined in complex and uncertain decision frameworks in which linguistic modeling is not enough, being necessary the use of numerical or interval domains (heterogeneous frameworks), multiple linguistic scales (multi-granular linguistic frameworks) or unbalanced linguistic scales (unbalanced linguistic frameworks). In [8,9] was shown that the 2-tuple linguistic model [4] is an excellent option to manage not only linguistic decision making problems but also complex decision problems due to the fact that it provides a flexible computational model that offers linguistic results in the original linguistic domain in a precise way and has been extended to carry out CWW processes in complex frameworks.

In the literature have been proposed several software tools to solve linguistic decision problems [7]. Nonetheless, there is not a software tools suite that implements the 2-tuple linguistic model and its extensions.

In this contribution, we present the architecture and functionality of FLINTSTONES, a fuzzy linguistic decision tools enhancement suite to solve linguistic decision making problems based on the 2-tuple linguistic model and its extension as well as the FLINTSTONES website.

This contribution is structured as follows: Section 2 reviews the theoretical fundamentals of 2-tuple linguistic model and its extensions. Section 3 presents FLINTSTONES architecture and functionality as well as its website. Finally, in Section 4, conclusions are drawn.

## 2. Preliminaries

In this section we review briefly some concepts about the 2-tuple linguistic model and its extensions.

The 2-tuple linguistic model was presented in [4] in order to represent the information by means of a 2-tuple, $(s, \alpha)$, where $s$ is a linguistic term with a syntax and semantics, and $\alpha \in [-0.5, 0.5)$ is a numerical value that represents

the *symbolic translation*. The 2-tuple linguistic model facilitates the CWW process by its computational model.

Sometimes, decision making problems are defined in complex frameworks and the 2-tuple linguistic model has been extended to carry out processes of CWW in the following complex decision frameworks:

- *Heterogeneous frameworks* in which assessments are expressed in different domains such as numerical, interval or linguistic. In [6] was proposed an extension to deal with this framework.
- *Multi-granular linguistic frameworks* in which the assessments are expressed in multiple linguistic scales. In [1], [2] and [5] were presented three different extensions to manage this framework.
- *Unbalanced linguistic frameworks* in which the assessments are expressed in an unbalanced linguistic scale, i.e., a scale with different number of labels on each side. In [3] was presented an extension to deal with this framework.

## 3. FLINTSTONES

This section introduces FLINTSTONES, a software tools suite to solve linguistic decision making problems based on the 2-tuple linguistic model and its extensions. To do so, we first present the architecture of the software suite, its functionality and, finally, the FLINTSTONES website.

### 3.1. *Architecture*

FLINTSTONES has been developed as an Eclipse Rich Client Platform (Eclipse RCP) application that is a platform for building and deploying rich client applications developed by IBM and maintained by Eclipse Community. The key value of Eclipse RCP is that allows to quickly developing professional applications with native look-and-feel on multiple platforms. An Eclipse RCP application consists of several *Eclipse components*, also called *plug-ins, bundles* or *OSGi components*. FLINTSTONES includes more than 15 components, which can be grouped into four basic types: i) libraries, ii) Graphical User Interface (GUI), iii) methods and iv) operators (see Figure 3a).

Figure 3: a) FLINTSTONES architecture    b) Framework

## 3.2. *Functionality*

FLINTSTONES is based on the main steps of decision resolution scheme that were shaded in Figure 1. In this section, we describe these three steps in detail.

The *framework* of the decision making problem is defined in Framework perspective (see Figure 3b). The set of alternatives and the set of criteria which characterize the alternatives are established and, finally, the group of experts that will evaluate the alternatives is fixed. Furthermore, the expression domains used to assess the alternatives are also defined. FLINTSTONES allows creating different expression domains (linguistic, numeric and interval), using wizards that guide the user through the process.



Figure 4: a) Gathering information    b) Method selection

In the step of *gathering information*, experts provide their assessments for each criterion of each alternative in the expression domains defined in the

framework. This stage is performed in the Gathering perspective of FLINTSTONES (see Figure 4a).

In order to facilitate the gather process, FLINTSTONES allows users to create Excel spreadsheets.

For *Rating* alternatives is computed the global assessment for each alternative using a solving process that implements the 2-tuple linguistic model or its extensions, depending on the defined decision making problem. The suite is able to indicate the most suitable extension to solve the decision making problem (see Figure 4b). When an extension cannot be employed for the current problem, the suite shows a message to the user that specifies the reason. The solving process follows a common schema (see Figure 2) with the following three processes. It is noteworthy that each extension carries out these steps in a particular way:

1. *Unification process.* If an extension is used, a translation process is needed to represent the gathered information into a unified domain.

2. *Aggregation process.* In this process, the information is aggregated, selecting aggregation operators, in order to obtain a global assessment for each alternative that summarizes its gathered information.

3. *Retranslation process.* If an extension is carried out, a retranslation process is conducted to express the global assessment for each alternative in a linguistic expression domain that can be easily interpreted by experts.

### 3.3. *FLINTSTONES website*

The website[a] has been designed with the aim to publish all FLINTSTONES released versions and a repository of case studies with real datasets that can be solved with the presented software tools suite. Furthermore, the following interesting sections can be found in that website:

- *Description* that provides the theoretical foundations of FLINTSTONES.
- *Software tool* that offers FLINTSTONES released versions.
- *Case studies repository* with decision making problems to solve by the suite.
- *Video tutorials* that illustrate the functionality of our suite.

### 4. Concluding Remarks

Considering the merits and value of 2-tuple linguistic model and its extensions, in this contribution we have presented FLINSTONES, a fuzzy linguistic decision tools enhancement suite to solve linguistic decision making problems based on the 2-tuple linguistic model and its extensions. The proposed suite is a component-based application and its design is focused on reusability and the

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inclusion of new features. The FLINTSTONES website includes a repository of case studies and datasets for different linguistic decision making problems in order to verify the performance of the software tools suite with real datasets and that allows making comparisons with either other proposals or problems.

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