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Linguistic negation and 2-tuple fuzzy linguistic representation model: a new proposal

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In this paper we focus on linguistic negation, *i.e.* the way to handle negative statements while making a decision. Indeed negation is an important issue in decision making, especially when data are provided by human beings where vagueness, ignorance and uncertainty are high. This article highlights the existing works about negation in semiotics and semantics. It is an attempt to give clues to model linguistic negation while building bridges between the 2-tuple fuzzy linguistic representation model and semantics.

Keywords: Linguistic negation and contradiction, vagueness, 2-tuple fuzzy linguistic representation model.

1. Introduction

Decision making is a widely known area for researchers since decades [1]. It deals with *computing with words* [2] as soon as decisions are made for human beings and/or come from linguistic data such as preferences, feelings, opinions, perceptions, etc., and errors may occur as a result due to ignorance, vagueness or uncertainty. In particular, linguistic data may represent judgements or comments such as those that can be found in narrative report cards for pupils, or opinions drawn up on patients by doctors in a hospital, etc.

Many models to deal with such data have been proposed, such as fuzzy sets [3], fuzzy linguistic 2-tuples [4,5] which exhibit linguistic terms expressed as a pair (s_i, α) where s_i is a term and α a symbolic translation, proportional 2-tuples [6] or semantic 2-tuples [7]. However, the problem still

offers a wide range of potential research subjects because words don't have "good mathematical properties" as numbers of course have. For example the issue of *polarity* (affirmative *vs.* negative terms) is not easy to tackle because linguistic negation is much more complicated than logical negation [8–10]. Negation, as a unique feature of human communication [11], has also been addressed from a linguistic, logical and psycholinguistic point of view [12–14]. From Aristotle's original square of opposition (where A and E are contraries, I and O are sub-contraries and A and O as well as E and I are contradictories, see Table 1) to Greimas' semiotic square [15], there still remains several ways to consider the linguistic negation.

Table 1. The Four Aristotelian Propositions.

| Name | Symbol | Translation in English |
|------------------------|--------|-----------------------------|
| Universal affirmative | A | Every S is P (All S are P) |
| Universal negative | E | No S is P (All S are not P) |
| Particular affirmative | I | Some S are P |
| Particular negative | O | Some S are not P |

Yet dealing with negative statements is often very useful in particular in preference matrices where positive and negative terms may appear [16]]. For instance, let f_{ij} be the preference degree of alternative i over alternative j . If f_{ij} is "much less preferred", f_{ji} should be "much more preferred". But the real cases are rarely so simple. f_{ji} can be a more complex negation of f_{ij} . Of course, loosing reciprocity in the matrices is a problem, but when computing with words, this kind of property cannot be guaranteed. Thus this article tries to imagine how to model different kinds of linguistic negation, in order to perform a **semantic computation with words**.

The paper is organized as follows: Section 2 is dedicated to the related works about semiotics and semantics. Then the notions of negation, contrary, contradiction, etc. are highlighted in Section 3 while Section 4 gives clues to imagine a simple model to represent the negation. Finally Section 5 concludes this study, while giving some ideas for future works.

2. Related works

To be efficient, computing with words needs to take into account features of the language. For example, in a hospital, when doctors give advices about a same patient, a decision will have to be made to sum up the advice. Another example is when patients are asked to give comments, proposals and opinion prior to the making decisions on specific equipments, plans and

programmes. Questionnaires and pain scales that are usually dedicated to persons being impaired (visually impaired, mobility impaired, etc.) measure a patient’s pain intensity with numerical scales [17]. But pain assessments should be enhanced with linguistic scales to better catch the feeling of the patients.

Semiotics is the study of the meaning of words, signs, sign processes, etc. Three dimensions are distinguished: semantics, syntax and pragmatics. Semantics that aims to study the signs and their meaning is the one interesting for the current work. Yet an stimulating proposal has been suggested by Greimas in the 60’s: the *semiotic square* [15] derived from Aristotle’s square of opposition and composed of four terms: S1, S2, \sim S1 and \sim S2. S1 and S2 have an *opposition* relationship while S1 and \sim S1, S2 and \sim S2 are in *contradiction*. This permits to reflect that there are terms that are antonyms only in a certain context. For example, in a advertisement, one can read: “With car X, no need to select between comfort and sportiness”. In this case, “comfort” seems to be an antonym of “sportiness”, which is not the case, generally speaking.

3. Negation and Contradiction

According to Greimas, antinomy is represented by two kinds of relationships: **contradiction** and **contrary**. Two terms are contradictory when the affirmation of one is the negation of the other, and vice-versa (the principle of the excluded middle is fulfilled). Two terms are contrary when the affirmation of one is the negation of the other, but the negation of one is not necessary equivalent to the affirmation of the other.

Recently, an alternative to the classification of Greimas has been proposed by Franceschi [18] to take into account a kind of neutral term. Indeed, in Greimas’ square, pairs of words only express the contrary (negation) of each other, *i.e.* the *strong negation*. *Weak negation* which is related to *indifference* is lacking in the square [19]. So the square is replaced by a matrice of concepts providing six terms instead of four. For a given *duality* A/\bar{A} , we have thus the six following canonical poles: $\{A_+, A_0, A_-, \bar{A}_+, \bar{A}_0, \bar{A}_-\}$ that depend on a contrary component c and a canonical polarity p (cf. Table 2).

A duality can be, *e.g.* Exceptional/Normal, Audacity/Cowardice, etc. A_0 and \bar{A}_0 are dual or inverse; A_+ and \bar{A}_- are contraries (or antinomial) in the same way as A_- and \bar{A}_+ ; A_+ and \bar{A}_+ are complementary, in the same way as A_- and \bar{A}_- ; A_+ and A_- are corollary, in the same way as \bar{A}_+ and \bar{A}_- ; A_0 and A_+ are related (connected), in the same way as A_0 and A_- , \bar{A}_0 and \bar{A}_+ , \bar{A}_0 and \bar{A}_- ; A_0 and \bar{A}_+ are anti-connected, in the same

way as A_0 and \bar{A}_- , \bar{A}_0 and A_+ , \bar{A}_0 and A_- .

Table 2. The six canonical poles, according to Franceschi.

| | A_+ | A_0 | A_- | \bar{A}_+ | \bar{A}_0 | \bar{A}_- |
|------------------------|-------|-------|-------|-------------|-------------|-------------|
| contrary component c | 1 | 1 | 1 | -1 | -1 | -1 |
| canonical polarity p | 1 | 0 | -1 | 1 | 0 | -1 |

Taking for instance the duality Audacity/Cowardice, we obtain the scheme of Figure 1.

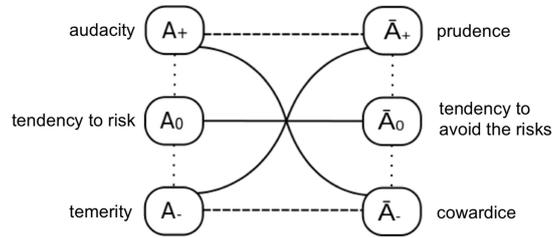


Fig. 1. The matrix of concepts for Audacity/Cowardice, according to Franceschi.

But how to model those concepts?

4. A proposal to model the linguistic negation

Among the combinations of relations existing between the 6 canonical poles we shall emphasize the following relations: duality, antinomy, complementarity and anti-connexity, which represent the linguistic negation. It is obvious that four distinct negation operators should be proposed.

The other two (corollary relation and connexity) are similar to a kind of synonymy, so they should be represented by resemblance operators or implication operators.

From Table 2, we assume that two components are compulsory to express the relations between the poles: c and p . These two components are related to each other so we can draw a two-dimensional graphic. The x -axis indicates the contrary component c and the y -axis indicates the canonical polarity p . Using a partitioning with fuzzy linguistic 2-tuples (for more details, see a complete review [20]) for both axes permits to put linguistic terms while assigning them a membership value, depending on whether they really belong to this “class” or not. What we call “class” here is a

semantic network of linguistic terms. Finally, the membership value adds a third dimension to the graphic. Figure 2 depicts the three intersecting dimensions of linguistic negation for the duality Audacity/Cowardice.

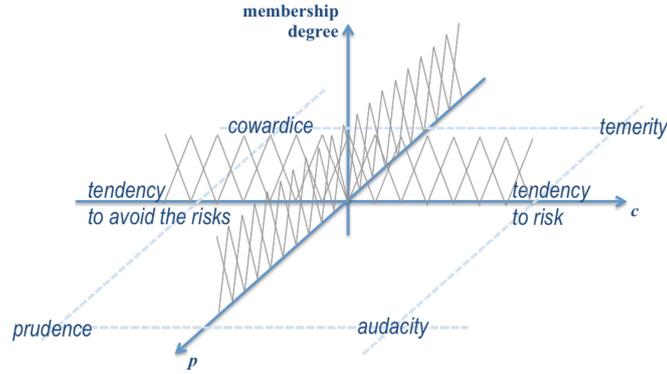


Fig. 2. Modeling the linguistic negation thanks to fuzzy linguistic 2-tuples. Example with the duality Audacity/Cowardice.

On that basis, four distinct negation operators will be defined: $Neg_d(\cdot)$, $Neg_a(\cdot)$, $Neg_c(\cdot)$ and $Neg_n(\cdot)$ to express **d**uality, **a**ntinomy, **c**omplementarity and **a**nti-**c**onnexity.

- (i) $Neg_d(\cdot)$ is an 2-dimensional operation because the only interesting axis is the contrary component c . So it can be defined through existing 2-tuple negation operators, such as $Neg((s_i, \alpha))$ [20].
- (ii) $Neg_a(\cdot)$ is an 3-dimensional operation because both axis c and p are important. So it must be defined specifically.
- (iii) $Neg_c(\cdot)$ is an 3-dimensional operation because both axis c and p are important. So it must be defined specifically.
- (iv) $Neg_n(\cdot)$ is an 3-dimensional operation because both axis c and p are important. So it must be defined specifically.

As we can see, there is a need to define those new operators since they actually represent the wide majority of the terms. Indeed, for each duality, among the 15 possible relations (we should say: the 15 possible “classes”), there is only one dual term pair, but there are two antinomy term pairs, two complementary term pairs and four anti-connected term pairs. Of course, the size of each “class” (*i.e.* the number of dual term pairs, the number of antinomy term pairs, etc.) depends on the language.

5. Conclusions

In this paper we have highlighted the existing works in the literature regarding the linguistic negation. Then we focused on Franceschi's matrices of concept and proposed to shed new light on the linguistic negation in building bridges between Franceschi's work and the fuzzy linguistic 2-tuple model. As a future work, we will propose formal definitions of the four negation operators in the fuzzy linguistic 2-tuple model. Long term, we will propose to consider the unbalanced linguistic term sets to achieve a real semantic computing with words.

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