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The LTOPSIS: An alternative to TOPSIS decision-making approach for linguistic variables

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ABSTRACT

This paper develops an evaluation approach based on the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). When the input for a decision process is linguistic, it can be understood that the output should also be linguistic. For that reason, in this paper we propose a modification of the TOPSIS algorithm which develops the above idea and which can also be used as a linguistic classifier. In this new development, modifications to the classic algorithm have been considered which enable linguistic outputs and which can be checked through the inclusion of an applied example to demonstrate the goodness of the new model proposed.

1. Introduction

In multiple criteria decision analysis, a number of alternatives have to be evaluated and compared using several criteria. The aim of is to provide support to the decision-makers in the process of making the choice among different options. In this way, practical problems found in business, services or manufacturing are often characterized by several conflicting criteria, and there may be no solution which satisfies all the criteria simultaneously, that is to say, that there is no one decision which is the best for all the criteria. Thus, the solution is a compromise solution according to the decision-maker's preferences.

MCDA has been an area of very rapid growth in recent decades. These techniques can be used to identify a single preferred option; to rank options; or to list a limited number of alternatives for subsequent evaluation. These decision problems involve six components (Keeney & Raiffa, 1976):

- A goal or a set of goals the decision-maker seeks to achieve.
- A set of criteria.
- The set of decision alternatives.
- The set of weights associated with the criteria.
- The set of outcomes or consequences associated with each alternative/criteria pair.
- The decision-maker or group of decision-makers involved in the decision making process with their preferences.

The Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) approach is a method for the arrangement of ratings to an ideal solution by similarity. The TOPSIS approach was developed by (Hwang & Yoon, 1981), and improved by the same authors in 1987 and 1992. Lai, Liu, and Hwang (1994) and Zeleny (1982) and many other researchers have also worked on this theme. Some examples using the fuzzy set theory can be seen in Braglia, Frosolini, and Ontanari (2003), Chu (2002a, 2002b), Jahanshsloo, Hosseinzadeh, and Izadikhah (2006), Kelemenis and Askonus (2010) and Garcia-Cascales and Lamata (2009a).

Most of the time the decision-maker is not able to define the importance of the criteria or the goodness of the alternatives with respect to each criterion in a numeric way. In many situations, we use measures or quantities which are not exact but approximate. In these situations, a more realistic approach may be to use linguistic assessments instead of numerical values, that is, to suppose that the ratings and/or weights of the criteria are assessed by means of linguistic variables. It is well known that fuzzy sets have been employed in handling inexact and vague information, since they can employ natural languages in terms of linguistic variables. Aristoteles explained that a sign of a well-trained mind was to not seek to find greater accuracy than that which the nature of the problem allows. Taking this assertion into account, our discussion will be focused on developing a model, the TOPSIS model, in such a way that both the inputs and the outputs are linguistic terms.

In the classical TOPSIS method, the performance ratings and the weights of the criteria are given as real values, with the outputs being an index, whose value belongs to the interval [0, 1]. In this article we seek to not only obtain a ranking but also the possibility

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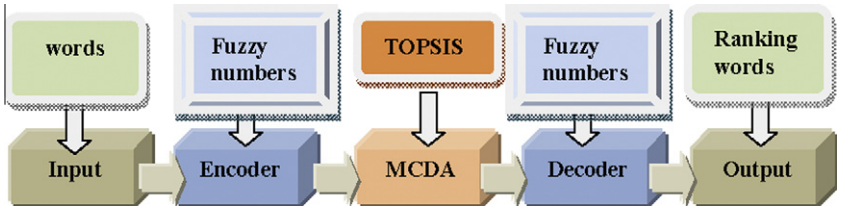

Fig. 1. Structure of the system.

to obtain a linguistic output and thus treat the TOPSIS method as a classifier.

To do so we shall employ the input of data to the system by means of linguistic variables which will be modeled as fuzzy numbers, which will then be treated using the TOPSIS method, obtaining as a result not only a numerical ranking but also a linguistic output, as can be appreciated in Fig. 1.

The paper is organized as follows: In the following section a literature review is carried out of the different developments of the TOPSIS method. Section 3 introduces the linguistic variables and the fuzzy sets are described. In Section 4, the framework for TOPSIS evaluation and the modifications for linguistic variables are detailed. Section 5 examines an illustrative example. The final section outlines the most important conclusions.

2. Literature review

In recent years, diverse papers have appeared in the literature in distinct applied fields utilizing the TOPSIS method as the multi-criteria decision making method, either on its own or in a hybrid form with other methodologies, and thus we present some of the most noteworthy communications published recently.

A wide variety of publications exist in which fuzzy logic has been employed together with the TOPSIS method in order to manage uncertainty or lack or accuracy in different applications. Therefore, we have a number of examples such as in the case of Kahraman, Cevik, Ates, and Gulbay (2007a) who apply the fuzzy TOPSIS method for the evaluation of industrial robotic systems. Kahraman, Ates, Cevik, Gulbay, and Erdogan (2007b) also propose a fuzzy TOPSIS approach to resolve a problem in logistic information technology. The total quality management consultant selection under fuzzy environment is viewed in Saremi, Mousavi, and Sanayei (2009) and the applications in aggregate planning in Wang and Liang (2004); whereas in Wang and Chang (2007), the application is related with the Air Force Academy in Taiwan to evaluate the initial training aircraft. Sun and Lin (2009) develop a fuzzy TOPSIS method for evaluating the competitive advantages of shopping websites. Mobile telephone alternatives are studied in Işıklar and Büyüközkan (2007). In Tansel and Yurdakul (2010) a quick credibility scoring decision support system is developed for banks to determine the credibility of manufacturing firms in Turkey, the proposed credit scoring model is based on financial ratios and the fuzzy TOPSIS approach. A new fuzzy TOPSIS for evaluating alternatives by integrating using subjective and objective weights is developed in Wang and Lee (2009).

Similarly, there is a wide range of literature on group decisions in which the TOPSIS method is used in group in conjunction with fuzzy logic. Examples of this can be seen in Chen (2000) and Chu (2002a, 2002b), who give the extension for group decision, the former for solving supplier selection problems in a fuzzy environment and the latter for problems in location selection. Fan and Liu (2010) propose a method to solve the group decision-making problem with multi-granularity uncertain linguistic information with an appropriate extension of the classical TOPSIS to a group fuzzy TOPSIS.

Other authors have utilized an AHP method to determine the importance weights of the criteria, and TOPSIS to obtain the performance ratings of the alternatives. This hybrid approach is used by Tsaur, Chang, and Yen (2002) to evaluate airline service quality, by Garcia-Cascales, Lamata, and Verdegay (2007a) and Garcia-Cascales and Lamata (in press) for the best parts cleaning system in an engine factory, Yurdakul and Tansel (2005) developed a performance model for manufacturing companies, Lin, Wang, Chen, and Chang (2008) integrate AHP and TOPSIS approaches into the customer-driven product design process and Buyukozkan and Ruan (2007) combine both e-government and website quality assessment methodologies to improve the evaluation phase and include all aspects related to service quality through the website. Also, Gharehgozli, Rabbani, Zaerpour, and Razmi (2008) work with this methodology in the acceptance/rejection of incoming orders, Ertugrul and Karakasoglu (2009) used the methodology in the evaluation of Turkish cement firms and Amiri (2010) utilized the methodology in project selection for oil-fields.

It is also possible to find other hybrid methodologies in the literature such as Celik, Kandakoglu, and Deha (2009) which combines SWOT (strengths, weaknesses, opportunities and threats) with fuzzy AHP and fuzzy TOPSIS for a systematic decision aid mechanism which could be adopted into the official recruitment procedures of academic administrations. Amiri, Zandieh, Soltani, and Vahdani (2009) present a hybrid multi-criteria decision-making model to evaluate the competence of the firms with an adaptative AHP approach with the use of interval data and TOPSIS method. Chen and Chen (2010) present a conjunctive multi-criteria decision-making approach based on decision-making trial and evaluation laboratory DEMATEL, fuzzy analytic network process FANP and TOPSIS as an innovations support system for Taiwanese higher education.

Finally, it is possible to find papers in the literature which compare TOPSIS and VIKOR approaches. In this sense, we emphasize the works of Opricovic and Tzeng (2004, 2007) and Chu, Shyu, Tzeng, and Khosla (2007).

3. Linguistic variable and fuzzy sets

3.1. Linguistic variable

Natural language to express perception or judgement is always subjective, uncertain, or vague. Since words are less precise than numbers, the concept of a linguistic variable approximately characterizes phenomena which are poorly defined to be described with conventional quantitative terms (Delgado, Verdegay, & Vila, 1992, 1993; Herrera & Herrera-Viedma, 2002). The concept of a linguistic variable is very useful in dealing with situations which are too complex or not well defined to be reasonably described in conventional quantitative expressions (Zimmermann, 1996), where fuzzy numbers are introduced to appropriately express linguistic variables. To resolve the vagueness, ambiguity, and subjectivity of human judgement, fuzzy sets theory was introduced to express the linguistic terms in decision-making processes. Bellman and