Engineering Applications of Artificial Intelligence 57 (2017) 184–196

Contents lists available at ScienceDirect

Engineering Applications of Artificial Intelligence

journal homepage: www.elsevier.com/locate/engappai

Interval target-based VIKOR method supported on interval distance and preference degree for machine selection

Arian Hafezalkotob[a], Ashkan Hafezalkotob[b,*]

[a] Department of Mechanical Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran
[b] Department of Industrial Engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran

ARTICLE INFO

Keywords:
Multiple attribute decision making
VIKOR
Target-based attributes
Interval distance
Preference degree
Machine selection

ABSTRACT

By considering target values for attributes in addition to beneficial and non-beneficial attributes, a traditional MADM technique is converted to a comprehensive form. In many machine selection problems, some attributes have given target values. The target value regarding a machine attribute can be reported as a range of data. Some target-based decision-making methods have recently been developed; however, a research gap exists in the area. For example, fuzzy axiomatic design approach presents a target-based decision-making supported on common area of membership functions of alternative ratings and target values of attributes. However, it has detects on finding a complete ranking because of probable infinite values of assessment index. Two target-based VIKOR models with interval data exist in the literature; however, the target values of attributes or ratings of alternatives on attributes are crisp numbers in the models and their formulations may have some limitations. The present paper tries to fill the gap by developing the VIKOR method with both interval target values of attributes and interval ratings of alternatives on attributes. Moreover, we attempt to utilize the power of interval computations to minimize degeneration of uncertain information. In this regard, we employ interval arithmetic and introduce a new normalization technique based on interval distance of interval numbers. We use a preference matrix to determine extremum and rank interval numbers. Two machine selection problems concerning punching equipment and continuous fluid bed tea dryer are solved employing the proposed method. Preference-degree-based ranking lists are formed by calculating the relative degrees of preference for the arranged assessment values of the candidate machines. The resultant rankings for the problems are compared with the results of fuzzy axiomatic design approach and the interval target-based MULTIMOORA method and its subordinate parts.

1. Introduction

The selection of suitable machine is a crucial decision that leads to a streamlined production environment. Engineers often encounter a pool of candidate machines for selection. A useful alternative may be ignored if machines are only chosen based on experience. A multiple attribute decision making (MADM) method can make a framework for the process of machine selection. Several often conflicting attributes must be considered in the selection process of the best machine. In the traditional MADM methods, only beneficial and non-beneficial attributes exist. For example, cost and machine dimensions often are non-beneficial in most machine selection problems. However, other attributes like safety and user friendliness must be maximized. A number of machine selection problems are more complex. That is, given target values are desired for some attributes. These target values can be crisp numbers or represented as interval, gray, fuzzy, or rough sets. For instance, a given target value may be considered for cost and speed of machines. The target values may be variable as a range of data in some practical cases (Çakır, 2016; Kulak, 2005). The application of target-based MADM techniques is not only restricted to machine selection. In many material selection problems, the chosen materials for a product should be compatible with other materials available in the system. Therefore, given target values are considered for material properties to ensure compatibility between materials (Farag, 2013). For example, a target value for the thermal expansion coefficient is important in the selection process of electrical insulating materials (Jahan et al., 2012). Density and elastic modulus can also be regarded as target-based attributes to have a compatible design. These two material properties are especially important to select suitable biomaterials for implants and prostheses (Bahraminasab et al., 2014; Hafezalkotob and Hafezalkotob, 2015; Jahan and Edwards, 2013b). Generally, the target-based MADM approaches can be regarded as comprehensive

* Corresponding author.
E-mail address: a_hafez@azad.ac.ir (A. Hafezalkotob).

http://dx.doi.org/10.1016/j.engappai.2016.10.018
Received 10 May 2016; Received in revised form 23 October 2016; Accepted 27 October 2016

forms of the traditional MADM methods. Because in target-based decision-making, all kinds of attributes (beneficial, non-beneficial, and target-based attributes) are considered.

Target-based MADM techniques can be generally divided into two categories on the basis of "distance" between alternatives ratings and target values of attributes or "common area" of membership functions of alternatives ratings and target values of attributes. In the first category, a normalization technique is used based on distance between alternatives ratings and target values of attributes. These approaches are named as MADM methods with target-based attributes in the literature. The majority of the studies in this category have focused on the field of material selection process. The fuzzy axiomatic design (FAD) method and its extensions comprise the second category. In this group, information content is obtained based on Suh entropy. In this context, alternatives ratings and target values of attributes are called system and design ranges, respectively. In FAD approach, the common area is the intersection of the areas under membership functions of system and design ranges. Recently, the risk-based fuzzy axiomatic design (RFAD) approach has been developed to solve some real-world decision-making problems (Gören and Kulak, 2014; Kulak et al., 2015; Hafezalkotob and Hafezalkotob, 2016b). The RFAD approach has the ability to model the problems in which the alternatives ratings have some risks regarding their attributes.

The compromise ranking method also named as vlse kriterijumska optimizacija kompromisno resenje (VIKOR) – in Serbian is based on an aggregating function (L_p – metric). The VIKOR method uses L_1 and L_∞ (Opricovic and Tzeng, 2004). Crisp target-based extensions of the method have been previously discussed in several studies (Bahraminasab and Jahan, 2011; Bahraminasab et al., 2014; Cavallini et al., 2013; Jahan, 2012; Jahan and Edwards, 2013b; Jahan et al., 2011; Liu et al., 2014). Only two interval target-based VIKOR models exist in the literature that are not comprehensive (Jahan and Edwards, 2013a; Zeng et al., 2013). In this paper, we develop the VIKOR approach for target-based decision making with interval data to choose appropriate machines. The ratings are normalized based on the concept of interval distance of interval numbers. Moreover, the concept of the preference degree of interval numbers is used for performing comparison as well as finding extremum and ranking. Thus, we try to reduce degenerating interval numbers by employing all capacities of interval computations.

The remainder of the paper has been arranged as follows. A classified literature survey and description of the research gap are presented in Section 2. We introduce the crisp target-based VIKOR method in Section 3. The principles and computations of interval numbers are explained in Section 4. The developed interval target-based VIKOR method and its algorithm are described in Section 5. We discuss two practical machine selection problems in different industrial areas in Section 6. Concluding remarks and some directions for future research are mentioned in Section 7.

2. literature review

2.1. Survey on applications of MADM techniques in machine selection

Various MADM methods have been previously employed for the process of machine selection. Wang et al. (2000) evaluated appropriate machines in a flexible manufacturing cell utilizing a novel fuzzy MADM method. Kulak (2005) employed a decision support system and the FAD approach to choose material handling equipment. Kulak et al. (2005) employed the FAD technique for a punching machine selection problem. Aghdaie et al. (2013) consolidated step-wise weight assessment ratio analysis (SWARA) and complex proportional assessment with gray relations (COPRAS-G) to rank candidate alternatives of machine tools. Chakraborty and Zavadskas (2014) employed the weighted aggregated sum product assessment (WASPAS) to tackle several manufacturing decision-making problems including electroplating machines and industrial robots. Ada et al. (2014) utilized an integrated model based on the technique for order preference by similarity to ideal solution (TOPSIS) and goal programming approach under fuzzy environment in a machine selection problem. Chakraborty et al. (2015) applied the WASPAS technique to select machines in a flexible manufacturing cell. Nguyen et al. (2015) created a hybrid model based on the fuzzy analytic hierarchy process (FAHP) and the fuzzy COPRAS (F-COPRAS) to evaluate a machine tool selection problem. Ozfirat (2015) exploited the FANP method to choose suitable tunneling machine. Kumru and Kumru (2015) also employed the FANP technique to decide on the appropriate 3D coordinate-measuring machine. Khandekar and Chakraborty (2015) utilized the principles of the FAD approach to rank material handling equipment. Ertuȷrul and Öztaş (2015) applied the multi-objective optimization on the basis of ratio analysis (MOORA) technique to choose sewing machine. Özceylan et al. (2016) applied a hybrid model based on the fuzzy analytic network process (FANP) and the preference ranking organization method for enrichment evaluations (PROMETHEE) to select a CNC router machine. Çakır (2016) used an combinatory approach supported on the fuzzy simple multi-attribute rating technique (SMART) and the weighted fuzzy axiomatic design (WFAD) method to find the best continuous fluid bed tea dryer. Wu et al. (2016) developed a multi-criteria group decision-making approach supported on the VIKOR technique to discover a suitable CNC machine tool.

2.2. Survey on the target-based MADM methods

Some researchers have studied target-based MADM techniques on the basis of distance between alternatives ratings and target values of attributes. Zhou et al. (2006) developed a target-based norm to construct a composite environmental index to compare various MADM methods. Jahan et al. (2011) presented a target-based VIKOR approach to choose the best material for a rigid pin related to hip prosthesis. Bahraminasab and Jahan (2011) used the target-based VIKOR to select an appropriate material for the femoral component of knee replacement. Jahan et al. (2012) developed a target-based normalization technique for TOPSIS model. Jahan (2012) compared the results of a goal programming model and the target-based VIKOR for a material selection problem of hip implant. Zeng et al. (2013) proposed a normalization formula based on the distance to target values to extend the VIKOR method for application in healthcare management. Jahan and Edwards (2013a) extended the VIKOR approach with both target values of attributes and interval ratings. Jahan and Edwards (2013b) developed the target-based TOPSIS and VIKOR methods utilizing the integrated weights of attributes. Liu et al. (2014) consolidated the target-based VIKOR and DEMATEL-based ANP methods to choose bush material for the design of a split journal bearing. Hafezalkotob and Hafezalkotob (2015) employed an exponential norm and the integrated weights of attributes to derive a target-based modified MOORA (MULTIMOORA) model for biomaterial selection. Jahan and Edwards (2015) reviewed the applications of target-based norms in decision making models. Aghajani Mir et al. (2016) employed the target-based TOPSIS and VIKOR techniques to evaluate municipal solid waste management methods. Hafezalkotob and Hafezalkotob (2016a) tackled two biomaterial selection problems employing the interval target-based MULTIMOORA technique.

Many researchers have developed target-based MADM techniques on the basis of common area of membership functions of alternatives ratings and target values of attributes. The FAD approach and its extensions constitute this group. Kulak and Kahraman (2005) developed the FAD method. Kulak et al. (2005) added weights of attributes to the FAD model. Kahraman and Çebı (2009) improved the FAD method to solve decision-making problems with hierarchical structures. Their developed method is called hierarchical fuzzy axiomatic design (HFAD) approach. Kulak et al. (2015) employed the FAD method considering risk factors, i.e., the RFAD, to tackle a decision-