Engineering Applications of Artificial Intelligence 39 (2015) 157–167

Contents lists available at ScienceDirect

Engineering Applications of Artificial Intelligence

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

An intuitionistic fuzzy grey model for selection problems with an application to the inspection planning in manufacturing firms

S.M. Mousavi [a,b,*], S. Mirdamadi [b], A. Siadat [b], J. Dantan [b], R. Tavakkoli-Moghaddam [c,d]

[a] Industrial Engineering Department, Faculty of Engineering, Shahed University, Tehran, Iran
[b] LCFC, Arts et Métier Paris Tech, Centre de Metz, Metz, France
[c] School of Industrial Engineering and Engineering Optimization Research Group, College of Engineering, University of Tehran, Tehran, Iran
[d] Research Center for Organizational Processes Improvement, Sari, Iran

ARTICLE INFO

Article history:
Received 6 June 2014
Received in revised form
30 November 2014
Accepted 4 December 2014
Available online 31 December 2014

Keywords:
Multi-attributes analysis
Intuitionistic fuzzy sets (IFSs)
Grey relational analysis
Inspection planning
Manufacturing firms

ABSTRACT

Most of complex selection problems in real-life applications are considered under multiple conflicting attributes for manufacturing firms. The appropriate selection plays an important role in the firm's performance from the tactical and operational viewpoints. The classical methods for the selection problems in manufacturing firms are inadequate to deal with uncertainties, including insufficiency in information availability and the imprecise or vague nature in experts' judgments and preferences. To overcome these difficulties, this paper introduces a novel distance-based decision model for the multi-attributes analysis by considering the concepts of intuitionistic fuzzy sets (IFSs), grey relations and compromise ratio approaches. A weighting method for the attributes is first developed based on a generalized version of the entropy and IFSs along with experts' judgments. Then, a new grey relational analysis is introduced to analyze the extent of connections between two potential scenarios by an intuitionistic fuzzy distance measurement. Finally, a new intuitionistic fuzzy compromise ratio index to prioritize the scenarios is proposed by considering the weight of the strategy for the maximum group utility in intuitionistic fuzzy grey environment. The feasibility and practicability of the proposed distance-based decision model is illustrated in detail, and it is implemented in a real case study to the inspection planning for the oil pump housing from Renault automobile manufacturing.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Multi-attributes decision making (MADM) is the process of finding the most suitable alternative or candidate from all of the feasible alternatives for evaluation and selection problems. The increasing complexity of the manufacturing environment makes it less possible for decision makers (DMs) or experts to take into account all relevant properties of the evaluation and selection problem (Mojtahedi et al., 2010; Mousavi et al. 2013a,c), and then to provide performance ratings of each alternative and the relative importance of each attribute by precise values. In fact, much knowledge presented by the DMs or experts would be imprecise or incomplete judgments rather than exact and numerical values; As a result, uncertain situations should be considered for MADM methods in real-life applications. The MADM methods under uncertainty have been widely spread in real-world decision situations in the manufacturing environment; for instance, selection of e-sourcing (Singh and Benyoucef, 2011), evaluation of flexible manufacturing systems (Vahdani et al., 2013b) and new product selection (Mousavi et al., 2013b).

Regarding the recent application of MADM methods in real-life complex decision problems, for instance, Mojtahedi et al. (2010) applied group decision-making approach based on the technique for order preference by similarity to ideal solution (TOPSIS) for concurrently identifying and evaluating risks in gas refinery plants. Singh and Benyoucef (2011) proposed a fuzzy TOPSIS based methodology to solve the sealed-bid, multi-factors reverse auction problem of e-sourcing. Vahdani et al. (2011) developed fuzzy multi-criteria analysis for ranking and selecting the potential alternatives based on the fuzzy modified TOPSIS method. Then, the presented method was applied to the rapid prototyping process selection and the robot selection problems. Hamzacebi and Pekkaya (2011) used the grey relational analysis (GRA) to determine stock investments and three different methods, including heuristic, analytic hierarchy process (AHP), and learning via sample, were considered to obtain the attributes' weights. Ebrahimnejad et al. (2012) hybridized a modified analytic network process (ANP) and an improved VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje in Serbian, it means multi-criteria optimization and compromise) for construction

* Corresponding author at: Industrial Engineering Department, Faculty of Engineering, Shahed University, Tehran, Iran. Tel.: +98 21 51212091.
E-mail addresses: sm.mousavi@shahed.ac.ir (S.M. Mousavi), ali.siadat@ensam.eu (A. Siadat).

http://dx.doi.org/10.1016/j.engappai.2014.12.004
0952-1976/© 2014 Elsevier Ltd. All rights reserved.

project selection in the fuzzy environment. Vahdani et al. (2013a) introduced the compromise solution method for solving fuzzy group decision-making problems by considering both conflicting evaluation criteria. The proposed method is then applied to a case study for the contractor selection problem in construction industry.

In the manufacturing environment, numerous companies are brought to be more and more attentive to the process variations, resulting in product's dimensional and geometrical specification variations. Facing production variations and tight geometrical tolerances, modern manufacturing intends as well to ensure the product functionalities and requirements through adequate solutions. These two go through an effective inspection plan with certain particularity as major functions to satisfy the global criteria (attributes) common on all design stages. Hence, the performance despite conflicting industrial objectives of a production system has become to take global, not local, proportions so that the inspection planning is regarded as an integral part of the design, manufacturing process selection and process planning (Zhao et al., 2009).

Elaborating an inspection plan, experts' knowledge is integrated to decision making, and human subjectivities are attached. Sometimes they are brought to estimate risk factors while no explicit knowledge is available. The granularity of information provided by the experts determines the development of solutions. Despite quantitative and qualitative information, an inspection plan should be associated to an adequacy note, regarding to the global performance. In a decision-making context, multiple facets of performance can be translated and dispersed across multiple sub-criteria. They cause complex problems as sets of conflicting criteria are usually treated concurrently. The definition and the decomposition of the criteria (i.e., main strategic guidelines) impact on the final operational decisions regarding the relevance of inspection plan candidates. Also, this is suitable for the evaluation of criteria regarding the granularity of information.

For all the above-mentioned purposes, industries should concentrate on the inspection planning from tactical and operational point of views to meet their objectives in terms of quality, cost and time, and to respect their constraints as feasibility and competitive economic contexts. This problem can be viewed within the context of an MADM framework. Decision-making techniques can aggregate multiple criteria and their weights to one global adequacy note for each inspection scenario associated to the criteria. A significant decision for an inspection plan, including product conformity control and process monitoring, proposes a compromise solution among the non-conformity rate seen by customers, the manufacturing and inspection cost and the realization difficulty of products regarding the awaited functionalities and requirements.

Most researchers have focused on the computer-aided inspection planning; however, few studies have been conducted on the selection of the best inspection scenario in manufacturing firms. Regarding the related literature on decision-making methods in the inspection process planning, Pandey and Kengpol (1995) developed a model for selecting the best possible automated inspection device in flexible manufacturing systems. For this purpose, they employed the preference ranking organization method for enrichment evaluations (PROMETHEE) to appraise alternatives. Ferreira et al. (2009) presented a decision model with the multi-attribute utility theory to determine inspection intervals of condition monitoring based on delay time analysis. Bana e Costa et al. (2012) introduced a multi-attribute model for auditing a predictive maintenance programme (PMP) developed and implemented in the general hospital of ciudad real (GHCR) in Spain, and applied the measuring attractiveness by a categorical based evaluation technique (MACBETH) to establish a hierarchical additive value model with attributes' weights.

The review of the related literature indicates that although some researchers have studied the inspection planning from tolerance-driven and geometry-based computer-aided planning in manufacturing systems; none of them have considered the selection of inspection scenarios by the MADM methods. Moreover, multi-attributes analysis and inspection scenario selection have not been investigated in an uncertain environment.

For the first time in the literature, this paper presents a new distance-based intuitionistic fuzzy grey model to solve inspection scenario selection problems in manufacturing firms. In numerous decision problems for real-world manufacturing applications, for some of attributes while exact evaluations can be determined, for others they cannot. Experts or DMs usually need to express their preferences over alternatives versus the selected attributes. Considering the competitive market environment, the decisions become more complex. The preference information and judgments provided by the DMs may be incomplete and insufficient. They can be regarded as uncertain or hesitation issues because they have made decisions under time pressure and lack of knowledge or data in practice. In fact, since experts' opinions and preferences are often vague and complex and they cannot estimate their preferences with exact values, linguistic evaluations can only be given instead of exact evaluations. In such cases, it seems to be well suited to express the DMs' preferences in intuitionistic fuzzy sets (IFSs) with ill-known membership grades, which is a generalization of the Zadeh's fuzzy set. The IFS theory is proper and suitable for expressing hesitation of the DMs or experts for manufacturing decision problems and applications under uncertainty (Vahdani et al., 2013b). It assists the DMs to utilize more flexible ways to express real-world decision situations provided by the truth-membership function and non-truth-membership function for an element in order to indicate the degrees of satisfaction and non-satisfaction. In recent years, the IFS has been widely employed to many decision-making problems with remarkable results (e.g., Boran et al., 2009; Jiang et al., 2011; Vahdani et al., 2013b).

Since there is a few research on fuzzy grey MADM by considering their advantages and these kinds of problem solving approaches can be more objective in expressing some decision-making situations under uncertainty in reality, the fuzzy and grey theories are worthy of more attention. Hence, this paper introduces a new decision model to meet the demands of practical decision problems in manufacturing firms. For this purpose, a new design of distance-based model is proposed in this paper to handle complex decision-making problems in an uncertain environment. The presented model is based on the integration of the IFS theory and the grey relational analysis (GRA) along with multi-attributes analysis. Firstly, linguistic terms characterized by intuitionistic fuzzy numbers along with numerical values are taken into account to obtain the importance of selected scenario (i.e., alternative) and to provide the performance rating of scenarios in terms of the conflicting attributes. The intuitionistic fuzzy numbers employ the truth-membership function and non-truth-membership function to point out the degrees of satisfaction and non-satisfaction of each scenario by considering a set of attributes, respectively. Secondly, a weighting method is developed based on a generalized version of the entropy and IFSs as well as experts' judgments to determine the importance of attributes. Thirdly, a new GRA is introduced to analyze the extent of connections between two potential scenarios by an intuitionistic fuzzy distance measurement, which plays an important role in the selection problem. Finally, a new intuitionistic fuzzy compromise ratio index is presented to evaluate the scenarios and to select the most suitable scenario in a complex environment.

A real case study in the automotive industry in France for the selection problem of the inspection planning is presented to demonstrate the applicability of the intuitionistic fuzzy grey distance-based model. The computational results illustrate that the proposed model is suitable and proper as the decision-making approach to analyze

Download English Version:

https://daneshyari.com/en/article/380414

Download Persian Version:

https://daneshyari.com/article/380414

Daneshyari.com