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Decision Aiding

A new fuzzy multiple attributive group decision making methodology and its application to propulsion/manoeuvring system selection problem

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Abstract

In this paper, a new fuzzy multiple attribute decision-making (FMADM) method, which is suitable for multiple attributive group decision making (GDM) problems in fuzzy environment, is proposed to deal with the problem of ranking and selection of alternatives. Since the subjectivity, imprecision and vagueness in the estimates of a performance rating enter into multiple attribute decision-making (MADM) problems, fuzzy set theory provides a mathematical framework for modelling vagueness and imprecision. In the proposed approach, an attribute based aggregation technique for heterogeneous group of experts is employed and used for dealing with fuzzy opinion aggregation for the subjective attributes of the decision problem. The propulsion/manoeuvring system selection as a real case study is used to demonstrate the versatility and potential of the proposed method for solving fuzzy multiple attributive group decision-making problems. The proposed method is a generalised model, which can be applied to great variety of practical problems encountered in the naval architecture from propulsion/manoeuvring system selection to warship requirements definition.

Keywords: Multiple criteria analysis; Fuzzy sets; Group decision-making; Heterogeneous group of experts; Aggregation; Consensus

1. Introduction

This research was initiated with a desire to utilise a fuzzy decision making tool in the selection of a propulsion/manoeuvring system. By its very nature the solution methodology should model the following principle requirements to emulate the practice:

- Presence of multiple attributes which may be assigned crisp or fuzzy valuations.
- Multiple decision makers whose expertise on attributes are not uniform or are not considered to be uniform by the final decision maker, i.e. the moderator.

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- Moderator may have a bias towards one of the alternatives.

The literature review has revealed that none of the existing methodologies provided a satisfactory solution, although for each item of the above requirements there was a wealth of methods available. In the development of the research a new methodology has been devised which satisfies all of the above requirements. This paper presents the methodology with an application to the propulsion/manoeuvring system selection problem.

From a methodological point of view, the propulsion/manoeuvring system selection problem is a fuzzy multiple attributive group decision-making problem where fuzzy assessments and multiple expert opinions are considered.

A decision maker (or expert) is often faced with the problem of selecting a solution from a given set of finite number of alternatives. The chosen alternative is the best one or a compromise option that meets certain predefined objectives/goals. The multiple attribute decision making (MADM) methods are engineering and management decision aids in evaluating and/or selecting the desired one from a finite number of alternatives, which are characterised by multiple attributes.

MADM problems are of importance in a variety of fields including engineering, economics, etc. For a review of the various MADM methods the reader is referred to, for example, Hwang and Yoon (1981), Chen and Hwang (1992), Stewart (1992) and Yoon and Hwang (1995).

In propulsion/manoeuvring system selection decision problem, where ranking and selection is required, MADM situations are characterised by the following interrelated problems:

The problems involve vagueness and fuzziness and the decision maker has the difficult task of choosing among the many alternatives to specify the best alternative. The imprecision comes from a variety of sources such as (i) unquantifiable information, (ii) incomplete information, (iii) non-obtainable information (Chen and Hwang, 1992). In many cases the decision maker has inexact information about the alternatives with respect to an attribute.

The classical MADM methods cannot effectively handle problems with such imprecise information. These classical methods, both deterministic and random processes, tend to be less effective in conveying the imprecision and vagueness characteristics. This has led to the development of fuzzy set theory (FST) by Zadeh (1965), who proposed that the key elements in human thinking are not numbers but labels of fuzzy sets. FST is a powerful tool to handle imprecise data and fuzzy expressions that are more natural for humans than rigid mathematical rules and equations.

It is obvious that much knowledge in the real world is fuzzy rather than precise. In propulsion/manoeuvring system ranking/selection problems, decision data of MADM problems are usually fuzzy, crisp, or mixture of them. Hence, a useful decision model is to provide the ability to handle both fuzzy and crisp data.

The most of the decision problems in ship design involves the work of a team of experts or specialists (naval architects, design engineers, ship owners, etc.) and are focused on an analysis and evaluation of attributes of decision-making process. Human opinions often conflict because of group decision-making in fuzzy environment. Consequently, they are, in fact, cases of fuzzy multiple attributive GDM problems. The important issue of fuzzy multiple attributive GDM is to aggregate conflicting opinions.

In general, the importance of each expert against an attribute may not be equal. Sometimes there are important experts in decision group, such as the executive manager of a shipyard, or some experts who are more experienced than others, the final decision is influenced by the degree of importance of each expert. Therefore, a good method of aggregating multiple expert opinions must consider the attribute based assigned degree of importance of each expert in the aggregation procedure.

Therefore, this research is devoted to find a useful and rational decision making model that provides the ability to handle the aforementioned problems. The main aim of this research is to contribute to the development of an MADM method with multiple decision makers, capable of working in a fuzzy environment.