DECISION BY OPINION SCORE METHOD (DOSM): A NOVEL SOLUTION FOR MULTI CRITERIA DECISION MAKING PROBLEM

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ABSTRACT

This research aimed to propose a new multi-criteria decision-making method called “Decision by Opinion Score Method” (DOSM), which was based on the idea of an ideal solution that has been utilized for reference comparison. This research used the TOPSIS method to design DOSM because both depended on an ideal solution to solve the MCDM problem. Meanwhile, TOPSIS consisted of a series of mathematical operations that has several problems, and DOSM was intended to solve these problems. DOSM rank was obtained from direct aggregation, or compromise rank, or grey relational analysis. The case study in a computer network was used in this research which has 9 alternatives (A1- A9) and four criteria. Three experts were involved in the evaluation for the reference comparison process to obtain the best alternative. The result of A9 obtained 88.8% in terms of ranking and it was the best alternative for experts 1 and 3. For expert 2, A1 was ranked as the worst alternative and the A5 was ranked the best alternative. DOSM was also developed for group decision making with internal and external aggregation besides the voting method. In an internal aggregation, A4 was the best alternative with direct aggregation and compromise rank, while A9 was the best alternative for grey relational. As for external aggregation, the best alternative was A9 for direct aggregation and grey relational analysis ranks. For the voting method, A9 obtained a majority of votes (66.7%) was the winner, which has the plurality and majority. A4 was the winner of the Borda method with 23 scores. The second case study for the mobile section problem was solved by DOSM, AHP, and BWM. A comparison was made among them to demonstrate the significance of DOSM. In conclusion, the DOSM is an effective solution for multi criteria decision making problems. This study implicates that DOSM is an optimal method for making decision and it could be applied in different real-life situations.

KEPUTUSAN MELALUI KAEDAH SKOR PENDAPAT (DOSM) PENYELESAIAN BAHARU BAGI MASALAH MEMBUAT KEPUTUSAN BERBILANG KRITERIA (MCDM)

ABSTRAK

Kajian ini bertujuan mencadangkan kaedah membuat keputusan berbilang kriteria yang dipanggil "Keputusan melalui Kaedah Skor Pendapat" (DOSM), yang berdasarkan idea penyelesaian sempurna yang telah digunakan untuk perbandingan rujukan. Kajian ini menggunakan kaedah TOPSIS untuk mereka bentuk DOSM kerana kedua-dua kaedah bergantung pada penyelesaian sempurna untuk menyelesaikan masalah MCDM. Sementara itu, TOPSIS terdiri daripada suatu siri operasi matematik yang mempunyai beberapa masalah, dan DOSM bertujuan untuk menyelesaikan masalah-masalah ini. Taraf DOSM diperoleh daripada pengagregatan langsung, atau taraf tolak ansur, atau analisis hubungan samar. Kajian kes dalam rangkaian komputer digunakan dalam penyelidikan ini yang mempunyai 9 alternatif (A1-A9) dan empat kriteria. 3 orang pakar terlibat dalam penilaian untuk proses perbandingan bagi mendapatkan alternatif terbaik. Keputusan A9 memperoleh 88.8% dari segi penarafan dan dinyatakan sebagai alternatif terbaik oleh pakar 1 dan 3. Bagi pakar 2, A1 ditarafkan sebagai alternatif paling lemah dan A5 ditarafkan sebagai alternatif terbaik. DOSM juga dibangunkan untuk pengambilan keputusan kelompok dengan pengagregatan dalaman dan luaran selain kaedah pengundian. Dalam pengagregatan dalaman, A4 ialah alternatif terbaik dengan pengagregatan langsung dan taraf tolak ansur, manakala A9 ialah alternatif terbaik untuk hubungan samar. Bagi pengagregatan luaran, alternatif terbaik ialah A9 bagi taraf pengagregatan langsung dan analisis hubungan samar. Bagi kaedah pengundian, A9 mendahului dengan memperoleh undi majoriti (66.7%), yang mempunyai kemajmukan dan kelebihan undi. A4 ialah pemenang kaedah Borda dengan skor 23. Kajian kes kedua untuk masalah bahagian bergerak diselesaikan oleh DOSM, AHP, dan BWM. Perbandingan dibuat dalam kalangan semua kaedah untuk menunjukkan kepentingan DOSM. Kesimpulannya, DOSM adalah penyelesaian yang berkesan bagi masalah membuat keputusan berbilang kriteria. Kajian ini mengaitkan bahawa DOSM ialah kaedah terbaik untuk membuat keputusan dan kaedah ini boleh diterapkan dalam situasi hidup nyata yang berbeza.

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LIST OF ALGORITHMS

LIST OF AND ABBREVIATION

AHP	Analytical hierarchy process
ANP	Analytical network process
BWM	Best worst method
DM	Decision Making
DEA	Data envelopment analysis
GRA	Grey relation analysis
GDM	Group decision-making
MCDM	Multiple-Criteria Decision-Making
NIS	Negative Ideal Solution
PIS	Positive Ideal Solution
SAW	Simple Additive Weighting
SAW	Simple Additive Weighting
TOPSIS	Techniques for order preference by similarity to an ideal solution
VIKOR	VlseKriterijumska Optimizacija I Kompromisno Resenje

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CHAPTER 1

RESEARCH INTRODUCTION

2.1 Introduction

This chapter presented a brief background about the research, the state of the problem, the motivations and inspiration of this research, and research purposes.

In Section 1.2, a research background about the research in Multiple criteria decision-making (MCDM) is presented. In Section 1.3, the presentation of the problem of the research has been recognized and presented. In Section 1.4 and Section 1.5, research objectives, and the scope of the research are described correspondingly. Finally, outline the foremost construction of the thesis are briefly described in section 1.6.3.

2.2 Research Background

Once upon a time in Auckland, an old man named Tom wants to buy a car. There were several options suite with his budge. The finalist involves seven cars with several numbers represent the comfortability, speed, cost, color, brand, etc, as showing in figure (1.1).

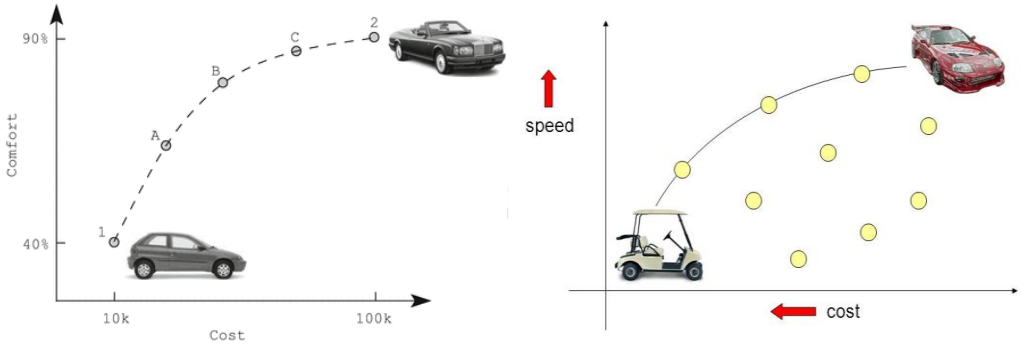

Figure 2.1. Car Selection Problem

Our story actor Mr. Tom consults his friend Mr. Jiff (the expert in statistics and decision making). Mr. Jiff introduced several techniques with its software however, Mr. Tom is not convinced to use this software due to the technical difficulties. For example, Mr. Tom knows that the cost is important when compared to color, but he would not be able to quantify his comparisons. He also confused when comparing fuel consumption with car comfortability. Which one is more important? He can provide an answer, but he is not confident whether this answer is reflecting his opinion.

He also cannot deliberate among several criteria towards identifying the important one and tell how many times the best criterion is better when compared to other criteria. Mr. Jiff has given up and asks Mr. Tom to at least identify the cost and benefit criteria for instance which criterion on which, the maximum/minimum the better. He identified several criteria however, he stacked with the price, where all are within his budge. He also stopped at the categorical values on which he needs to compare linguistic terms such as color, brand, and type of car transmission. Apart from that, there are few numerical values where neither minimum no maximum the best for him is (e.g. car speed). Mr. Tom loves fast cars however; he never drives more than 200 km/h and he would not do if the option is available. All the available options are faster than 260 km/h while the faster options are 320 km/h. Despite the fact that Mr. Tom prefers the fast car, he would not be able to say the faster the better. Mr. Tom believed that minimum and maximum is not always the best option and he provides several examples of cases that value in the middle represents the best solution among other solutions (e.g. mobile screen size, blood pressure, and sugary level in the blood).

Mr. Tom expressed his concerns to Mr. Jiff and Mr. Jiff convinced with Mr. Tom's replies. He started rethinking of the problem from other angel, he found that, these algorithms are designed for experts in dealing with decision making problems and required a large brain cognitive power to solve a single decision-making problem. He also notices that multi criteria decision making (shortly MCDM) methods are suffering from several issues such as mathematical operations (e.g. normalization, distance measurements, weighing and aggregations). Not to mention the group opinion aggregation. Therefore, Mr. Jiff raised a research question, how to help Mr. Tom to select the best car?

This research is considered as an attempt to help Mr. Jiff to answer his research question towards helping Mr. Tom to buy a new car. MCDM problem can be briefly expressed as a complex and dynamic method including the decision maker and mathematical procedures Du & Yu (2008); Wei, Qin, Yan, Hou, & Yuan (2016) .

The decision maker (DM) aim is to select the best suitable alternative based on the assessment criteria Y. Wang & He (2007a) . Several MCDM methods produced and developed to explain and provide a solution for this kind of problem. There are two approaches to the MCDM developed in the academic literature. The first type involves human preferences in the decision loop, while the other one is utilized mathematical models and procedures to produce the final decision.

The first approached concerned about the human involvement in the process of decision by performing comparisons between criteria to produce criteria weights, for example Analytical Hierarchy Process (AHP). AHP depend on the decisions of decision makers to decompose a difficult problem into a hierarchy through the aim by the highest level of the hierarchy Işıklar & Büyüközkan (2007) . The criteria of the sub -level of the hierarchy, and choose alternatives at the bottom level of the hierarchy Yousefi & Hadi-Vencheh (2010) . Analytical Network Process (ANP) for DMs through dependency and response Shyur (2006) . Other approaches are considered mathematical operations more than human comparative, for example, Techniques for order preference by similarity to an ideal solution (TOPSIS) L.-y. Sun, Miao, & Yang (2017) .

TOPSIS is established on the idea which the most significant decision must remain the nearby the best solution and furthest from the worst solution Jahanshahloo, Lotfi, & Izadikhah (2006) . Other examples of techniques of mathematical decision-making models included, Data Envelopment Analysis (DEA) defines a clarification by determining the comparative representation of alternatives for decision-making divisions Kao (2010) . Grey Relation Analysis (GRA) is appropriate for resolving complications with complex interrelationships among several elements and variables Yue (2013) . The compromise ranking method (VIKOR) method presents a multi criteria classification alternative based on the specific degree of closeness to the ideal solution.

These MCDM methods are vary and performed using different procedures and philosophies Krohling, Lourenzutti, & Campos (2015); H.-C. Wang, Chiu, & Wu (2015) . While, some principals are shared between these methods Jahanshahloo et al. (2006); Sabokbar, Hosseini, Banaitis, & Banaitiene (2016) . Different methods produce different decision solutions Fu, Yang, & Lu (2007) while different decision makers usually required different experiences, knowledge, and understanding P. Wang, Zhu, & Wang (2016) .

2.3 Problem Statement

Looking at the microlevel of multicriteria decision making methods/techniques, challenges are mainly related to either the mathematical operations (i.e. normalization, the distance between vectors and values aggregation) or the human comparisons (i.e. number of comparisons, high cognitive power required for comparisons and consistency of the comparisons) Yousefi & Hadi-Vencheh (2010) .

No run from mathematical operations when it comes to MCDM due to several reasons includes, multiple values aggregations into a single score, uniforming parameters to enable variable aggregations and performing a number of mathematical processes to achieve the final ranking of alternatives Pu, Ma, Zhang, & Yang (2018); Shih, Shyur, & Lee (2007) . However, there are several arguments in the academic literature about utilizing these operations during data processing of multicriteria decision making Daghouri, Mansouri, & Qbadou (2018); Jahanshahloo et al. (2006) . Perhaps, one of the reasons could be the difficulties of methods/techniques benchmarking. And thus, the only visible solution for the mentioned problems is to reduce the mathematical operations to the minimum while maintaining similar output Kao (2010); W. Wu, Kou, & Peng (2012); Z. Zhang, Liu, & Guan (2007) .

Apart from the mathematical operation, weights measurement is another burden that faces researchers which is measured utilizing algorithms such as AHP, BWM or ANP. These techniques involve human in the loop of the decision via performing comparisons (i.e. pairwise comparison and reference comparisons) Du & Yu (2008); Jinchao & Jinying (2011); Sheng-mei, Su, & Ming-hai (2010); L.-y. Sun et al. (2017); H. Zhou, Sun, Yeow, & Ren (2016) . These types of comparisons are crucial to measuring the preference of decision makers. However, these techniques are running out of consistency and required high cognitive power to perform it Guo, Zhou, Cao, & Yang (2015); R. Sun, Zhang, & Liu (2016) . These problems resulted from the way of comparison which performed between different quantities (i.e. different criteria) which in a way unnatural comparisons and decision makers found it difficult to perform.

In addition to that, multiple references comparisons generate inconsistency in their answers Hsu, Ou, & Ou (2015); Kuo (2016) Parkhan, Vatimbing, & Widodo (2018) .

To overcome these challenges, a single reference comparison if possible, can produce a consistent comparison while similar quantities comparison (i.e. between different alternatives achievements per criterion) would make the comparisons more natural and required less brain cognitive power.

Therefore, this research aims to develop a new multi-criteria decision-making method which utilized a single reference comparison. This technique is named Decision by Opinion Score Method (shortly DOSM). This method utilized the idea of ideal solution (i.e. ideal solution used in TOPSIS in the literature) to create a new way of comparisons and reduce the mathematical operations. Different scenarios with single and group decision maker(s) are proposed and tested to produce a new method that can handle the microlevel MCDM problems.

2.4 Research Objectives

This research aimed to propose a new decision-making method in MCDM called Decision by Opinion Score Method (DOSM). The decision method utilized the idea of the ideal solution in the process. The proposed method is an aim to introduce new steps to process multi-criteria decision-making problems towards identifying the best alternative. The principal idea is to measures the opinion distance between each alternative and the ideal solution. Towards this end, five objectives are proposed to develop DOSM:

1- To investigate the related techniques, methods, procedures in the academic literature on TOPSIS MCDM by utilizing the systematic review approach.

2- To design a new method in Multi-criteria Decision-Making problem called Decision by Opinion Score Method (DOSM).

3- To extend the development of DOSM method to group decision-making environment (GDOSM).

4- To utilized both (DOSM and GDOSM) in numerical illustration of the network selection problem towards testing and parameter recommendations.

5- To evaluate and compare a different aspect of the usability of DOSM with other MCDM techniques.

2.5 Research Scope

1- The core idea of comparing each solution to the ideal solutions is presented in TOPSIS Huang Yoon (1981). However, there are several issues associated with every single step in TOPSIS. The new method proposed (i.e. DOSM) is also utilized as the ideal solution in the data processing steps, Therefore, the literature review is limited to TOPSIS method developments and improvements to understand and analyze TOPSIS related problems.

Despite the fact that methods like AHP and BWM are not discussing ideal solution development, both methods are discussed in the literature since DOSM involved humans in the comparison before acquiring the final rank.

The selected study case is in the computer network (i.e. numerical illustration) to apply the developed method and demonstration its capabilities to handle MCDM problems. It should be noted here, this process is common in the academic literature, for example, Evaluation of urban areas Lin Ding, Shao, Zhang, Xu, & Wu (2016), Supplier selection problem Rajnish Kumar, Padhi, & Sarkar (2019), Unconventional modes of transport (UCMs) Sobhani, Imtiyaz, Azam, & Hossain (2019).

2- Comparison between the proposed technique and the available MCDM is limited to AHP, BWM. The AHP is the most MCDM used and involved pairwise comparisons. BWM is a new technique proposed to reduce the number of comparisons and improve the consistency of BWM.

2.6 Operational Definition

Below are the operational definitions for the teams per use in this thesis:

- Pairwise comparison is the process of comparing different entities in pairs to judge which of each entity is preferred, identical, or has a greater amount of preferences.
- Reference Comparisons: is a process of comparing different criteria with reference criterion.

- Unnatural/Natural Comparisons: the natural comparison is the comparison performed between different criteria in a way, decision makers are familiar with it. Unnatural comparison is the comparison between criteria, in a way, that decision has rarely or not utilized such comparison before.

2.7 Thesis Outlines

This thesis consists of three chapters.; Chapter One provided background about the multi-criteria decision making and the methods utilized in decision making, research objective, scope and, the rest of the thesis is organized as follows:

Chapter Two: In Chapter Two, in-depth investigation Techniques for order preference by similarity to an ideal solution (TOPSIS). A systematic review protocol is developed for the literature review to analyze the challenges and develop a taxonomy for the research articles in the area of MCDM.

Chapter Three: In Chapter Four, the research methodology and the flow of the research are proposed a new method call decision by opinion score method (DOSM). In addition to that, extend DOSM to use in group decision making environment (GDOSM). Moreover, applied the proposed method in a study case.

Chapter Four: In this chapter, applied DOSM for single decision making in the network case study. The purpose of this case study is to provide DOSM that can apply and the process understandable for decision making also analysis for the selected final rank by different techniques and its configurations.

Chapter Five: In this chapter, a study case for group decision analysis is conducted on the aggregation type (internal and external aggregation) and voting method. The purpose of the develop DOSM into group decision making is to identify the methodological steps of GDM with different group preferences.

Chapter six: In this chapter, A comparison between MCDM methods is directed based on the usability test and the difficulty of process related to each one of them. The comparison is also applied in another case study of mobile selection.

Chapter Seven: In Chapter, the summary of the research finding, contribution, summary for claims, and comparative analysis about the research output are reported. Moreover, research recommendations, further research proposals, and the conclusion are reported.