

Integrated Fuzzy TOPSIS and AHP Approach for Selecting Car Brand using Multiple Decision Features

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Abstract.

Car or an automobile is a four-wheeled vehicle primarily designed for transportation on roads and has become an essential part of modern life. The automobile industry is considered one of the major indicators of a developed economy due to its contribution to industrial growth, mobility, and technological advancement. With over one billion cars currently in use worldwide, selecting the most suitable car has become a challenging task for consumers because of the availability of numerous models with varying features, costs, fuel efficiency, safety standards, and performance characteristics. Therefore, this paper presents a comprehensive analysis that integrates the Fuzzy TOPSIS and Analytic Hierarchy Process (AHP) approaches for effective car evaluation and selection. The proposed methodology considers multiple decision-making criteria. The obtained results demonstrate that the proposed hybrid approach can efficiently assist customers, automobile industries, and decision-makers in identifying the most suitable vehicle. Furthermore, this work supports the United Nations Sustainable Development Goals (SDGs), particularly SDG 9, 11, 12.

Keywords. Selecting a car brand, Fuzzy AHP, Fuzzy TOPSIS

1. INTRODUCTION

A French innovator Nicolas-joseph Cugnot developed a first steam powered car vehicle in 1769. Over the period additional features and controls have been added and made progressively more complex. The automotive industry which is rapidly evolving. Where selecting a car becomes a complex decision making due to the overwhelming factors like performance, safety, reliability, brand reputation and individual preference. Traditional decision-making cannot be performed on multiple inheritance. To solve this problem applications of fuzzy logic developed. By using a fuzzy logic, we can obtain an accurate and tailored recommendation. This approach not only gives us decision making criteria but also allows us to prefer the priorities of individual consumers. This research introduces an efficient approach that combines the Fuzzy Technique for Order Preference by Similarity to an Ideal Solution (Fuzzy TOPSIS) with the Analytic Hierarchy Process (AHP).

2. RELATED WORK

[1] The authors have employed a conceptual framework to examine business dynamics and competitiveness through a hybrid integrated enterprise model. They utilized the FAHP ranking technique to identify solutions closest to the ideal. The hybrid approach, known as Fuzzy AHP-TOPSIS [2], was used to evaluate various aspects of web application information security, aiming to provide valuable and practical insights. [3] Eco-friendly cars are anticipated to become a major market force in global transportation and technology, as they are crucial for achieving environmental and societal sustainability. [4] This paper aims to analyze consumer perspectives on purchasing eco-friendly vehicles and assess the necessity of these vehicles. Incorporating FAHP can improve decision-making regarding the selection of environmentally friendly cars. The results from FAHP [5] are then compared with those obtained using the traditional Analytic Hierarchy Process (AHP) [6]. Four main water sources are assessed based on five criteria. The evaluation identified groundwater wells as the most suitable option. The findings provide valuable insights to help decision-makers and researchers make practical and effective decisions regarding the allocation of rural water resources. Paper [9] showed the analysis of mental health using fuzzy techniques such as AHP and TOPSIS. Password security strength analysis and factors influencing them was implemented in [10]. Prediction of Schizophrenia disease was carried out using the very popular methods such as Fuzzy AHP and TOPSIS methods in paper [11].

3. METHODOLOGY

Our research employs the Fuzzy techniques like fuzzy AHP, fuzzy AHP using a geometric means and fuzzy TOPSIS method in selecting the car brand based on multiple features. We define eight essential attributes: price (c1), Range kmph (c2), Capacity (c3), Seats (c4), Variants (c5), comfort (c6), and fuel type(c7). The output of this is giving a rank to the important attributes that will help in decision making of selection of a car brand. By knowing the relevant features, it is easy to remove the irrelevant or redundant features thereby reducing the computational expenses like power, memory and so on.

3.1. *Fuzzy AHP*

AHP is an effective method for calculating the weights of criteria related to a defined output. The process involves seven steps: Identify the problem and define the criteria; Evaluate the alternatives. The evaluation criteria consist of eight attributes used for selecting a car brand. Out of eight criteria we check which of them are really important for deciding car brand.

3.2. *AHP using Geometric Mean*

The technique of integrating qualitative and quantitative methods is known as the AHP process. AHP is mainly utilizes decision-making tool. It uses pair-wise comparisons for multiple criteria. This method consists of eight steps. Fuzzy AHP relative importance scale, which is used to express pairwise comparisons under uncertainty. Each importance level is shown using a Triangular Fuzzy Number (TFN) consisting of lower, middle, and upper values. A value of 1 refers to the condition that two criteria are equally important and is represented as (1,1,1). Values such as 3, 5, 7, and 9 show moderate, strong, very strong, and extreme importance respectively. For Intermediate judgments values such as 2, 4, 6, and 8 are being used when the preference lies between two adjacent importance levels. For example, strong importance is represented by (4,5,6). The reciprocal values $1/3$, $1/5$, $1/7$, and $1/9$ denote inverse comparisons when one criterion is less important than another. Using TFNs allows decision-makers to capture vagueness and subjectivity more effectively than exact numerical values.

3.3. *TOPSIS*

Triangular Fuzzy Numbers (TFNs) are used to convert linguistic evaluations into numerical fuzzy values. Terms such as Very Poor, Poor, Good, Very Good, and Extreme Good are expressed as fuzzy ranges to capture uncertainty and human judgment in decision-making.

4. **RESULTS**

4.1. *AHP Method*

The attribute with the highest criteria weight, 0.3587 (Price), is identified as the primary selecting factor, while the attribute with the lowest criteria weight, 0.0393 (Fuel Type), is determined to be the least influential factor in the selection process.

4.2. *Fuzzy AHP*

The normalized weights show the relative importance of each criterion, with Price (0.35) having the highest priority, followed by Seats (0.20) and Range (0.17). Criteria such as CC (0.10), Comfort (0.08), Variants (0.036), and Fuel Type (0.036) have lower influence on the final decision. Because the eigen values calculated are same as the ones obtained when AHP method was used, the pairwise comparison matrix is considered as consistent. This shows that the feature weights calculated is trustworthy, reliable and also stable. Also this can help us in building a hybrid technique such as concatenating two techniques, stacking two techniques which can be called as assembling two techniques. This can be used as future scope of this research paper.

4.3. *Fuzzy TOPSIS*

In this method, Alternative A7, with a closeness coefficient of 0.7585, ranks first. It is the most preferred choice among customers selecting a car, while Alternative A3, with a coefficient of 0.4967, is the least preferred.

5. CONCLUSION

In this paper we have used the AHP, Fuzzy AHP, and TOPSIS techniques for selecting the prevalent features for selecting a car brand. In the AHP method we defined the problem statement, written the hierarchy, defined the criteria, found the criteria weights, and then determined the rank for all the alternatives. The outputs got from AHP method proved to be similar to other MCDM methods. The second method that we used is the Fuzzy AHP method where we converted the crisp values into actual fuzzy numbers. When compared the AHP and Fuzzy AHP methods, the car selected via the Fuzzy AHP method was more correct and precise. The third method that we employed was the TOPSIS method where the Positive Ideal and Negative Ideal Solutions were considered and their distance were estimated from the alternatives. The closer the distance the better the decision was. After combining all three methods, the best criteria and the alternative was determined which helped in car purchase. When the ranking differed from one method to the other, Fuzzy AHP method was preferred.

6. REFERENCES

- [1] D. Jun Yi Tey et al.: Novel NDAHP for MCDM Method: Case Study in KLSE A.
- [2] Agrawal et al.: Evaluating the Security Impact of Healthcare Web Applications Through Fuzzy-Based Hybrid Approach
- [3] W. Liang et al.: Performance Evaluation of Green Mine Using a Combined MCDM Method With Picture Fuzzy Information.
- [4] N. V. Thanh et al.: Strategic Decision Making at a Steel Industry Assisted by Fuzzy Theory
- [5] Adam Shariff Adli Aminuddin et al 2019 J. Phys.: Conf. Prediction of Schizophrenia in Patients Using Fuzzy AHP and TOPSIS
- [6] Integrated Fuzzy TOPSIS And AHP Approach for Efficient Water Resources Allocation in Rural Areas
- [7] Analysis of Mental Health of a Young Adult: Post Covid Using Fuzzy TOPSIS & Fuzzy AHP
- [8] Enhancing Password Security: Fuzzy AHP and TOPSIS-based Vulnerability Assessment.
- [9] Uttarkar, C., Arun, C. B., Anusha, M., Khushi, N., Kodipalli, A., & Rao, T. (2023, October). Analysis of Mental Health of a Young Adult: Post Covid Using Fuzzy TOPSIS & Fuzzy AHP. In 2023 4th IEEE Global Conference for Advancement in Technology (GCAT) (pp. 1-7). IEEE.
- [10] Kumar, A., Kodipalli, A., Rao, T., Soma, B., & Gargi, N. (2024, April). Enhancing Password Security: Fuzzy AHP and TOPSIS-based Vulnerability Assessment. In 2024 IEEE 9th International Conference for Convergence in Technology (I2CT) (pp. 1-6). IEEE.
- [11] Anoop, R., Anand, I., Rehan, M., Yashvanth, R., Kodipalli, A., Rao, T., & Kamal, S. (2023, March). Prediction of Schizophrenia in Patients Using Fuzzy AHP and TOPSIS Methods. In International Conference on Machine Learning, IoT and Big Data (pp. 517-527). Singapore: Springer Nature Singapore.