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Advancements in Critical Path Method Using Neutrosophic Theory: A Review

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Abstract

By integrating neutrosophic principles, recent optimization advances give a thorough analysis of decision-making processes. The focus of the research is on project management, and more especially on the difficulties of using the Critical Path Method and the Time Cost Tradeoff in contexts where there is a high degree of uncertainty. To deal with data in various uncertain contexts was further detailed in the investigation to resolve such issues. According to recent research, using neutrosophic in project scheduling can significantly improve efficiency, effectiveness, and accuracy, especially in uncertain environments. The project might finish in the least amount of time possible if all the relevant factors, including time, money, and quality, are considered. The critical path method can significantly improve by incorporating neutrosophic ideas into project management. This study surveys the state of the art and delves into possible directions for future work with other uncertain environments.

Keywords: Operational research, Critical path problem, Time cost tradeoff, Uncertainty, Extended fuzzy principles, Time-cost tradeoff.

1 | Introduction

Operations Research (OR) plays a crucial role in developing modern analytical tools. Its primary purpose is facilitating the settlement of complex challenges by decision-makers in the public, corporate, and nonprofit sectors. Organizational behavior encompasses examining different problem-solving methods, including Markov decision processes [1], and queuing theory [2]. Many classical OR studies often overlook the uncertainty and unpredictability of real-world scenarios, assuming deterministic models. It is unreasonable to anticipate them to possess a comprehensive grasp of all variables when there is insufficient or ambiguous

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data. Furthermore, the challenges of scalability and computational complexity pose significant obstacles for these methods when it comes to addressing intricate, extensive problems. The rapid pace of change in systems and environments may make traditional methods outdated.

The interconnected nature of uncertainty and information is crucial for making accurate decisions. In many areas of study and technology, the representation of ambiguity is crucial for data-to-information conversion, decision-making, and processing sequence activities. In 1965, Zadeh [3] introduced fuzzy set theory as a means of analyzing data that is not clearly defined. Enhancements were made to the initial constraints by incorporating extended fuzzy principles in fuzzy set theory. Recently, new research studies have shown greater impact while working with neutrosophic methodological approaches under control and optimization issues, especially when there are unknown parametric factors. Neutrosophic techniques are widely used in many fields, resulting in flexibility and usefulness while dealing with uncertain situations. Gayen et al. [4], [5] investigated neutrosophic and soft subrings with interval-valued data. Researchers found a new idea for solving interval-valued neutrosophic subrings used for algebraic structures. Dey et al. [6] demonstrated many graph theory operations under neutrosophic principles in their study. *Table 1* explores these enhancements through a range of OR techniques.

Table 1. Recent advancements in extended fuzzy principles using different techniques.

Author	Technique	Application and Significance
Sikder et al. [7]	Linear programming	Finding critical paths using spreadsheet-based linear programming.
Kumar et al. [8]	Fuzzy shortest path problem	An ideal approach for path selection in the context of reliability under fuzzy logic.
Das et al. [9]	Dual simplex method	Implementing the dual simplex approach to resolve triangle neutrosophic linear fractional programming problems.
Veeramani et al. [10]	Goal programming	To solve multi-objective fractional transportation problems using neutrosophic goal programming.
Pratihar et al. [11]	Modified Vogel's approximation method	Displays a transportation-related variation of Vogel's approximation that accounts for uncertain situations.
Edalatpanah [12]	Linear Programming Problem (LPP)	Introducing a new approach in linear programming that avoids the need for arbitrary variables.
Alburaikan et al. [13]	Goal programming	Offering a systematic renovation by intricating linear programming issues in the presence of neutrosophic conditions.
Bahrampour et al. [14]	Supply chain	A hybrid metaheuristic algorithm for closed-loop supply chains that prioritizes dependability.
Bazargan et al. [15]	Network analysis	An approach for evaluating oil industry productivity is presented by the author, under Malmquist network analysis.
Akram et al. [16]	Extended DEA method with fermatean fuzzy sets	Addresses multi-objective transportation problems using an enhanced DEA method with fermatean fuzzy sets.

Several optimization issues have also shown the practical applicability of these theoretical developments. Dey et al. [17] presented a genetic algorithm to solve the neutrosophic traveling salesman problem with neutrosophic edge weights to demonstrate the use of neutrosophic methods in combinatorial optimization. Additionally, anti-neutrosophic subgroups have been defined by Gayen et al. [18], expanding the group theory foundation of neutrosophic sets.

In addition, Dubey and Kumar [19], [20] examined inventory control and more recent developments in inventory management, offering comprehensive overviews of neutrosophic principles that can be used to manage inventory in both certain and uncertain situations. They also created an inventory model with sensitivity analysis in indeterminate environments, demonstrating the usefulness of neutrosophic approaches in actual inventory management [21]. Tripathi and Kumar worked on the classical sense [22], [23] and later the neutrosophic study [24] evaluated many methods for solving problems, including linear programming. Tripathi and Kumar [22], [23] evaluated many methods for solving problems, including linear programming.

Additional research on network models for minimizing cost flow problems through multi-objective linear programming sheds light on neutrosophic when solving LPPs with numerous constraints, which Tripathi and Kumar [24] implemented using the LINGO solver package system to reduce time-consuming. Additionally, the Critical Path Problem (CPM) has been improved through neutrosophic reviews [25], [26]. Numerical studies conducted by Pratyusha and Kumar [27] using Python to resolve neutrosophic CPMs show these techniques' computational efficiency and practical utility in optimization and project management. Research like this highlights solving complicated network challenges by combining computational efficiency with sophisticated theoretical models. Combining state-of-the-art computational methods with theoretical models creates a solid foundation to tackle different optimization problems in the face of uncertainty.

2 | CPM and Time-Cost Tradeoff in Uncertain Environments

Project management networks, the subset of the Time-Cost Tradeoff Problem (TCTP), are an essential part of OR. Its main objective is reducing the original project duration as determined by the critical path analysis to meet a deadline while keeping up with the cost minimization. Also, there may be a deadline by which the task must be finished. Every real-world project decision-maker must consider environmental uncertainty and the time-cost tradeoff. Precise time scheduling is a distinctive project management feature for important domains like business and industry. Much research has been carried out to investigate different approaches for finding the most efficient length while reducing expenses. Each academic discipline aims to discover pragmatic and cost-effective solutions [28]. Rekh and Dhodiya [29] provided a novel viewpoint on the tasks involved in project management. After employing alpha-level set analysis, decision-makers better-understood project risk, budget, and quality.

In recent years, considerable progress has been made in managing different forms of uncertainty, particularly in addressing the difficulties posed by the TCTP and CPM issues. One example is the TCTP framework by Haghighi et al. [30], which accounts for quality loss cost in the context of interval fuzzy uncertainty. Based on their level of uncertainty, the preceding framework divided tasks into three categories. A framework was developed by Abdel-Basset et al. [31] to address scheduling issues by utilizing neutrosophic activity duration periods. While contemplating the project's actual and uncertain situation, they considered essential aspects of TCTP.

In further studies, Nasrolahi and Shahsavari-Pour [32] emphasize managing project objectives in case of issues. CPM project management merits and demerits were examined against cost, time, and risk. Mahdavi-Roshan et al. [33] blended fermatean fuzzy grey data in a novel way. This project management method uses key performance measurements and project parameters. Abinaya et al. [34] discovered a novel CPM network analysis key route method to strive for precise and efficient task planning.

3 | Conclusion

The time-cost tradeoffs and the CPM are both improved by consistency. These advancements use neutrosophic design concepts to improve the accuracy and effectiveness of project scheduling. Considering these parameters saves costs, protects the environment, and increases effectiveness. The development phase and controlling project plan for the CPM and neutrosophic environment are substantial. This occurred due to their exceptional skill in handling situations and handling uncertainty regularly. Advanced computer tools and project management techniques can facilitate smarter decision-making, ultimately leading to greater advantages.

Authors' Contributions

M. N. P.: Research design, Conceptualization, and Validation, Methodology, Visualization and Formal Analysis. R. K.: Computing, editing, and Validation. The authors have read and agreed to the published version of the manuscript.

Consent for Publication

Consent for publication has been obtained from the authors.

Ethics Approval and Consent to Participate

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Data Availability

No new data were created or analyzed in this study. Data sharing does not apply to this article.

Conflicts of Interest

The author has no conflicts of interest to declare relevant to this article's content.No new data were created or analyzed in this study. Data sharing does not apply to this article.

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