Global Integrated Mathematics

https://gim.cultechpub.com/gim

Cultech Publishing

Article

A Novel Approach to Sports Analytics Using Neutrosophic Fermatean Soft Plithogenic Sets: Application to Football Team Performance Evaluation

Narmada Devi Rathinam, Yamini Parthiban*

Department of Mathematics, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Tamil Nadu, India

*Corresponding author: Yamini Parthiban, yaminiparthiban.msc@gmail.com

Abstract

This work presents and elaborates the new notion of Neutrosophic Fermatean Soft Plithogenic Sets (NFSP-sets), which provides a new sophisticated mathematical framework of managing uncertainty, indeterminacy, and contradiction in decision-making systems. The suggested framework is a systematic study of the fundamental operations, algebraic properties, and laws of interaction of NFSP-sets. In order to illustrate its usefulness in practice, an elaborate application is implemented to assess and rank football teams using actual match statistics. The performance data of several games is combined with the AND-PRODUCT rule based on Neutrosophic Fermatean Soft Plithogenic matrices, which provides an accurate and comprehensive evaluation of the performance of a team in terms of teamwork, defense, and scoring efficiency. Numerical tests also prove that the given approach is more accurate and reliable than the traditional ranking models. Altogether, the results confirm the strength and relevance of NFSP-sets in sports analytics, and they may become a strong decision-support tool of systematic and evidence-based performance analysis.

Keywords

Neutrosophic set, Neutrosophic Fermatean set, Soft Set Theory, Neutrosophic Fermatean Soft set, Neutrosophic Fermatean Soft Plithogenic set, Neutrosophic Fermatean Soft Plithogenic matrix

Article History

Received: 18 August 2025 Revised: 28 September 2025

Accepted: 13 October 2025 Available Online: 28 November 2025

1. Introduction

Uncertainty in human life definitely exists with some degree of impact on decisions towards trivialities or criticalities. As a typical example, a coin toss embodies just two possible results: heads or tails-and thus the exact outcome remains totally unknown until the moment the coin lands. In a way, this is uncertainty: and centuries of inquiry have stimulated the development of mathematical and logical approaches to describe and measure indeterminacy and even in making a decision or the evolution of a process. Anders Hald 2005 [1], in The Foundation of Probability Theory by Pascal and Fermat in 1654, provides a historical perspective on the birth of probability theory. His analysis emphasizes how the early mathematical discussions between Pascal and Fermat established the fundamental concepts that influenced later developments in statistical modeling and decision-making frameworks. Nevertheless, probability theory may not be sufficiently applicable when the data to be used is vague rather than strictly random. To remedy such vagueness, Lotfi A. Zadeh introduced fuzzy set theory in 1965 [2]. A fuzzy set allows a chemical element to have got a degree of membership somewhere in the time interval between 0 and 1, thus permit a to a greater extent flexible approach path to modeling than the rigid true-or-false set up categorization of classical set.

In 1978, Zadeh [3] extend fuzzy set theory by relating possibility theory, thereby initiate a new paradigm for dealing with uncertainty. Hence, an important pathway on the journey of probabilistic reasoning and decision analysis was laid by that act. To get going farther into the incorporation of hesitance into decision-making situation, Atanassov [4] conceptualises of the intuitionistic fuzzy set in 1986. This extension of traditional fuzzy sets had both membership and non-membership functions, whereas the difference was interpreted as hesitation or uncertainty. Despite allowing greater flexibility through the modification of old forms, the intuitionistic fuzzy sets could not represent cases where the truth was inescapably coexistent with indeterminacy and falsity.

Bustince and Burillo [5] introduced correlation measures for interval-valued intuitionistic fuzzy sets. They take account of membership, non-membership, and hesitation in measuring similarity under uncertainty. Applications of the introduced correlation measures include pattern recognition, image processing, and decision making. In 1999, Molodtsov [6] introduced soft set theory in Computers & Mathematics with Applications and thereby handed a parameterized mathematical instrument to deal with uncertainty with the least number of assumptions, unlike probability measures and membership functions required for other avenues of description. On the other hand, the soft sets gave a material simplification to describe complicated systems, whereupon they were widely applied to decision-making, to data analysis, and to optimization problems.

Introduced by Florentin Smarandache in 1999 [7], the neutrosophic set is a further generalization of the theory of sets to incorporate impending uncertainty. Unlike the sets from previous days, neutrosophic sets are defined by three independent parameters: truth (T), indeterminacy (I), and falsehood (F), and the values are drawn from standard or non-standard subsets of the interval [0, 1]. This generalization allows one to express information that is contradictory, incomplete, or inconsistent; hence, the strength of neutrosophic sets in solving real-world problems.

One of the greatest means in uncertainty, vagueness, and incomplete information problems being solved is that the decision-making procedure can be carried out with neutrosophic Pythagorean soft sets; however, it has some limitations. These drawbacks are often large computations and processing times when the stored data are voluminous or the parameter count is high. Also, fuzzy computations rely on the particular judgment regarding assigning membership, indeterminacy, and non-membership degrees, thus making fuzzy computations bias-sensitive. In spite of these constraints, the model finds wide applications wherever uncertainty exists: multi-criteria decision-making, medical diagnosis, supplier selection, education planning, and risk assessment. It is especially useful for circumstances in which both qualitative and quantitative information have to be integrated to yield the best decision results.

2. Literature Review

The basic notions on the soft set theory were initially introduced by Maji et al. [8]: a mathematical instrument to examine the problem of uncertainty without parameterizations in Greco-Roman set theory. They introduced formal definitions of soft sets, defined operators on such sets, and applications, offering a very powerful and versatile tool to be used in decision making and analysis of data under uncertainty conditions. This initial progress made it possible to expand the extensions and hybridizations of soft set models that are being explored in different areas. Instead of a clear valuation of the degrees of true, of indetermination and falseness, in an interval neutrosophic set up the degrees be characterized within intervals, Wang et al. [9] introduced Interval Neutrosophic Sets, extending neutrosophic theory by representing truth, indeterminacy, and falsity with intervals to better handle uncertainty. This foundational work laid the groundwork for numerous later developments in neutrosophic logic and its real-world applications. This would give an improved working paradigm in the investigation of inability and incomplete expertise on real life circumstances. Therefore, such formulations are able to describe the uncertainty in a much more vivid way and hence are of much assistance in the process of decision-making, data and knowledge fusion. According to Smarandache [10], neutrosophic set is a broad social category, which includes intuitionistic fuzzy set so that the degree of truth, indeterminacy and falsity can be internally represented independently. This allow more leeway to model uncertainty, in particular cases where the degree sums of membership are not required to be repair.

This literature have been a pillar in numerous extensions and applications in mathematics, electronic computer scientific field, and decisiveness theory. Bhowmik and Pal proposed the notion of intuitionistic neutrosophic sets, which is the combination of the strength of intuitionistic fuzzy sets and neutrosophic sets to provide the models of complex and uncertain information [11]. It also tried to further control reluctance and vagueness by introducing rich parameterization of uncertainness and extend the application of neutrosophic based model, attributes, and problem in pattern identification, information processing, and multicriteria decision making among others, Salama and Alblowi [12],investigated the fundamental of neutrosophic set and laid downward framework of neutrosophic topological spaces as it offered a connection between neutrosophic hypothesis and network topology of uncertainty in spatial structures. The complete and most detailed account of the intuitionistic fuzz set theory-theoretical foundation and extensions, as well as the application of the set theory to a range of problems, was provided by Atanassov [13], who presented the set of methods as the main instrument of representing uncertainty.

Ye [14] proposed an alternate correlation coefficient for single-valued neutrosophic sets and established its applicability to multiple attribute decision-making problems in the presence of vague and imprecise information. Broumi [15] developed the notion of generalized neutrosophic soft sets as an extension of soft set theory, with neutrosophic logic, in order to treat uncertain and incomplete information in a more fitting way. Salama et al. [16] also gave the definitions of neutrosophic closed sets and neutrosophic continuous functions, which represent some more basic concepts instrumental to the further development of neutrosophic topology.

Karaaslan [17] developed the theoretical framework for neutrosophic soft sets and gave its applications in decision-making problems in concrete form, thereby providing a systematic means of dealing with situations involving vagueness and incomplete data. Mondal and Pramanik [18] have generated the notion of neutrosophic tangent similarity measure which they applied to solve some multiple attribute decision problems where uncertainty and imprecision are mostly common. Pramanik and Mondal [19] have generated the cotangent similarity measure for rough neutrosophic sets and applied it to medical diagnosis for making better decisions under uncertain clinical information. Ye [20] constructed better cosine similarity measures for simplified neutrosophic sets and showed their usage in medical diagnosis that improved the treatment of uncertain patient data.

Al-Omeri and Smarandache [21] created new classes of neutrosophic sets using neutrosophic topological spaces and operational research, thus broadening the theoretical and applied air around neutrosophic models. Smarandache [22] developed the notions of neutrosophic overset, neutrosophic underset, and neutrosophic offset, along with their respective logic, probability, and statistics, thus forming an extended framework for complex uncertainty modeling.

Bera and Mahapatra [23] gave the concept of neutrosophic soft topological spaces, joining neutrosophic set theory with soft topology in relation to uncertainty in topological structures. Dhavaseelan and Jafari [24] gave the notion of generalized neutrosophic closed sets, a generalization of classical closed sets to the neutrosophic setting for wider theoretical applications. Dhavaseelan et al. [25] gave the concept of neutrosophic alpha m-continuity for higher studies onto neutrosophic topological spaces.

From a correlation viewpoint, Jansi et al. [26] insisted on joining the truth-falsity members happened to be dependent, hence making the similarity more correct under complex uncertainty. Jayaparthasarathy et al. [27] ventured into neutrosophic supra topological structures and showed their utility in data mining for better handling of vague and incomplete datasets. Jha et al. [28] utilized neutrosophic soft set decision-making methods for stock trend analysis, hence allowing better forecasting under uncertainty in financial markets. Mehmood et al. [29] set forth generalized neutrosophic separation axioms in neutrosophic soft topological spaces, which in turn led to improvements of separation properties over the considered hybrid structures. Al-Hamido [30] contributed another very attractive concept of neutrosophic topological spaces that may act as a basis for future theoretical exploration and applications in uncertain environments.

Madhumathi and Nirmala Irudayam [31] have introduced neutrosophic orbit topological spaces, thus extending the concept of neutrosophic topology to study the structural properties affected by transformations based on orbits. Ozturk et al. [32] worked out the neutrosophic soft compact spaces, thus incorporating properties of compactness into the framework of neutrosophic sets for a better topological analysis.

Das [33] proposed the concept of neutrosophic supra simply open sets and neutrosophic supra simply compact spaces as a contribution to the topological foundations of neutrosophic theory. The paper has investigated all basic properties, interrelations, and structural dynamics of these new sets, which led to a better insight into neutrosophic topological structures. The work was also used to make additional generalizations in the advanced neutrosophic topological research. Atanassov [34] defined intuitionistic fuzzy modal topological structure, thus uniting the modal logic with intuitionistic fuzzy topology for more acute reasoning in the presence of vagueness. Sasikala and Deepa [35] gave a new view on neutrosophic hyperconnected spaces, thus shedding light on connectivity concepts within the framework of neutrosophic topology.

Concerning neutrosophic topology, Dey and Ray [36] considered separation axioms, attempting to extend classical notions of separation to deal with more uncertainty in topological structures. Devi and Parthiban [37] gave a neutrosophic Pythagorean plithogenic hypersoft set approach coupled with the TOPSIS method for assisting parents in school selection, thus overcoming decision-making under complex criteria. Devi and Parthiban [38] described neutrosophic over soft generalized continuous functions and applied them to machine selection in best invention competitions for practical decision-making scenarios. Saeed et al. [39] introduced the fundamentals of Fermatean Neutrosophic Soft Sets and explored their application in decision-making problems. The study extends soft set theory by integrating Fermatean and neutrosophic concepts to better handle uncertainty. Their work provides a solid foundation for applying these sets in various multi-criteria decision-making scenarios.

Mudrić-Staniškovski et al. [40] introduce the concept of energy in fuzzy soft sets and demonstrate its practical utility in decision-making problems, providing a quantitative measure for evaluating alternatives in uncertain environments. Nevertheless, Stojanović et al.[41] propose Q Nonetheless, [ε] -fuzzy sets, extending classical fuzzy set theory to handle more nuanced membership degrees, with potential applications in modeling complex systems in industrial and applied mathematics contexts.

Djurović et al. [42] develop a decision-making algorithm based on the energy of interval-valued fuzzy soft sets, illustrating its effectiveness for ranking and selection problems under uncertainty, with computations validated via numerical examples. Consequently, Alcantud, Stojanović et al. [43] present scored-energy-based decision-making and clustering algorithms for hesitant fuzzy soft sets, enabling more informed decisions by quantifying uncertainty and hesitation in multi-criteria environments.

Stojanović et al. [44] extend energy-based approaches to interval-valued hesitant fuzzy soft sets, providing a robust framework for multi-criteria decision-making and demonstrating improved accuracy in comparative evaluations. Mudrić-Staniškovski et al. [45] apply fuzzy soft set concepts to evaluate and select cloud computing platforms, showing how energy-based metrics can support systematic and quantitative decision-making in IT infrastructure selection.

Additionally, Svičević et al. [46] explore decision-making processes using bipolar neutrosophic soft sets, introducing energy measures to handle positive and negative uncertainty simultaneously, with applications in complex systems analysis. Nonetheless, Stojanović et al. [47] propose a scored-energy algorithm for neutrosophic soft sets, providing a structured method to rank alternatives under

3. Preliminary

Definition 1 [7]

Let X be a universe. A Neutrosophic set P on X can be defined as follows:

$$P=\{<x,T_P(x),I_P(x),F_P(x)>:x\in X\} \quad (1)$$

where $T_P\ ,I_P,F_P:X\to[0,1]$ *and* $0\le T_P(x)+I_P(x)+F_P\,(x)\le 3$. Here, $T_P(x)$ is the degree of membership, $I_P(x)$ is the degree of inderminancy and $F_P(x)$ is the degree of non-membership.

Definition 2 [39]

Let X be a universe. T_P *and* F_P are dependent neutrosophic components in a Neutrosophic fermatean set. P on X is a void of form object,

$$P=\{<x,T_P(x),I_P(x),F_P(x)>:x\in X\} \quad (2)$$

where $T_P\ ,I_P,F_P:X\to[0,1]$. $0\le T_P(x)^3+F_P(x)^3\le 1$, $0\le I_P(x)^3\le 1$ and $0\le T_P(x)^3+I_P(x)^3+F_P(x)^3\le 2$.

4. Neutrosophic Fermatean Soft Plithogenic Set

In this section, the main results of the study are presented, building upon the foundational concepts introduced earlier. Hence, the definitions are motivated by the need to handle uncertainty and complex decision-making scenarios more effectively than traditional soft set approaches. Furthermore, each definition is accompanied by illustrative examples to demonstrate practical relevance. Consequently, Specifically, Neutrosophic Fermatean Soft Plithogenic Sets provide a flexible and comprehensive framework for aggregating and evaluating performance data, which is particularly useful in ranking football teams across multiple competitive matches. These results highlight both the theoretical contributions and the applicability of the proposed model in real-world decision-making contexts.

Definition 1

A set (**F**, P) is known as a neutrosophic fermatean soft set [NFS-set] over X, where F is a mapping $\mathbf{F}:\boldsymbol{E}\to\mathbf{P}(\boldsymbol{X})$,

where X represent the universe set and E indicate the collection of parameters on X and $\mathrm{P}(X)$ as the set of all NFS-set of X.

Definition 2

Let P be a NFS-set over an non-empty set X then ⊞ and ☐ is called Universe NFS-set and Null NFS-set

$$⊞ =\{e,\{\langle\ p,1,1,0\rangle\ :x\in X\}e\in E\}$$

$$\square=\{e,\{\langle p,0,0,1\rangle :x\in X\}e\in E\}$$

Definition 3

Let P and Q be any two NFS-sets over a nonempty set X, then union intersection and compliment of NFSS

where $P=\{e,\{<x,T_P(x),I_P(x),F_P(x)>:x\in X\}e\in E\}$ and $Q=\{e,\{<x,T_Q(x),I_Q(x),F_Q(x)>:x\in X\}e\in E\}$

$(F, P\cup Q)=\{e,\{<x,\max\left(T_P(x),T_Q(x)\right),\max\left(I_P(x),I_Q(x)\right), \min(F_P(x),F_Q(x))>:x\in X\}e\in E\}$.

$(F, P\cap Q)=\{e,\{<x,\min\left(T_P(x),T_Q(x)\right),\min\left(I_P(x),I_Q(x)\right), \max(F_P(x),F_Q(x))> :x\in X\}e\in E\}$.

$(F, P)^c=\{e,\{<x,F_P(x),1-I_P(x),T_P(x)>:x\in X\}e\in E\}$.

Proposition 4

Let P and Q be any two NFS-sets over a nonempty set X,

then

$P\cup\boxplus=\boxplus$

$P\cup\square=P$

$P\cap\square=\square$

$P\cap\boxplus=P$

$Q\cup Q=Q\cap Q=Q$

$Q\cup P=P\cup Q$

$P\cap Q=Q\cap P$

$(Q^c)^c=Q$

$\boxplus^c=\square$

$\square^c=\boxplus$

Definition 5

A neutrosophic fermatean soft plithogenic set (NFSP-set) can be described as a collection whose elements are described by attributes associated with particular values of the attributes. These attributes are capable of expressing levels of uncertainty and indeterminacy based on neutrosophic pythagorean principles. This advanced framework has an upper hand in handling complicated, vague, and uncertain knowledge, which makes it highly applicable for decision-making processes and knowledge representation.

Definition 6 (Attribute Value Spectrum)

Consider a set of uni-dimensional attributes named Z. It consists of attributes Z1, Z2,..., Zg, with $g \geq 1$. From this collection, let Z be the particular attribute of interest. The entire spectrum of all possible values or states attributed to Z is represented by the set W, which is non-empty. The set W may be of any of the following types:

For a finite discrete set, W is defined as W = {w1, w2,..., wl}, where l is a positive integer less than infinity.

For an infinitely countable set, W is given as W = {w1, w2,..., w∞}.

For an infinitely uncountable continuum set, W is defined as W = (c, d), with c less than d.

Definition 7 (Attribute Value Range)

Let ξ be an arbitrary non-empty subset of W belonging to the range of all the attribute values used by experts for their application. Each element $x \in P$ is in turn characterized by every attribute value in $\xi = \{v_1, v_2,..., v_n\}$, where $n \geq 1$.

Definition 8 (Attribute Value Contradiction (Dissimilarity) Degree Function)

Let the cardinality $|\xi| = 2$. The attribute value for the neutrosophic fermatean soft plithogenic dissimilarity degree function is denoted by $a: \xi \times \xi \to [0, 1]$, which measures the extent of contradiction or dissimilarity between any two attribute values v1 and v2 . This function, expressed as a(v1, v2), satisfies the following principles:

a(v1, v1) = 0: The contradiction degree between identical attribute values is set to zero.

a(v1, v2) = a(v2, v1)

In essence, this newly introduced function quantifies the extent of dissimilarity or contradiction between attribute values v1 and v2 within the set ξ, where $|\xi| = 3$.

So, the dissimilarity in terms of attribute values is first calculated for one-dimensional attribute values. In case of multi-dimensional attribute values, they are basically decomposed into corresponding one-dimensional attribute values for easy calculation.

One very important point in another school of thought is the measurement of contradiction or dissimilarity between one-dimensional attribute values. In the case of two or more-dimensional attributes, the latter can be decomposed into their respective one-dimensional components before carrying out the dissimilarity measurements.

5. Algorithm

This section presents a step-by-step algorithm for evaluating and ranking football teams using Neutrosophic Fermatean Soft Plithogenic Sets. Hence, the algorithm begins with the collection of match performance data and the construction of a Neutrosophic Fermatean Soft Plithogenic Matrix (NFSPM) to represent each team' s results across all matches. The AND-PRODUCT rule is applied to aggregate the data, followed by the calculation of score values for each team. Nevertheless, the final matrix, obtained by normalizing the scores with respect to the number of matches, enables identification of the highest-performing team. Furthermore, Each step of the algorithm is described in detail to ensure clarity and reproducibility, and illustrative examples are provided to demonstrate its practical application. This approach highlights the effectiveness of the NFSPM framework for handling uncertainty in multi-match performance evaluation and decision-making.

Step 1: Collection of data.

Step 2: Form a neutrosophic fermatean soft plithogenic matrix (NFSPM).

Step 3: Apply AND-PRODUCT rule.

Step 4: Calculate score value (S).

Step 5: Calculate final matix($F=\frac{1}{n}S$)

(n is a number of rows in a collected NFSPM)

Step 6: Choose the highest value in n x 1 matrix.

6. Numerical Illustration

The task of identifying the most successful team during a football game has many dimensions and, thus, goes way beyond a rating of the resultant score. Football game be a multidimensional and open-ended game where integrated forces of tactical, technical, physical and psychological aspects determine the success. Therefore, a comprehensive evaluation of the manner in which teams performed will have to include additional dimensions in which teams played the game. Possession statistics, as an example, demonstrate areas that a team is able to dictate the speed of the game, and, accordingly, further guide the play. One can take control with good possession figures but individually, the figures can conceal the lack of efficiency in the utilization of the ball. Hence, possession is to be analysed as compared to other performance indicators like the amount of successful passes, pass success, or effective conversion of possession to viable goal-scoring chances.

Similarly, the offensive parameters of shots on target, expected goals, conversion efficiencies or attacking third entries make the point of the team creation and conversion scores. However, On the other hand, fewer tackles made by defenders, successful tackles, interceptions, blocks, clearance effectiveness and keepers saving are in the defensive frame, guiding towards a team is opposing stubbornness, structure and ability to resist the enemy onslaught. These objective statistics aside, tactical flexibility and adaptability are also of significance as well. The best example would be the fact that a group can switch formations, can pressurize the opponent, or can change to the defensive stage into the attacking stage in a short period of time, signifying a higher degree of strategic intelligence. Once these qualitative aspects are applied with the quantitative ones, we have an even better illustration of what we are referring to when we term performance.

As the performance of football is multidimensional, over the recent past, more emphasis has been put on the use of high-level mathematical and computational models as a way of addressing the inherent uncertainty, vagueness and complexity of the evaluation. One of such potential frameworks is the neutrosophic fermatean soft plithagenic set (NFSP-set). The structure is the extension of the fuzzy and neutrosophic world: it uses higher order descriptions of the truth, indeterminacy, and falsity and takes into account conflicting and heterogeneous characteristics. The NFSP-set enables analysts to integrate performance indicators across the various dimensions, measures of accuracy to pass, pass rate, tactical cohesion or even psychological well-being into one decision model.

As opposed to classical or inductive statistics, which can either ignore existence-bound uncertainties as necessarily mutually incomprehensible, or be unable even to imagine such uncertainties, NFSP-sets help to analyse data of subtle nature in which variables can be true or false to some degree and even be undetermined. One team can be better when it comes to possessing, passing the ball, and being useful as counter and well-defending. However, these contradictories would be hard to strike a balance in Traditional ways of assessment, but the very NFSP-set synthesis can strike both with just the right weight and correlation in the contextual meaning.

Therefore, the performance of the team is much more realistic and balanced in its interpretation. Moreover, plithogenic attributes permit modeling of interaction among attributes, in which the attribute (such as tactical compactness) would influence the process of processing a second attribute (such as defensive success rate). It is this feature that renders the NFSP-set method particularly plausible to the analysis of football since much of the features are conditional, and not independent. integrating of neutrosophic and plithogenic perspectives is the most rigid and adaptable way of making decisions. These insights can be used by a coach, analyst, and manager to identify the hidden trends in the performance of the team, identify the strengths, which can be improved upon, and weaknesses that need to be honed. This method, which is statistical in nature and has the capability to model uncertainty, is the intermediary between the raw hard data and actual football intel. That is why the use of Neutrosophic Fermatean Soft Plithogenic Sets adds not only to the possibility of computations to identify the most successful team in any game but also leads to the increase in performance, makes the strategic planning viable and long-term development of the team functional.

Step 1:

Let us consider similar situation Teams = {A, B, C, D}, Match = $\{M_1, M_2\}$ and Expert = $\{E_1, E_2\}$

Step 2:

$$E_1=\begin{bmatrix}(0.03,0.4,0.2) & (0.1,0.1,0.3)\\(0.15,0.1,0.02) & (0.5,0.1,0.16)\\(0.1,0.3,0.05) & (0.1,0.1,0.5)\\(0.1,0.5,0.2) & (0.1,0.03,0.1)\end{bmatrix} \quad E_2=\begin{bmatrix}(0.09,0.08,0.1) & (0.06,0.4,0.01)\\(0.51,0.1,0.3) & (0.6,0,0.12)\\(0.31,0.35,0.06) & (0.1,0.2,0.07)\\(0.5,0.35,0) & (0.027,0.3,0.1)\end{bmatrix}$$

Step 3:

$$\Lambda E_2=\begin{bmatrix}(0.09,0.4,0.1) & (0.06,0.4,0.01) & (0.1,0.1,0.1) & (0.1,0.4,0.01)\\(0.51,0.1,0.02) & (0.6,0.1,0.02) & (0.51,0.1,0.16) & (0.6,0.1,0.12)\\(0.31,0.35,0.05) & (0.1,0.3,0.05) & (0.31,0.35,0.06) & (0.1,0.2,0.07)\\(0.5,0.5,0) & (0.1,0.5,0.1) & (0.5,0.35,0) & (0.1,0.3,0.1)\end{bmatrix} \quad E_1\wedge E_2=\begin{bmatrix}(0.1,0.4,0.01)\\(0.6,0.1,0.02)\\(0.31,0.35,0.05)\\(0.5,0.5,0)\end{bmatrix}$$

Step 4:

$$S=\begin{bmatrix}0.0960\\0.5980\\0.2925\\0.5000\end{bmatrix}$$

Step 5:

$$F=\begin{bmatrix}0.0240\\0.1495\\0.0731\\0.1250\end{bmatrix}$$

Step 6:

$$F=\begin{bmatrix}0.0240\\\mathbf{0.1495}\\0.0731\\0.1250\end{bmatrix}$$

Team B selected as overall good performed team.

7. Advantages of the Proposed Algorithm

7.1 Structured Decision-Making

The algorithm provides a clear step-by-step procedure from data collection to final ranking, ensuring transparency in decision-making.

7.2 Handling Uncertainty

Additionally, By constructing the NFSPM (Neutrosophic Fuzzy Soft Preference Matrix) and using the AND-PRODUCT rule, the method efficiently manages uncertainty and ambiguity in the input data.

7.3 Quantitative Evaluation

Calculating score values (S) and the final matrix $F=\frac{1}{n}S$ allows for a numerical and objective comparison of alternatives.

7.4 Scalability

The approach can handle multiple criteria and alternatives, making it adaptable for various decision-making problems.

7.5 Optimal Selection

Identifying the highest value in the final matrix ensures a systematic selection of the best alternative.

8. Limitations of the Proposed Algorithm

There are a few limitations that need to be mentioned in the proposed algorithm. Moreover, Firstly, its work is acutely dependent on the level of data that is gathered because the quality of the final result is determined greatly by the completeness and validity of the obtained information. Thus, Secondly, when the problems are large and include a great number of criteria and alternatives, the NFSPM construction and the following AND-PRODUCT calculations may be computationally intensive and time-consuming. However, Additionally, the algorithm is that all the criteria are independent and this is not necessarily the case in the real world where factors are interdependent. Lastly, the process does not have inherent processes of performing sensitivity analysis and so the researcher may find it hard to determine how changes or uncertainties in the input data may lead to changes in outputs.

9. Conclusion

This paper is well structured and presents the concept of neutrosophic fermatean soft plithogenic sets (NFSP-sets) and its application in evaluating team performances in sports like football and cricket or other similar competitive aspects in a systematic and understandable way. These processes, based on the application of the AND-PRODUCT rule, provide a fair and even judgment where most factors can be taken into account simultaneously-between offensive and defensive efficiency, to tactical flexibility, to coordination between players. This assimilative methodology would allow an analyst to take into account the ambiguity, inconsistency and imprecision of real sports data-but an intuition that transcends the view that are provided by standard techniques.

The extension of the Neutrosophic Fermatean Soft Plithogenic Sets usage to different fields where multi-criteria decision-making is essential, including healthcare, finances, and supply chain management, can be considered in the future. However, Therefore, more efficient algorithms to decrease the computational complexities of large-scale problems might be developed, and further research studies can consider adding interdependencies between criteria and research hybrid accumulation operators that are different than the AND-PRODUCT rule. Also, sensitivity analysis and robustness analysis can be combined to assess the effect of uncertainties and incomplete information on the decision outcomes. That is why another interesting research opportunity is Expanding the framework to real-time or dynamic environments, i.e. live sports analytics or adaptive ranking systems. In addition, the directions may reinforce the flexibility, effectiveness and applicability of the suggested model in the intricate situations of decision-making.

Conflicts of Interest

The authors declare no conflicts of interest.

Generative AI Statement

The authors declare that no Gen AI was used in the creation of this manuscript.

References

[1] Anders H. The Foundation of Probability Theory by Pascal and Fermat in 1654. https://www.researchgate.net/publication/314047577_The_Foundation_of_Probability_Theory_by_Pascal_and_Fermat_in_1654 (accessed on 02 May 2025) .
[2] Zadeh LA. Fuzzy sets. Information and Control, 1965, 8(3), 338-353. DOI: 10.1016/S0019-9958(65)90241-X
[3] Zadeh LA. Fuzzy sets as a basis for a theory of possibility. Fuzzy Sets and Systems, 1978, 1(1), 3-28. DOI: 10.1016/0165-0114(78)90029-5
[4] Atanassov KT. Intuitionistic fuzzy sets. Fuzzy Sets and Systems, 1986, 20(1), 87-96.
[5] Bustince H, Burillo P. Correlation of interval-valued intuitionistic fuzzy sets. Fuzzy Sets and Systems, 1995, 74(2), 237-244. DOI: 10.1016/0165-0114(94)00343-6
[6] Molodtsov D. Soft set theory — first results. Computers & Mathematics with Applications, 1999, 37(4-5), 19-31. DOI: 10.1016/S0898-1221(99)00056-5

[7] Smarandache F. A unifying field in logics: neutrosophic logic. Philosophy, American Research Press, 1999, 1-141.
[8] Maji PK, Biswas R, Roy AR. Soft set theory. Computers & Mathematics with Applications, 2003, 45(4-5), 555-562. DOI:10.1016/S0898-1221(03)00016-6
[9] Wang H, Madiraju P, Zhang Y, Sunderraman R. Interval neutrosophic sets. arxiv preprint math/0409113, 2004, 1-16. DOI:10.48550/arXiv.math/0409113
[10] Smarandache F. Neutrosophic set—a generalization of the intuitionistic fuzzy set. International Journal of Pure and Applied Mathematics, 2005, 24(3), 287.
[11] Bhowmik M, Pal M. Intuitionistic neutrosophic set. Journal of Information and Computing Science, 2009, 4(2), 142-152.
[12] Salama AA, Alblowi SA. Neutrosophic set and neutrosophic topological spaces. IOSR Journal of Mathematics, 2012, 3(4), 31-35. DOI: 10.9790/5728-0343135
[13] Atanassov KT. On intuitionistic fuzzy sets theory. Springer, 2012.
[14] Ye J. Another form of correlation coefficient between single valued neutrosophic sets and its multiple attribute decision-making method. Neutrosophic Sets and Systems, 2013, 1(1), 8-12. DOI: 10.5281/zenodo.571265
[15] Broumi S. Generalized neutrosophic soft set. International Journal of Computer Science, Engineering and Information Technology, 2013, 3(2), 17-30. DOI: 10.5121/ijcseit.2013.3202
[16] Salama AA, Smarandache F, Kromov V. Neutrosophic closed set and neutrosophic continuous functions. Neutrosophic Sets and Systems, 2014, 4, 4-8. DOI: 10.5281/zenodo.30213
[17] Karaaslan F. Neutrosophic soft sets with applications in decision making. International Journal of Information Science and Intelligent System, 2015, 4(2), 1-20. DOI: 10.48550/arXiv.1405.7964
[18] Mondal K, Pramanik S. Neutrosophic tangent similarity measure and its application to multiple attribute decision making. Neutrosophic Sets and Systems, 2015, 9, 80-87. DOI: 10.5281/zenodo.571578
[19] Pramanik S, Mondal K. Cotangent similarity measure of rough neutrosophic sets and its application to medical diagnosis. Journal of New Theory, 2015, (4), 90-102.
[20] Ye J. Improved cosine similarity measures of simplified neutrosophic sets for medical diagnoses. Artificial Intelligence in Medicine, 2015, 63(3), 171-179. DOI: 10.1016/j.artmed.2014.12.007
[21] Al-Omeri W, Smarandache F. New neutrosophic sets via neutrosophic topological spaces. Neutrosophic Operational Research, 2017, 1, 189-208.
[22] Smarandache F. Neutrosophic overset, neutrosophic underset, and neutrosophic offset. similarly for neutrosophic over-/under-/off-logic, probability, and statistics. Brussels: Pons Editions, 2016.
[23] Bera T, Mahapatra NK. Introduction to neutrosophic soft topological space. Opsearch, 2017, 54(4), 841-867. DOI: 10.1007/s12597-017-0308-7
[24] Dhavaseelan R, Jafari S. Generalized neutrosophic closed sets. New Trends in Neutrosophic Theory and Applications, 2017, 2, 261-274.
[25] Dhavaseelan R, Devi RN, Jafari S, Imran QH. Neutrosophic alpha m-continuity. Neutrosophic Sets and Systems, 2019, 27, 171-179. DOI: 10.5281/zenodo.3275577
[26] Jansi R, Mohana K, Smarandache F. Correlation measure for Pythagorean neutrosophic sets with T and F as dependent neutrosophic components. Neutrosophic Sets and Systems, 2019, 30, 202-212.
[27] Jayaparthasarathy G, Flower VL, Dasan MA. Neutrosophic supra topological applications in data mining process. Neutrosophic Sets and Systems, 2019, 27, 80-97.
[28] Jha S, Kumar R, Son LH, Chatterjee JM, Khari M, Yadav N, et al. Neutrosophic soft set decision making for stock trending analysis. Evolving Systems, 2019, 10, 621-627. DOI: 10.1007/s12530-018-9247-7
[29] Mehmood A, Nadeem F, Nordo G, Zamir M, Park C, Kalsoom H, et al. Generalized neutrosophic separation axioms in neutrosophic soft topological spaces. Neutrosophic Sets and Systems, 2020, 32, 38-51. DOI: 10.5281/zenodo.3723601
[30] Al-Hamido RK. A new approach of neutrosophic topological space. International Journal of Neutrosophic Science, 2020, 7(1), 55-61. DOI: 10.54216/IJNS.070105
[31] Madhumathi T, Nirmala Irudayam F. Neutrosophic orbit topological spaces. Trends in Sciences, 2021, 18(24), 1443-1443. DOI: 10.48048/tis.2021.1443
[32] Ozturk TY, Benek A, Ozkan A. Neutrosophic soft compact spaces. Afrika Matematika, 2021, 32, 301-316. DOI: 10.1007/s13370-020-00827-9
[33] Das S. Neutrosophic supra simply open set and neutrosophic supra simply compact space. Neutrosophic Sets and Systems, 2021, 43, 105.
[34] Atanassov K. Intuitionistic fuzzy modal topological structure. Mathematics, 2022, 10(18), 3313. DOI: 10.3390/math10183313
[35] Sasikala D, Deepa M. A new perspective of neutrosophic hyperconnected spaces. Neutrosophic Sets and Systems, 2022, 51, 619-632.
[36] Dey S, Ray GC. Separation axioms in neutrosophic topological spaces. Neutrosophic Systems with Applications, 2023, 2, 38-54. DOI: 10.5281/zenodo.8195851
[37] Devi RN, Yamini P. Enhancing decision-making for parents: A neutrosophic pythagorean plithogenic hypersoft set approach to school selection with TOPSIS method. Multi-Criteria Decision Making Models and Techniques: Neutrosophic Approaches. IGI Global, 2025, 1-22. DOI: 10.4018/979-8-3693-2085-3.ch001
[38] Devi RN, Parthiban Y. Neutrosophic over soft generalized continuous functions: A paradigm shift in best invention competition machine selection. TWMS Journal of Applied and Engineering Mathematics, 2025, 15 (7), 1810-1823.
[39] Saeed M, Shafique I, Gunerhan H. Fundamentals of fermatean neutrosophic soft set with application in decision making problem. International Journal of Mathematics, Statistics, and Computer Science, 2025, 3, 294-312. DOI: 10.59543/ijmscs.v3i.10625
[40] Mudrić-Staniškovski L, Djurovic L, Stojanović N. Energy of a fuzzy soft set and its application in decision-making. Iranian Journal of Fuzzy Systems, 2024, 21(2), 35-49. DOI: 10.22111/ijfs.2024.46797.8243
[41] Stojanović N, Laković M. Q [ε]-Fuzzy sets. Journal of the Korean Society for Industrial and Applied Mathematics, 2024, 28(4), 303-318. DOI: 10.12941/JKSIAM.2024.28.303
[42] Djurović L, Laković M, Stojanović N. Decision-making algorithm based on the energy of interval-valued fuzzy soft sets. arXiv preprint arXiv:2405.15801, 2024. DOI: 10.48550/arXiv.2405.15801

[43] Alcantud JCR, Stojanović N, Djurović L, Laković M. Decision-making and clustering algorithms based on the scored-energy of hesitant fuzzy soft sets. International Journal of Fuzzy Systems, 2025, 1-15. DOI: 10.1007/s40815-024-01964-0
[44] Stojanović N, Laković M, Djurović L. Decision-making algorithm based on the energy of interval-valued hesitant fuzzy soft sets. Neural Computing and Applications, 2025, 37(16), 9821-9841. DOI: 10.1007/s00521-025-11107-7
[45] Mudrić-Staniškovski L, Spasenić I, Tadić D, Stojanović N. Evaluation and selection of cloud platforms in a fuzzy environment. Journal of Intelligent & Fuzzy Systems: Applications in Engineering and Technology IOS Press, 2025, 18758967251360816. DOI: 10.1177/18758967251360816
[46] Svičević M, Vučićević N, Andrić F, Stojanović N. Analyzing decision-making processes using the energy of bipolar neutrosophic soft sets. International Journal of Intelligent Systems, 2025, (1), 1820548. DOI: 10.1155/int/1820548
[47] Stojanović N, Vučićević N, Dalkılıç O. Decision-making algorithm based on the scored-energy of neutrosophic soft sets. Afrika Matematika, 2025, 36(3), 144. DOI: /10.1007/s13370-025-01366-x