Journal of Operational and Strategic Analytics
https://www.acadlore.com/journals/JOSA

Optimizing Hard Disk Selection via a Fuzzy Parameterized Single-Valued Neutrosophic Soft Set Approach

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Received: 05-09-2023 **Revised:** 06-11-2023 **Accepted:** 06-17-2023

Citation: M. Ihsan, M. Saeed, A. U. Rahman, "Optimizing hard disk selection via a fuzzy parameterized single-valued neutrosophic soft set approach," *J. Oper. Strateg Anal.*, vol. 1, no. 2, pp. 62–69, 2023. https://doi.org/10.56578/josa010203.

Abstract: This study introduces a novel approach to decision-making problems, especially in the context of hard disk selection, using the concept of the fuzzy parameterized single-valued neutrosophic soft set (FP-SVNSS). Primarily, the focus is on assigning different levels of importance to each parameter within the set, which enables a more nuanced and flexible evaluation process. This is underpinned by the development of several related concepts and the definition of basic operations such as complement, subset, union, and intersection. In the quest for clarity, the nuances of these operations and the overall framework of the FP-SVNSS method are illustrated via numerous examples. The superiority of the FP-SVNSS method over other decision-making methods is affirmed through a comprehensive comparison. The unique strength of the proposed approach lies in its ability to handle imperfect, ambiguous, and inconsistent data. Consequently, it offers greater accuracy and practicality than existing models. In the latter part of the study, the theory is put to the test by tackling a real-world decision-making problem. The selected case involves the optimal selection of hard disks, a common issue in information technology procurement. The successful application of the FP-SVNSS method to this issue provides a compelling demonstration of its potential value in practical settings. Through the exploration of this innovative decision-making methodology, this research contributes to the broader field of soft computing and decision-making theory. The findings suggest a myriad of future applications of the FP-SVNSS method in dealing with various complex and fuzzy problems in both academic and industrial contexts.

Keywords: Soft set; Fuzzy soft set; Neutrosophic set; Single-valued neutrosophic soft set; Fuzzy parameterized single-valued neutrosophic soft set

1 Introduction

Decision-making under uncertain circumstances entails making judgments with incomplete information or knowledge about potential outcomes. This is applicable in situations characterized by high levels of risk or ambiguity, where decision-makers must evaluate the probable consequences of various options to make the best choice. Techniques such as decision analysis, game theory, or other decision-making models accounting for elements like risk, probability, and uncertainty can be employed to achieve this. Uncertainty, inaccuracy, and ambiguity are pervasive in the real world, and most encountered problems are, in fact, imprecise rather than specific. The complexity of these issues renders classical methods often ineffective in handling imprecise data. It is widely acknowledged that mathematical theories such as probabilities, fuzzy sets, rough sets, and others are frequently useful in addressing uncertainty [1, 2]. Smarandache [3] introduced the neutrosophic set as a generalization of classical sets, fuzzy sets, and intuitionistic fuzzy sets. The neutrosophic set has been utilized in various fields, including topology, control theory, databases, and medical diagnosis. In a neutrosophic set, indeterminacy is quantified directly, and memberships in truth, indeterminacy, and falsehood are entirely independent of each other. Providing a scientific or technical explanation of the neutrosophic set and set-theoretic view operators is essential; otherwise, submitting genuine applications becomes challenging. Wang et al. [4] first established a single-valued neutrosophic set (SVNS) to demonstrate its various properties and set-theoretic operations. Neutrosophic set (NS) theories and applications, along with their hybrid structures, have progressed.

Molodtsov [5] identified that each of these explanations has its drawbacks. To overcome these issues, Molodtsov proposed a new approach to modeling uncertainty, known as the soft set. Utilization of this theory has benefited numerous domains, including game theory, operations research, measurement theory, probability theory, and smoothness of functions. Cybernetics, machine learning, intelligent systems, information sciences, and other disciplines are similarly affected. Many of these applications are already illustrated in Molodtsov's article [6]. To date, research on soft sets has developed rapidly.

Maji et al. [7] defined several fundamental operations on soft sets. In 2009, Ali et al. [8] proposed several inventive soft set techniques. Maji et al. [9] also developed a fuzzy soft set and demonstrated its use in a decision-making scenario in their example [10]. These definitions have stimulated further investigation into applications of soft set theory. Çağman and Enginoğlu [11, 12] applied soft set theory for decision-making purposes. Chen et al. [13] discussed the parameterization reduction of soft sets and their applications. Concurrently, Feng et al. [14] introduced the use of level soft sets in decision-making based on interval-valued fuzzy soft sets. Jiang et al. [15] provided a novel approach for exploiting interval-valued intuitionistic fuzzy sets in decision-making. Later researchers, such as Feng, Maji, and others, investigated the more general properties and applications of soft set theory; for example, the studies [16, 17]. Soft set theory has been extended by fuzzy soft sets, as mentioned in the studies [18, 19]. Zhan et al. [20] recently introduced rough soft sets to hemi rings for the first time and reported on some rough soft hemi ring properties. Basu et al. [21] offered a reasonable solution to a decision-making issue based on a fuzzy soft set. Some intriguing contemporary applications of soft set theory have combined rough set theory and intuitionistic fuzzy sets. Jiang et al. [22] expanded the adaptable fuzzy soft set decision-making approach. They explicitly offered an adjustable method for generating decisions based on intuitionistic fuzzy soft sets and provided various pertinent examples using level soft sets of intuitionistic fuzzy soft sets. On soft sets, Rahman et al. [23, 24] presented a variety of convexity (concavity) structures. They examined various concavity and convexity qualities in soft set and fuzzy set environments, yielding different results. Ihsan et al. [25, 26] extended the concept of convexity with generalized properties on soft and fuzzy soft expert sets.

Çağman et al. [27] conceptualized the fuzzy parameterized soft set (FPS-set), assigning an essential degree to parameters. Çağman et al. [28] provided a concept of operations on fuzzy parameterized fuzzy soft sets (FPFS-set). The FPSF-set aggregation operator was then designed to construct the FPSF-set decision-making method, enabling the development of more efficient decision-making processes. The t-norms and t-conorms products of fuzzy parameterized fuzzy soft sets were established by Zhu and Zhan [29]. Using these FPFS-sets, the AND-FPFS-set decision-making method and the OR-FPFS-set decision-making method were constructed, respectively. Finally, decision-making strategies were employed to address problems involving uncertainty.

Sulukan et al. [30] proposed the concept of interval-valued fuzzy parameterized soft sets (IVFPSS) as an extension of fuzzy parameterized soft sets. They defined various set-theoretic operations on IVFPSS and showed that these operations possessed some useful properties. They also demonstrated the application of IVFPSS in decision-making problems.

The combination of neutrosophic sets and soft sets has also been investigated in recent years. Jun et al. [31] introduced neutrosophic soft sets and studied their basic properties and operations. They also examined the application of neutrosophic soft sets in decision-making problems. Biswas et al. [32] proposed interval-valued neutrosophic soft sets (IVNSS) as an extension of neutrosophic soft sets and studied their properties and operations. They also demonstrated the application of IVNSS in decision-making scenarios. The combination of neutrosophic sets, soft sets, and other theories has led to the development of various hybrid structures, which have been applied in many fields, including decision-making, optimization, and pattern recognition.

In conclusion, the study of uncertainty and its management in decision-making has led to the development of various mathematical theories and models, such as neutrosophic sets, soft sets, and their extensions. These theories have been applied in numerous domains, including operations research, game theory, control theory, and more. The combination of these theories has resulted in the development of hybrid structures that have been successfully employed in addressing complex real-world problems involving uncertainty, ambiguity, and imprecision. The ongoing research in this area is expected to contribute further to our understanding of uncertainty management and improve our ability to make better decisions under uncertain circumstances.

2 Preliminary

In this section, basic definitions and terms related to the main study are presented, drawing from the existing literature.

Definition 2.1

A single valued neutrosophic set M on $\aleph$ is defined by $M = \{\chi, (|\mathrm{T}_{M(\chi)}, \mathrm{I}_{M(\chi)}, \mathrm{F}_{M(\chi)}) : \chi \in \mathrm{E}, |\mathrm{T}_M, \mathrm{I}_M, \mathrm{F}_M \in [0,1]\}$, where, $\mathrm{T}_M, \mathrm{I}_M, \mathrm{F}_M$ represent membership, indeterminacy, and non-membership functions, respectively, and $0 \leq |\mathrm{T}_{M(\chi)} + \mathrm{I}_{M(\chi)} + \mathrm{F}_{M(\chi)}| \leq 3$.

Definition 2.2

Let the collection of parameters be denoted by ∇, and let $\mho$ represents the universe with power set P ($\mho$). Then $\mathrm{T} = \{\alpha^{\mathrm{f}(\alpha):\alpha\in\nabla}\}$ represents a fuzzy set, h: $\nabla \rightarrow \mathrm{Y} = [0,1]$, and $\mathrm{h}(\alpha) = \{\eta^{\mu(\alpha),v(\alpha)} : \alpha \in \nabla\}$ is referred to an intuitionistic fuzzy set over $\mho$. Then $\mathrm{R} = \{(\alpha^{\mathrm{f}(\alpha)}, \mathrm{h}(\alpha) : \alpha \in \nabla)\}$ is termed as a fuzzy parameterized intuitionistic fuzzy soft set, where, h (a) represents the approximate function of the *R*.

Definition 2.3

A FPIFS-set $\check{\mathrm{C}}$ is considered a subset of another FPIFS-set $\tilde{\mathrm{N}}$ if h_1 (a) $\subseteq$ h_2 (a) and f_1 (a) $\leq$ f_2 (a) for all $\mathrm{a} \in \nabla$.

Definition 2.4

A FPIFS-set $\check{\mathrm{C}}$ is considered equal to another FPIFS-set $\tilde{\mathrm{N}}$ if $\mathrm{h}_1(\mathrm{a}) = \mathrm{h}_2(\mathrm{a})$ and $\mathrm{f}_1(\mathrm{a}) = \mathrm{f}_2(\mathrm{a})$ for all $\mathrm{a} \in \nabla$.

Definition 2.5

The union of two FPIFS-sets $\check{\mathrm{C}}$ and $\tilde{\mathbf{N}}$ is given by: $\check{\mathrm{C}} \cup \tilde{\mathrm{N}} = \{(\mathrm{b}^{\max\{\mathrm{f1(a)},\mathrm{f1(a)}\}}, \mathrm{h}_1(\mathrm{a}) \cup \mathrm{h}_2(\mathrm{a}))\}$.

Definition 2.6

The intersection of two FPIFS-sets $\check{\mathrm{C}}$ and $\tilde{\mathbf{N}}$ is given by: $\check{\mathrm{C}} \cap \tilde{\mathrm{N}} = \{(\mathrm{b}^{\min\{\mathrm{f1(a)},\mathrm{f1(a)}\}}, \mathrm{h}_1(\mathrm{a}) \cap \mathrm{h}_2(\mathrm{a}))\}$.

3 Methodology

A decision-making approach focusing on multi-attribute decision making is employed for the selection process. The innovative technology of fuzzy parameterized single-valued neutrosophic soft sets is utilized, with relevant concepts explored to establish the methodology which is shown in Figure 1.

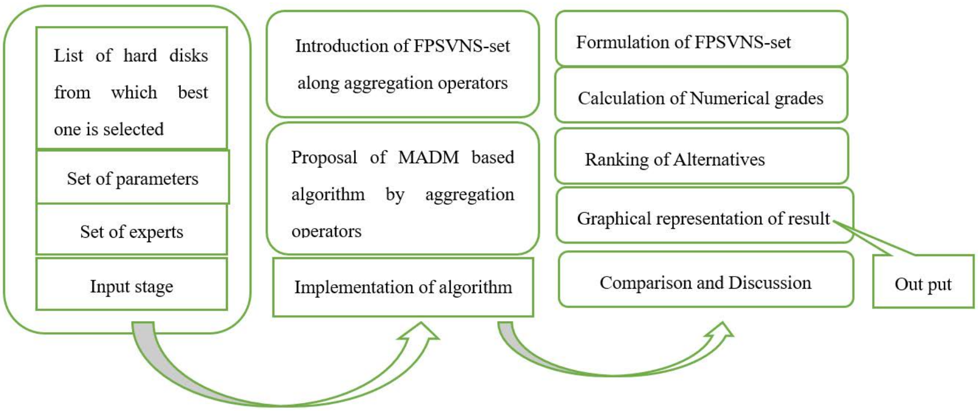

Figure 1. Graphical representation of proposed decision support framework

Definition 3.1

A fuzzy parameterized single-valued neutrosophic soft set can be considered as a pair $(\mathrm{F}, \nabla)_\Omega$ over $\mho$, where F_Ω is a mapping defined as $\mathrm{F}_{\Omega:}\nabla \rightarrow \mathrm{N}$ ($\mho$), and N ($\mho$) represents the set of all single-valued neutrosophic subsets of $\mho$.

Consider a scenario where a hotel chain seeks a construction company for modernization to keep up with globalization, and requests the advice of experts. Let $\mho = \{\mathrm{O}_1, \mathrm{O}_2\}$ be a set of construction companies, and the distinct attributes set be $\{< \Gamma_1 = \text{cheap}, \Gamma_2 = \text{standard}, \Gamma_3 = \text{good service}, \Gamma_4 = \text{quality}, \Gamma_5 = \text{location}\}$. Let $\{< \Gamma_1/0.2, \Gamma_2/0.3, \Gamma_3/0.4, \Gamma_4/0.5, \Gamma_5/0.6\}$ be the fuzzy subset of $\mathrm{I}^{\mho}$ (set of fuzzy subsets of $\mho$). The following survey depicts choices of three experts:

$$\begin{aligned}
\mathrm{F}(\Gamma_1/0.2) &= \{\mathrm{O}_1/ < 0.2, 0.3, 0.4 >, \mathrm{O}_2/ < 0.1, 0.5, 0.4 >\},\\
\mathrm{F}(\Gamma_2/0.3) &= \{\mathrm{O}_1/ < 0.1, 0.3, 0.7 >, \mathrm{O}_2/ < 0.1, 0.6, 0.4 >\},\\
\mathrm{F}(\Gamma_3/0.4) &= \{\mathrm{O}_1/ < 0.4, 0.1, 0.5 >, \mathrm{O}_2/ < 0.3, 0.2, 0.8 >\},\\
\mathrm{F}(\Gamma_4/0.5) &= \{\mathrm{O}_1/ < 0.5, 0.6, 0.8 >, \mathrm{O}_2/ < 0.3, 0.8, 0.9 >\},\\
\mathrm{F}(\Gamma_5/0.6) &= \{\mathrm{O}_1/ < 0.9, 0.3, 0.6 >, \mathrm{O}_2/ < 0.5, 0.5, 0.4 >\}.
\end{aligned}$$

The fuzzy parameterized single-valued neutrosophic soft set can be described as:

$$(\mathrm{S}, \mho) = \left\{ \begin{array}{l}
\left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.2,0.3,0.4\rangle}, \frac{O_2}{\langle 0.1,0.4,0.5\rangle}, \right\}\right)\\
\left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.7\rangle}, \frac{O_2}{\langle 0.1,0.6,0.4\rangle}, \right\}\right)\\
\left((\Gamma_3/0.4), \left\{\frac{O_1}{\langle 0.4,0.1,0.5\rangle}, \frac{O_2}{\langle 0.3,0.2,0.8\rangle}, \right\}\right)\\
\left((\Gamma_4/0.5), \left\{\frac{O_1}{\langle 0.5,0.6,0.8\rangle}, \frac{O_2}{\langle 0.3,0.8,0.9\rangle}, \right\}\right)\\
\left((\Gamma_5/0.6), \left\{\frac{O_1}{\langle 0.9,0.3,0.6\rangle}, \frac{O_2}{\langle 0.5,0.4,0.4\rangle}, \right\}\right)
\end{array} \right\}.$$

Definition 3.2

A fuzzy parameterized single-valued neutrosophic soft set (S, W) is said to be a subset of another fuzzy parameterized single-valued neutrosophic set (R, Y) if (i) W is a subset of Y, and (ii) S(d) is a single-valued neutrosophic subset of Y(d) for all d in S.

Definition 3.3

The complement of a fuzzy parameterized single-valued neutrosophic subset $(\mathrm{S}, \mathrm{W})^{\mathrm{C}}$ is denoted by ḉ(S (β)) for all β belonging to $\mho$, where ḉ represents a single-valued neutrosophic complement. The complement of the aforementioned fuzzy parameterized single-valued neutrosophic set is:

$$(\mathrm{S}, \mho)^c = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.4,0.7,0.2\rangle}, \frac{O_2}{\langle 0.9,0.6,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.7,0.7,0.3\rangle}, \frac{O_2}{\langle 0.4,0.4,0.1\rangle},\right\}\right) \\ \left((\Gamma_3/0.4), \left\{\frac{O_1}{\langle 0.5,0.9,0.4\rangle}, \frac{O_2}{\langle 0.8,0.8,0.3\rangle},\right\}\right) \\ \left((\Gamma_4/0.5), \left\{\frac{O_1}{\langle 0.8,0.4,0.5\rangle}, \frac{O_2}{\langle 0.9,0.2,0.3\rangle},\right\}\right) \end{array} \right\}.$$

Definition 3.4

The union of two fuzzy parameterized single-valued neutrosophic soft sets (S, W) and (R, Y) is defined as: u(S(β), R(β))={$< \mathrm{a}, \max\{\mathrm{p}_1(\beta), \mathrm{p}_2(\beta)\}, \min\{\mathrm{q}_1(\beta), \mathrm{q}_2(\beta)\}, \min\{\mathrm{r}_1(\beta), \mathrm{r}_2(\beta)\} >$}.

$$(\mathrm{S}, \mathrm{A}) = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.2,0.3,0.4\rangle}, \frac{O_2}{\langle 0.1,0.4,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.7\rangle}, \frac{O_2}{\langle 0.1,0.6,0.4\rangle},\right\}\right) \\ \left((\Gamma_3/0.4), \left\{\frac{O_1}{\langle 0.4,0.1,0.5\rangle}, \frac{O_2}{\langle 0.3,0.2,0.8\rangle},\right\}\right) \end{array} \right\},$$

$$(\mathrm{U}, \mathrm{B}) = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.1,0.3,0.2\rangle}, \frac{O_2}{\langle 0.1,0.6,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.9\rangle}, \frac{O_2}{\langle 0.1,0.3,0.4\rangle},\right\}\right) \end{array} \right\}.$$

The union of two FPSVN-sets can be calculated as:

$$(\mathrm{V}, \mathrm{C}) = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.2,0.3,0.2\rangle}, \frac{O_2}{\langle 0.1,0.4,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.7\rangle}, \frac{O_2}{\langle 0.1,0.3,0.4\rangle},\right\}\right) \\ \left((\Gamma_3/0.4), \left\{\frac{O_1}{\langle 0.4,0.1,0.5\rangle}, \frac{O_2}{\langle 0.3,0.2,0.8\rangle},\right\}\right) \end{array} \right\}.$$

Definition 3.5

The intersection of two fuzzy parameterized single-valued neutrosophic soft sets (S, W) and (R, Y) is defined as: $\mathrm{u}(\mathrm{S}(\beta), \mathrm{R}(\beta)) = \{< \mathrm{a}, \min\{\mathrm{p}_1(\beta), \mathrm{p}_2(\beta)\}, \max\{\mathrm{q}_1(\beta), \mathrm{q}_2(\beta)\}, \max\{\mathrm{r}_1(\beta), \mathrm{r}_2(\beta)\} >\}$.

$$(\mathrm{S}, \mathrm{A}) = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.2,0.3,0.4\rangle}, \frac{O_2}{\langle 0.1,0.4,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.7\rangle}, \frac{O_2}{\langle 0.1,0.6,0.4\rangle},\right\}\right) \\ \left((\Gamma_3/0.4), \left\{\frac{O_1}{\langle 0.4,0.1,0.5\rangle}, \frac{O_2}{\langle 0.3,0.2,0.8\rangle},\right\}\right) \end{array} \right\},$$

$$(\mathrm{U}, \mathrm{B}) = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.1,0.3,0.2\rangle}, \frac{O_2}{\langle 0.1,0.6,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.9\rangle}, \frac{O_2}{\langle 0.1,0.3,0.4\rangle},\right\}\right) \end{array} \right\}.$$

The intersection of these two FSVN-sets can be defined as:

$$(\mathrm{V}, \mathrm{C}) = \left\{ \begin{array}{l} \left((\Gamma_1/0.2), \left\{\frac{O_1}{\langle 0.1,0.3,0.4\rangle}, \frac{O_2}{\langle 0.1,0.6,0.5\rangle},\right\}\right) \\ \left((\Gamma_2/0.3), \left\{\frac{O_1}{\langle 0.1,0.3,0.9\rangle}, \frac{O_2}{\langle 0.1,0.6,0.4\rangle},\right\}\right) \end{array} \right\}.$$

3.1 Decision-making Application

This subsection demonstrates the application of fuzzy parameterized single-valued neutrosophic soft set theory to a decision-making problem. Suppose a business requires hard drives for its workstation computers. To make a purchase, the office manager seeks assistance from computer experts, who analyze various factors, such as buffer memory, access times, platter diameter, spindle speed, drive form factor, and disk partitioning.

The function of parameters is explained as follows:

(1) Disk Partitioning: The process of dividing a secondary storage device into one or more manageable areas called partitions. Partition editors are used by system administrators to create, resize, delete, and manipulate partitions.

(2) Buffer Memory: A short-term storage space for data being transferred between two or more devices or between an application and a device. Buffering compensates for discrepancies in data transfer speeds.

(3) Access Time: The total time required for a computer to request and receive data. It is typically measured in nanoseconds or milliseconds.

(4) Platter Diameter: The size of the platter, which varies depending on the type of food it holds. A standard oval plate measures approximately 14 inches wide and 10 inches across, while a typical round platter measures between 10 and 12 inches in diameter.

(5) Spindle Speed: The rotating frequency of the machine's spindle, expressed in revolutions per minute (RPM). The preferred speed is determined by working backward from the desired surface speed and taking the diameter into account.

(6) Drive Form Factor: The physical size and shape of a hard drive, which determines its compatibility with various devices and systems. Common form factors include 3.5-inch (desktop), 2.5-inch (laptop), and 1.8-inch (ultra-portable).

3.2 Proposed Algorithm

An algorithm utilizing the aggregation operators of the fuzzy parameterized single-valued neutrosophic sets is proposed and is shown in Figure 2.

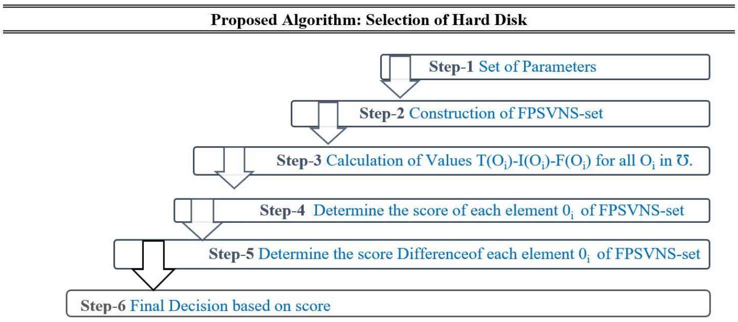

Figure 2. A proposed algorithm

Step-1: Let $\Pi = \{\kappa_1, \kappa_2, \kappa_3, \kappa_4\}$ represent the universe set and $\partial_1, \partial_2, \partial_3, \partial_4, \partial_5, \partial_6$ denote the set of parameters. Define $\partial_1/0.2, \partial_2/0.4, \partial_3/0.5, \partial_4/0.6, \partial_5/0.7, \partial_6/0.8$, as the fuzzy subsets of $\mathrm{I}^{\mho}$ (the set of fuzzy subsets of $\mho$). The fuzzy parameterized single-valued neutrosophic soft set can be described as follows:

$$(\mathrm{N}, \mathrm{M}) = \left\{ \begin{array}{l} \left((\partial_1/0.2), \left\{ \frac{\kappa_1}{\langle 0.3,0.4,0.6 \rangle}, \frac{\kappa_2}{\langle 0.1,0.4,0.5 \rangle}, \frac{\kappa_3}{\langle 0.3,0.1,0.4 \rangle}, \frac{\kappa_4}{\langle 0.5,0.4,0.2 \rangle} \right\} \right) \\ \left((\partial_2/0.4), \left\{ \frac{\kappa_1}{\langle 0.3,0.1,0.4 \rangle}, \frac{\kappa_2}{\langle 0.6,0.4,0.3 \rangle}, \frac{\kappa_3}{\langle 0.4,0.5,0.3 \rangle}, \frac{\kappa_4}{\langle 0.1,0.2,0.5 \rangle} \right\} \right) \\ \left((\partial_3/0.5), \left\{ \frac{\kappa_1}{\langle 0.7,0.5,0.4 \rangle}, \frac{\kappa_2}{\langle 0.4,0.6,0.2 \rangle}, \frac{\kappa_3}{\langle 0.6,0.3,0.4 \rangle}, \frac{\kappa_4}{\langle 0.8,0.6,0.4 \rangle} \right\} \right) \\ \left((\partial_4/0.6), \left\{ \frac{\kappa_1}{\langle 0.1,0.4,0.2 \rangle}, \frac{\kappa_2}{\langle 0.4,0.2,0.1 \rangle}, \frac{\kappa_3}{\langle 0.2,0.1,0.5 \rangle}, \frac{\kappa_4}{\langle 0.5,0.2,0.1 \rangle} \right\} \right) \\ \left((\partial_5/0.7), \left\{ \frac{\kappa_1}{\langle 0.5,0.1,0.9 \rangle}, \frac{\kappa_2}{\langle 0.5,0.4,0.4 \rangle}, \frac{\kappa_3}{\langle 0.7,0.4,0.1 \rangle}, \frac{\kappa_4}{\langle 0.9,0.2,0.3 \rangle} \right\} \right) \\ \left((\partial_5/0.8), \left\{ \frac{\kappa_1}{\langle 0.7,0.3,0.3 \rangle}, \frac{\kappa_2}{\langle 0.8,0.2,0.5 \rangle}, \frac{\kappa_3}{\langle 0.9,0.2,0.5 \rangle}, \frac{\kappa_4}{\langle 0.8,0.2,0.5 \rangle} \right\} \right) \end{array} \right\}.$$

Step-2: In this step, Table 1 is constructed for the values of $|\mathrm{T}(\mathrm{o_i}) - \mathrm{I}(\mathrm{o_i}) - \mathrm{F}(\mathrm{o_i})|$.

Table 1. Values of $|\mathrm{T}(\mathrm{o_i}) - \mathrm{I}(\mathrm{o_i}) - \mathrm{F}(\mathrm{o_i})|$

Pairs	$\boldsymbol{k}_1$	$\boldsymbol{k}_2$	$\boldsymbol{k}_3$	$\boldsymbol{k}_4$
$(\partial_1/0.2)$	0.7	0.8	0.2	0.1
$(\partial_2/0.4)$	0.2	0.1	0.4	0.6
$(\partial_3/0.5)$	0.2	0.4	0.1	0.2
$(\partial_4/0.6)$	0.5	0.1	0.6	0.2
$(\partial_5/0.7)$	0.5	0.3	0.2	0.4
$(\partial_6/0.8)$	0.1	0.1	0.2	0.1

Step-3: In this step, Table 2 is constructed for the numerical grades of the FPSVNS-set.

Table 2. Calculation of numerical grades of FPSVNS-set

Pairs	$\boldsymbol{k_i}$	Numerical Grades
$(\partial_1/0.2)$	$\boldsymbol{k_2}$	0.8
$(\partial_2/0.4)$	$\boldsymbol{k_4}$	0.6
$(\partial_3/0.5)$	$\boldsymbol{k_2}$	0.4
$(\partial_4/0.6)$	$\boldsymbol{k_3}$	0.6
$(\partial_5/0.7)$	$\boldsymbol{k_1}$	0.5
$(\partial_6/0.8)$	$\boldsymbol{k_3}$	0.2

Step-(4-5): The numerical grades of the FPSVNS-set are calculated in these steps.

Table 3. Calculation of numerical grades of FPSVNS-set

Scores	$\boldsymbol{k_i}$	Addition
SCR (k_l)	k_1	0.5
SCR (k_2)	k_2	$0.8 + 0.4 = 1.2$
SCR (k_3)	k_3	$0.6 + 0.2 = 0.8$
SCR (k_4)	k_4	0.6

Step-6: The final decision is made by selecting the highest score of the alternative. Since the score of k_2 is the highest in Table 3, k_2 is selected. The ranking of the alternatives is depicted in Figure 3.

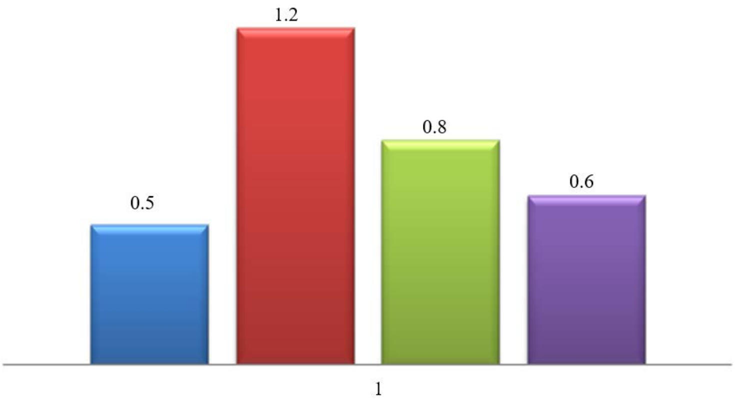

Figure 3. Ranking of alternatives

4 Discussion and Comparison Analysis

The FPSVN-set exhibits superior resemblance, accuracy, and acceptability when compared to existing soft set-like models. A comparison of FPSVNS-sets with other structures is presented to demonstrate this assertion. The proposed model offers more advantages than its counterparts, primarily due to the incorporation of the single-argument approximate function, which proves particularly useful in decision-making scenarios. A comparison analysis is provided in Table 4.

Table 4. Comparison analysis

Models	Truthiness	Indeterminacy	Falsity	Parameterization
FPS-set [27]	No	No	No	Yes
FPFS-set [28]	Yes	No	No	Yes
FPIFS-set [29]	Yes	No	Yes	Yes
Proposed Model	Yes	Yes	Yes	Yes

5 Conclusions

The concept of neutrosophic soft sets has been extended to formulate the notion of fuzzy parameterized single-valued neutrosophic soft sets. Basic operations on fuzzy parameterized single-valued neutrosophic soft sets, such as complement, subset, union, and intersection operations, have been defined. Subsequently, the fundamental characteristics of these operations and pertinent laws relating to the concept of fuzzy parameterized single-valued neutrosophic soft sets have been established.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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