An Innovative Approach to Fuzzy Soft Set Based Investment Framework Using Machine Learning Algorithm

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1 Introduction

Useful applications of soft set theory (SST) [20], mainly its use in economics, computational intelligence, and data engineering, have gained prominence. Since classical mathematical techniques are insufficient to explain many complex problems in these fields, vague principles have been used in recent years in various fields such as information technology, computer applications, pharmacology, medicine, engineering, etc. Since the classification of objects in SST [20] is not constrained, researchers may select the various types of parameters they want, significantly simplifying the decision-making (DM) process and making it more capable in the lack of incomplete knowledge. While several mathematical methods for dealing with uncertainties are available, such as fuzzy set [34], probability theory, interval-valued mathematics, and so on, each of these techniques has its own set of challenges. Furthermore, all of these methods are deficient in the parameterization of tools, which means they cannot be used to solve problems, especially in the economic, environmental, and social realms. In the sense that it is clear of the aforementioned difficulties, SST [20] stands out. Molodstov [20] proposed soft set theory (SST) as a numerical method for modeling with uncertainties. Maji et al. [16] went on to present several new concepts on SST, such as intersection, union, complements, and subset, as well as a detailed discussion of the use of SST in DMPs. Ali et al. [1] provided several definitions on SST and shown that De Morgan's conditions satisfied in SST to these novel operations. Maji et al. [17] had shown the applications based on SST in DMPs. Thereafter,

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several researchers doing their innovative research work in this theory and applied in various field. Recently, Zhan and Alcantud [35] introduced the concept of soft rough covering and demonstrated how it can be used in DMPs. Rajput et al. [28] defined soft almost ββ-continuity in soft topological spaces. Dalkılıç [4] introduced a novel approach to SST-based DM under uncertainty.

Since Zadeh [34] introduced the idea of fuzzy sets, several new approaches and theories for dealing with imprecision and ambiguity have been proposed. Deng and Jiang [8] presented the D number-based game theory and adversarial DM in a fuzzy situation. Mandal and Ranadive [18] introduced the concept of multi granulation fuzzy probabilistic rough sets and their applications in DM. Thereafter, Wan Mohd et al. [33] presented a DM method using the Pythagorean fuzzy sets. Li et al. [14] described the method of uncertainty using the Gaussian kernel. Maji et al. [15] described FSS by combining soft set [20] and fuzzy set [34], which have a lot of prospective for solving DMPs. The applications of FSS theory have been gradually concentrated by using these concepts. Roy and Maji [29] first proposed FSS base DM. Thereafter, Kong et al. [12] provided an FSS theoretic approach to DMPs and Feng et al. [9] introducing an advanced and adjustable method to solve FSS-based DMPs. Thereafter, Zhu and Zhan [36] described and presented the t-norm operations on fuzzy parameterized FSSs, as well as their applications in DM. Vimala et al. [32] studied the fuzzy soft cardinality in lattice ordered fuzzy soft groups as well as shown their applications in DMPs. Peng and Li [26] proposed an algorithm for hesitant fuzzy soft DM using revised aggregation operations. Shakila and Selvi [30] had written a note on fuzzy soft paraopen sets and maps in fuzzy soft topological space (FSTS) and Nihal [23] studied the concept of pasting lemma on an FSTS with mixed structure. Lathamaheswari et al. [13] provided the concept of triangular interval type-2 FSS and also shown its applications. Petchimuthu et al. [27] defined the generalized products and mean operations of fuzzy soft matrices as well as discussed their applications in DMPs. Smarandache et al. [31] reviewed the concepts FSTS, intuitionistic FSTS, and neutrosophic soft topological spaces. Paik and Mondal [24] introduced a distance-similarity technique using fuzzy sets and FSSs. Chinram et al. [3] introduced some geometric aggregation functions under q-rung orthopair FSS as well as their applications in MCDM. Deli and Çağman [7] presented intuitionistic fuzzy parameterized soft set theory and its application in DM and Jamkhaneh and Nadarajah [11] developed a new generalized intuitionistic fuzzy set. Mukherjee and Das [21, 22] proposed fuzzy soft multi sets based DM problems as well as interval valued intuitionistic fuzzy soft set in investment DM. Paik and Mondal [25] had shown the applications of FSSs in a type-2 environment. Močkoř and Hurtik [19] used the concept FSSs in image processing applications. Gao and Wu [10] defined filter and also applied in FSTSs. Dalkılıç and Demirtaş [5] introduced the idea of bipolar fuzzy soft D-metric spaces. Dalkiliç [6] defined topology on virtual fuzzy parametrized-FSSs. Bhardwaj and Sharma [2] described an advanced uncertainty measure using FSSs and shown its application in DMPs.

In this research, we have introduced a new approach focused on FSS for an investing plan in a risky situation. First, we will go through some concepts and outcomes that will help us continue our discussion, then we have defined TNP and

TCP on FAVSs of an FSS, and applying these two products we present a strategy based on an FSS. In the end, we discuss the use of an FSS in IDM and numerical examples demonstrate the viability of our proposed FSS-based strategy in practice.

2 Preliminary

In this part, we will go through some basic concepts and outcomes that will help us think more deeply. Let V represents a universe and Q represents a collection of decision attributes with D ⊆ Q. Also, let P(V) means the power set of V.

Definition 2.1 [34] A fuzzy set (simply, FS) Y on V is of the form $Y = \{(d,\ \mu_Y(d)) : d \in V\}$, where $\mu_Y : V \to [0,\ 1]$ is called the membership function and $\mu_Y(d)$ means the membership value (MV) of $d \in V$.

If $\forall d \in V$, $\mu_Y(d) = 1$, then Y becomes a crisp set. Let FS(V) means the collection of all fuzzy subsets of V and $X_1, X_2, X_3, X_4 \in FS(V)$.

Definition 2.2 [36] t-norm is monotonic, associative, and commutative function t: [0,1] × [0,1] → [0,1] such that

(a) $t(0, 0) = 0$ and $t(1, \mu_{X_1}(d)) = \mu_{X_1}(d),\ d \in V$;

(b) If $\mu_{X_1}(d) \le \mu_{X_3}(d)$ and $\mu_{X_2}(d) \le \mu_{X_4}(d)$, then $t(\mu_{X_1}(d), \mu_{X_2}(d)) \le t(\mu_{X_3}(d), \mu_{X_4}(d))$;

(c) $t(\mu_{X_1}(d), \mu_{X_2}(d)) = t(\mu_{X_2}(d), \mu_{X_1}(d))$;

(d) $t(\mu_{X_1}(d), t(\mu_{X_2}(d), \mu_{X_3}(d))) = t(t(\mu_{X_1}(d), \mu_{X_2}(d)), \mu_{X_3}(d))$.

Definition 2.3 [36] t-conorm is associative, monotonic, and commutative function s: [0,1] × [0,1] → [0,1], such that

(a) $s(1, 1) = 1$ and $s(0, \mu_{X_1}(d)) = s(\mu_{X_1}(d), 0) = \mu_{X_1}(d),\ d \in V$;

(b) If $\mu_{X_1}(d) \le \mu_{X_3}(d)$ and $\mu_{X_2}(d) \le \mu_{X_4}(d)$, then $s(\mu_{X_1}(d), \mu_{X_2}(d)) \le s(\mu_{X_3}(d), \mu_{X_4}(d))$;

(c) $s(\mu_{X_1}(d), \mu_{X_2}(d)) = s(\mu_{X_2}(d), \mu_{X_1}(d))$;

(d) $s(\mu_{X_1}(d), s(\mu_{X_2}(d), \mu_{X_3}(d))) = s(s(\mu_{X_1}(d), \mu_{X_2}(d)), \mu_{X_3}(d))$.

Definition 2.4 [20] Soft set on V refers to a couple (*F, D*), where *F: D → P(V)* is a function.

Definition 2.5 [15] A pair (ψ, D) is said to be an FSS over V, where $\psi : D \to FS(V)$ is a mapping.

The FAVS of the parameter o is referred to as ψ(o) for any o ϵ D, and it can be written as

$$\Psi(o) = \left\{ \frac{d}{\mu_{\Psi(o)}(d)} : d \in V \right\},$$

where $\mu_{\Psi(o)}(d)$ is the fuzzy MV of the element (object) d holds on the parameter o ϵ D.

Simply, $FAVS(\Psi, D) = \{\Psi(o) : o \in D\}$.

3 TNP and TCP on $FAVS(\Psi, D)$

In this part, we define the *TNP* and *TCP* on $FAVS(\Psi, D)$. Let $(\Psi,\ D)$ be an FSS over (V, Q) and let $\Psi(o_1), \Psi(o_2), ..., \Psi(o_n) \in FAVS(\Psi, D)$.

Definition 3.1 *TNP* is denoted by $\Psi(o_1) \otimes \Psi(o_2) \otimes .... \otimes \Psi(o_n)$ and defined as

$$\Psi(o_1) \otimes \Psi(o_2) \otimes .... \otimes \Psi(o_n) = \left\{ \frac{d}{\mu_{\Psi(o_1)\otimes\Psi(o_2)\otimes....\otimes\Psi(o_n)}(d)} : d \in V \right\}$$

where

$$\mu_{\Psi(o_1)\otimes\Psi(o_2)\otimes....\otimes\Psi(o_n)}(d) = \frac{\mu_{\Psi(o_1)}(d).\mu_{\Psi(o_2)}(d)...\mu_{\Psi(o_n)}(d)}{n - [\mu_{\Psi(o_1)}(d) + \mu_{\Psi(o_2)}(d) + ... + \mu_{\Psi(o_n)}(d) - \mu_{\Psi(o_1)}(d).\mu_{\Psi(o_2)}(d)...\mu_{\Psi(o_n)}(d)]}$$

Definition 3.2 *TCP* is denoted by $\Psi(o_1) \oplus \Psi(o_2) \oplus .... \oplus \Psi(o_n)$ and defined as

$$\Psi(o_1) \oplus \Psi(o_2) \oplus .... \oplus \Psi(o_n) = \left\{ \frac{d}{\mu_{\Psi(o_1)\oplus\Psi(o_2)\oplus....\oplus\Psi(o_n)}(d)} : d \in V \right\}$$

where

$$\mu_{\Psi(o_1)\oplus\Psi(o_2)\oplus....\oplus\Psi(o_n)}(d) = \frac{\mu_{\Psi(o_1)}(d) + \mu_{\Psi(o_2)}(d) + ... + \mu_{\Psi(o_n)}(d)}{n + \mu_{\Psi(o_1)}(d).\mu_{\Psi(o_2)}(d)...\mu_{\Psi(o_n)}(d)}$$

4 FSS-Based IDM

In this present sec., we propose our IDM based on FSS.

Algorithm 1

Step 1. Enter the (resultant) FSS (Ψ, D).
Step 2. Enter the preference of investment-factors $o_1, o_2, ..., o_n \in D$ by the investor.
Step 3. Obtain the *TNP* (or *TCP*) on $\Psi(o_1), \Psi(o_2), ..., \Psi(o_n) \in FAVS(\Psi, D)$.
Step 4. The optimal decision is to select d_k if the membership value (MV) of d_k i.e. $\mu_{\Psi(o_1)\otimes\Psi(o_2)\otimes....\otimes\Psi(o_n)}(d_k)$ is maximized.
Step 5. If d_k has more than one value then any one of d_k may be chosen.

5 Result and Discussions

To apply the concept of *FSS* in IDM problems, we select the following investment-factors which manipulate the investment plan and different avenues that prefer by an investor.

5.1 Investment-Factors (IFs)

Following are the most important investment-factors that influence the investment plan:

IF1 = Interest rates
IF2 = High returns
IF3 = Stable return
IF4 = Minimum risk
IF5 = Tax concession
IF6 = Easy accessibility
IF7 = Max profit in short time
IF8 = Safety of funds
IF9 = Technological developments
IF10 = Government policy

5.2 Investment-Avenues (IAs):

Some most important avenues that are mostly preferred by investors are as follows:

IA_1—Recurring Deposits
IA_2—Public Provident Fund (PPF)
IA_3—National Pension Scheme (NPS)
IA_4—Gold
IA_5—Mutual Fund
IA_6—Shares and Stocks
IA_7—Bank Deposit
IA_8—Postal Savings
IA_9—Insurance
IA_{10}—Employee Provident Fund (EPF)

To apply FSS in IDM, we have considered the different avenues as a universal set $V = \{IA_1, IA_2, IA_3, IA_4, IA_5, IA_6\}$ and the factors as a set of parameters $Q = \{IF1, IF2, IF3, IF4, IF5, IF6, IF7, IF8, IF9, IF10\}$ and let $D = \{IF1, IF2, IF3, IF4, IF5\} \subseteq Q$.

Also, we consider an FSS (Ψ, D) as in Table 1.

Table 1 The FSS (Ψ, D)

V	ψ(IF1)	ψ(IF2)	ψ(IF3)	ψ(IF4)	ψ(IF5)
IA_1	0.85	0.5	0.45	0.85	0.75
IA_2	0.8	0.6	0.35	0.8	0.9
IA_3	0.85	0.5	0.45	0.7	0.9
IA_4	0.4	0.6	0.9	0.6	0.1
IA_5	0.5	0.6	0.7	0.6	0
IA_6	0.8	0.8	0.7	0.9	0

We are developed an IDM model using *TNP* and *TCP* by selecting a set of factors from $FAVS(\Psi, D)$ chosen by an investor to classify the avenue that suits the best requirements.

Example 5.3 Let the preferences of factors by an investor Mr. Singh are as follows:

(i) High returns (IF2),
(ii) Stable return (IF3) and
(iii) Tax concession (IF5).

Then we have the *TNP* $\Psi(IF2) \otimes \Psi(IF3) \otimes \Psi(IF5)$ as in Table 2 and *TCP* $\Psi(IF2) \oplus \Psi(IF3) \oplus \Psi(IF5)$ as shown in Table 3.

Here IA_3 has the highest MV, i.e. $\mu_{\Psi(IF2)\otimes\Psi(IF3)\otimes\Psi(IF5)}(IA_3) = 0.15$, so the NSP is the best suit for Mr. Singh.

Table 2 TNP-$\Psi(IF2) \otimes \Psi(IF3) \otimes \Psi(IF5)$

V	ψ(IF2)	ψ(IF3)	ψ(IF5)	$\Psi(IF2) \otimes \Psi(IF3) \otimes \Psi(IF5)$
IA_1	0.5	0.45	0.75	0.115
IA_2	0.6	0.35	0.9	0.141
IA_3	0.5	0.45	0.9	0.15
IA_4	0.6	0.9	0.1	0.037
IA_5	0.6	0.7	0	0
IA_6	0.8	0.7	0	0

Table 3 TCP-$\Psi(IF2) \oplus \Psi(IF3) \oplus \Psi(IF5)$

V	ψ(IF2)	ψ(IF3)	ψ(IF5)	$\Psi(IF2) \oplus \Psi(IF3) \oplus \Psi(IF5)$
IA_1	0.5	0.45	0.75	0.536
IA_2	0.6	0.35	0.9	0.58
IA_3	0.5	0.45	0.9	0.575
IA_4	0.6	0.9	0.1	0.524
IA_5	0.6	0.7	0	0.433
IA_6	0.8	0.7	0	0.5

Here IA_2 has the highest MV, i.e., 0.58, so in this case, the PPF is the best suit for Mr. Singh.

Similarly, an investor's preference of investment-avenue may be based on any set of investment-factors that the investor prefers.

Example 5.4 If the preferences of factors by another investor Mrs. Singh are

(i) Interest rates (IF1),
(ii) Stable return (IF3),
(iii) Minimum risk (IF4) and
(iv) Tax concession (IF5).

Then we have the *TNP* $\Psi(IF1) \otimes \Psi(IF3) \otimes \Psi(IF4) \otimes \Psi(IF5)$ as in Table 4 and also *TCP* $\Psi(IF1) \oplus \Psi(IF3) \oplus \Psi(IF4) \oplus \Psi(IF5)$ as shown in Table 5.

Here IA_1 has the highest MV, i.e., 0.182, so recurring deposit is the best suit for the requirement of Mrs. Singh.

Here IA_3 has the greatest MV, i.e., 0.6840, so NSP is the best suit for the requirement of Mrs. Singh.

Advantages 5.6: By employing Algorithm1, we can be able to obtain a smaller number of object options, allowing us to settle the IDM more effortlessly. However, by using our method, we can obtain more comprehensive data, which will help leaders in their decision-making.

Table 4 TNP-$\Psi(IF1) \otimes \Psi(IF3) \otimes \Psi(IF4) \otimes \Psi(IF5)$

V	ψ(IF1)	ψ(IF3)	ψ(IF4)	ψ(IF5)	$\Psi(IF1) \otimes \Psi(IF3) \otimes \Psi(IF4) \otimes \Psi(IF5)$
IA_1	0.85	0.45	0.85	0.75	0.182
IA_2	0.8	0.35	0.8	0.9	0.149
IA_3	0.85	0.45	0.7	0.9	0.179
IA_4	0.4	0.9	0.6	0.1	0.011
IA_5	0.5	0.7	0.6	0	0
IA_6	0.8	0.7	0.9	0	0

Table 5 TCP-$\Psi(IF1) \oplus \Psi(IF3) \oplus \Psi(IF4) \oplus \Psi(IF5)$

V	ψ(IF1)	ψ(IF3)	ψ(IF4)	ψ(IF5)	$\Psi(IF1) \oplus \Psi(IF3) \oplus \Psi(IF4) \oplus \Psi(IF5)$
IA_1	0.85	0.45	0.85	0.75	0.683
IA_2	0.8	0.35	0.8	0.9	0.678
IA_3	0.85	0.45	0.7	0.9	0.684
IA_4	0.4	0.9	0.6	0.1	0.497
IA_5	0.5	0.7	0.6	0	0.45
IA_6	0.8	0.7	0.9	0	0.6

6 Conclusion

In this chapter, we characterize TNP and TCP on *FAVSs* and then applying these products we have implemented a novel machine learning approach to FSS-based IDM, in order to invest in a risky situation. Some numerical examples demonstrate the viability of our proposed machine learning method in practice. We believe that this investigation in this area can be done ahead of time. The approach should be expanded in the future to address relevant issues such as computer science, economics, software engineering, machine learning, and so on.

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