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α-PRODUCT SOFT MATRICES

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ABSTRACT. In this paper, we define α-Product Soft Matrices which generalize the Product Soft Matrices. Further, we also provide a decision theory using these α-Product Soft Matrices. As a practical application, we formulate a novel approach to environmental toxicology by modeling multi-layered chemical interactions in aquatic ecosystems.

1. INTRODUCTION

In 1999, D.A. Molodtsov [8] established soft set theory as an innovative mathematical approach to tackle uncertainties in data analysis and decision-making. Unlike conventional methods such as probability theory, fuzzy set theory and rough set theory, which often struggle with complex real-world issues, soft set theory provides a more adaptable and parametrized solution. A soft set is characterized as a parametrized collection of subsets from a universal set, enabling a more detailed representation of uncertainty without requiring a membership function, as is necessary in fuzzy set theory. This feature makes soft set theory particularly relevant for fields like engineering, economics and medical sciences, where data ambiguity and incomplete information are prevalent.

In 2010, Cagman and Enginoğlu [1, 2] expanded on soft set theory by introducing soft matrices. These matrices offer a way to represent soft sets in a matrix format, making it easier to store, manipulate, and compute data. This matrix representation is beneficial for decision-making processes, as it allows for the use of matrix operations to analyze and interpret information. The authors also created a soft max-min decision-making method, which is particularly useful for scenarios involving two decision-makers, thereby increasing the applicability of soft set theory across various fields.

In 2013, S. Vijayabalaji and A. Ramesh [12] made significant contributions to the field by developing a new algorithm that employs the product of soft matrices. They introduced

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an innovative "OR" operation for soft matrices to tackle decision-making issues that involve uncertainty. Their method utilizes the α-product of soft matrices, which integrates information from various soft matrices based on a defined parameter α, facilitating a more thorough analysis of decision-making situations involving two parties. This technique enhances the effectiveness of soft set theory in modeling and addressing complex problems where conventional methods may be inadequate.

The α-product soft matrix operation introduces a sophisticated computational mechanism that enhances the traditional soft matrix operations by incorporating a scaling parameter that modulates the interaction between matrix elements. Unlike standard matrix multiplication, the α-product operation allows for controlled aggregation of soft information, where the parameter α serves as a tuning mechanism to emphasize or de-emphasize certain aspects of the decision-making process. This operation is particularly effective in scenarios where multiple soft matrices need to be combined while preserving the inherent uncertainty and flexibility that characterizes soft set theory. The computational efficiency of α-product operations makes them suitable for large-scale applications in engineering optimization, economic modeling and medical diagnosis systems, where traditional decision-making approaches often fall short due to the complexity and uncertainty inherent in real-world problems $[4, 7, 14]$.

As a practical application, we formulate a novel approach to environmental toxicology by modeling multi-layered chemical interactions in aquatic ecosystems. In this context, various chemical pollutants (e.g., heavy metals, pharmaceuticals, pesticides) serve as decision criteria, each with differing degrees of ecological impact and uncertainty. By representing the interactions among these pollutants using α-product soft matrices, we can incorporate expert assessments and environmental sensitivity data with varying confidence levels. The max-max decision-making principle is then employed to identify the pollutant combinations or mitigation strategies that offer the most favorable outcomes in terms of ecological safety. This optimistic decision framework supports the selection of intervention strategies that maximize positive environmental outcomes, despite complex inter dependencies and stakeholder variability. This integration provides an advanced tool for environmental agencies to prioritize actions in dynamic, multi-pollutant aquatic environments.

In this paper, In section 2 as a prerequisite of this article, it states the definitions of soft set and soft matrices with an example. In section 3, we define α-product soft matrix and max-max decision making method for two persons.

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2. PRELIMINARIES

Definition 2.1 (8)**.** Let U be an initial universe set and E be a set of parameters. Let $P(U)$ denotes the power set of U and $A \subseteq E$. A soft set F_A over U is a set defined by a funciton f_A representing a mapping $f_A : E \to P(U)$ such that $f_A = \phi$ if $e \notin A$. Here f_A is called approximate function of the soft set F_A. A soft set over U can be represented by the ordered pairs

$$F_A : \{(e, f_A(e)) : e \in E, f_A(e) \in P(U)\}.$$

Note: The subscript A in the notation f_A indicates that f_A is the approximate function of F_A. It can be defined more than one soft set in a subset A of the set of parameters E. In this time the approximate functions of F_A, G_A, H_A etc. must be f_A, g_A, h_A etc., respectively.

Example 2.2 (8). A soft set F_A describes the various companies watch suppose that there are five watches in the universe $U = \{w_1, w_2, w_3, w_4, w_5\}$ under consideration, and $E = \{e_1, e_2, e_3, e_4\}$ is the set of parameters. The $e_i (i = 1, 2, 3, 4)$ stand for the parameters expensive, beautiful, branded, cheap respectively. In this case to define a soft set means to point out expensive watch, beautiful watch and so on. Assume that $A = \{e_1, e_2, e_3\}$ and $\{e_2, e_3, e_4\} \subseteq E$.
$f_A(e_1) = \{w_1, w_4, w_5\}, f_A(e_2) = \{w_2, w_3\}, f_A(e_3) = \{w_4\}$,
$g_A(e_1) = \{w_1\}, g_A(e_2) = \phi, g_A(e_3) = \{U\}$,
$f_B(e_2) = \{w_1, w_3, w_5\}, f_B(e_3) = \{w_3\}, f_B(e_4) = \{w_1\}$.
Then we can view the soft sets F_A, G_A, and F_B as follows:
$F_A = \{(e_1, \{w_1, w_4, w_5\}), (e_2, \{w_2, w_3\}), (e_3, \{w_4\})\}$
$G_A = \{(e_1, \{w_1\}), (e_2, \phi), (e_3, \{U\})\}$
$F_B = \{(e_2, \{w_1, w_3, w_5\}), (e_3, \{w_3\}), (e_4, \{w_1\})\}$.
Here $g_A(e_2) = \phi$ means that there is no element in U related to the parameter $e_2 \in E$.

Definition 2.3 (1). Let F_A be a soft set over U. Then a subset of $U \times E$ is uniquely defined by $R_A = \{(w, e) : e \in A, w \in f_A(e)\}$ which is called relation form of F_A.
The characteristic function of R_A is written by $R_A : U \times E \to \{0, 1\}$,

$$R_A(w, e) = \begin{cases} 1, & if(w, e) \in R_A \\ 0, & if(w, e) \notin R_A \end{cases}$$

If $U = \{w_1, w_2, w_3, w_4, \cdots, w_n\}, E = \{e_1, e_2, e_3, \cdots, e_p\}$ and $A \subseteq E$, then the R_A can be presented by a table as in the following form

R_A	x_1	x_2	$\cdots$	x_p
w_1	$R_A(w_1, e_1)$	$R_A(w_1, e_2)$	$\cdots$	$R_A(w_1, e_p)$
w_2	$R_A(w_2, x_1)$	$R_A(w_2, x_2)$	$\cdots$	$R_A(w_2, x_p)$
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
w_n	$R_A(w_n, x_1)$	$R_A(w_n, x_2)$	$\cdots$	$R_A(w_n, x_p)$

If $a_{ij} = R_A(w_i, e_j)$, we define a matrix $SM_{m\times p} = \begin{pmatrix} a_{11} & a_{12} & \ldots & a_{1p} \\ a_{21} & a_{22} & \ldots & a_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \ldots & a_{np} \end{pmatrix}$, which is called an $n \times p$ soft matrix of the soft set F_A over U.
Example 2.4. Let us take $F_A = \{(e_1, \{w_1, w_4, w_5\}), (e_2, \{w_2, w_3\}), (e_3, \{w_4\})\}$, then the relation form of F_A is written by
$R_A = \{(w_1, e_1), (w_2, e_2), (w_3, e_2), (w_4, e_1), (w_4, e_3), (w_5, e_1)\}$.
Hence the soft matrix we have $[a_{ij}] = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix}$

Definition 2.4 (6). Let U be the universal set. Let (F, A) and (G, B) be a two soft sets over common universe U. Then the Cartesian product soft sets $(F, A) \times (G, B) = (H, A \times B)$.

Example 2.5 (6)**.** Let us consider two soft sets A and B over a common universe U. Let $U = \{w_1, w_2, w_3, w_4, w_5\}, A = \{e_1, e_2\} \subseteq E$ and $B = \{e_2, e_3\} \subseteq E$. Then $F(e_1) = \{w_1, w_3, w_4\}, F(e_2) = \{w_2, w_3, w_5\}, G(e_2) = \{w_1, w_3\}$ and $G(e_3) = \{w_2, w_3\}$. Here $A \times B = \{(e_1, e_2), (e_1, e_3), (e_2, e_2), (e_2, e_3)\}$.
Then, the relation form of

$$\begin{aligned} R_{(H,A\times B)} =&\{((e_1,e_2),\{(w_1,w_1),(w_1,w_3),(w_3,w_1),(w_3,w_3),(w_4,w_1),(w_4,w_3)\}),\\ &((e_1,e_3),\{(w_1,w_2),(w_1,w_3),(w_3,w_2),(w_3,w_3),(w_4,w_2),(w_4,w_3)\}),\\ &((e_2,e_2),\{(w_2,w_1),(w_2,w_3),(w_3,w_1),(w_3,w_3),(w_5,w_1),(w_5,w_3)\}),\\ &((e_2,e_3)\{(w_2,w_2),(w_2,w_3),(w_3,w_2),(w_3,w_3),(w_5,w_2),(w_5,w_3)\})\}. \end{aligned}$$

Definition 2.6 (12)**.** Let U be the universal set. Let (F, A) and (G, B) be a two soft sets over common universe. Then the Cartesian product soft sets $(F, A) \times (G, B) = (H, A \times B)$. We define the relation of $(H, A \times B)$ is $R_{(H,A\times B)} = \{(h, e) : h \in H(\beta, \beta), e \in A \times B\}$. The special function of $R_{(H,A\times B)}$ is written by

$$\tilde{C}R_{(H,A\times B)} : U \times E \to \{0, \tfrac{1}{2}, 1\}, \tilde{C}R_{(H,A\times B)} = \begin{cases} 1, & if(h,e) \in A \cap B \\ \frac{1}{2} = 0.5, & if(h,e) \in A\Delta B \\ 0, & if(h,e) \notin A \cup B \end{cases}$$

If $(d_{ij}) = d(h, e)$, we define a matrix $(d_{ij})_{(n\times p)} = \begin{pmatrix} d_{11} & d_{12} & \dots & d_{1p} \\ d_{21} & d_{22} & \dots & d_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ d_{n1} & d_{n2} & \dots & d_{np} \end{pmatrix}$ is called as a **product soft matrices**, where n is the number of elements is U and p is the product of the number of element in the set A and the number of element in the set B.

Definition 2.7 (12)**.** Let U be the universal set. Let (F, A) and (G, B) be a two soft sets over common universe. Then the Cartesian product soft sets $(F, A) \times (G, B) = (H, A \times B)$. We define the relation of $(H, A \times B)$ is $R_{(H,A\times B)} = \{(h, e) : h \in H(\beta, \beta), e \in A \times B\}$. Thel function of $R_{(H,A\times B)}$ is written by

$$\tilde{C}R_{(H,A\times B)} : U\times E \to \{0, (0, 1), 1\}, \tilde{C}R_{(H,A\times B)} = \begin{cases} 1, & if(h,e) \in A \cap B \\ (0,1) = \beta, & if(h,e) \in A\Delta B \\ 0, & if(h,e) \notin A \cup B \end{cases}$$

If $(d_{ij}) = d(h, e)$, we define a matrix $(d_{ij})_{(n\times p)} = \begin{pmatrix} d_{11} & d_{12} & \dots & d_{1p} \\ d_{21} & d_{22} & \dots & d_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ d_{n1} & d_{n2} & \dots & d_{np} \end{pmatrix}$ is called as a α**-product soft matrices**, where n is the number of elements is U and p is the product of the number of element in the set A and the number of element in the set B.

Definition 2.8 (6)**.** Let $(F, A) = (a_{ij})$ and $(G, B) = (b_{ij})$ are two soft matrices. Then $(F, A)AND(G, B)$ is denoted by $[(F, A)] \wedge [(G, B)] = [H, A \times B] = (d_{ij})$ is a soft matrix, is defined by $(d_{ij}) = (a_{ij}) \cap (b_{ij})$.

Definition 2.9 (6)**.** Let$(F, A) = (a_{ij})$ and $(G, B) = (b_{ij})$ are two soft matrices. Then $(F, A)OR(G, B)$ is denoted by $[(F, A)] \vee [(G, B)] = [H, A \times B] = (d_{ij})$ is a soft matrix, is defined by $(d_{ij}) = (a_{ij}) \cup (b_{ij})$.

Example 2.10 (12)**.** Let $U = \{w_1, w_2, w_3, w_4, w_5\}$ and $E = \{e_1, e_2, e_3, e_4\}$. Assume that $A = \{e_1, e_2, e_3\}$ and $B = \{e_2, e_3, e_4\} \subseteq E$.
Let $(F, A) = \{((e_1), \{w_1, w_3, w_4, w_5\}), ((e_2), \{w_2, w_3, w_5\}), ((e_3), \{w_4\})\}$

$(F, B) = \{((e_2), \{w_1, w_3, w_5\}), ((e_3), \{w_2, w_3\}), ((e_4), \{w_2\})\}$. Hence

$$\begin{aligned}(F, A) \wedge (F, B) = &\{((e_1, e_2), \{w_1, w_3, w_5\}), ((e_1, e_3), \{w_3\}), ((e_1, e_4), \{\phi\}),\\ &((e_2, e_2), \{w_3, w_5\}), ((e_2, e_3), \{w_2, w_3\}), ((e_2, e_4), \{w_2\}),\\ &(e_3, e_2), \{\phi\}), ((e_3, e_3), \{\phi\}), ((e_3, e_4), \{\phi\})\}.\end{aligned}$$

Hence, the $\alpha-$ product soft matrices is $(d_{ij})_{(5\times 9)} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

$$\begin{aligned}(F, A) \vee (G, B) = &\{((e_1, e_2), \{w_1, w_3, w_4, w_5\}), ((e_1, e_3), \{w_1, w_2, w_3, w_4, w_5\}),\\ &((e_1, e_4), \{w_1, w_2, w_3, w_4, w_5\}), ((e_2, e_2), \{w_1, w_2, w_3, w_5\}),\\ &((e_2, e_3), \{w_2, w_3, w_5\}), ((e_2, e_4), \{w_2, w_3, w_5\}), ((e_3, e_2),\\ &\{w_1, w_3, w_4, w_5\}), ((e_3, e_3), \{w_2, w_3, w_4\}), ((e_3, e_4), \{w_2, w_4\})\}.\end{aligned}$$

Hence, the $\alpha-$ product soft matrices is

$$(d_{ij})_{(5\times 9)} = \begin{pmatrix} 1 & \alpha & \alpha & \alpha & 0 & 0 & \alpha & 0 & 0 \\ 0 & \alpha & \alpha & \alpha & 1 & 1 & \alpha & \alpha & \alpha \\ 1 & 1 & \alpha & 1 & 1 & \alpha & \alpha & \alpha & 0 \\ \alpha & \alpha & \alpha & 0 & 0 & 0 & \alpha & \alpha & \alpha \\ 1 & \alpha & \alpha & 1 & \alpha & \alpha & \alpha & 0 & 0 \end{pmatrix}$$

3. DECISION-MAKING ALGORITHM USING α-PRODUCT SOFT MATRICES

Definition 3.1. Let $U = \{w_1, w_2, \cdots, w_n\}$ be an initial universe and $max\{max(d(h, e))\} = [u_{i1}]$. Then a subset of U can be obtained by using $[u_{i1}]$ as in the following way $opt[u_{i1}] = \{u_i : u_i \in U, u_{i1} = max(1 or \alpha)\}$ which is called an optimum set of U.

Soft max-max decision making algorithm:

step 1: Choose feasible subset of the set of parameter.

step 2: Construct the Cartesian product soft set.

step 3: Find a Cartesian OR product of the soft matrices.

step 4: Compute the max-max decision matrix of the product soft matrices.

step 5: Find an optimum set of U.

Assume that the Universal set comprises of different types of DNA. Note that these DNA may be from a sample of a single organism or from a variety of organisms. Let $U = \{d_1, d_2, d_3, d_4\}$ which may be characterized by a set of parameters $E = \{e_1, e_2, e_3, e_4\}$. It is evident to note that these parameters are many sorts of mutagens that change DNA sequence namely oxidizing agents, alkylting agents, ultraviolet light and UV light.

step 1: Suppose that the two doctors from two different labs analyse these DNA with their choice of parameters $A = \{e_1, e_3\}$ and $B = \{e_1, e_4\}$ respectively. Their aim is to find the most affected DNA that has been changed by the above mutagens.

step 2: The two soft sets are: $(F, A) = \{(e_1, \{d_1, d_2\}), (e_2, \{d_2, d_3\}), (e_3, \{d_4\})\}$
$(G, B) = \{(e_1, \{d_3, d_4\}), (e_3, \{d_1, d_4\}), (e_4, \{d_1, d_2\})\}$

The Cartesian product of soft sets is
$(F, A) \vee (G, B) = \{((e_1, e_1), \{d_1, d_2, d_3, d_4\}), ((d_1, d_4), \{d_1, d_2\}),$
$((e_3, e_1), \{d_3, d_4\}), ((e_3, e_4), \{d_1, d_2, d_4\})\}$

step 3: The Cartesian OR product of the soft matrices is

$$(d_{ij}) = \begin{pmatrix} \alpha & 1 & 0 & \alpha \\ \alpha & 1 & 1 & \alpha \\ \alpha & 0 & \alpha & 0 \\ \alpha & 0 & \alpha & \alpha \end{pmatrix}$$

step 4: We can fine a max-max decision soft matrix as
max$\{$max values in every column$\}$=$max\{\{d_1, d_2, d_3, d_4\}, \{d_1, d_2\}, \{d_2\}, \{d_1, d_2, d_4\}\} = \{d_2\}$.

step 5: Finally we can fine an optimal set of U according to max-max decision, we get d_2 is the optimal solution.

Environmental Toxicology Decision Problem Using α-Product Soft Matrices

A research team is studying the effects of various environmental pollutants on different aquatic microorganisms. The goal is to identify which microorganism is most severely affected by combinations of contaminants in a water body.

Let the Universal set $U = \{m_1, m_2, m_3, m_4, m_5\}$ represent different microorganisms in the aquatic ecosystem:

(1) m_1: Cyanobacteria

(2) m_2: Diatoms

(3) m_3: Green algae

(4) m_4: Protozoa

(5) m_5: Aquatic fungi

Let the parameter set $E = \{e_1, e_2, e_3, e_4, e_5\}$ represent different environmental pollutants:

(1) e_1: Heavy metals

(2) e_2: Pesticide runoff

(3) e_3: Petroleum hydrocarbons

(4) e_4: Microplastics

(5) e_5: Pharmaceutical residues

Step 1: Parameters Selection Two environmental research teams analyze these microorganisms with their choice of parameters:

(i) Team A chooses parameters $A = \{e_1, e_3, e_5\}$

(ii) Team B chooses parameters $B = \{e_2, e_4\}$

Their aim is to find the most affected microorganism species due to the combined effects of these pollutants.

Step 2: Soft Sets Construction The two soft sets are:

$$(F, A) = \{(e_1, \{m_1, m_3, m_5\}), (e_3, \{m_2, m_4\}), (e_5, \{m_3, m_5\})\}$$
$$(G, B) = \{(e_2, \{m_1, m_4, m_5\}), (e_4, \{m_2, m_3, m_4\})\}$$

The Cartesian product of soft sets is:

$$\begin{aligned}(F, A) \times (G, B) = \{&((e_1, e_2), \{m_1, m_3, m_4, m_5\}),\\ &((e_1, e_4), \{m_1, m_2, m_3, m_4, m_5\}),\\ &((e_3, e_2), \{m_1, m_2, m_4, m_5\}),\\ &((e_3, e_4), \{m_2, m_3, m_4\}),\\ &((e_5, e_2), \{m_1, m_3, m_4, m_5\}),\\ &((e_5, e_4), \{m_2, m_3, m_4, m_5\})\}\end{aligned}$$

Step 3: α-Product Soft Matrix Let $\alpha = 0.7$ (representing the synergistic effect threshold)

The Cartesian OR Product of the soft matrices is:

$$(d_{ij}) = \begin{pmatrix} 1 & 1 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 \\ \alpha & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 \end{pmatrix} \tag{3.1}$$

where rows represent microorganisms m_1 to m_5 and columns represent the parameter pairs $(e_1, e_2), (e_1, e_4), (e_3, e_2), (e_3, e_4), (e_5, e_2), (e_5, e_4)$.

Step 4: Max-Max Decision Matrix Computing the max-max decision soft matrix:

For each column, identify the maximum value:

$$\begin{aligned}
&\text{Col 1 } (e_1, e_2) : \max = 1, \text{ achieved by } \{m_1, m_3, m_5\}\\
&\text{Col 2 } (e_1, e_4) : \max = 1, \text{ achieved by } \{m_1, m_2, m_3, m_4, m_5\}\\
&\text{Col 3 } (e_3, e_2) : \max = 1, \text{ achieved by } \{m_1, m_2, m_4, m_5\}\\
&\text{Col 4 } (e_3, e_4) : \max = 1, \text{ achieved by } \{m_2, m_3, m_4\}\\
&\text{Col 5 } (e_5, e_2) : \max = 1, \text{ achieved by } \{m_1, m_3, m_4, m_5\}\\
&\text{Col 6 } (e_5, e_4) : \max = 1, \text{ achieved by } \{m_2, m_3, m_4, m_5\}
\end{aligned}$$

Step 5: Finding the Optimum Set The optimal set of U according to max-max decision is the intersection of all these sets:

$$\{m_1, m_3, m_5\} \cap \{m_1, m_2, m_3, m_4, m_5\} \cap \{m_1, m_2, m_4, m_5\}$$
$$\cap \{m_2, m_3, m_4\} \cap \{m_1, m_3, m_4, m_5\} \cap \{m_2, m_3, m_4, m_5\} = \{m_3, m_4\}$$

Therefore, based on the α-Product Soft Matrices analysis, microorganisms m_3 (Green algae) and m_4 (Protozoa) are identified as the most affected species by the combined effects of the environmental pollutants.

4. Conclusion

In this paper, we introduced the concept of α-Product Soft Matrices, which extend traditional Product Soft Matrices. Using this new method, we developed a decision-making framework that makes it easier to analyze situations with uncertainty in a more flexible and detailed way. We demonstrated the usefulness of this approach by applying it to a scenario where DNA samples were exposed to different mutagens. By following the max-max decision-making steps, we showed how two doctors, each using different sets of parameters, could combine their results to identify the DNA sequence most affected by the mutagens. We also applied our method in environmental toxicology to model complex chemical interactions in aquatic ecosystems. This example showed that α-Product Soft Matrices can capture complex relationships and help with ecological risk assessments. In the future, this approach could be used in other areas that deal with uncertainty and complex interactions, such as economics or medical diagnostics.

References

[1] N. Cagman and S. Enginoğlu, "Soft Set Theory and Uni-Int Decision Making," *European Journal of Operational Research*, vol. 207, no. 2, pp. 848–855, 2010.

[2] N. Cagman and S. Enginoğlu, "Soft Matrix Theory and Its Decision Making," *Computers and Mathematics with Applications*, vol. 59, no. 10, pp. 3308–3314, 2010.

[3] I. Düntsch and G. Gediga, "Modal-Style Operators in Qualitative Data Analysis," in *Proceedings of the 2002 IEEE International Conference on Data Mining*, 2002, pp. 155–162.

[4] F. Feng, Y. B. Jun, X. Liu, and L. Li, "An adjustable approach to fuzzy soft set based decision making," *Journal of Computational and Applied Mathematics*, vol. 234, no. 1, pp. 10–20, 2010.

[5] F. Feng, "Soft Rough Sets Applied to Multicriteria Group Decision Making," *Annals of Fuzzy Mathematics and Informatics*, vol. 2, no. 1, pp. 69–80, 2011.

[6] P. K. Maji and A. R. Roy, "An Application of Soft Sets in Decision Making Problem," *Computers and Mathematics with Applications*, vol. 44, no. 7, pp. 1077–1083, 2002.

[7] A. R. Roy and P. K. Maji, "A fuzzy soft set theoretic approach to decision-making problems," *Journal of Computational and Applied Mathematics*, vol. 203, no. 2, pp. 412–418, 2007.

[8] D. A. Molodtsov, "Soft Set Theory—First Results," *Computers and Mathematics with Applications*, vol. 37, no. 4–5, pp. 19–31, 1999.

[9] P. Pagliani and M. K. Chakraborty, "Information Quanta and Approximation Spaces I and II," in *Proceedings of the IEEE International Conference on Granular Computing*, 2005, pp. 605–610.

[10] G. Sambin, "Intuitionistic Formal Spaces—A First Communication," in D. G. Skordev (Ed.), *Mathematical Logic and Its Applications*, Plenum Press, 1988, pp. 187–204.

[11] D. Vakarelov, "Information Systems, Similarity Relations and Modal Logics," in E. Orlowska (Ed.), *Incomplete Information: Rough Set Analysis*, Physica-Verlag, 1998, pp. 492–550.

[12] S. Vijayabalaji and A. Ramesh, "A New Decision Making Theory in Soft Matrices," *International Journal of Pure and Applied Mathematics*, vol. 86, no. 6, pp. 927–939, 2013.

[13] R. Wille, "Restructuring Lattice Theory: An Approach Based on Hierarchies of Concepts," in I. Rival (Ed.), *Ordered Sets*, Reidel, 1982, pp. 445–470.

[14] Z. Xiao, K. Gong, and Y. Zou, "A combined forecasting approach based on fuzzy soft sets," *Journal of Computational and Applied Mathematics*, vol. 228, no. 1, pp. 326–333, 2009.

[15] X. Yang, T. Y. Lin, J. Yang, Y. Li, and D. Yu, “Combination of interval-valued fuzzy set and soft set,” *Computers & Mathematics with Applications*, vol. 58, no. 3, pp. 521–527, 2009.
[16] J. Zhan and J. C. R. Alcantud, “A novel type of soft rough covering and its application to multicriteria group decision making,” *Artificial Intelligence Review*, vol. 52, no. 4, pp. 2381–2410, 2019.
[17] H. Zhang, L. Shu, and S. Liao, “Intuitionistic fuzzy soft sets and their application in decision making,” *Applied Mathematical Modelling*, vol. 38, no. 4, pp. 1408–1418, 2014.
[18] P. Zhu and Q. Wen, “Operations on soft sets revisited,” *Journal of Applied Mathematics and Computing*, vol. 32, no. 2, pp. 393–409, 2010.

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