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Application of Fuzzy N-Soft Set for Grouped Data Analysis and Decision-Making Problems

Febi Fortuna Megis[1], Admi Nazra[2*], Yanita[3] & Efendi[4]

[1-4]Department of Mathematics and Data Science, University of Andalas, Padang, 25163, Indonesia.
Corresponding Author (Admi Nazra) Email: nazra@sci.unand.ac.id[*]

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ABSTRACT

This study proposes an application of the fuzzy N-soft set framework to decision-making problem that involve data from grouped object. Motivated by the inherent uncertainty in real-word dataset, the approach integrates the concept of strait fuzzy set, strait soft set, and fuzzy N-soft set to capture both the membership degrees and the ranking of object within groups. A score-based method is used to evaluate the dominance of groupings of object under multiple parameters. The proposed framework is illustrated through a case study on student performance evaluation, where object are clustered by grade and fuzzy membership intervals. The result demonstrate that the scoring method successfully identifies the most dominant group across different evaluation parameters, offering an interpretable classification structure. The main contribution of study lies in generalizing fuzzy N-soft sets to grouped data structures, the providing a two-level decision-making process that account for intra-group and intre-group education, agriculture, and healthcare, particularly in context where decision-making involves clustered or partitioned data with uncertainty.

Keywords: Fuzzy; Fuzzy Set; Soft Set; Fuzzy N-Soft Set; Strait Fuzzy Set; Strait Soft Set; Grouped Data; Decision Making; Soft Computing; Multi-Criteria Decision Making.

1. Introduction

Zadeh [10] first introduced the fuzzy set theory to handle decision-making problems, involving uncertainty, where the degree of membership of each element is expressed as a single value in the interval $[0,1]$. Despite its usefulness, fuzzy set theory has certain limitations, which motivated Molodtsov [5] to propose soft set theory as a parameterized approach to decision-making. In soft set theory, each object associated with a parameter is assigned either 0 or 1. However, real-life decision problems are often not strictly binary. Fatimah [3] later extended this concept by introducing N-soft sets, in which object are ranked or garded, rather than being limited to binary classification.

Previously, Maji [4] combined fuzzy sets and soft sets to develop fuzzy soft set theory, where each object associated with a parameter is assigned a membership degree in $[0,1]$ and multiple paramaters are considered simultaneously. Subsequently, Nazra [6] proposed Generalized hesitan fuzzy N-soft sets, which integrate fuzzy sets with N-soft sets by considering both grades and membership degrees.

In parallel, Ataguň and Kamaci introduced further generaliztions. They proposed strait soft sets [2] , in wich the universe of objects is partitioned based on parameter evaluations, and strait fuzzy sets [1], in wich decision-making is based not on single-valued membership degrees but on interval-valued membership, corresponding to partitions of $[0,1]$. Building upon these concept, Putri [7] proposed strait fuzzy soft sets that focus on grouped data within specific intervals, while Shodik [9], developed strait N-soft sets by combining the principals of srtait soft sets and N-s-soft sets.

However, existing studies reveal an important gap. While fuzzy N-soft sets and strait fuzzy or soft sets provide powerful tools for uncertainty modeling, no existing approach has integred fuzzy N-soft sets with grouped-object data using strait-based constructions. This limitation restricts their applicabilility in decision-making scenarios where fuzzy membership and group-based evaluatin are essential.

Therefore, this study proposes a novel framework that extends fuzzy N-soft sets to grouped-object data by incorporating the concept of strait fuzzy sets and strait soft sets. A score-based method is used to evaluate the dominance of groups under multiple parameters. The proposed model represent a generalization that enables a two-level decision-making process—within groups and across groups—and thus offers new opportunities for application in education, agriculture, and healthcare.

1.1. Study Objectives

In this review we aim to:

1) To apply the Fuzzy N-Soft Set approach to grouped data analysis in order to effectively represent data involving uncertainty.
2) To utilize the Fuzzy N-Soft Set framework in decision-making processes for problems based on grouped data.
3) To present a systematic and procedural implementation of the fuzzy N-soft set method for data analysis and decision making.
4) To demonstrate the applicability of the proposed approach through numerical examples or case studies.
5) To evaluate the effectiveness of the Fuzzy N-Soft Set method in supporting decision-making compared to conventional approach.

2. Methodology

This study employs a qualitative descriptive research design with a case study approach, in which a real world problem is represented using the framework of fuzzy N-soft sets. The qualitative descriptive method aims to provide a comprehensive and detailed description of te phenomenon under investigation. The approach not only focuses on numerical data processing, but also emphasizes the interpretation of context, meaning, and experience of the subjects involed. In this research, the case study is modeled in the form of fuzzy N-soft set, where the objects are considered as subsets of the universal set of objects. Each subset is characterized by both the average of fuzzy membership values and the assigned grade ranking within the set itself. This dual representation captures not only the degree of membership, but also the hierarchical position of objects across different evaluation parameters.

The proposed methode therefore combines fescriptive case stdy analysis with the mathematical structure of fuzzy N-soft sets, enabling the construction of a decision-making framework that accounts for grouped-object data under uncertainty.

3. Result and Discussion

In this section, a case study is presented to illustrate the application of fuzzy N-soft sets in decision-making problems. The case is not intended to describe in detail the technical process of data collection; rather, it serves as an illustrative example of how the proposed framework can be applied to grouped-object data. The main objective of this illustration is to identify which group demonstrates the highest dominance under a set of evaluation parameters.

The notation of a fuzzy N -soft set on grouped data is denotes by (μ_s, V), where V represents the universe of objects and μ_s is a fuzzy N -soft set on V associated with a parameter $a \in A$.

Case. At the end of the semester, examinations are conducted in four courses $\{\alpha_1, \alpha_2, \alpha_3, \alpha_4\}$. Each course is assessed through is then expressed in terms of a grade ranking form 0 to 6, determined by the number of correct answers obtained by each student according to the following criteria:

1) Rank "0" for 0 correct answers.
2) Rank "1" for 1-5 correct answers.
3) Rank "2" for 6-10 correct answers.
4) Rank "3" for 11-15 correct answers.
5) Rank "4" for 16-20 correct answers.
6) Rank "5" for 21-25 correct answers.
7) Rank "6" for 26-30 correct answers.

In the second stage, an oral examination is conducted through presentations. Each students is required to present a predetermined topic related to the course being examined. The evaluation of the presentation is expressed as a real number in the interval $[0,1]$, which represent the stident's comprehension and mastery of the material.

After both evaluations are carried out by an expert acting as the decision-maker, the resulting data are represented in Table 1 in the form of a fuzzy 7-soft set.

Table 1. Fuzzy 7-soft set

	a_1	a_2	a_3	a_4
u_1	(1 ; 0.3)	(3 ; 0.5)	(5 ; 0.7)	(4 ; 0.6)
u_2	(2 ; 0.2)	(3 ; 0.6)	(6 ; 0.7)	(3 ; 0.4)
u_3	(6 ; 1)	(2 ; 0.7)	(4 ; 0,7)	(5 ; 0.8)
u_4	(5 ; 0.9)	(2 ; 0.6)	(4 ; 0.5)	(5 ; 0.9)
u_5	(5 ; 0.3)	(1 ; 0.5)	(3 ; 0.6)	(6 ; 0.8)
u_6	(5 ; 0.1)	(2 ; 0.6)	(3 ; 0.7)	(6 ; 0.9)

Next, an expert acting as the decision-maker assume a partition of the grade (ranking) set G and the interval $[0,1]$ $\mathcal{A}$ respectively, as follow:

$$G = \{K_1^1 = \{0,1,2\}, K_1^2 = \{3,4\}, K_1^3 = \{5,6\}\}$$
$$\mathcal{A} = \{\bar{Y}_1^1 = [0\,;0.4), \bar{Y}_1^2 = [0.4\,;0.8), \bar{Y}_1^3 = [0.8\,;1]\}$$

Based on Table 1, a partition of the set V can be constructed, denoted by $V_1 = \{\bar{V}_1^1, \bar{V}_1^2, \bar{V}_1^3\}$, where each $\bar{V}_i^k$ represents the groups of students that belong to the same grade class and membership interval. Consequently, we obtain $\bar{V}_1^1 = \{u_1, u_2\}$, $\bar{V}_1^2 = \{u_3, u_4\}$, and $\bar{V}_1^3 = \{u_5, u_6\}$.

The membership value of each $\bar{V}_i^k$ is defined as the average of the membership values of the students contained in the corresponding subset $\bar{V}_i^k$. Thus, the combined structure of the strait fuzzy set and the strait N-soft set can be expressed as follows:

$$\mu_s(a_1) = (\bar{V}_1^1\ ;\ K_1^1\ ;\ \bar{Y}_1^1\ ), (\bar{V}_1^2\ ;\ K_1^3\ ;\ \bar{Y}_1^3), (\bar{V}_1^3\ ;\ K_1^3\ ;\ \bar{Y}_1^1)$$
$$\mu_s(a_2) = (\bar{V}_1^1\ ;\ K_1^2\ ;\ \bar{Y}_1^2), (\bar{V}_1^2\ ;\ K_1^1\ ;\ \bar{Y}_1^2), (\bar{V}_1^3\ ;\ K_1^1\ ;\ \bar{Y}_1^2)$$
$$\mu_s(a_3) = (\bar{V}_1^1\ ;\ K_1^3\ ;\ \bar{Y}_1^2), (\bar{V}_1^2\ ;\ K_1^2\ ;\ \bar{Y}_1^2), (\bar{V}_1^3\ ;\ K_1^2\ ;\ \bar{Y}_1^2)$$
$$\mu_s(a_4) = (\bar{V}_1^1\ ;\ K_1^2\ ;\ \bar{Y}_1^2), (\bar{V}_1^2\ ;\ K_1^3\ ;\ \bar{Y}_1^3), (\bar{V}_1^3\ ;\ K_1^3\ ;\ \bar{Y}_1^3)$$

Specially, the group $\bar{V}_1^1$ is classified into the grade category as K_1^1 with the membership interval as $\bar{Y}_1^1$, the group $\bar{V}_1^2$ belongs to the grade category as K_1^3 with the membership interval as $\bar{Y}_1^3$, and the group $\bar{V}_1^3$ belongs to the grade category as K_1^3 with the membership interval as $\bar{Y}_1^1$. The same interpretation also applies to the other courses under consideration.

Therefore, the observation can also be represented in tabular form, as shown in Table 2.

Table 2. Representation (μ_s, V)

$(\boldsymbol{\mu_s}, \boldsymbol{V})$	$\boldsymbol{a_1}$	$\boldsymbol{a_2}$	$\boldsymbol{a_3}$	$\boldsymbol{a_4}$
$\bar{V}_1^1$	$K_1^1\ ;\ \bar{Y}_1^1$	$K_1^2\ ;\ \bar{Y}_1^2$	$K_1^3\ ;\ \bar{Y}_1^2$	$K_1^2\ ;\ \bar{Y}_1^2$
$\bar{V}_1^2$	$K_1^3\ ;\ \bar{Y}_1^3$	$K_1^1\ ;\ \bar{Y}_1^2$	$K_1^2\ ;\ \bar{Y}_1^2$	$K_1^3\ ;\ \bar{Y}_1^3$
$\bar{V}_1^3$	$K_1^3\ ;\ \bar{Y}_1^1$	$K_1^1\ ;\ \bar{Y}_1^2$	$K_1^2\ ;\ \bar{Y}_1^2$	$K_1^3\ ;\ \bar{Y}_1^3$

Based on Table 2, the structure (μ_s, V) can be illustrated as shown in Figure 1.

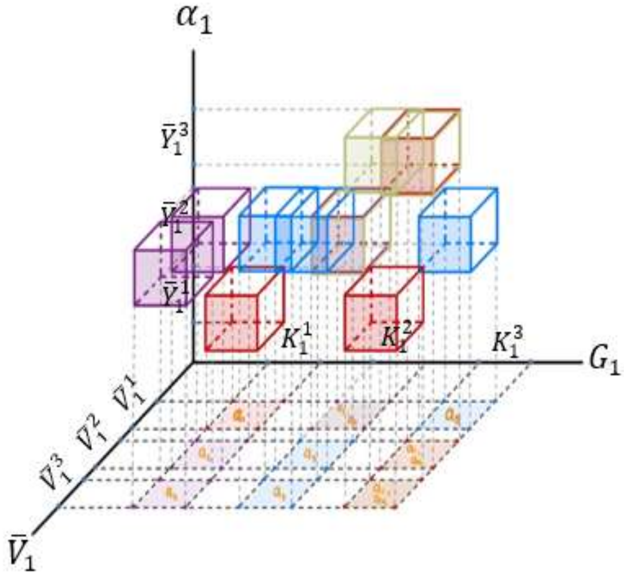

Figure 1. Ilustration of (μ_s, V)

Referring to the score method fuzzy soft set [8], a comparison table P of size $|V_1| \times |V_1|$ is constructed. The i-th row and the j-th column of P correspond to $\bar{V}_1^i$ and $\bar{V}_1^j$, respectively. The entry h_{ij} of P denotes the number of parameters α_i for which the membership value of $\bar{V}_1^i$ is greater than or equal to that of $\bar{V}_1^j$.

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Next, the following quantities are defined:

$$k_i = \sum_{n=1}^{p} h_{in}$$

which represent the sum of the entries h_{in}in the i-th row of P associated with $\bar{V}_1^i$, and

$$t_j = \sum_{m=1}^{p} h_{mj}$$

which represent the sum of the entries h_{mj} in the j-th column of P associated with $\bar{V}_1^j$, where $p = |V_1|$.

The comparison table P obtained from Table 2 is presents in Table 3.

Table 3. The Comparison Table P of SF7SS (μ_s, V)

	$\bar{V}_1^1$	$\bar{V}_1^2$	$\bar{V}_1^3$
$\bar{V}_1^1$	4	1	1
$\bar{V}_1^2$	2	4	2
$\bar{V}_1^3$	2	1	4

Next, the score table is computed using the following formula:

$$s_i = k_i - t_j$$

Where k_i and t_j denote the sum of the i-th row and the j-th column of the comparison matrix P, respectively.

The score table derived from Table 3 is presented in Table 4.

Table 4. Score table of SF7SS (μ_s, V)

Group	Row sum k_i	Column sum t_1	Final score S_i
$\bar{V}_1^1$	6	8	-2
$\bar{V}_1^2$	8	6	2
$\bar{V}_1^3$	7	7	0

Based on the score results in Table 4, it is obtained that $S_2 > S_3 > S_1$. This implies that the group of students $\bar{V}_1^2$ has the highest performance across the two stages of evaluation and four sourses, followed by $\bar{V}_1^3$, while $\bar{V}_1^1$ ranks last.

4. Conclusion

This case study demonstrates the possibility of constructing groupings of objects within a fuzzy N-soft set framework by employing the concepts of strait fuzzy soft set and strait N-soft set. The integration of these approaches provides a two level decision-making structure that account s for both fuzzy membership values and group-based evaluations. The findings highlight that combining fuzzy N-soft set with strait fuzzy and strait N-soft sets not only strengthens the theoretical foundation but also broadens the applicability of these models to real-world problems involving grouped-object data under uncertainty. This work therefore opens opportunities for further theoretical studies and pratical applications in various domains, such as education, agriculture, and healthcare, where uncertainty and stryctured group evaluations are crucial.

5. Future Recommendations

Based on the findings of this study, the following recommendations are proposed for future research:

1) The application of the Fuzzy N-soft Set method can be extended to more complex and large-scale real-world datasets to further validate its robustness and applicability.
2) Future studies may integrate the Fuzzy N-soft Set approach with other soft computing technique to enhance decision-making accuracy and efficiency.
3) The proposed method can be explored in various domains such as medical diagnosis, financial analysis, and engineering decision-making problems.
4) Further research can focus on developing computational tools or algorithms to automate the implementation of the Fuzzy N-soft Set approach.
5) Comparative studies with other uncertainty-handling models can be conducted to better assess the performance and advantages of the proposed method.
6) The extension of the method to dynamic or time-dependent data environments can be considered for broader applicability.

Declarations

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Competing Interests Statement

The authors have not declared any conflict of interest.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis and manuscript writing equally.

Informed Consent

Not applicable for this study.

Availability of data and material

Supplementary information is available from the authors upon request.

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