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Application of Soft Set Theory in Decision-making Problem with the Aid of Soft "AND-OPERATION" Approach

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The term "soft set", F_A over $X \subseteq U$, denoted by F_A^X or (F, A), is described in this research work as $F_A^X = \{(e, f_A^X(e): e \in E, f_A^X(e) \in S^X\}$, along with a thorough theoretical analysis of the fundamental operations of soft sets, including intersection, extended intersection, union, restricted union, complement and relative complement, Null, and universal soft set. We were able to demonstrate the importance and practical use of soft sets in decision-making through the use of soft "AND-OPERATION" and tabular representation of soft sets. This paper's major goal is to select the top two applicants from the pool of five airline interview by using the notation of the soft AND operation. We identified and demonstrated a few specific properties of how soft set operations work.

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1. INTRODUCTION

The reduction of uncertainty is one of the most crucial features that must be addressed in order to improve the robustness of the results acquired from data analysis. However, breaking down the existing uncertainty in order to remove it is frequently a difficult task. For this reason, [1], developed soft set theory, a novel method for handling uncertainty. After the work of [1] several researcher's also work on soft set theory [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16]. The development of soft set theory has led to the development of different approaches for addressing uncertainty include probability theory, fuzzy set theory, and rough set theory, [17,18,19,20,21,22,23]. Despite the fact that these theories have been effectively applied to several issues, there are still significant challenges with these theories. For instance, many trials are required to verify the system's stability in probability theory. In the fields of economics and environmental sciences, such experimentation is not feasible. Perhaps the lack of funding for parameterization tools is the cause of the problems with these hypotheses mentioned above. The soft set theory contains enough parameters that none of the aforementioned issues arise. While soft set theory contains sufficient tools for parameterization, it also deals with ambiguity and uncertainty [21]. Soft set theory has a wide range of potential applications, only a few of which have been demonstrated by [1], in his groundbreaking work. Soft sets, as defined by [24], are a specific case of context dependent fuzzy sets and are referred to as (binary, basic, elementary) neighborhood systems. Soft set theory is well-liked by academics and industry professionals working in a range of fields due to these characteristics. Both rough set theory and soft set theory take different stances on vagueness. [7], suggested that rough sets and soft sets might be combined. They proposed the idea of "soft rough sets," which use parameterized set subsets to find lower and upper approximations of subsets rather than equivalence classes. However, this strategy has led to a few peculiar circumstances. For instance, a nonempty set's upper approximation might be empty. Furthermore, the set not be contained in the upper approximation of a subset of the universe. Since [1] first described soft set theory, it has attracted a lot of interest. Many fields have utilized soft set theory. [12], worked on some novel soft set theory operations [11] examined foundation of soft set theory. Interval valued fuzzy soft gamma semigroups and intuitionistic fuzzy soft gamma semigroups were studied [25]. This work examines the "soft set AND operation" which include soft union, soft restricted union, soft extended union, soft intersection, soft complement, symmetric difference, absorption, associative characteristics, and many more. Additionally, we demonstrate the use of soft sets in a decision-making scenario with the aid of some crude Pawlakian mathematics. Here, we have employed a binary information table as a nearly equivalent representation of the soft sets AND operation.

2. METHODOLOGY

Soft set concept and its basic definitions:

We define the following concept of soft set using the soft set theory. Where necessary, we create a few satisfying examples.

Definition 2.1: A soft set F_A over $X \subseteq U$, denoted by $F_A^X \; or \; (F, A)$, is a set defined by:

$f_A^X: E \to S^X$ such that $f_A^X(e) = \emptyset \; if \; e \notin A$. Hence, f_A^X is called approximation function of F_A^X, and the value $f_A^X(e)$ is a set called e-element of $F_A^X$for all $e \in E$. Thus, a soft set over X can be expressed by

$F_A^X = \{(e, f_A^X(e): e \in E, f_A^X(e) \in S^X\}$.

Example 2.1: Assume that $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be a universal set consisting of a set of six houses under consideration, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, where each parameter $e_i, i = 1,2,3,4,5$ stands for "expensive", "lovely", "affordable", "modern", "wooden", respectively and $A = \{e_1, e_2, e_3\} \subseteq E$.

Suppose a soft set F_A^X describes the attractions of the houses, such that

$f_A^X(e_1) = \{h_2, h_4\}$,

$f_A^X(e_2) = \{h_1, h_3\} and$

$f_A^X(e_3) = \{h_3, h_4, h_5\}$.

Then the soft set F_A^X is a parameterized family $\{f_A^X(e_i): i = 1,2,3\}$ of subset of U defined as

$F_A^X = \{f_A^X(e_1), f_A^X(e_2), f_A^X(e_3)\},$

i.e, $F_A^X = \{\{h_2, h_4\}, \{h_1, h_3\}, \{h_3, h_4, h_5\}\}$.

The soft set F_A^X can also be represented as a set of ordered pairs as:

$F_A^X = \{(e_1, f_A^X(e_1)), (e_2, f_A^X(e_2)), (e_3, f_A^X(e_3))\}$ i.e

$F_A^X = \{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3\}, (e_3, \{h_3, h_4, h_5\})\}$

Definition 2.2: Null soft set (see[15])

A soft set F_A^X over U is called a null soft set, denoted byϕ, if $e \in A$,

$F_A^X(e) = \emptyset$ (null-set).

Example 2.2: Suppose that, U is the set of wooden houses under consideration;

A is the set of parameters. Let there be five houses in the universe U given by

$U = \{h_1, h_2, h_3, h_4, h_5\}$ and A = {brick; muddy; steel; stone}.

The soft set F_A^Xdescribes the "construction of the houses". The soft sets $F_A^X$is defined as:

f_A^X (brick) means the brick-built houses,
f_A^X (muddy) means the muddy houses,
f_A^X (steel) means the steel-built houses,
f_A^X (stone) means the stone-built houses.
The soft set F_A^X is the collection of approximations as below:
F_A^X= {brick-built houses =∅, muddy houses = ∅, steel-built houses = ∅,
stone built houses = ∅)
Here, $F_A^X$is NULL soft set.

Definition 2.3

Soft union (See[15])

Let (F, A) and (G, B) be two soft sets over a common universe U. The union of (F, A) and (G, B) is defined to be the soft set (H, C) satisfying the following conditions:

(i) C =A∪B;
(ii) For all e∈ C,

$$H(e) = \begin{cases} F(e) & if\ e \in A \backslash B \\ G(e) & if\ e \in B \backslash A \\ F(e) \cup G(e) & if\ e \in A \cap B \end{cases}$$

This relation is denoted by $(F, A) \cup (G, B) = (H, C)$.

Example 2.3:

Let $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be a universe, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, and $A = \{e_1, e_2, e_3\} \subset E$.

Let a soft set (F, A) over U be given by

$(F, A) = \{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}), (e_3, \{h_3, h_4, h_5\})\}$

Suppose $B = \{e_3, e_4, e_5\}$ and (G, B) is a soft set over U given by

$(G, B) =$

$\{(e_3, \{h_1 h_2, h_3\}), (e_4, \{h_2, h_3, h_6\}), (e_5, \{h_2, h_3, h_4\})\}$.
Then,

$(F, A) \cup (G, B)$
$= \{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}, (e_3, \{h_1 h_2, h_3, h_4, h_5,\}), (e_4, \{h_2, h_3, h_6\}), (e_5,$

Definition 2.4:

Soft restricted union (see [15])

Let (F, A) and (G, B) be two soft sets over a common universe U such that $A \cap B \neq \emptyset$. The restricted union of (F, A) and (G, B) is denoted by $(F, A) \cup_R (G, B)$, and is defined as

$(F, A) \cup_R (G, B) = (H, C),$

where $C = A \cap B$ and for all $c \in C, H(c) = F(c) \cup G(c)$.

Example 2.4:

Let $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be a universe, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, and $A = \{e_1, e_2, e_3\} \subset E$ Let a soft set (F, A) over U be given by

(F, A)
$= \{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}), (e_3, \{h_3, h_4, h_5\})\}$

Suppose $B = \{e_3, e_4, e_5\}$ and (G, B) is a soft set over U given by

$(G, B) =$

$\{(e_3, \{h_1 h_2, h_3\}), (e_4, \{h_2, h_3, h_6\}), (e_5, \{h_2, h_3, h_4\})\}$.
Then,

$(F, A) \cup_R (G, B) = \{(e_3, \{h_1 h_2, h_3, h_4, h_5,\})\}$

Definition 2.5:

Soft intersection (See [15])

Let (F, A) and (G, B) be two soft sets over U with $A \cap B \neq O$. The intersection of (F, A) and (G, B) denoted $(F, A) \cap (G, B)$ is a soft set (H, C), where $C = A \cap B$ and $\forall e \in C$,

$H(e) = F(e) \cap G(e)$.

Example 2.5: Let $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be a universe, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, and $A = \{e_1, e_2, e_3\} \subset E$. Let a soft set (F, A) over U be given by

$(F, A) =$

$\{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}), (e_3, \{h_3, h_4, h_5\})\}$

Suppose $B = \{e_3, e_4, e_5\}$ and (G, B) is a soft set over U given by

$(G, B) =$
$\{(e_3, \{h_1 h_2, h_3\}), (e_4, \{h_2, h_3, h_6\}), (e_5, \{h_2, h_3, h_4\})\}$.

$(F, A) \cap (G, B) = \{(e_3, \{h_3\})$

Definition 2.6:

Soft extended intersection:

Let (F, A) and (G, B) be two soft sets over a common universe U. The extended intersection of (F, A) and (G, B) is defined to be the soft set (H, C) where C =A∪B and for all e∈ C,

$$H(e) = \begin{cases} F(e) & if\ e \in A \backslash B \\ G(e) & if\ e \in B \backslash A \\ F(e) \cap G(e) & if\ e \in A \cap B \end{cases}$$

This relation is denoted by $(F, A) \cap_E (G, B) = (H, C)$

Example 2.6 Let $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be a universe, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, and $A = \{e_1, e_2, e_3\} \subset E$. Let a soft set (F, A) over U be given by

$(F, A) =$

$\{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}), (e_3, \{h_3, h_4, h_5\})\}$

Suppose $B = \{e_3, e_4, e_5\}$ and (G, B) is a soft set over U given by
$(G, B) =$

$\{(e_3, \{h_1 h_2, h_3\}), (e_4, \{h_2, h_3, h_6\}), (e_5, \{h_2, h_3, h_4\})\}$.

$(F, A) \cap_E (G, B) =$
$\{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}), (e_3, \{h_3\}), (e_4, \{h_2, h_3, h_6\}), (e_5, \{h_2, h_3, h_4\})\}$
.

Definition 2.7:

Soft complement:

The complement of a soft set (F, A) denoted by $(F, A)^c$ is defined as

$(F, A)^c = (F^c, \neg A)$

where$F^c: \neg A \to P(U)$ is a mapping given by

$F^c(\alpha) = U - F(\neg\alpha) \forall \alpha \in \neg A$

Let us call F^c to be the soft complement function of F. Clearly $(F^c)^c$ is the same as F and

$((F, A)^c)^c$= *(F, A).*

Example 2.7:

Consider Example 3.1

Here $(F, E)^c$ = {not expensive houses= $\{h_1, h_3, h_5, h_6\}$,

not lovely houses = $\{h_2, h_4, h_5, h_6\}$,

not wooden houses = $\{h_1, h_2, h_6\}$,

not affordable houses = $\{h_2, h_4, h_6\}$,

not in the green surroundings Houses = $\{h_2, h_3, h_4, h_5, h_6\}$}.

Definition 2.8:

Relative complement

The relative complement of a soft set (F, A) denoted by $(F, A)^r$ is defined by

$(F, A)^r = (F^r, A)$

where $F^r: A \to P(U)$ is a mapping given by

$F^r(\alpha) = U - F(\alpha), \forall \alpha \in A.$

Example 2.8:

Let $U = \{h_1, h_2, h_3, h_4, h_5\}$ be a universal set, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, and $A = \{e_1, e_2, e_3\} \subset E$ Such that the soft set (F, A) over U be given by

$(F, A) = \{(e_2, \{h_2, h_4\}), (e_4, U)\}$

Then,

$(F, A)^c = \{(\neg e_2, \{h_1, h_3, h_5\}), (\neg e_3, U)\}$

$(F, A)^r = \{(e_2, \{h_1, h_3, h_5\}), (e_3, U)\}$

Definition 2.9:

Soft Conjunction ($-AND-$):

Let (F, A) and (G, B) be two soft sets over a common universe U. Then:

the AND-operation of (F, A) and (G, B) denoted by $(F, A) \wedge (G, B)$ is a soft set defined by

$(F, A) \wedge (G, B) = (H, A \times B)$ where

$H(x, y) = F(x) \cap G(y), \forall (x, y) \in A \times B.$

Example 2.9:

Let $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$ be a universe, $E = \{e_1, e_2, e_3, e_4, e_5\}$ be a set of parameters with respect to U, and $A = \{e_1, e_2, e_3\} \subset E$. Let a soft set (F, A) over U be given by

$(F, A) = \{(e_1, \{h_2, h_4\}), (e_2, \{h_1, h_3, h_5\}), (e_3, \{h_3, h_4, h_5\})\}$

Suppose $B = \{e_3, e_4, e_5\}$ and (G, B) is a soft set over U given by

$(G, B) = \{(e_3, \{h_1 h_2, h_3\}), (e_4, \{h_2, h_3, h_6\}), (e_5, \{h_2, h_3, h_4\})\}.$

$(F, A) \wedge (G, B) =$

$\{((e_1, e_3), \{h_2\}), ((e_1, e_4), \{h_2\}), ((e_1, e_5), \{h_2, h_4\}),$

$((e_2, e_3), \{h_1 h_3\}), ((e_2, e_4), \{h_3\}), ((e_2, e_5), \{h_3\}),$

$((e_3, e_3), \{h_3\}), ((e_3, e_4), \{h_3\}), ((e_3, e_5), \{h_3, h_4\})\}.$

3. RESULTS

3.1 Application of Soft Set in Decision Making Problem Using "AND-Operation"

The study of smoothness of functions, game theory, operations research, Riemann-integration, Perron integration, probability, theory of measurement, etc. were just a few of the applications of soft set theory that [16] discussed. In this section, we demonstrate how to use "AND" function of soft sets to apply soft set theory to problem involving decision-making.

Problem: Two out of every five flight attendants (hostesses) employed by the aviation business are expected to possess particular traits. B.Sc., M.Sc., and PhD degree holders are among the qualifications required by the industry; nevertheless, while the attributes of the applicants include Beautiful, Tall, and Brilliant, there are also qualified applicants who are unattractive. Soft sets are employed to select the most qualified candidates in order to address this issue as follows:

Let $U = \{p_1, p_2, p_3, p_4, p_5\}$ denotes the set of people in the interview for the job,

Let $A = \{a_1 = beautiful,\ a_2 = tall,\ a_3 = ugly,\ a_4 = brilliant\}$ are set of parameters representing the qualities of the applicants and

$B = \{b_1 = B.Sc,\ b_2 = M.Sc,\ b_3 =$ PhD$\}$ are the set of parameters representing the *qualification* of the candidates. The soft set

$(F, A) = \{F(a_1), F(a_2), F(a_3), F(a_4)\}$

where
$F(a_1) = \{p_1, p_2\}$,
$F(a_2) = \{p_1, p_3, p_5\}$
$F(a_3) = \{p_3, p_5\}$
$F(a_4) = \{p_1, p_2, p_3, p_4\}$

And
$(G, B) = \{G(b_1), G(b_2), G(b_3)\}$
$G(b_1) = \{p_1, p_2, p_3, p_4, p_5\}$,
$G(b_2) = \{p_1, p_2, p_5\}$,
$G(b_3) = \{p_1, p_2\}$

Then,

$(F, A) \wedge (G, B) = (H, A \times B),$

Table 1. Tabular representations of a soft set

(H,A×B)	$\boldsymbol{a_1, b_1}$	$\boldsymbol{a_1, b_2}$	$\boldsymbol{a_1,b_3}$	$\boldsymbol{a_2,b_1}$	$\boldsymbol{a_2, b_2}$	$\boldsymbol{a_2, b_3}$	$\boldsymbol{a_3, b_1}$	$\boldsymbol{a_3, b_2}$	$\boldsymbol{a_3,b_3}$	$\boldsymbol{a_4,b_1}$	$\boldsymbol{a_4 b_2}$	$\boldsymbol{a_4 b_3}$	**Choice value**
p_1	1	1	1	1	1	1	0	0	0	1	1	1	p_1 =9
p_2	1	1	1	0	0	0	0	0	0	1	1	1	p_2 =6
p_3	0	0	0	1	0	0	1	0	0	1	0	0	p_3 =3
p_4	0	0	0	0	0	0	0	0	0	1	0	0	p_4 =1
p_5	0	0	0	1	1	0	1	1	0	0	0	0	p_5 =4

Where;

$A \times B =$

$\{(a_1, b_1), (a_1, b_2), (a_1, b_3), (a_2, b_1), (a_2, b_2), (a_2, b_3), (a_3, b_1), (a_3, b_2), (a_3, b_3), (a_4, b_1), (a_4, b_2), (a_4, b_3)\}$ and

$$H\,(a_1, b_1) = F\,\{p_1, p_2\} \cap G\{p_1, p_2, p_3, p_4, p_5\} = \{p_1, p_2\} \quad (1)$$

$$H(a_1, b_2) = F\{p_1, p_2\} \cap G\{p_1, p_2, p_5\} = \{p_1, p_2\} \quad (2)$$

$$H(a_1, b_3) = F\{p_1, p_2\} \cap G\{p_1, p_2\} = \{p_1, p_2\} \quad (3)$$

$$H(a_2, b_1) = F\{p_1, p_3, p_5\} \cap G\{p_1, p_2, p_3, p_4, p_5\} = \{p_1, p_3, p_5\} \quad (4)$$

$$H(a_2, b_2) = F\{p_1, p_3, p_5\} \cap G\{p_1, p_2, p_5\} = \{p_1, p_5\} \quad (5)$$

$$H(a_2, b_3) = F\{p_1, p_3, p_5\} \cap G\{p_1, p_2\} = \{p_1\} \quad (6)$$

$$H(a_3, b_1) = F\{p_3, p_5\} \cap G\{p_1, p_2, p_3, p_4, p_5\} = \{p_3, p_5\} \quad (7)$$

$$H(a_3, b_2) = F\{p_3, p_5\} \cap G\{p_1, p_2, p_5\} = \{p_5\} \quad (8)$$

$$H(a_3, b_3) = F\{p_3, p_5\} \cap G\{p_1, p_2\} = \emptyset \quad (9)$$

$$H(a_4, b_1) = F\{p_1, p_2, p_3, p_4\} \cap G\{p_1, p_2, p_3, p_4, p_5\} = \{p_1, p_2, p_3, p_4\} \quad (10)$$

$$H(a_4, b_2) = F\{p_1, p_2, p_3, p_4\} \cap G\{p_1, p_2, p_5\} = \{p_1, p_2\} \quad (11)$$

$$H(a_4, b_3) = F\{p_1, p_2, p_3, p_4\} \cap G\{p_1, p_2\} = \{p_1, p_2\} \quad (12)$$

We observed the following:

(1) Means beautiful candidates with B.Sc. are $\{p_1, p_2\}$
(2) Means beautiful candidates with M.Sc. are $\{p_1, p_2\}$

……………………………………………

(10) Means Brilliant applicants with B.Sc. are $\{p_1, p_2, p_3, p_4\}$
(11) Means Brilliant applicants with M.Sc. are $\{p_1, p_2\}$
(12) Means Brilliant applicants with PhD are $\{p_1, p_2\}$

By representing (1) to (12) in a tabular form as in Table 1, the interviewer can select the best suitable candidates for the position.

The highest choice values, p_1 and p_2, may be seen in the table above and will help the interviewer choose the best candidates for the job. As a result, p_1 and p_2 were the best options because they had all of the necessary skills and certifications.

4. DISCUSSION

We succinctly outlined the fundamental ideas of soft set theory and listed some of its many current applications in diverse fields. A device for handling uncertainty issues is the soft set. Its parameterized concept makes it effective in handling uncertainty concerns. These applications condense the extensive body of knowledge in this topic into a manageable amount of time. Basic supporting structures have adequate time to form in soft sets. Through this field, many algebraic structures could be created. There was a thorough theoretical analysis of operations on soft sets. The smoothness of functions and the extension of soft set theory to real-world analysis are only two examples of the several disciplines in which soft set theory may find use. This paper effectively used a deep investigation of how two flight attendants (hostesses) were chosen in the airline sector. The soft set theory is therefore useful in all real-world decision-making processes.

5. CONCLUSION

As a result, we can see that soft set theory is both fascinating and helpful for resolving common issues. Making a decision in a pressing circumstance is helpful. However, we are able to demonstrate that soft set has significant and practical applications in decision-making problems with the help of the definition of AND operation of soft sets and chart representation of soft set. An interview helped by a specific aviation industry successfully chose the top two candidates out of five applications.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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