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Optimising College Selection Using Soft Set Theory: A Decision-Making Approach

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Abstract- **Selecting the right college is a critical decision for students, as it significantly impacts their academic, professional, and personal growth. However, the process is often complex, involving multiple criteria such as academic reputation, location, cost, facilities, and career opportunities. Traditional decision-making methods may struggle to handle the uncertainty and subjectivity inherent in such evaluations. This paper explores the application of Soft Set Theory as a robust framework for decision-making in college selection. Soft Set Theory, with its ability to handle vagueness and incomplete information, provides a flexible and systematic approach to evaluating and ranking colleges based on diverse parameters. By modelling the decision-making process using soft sets, this study demonstrates how students can make informed and optimal choices tailored to their preferences and goals. The proposed methodology is illustrated with a case study, showcasing its effectiveness in simplifying complex decisions and enhancing the accuracy of college selection. This research highlights the potential of Soft Set Theory as a valuable tool in educational decision-making and beyond.**

Keywords- **Soft set, Reduct-softest, choice-value, weighted, choice-value, decision making, Fuzzy set, rough set**

1. INTRODUCTION

Most of our traditional tools for formal modelling, reasoning, and computing are crisp, deterministic, and precise. But many complicated problems in economics, engineering, environment, social science, medical science, etc., involve data that are not always all crisp. We cannot always use the classical methods because of the various types of uncertainties presented in these problems. The important existing theories, that is, the theory of probability, the theory of fuzzy sets [14, 17, 19], the theory of intuitionistic fuzzy sets [1, 2], the theory of vague sets [3], the theory of interval mathematics [2, 4], theory of rough sets.

[11] can be considered as mathematical tools for dealing with uncertainties. But all these theories have their difficulties as pointed out in [9]. The reason for these difficulties is, possibly, the inadequacy of the parametrization tool of the theories and consequently in the year 1999, Molodtsov [9] initiated the concept of soft set theory as a new mathematical tool for dealing with uncertainties or vagueness which is free from the above difficulties. Soft set theory has a rich potential for applications in several directions like economics, engineering, medical science, etc., a few of which had been shown by Molodtsov in his pioneer work [9]. Soft sets are called (binary,

basic, elementary) neighbourhood systems [16] and are a special case of context-dependent fuzzy sets, as defined by Thielle [15]. Applications of soft set theory in other disciplines and real-life problems are now catching momentum. Maji et. al., [7], in the year 2002, offered the first practical application of soft sets in decision-making problems. It is based on the notion of knowledge of reduction in rough set theory. In this paper, we present another application of soft sets in a decision-making problem for real estate marketing with the help of the rough mathematics of Pawlak [11, 12, 13] and provide an algorithm to select the optimal choice of an object. The algorithm used fewer parameters to select the optimal object for a decision problem.

II. PRELIMINARIES

In this section, we present some basic definitions which are needed in further Study of this paper. Let U be an initial universe set and E_U (or simply be a collection of all possible parameters to U, where parameters are the characteristics or properties of objects in U. Let $P(U)$ be the collection of all subsets of U.

Definition 2.1: A pair (F, A) is said to be a soft set over U of A $A \subseteq E$ and $F: A \subseteq P(U)$. We write F_A. for (F, A).

Example 2.1: A Soft set (F, E) Describes the attractiveness of the House that Mr. X is going to buy.

U= The set of houses under consideration

E= the set of parameters. Each parameter is a word or a sentence.

E = {Expensive, Beautiful; Wooden; cheap; in the green surroundings; in good repair}

In this case to define a soft set means to point out expensive houses, beautiful houses and so on. It is worth noting that the set F(a) may be empty for some $a \in E$.

Definition 2.2: Let F_A and G_B be soft sets over a common universe set U and $A, B \subseteq$ E. Then we say that

(a) F_A is a ***soft subset*** of G_B, if (i) $A \subseteq B$ and (ii) $F(a) \subseteq G(a)\ \forall\ a \in A$. It is denoted by $F_A \subseteq G_B$,

(b) F_A Equals to G_B, if $F_A \subseteq G_B$ and $G_B \subseteq F_A$.It is denoted as $F_A = G_B$.

Definition 2.3 A soft set F_A over U is said to be a ***null soft set*** if $a \in A, F(a) = \varnothing$ and it is denoted by $\emptyset$.

Definition 2.4 A soft set F_A over U is said to be an ***absolute soft set*** if $a \in A, F(a) = U$, and denoted by G.

Definition 2.5: The ***union*** of two soft sets F_A and G_B over a common universe U is the soft set H_C, where $C = A \cup B$, and for all $a \in C$, We write $F_A \cup G_B = H_C$.

$$H(a) = \begin{cases} F(a)\ if\ a \in A - B \\ G(a)\ if\ a\ \in B - A \\ F(a)\ \cup\ G(a)\ if\ a \in A \cap B \end{cases}$$

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Definition 2.6: The intersection of two soft sets F_A and G_B over a Common Universe U is the soft set H_C, where $C = A \cap B$, and for all $a \in C$, $H(a) = F(a) \cap G(a)$. We write $F_A \cap G_B = H_C$.

III. Relationship between Soft Set and Information System

Let $U = \{u_1, u_2, u_3, u_4, u_5, u_6\}$ be a universal set consisting of a set of six colleges under consideration. Let $A = \{e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$ be a set of parameters, where e_1: stands for Training and Placements; e_2: stands for Play Ground; e_3: stands for Transportation; e_4: stands for Courses; e_5: stands for Qualified Faculty; e_6: stands for Hostel and e_7: Library for student service.

The table 1 soft set (F, A) describes the" College Info" that a student chooses Suppose that we have:

$(F, e_1) = \{u_1, u_4, u_5\}$;

$(F, e_2) = \{u_2, u_6\}$;

$(F, e_3) = \{u_1, u_3, u_5\}$;

$(F, e_4) = \{u_1, u_4, u_6\}$;

$(F, e_5) = \{u_1, u_3, u_6\}$;

$(F, e_6) = \{u_2, u_5\}$;

$(F, e_7) = \{u_2, u_3\}$.

In order to store soft sets in the computer easily, the 0-1 two-dimensional table is used to represent a soft set in Table 1.

Table 1: Soft Set (F, A)

U	e_1	e_2	e_3	e_4	e_5	e_6	e_7
u_1	1	0	1	1	1	0	0
u_2	0	1	0	0	0	1	1
u_3	0	0	1	0	1	0	1
u_4	1	0	0	1	0	0	0
u_5	1	0	1	0	0	1	0
u_6	0	1	0	1	1	0	0

Let $U = \{c_1, c_2, c_3, c_4, c_5, c_6\}$ be a set of six Seminary and E = {Training and Placements Playground, Transportation, Courses, Qualified Faculty, Hostel, Library} be a set of parameters. Consider the soft set (F, E) which describes the "College Info" given by:

Here is the text extracted from the image:

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Library Seminary = φ,

Training and Placements Seminary = $\{c_1, c_2, c_3, c_4, c_5, c_6\}$,

Qualified Faculty Seminary = $\{c_1, c_2, c_6\}$,

(F, E) Transportation Seminary = $\{c_1, c_2, c_6\}$,

Courses =Seminary $\{c_1, c_2, c_3, c_4, c_5, c_6\}$,

Hostel = Seminary $\{c_1, c_2, c_6\}$,

Playground Seminary= $\{c_1, c_2, c_3, c_4, c_6\}$,

Suppose that, Mr. X is interested in joining a college based on his choice parameters Library, Training and Placements, Qualified Faculty, Transportation, Courses etc., which constitute the subset **A = {e1 = Library; e2 = Training and Placements; e3 = Qualified Faculty; e4 = Transportation; e5 = Courses}** of the set E.
That means, out of the chalets available in U, he is to select the chalet that qualifies with all (or a maximum number) of parameters of the soft set A.
Suppose that, another customer Mr. Y wants to join a seminary based on the sets of his choice parameters B ⊂ E, where **B = {Training and Placements, Playground, Transportation, Courses, Qualified Faculty, Hostel, Library}**. Also, Mr. Z wants to join a seminary based on another set of parameters C ⊂ E. The problem is to select the seminary that is most suitable with the choice parameters of Mr. X. The seminary that is most suitable for Mr X, need not be the most suitable for Mr. Y.

3.1 Tabular Representation of a Soft Set (F, A)

We present an almost analogous representation in the form of a binary table. For this, consider the soft set (F, A) above based on the set A of choice parameters of $Mr \cdot X$. Then, consider the soft set (F, A):

$(F, A) = \{(e_1, U), (e_2, \{c_1, c_2, c_6\}), (e_3, U), (e_4, \{c_1, c_2, c_3, c_4, c_6\}), (e_5, \{c_1, c_3, c_6\})\}$.

We can represent this soft set (F, A) in a tabular form as shown below. This style of representation will be useful for storing a soft set in a computer memory.

If $c_i \in F(e_j)$, then $c_{ij} = 1$, otherwise $c_{ij} = 0$, where c_{ij} are the entries in Table 2.

Thus, a soft set can now be viewed as a knowledge representation system, where the set of attributes is replaced by a set of parameters.

3.2 Reduct-Table of a Soft Set

Consider the soft set (F, E). Clearly, for any $A \subset E$, the set (F, A) is a soft subset of (F, E). We will now Table 2 define a reduct-soft set of the soft set (F, A).

Table 2: Reduct-Table of a Soft Set

	Training and Placements	Playground	Transportation	Courses	Qualified Faculty
c1	1	1	1	1	1
c2	1	1	1	1	0
c3	1	0	1	1	1
c4	1	0	1	1	0

c5	1	0	1	0	0
c6	1	1	1	1	1

Consider the tabular representation of the soft set (F, A). If B is a reduction of A, then the soft set (F, B) is called the reduct-soft-set of the soft set (F, A).

Intuitively, a reduct-soft-set (F, B) of the soft set (F, A) in the essential part, which suffices to describe all basic approximate descriptions of the soft set (F, A).

The core soft set of (F, A) in the soft set (F, C), where C is the CORE (A) (i.e., CORE (A) = ∩RED(A)).

3.3 Choice Value of an Object Vi

The Choice Value of an object $c_i \in U$ is v_i given by

$$V_i = \sum_j C_{ij}$$

where Vi are the entries in the table of the reduct-soft-set

3.4 Algorithm for Selection of the Seminary

The following algorithm may be followed by $Mr. X$ to select the seminary he wishes to join:

3.2.1 Input the soft set (F, E);
3.2.2 Input the set A of choice parameters of $Mr. X,$ which is a subset of E;
3.2.3 Find all reduct-soft-sets of (F, A);
3.2.4 Choose one reduct-soft-set say (F, B) of (F, A);
3.2.5 Find k, for which $v_k = max\ v_i$.

Then, v_k is the optimal choice object. If k has more than one value, then any one of them could be chosen by $Mr. X$ by using his option. Now, we use the algorithm to solve our original problem. Clearly, from Table (2) we see that {e1, e2, e4, e5} and {e2, e3, e4, e5} are two reductions of A = {e1, e2, e3, e4, e5}. Choose any one say, B = {e1, e2, e4, e5}.
Incorporating the choice values, the reduct-soft-set can be represented in Table (3) below:
Decision: $Mr. X$ can join either the seminary c_1 or the seminary c_6.
Table 3 Reduct-soft-set

	e_1	e_2	e_4	e_6	*Choice value* $\left(V_i = \sum_j C_{ij}\right)$
c_1	1	1	1	1	$v_1 = 4$
c_2	1	1	1	0	$v_2 = 3$
c_3	1	0	1	1	$v_3 = 3$
c_4	1	0	1	0	$v_4 = 2$
c_5	1	0	0	0	$v_5 = 1$
c_6	1	1	1	1	$v_6 = 4$

It may happen that for joining a seminary, all the parameters belonging to A are not of equal importance to $Mr \cdot X.$ He likes to impose weights on his choice parameters that correspond to each element $a_i \in A$, there is a weight $w_i \in (0, 1)$.

3.4 Weighted Table of a Soft Set

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In 1996 defined a new theory of mathematical analysis, which is the" theory of W-soft sets", which means weighted soft sets. Following Lin's style, we define the weighted table of the reduct-soft-set (F, B), which have entries $d_{ij} = w_j \cdot c_{ij}$, instead of 0 and 1 only. where c_{ij} are the entries in the table of the reduct-soft-set (F, B).

3.5 Weighted Choice Value of an Object c_i

The weighted choice value of an object $c_i \in U$ is c_i, given by

	e_1 ($w_1 = 0.8$)	e_2 ($w_2 = 0.3$)	e_4 ($w_4 = 0.9$)	e_5 ($w_5 = 0.8$)	Choice Value (v_i)
c_1	1	1	1	1	$v_1 = 2.8$
c_2	1	1	1	0	$v_2 = 2.0$
c_3	1	0	1	1	$v_3 = 2.5$
c_4	1	0	1	0	$v_4 = 1.7$
c_5	1	0	0	0	$v_5 = 0.8$
c_6	1	1	1	1	$v_6 = 2.8$

$$V_i = \sum_j d_{ij} \ where \ d_{ij} = W_j . C_{ij}$$

Imposing weights on his choice parameters, $Mr\ X$ now could use the following revised algorithm for arriving at his final decision.

3.6 Revised Algorithm for Selection of the Seminary

3.6.1 Input the soft set (F, E),

3.6.2 Input the set A of choice parameters of $Mr \cdot X$ which is a subset of E,

3.6.3 Find all reduct-soft-sets of (F, A),

3.6.4 Choose one reduct-soft-set say (F, B) of (F, A),

3.6.5 Find theweighted table of the soft set (F, B) according to the weights decided by $Mr \cdot X$,

3.6.6 Find k, for which $v_k = \max v_i$.

Then c_k is the optimal choice object. If k has more than one value, then any one of them could be chosen by $Mr. \cdot X$, by taking his option.

3.6.6.1 Let us solve now the original problem using the revised algorithm.

3.6.6.2 Suppose that $Mr. X$ decides the following weights for the parameters of B.

for the parameter" Training and placements = e_1" put $w_1 = 0.8$, for the parameter" Transportations = e_2" put $w_2 = 0.3$, for the parameter" courses = e_4, choose $w_4 = 0.9$, and for the parameter" in Library = e_5, choose $w_5 = 0.8$.

Here's your table formatted properly

From Table (4), it is clear that $Mr \cdot X$ will select the Seminary, the college c_1 or c_6 for choosing according to his choice parameters in A.

Table 4 – Weighted choice value of a softest

IV. CONCLUSION

The selection of an appropriate college is a pivotal decision that shapes a student's academic and professional trajectory. Traditional decision-making methods often fall short in addressing the inherent uncertainties and subjective preferences involved in this process. This study demonstrates the efficacy of Soft Set Theory as a powerful and flexible tool for tackling such complex decisions. By providing a structured framework to evaluate multiple criteria—ranging from academic quality and financial considerations to location and personal preferences—Soft Set Theory enables students to make informed and optimal choices.

The proposed methodology not only simplifies the decision-making process but also enhances its accuracy by effectively handling vagueness and incomplete information. Through a practical case study, this research highlights the adaptability and robustness of the Soft Set Theory in real-world educational decision-making scenarios. Future work could explore the integration of this approach with other soft computing techniques, such as fuzzy logic or neural networks, to further refine the decision-making process. Ultimately, this study underscores the potential of Soft Set Theory as a valuable tool not only in education but also in other domains requiring multi-criteria decision-making under uncertainty.

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