RESEARCH PAPER

A Mathematical Decision-Making Framework Based On Soft Topology for Diabetes Drug Delivery Systems

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ABSTRACT
Soft sets are powerful tools used across various disciplines to manage ambiguity, uncertainty, and indeterminate data. Researchers in domains including game theory, operations research, probability, and decision-making have thoroughly examined the idea of soft sets. This study introduces the fundamental concepts of soft sets used in decision making theory. Real-world examples are included to illustrate several characteristics of this field. As a survey of the literature, We outline some of the key advancements in the applications of soft set theory in this work. These methodologies have proven to be highly effective in numerous practical applications.
Keywords: Soft set, Reduction of soft set, Choice Value, Decision of Choice Value.
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I - INTRODUCTION

Molodtsov first presented soft set theory in 1999., is a generalization of fuzzy set theory designed to address uncertainty in a parameterized manner. A soft set, in contrast to classical or fuzzy sets, is characterized as a parameterized family of subsets; its dependence on changing parameters gives it its "soft" quality. One of the key advancements in the theory of soft sets was the introduction of mappings on soft sets, a development made by Athar Kharal and Bashir Ahmad in 2009 and 2011. Soft set theory has proven to be a valuable tool in various domains, including medical diagnosis, where it supports decision-making processes under uncertainty. In particular, it has been applied in the development of medical expert systems. In this study, we explore the application of **soft topology** a combination of topology and soft set theory—for the prognosis of diabetes. The analysis is conducted within the framework of a decision-making problem. we collected data from a sample of 25 diabetic patients and applied soft set-based methods to interpret and analyze the data. The results demonstrate the potential of soft set theory as a useful approach for diagnosing and understanding diabetic conditions in uncertain and variable medical environments.

II- PRELIMINARIES

SOFT SETS

Definition : 2.1[4]
"A soft set F_A on the universe U is defined by the set of ordered pairs, E be the set of parameters and $A \subseteq E$, then $F_A = \{(x, f_A(x)) : x \in E\}$ where $f_A : E \rightarrow P(U)$ such that $f_A(x) = \emptyset$ if $x \notin A$. Here the value of $f_A(x)$ may be aribitary. Some of them may be empty some may have non-empty intersection.

Note that the set of all soft sets with the parameter set E over U will be denoted by $S(U)$."

"Definition : 2.2[4]

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"Let $F_A \in S(U)$. If $f_A(x) = \emptyset$ for all $x \in A$ then F_A is called an empty soft set, denoted by $F_{\emptyset}$."

Definition: 2.3[4]
"Let $F_A \in S(U)$. If $F_A(x) = U$ for all $x \in A$ then F_A is called a A-universal soft set, denoted by $F_{\tilde{A}}$. If $A = E$, then the A-universal soft set is called universal soft set denoted by $F_{\tilde{E}}$."

Definition: 2.4[4]
"Let $F_A, F_B \in S(U)$. Then soft union $F_A \tilde{\cup} F_B$, Soft intersection $F_A \tilde{\cap} F_B$, and soft difference $F_A \tilde{\setminus} F_B$ of F_A and F_B are defined by respectively.

$f_{A\tilde{\cup}B}(x) = f_A(x) \cup f_B(x)$, $f_{A\tilde{\cap}B}(x) = f_A(x) \cap f_B(x)$, $f_{A\tilde{\setminus}B}(x) = f_A(x) \setminus f_B(x)$,

and the soft complement $F^{\tilde{c}}{}_A$ of F_A is defined by $f^{\tilde{c}}{}_A(x) = f^c{}_A$ where $f^c{}_A(x)$ is complement of the set $f_A(x)$, that is $f^c{}_A(x) = U \setminus f_A(x)$ for all $x \in E$."

Definition: 2.5[4]
"Let $F_A \in S(U)$. The relative complement of F_A is denoted by F'_A and is defined by $(F_A)' = (F'_A)$ where $F'_A : A \to P(U)$ is a mapping given by $F'_{\propto} = U \setminus F_{\propto}$ for all $\propto \in A$."

Definition: 2.6[4]
"Let $(F_A, \tilde{\tau})$ be a soft topological space, then every element of $\tilde{\tau}$ is called a soft open sets in $\tilde{\tau}$."

Definition: 2.7[4]
"Let $(F_A, \tilde{\tau})$ be a soft topological space. A soft set F_A is said to be a soft closed set, if its relative complement F'_A belongs to $\tilde{\tau}$."

Definition: 2.8[4]
"Let $(F_A, \tilde{\tau})$ be a soft topological space, then soft interior of soft set F_A is defined as the union of all soft open sets contained in F_A. It is denoted by $int(F_A)$."

Definition : 2.9[4]
"Let $(F_A, \tilde{\tau})$ be a soft topological space, then soft closure of soft set F_A is defined as the intersection of all soft closed super sets containing in F_A. It is denoted by $cl(F_A)$."

III- PROGNOSIS OF DIABETIC CONDITION BY SOFT SET THEORY USING DECISION MAKING PROBLEM

In this chapter, a novel "application of soft set theory" is presented for the prognosis of diabetic conditions, formulated as a decision-making problem. Data were collected from 25 diabetic patients in a hospital setting, with each patient reporting a distinct set of symptoms. After analyzing the collected data, the symptoms were classified into five categories, each representing a subset of the overall parameter set. These categories reflect the diversity in symptom patterns among the patients and are described as follows

"Let U = {P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}}"

E = {Urinate a Lot (UL)

Very Thirsty (VTH),

Lose Weight (LW)

Very Hungry (VH)

Blurry Vision (BV)

Numb Tingling (NT)

Very Tired (VT)

Dry Skin (DS)

Heals Slowly (HS)

More Infections (MI)}

A={UL, VTH, LW, HS, VT} $\subseteq$ E

" $\Rightarrow F_A$ = {(UL,{P_1,P_3,P_5,P_7, P_8, P_9,P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}}), (VTH,{P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}}), (LW,{P_1, P_2, P_3, P_4, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}, P_{19}, P_{20}, P_{22}, P_{23}, P_{25}}), (HS,{P_1, P_2, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}}), (VT,{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}})}."

"B= {VH, HS, DS, LW} $\subseteq$ E

$\Rightarrow F_B$ = {(VH,{P_2, P_4, P_6, P_{10}, P_{11}}, (HS,{P_1, P_2, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}}) (DS,{ P_2, P_4, P_6, P_{10}, P_{11}}), (LW,{ P_1, P_2, P_3, P_4, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}, P_{19}, P_{20}, P_{22}, P_{23}, P_{25}})}."

C= {UL, BV, VT, LW, VTH} $\subseteq$ E

" $\Rightarrow F_C$ = {(UL, {P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}},(BV,{ P_3,P_{12},P_{13}, P_{14}, P_{15}, P_{16},P_{17}, P_{18}, P_{21}, P_{24} }), (VT,{P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}}), (LW,{P_1, P_2, P_3, P_4, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}, P_{19}, P_{20}, P_{22}, P_{23}, P_{25}}), (VTH,{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}})}."

D= {NT, MI, BV, UL} $\subseteq$ E

"$\Rightarrow F_D$ = {(NT,{ P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22}, P_{23}, P_{24}, P_{25} }), (MI,{P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}}),(BV, { P_3, P_{12},P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{21}, P_{24}

}(UL,{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}})}.”

G= {MI, UL, NT, LW}$\subseteq$E

“$\Rightarrow$ F_G = {(MI, { P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}}),(UL,{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22} P_{23}, P_{24}, P_{25}}), (NT, { P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22}, P_{23}, P_{24}, P_{25}}),(LW,{P_1, P_2, P_3, P_4, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16}, P_{19}, P_{20}, P_{22}, P_{23}, P_{25}})}.”

“**Choice value:**

The Choice value of an object $h_i \in U$ is C_i is given by $C_i = \sum_j h_{ij}$, where h_{ij} are the entries in the table of the reduct soft set.”

Algorithm:

1. Input the soft set F_A, F_B, F_C, F_D, F_G.
2. Input the set A,B,C,D,G of choice parameters which is a subset of E.
3. Find all reduct soft sets of F_A, F_B, F_C, F_D, F_G.
4. Find the core of all reduct.
5. Find k, for which C_K=max C_i.

Then h_k is the optimal choice object.”

Tabular Presentation of reduction of soft set

“Patients	UL	VTH	LW	VH	BV	NT	VT	DS	HS	MI	Choice value
P_1	1	1	1	0	0	0	1	0	1	0	5
P_2	0	0	1	1	0	0	0	1	1	0	4
P_3	1	1	1	0	1	0	1	0	0	0	5
P_4	0	0	1	1	0	0	0	1	1	0	4
P_5	1	1	1	0	0	0	1	0	1	0	5
P_6	0	0	0	1	0	0	0	1	1	0	3
P_7	1	1	1	0	0	0	1	0	1	0	5
P_8	1	1	1	0	0	0	1	0	1	0	5
P_9	1	1	1	0	0	0	1	0	1	0	5
P_{10}	0	0	0	1	0	0	0	1	1	0	3
P_{11}	0	0	0	1	0	0	0	1	1	0	3
P_{12}	1	1	1	0	1	0	1	0	0	0	5
P_{13}	1	0	0	0	1	1	0	0	0	1	4
P_{14}	1	1	1	0	1	0	1	0	0	0	5
P_{15}	1	1	1	0	1	0	1	0	0	0	5
P_{16}	1	1	1	0	1	0	1	0	0	0	5
P_{17}	1	0	0	0	1	1	0	0	0	1	4
P_{18}	1	0	0	0	1	1	0	0	0	1	4
P_{19}	1	0	1	0	0	1	0	0	0	1	4
P_{20}	1	0	1	0	0	1	0	0	0	1	4
P_{21}	1	0	0	0	1	1	0	0	0	1	4
P_{22}	1	0	1	0	0	1	0	0	0	1	4
P_{23}	1	0	1	0	0	1	0	0	0	1	4
P_{24}	1	0	0	0	1	1	0	0	0	1	4
P_{25}	1	0	1	0	0	1	0	0	0	1	4”

“**Decision of a Choice Value:**

5 $\rightarrow$ { P_1 ,P_3 ,P_5 ,P_7 , P_8 ,P_9 ,P_{12} ,P_{14} ,P_{15} ,P_{16} }

4 $\rightarrow$ { P_2 ,P_4 ,P_{13} ,P_{17} , P_{18} ,P_{19} ,P_{20} ,P_{21} ,P_{22} ,P_{23} ,P_{24} ,P_{25}}

3 $\rightarrow$ { P_6 ,P_{10} ,P_{11}}”

“**Reduct Table of a soft set:**

Consider the soft sets F_A , F_B, F_C, F_D, F_G . Clearly A,B,C,D,G $\subseteq$ E be the soft subsets of E. We will now define a reduct set Q. If Q is a reduct set of the soft sets F_A , F_B, F_C, F_D, F_G then a reduct set Q is the essential part which describes all basic approximate descriptions of the above soft sets . Here the two reduct soft sets are

P = {UL,VT,LW,BV,NT,VT,DS,HS,MI} and Q = {UL,VT,LW,VH, BV,NT,VT,HS,MI}”

Tabular Representation of reduction of soft Set without P

“Patients	UL	VTH	LW	BV	NT	VT	DS	HS	MI	Choice value
P_1	1	1	1	0	0	1	0	1	0	5
P_2	0	0	1	0	0	0	1	1	0	3
P_3	1	1	1	1	0	1	0	0	0	5
P_4	0	0	1	0	0	0	1	1	0	3
P_5	1	1	1	0	0	1	0	1	0	5
P_6	0	0	0	0	0	0	1	1	0	2
P_7	1	1	1	0	0	1	0	1	0	5
P_8	1	1	1	0	0	1	0	1	0	5
P_9	1	1	1	0	0	1	0	1	0	5
P_{10}	0	0	0	0	0	0	1	1	0	2
P_{11}	0	0	0	0	0	0	1	1	0	2
P_{12}	1	1	1	1	0	1	0	0	0	5
P_{13}	1	0	0	1	1	0	0	0	1	4
P_{14}	1	1	1	1	0	1	0	0	0	5
P_{15}	1	1	1	1	0	1	0	0	0	5
P_{16}	1	1	1	1	0	1	0	0	0	5
P_{17}	1	0	0	1	1	0	0	0	1	4
P_{18}	1	0	0	1	1	0	0	0	1	4
P_{19}	1	0	1	0	1	0	0	0	1	4
P_{20}	1	0	1	0	1	0	0	0	1	4
P_{21}	1	0	0	1	1	0	0	0	1	4
P_{22}	1	0	1	0	1	0	0	0	1	4
P_{23}	1	0	1	0	1	0	0	0	1	4
P_{24}	1	0	0	1	1	0	0	0	1	4
P_{25}	1	0	1	0	1	0	0	0	1	4”

“Decision of a Choice Value:

$5 \rightarrow \{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16} \}$

$4 \rightarrow \{P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22}, P_{23}, P_{24}, P_{25}\}$

$3 \rightarrow \{ P_2, P_4\}$

$2 \rightarrow \{ P_6, P_{10}, P_{11}\}$”

Tabular Representation of reduction of soft set without Q

“Patients	UL	VTH	LW	VH	BV	NT	VT	HS	MI	Choice value
P_1	1	1	1	0	0	0	1	1	0	5
P_2	0	0	1	1	0	0	0	1	0	3
P_3	1	1	1	0	1	0	1	0	0	5
P_4	0	0	1	1	0	0	0	1	0	3
P_5	1	1	1	0	0	0	1	1	0	5
P_6	0	0	0	1	0	0	0	1	0	2
P_7	1	1	1	0	0	0	1	1	0	5
P_8	1	1	1	0	0	0	1	1	0	5
P_9	1	1	1	0	0	0	1	1	0	5
P_{10}	0	0	0	1	0	0	0	1	0	2
P_{11}	0	0	0	1	0	0	0	1	0	2
P_{12}	1	1	1	0	1	0	1	0	0	5
P_{13}	1	0	0	0	1	1	0	0	1	4
P_{14}	1	1	1	0	1	0	1	0	0	5
P_{15}	1	1	1	0	1	0	1	0	0	5
P_{16}	1	1	1	0	1	0	1	0	0	5
P_{17}	1	0	0	0	1	1	0	0	1	4

P_{18}	1	0	0	0	1	1	0	0	1	4
P_{19}	1	0	1	0	0	1	0	0	1	4
P_{20}	1	0	1	0	0	1	0	0	1	4
P_{21}	1	0	0	0	1	1	0	0	1	4
P_{22}	1	0	1	0	0	1	0	0	1	4
P_{23}	1	0	1	0	0	1	0	0	1	4
P_{24}	1	0	0	0	1	1	0	0	1	4
P_{25}	1	0	1	0	0	1	0	0	1	4”

“**Decision of a Choice Value:**

$5 \rightarrow \{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16} \}$

$4 \rightarrow \{P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22}, P_{23}, P_{24}, P_{25}\}$

$3 \rightarrow \{P_2, P_4\}$

$2 \rightarrow \{ P_6, P_{10}, P_{11}\}$”

Tabular Representation of reduction of soft set without P and Q

“Patients	UL	VTH	LW	BV	NT	VT	HS	MI	Choice value
P_1	1	1	1	0	0	1	1	0	5
P_2	0	0	1	0	0	0	1	0	2
P_3	1	1	1	1	0	1	0	0	5
P_4	0	0	1	0	0	0	1	0	2
P_5	1	1	1	0	0	1	1	0	5
P_6	0	0	0	0	0	0	1	0	1
P_7	1	1	1	0	0	1	1	0	5
P_8	1	1	1	0	0	1	1	0	5
P_9	1	1	1	0	0	1	1	0	5
P_{10}	0	0	0	0	0	0	1	0	1
P_{11}	0	0	0	0	0	0	1	0	1
P_{12}	1	1	1	1	0	1	0	0	5
P_{13}	1	0	0	1	1	0	0	1	4
P_{14}	1	1	1	1	0	1	0	0	5
P_{15}	1	1	1	1	0	1	0	0	5
P_{16}	1	1	1	1	0	1	0	0	5
P_{17}	1	0	0	1	1	0	0	1	4
P_{18}	1	0	0	1	1	0	0	1	4
P_{19}	1	0	1	0	1	0	0	1	4
P_{20}	1	0	1	0	1	0	0	1	4
P_{21}	1	0	0	1	1	0	0	1	4
P_{22}	1	0	1	0	1	0	0	1	4
P_{23}	1	0	1	0	1	0	0	1	4
P_{24}	1	0	0	1	1	0	0	1	4
P_{25}	1	0	1	0	1	0	0	1	4”

“**Decision of a Choice Value:**

$5 \rightarrow \{ P_1, P_3, P_5, P_7, P_8, P_9, P_{12}, P_{14}, P_{15}, P_{16} \}$

$4 \rightarrow \{P_{13}, P_{17}, P_{18}, P_{19}, P_{20}, P_{21}, P_{22}, P_{23}, P_{24}, P_{25}\}$

$2 \rightarrow \{P_2, P_4\}$

$1 \rightarrow \{ P_6, P_{10}, P_{11}\}$”

Patient Risk Classification and Treatment Guidelines

➢ *High Risk (Choice Value: 5)*

- **Pre-fasting Sugar Level**: ≥ 126 mg/dL
- **Post-fasting Sugar Level**: ≥ 200 mg/dL
- **Interpretation**: Diabetic

❖ **Treatment**:

Based on **age** and **overall health condition**, doctors may prescribe:

- **Higher dose capsules**, or
- **Insulin injections**

➢ *Moderate Risk (Choice Value: 4)*

- **Pre-fasting Sugar Level**: Between **140–160 mg/dL**
- **Interpretation**: Impaired Glucose Tolerance (pre-diabetic condition)

❖ **Treatment**:

- Preferably **capsules**

Note:
There is a slight inconsistency here—normally **impaired glucose tolerance** refers to values *lower* than full diabetes levels, and the typical impaired fasting glucose range is **100–125 mg/dL**. The 140–160 range seems high for "pre-diabetic" and may require clarification or correction.

➢ *Normal Range (Choice Values: 1 and 2)*

- **Pre-fasting Sugar Level**: Between **80–100 mg/dL**
- **Post-fasting Sugar Level**: Between **120–140 mg/dL**
- **Interpretation**: Normal blood sugar levels

❖ **Treatment**:

- No medical intervention needed (possibly just lifestyle recommendations)

IV- CONCLUSION

Soft set theory, introduced by Molodtsov, has emerged as an effective mathematical tool for handling uncertainty and vagueness in various real-world problems. Topology, as a fundamental branch of mathematics, has been enriched by the incorporation of soft set concepts. In this paper, we define a soft topological space using the notion of pre-open soft sets and examine several related properties. The proposed framework extends classical topological concepts and provides greater flexibility in dealing with imprecise information. Furthermore, the Pawlak rough set approach is applied to a decision-making problem to demonstrate the practical applicability of soft set theory. The results indicate that soft topological spaces offer a robust and adaptable structure for modeling decision-making processes under uncertainty. Future research will focus on exploring additional properties of soft topological spaces and their wider applications in decision-making and information systems

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