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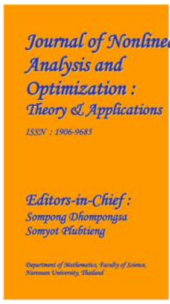

APPLICATION OF SOFT SETS IN MEDICAL SCIENCE

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Abstract

Mathematics has had a big effect on how far medical science has come. Mathematically based intelligent systems have been shown to be good at finding a wide range of diseases. In recent years, artificial intelligence has made a lot of progress because it is easy to use in many fields,such as medicine, engineering, and economics, to name a few. Molodtsov made soft set theory,which has been praised as a useful way to deal with uncertainty in math. Soft set theory is a general mathematical method for dealing with things that aren't clear, precise, or well defined. In this paper, we give a matrix representation of Sanchez's well-known strategy for medical diagnosis based on fuzzy arithmetic operations, as well as a hypothetical case study toshow how the technique works.

1 Introduction

Ambiguous data are a big part of many hard problems in economics, engineering, the social sciences, the medical sciences, and other fields. These problems that people facein life can't be solved by traditional math methods. In classical mathematics, a mathe-matical model of an object is built, and the exact solution to this model is figured out.Because of this, the math model is too complicated to give an exact answer. Several well-known theories describe uncertainty. Some math techniques are fuzzy set theory, rough set theory, and others. Molodtsov points out, though, that each of these theories has its own problems. Molodtsov came up with the idea of a "soft set" as a new way to deal with uncertainty in math that didn't have the problems that other methods did.Molodtsov's groundbreaking work showed how the theory of soft sets can be used in many different ways. Research on soft set theory is moving forward quickly right now. Majiet al. introduced the idea of fuzzy soft sets by describing their properties, such as fuzzy soft union, intersection, the complement of a fuzzy soft set, De Morgan's law, and so on. Neog and Sut have brought back the idea of fuzzy soft sets and rethought what goes withthem.[1],[2],[3],[4],[5]

2 Preliminaries [3]

To avoid problems, It is required to apply proper parameterization.Let E represent a set of parameters and U represent the beginning universe.

Definition[3]

We define soft set (over U) as a pair (F,E) in which E is mapped to F into the set of all U's subsets.

To put it another way, the soft set is a set of parameterized subsets of set U. Every set$F(\varepsilon)$,$\varepsilon \in E$,this family can be taken as the soft set's set of ε-elements (F, E), or as the soft set's set of ε-approximate elements (F, E).

As an example, consider the following scenario:

(1) The beauty of the houses Mr.X is intending to buy is described through a soft set (F,E).

U - is the collection of houses that is being considered.

E - is a grouping of parameters. Each parameter is a single word or phrase..

E = *{expensive; beautiful; wooden; cheap; in the green surroundings; modern; in good repair; in bad repair}*.

To define a soft set in this context, it implies pointing out expensive houses, gorgeous houses, and so on. It's important to remember that the sets $F(\varepsilon)$ can be anything. Some of them might beempty, and

some might have intersections that aren't empty.
(2) Zadeh's fuzzy set can be considered as a subset of the soft set. Let A be a fuzzy set,and μ_A be the membership function of the fuzzy set A, that is μ_A is a mapping of U into[0,1].
Let us consider the family of α-level sets for function μ_A

$$F(\alpha) = \{x \in U|\mu_A(x) \geq \alpha\}, \alpha \in [0, 1].$$

If we know the family F, we may use the following formula to obtain the functions

$$\mu_A(x): \mu_A(x) = sup\alpha, \alpha \in [0, 1] x \in F(\alpha)$$

Thus, every Zadeh's fuzzy set A may be contemplated as the soft set $(F, [0, 1])$.
(3) Let (X, τ)- be a topological space, where X is a set and τ is a topology, or a collection of subsets of X, referred to as the open sets of X.
Then, the family of open neighborhoods $T(x)$ of point x, where $T(x) = \{V \in \tau|x \in V\}$, ,may be considered as the soft set $(T(x), \tau)$.

In soft set theory, the way we set (or describe) any item is fundamentally different from how we utilise classical mathematics.

We construct a mathematical model of an object and then explain the idea of an exact solution to this model according to the standards of traditional mathematics. In most cases, the mathematical model is too complicated, and as a result, we are unable to geta solution that is accurate.

The soft set theory takes the opposite approach to solving this problem than tradi-tional set theory does. Due to the fact that the first description of the object is just approximate, it is not necessary for us to explain the idea of a precise solution.

Soft set theory is particularly convenient and easy to apply in reality because thereare no limits on the approximate description. Any parameterization method can be used, including words and sentences, real numbers, functions, maps, and so on. It means that in soft set theory, the difficulty of setting the membership function orany other equivalent problem does not occur.

Definition [3]
Let A ⊆ E. A pair (F,A) is called a soft set over U, where F is a mapping given by F : A→ P(U), where E is the set of parameters. The soft set, in other terms, is a parameterized family of U subsets. Every set F(e), e ∈ E from this family may be considered as the setof e-elements of the soft set (F,E), or the set of e-approximate elements of the soft set.

Example 2.1
Mr. X and Miss Y are getting married and need to rent a wedding venue. The soft set(F,E) refers to the 'wedding room's capacity'.
Let U =$\{u_1, u_2, u_3, u_4, u_5, u_6\}$be the wedding venues being considered,and E=$\{e_1, e_2, e_3, e_4, e_5\}$ be the parameter set: $F(e_1) = \{u_2, u_4\}$,$F(e_2) = \{u_1 u_3, u_4\}$,

$F(e_3) = \phi$,

$F(e_4) = \{u_1, u_3, u_5\}$,

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

The soft set (F,E) is as follows: $(F, E) = \{e_1 = \{u_2, u_4\}, e_2 = \{u_1, u_3, u_4\}, e_3 = \phi, e_4 =$

$\{u_1, u_3, u_5\}, e_5 = \{u_1, u_6\}\}$

Definition [1]

Over U, draw two soft sets (F,A) and (G,B). The combination of (F,A) and (G,B) isrepresented by (F,A) ∈ (G,B) is defined as the soft set (H,C), where C = A ∪ B, and ∀e ∈ C,

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

Definition [4]

1. A fuzzy soft set (F, A) is said to be the *absolute fuzzy soft set* over U, denotedby **Ω**, if $F(a) = 1_U$ for all a ∈ A.
2. A fuzzy soft set (F, A) is said to be the *null fuzzy soft set* over U, denoted by ϕ,if $F(a) = 0_U$ for all a ∈ A.

$$(J, K)\tilde{\cup}(J, K) = (J, K),$$

$$(J, K)\tilde{\cap}(J, K) = (J, K),$$

$$((J, K)\tilde{\cup}(L, M))^c = (J, K)^c\tilde{\cap}(L, M)^c,$$

$$((J, K)\tilde{\cap}(L, M))^c = (J, K)^c\tilde{\cup}(L, M)^c,$$

$$((J, K)\tilde{\vee}(L, M))^c = (J, K)^c\tilde{\wedge}(L, M)^c,$$

$$((J, K)\tilde{\wedge}(L, M))^c = (J, K)^c\tilde{\vee}(L, M)^c.$$

Definition[6]

1. A fuzzy subset μ on R's (the set of all real numbers) discourse universe is convexiff, for $a, b \in U \mu(\alpha a + \beta b) \geq \mu(a) \wedge \mu(b)$, where $\alpha + \beta$=1.
2. A fuzzy subset μ on U's discourse universe is called a *normal fuzzy subset* if thereexist $a_i \in U$ such that $\mu(a_i)$=1.
3. A *fuzzy number* is a fuzzy subset of the universe of discourse R that is both convexand normal.

A fuzzy number μ on the discourse R universe can be described by a triangular dis- tribution function parameterized by a triplet (a, b, c). The fuzzy number μ's membership function is defined as

$$\mu[u] = \begin{cases} 0 & if u < a, \\ \frac{u-a}{b-a} & if, a \leq u \leq b, \\ \frac{c-u}{c-b} & if, b \leq u \leq c, \\ 0 & if, u > c. \end{cases}$$

If the membership function μ(u) is piece-wise linear,then μ is said to be *trapezoidalfuzzy number*.

$$\mu \oplus \beta = \tilde{a}_2 \oplus \tilde{b}_2 = (a_1, a_2, a_3) \oplus (b_1, b_2, b_3)$$
$$= (a_1 + b_1, a_2 + b_2, a_3 + b_3)$$
$$\mu \otimes \beta = \tilde{a}_2 \otimes \tilde{b}_2 = (a_1, a_2, a_3) \otimes (b_1, b_2, b_3)$$

The defuzzification method for a trapezoidal fuzzy integer is then presented.
The fuzzy number's defuzzification value t is then determined as follows:

$$(t-q)(1)+\frac{1}{2}(q-p)(1)=(r-t)(1)+\frac{1}{2}(s-r)(1)$$
$$\Longrightarrow\ (t-q)+\frac{1}{2}(q-p)=(r-t)+\frac{1}{2}(s-r)$$
$$\Longrightarrow\ 2t=\frac{s-r-q+p}{2}$$
$$\Longrightarrow\ 2t=\frac{p+q+r+s}{2}$$
$$\Longrightarrow\ t=\frac{p+q+r+s}{4}$$

A fuzzy triangular number (a,b,c) has a defuzzification value of k, which is equal to

$$k=\frac{a+2b+c}{4} \qquad (1)$$

3 Methodology and Algorithm[7, 8]

In this section, we provide a medical diagnostic algorithm based on fuzzy arithmetic operations. Let's pretend there are m patients., P = $\{p_1, p_2, p_2, ..., p_m\}$,each presenting its own unique collection of signs and symptoms. S = $\{s_1, s_2, s_3, ..., s_n\}$ is associated with
a number of different diseases and conditions.D = $\{d_1, d_2, d_2, ..., d_k\}$.
Using Sanchez's method, we use **FSS** theory to provide a system for determining which patient is suffering from which ailment. We do this by layering a **FSS** (F, P) over S, where F is a mapping F:P→ F(S). This **FSS** produces Q, a patient-symptom matrix with fuzzy numbers as entries.
$\tilde{p}$ parameterized by a triplet $(p-1, p, p+1)$.
Create a new **FSS**(G, S) over D, where G is a mapping, G:S → F(D). The R relation
matrix (weighted matrix), also known as the symptom-disease matrix, is generated by this **FSS**, with each member representing the severity of symptoms for a certain ailment. These elements can alternatively be represented by triangular fuzzy numbers. Q's general form as a result is

$$Q=\begin{pmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \tilde{a}_{13} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \tilde{a}_{23} & \cdots & \tilde{a}_{2n} \\ \tilde{a}_{31} & \tilde{a}_{32} & \tilde{a}_{33} & \cdots & \tilde{a}_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{m1} & \tilde{a}_{m2} & \tilde{a}_{m3} & \cdots & \tilde{a}_{mn} \end{pmatrix}$$

and R in its most general form is

$$R=\begin{pmatrix} \tilde{b}_{11} & \tilde{b}_{12} & \tilde{b}_{13} & \cdots & \tilde{b}_{1k} \\ \tilde{b}_{21} & \tilde{b}_{22} & \tilde{b}_{23} & \cdots & \tilde{b}_{2k} \\ \tilde{b}_{31} & \tilde{b}_{32} & \tilde{b}_{33} & \cdots & \tilde{b}_{3k} \\ \cdot & \cdot & \cdot & \ddots & \cdot \\ \tilde{b}_{n1} & \tilde{b}_{n2} & \tilde{b}_{n3} & \cdots & \tilde{b}_{nk} \end{pmatrix}$$

We now have the patient-diagnosis matrix D^* as a result of the transformation operation $Q \otimes R$,

$$D^* = \begin{bmatrix} \tilde{c}_{11} & \tilde{c}_{12} & \tilde{c}_{13} & \dots & \tilde{c}_{1k} \\ \tilde{c}_{21} & \tilde{c}_{22} & \tilde{c}_{23} & \dots & \tilde{c}_{2k} \\ \tilde{c}_{31} & \tilde{c}_{32} & \tilde{c}_{33} & \dots & \tilde{c}_{3k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{c}_{n1} & \tilde{c}_{n2} & \tilde{c}_{n3} & \dots & \tilde{c}_{nk} \end{bmatrix}$$

Where

$$\tilde{c}_{il} = \left(\sum_{j=1}^{n} (a_{ij} - 1).(b_{jl} - 1), \sum_{j=1} a_{ij}.b_{jl}, \sum_{j=1} (a_{ij} + 1).(b_{jl} + 1) \right). \quad (2)$$

Then, by 1-defuzzifying all the elements of the aforementioned matrix, we get a crispdiagnosis matrix as follows:

$$D^{**} = \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \tilde{v}_{13} & \dots & \tilde{v}_{1k} \\ \tilde{v}_{21} & \tilde{v}_{22} & \tilde{v}_{23} & \dots & \tilde{v}_{2k} \\ \tilde{v}_{31} & \tilde{v}_{32} & \tilde{v}_{33} & \dots & \tilde{v}_{3k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{v}_{n1} & \tilde{v}_{n2} & \tilde{v}_{n3} & \dots & \tilde{v}_{nk} \end{bmatrix}$$

Now if max $v_{il} = v_{is}$ for $1 \leq l \leq k$, Then we deduce that the patient p_i has disease d_s.

3.1 Algorithms

Step I: To get the patient-symptom matrix Q, enter the soft set (F,P).
Step II: To get the symptom-disease matrix R, enter the soft set (G,S).
Step III: Execute the transformation procedure $Q \otimes R$ in order to obtain the patient's diagnosis matrix D^*.
Step IV: We then defuzzify all the elements of D^* by 1 in order to get the matrix D^{**}.Step V: Identify the s for which v_{is}= max v_{il}.
Then we deduce that patient p_i is afflicted with ailment d_s.

4 Case study

Three patients are in a hospital. Fever, headache, abdominal discomfort, weight loss, decreased appetite, indigestion, tiredness, diarrhoea, chest pain while breathing, nausea, and vomiting are all symptoms Nirman, Kunal, and Soraj are experiencing. P={p_1, p_2, p_3} is a ground set that represents the set of patients. As a set of universal symptoms, $S=\{\tilde{s}_1, \tilde{s}_2, \tilde{s}_3, ..., \tilde{s}_{10}\}$. $D=\{d_1, d_2, d_3\}$ refers to a collection of conditions that includes mi- graines, liver enlargement, and pneumonia.
let,

$$F(p_1) = \{\tilde{s}_1/\tilde{3}, \tilde{s}_2/\tilde{7}, \tilde{s}_3/\tilde{5}, \tilde{s}_4/\tilde{2}, \tilde{s}_5/\tilde{1}, \tilde{s}_6/\tilde{9}, \tilde{s}_7/\tilde{6}, \tilde{s}_8/\tilde{4}, \tilde{s}_9/\tilde{3}, \tilde{s}_{10}/\tilde{8}\}$$

$$F(p_2) = \{\tilde{s}_1/\tilde{7}, \tilde{s}_2/\tilde{2}, \tilde{s}_3/\tilde{1}, \tilde{s}_4/\tilde{6}, \tilde{s}_5/\tilde{9}, \tilde{s}_6/\tilde{3}, \tilde{s}_7/\tilde{5}, \tilde{s}_8/\tilde{4}, \tilde{s}_9/\tilde{7}, \tilde{s}_{10}/\tilde{8}\}$$

$$F(p_3) = \{\tilde{s}_1/\tilde{3}, \tilde{s}_2/\tilde{1}, \tilde{s}_3/\tilde{9}, \tilde{s}_4/\tilde{6}, \tilde{s}_5/\tilde{8}, \tilde{s}_6/\tilde{5}, \tilde{s}_7/\tilde{7}, \tilde{s}_8/\tilde{6}, \tilde{s}_9/\tilde{3}, \tilde{s}_{10}/\tilde{9}\}$$

As a result, a collection of approximation descriptions of patient symptoms in the hospital is produced by the fuzzy soft (F, P), a parameterized family of all fuzzy sets over S. The relation matrix (patient-symptom matrix) X is represented by this fuzzy soft set (F, P), which is provided by the fuzzy soft set (F, P) is then a parameterized familyof all fuzzy sets over S, giving a set of approximate patient-symptom descriptions in the hospital. This fuzzy soft set (F, P) represents the relation matrix (patient-symptom matrix) X.

$$X = \begin{bmatrix} \tilde{3} & \tilde{7} & \tilde{5} & \tilde{2} & \tilde{1} & \tilde{9} & \tilde{6} & \tilde{4} & \tilde{3} & \tilde{8} \\ \tilde{7} & \tilde{2} & \tilde{1} & \tilde{6} & \tilde{9} & \tilde{3} & \tilde{5} & \tilde{4} & \tilde{7} & \tilde{8} \\ \tilde{3} & \tilde{1} & \tilde{9} & \tilde{6} & \tilde{8} & \tilde{5} & \tilde{7} & \tilde{6} & \tilde{3} & \tilde{9} \end{bmatrix}$$

Next we take,

$G(\tilde{s}_1) = \{d_1/\tilde{3}, d_2/\tilde{8}, d_3/\tilde{9}\}$ $\quad$ $G(\tilde{s}_2) = \{d_1/\tilde{7}, d_2/\tilde{2}, d_3/\tilde{5}\}$

$G(\tilde{s}_3) = \{d_1/\tilde{4}, d_2/\tilde{1}, d_3/\tilde{8}\}$ $\quad$ $G(\tilde{s}_4) = \{d_1/\tilde{7}, d_2/\tilde{9}, d_3/\tilde{1}\}$

$G(\tilde{s}_5) = \{d_1/\tilde{5}, d_2/\tilde{4}, d_3/\tilde{7}\}$ $\quad$ $G(\tilde{s}_6) = \{d_1/\tilde{6}, d_2/\tilde{8}, d_3/\tilde{3}\}$

$G(\tilde{s}_7) = \{d_1/\tilde{2}, d_2/\tilde{8}, d_3/\tilde{4}\}$ $\quad$ $G(\tilde{s}_8) = \{d_1/\tilde{6}, d_2/\tilde{9}, d_3/\tilde{8}\}$

$G(\tilde{s}_9) = \{d_1/\tilde{4}, d_2/\tilde{3}, d_3/\tilde{1}\}$ $\quad$ $G(\tilde{s}_{10}) = \{d_1/\tilde{5}, d_2/\tilde{8}, d_3/\tilde{7}\}$

A parameterized family $\{G(s_1), G(s_2), G(s_3), G(s_4), G(s_5), G(s_6), G(s_7), G(s_8), G(s_9), G(s_{10})\}$ of all fuzzy sets over the set S makes up the fuzzy soft set (G, S),where $G : S \rightarrow F(D)$ and are based on the findings of medical experts. As a result, the soft fuzzy set (G, S)closely resembles the three diseases and the symptoms that accompany each of them. This soft set is represented by a relation matrix (symptom-disease matrix) Y.

$$Y = \begin{bmatrix} \tilde{3} & \tilde{8} & \tilde{9} \\ \tilde{7} & \tilde{2} & \tilde{5} \\ \tilde{4} & \tilde{1} & \tilde{8} \\ \tilde{7} & \tilde{9} & \tilde{1} \\ \tilde{5} & \tilde{4} & \tilde{7} \\ \tilde{6} & \tilde{8} & \tilde{3} \\ \tilde{2} & \tilde{8} & \tilde{4} \\ \tilde{6} & \tilde{9} & \tilde{8} \\ \tilde{4} & \tilde{3} & \tilde{1} \\ \tilde{5} & \tilde{8} & \tilde{7} \end{bmatrix}$$

The transformation operation $X \otimes Y$ is then used to obtain the patient-diagnosismatrix D^*.

$$X \otimes Y = D^* = \begin{bmatrix} 2\tilde{3}9 & 2\tilde{9}4 & 2\tilde{5}3 \\ 2\tilde{4}6 & 3\tilde{3}6 & 2\tilde{7}4 \\ 2\tilde{7}1 & 3\tilde{5}2 & 3\tilde{2}3 \end{bmatrix}$$

Where,

$2\tilde{3}9 = (152, 239, 346)$ $\quad$ $2\tilde{9}4 = (196, 294, 412)$ $\quad$ $2\tilde{5}3 = (162, 253, 364)$

$2\tilde{4}6 = (155, 246, 357)$ $\quad$ $3\tilde{3}6 = (239, 336, 458)$ $\quad$ $2\tilde{7}4 = (179, 274, 389)$

$2\tilde{7}1 = (175, 271, 387)$ $\quad$ $3\tilde{5}2 = (245, 352, 479)$ $\quad$ $3\tilde{2}3 = (162, 253, 364)$

The figures which can be seen above are based on 2: for i=1 & j=1 we get:

$$c_{11} = \big((3-1)(3-1)+(7-1)(7-1)+(5-1)(4-1)+(2-1)(7-1)+(1-1)(5-1)+(9-1)(6-1)+(6-1)(2-1)+(4-1)(6-1)+(3-1)(4-1)+(8-1)(5-1),\ (3\times 3+7\times 7+5\times 4+2\times 7+1\times 5+9\times 6+6\times 2+4\times 6+3\times 4+8\times 5),\ (3+1)(3+1)+(7+1)(7+1)+(5+1)(4+1)+(2+1)(7+1)+(1+1)(5+1)+(9+1)(6+1)+(6+1)(2+1)+(4+1)(6+1)+(3+1)(4+1)+(8+1)(5+1)\big)$$

$$= \big(2\times 2+6\times 6+4\times 3+1\times 6+0+8\times 5+5\times 1+3\times 5+2\times 3+7\times 4\},\ \{9+49+20+14+5+54+12+24+12+40\},\ \{4\times 4+8\times 8+6\times 5+3\times 8+2\times 6+10\times 7+7\times 3+5\times 7+4\times 5+9\times 6\big)$$

$$= \big((4+36+12+6+40+5+15+6+28),\ 239,\ (16+64+30+24+12+70+21+35+20+54)\big)$$

$$c_{11} = (152, 239, 346),$$

Similarly, we may calculate the value of $c_{12}, c_{13}, c_{21}, c_{22}, c_{23}, c_{31}, c_{32}, c_{33}$

$$c_{12} = (196, 294, 412) \qquad c_{13} = (162, 253, 364)$$

$$c_{21} = (155, 246, 357) \qquad c_{22} = (239, 336, 458) \qquad c_{23} = (179, 274, 389)$$

$$c_{31} = (175, 271, 387) \qquad c_{32} = (245, 352, 479) \qquad c_{33} = (162, 253, 364)$$

Following defuzzification of the matrix described above, the answer is

$$D^{**} = \begin{bmatrix} 244 & 299 & 258 \\ 251 & 342.25 & 279 \\ 276 & 357 & 258 \end{bmatrix}$$

From the above matrix, it is clear that all of the patients p_1, p_2, p_3 are experiencingthe effects of sickness d_2.

5 Conclusion

Throughout the course of this research, we worked to perfect Sanchez's methodology andthe idea of applying soft matrices. When additional symptoms are present, a diagnosis of a disease can be made with greater accuracy. As a consequence of this, Sanchez's method, when combined with soft matrices, has the potential to be utilised in the futureto diagnose diseases, with the accuracy of the detection being improved by increasing thenumber of symptoms.

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