AN APPLICATION OF FUZZY SOFT MATRIX IN MEDICAL DIAGNOSIS

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Abstract
In this paper, the patients having the symptoms of fever like Swine flu and Dengue has been collected. The awareness for the Swine flu and Dengue symptoms in the field of medical diagnosis can be made using fuzzy soft matrix. Here the fuzzy soft matrix is applied in Decision making problems. The proposed algorithms are used to finding fever affected patients.

Key words: Fuzzy set, Soft set, Fuzzy Soft set, Fuzzy Soft Matrix (FSM).

Introduction
The main concept of fuzzy set theory was introduced by Zadeh [1]. It was explained by Moldostov [2]. Fuzzy set considered as general mathematical and it is not clearly defined the object. This theory was developed into several basic notions of soft set theory. Maji [2, 10, 11] developed the theory again. Soft matrices representation of the soft sets and it was construct the soft max – min decision making method. This matrix is a representation of a fuzzy soft set and it was successfully applied to the proposed notion in fuzzy soft matrix [3]. Thus, there are many “decision can make” Fuzzy matrices are can use to study of Sanchez’s approach of medical diagnosis which has been made to apply to solving decision problem. Thus, fuzzy soft matrices are used to construct a decision making problem [5, 6, 13, 9]. Rajeshwari and Dhanalakshmi [5, 4, 7, 12] both are revealed the similarity between two fuzzy soft set based on its distance. Fuzzy soft matrices are introduced in agriculture by Sarala. N & Rajkumari [5, 9, 12] and also fuzzy soft matrices have introduced the orphans and also significant character of fuzzy soft matrices. Thus, this approach of fuzzy soft matrices based on the function in medical diagnosis.

Preliminaries
In this section, to recall some basic notion of fuzzy soft set and types of fuzzy soft set.

Soft Set [5]
Let U be an initial universe set and E be a set of parameters. Let P (U) denotes the power set of U. Let A ⊆ E. A pair (F_A, E) is called a soft set over U, where F_A is a mapping given by F_A: E → P (U) such that F_A(e) = ∅ if e ∉ A. Here F_A is called approximate function of the soft set (F_A, E). The set F_A (e) is called e ≈ approximate value set which consist of related objects of the parameter e ∈ E.

Example 1
Let U= {u_1, u_2, u_3, u_4} be set of four varieties of cloths and E = {High Quality (e_1), Medium Quality (e_2), Low Quality (e_3)} be the set of parameters. If A= {e_1, e_2} ⊆ E. Let F_A (e_1) = {u_1, u_2, u_3, u_4} and F_A (e_2) = { u_1, u_2, u_3}. Then we write the soft set (F_A, E) = {(e_1, {u_1, u_2, u_3, u_4}), (e_2, { u_1, u_2, u_3})} over U which describe the “Quality of cloths” which Mrs. John is going to bye. We may represent the soft set in the following form
Table 1

<table>
<thead>
<tr>
<th>U</th>
<th>e₁</th>
<th>e₂</th>
<th>e₃</th>
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<tbody>
<tr>
<td>u₁</td>
<td>1</td>
<td>1</td>
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<tr>
<td>u₂</td>
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<td>u₄</td>
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**Fuzzy Soft Set** [5]

Let U be an initial universe set and E be a set of parameters. Let \( A \subseteq E \). A pair \((\tilde{F}, E)\) is called a fuzzy soft set (FSS) over U, where \( \tilde{F} \) is a mapping given by, \( \tilde{F}: E \rightarrow I^U \), where \( I^U \) denotes the collection of all fuzzy subsets of \( U \).

**Example 2**

Consider the example 1 here we cannot express with only two real numbers 0 and 1, we can characterized it by a membership function instead of crisp number 0 and 1, which real numbers 0 and 1, we can characterized it by a

Then \((\tilde{F}, E) = \{(F_A(e_1) = \{(u_1,0.7), (u_2,0.8), (u_3,0.2), (u_4,0.5)\}, \tilde{F}_A(e_2) = \{(u_1,0.3), (u_2,0.6), (u_3,0.8)\}\) is the fuzzy soft set representing the “Quality of Cloths” which Mrs. John is going to buy. We may represent the fuzzy soft set in the following form

Table 2

<table>
<thead>
<tr>
<th>U</th>
<th>e₁</th>
<th>e₂</th>
<th>e₃</th>
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<tbody>
<tr>
<td>u₁</td>
<td>0.7</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>u₂</td>
<td>0.8</td>
<td>0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>u₃</td>
<td>0.2</td>
<td>0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>u₄</td>
<td>0.5</td>
<td>0.0</td>
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**Fuzzy soft complement set** [5]

The complement of fuzzy soft set \((\tilde{F}, E)\) denoted by \((\tilde{F}_C, E)_C\) is defined by \((\tilde{F}, E)_C = (\tilde{F}_C, E), \) where \( \tilde{F}_C: E \rightarrow I^U \) is a mapping given by \( \tilde{F}_C(e) = [F_A(e)]^c \). Fuzzy soft matrices

**Fuzzy soft matrices** [6]

Let \((\tilde{F}, E)\) be a fuzzy soft set over U. Then a subset of \( U \times E \) is uniquely define by \( R_A = \{(u, e): e \in A, u \in \tilde{F}_A(e)\} \) which is called a relation form of \((\tilde{F}, E)\), Now the characteristic function of \( R_A \) written by, \( \mu_{R_A}: u \times E \rightarrow [0,1] \) such that \( \mu_{R_A}(u, e) \) is in \([0,1]\) is the membership value of the object \( u \in U \) for each \( e \in E \). If \([\mu_{ij}] = \mu_{R_A}(u, e)\), we can define a matrix

\[
\begin{pmatrix}
\mu_{11} & \mu_{12} & \ldots & \mu_{1n} \\
\mu_{21} & \mu_{22} & \ldots & \mu_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
\mu_{m1} & \mu_{m2} & \ldots & \mu_{mn}
\end{pmatrix}
\]

Which is called a fuzzy soft matrix of order \( m \times n \) corresponding to the fuzzy soft set \((\tilde{F}, E)\) over U.

**Membership Value Matrix** [5]

The membership value matrix corresponding to the matrix \( \tilde{A} \) as

\[
\text{MV}(\tilde{A}) = [\tilde{A} \delta_{ij}^\tilde{A}]_{m \times n}, \quad \text{where} \quad \tilde{A} = \mu_{\tilde{A}} \cdot \gamma_{\tilde{A}}^i \quad \forall \quad i = 1,2,3,\ldots,m \quad \text{and} \quad j = 1,2,3,\ldots,n \, \text{where} \, \mu_{\tilde{A}} \, \text{and} \, \gamma_{\tilde{A}}^i \\
\]

represent the fuzzy membership function respectively of \( u_i \) in the fuzzy set \( \tilde{F}_A(e_i) \).

**Complement of fuzzy soft matrices** [5]

Let \( \tilde{A} = [(\tilde{A}_{ij}, 0)] \in \text{FSM}_{m \times n} \) where \( \tilde{A}_{ij} = (\mu_{\tilde{A}} \cdot \gamma_{\tilde{A}}^i) \) according to the definition in [13], the representation of the complement of the fuzzy matrix \( \tilde{A} \) which is denoted \( \tilde{A}^c \) and \( \tilde{A}^c \) is called fuzzy soft complement matrix if \( \tilde{A}^c = [(1, a_{ij}^c)] \) \( m \times n \) for all \( a_{ij}^c \in [0, 1] \). Then the matrix obtained from so called membership value would be the following \( \tilde{A}^c = [(a_{ij}^c)] = [(1 - a_{ij})] \) for all \( i \) and \( j \).

**Product of fuzzy soft matrices** [5]

Let \( \tilde{A} = [(\tilde{A}_{ij})_{m \times n}] \) \( \tilde{A}_{ij} = (\mu_{\tilde{A}} \cdot \gamma_{\tilde{A}}^i) \); where \( \mu_{\tilde{A}} \) and \( \gamma_{\tilde{A}}^i \) represent the fuzzy membership function and fuzzy reference function \( u_i \), so that \( \delta_{ij}^\tilde{A} = \mu_{\tilde{A}} \cdot \gamma_{\tilde{A}}^i \) gives the fuzzy
membership value $u_i$. Also let $\tilde{B} = [B_{jk}]_{n \times p}, \mu_{jk}^B = (\mu_{jk}^B :: \gamma_{jk}^B)$; where $\mu_{jk}^B$ and $\gamma_{jk}^B$ represent the fuzzy membership function and fuzzy reference function of $u_i$. We now define $\tilde{A} \cdot \tilde{B}$, the product of $\tilde{A}$ and $\tilde{B}$ as $\tilde{A} \cdot \tilde{B} = (d_{ik}^{AB})_{m \times p} = [\max(\mu_{ik}^A, \mu_{jk}^B), \min(\gamma_{ik}^A, \gamma_{jk}^B)]_{m \times p}, 1 \leq i \leq m, 1 \leq k \leq p \text{ for } j = 1, 2, 3, \ldots n.$

### Application of FSM in Medical Diagnosis

In this section, we are putting forward the problem which is based upon FSM in medical diagnosis.

#### Fuzzy Soft Matrices in Diagnosis

Let us assume $S$ is the set of Symptoms of fever like Swine – flu and Dengue, $D$ is the side effects related to these symptoms and $P$ is the set of patients showing the symptoms present in the set $S$. We construct a fuzzy soft set $(\tilde{F}_s, D)$ over $S$. A relation matrix $\chi^I$ is obtained from the fuzzy soft set $(\tilde{F}_s, D)$. We would name the matrix as symptoms disease matrix. Similarly is complement $(\tilde{F}_s, D)$ gives another relation matrix $\chi^C$, called non symptom diseases matrix. We call the matrices $\chi^I$ and $\chi^C$ as medical knowledge of fuzzy soft set. Further, we construct another fuzzy soft set $(\tilde{F}_y, S)$ over $P$. This fuzzy soft set gives the relation matrix $\gamma$ called patient – symptom matrix and its complement $(\tilde{F}_y, S)$ gives the relation matrix $\chi^C$ is called patient – non symptom matrix. Then using **Definition of product of fuzzy soft matrix**, we obtain two new relation matrices $\tilde{Q}_1 = \gamma^x$ and $\tilde{Q}_2 = \gamma^y$ called patient symptom disease matrix and patient symptom non – disease matrix respectively. In a similar manner, we obtain the relation matrices $\tilde{Q}_3 = \gamma^x$ and $\tilde{Q}_4 = \gamma^y$ called the patient non – symptom disease matrix and patient non – symptom non – disease matrix respectively.

Now $\tilde{Q}_1 = \gamma^x$, $\tilde{Q}_2 = \gamma^y$, $\tilde{Q}_3 = \gamma^x$ and $\tilde{Q}_4 = \gamma^y$. Using definition 3.1 we may obtain corresponding membership value matrices $\text{MV}(\tilde{Q}_1)$, $\text{MV}(\tilde{Q}_2)$, $\text{MV}(\tilde{Q}_3)$, $\text{MV}(\tilde{Q}_4)$. We calculate the diagnosis score $\text{S} \tilde{Q}_1$ and $\text{S} \tilde{Q}_2$ for and against the disease respectively as $\text{S} \tilde{Q}_1 = [\gamma ((\tilde{Q}_1))_{ij}]_{m \times n}$, where $\gamma ((\tilde{Q}_1))_{ij} = \delta ((\tilde{Q}_1))_{ij} - \delta ((\tilde{Q}_3))_{ij}$ and $\text{S} \tilde{Q}_2 = [\gamma ((\tilde{Q}_2))_{ij}]_{m \times n}$, where $\gamma ((\tilde{Q}_2))_{ij} = \delta ((\tilde{Q}_2))_{ij} - \delta ((\tilde{Q}_4))_{ij}$. Now if $\max \left(\text{S} \tilde{Q}_1((p_i, d_i)) - \text{S} \tilde{Q}_2((p_i, d_i))\right)$ occurs for exactly $(p_i, d_i)$ only, then we would be in a position to accept that diagnosis hypothesis for patient $p_i$ is the disease $d_i$. In case there is a tie, the process is repeated for patient $p_i$ by reassessing the symptoms.

### Algorithm

1. Choose the set of parameter.
2. Construct the fuzzy soft set $(\tilde{F}_s, D)$ and compute $(\tilde{F}_s, D)^t$. Compute the corresponding fuzzy soft set matrices $\chi^I$ and $\chi^C$.
3. Construct the fuzzy soft set $(\tilde{F}_y, S)$ and compute $(\tilde{F}_y, S)^t$. Compute the corresponding fuzzy soft set matrices $\gamma^I$ and $\gamma^C$.
4. Compute $\tilde{Q}_1 = \gamma^x$, $\tilde{Q}_2 = \gamma^y$, $\tilde{Q}_3 = \gamma^x$ and $\tilde{Q}_4 = \gamma^y$.
5. Compute corresponding membership value of fuzzy soft matrix $\text{MV}(\tilde{Q}_1)$, $\text{MV}(\tilde{Q}_2)$, $\text{MV}(\tilde{Q}_3)$ and $\text{MV}(\tilde{Q}_4)$.
6. Find $S_1 = \max_j \left(\text{S} \tilde{Q}_1((p_i, d_i)) - \text{S} \tilde{Q}_2((p_i, d_i))\right)$. We conclude the patient $p_i$ is suffering the disease $d_i$. 


Case Study
Suppose there are three patients $p_1$, $p_2$, $p_3$ are admitted in the hospital those who affected by the disease of Swine – Flu and Dengue. If the patients affecting from dengue and swine – flu fever with symptoms of nausea, body aches, fever, bleeding from the noses and gums, weakness respectively. Let, we consider the set $S= \{e_1, e_2, e_3\}$ has universal set where $e_1$, $e_2$, $e_3$ represent the symptoms. Let the set $D= \{d_1, d_2\}$ where $d_1$ and $d_2$ represents the parameter of the fever in the human body.

Step 1
Choose the parameter

Step 2
Let the fuzzy soft set $(\tilde{F}_s, D)$ over $S$, where $\tilde{F}_s$ is a mapping $\tilde{F}_s: D \rightarrow \tilde{F}(S)$, gives an approximate description of fuzzy soft medical knowledge of the symptoms appeared due to the fevers.

Let $(\tilde{F}_s, D)=\{(\tilde{F}_s(d_1) = \{(0.3, 0), (0.6, 0), (0.5, 0)\}, \tilde{F}_s(d_2) = \{(0.9, 0), (0.7, 0), (0.8, 0)\})$}

Complement of $(\tilde{F}_s, D)$ i.e. $(\tilde{F}_y, D)$ is given by $(\tilde{F}_y, D) = \{(\tilde{F}_y(d_1) = \{(1, 0.3), (2, 1, 0.6), (3, 1, 0.5)\}, \tilde{F}_y(d_2) = \{(1, 0.9), (2, 1, 0.7), (3, 1, 0.8)\})$}

$$\begin{pmatrix} d_1 & d_2 \\ e_1 & \begin{pmatrix} (0.3, 0) \\ (0.6, 0) \\ (0.5, 0) \end{pmatrix} \\ x = e_2 & \begin{pmatrix} (0.9, 0) \\ (0.7, 0) \\ (0.8, 0) \end{pmatrix} \end{pmatrix}$$

and

$$\begin{pmatrix} d_1 & d_2 \\ e_1 & \begin{pmatrix} (1, 0.3) \\ (1, 0.6) \\ (1, 0.5) \end{pmatrix} \\ x = e_2 & \begin{pmatrix} (1, 0.9) \\ (1, 0.7) \\ (1, 0.8) \end{pmatrix} \end{pmatrix}$$

Step 3
Take $P = \{p_1, p_2, p_3\}$ as the universal where $p_1$, $p_2$ and $p_3$ are three patients respectively and $S= \{e_1, e_2, e_3\}$ as the set of parameters, where $e_1$, $e_2$ and $e_3$ represent the symptoms of fevers. Let the fuzzy soft set $(\tilde{F}_y, s)$ over $S$, where $\tilde{F}_y$ is a mapping $\tilde{F}_y: s \rightarrow \tilde{F}(P)$, gives an approximate description of the patient symptoms in the hospital. Let $(\tilde{F}_y, s) = \{(\tilde{F}_y(e_1) = \{(p_1, 0.7, 0), (p_2, 0.5, 0), (p_3, 0.2, 0)\}, \tilde{F}_y(e_2) = \{(p_1, 0.8, 0), (p_2, 0.5, 0), (p_3, 0.6, 0)\}, \tilde{F}_y(e_3) = \{(p_1, 0.3, 0), (p_2, 0.6, 0), (p_3, 0.7, 0)\})$ Complement of $(\tilde{F}_y, s)$ i.e. $(\tilde{F}_y, s)$ is given by $(\tilde{F}_y, s) = \{(\tilde{F}_y(e_1) = \{(p_1, 1, 0.7), (p_2, 1, 0.8), (p_3, 1, 0.2)\}, \tilde{F}_y(e_2) = \{(p_1, 1, 0.8), (p_2, 1, 0.5), (p_3, 1, 0.6)\}, \tilde{F}_y(e_3) = \{(p_1, 1, 0.3), (p_2, 1, 0.6), (p_3, 1, 0.7)\})$}

$\tilde{F}_y(e_1) = \{(p_1, 0.7, 0), (p_2, 0.5, 0), (p_3, 0.2, 0)\}
\tilde{F}_y(e_2) = \{(p_1, 0.8, 0), (p_2, 0.5, 0), (p_3, 0.6, 0)\}
\tilde{F}_y(e_3) = \{(p_1, 0.3, 0), (p_2, 0.6, 0), (p_3, 0.7, 0)\}

Note this fuzzy soft set $(\tilde{F}_y, s)$ by the matrix $\tilde{y}$ is called the patient non – symptoms matrix.

Step 4
Let $\tilde{Q}_1 = \tilde{y} x = e_2 \begin{pmatrix} (0.6,0) \\ (0.5,0) \\ (0.6,0) \end{pmatrix}$

and

$\tilde{Q}_2 = \tilde{y} x = e_3 \begin{pmatrix} (0.7,0) \\ (0.8,0) \end{pmatrix}$

$\tilde{Q}_3 = \tilde{y} x = p_1 \begin{pmatrix} (0.6,0) \\ (0.6,0) \\ (0.6,0) \end{pmatrix}$

$$\begin{pmatrix} d_1 & d_2 \\ e_1 & \begin{pmatrix} (0.6,0) \\ (0.5,0) \\ (0.6,0) \end{pmatrix} \\ x = e_2 & \begin{pmatrix} (0.7,0) \\ (0.8,0) \end{pmatrix} \end{pmatrix}$$

$$\begin{pmatrix} d_1 & d_2 \\ e_1 & \begin{pmatrix} (0.8,0) \\ (0.8,0) \\ (0.7,0) \end{pmatrix} \\ x = e_2 & \begin{pmatrix} (0.8,0) \\ (0.7,0) \end{pmatrix} \end{pmatrix}$$
\[ \hat{Q}_4 = \hat{y} \hat{x} = p1 \begin{pmatrix} (1.05) & (1.08) \\ \end{pmatrix} \\
\]
\[ \begin{pmatrix} (1.06) & (1.07) \\ (1.03) & (1.07) \end{pmatrix} \]

**Step 5**

\[
\text{MV} (\hat{Q}_4) = p1 \begin{pmatrix} 0.6 & 0.7 \\ 0.5 & 0.8 \\ 0.6 & 0.7 \end{pmatrix}
\]

**Step 6**

The diagnosis score \( S \hat{Q}_1 \) and \( S \hat{Q}_2 \) for and against the diseases below

\[
\begin{pmatrix} 0.3 & 0.1 \\ 0.4 & 0.4 \\ 0.2 & 0.0 \end{pmatrix}
\]

Conclude that \( p_2 \) is suffering from more serious Swine – Flu from disease \( d_2 \) and \( p_1 \) and \( p_3 \) are suffering from disease \( d_1 \).

**Conclusion**

In this paper, the theory of fuzzy soft matrix in the field of medical diagnosis is identified. Some new concepts such as complement of fuzzy soft matrix based on reference function have been enhanced. The fevered person should be given for awareness about symptoms of the affected body. Future work is required to study whether the notion put forward in this paper yield a fruitful result.

**References**