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An Application of the Complement of Interval-Valued Fuzzy SoftSets in Metal Work Designer's Medical Diagnosis

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Abstract- In this paper we havepresented sanchez'sapproach for metal work designer's medical diagnosis using the complement of interval-valued fuzzy soft sets and exhibit the technique with a hypothetical case study.

Keywords-soft set, interval-valued fuzzy soft set, soft medical knowledge.

I. INTRODUTION

Most of our real life problems in economics, engineering, medical sciences, management, environment and social sciences etc., involve imprecise data and the solution involves the use of mathematical principles based on uncertainty and imprecision.Such uncertainties are being dealt with the help of the topics like probability fuzzy set theory,intuitionistic fuzzy sets,vague sets, theory of interval mathematics, rough sets etc. Although, Molodtsov [3] has shown that every one of the above topics don't posses of their parametrizationtools and overcome this shortcoming,introduceda concept called "Soft set theory", having parametrization tools for prosperous dealing with various types of uncertainties.The absence of any restrictions on the approximate description in soft set theory makes this theory quite convenientand easily applicable in practice.Soft set theory has richpotential for applications in several directions,few of which had been explained by Molodtsov in his pioneer work [3] and by Maji et al[2]. Recently,Yang et al.[7] introduced the interval-valued fuzzy soft set[IVFSS].De et al [1] have studied sanchez's[6] method of medical diagnosis using intuitionistic fuzzy set. Also, Saikia et al [5] have extended method in [1] using intuitionistic fuzzy soft set theory.Our proposed method is an attempt to improve the results in [1,5] using the complement concept of IVFSS to formulate a pair of medical knowledge, hereafter called soft medical knowledge.In this paper we study Sanchez's approach of medical diagnosis using the notion of IVFSS together complement of IVFSS and exhibit the technique with hypothetical case study.

II. PRILIMINARIES

A. Definition

Let U be a universal set, E a set of parameters. Let P(U) denote the power set of U and A ⊂ E. Then a pair (F,A) is called soft set over U, where F is a mapping from A to P(U).Example- Let U= $\{w_1, w_2, w_3\}$ be the set of three washing machines and E={costly(e_1),metallic colour(e_2), cheap(e_3)} be the set of parameters, where A=$\{e_1,e_2,\} \subset$ E.

Then (F,A)={F(e_1) = $\{w_1,w_2,w_3\}$,F(e_2)=$\{w_1,w_3\}$} is the crisp soft set over U which describes the "attractiveness of the washing machines" which Mr.Saran (say) is going to buy.

B. Definition

Let U be a universal set , E a set of parameters and A ⊂ E. Let F(U) denotes the set of all fuzzy subsets of U. Then a pair (F,A) is called fuzzy soft set over U, where F is mapping from A to F(U).Example-Let U=$\{w_1,w_2,w_3\}$ be the set of three washing machines and E={costly(e_1),metallic colour(e_2), cheap(e_3)}be the set of parameters, where A=$(e_1,e_2) \subset$ E.

Then(G,A)

={G(e_1)=$\{w_1/.6,w_2/.4,w_3/.3\}$,G(e_2)=$\{w_1/.5,w_2/.7,w_3/.8\}$} is the fuzzy soft set over U describes the "attractiveness of the washing machines" which Mr.Saran(say) is going to buy.

C. Definition

An interval – valued fuzzy sets Ẽ on the universe U is a mapping such that Ẽ is mapping from U to *Int*([0,1]) where *Int*([0,1]) stands for all closed subintervals of [0,1], the set of all interval – valued fuzzy sets on U is denoted by Ẽ(U).Suppose that Ẽ ∈ F̃(U), ∀ x∈ U,$\mu_{\tilde{E}}(x) = [\mu^L_{\tilde{E}}(x),\mu^U_{\tilde{E}}(x)]$ is called the degree of membership of an element x to Ẽ. $\mu^L_{\tilde{E}}(x)$ and $\mu^U_{\tilde{E}}(x)$ are referred to as the lower and upper degree of membership x to Ẽ where $0 \le \mu^L_{\tilde{E}}(x) \le \mu^U_{\tilde{E}}(x) \le 1$

D. Definition

LetŶ and Ẑ∈ F̃(U), then

- The union of Ŷ and Ẑ,denoted by Ŷ∪Ẑ,is given by $\mu_{\hat{Y}\cup\hat{Z}}(x)$= sup $[\mu_{\hat{Y}}(x),\mu_{\hat{Z}}(x)]$=[sup($\mu^L_{\hat{Y}}(x),\mu^L_{\hat{Z}}(x)$), sup($\mu^U_{\hat{Y}}(x),\mu^U_{\hat{Z}}(x)$)];
- The intersection of Ŷ and Ẑ, denoted by Ŷ∩Ẑ, is given by $\mu_{\hat{Y}\cap\hat{Z}}(x)$ = inf $[\mu_{\hat{Y}}(x), \mu_{\hat{Z}}(x)]$= [inf($\mu^L_{\hat{Y}}(x),\mu^L_{\hat{Z}}(x)$), inf ($\mu^U_{\hat{Y}}(x), \mu^U_{\hat{Z}}(x)$)];
- The complement of Ŷ, denoted by $\hat{Y}^c$, is given by $\mu_{\hat{Y}^c}(x)$ = 1-$\mu_{\hat{Y}}(x)$= [1-$\mu^U_{\hat{Y}}(x)$, 1-$\mu^L_{\hat{Y}}(x)$].

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E. Definition

Let U be a universal set,E a set of parameters and A $\subset$ E.Let $\tilde{F}(U)$ denotes the set of all interval-valued fuzzy sets on U.Then a pair(F,A) is called interval-valued fuzzy soft set over U, where F is a mapping from A to $\tilde{F}(U)$.Remarks-An interval-valued fuzzy soft set is a parameterized family of interval valued fuzzy subsets of U. Thus, its universe is the set of all interval-valued fuzzy sets of U i.e. $\tilde{F}(U)$. An interval-valued fuzzy soft set is also a special case of a soft set because it is still a mapping from parameters to $\tilde{F}(U)$. For all e $\in$ E, F(e) is referred as the inter fuzzy value set of parameter e $\in$ E , it can be written as : F(e) = $\{(x,\mu_{F(e)}(x)): x\in U\}$,here,F(e) is the interval-valued fuzzy membership degree that object x holds on parameter e.If$\forall$ e $\in$ E,$\forall$ x $\in$ U, $\mu^{L}_{F(e)}(x) = \mu^{U}_{F(e)}(x)$,then F(e) will degenerated to be a standared fuzzy set and then (F,E) will be degenerated to be a traditional fuzzy soft set.

F. Definition

The complement of a interval valued fuzzy soft set (F,A) is denoted by $(F,A)^c$ and is defined by $(F,A)^c=(F^c,\neg A)$,where$\forall\alpha\epsilon A,\neg\alpha$ =notα, is the not set of the parameter α, which holds the opposite meanings of parameter α;$F^c;\neg A\rightarrow\tilde{F}(U)$ is a mapping given by $F^c(\beta)=(F(\neg\beta))^c,\forall\beta\in\neg A$.Example -Let U={$w_1,w_2,w_3$} be the set of three washing machines and E={costly(e_1),metalliccolour(e_2) cheap(e_3)} be the set of parameters, where A={e_1,e_2} $\subset$ E.Then(G,A)={G(e_1)=<w_1,[.6,.9]>,<w_2,[.4,.6]>,< w_3,[.3,.5]>,G(e_2)=<w_1,[.5,.7]>,<w_2,[.7,.9]>,<w_3,[.6,.9]>}is the interval-valued fuzzy soft set over U describes the “attractiveness of the washing machines” which Mr.Saran(say) is going to buy.

Example$(G,A)^c$={G($\neg e_1$)=<w_1,[.1,.4]>,<w_2,[.4,.6]>,<w_3,[.5,.7] >,G($\neg e_2$)= <w_1,[.5,.5]>,<w_2,[.1,.3]>,<w_3,[.1,.3]>} is the compliment of (G,A).

III. ANAPPLICATION OF COMPLEMENT OF INTERVAL VALUED FUZZY SET IN MEDICAL DIAGNOSIS

Suppose S is a set of symptoms of certaindiseases,D is a set of diseases and P is a set of patients. Construct an interval valued fuzzy soft set (F,D) over S, where F is a mapping $F:D\rightarrow\tilde{F}(S)$. A relation matrix say, R_1 is constructed from the interval-valued fuzzy soft set (F,D) and called symptom-disease matrix. The complement of (F,D) gives another relation matrix,say,R_2,called non symptoms-disease another interval-valued fuzzy soft set(F_1,S) over P, where F_1 is a mapping given by $F_1:S\rightarrow\tilde{F}(P)$.This interval valued fuzzy soft set gives another relation matrix Q called patient-symptom matrix.Thenwe obtain to new relation matrices $T_1=Q\circ R_1$and $T_2=Q\circ R_2$ called symptom-patient matrix and non symptom patient matrix respectively, in which the membership values are given by$\mu_{T1}(p_i,d_k)$ $=[\inf\{\mu^{L}_{Q}(p_i,e_j)\wedge\mu^{L}_{R1}(e_j,d_k)\},\sup\{\mu^{U}_{Q}(p_i,e_j)\wedge\mu^{U}_{R1}(e_j,d_k)\}$-------------(1)

$\mu_{T2}(p_i,\neg d_k)=[\inf\{\mu^{L}_{Q}(p_i,e_j)\wedge\mu^{L}_{R2}(e_j,d_k)\}$, $\sup\{\mu^{U}_{Q}(p_i,e_j)\wedge\mu^{U}_{R2}(e_j,d_k)\}]$----------(2)

Where $\vee$= max and $\wedge$= min.
We calculate
$S_{T1}=\Sigma\{(\mu^{L}_{T1}(p_i,d_j)-\mu^{L}_{T1}(p_j,d_i)\}+\Sigma\{(\mu^{U}_{T1}(p_i,d_j)-\mu^{U}_{T1}(p_j,d_i)\}$--------------(3)and $S_{T2}=\Sigma\{(\mu^{L}_{T2}(p_i,d_j)-\mu^{L}_{T2}(p_j,d_i)\}+\Sigma\{(\mu^{U}_{T2}(p_i,d_j)-\mu^{U}_{T2}(p_j,d_i)\}$---------------(4),

Which we call as diagnosis scorefor and against the disease respectively. Now, if max$\{S_{T1}(p_i,d_j)-S_{T2}(p_i,\neg d_j)\}$ occursfor exactly (p_i,d_k) only ,then we conclude that the acceptable diagnostic hypothesis for patient p_i is the disease d_k.In case there is a tie ,the process has to be repeated for patient by reassessing the symptoms.

IV. ALGORITHM

1. Input the interval valued fuzzy soft set (F,D) and $(F,D)^c$ over the sets S of symptoms,where D is the set of diseases.Alsowrite the soft medical knowledge $R_1$and R_2 representing the relation matrices of the IVFSS (F,D) and $(F,D)^c$ respectively.
2. Input the IVFSS (F_1,S) over the P of patient and write it’s relation matrix Q.
3. Compute the relation matrices $T_1=Q\circ R_1$ and $T_2=Q\circ R_2$.
4. Compute the diagnosis scores S_{T1} and S_{T2}.
5. Find$S_k=\max\{S_{T1}(p_i,d_j)-S_{T2}(p_i,\neg d_j)\}$. Then we conclude that the patient P_i is suffering from the disease d_k.
6. IfS_k more than one value then go to step one and repeat theprocessand if $S_k< 1$ then stop.

V. CASE STUDY

Suppose there are three patients Raja, Kumar and Siva in a hospital with symptoms eye irritation, heat pimples, white palm and stomach pain. Let the possible diseases relating to the above symptoms be piles and ulcer problems.Now we take P = {p_1,p_2,p_3} as the universal set where p_1,p_2, and p_3 represent the patients Raja,Kumar and siva respectively. Next we consider the set S={e_1,e_2,e_3,e_4} as universal set, where e_1,e_2,e_3 and e_4 represent the symptoms eye irritation, heat pimples, white palm and stomach pain and the set D={d_1,d_2} where $d_1$and d_2 represent the parameters piles and ulcer.Suppose that F(d_1={<e_1,[.7,1]>,<e_2,[.1,.4]>,<e_3,[.5,.6]>,<e_4,[.2,.4]>)}F(d_2)={ <e_1,[.6,.9]>,<e_2,[.4,.6]>,<e_3,[.3,.6]>,<e_4,[.8,1]>}.The interval valued fuzzy soft set (F,D) is the parameterized family {F(d_1),F(d_2)} of all interval valued fuzzy sets over the set S and are determined from expert medical documentation. Thus the fuzzy soft set (F,D) gives an approximate description of the interval valued soft medical knowledge of the two diseases and their symptoms.This interval-valued fuzzy soft set (F,D) and its complement $(F,D)^c$ are represented by two relation matrices R_1 and R_2 called symptom-disease matrix and non symptom-disease matrix,given by,

$$\begin{matrix} & d_1 & d_2 \end{matrix} \quad R_1=\begin{matrix} e_1 \\ e_2 \\ e_3 \\ e_4 \end{matrix}\begin{bmatrix} [.7,1] & [.6,.9] \\ [.1,.4] & [.4,.6] \\ [.5,.6] & [.3,.6] \\ [.2,.4] & [.8,1] \end{bmatrix}$$ and

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$$R_2 = (1- R_1)^c$$

Here,

$$1\text{-}R_1 = 1 - \begin{bmatrix} [.7,.1] & [.6,.9] \\ [.1,.4] & [.4,.6] \\ [.5,.6] & [.3,.6] \\ [.2,.4] & [.8,1] \end{bmatrix}$$

$$= \begin{bmatrix} [.3,.0] & [.4,.1] \\ [.9,.6] & [.6,.4] \\ [.5,.4] & [.7,.4] \\ [.8,.6] & [.2,.0] \end{bmatrix}$$

$$d_1 \quad d_2 \quad R_2 = \begin{matrix} e_1 \\ e_2 \\ e_3 \\ e_4 \end{matrix} \begin{bmatrix} [.0,.3] & [.1,.4] \\ [.6,.9] & [.4,.6] \\ [.4,.5] & [.4,.7] \\ [.6,.8] & [.0,.2] \end{bmatrix}$$

Again we take P= $\{p_1,p_2,p_3\}$ as the universal set where p_1,p_2 and p_3 represent patients respectively and $S=\{e_1,e_2,e_3,e_4\}$ as the set of parameters. Suppose $F_1(e_1)=\{\langle p_1,[.3,.5]\rangle,\langle p_2,[.6,.9]\rangle,\langle p_3,[.6,.8]\rangle\}F(e_2)=\{\langle p_1,[.3,.5]\rangle,\langle p_2,[.2,.6]\rangle,\langle p_3,[.3,.7]\rangle\}F_1(e_3)=\{\langle p_1,[.8,1]\rangle,\langle p_2,[.2,.4]\rangle,\langle p_3,[.5,.7]\rangle\}$ and $F(e_4)=\{\langle p_1,[.2,.5]\rangle,\langle p_2,[.3,.5]\rangle,\langle p_3,[.6,.9]\rangle\}$The interval-valued fuzzy soft set (F_1,S) is another parameterized family of all interval-valued fuzzy sets and gives a collection of approximate description of the patients-symptoms in the hospital.This interval-valued fuzzy soft set (F_1,S) represents a relation matrix Q called patient-symptom matrix given by

$$\begin{matrix} & e_1 e_2 & & e_3\, e_4 \end{matrix}$$

$$Q = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{bmatrix} [.3,.5] & [.3,.7] & [.8,1] & [.2,.5] \\ [.6,.9] & [.2,.6] & [.2,.4] & [.3,.5] \\ [.6,.8] & [.3,.5] & [.5,.7] & [.6,.9] \end{bmatrix}$$

Then combining the relation matrices R_1 and R_2 separately with Q we get two matrices T_1 and T_2 called patient-disease and patient- non disease matrices respectively, given by

$$d_1 d_2 T_1 = Q \circ R_1 = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{bmatrix} [.1,.9] & [.3,.9] \\ [.1,.5] & [.2,.6] \\ [.1,.8] & [.2,.8] \end{bmatrix},$$

$$d_1 \; d_2 T_2 = Q \circ R_2 = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{bmatrix} [.0,.8] & [.0,.7] \\ [.0,.7] & [.0,.6] \\ [.0,.6] & [.0,.7] \end{bmatrix}$$

By applying the formula of equation (3) and (4) we get the values of S_{T1} and S_{T2}.

$$.d_1 d_2 \quad S_{T1} = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{bmatrix} .3 & .8 \\ .6 & .7 \\ .9 & .4 \end{bmatrix} \quad \text{and}$$

$$d_1 \quad d_2 S_{T2} = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{bmatrix} .2 & .6 \\ .3 & .1 \\ .4 & .3 \end{bmatrix}$$

Table-1

$S_{T1} \sim S_{T2}$	d_1	d_2
P_1	.1	.2
P_2	.3	.6
P_3	.5	.1

Now, it clear that the patient p_3 is suffering from the disease d_1 and patients p_1 and p_2 are both suffering from disease d_2.

VI. CONCLUSION

From the above table, we conclude that sanchez's approach can be applied to study the various diseases in patients by using representation of an complement of interval – valued fuzzy soft set.

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