International Journal of Clinical Medicine Research
2016; 3(2): 49-54
http://www.aascit.org/journal/ijcmr
ISSN: 2375-3838

American Association for Science and Technology

Keywords
Fuzzy Logic,
Fuzzy Certainty Factor,
Fuzzy Decision Set,
Medical and Surgery Intelligence

Received: February 14, 2016
Accepted: March 12, 2016
Published: March 30, 2016

Fuzzy Clinical Medicine and Surgery Intelligence

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Citation
Adala Sadana, Poli Venkata Subba Reddy. Fuzzy Clinical Medicine and Surgery Intelligence. *International Journal of Clinical Medicine Research.* Vol. 3, No. 2, 2016, pp. 49-54.

Abstract
Medical expert systems are now acceptable in Medicine and Surgery. Medical expert systems will assist to perform better medical diagnosis and better surgery. Medical expert systems are supporting system for the physician and surgeon to take decision. Information available to the medicine and surgery are fuzzy rather than likelyhood. Zadeh defined fuzzy logic with single membership function. The fuzzy logic with two membership functions will give more evidence than single membership function. Generalized fuzzy logic is discussed with two membership functions. Fuzzy certainty factor is discussed to eliminate conflict between two membership functions. The fuzzy decision set is studied for decision making. The clinical medicine and surgery intelligent systems are studied as an application.

1. Introduction

The physicians and surgeons usually encounter incomplete information during consultancy. The incomplete information has to deal with commonsense. Fuzzy locic is the method to deal incomplete information with commonsense. Various theories are available to deal with incomplete information and these theories deal with likelihood (probability) where as fuzzy logic deal with mind. Zadeh [11] formulated incomplete information as fuzzy set with single membership function. The fuzzy set with two membership function will give more evidence than single membership function, Zadeh [10], TSK [5] and Mamdani [3] proposed fuzzy conditional inference. This fuzzy conditional inference needs fuzziness for both precedent and consequent part. Some applications like medicine and surgery consequent part is depending on president part for proposition of the form “if x has symptoms then x is diagnosis”.

In the following fuzzy conditional inference is studied with two membership functions. The fuzzy certainty factor (FCF) is defined as difference of two membership function to eliminate conflict. The fuzzy decision set is studied to take decicion. The medicine and surgery intelligence are studied as application. It is necessary to discuss fuzzy logic with single membership function.

2. Fuzzy Logic

Zadeh [11] introduced the concept of a fuzzy set as a model to approximate incomplete information. The fuzzy theory allows us to represent set membership as a possibility distribution [10].

Definition 1.1 Given some universe of discourse X, a possibility subset A of X is defined by its membership function π_A taking values on the unit interval [0, 1] i.e. π_A (X): → [0, 1]

Definition: Given some universe of discourse X, a fuzzy set A of X is defined by its membership function μA taking values on the unit interval [0, 1] i.e. $\mu_A(x) = \pi_A(X): \rightarrow [0, 1]$.

Suppose X is a finite set. The fuzzy set A of X may be represented as

$$A = \mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + \ldots\ldots\ldots\ldots\ldots\ldots + \mu_A(x_n)/x_n$$

Where "+" is union

For instance, the fuzziness of "fever" may be given by commonsense.

Fever =0.1/98 + 0.2/99+ 0.4/100+ 0.6/101 + 0.7/102 + 0.8/103+0.9//104+0.95/105

There is an alternative way to defined by function

For example,

Fever = $\{\mu_{fever}(x)/x = 0$ if x϶ [0, 98] = [1+ ((x-98) 2)] -1 if x϶ [98, 106]

The graphical representation of fuzzy set of fever is shown in Fig.1

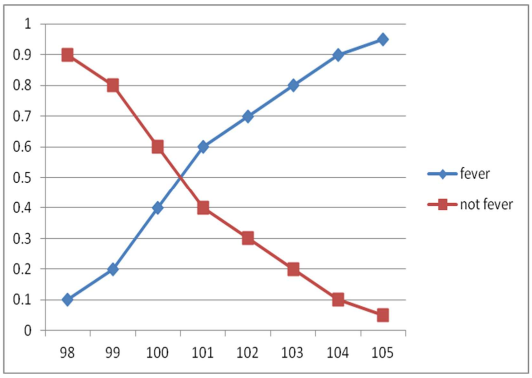

Fig. 1. *The fuzzy membership function.*

Let A and B be the fuzzy sets, and the operations on fuzzy sets are given below

AVB=max $(\mu_A(x), \mu_B(y))\}/(x, y)$ Disjunction

AΛB=min $(\mu_A(x), \mu_B(y))\}/(x, y)$ Conjunction

A′=1- $\mu_A(x)/x$ Negation

AXB=min $\{\mu_A(x), \mu_B(y)\}/(x, y)$ Relation

AoR=min $_x\{\mu_A(x), \mu_R(x, y)\}/y$ Composition

Zadeh [10], Mamdani [3] and TSK [5] are proposed different fuzzy conditional inferences.

The Zadeh [10] fuzzy condition inference s given by

If x is A then y is B=min $\{1, (1- \mu_A(x) + \mu_B(y)\}$

If (A_1 and A_2 ….. A_n) then y is B = min $\{1, (1\text{-min}(\mu_{A1}(x), \mu_{A2}(x), \ldots, \mu_{An}(x)) + \mu_B(y)\}$

The Mamdani [3] fuzzy condition inference s given by

If x is A then y is B=min $\{\mu_A(x), \mu_B(y)\}$

If (A_1 and A_2 ….. An) then y is B = min $(\mu_{A1}(x), \mu_{A2}(x), \ldots, \mu_{An}(x), \mu_B(x)\}$

The TSK [5] fuzzy condition inference s given by

If x is A then y=f (x) is B=

If (A_1 and A_2 ….. An) then y=f $(x_1, x_2, \ldots, x_n)$ is B

3. Some Methods of Fuzzy Conditional Inference

Zadeh [10], Mamdani [3] and TSK [5] are proposed fuzzy conditional inference. Zadeh and Mamdani fuzzy inferences need prior information for consequent part in "if … then …". TSK method is very difficult to compute linguistic terms for consequent part.

if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then y is B

When consequent part is not known

i.e., $\mu_B(y) = 1$

The fuzzy inference is given by taking Zadeh method as

if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then y is B

= min (1, 1-min $(A_1, A_2, \ldots, A_n) + B)$

= min (1, 1-min $(A_1, A_2, \ldots, A_n + 1))$

=1

Still not known

For instance $A_1 = 0.2/x_1 + 0.6/x_2 + 0.9/x_3 + 0.6/x_4 + 0.2/x_5$

$A_2 = 0.5/x_1 + 0.7/x_2 + 0.9/x_3 + 0.7/x_4 + 0.3/x_5$

if x is A1 and x is A2 then x is B=

$B = 1/x_1 + 1/x_2 + 1/x_3 + 1/x_4 + 1/x_5$ and is not known

Zadeh conditional inference is not suitable

The fuzzy inference is given by taking Mamdani method as

if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then y is B

= min $(A_1, A_2, \ldots, A_n, B)$

=min $(A_1, A_2, \ldots, A_n, 1)$

=min $(A_1, A_2, \ldots, A_n)$

For instance $A_1 = 0.2/x_1 + 0.6/x_2 + 0.9/x_3 + 0.6/x_4 + 0.2/x_5$

$A_2 = 0.5/x_1 + 0.7/x_2 + 0.9/x_3 + 0.7/x_4 + 0.3/x_5$

if x is A1 and x is A2 then x is B=

$B = 0.2/x_1 + 0.6/x_2 + 0.9/x_3 + 0.6/x_4 + 0.2/$

The TSK fuzzy conditional inferences is difficult to compute applications like Medical diagnosis. This fuzzy conditional inference needs modification.

Consider TSK fuzzy conditional inference

If (A_1 and A_2 ….. An) then y=f $(x_1, x_2, \ldots, x_n)$ is B

The fuzzy set B is defined as a function of A_1 and A_2 and … and A_n

The proposed method for TSK fuzzy conditional inference may be given using t-norm as

If x is A_1 and A_2 and, …, and A_n then y is B=t $(A_1 \Lambda A_2 \Lambda, \ldots, \Lambda A_n)$

Using t-norm is

t (aVb) =max (a, b)

t (a Λ b) =min (a, b)

If x is A_1 and A_2 and, …, and A_n then y is B = min$\{(\mu_{A1}(x), \mu_{A2}(x), \ldots, \mu_{An}(x)\}$

The proposed method is given by using Mamdani fuzzy conditional inference

"If x is A_1 or A_2 and, …, and A_n then y is B= min$\{(] \mu_{A1}(x), \mu_{A2}(x), \ldots, \mu_{An}(x)\}$ = = min $(A_1, A_2, \ldots, A_n, B)$

= min$\{(] \mu_{A1}(x), \mu_{A2}(x), \ldots, \mu_{An}(x)\}$

A new method is given by

If x is A_1 and A_2 and, …, and A_n then y is B = min$\{(\mu_{A1}(x), \mu_{A2}(x), \ldots, \mu_{An}(x)\}$

4. Presentation of Fuzzy Set Type-2

The fuzzy set type-2 is a type of (fuzzy set) ^{2} in which some additional degree of information is provided.

For instance “mild headache”, “moderate headache” and “savoir hesdache”

Definition: Given some universe of discourse X, a fuzzy set type-2 A of X is defined by its membership function μ_A (x) taking values on the unit interval [0, 1] i.e. $\mu_{\tilde{A}}$ (x) → [0, 1] $^{[0.1]}$

Suppose X is a finite set. The fuzzy set A of X may be represented as

A= $\mu_{\tilde{A}1}$ (x_1) /Ã1+ $\mu_{\tilde{A}2}$ (x_2) /Ã2+ ………………+ $\mu_{\tilde{A}n}$ (x_n) /Ãn

Headache= {0.4/mild, 0.6/moderate, 0.9/severe}

John has “mild headache” with fuzziness 0.4

The fuzzy set type-2 may be defined as

Definition: The fuzzy set type-2 Ã is characterized by membership function $\mu_{\tilde{A}}$: XxY→ [0, 1], x∈X and y∈A

Suppose X is a finite set. The fuzzy set A of X may be new represented by

Ã=⌠⌠$\mu_{\tilde{A}}$ (x, y) /x/y= ∑∑ $\mu_{\tilde{A}}$ (x, y) = ($\mu_{\tilde{A}}$ (x_1, y_1) /x_1 + $\mu_{\tilde{A}}$ (x_2, y_1) /$x_{2+\ldots+}$ $\mu_{\tilde{A}}$ (x_n, y_1) /x_n) /y_1

+ ($\mu_{\tilde{A}}$ (x_1, y_2) /x_1 + $\mu_{\tilde{A}}$ (x_2, y_2) /$x_{2+\ldots+}$ $\mu_{\tilde{A}}$ (x_n, y_2) /x_n) /y_2 +…+ ($\mu_{\tilde{A}}$ (x_1, y_m) /x_1 + $\mu_{\tilde{A}}$ (x_2, y_m) /$x_{2+\ldots+}$ $\mu_{\tilde{A}}$ (x_n, y_1) /x_n) /y_m

Ã ′=1-$\mu_{\tilde{A}}$ (x, y)

Ã = {(0.1/x_1+0.2/x_2+0.3/x_3+0.35/x_4+0.4/x_5) /high + (0.4/x_1+0.45/x_2+0.5/x_3+0.55/x_4+0.6/x_5) /normal + (0.7/x_1+0.75/x_2+0.8/x_3+0.85/x_4+0.9/x_5) /low}

Let Ĉ and Ď be the fuzzy sets.

The operations on fuzzy sets type-2are given as

ĈVĎ=max{$\mu_{\hat{C}}$ (x, y), $\mu_{\check{D}}$ (x, y)} Disjunction

ĈΛĎ=min{$\mu_{\hat{C}}$ (x, y), $\mu_{\check{D}}$ (x, y)} Conjunction

Ĉ→Ď=min{1, 1-$\mu_{\hat{C}}$ (x, y) + $\mu_{\check{D}}$ (x, y)} Implication

ĈXĎ=min{$\mu_{\hat{C}}$ (x, y), $\mu_{\check{D}}$ (x, y)} Relation

5. Generalized Fuzzy Logic

Zadeh [11] defined fuzzy set with single membership function. The generalized fuzzy logic is defending by two fold fuzzy set. The two fold fuzzy set is a fuzzy set with two membership functions “belief” and “disbelief”.

The generalized fuzzy set simply as two fold fuzzy set and is defined by

$$A' = \{1- \mu_A^{belief}(x), 1- \mu_A^{disbelief}(x)\}/x$$

The fuzzy logic is defined as combination of fuzzy sets using logical operators. Zadeh’s fuzzy logic is extended to these generalized fuzzy sets.

Negation

$$A' = \{1- \mu_A^{belief}(x), 1- \mu_A^{disbelief}(x)\}/x$$

Disjunction

$$AVB = \{\max (\mu_A^{belief}(x), \mu_A^{belief}(y)), \max (\mu_B^{disbelief}(x), \mu_B^{disbelief}(y))\} (x, y)$$

Conjunction

$$A\Lambda B = \{\min (\mu_A^{belief}(x), \mu_A^{belief}(y)), \min (\mu_B^{disbelief}(x), \mu_B^{disbelief}(y))\}/ (x, y)$$

Implication

If x is A then y is B= {min (1, 1- μ_A^{belief}(x) + μ_B^{belief}(y), min (1, 1- $\mu_A^{disbelief}$(x) + $\mu_B^{disbelief}$(y)} (x, y)

The fuzzy conditional inference is given when fuzziness of consequent part is not known.

If x is A then y is B= {μ_A^{belief}(x) $\mu_A^{disbelief}$(x)}

Composition

$$A1 \text{ o } R= \{\min(\mu_{A1}^{belief}(x), \mu_R^{belief}(x)) , \min (\mu_{A1}^{disbelief}(x), \mu_R^{disbelief}(x))\}$$

The fuzzy propositions may contain quantifiers like “very”, “more or less”. These fuzzy quantifiers may be eliminated as

Concentration

“x is very A

$$\mu_{very\ A} (x) = \{\mu_A^{belief}(x)^2, \mu_A^{disbelief}(x)\ \mu_A (x)^2\}$$

Diffusion

“x is more or less A”

$$\mu_{more\ or\ less\ A} (x) = (\mu_A^{belief}(x)^{0.5}, \mu_A^{disbelief}(x)\ \mu_A (x)^{0.5}$$

6. Medical Intelligence

In MYCIN [1], the certainty factor (CF) is defined as the deference between belief [MB] and disbelief [MD] of probabilities.

$$CF [h, e] =MB [h, e] -MD [h, e]$$

Where “e’ evidence and “h” is hypothesis.

The certainty factor (CF) may defied as The fuzzy certainty factor (FCF) by considering fuzziness instead of probability for the fuzzy proposition of type “x is A”.

$$CF [x, A] = MB [x, A] -MD [x, A]$$

$$\mu_A^{FCF}(x) = \mu_A^{belief}(x) - \mu_A^{disbelief}(x)$$

where “belief” and “disbelief” are fuzzy sets.

Generally “belief or “truth” is not known i.e.

$\mu_A^{belief}(x) =1$

The fuzzy certainty factor may be defined differently by

$\mu_A^{FCF}(x) = 1 - \mu_A^{disbelief}(x)$

For instance

μ vision clarity^{disbelief}(x) =

0..7/x_1 + 0.6/x_2 +0.4/x_3 + 0.3/x_4 + 0.2/x_5

$\mu_{vision\ clarity}^{FCF}(x) = 1 - \mu_{vision\ clarity}^{disbelief}(x)$

= 0..3/x_1 + 0.4/x_2 +0.6/x_3 + 0.7/x_4 + 0.8/x_5

The FCF is single membership function. So that fuzzy logic and reasoning for FCF is similar to the Zadeh fuzzy logic.

Usually in medicine, diagnosis will be made from symptoms i.e., if (symptoms) then (diagnosis).

The medical information may be interpreted as when consequent part is not known is given by using opposed prfuzzy conditional inference.

If x is s then x is d = $\{\mu_A(x)\}/x$
if x is s1 and x is s2 … x is sn then x is d
d= min $\{\mu_{S1}(x), \mu_{S2}(x), \mu_{sn}(x)\}/$
Where s is symptom and d is diagnosis
μ vision clarity$^{disbelief}(x) =$
$0.7/x_1 + 0.6/x_2 + 0.4/x_3 + 0.3/x_4 + 0.2/x_5$
$\mu_{\text{vision clarity}}{}^{FCF}(x) = 1 - \mu_{\text{vision clarity}}{}^{disbelief}(x) =$
$0.3/x_1 + 0.4/x_2 + 0.6/x_3 + 0.7/x_4 + 0.8/x_5$
Consider Eye diagnosis
If x has vision clarity then x needs spectacles
the vision clarity is given by

$$\mu_{\text{vision clarity}}{}^{FCF}(x) \rightarrow \text{spectacles}_I{}^{FCF}(x) =$$
$$= \{0.7/x_1 + 0.6/x_2 + 0.4/x_3 + 0.3/x_4 + 0.2/x_5\}$$
$$\mu_{\text{vision clarity}}(x)^2 = 0..49/x_1 + 0.36/x_2 + 0.16/x_3 + 0.09/x_4 + 0.04/x_5$$

if x is very less A then x is B = $\{\mu_A(x)^2\}$
μ very $_{\text{less vision clarity}} \rightarrow$ spectacles$_r{}^{FCF}(x) =$
if x is more A then x is B = $\{\mu_A(x)^{0.5}\}$
$\mu_{\text{more vision clarity}} \rightarrow$ spectacles$^{FCF}(x) =$
$= 0..84/x_1 + 0.77/x_2 + 0.63/x_3 + 0.55/x_4 + 0.45/x_5$

Consider the rule in medical diagnosis
if the patient has Red Eye
and Purulent Discharge
and matting Eye Lashes
then the patient diagnosed Conjunctivitis Eye

For instance, Fuzziness may be given for symptoms and diagnosis as
IF the patient has Red Eye (1, 0.2)
AND Purulent Discharge (1, 0.3)
AND Matting Eye Lashes (1, 0.2)
THEN the patient has Conjunctivitis Eye
if x is s1 and x is s2 and x is s3 then x is d
d = min $\{\mu_{S1}(x), \mu_{S2}(x), \mu_{s3}(x)\}$

The FCF may be given by
IF the patient has Red Eye (0.8)
AND Purulent Discharge (0.7)
AND Matting Eye Lashes (0.8)
THEN the patient diagnosed Conjunctivitis Eye Eye (0.7)

The fuzzy rule may be interpreted in Diagnosis IntSys [15]
Does the patient has Red Eye? Y
Give fuzziness: 0.8
Does the patient has Purulent Discharge? Y
Give fuzziness: 0.7
Does the patient has Eye Lashes? Y
Give fuzziness: 0.8
The system will give
The patient diagnosis: Conjectivites with fuzziness 0.7.

7. Fuzzy Decision Set

Zadeh [10] proposed fuzzy set to deal with incomplete information.

In MYCIN [1], the certainty factor (CF) is defined as the deference between belief [MB] and disbelief [MD].

$$CF[h, e] = MB[h, e] - MD[h, e]$$

Where MB and MD are probability, and "e' evidence and "h" is hypothesis

The certainty factor (CF) may defied by The fuzzy certainty factor (FCF) by considering fuzziness instead of probability for the proposition of type "x is A".

$$FCF[h, e] = MB[x, A] - MD[x, A]$$

$$\mu_A{}^{FCF}(x) = \mu_A{}^{belief}(x) - \mu_A{}^{disbelief}(x)$$

Generalized fuzzy set with two fold membership function is given by $\mu_A(x) = \{\mu_A{}^{Belief}(x), \mu_A{}^{Disbelief}(x)\}$

The fuzzy certainty factor may be defined differently by $\mu_A{}^{FCF}(x) = \mu_A{}^{Belief}(x) - \mu_A{}^{Disbelief}(x)$,
where
$\mu_A{}^{FCF}(x) = \mu_A{}^{Belief}(x) - \mu_A{}^{Disbelief}(x)$ $\mu_A{}^{Belief}(x) \geq \mu_A{}^{Disbelief}(x)$
$= 0$ $\mu_A{}^{Belief}(x) < \mu_A{}^{Disbelief}(x)$

The FCF is single membership function. So that fuzzy logic and reasoning for FCF is similar to the Zadeh fuzzy logic.

The graphical representation of FCF is shown in Fig.2

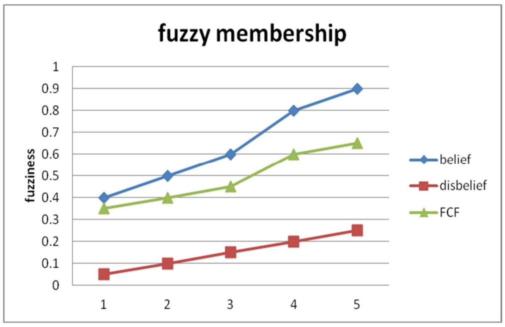

Fig. 2. *Fuzzy certainty factor.*

The fuzzy decision sets defined by

$$R = \mu_A{}^R(x) = 1 \quad \mu_A{}^{FCF}(x) \geq \alpha,$$
$$0 \quad \mu_A{}^{FCF}(x) < \alpha$$

where $\alpha \epsilon [0, 1]$ and α-cut is decision factor and is some threshold.

The fuzzy decision making is defined by
if fuzzy decision set R of the proposition" x is A" is
R $\geq \alpha$, the decision is Yes
R $< \alpha$, the decision is No
where α is decision factor. The decision factor is opinion of individual.

For instance,
infection $= \{0.3/x_1 + 0.4/x_2 + 0.5/x_3 + 0.7/x_4 + 0.8/x_5, 0/x_1 + 0/x_2 + 0.5/x_3 + .1/x_4 + .1/x_5\}$

$$\mu_{\text{infection}}{}^{FCF}(x) = 0.3/x_1 + 0.4/x_2 + 0.4.5/x_3 + 0.6/x_4 + 0.7/x_5$$

Surgery with infection R >0.6
The decision set is {0/x1+0/x2+0/x3+1/x4+1/x5}
Where yes for 1 and no for 0.
The fuzzy decision set is shown in Fig. 3

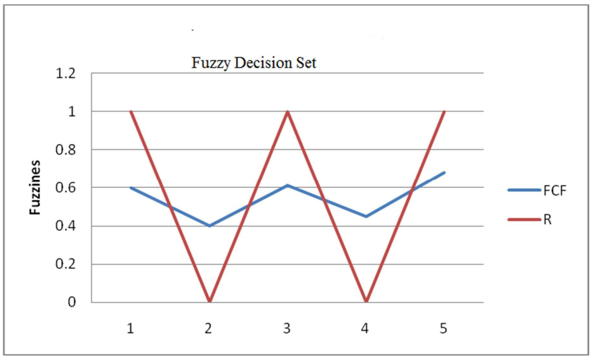

Fig. 3. *Fuzzy Decision set.*

The fuzzy logic is combination of logical operators.

Consider the logical operations on fuzzy Decision sets R1, R2 and R3

Negation

If x is not R1

$R1' = 1 - \mu_{R1}(x) / x$

Conjunction

x is R1 and y is R2→ (x, y) is R1 x R2

R1 x R2=min $(\mu_{R1}(x)), \mu_{R2}(y)\}$ (x, y)

If x=y

x is R1 and y is R2→ (x, y) is R1ΛR2

R1ΛR2=min $(\mu_{R1}(x)), \mu_{R2}(y)\}/x$ x is R1 or y is R2→ (x, y) is R1' x R2'

R1' x R2' =max $(\mu_{R1}(x)), \mu_{R2}(y)\}$ (x, y)

If x=y

x is R1 and x is R2→ (x, x) is R1 V R2

R1VR2=max $(\mu_{R1}(x)), \mu_{R2}(y)\}/x$ Disjunction

Implication

if x is R1 then y is R2 =R1→R2 = min$\{1, 1- \mu_{R1}(x)) + \mu_{R2}(y)\}/ (x, y)$

if x= y

R1→R2= min $\{1, 1- \mu_{R1}(x)) + \mu_{R2}(y)\}/x$

Composition

R1 o R2= R1 x R2=min$\{\mu_{R1}(x)), \mu_{R2}(y)\}/ (x, y)$

If x = y

R1 o R2==min$\{\mu_{R1}(x)), \mu_{R2}(y)\}/x$

The fuzzy propositions may contain quantifiers like "Very", "More or Less". These fuzzy quantifiers may be eliminated as

Concentration

x is very R1

$\mu_{very\ R1}(x)), = \mu_{R1}(x)^2$

Diffusion

x is very R1

$\mu_{more\ or\ less\ R1}(x) = \mu_{R1}(x)^{0.5}$

8. Surgeryitelligence

The medicine and surgery is need supported system for surgeon doing better surgery. The medicine and surgery intelligence are belief rather than likelihood (probability). The fuzzy logic deals with belief rather than probability. Zadeh proposed fuzzy logic with single membership function. Fuzzy set with set with two fuzzy membership functions give more evidence than the single membership function. A surgeon is better to have supported system for decision with two membership functions. The fuzzy decision set defined with threshold α-cut to take the decision.

Consider Surgery fuzzy rule

If x has infection then x need Surgery

infection $=\{0.3/x_1 + 0.4/x_2 + 0.6/x_3 + 0.8/x_4 + 0.9/x_5, 0/x_1 + 0/x_2 + 0.05/x_3 + 1/x_4 + 1/x_5\}$

$$\mu_{infection}^{FCF}(x) = 0.3/x_1 + 0.4/x_2 + 0.55/x_3 + 0.7/x_4 + 0.8/x_5$$

Using fuzzy conditional inference

if x is A then x is B= $\{\mu_A(x)\}$

the surgery is given by

$\mu_{infection \to Surgery}^{FCF}(x) =$

$0.3/x_1 + 0.4/x_2 + 0.55/x_3 + 0.7/x_4 + 0.8/x_5$

Surgery with ≥0.5

= 0/x1+0/x2+1/x3+1/x4+1/x5

Where Yes for 1 and No for 0

very infection $= \mu_{infection}(x)^2 =$

$$0.09/x_1 + 0.16/x_2 + 0.30/x_3 + 0.5/x_4 + 0.64/x_5$$

Using fuzzy conditional inference

if x is less A then x is B = $\{\mu_A(x)^2\}$

$\mu_{less\ infection \to Surgery}^{FCF}(x) =$

$0.09/x_1 + 0.16/x_2 + 0.30/x_3 + 0.5/x_4 + 0.64/x_5$

Surgery with very infection ≥0.5

$= 0./x_1 + 0/x_2 + 0/x_3 + 1/x_4 + 1/x_5$

Using fuzzy conditional inference

if x is more A then x is B = $\{\mu_A(x)^{0.5}\}$

more infection $= \mu_{infection}(x)^2$

$= 0.55/x_1 + 0.63/x_2 + 0.74/x_3 + 0.84/x_4 + 0.89/x_5$

Surgery with more infection ≥0.6

$= 0./x_1 + 1/x_2 + 1/x_3 + 1/x_4 + 1/x_5$

Consider Generalized fuzzy sets for surgery intelligence

cataract $=\{0.3/x_1 + 0.4/x_2 + 0.5/x_3 + 0.7/x_4 + 0.8/x_5,$
$0/x_1 + 0/x_2 + 0.5/x_3 + 1/x_4 + 1/x_5\}$

$$\mu_{cataract}^{FCF}(x) = 0.3/x_1 + 0.4/x_2 + 0.45/x_3 + 0.6/x_4 + 0.7/x_5$$

blood sugar $=\{0.4/x_1 + 0.5/x_2 + 0.6/x_3 + 0.8/x_4 + 0.9/x_5,$
$0/x_1 + 0/x_2 + 0/x_3 + 1/x_4 + 1/x_5\}$

$\mu_{blood\ sugar}^{FCF}(x) =$
$0.4/x_1 + 0.5/x_2 + .6/x_3 + 0.7/x_4 + 0.8/x_5$

Consider surgery fuzzy rule

If x has cataract and x has moderate blood sugar level then x need Surgery

Using fuzzy conditional inference

if x is A_1 and x is A_2 then y is B =min$\{\mu_{A1}(x), \mu_{A2}(x)\}$

$\mu_{cataract\ and\ moderate\ moderate\ blood\ sugar \to Surgery}^{FCF}(x) =$

min$\{0.3/x_1 + 0.4/x_2 + 0.55/x_3 + 0.7/x_4 + 0.8/x_5, 0.4/x_1 + 0.5/x_2 + .6/x_3 + 0.7/x_4 + 0.8/x_5\}$

$= 0.3/x_1 + 0.4/x_2 + 0.45/x_3 + 0.6/x_4 + 0.7/x_5$

$\mu_{cataract\ and\ moderate\ moderate\ blood\ sugar \to Surgery}^{FCF}(x) \geq 0.5$

= 0/x1+0/x2+1/x3+1/x4+1/x5

Consider surgery fuzzy rule

If x has cataract and x has moderate blood then x need Surgery

Using fuzzy conditional inference

$\mu_{cataract\ and\ moderate\ blood\ sugar \to Surgery}^{FCF}(x) =$

$\min\{0.3/x_1 + 0.4/x_2 + 0.55/x_3 + 0.7/x_4 + 0.8/x_5,$
$0.16/x_1 + 0.25/x_2 + .36/x_3 + 0.49/x_4 + 0.64/x_5\}$
$= 0.16/x_1 + 0.25/x_2 + .36/x_3 + 0.49/x_4 + 0.64/x_5$
$\mu_{\text{cataract and moderate blood sugar} \rightarrow \text{Surgery}}^{FCF}(x) \geq 0.5 =$ 0/x1+0/x2+0/x3+0/x4+1/x5

The fuzzy rule may be interpreted in surgery IntSys [15]
Does the patient has Cataract? Y
Give fuzziness: 0.8
Does the patient has ate moderate blood Sugar? Y
Give fuzziness: 0.65
Give the decision fuzziness: 0.6
The system will give
The patient need surgery.
Does the patient has Cataract? Y
Give fuzziness: 0.8
Does the patient has ate moderate blood Sugar? N
Give fuzziness: 0.4
Give the decision fuzziness: 0.6
The system will give
The patient not fit for surgery.

9. Conclusion

The medicine and surgery are need supported system for doing better diagnosis and surgery. The fuzzy logic deals with commonsense rather than probability. Fuzzy set with set with two fuzzy membership functions give more evidence than the single membership function. The fuzzy conditional inference is studied for two fold set. The fuzzy certainty factor is defined to eliminate conflict between two fuzzy membership function. Fuzzy decision set is defined to take decision. Fuzzy expert systems are supported systems to do to better diagnosis and better surgery. Some examples are discussed for clinical medicine and surgery.

Acknowledgment

The author thanks to the Editor-in-Chief and referees of this IJCMR for accepting the paper.

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