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№ 3257

Some Methods on Fuzzy Conditional Inference to Fuzzy Data Base

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April 25, 2020

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***Abstract*— — Zadeh and Mamdani, are proposed different fuzzy conditional inferences. Mamdani is also proposed for nested fuzzy conditional inference. In this paper, some methods on fuzzy conditional inference are studied to fuzzy databases. We have compared the methods. The Business Intelligence and Medical diagnosis are given as an example.**

Keywords— fuzzy inference, Fuzzy reasoning, business intelligence, fuzzy medical expert systems

I. INTRODUCTION

In the following, some methods on fuzzy conditional inference and fuzzy reasoning are studied for fuzzy conditional propositions of type "if x is A then y is B" and nested fuzzy conditional propositions of type " if x is A then if x is B then y is C" . The fuzzy medical diagnosis is given as example. It is necessary to discuss the preliminaries of fuzzy logic.

II. A BRIEF REVIEW OF FUZZY LOGIC

Zadeh [10] introduced the concept of a fuzzy set as a model of a vague fact. The use of the fuzzy set theory for expert system is now accepted because it is very convenient and believable.

Given a universe of discourse X, fuzzy proposition of type " x is A", xϵ X, a fuzzy subset A of X is defined by its membership function μ_A taking values on the unit interval[0,1] i.e.$\mu_A(x) \rightarrow [0,1]$.

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

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

Where "+" is union

The fuzziness may be defined with two ways, one is giving fuzziness with common sense and other is computing with some function.

For instance,

young =1.0/10+ 1.0/20 + 0.5/30+ 0.1/40 + 0/50

There is an alternative way to defined fuzzy subset with function and is given by

young may be defined as

$\mu_{young}(x) \rightarrow [0, 1], x \in X$

young = { 1 if xϵ[0,25]

=[1+((x-25)2)]-1 if xϵ[25,100]

young =1.0/10+ 1.0/20 + 0.4/30+ 0.01/40 + 0/50

For instance " Rama is tall" with fuzziness 0.6

For example, consider the Fuzzy proposition "x has Cold" .

The Fuzzy set 'Cold" is defined as

$\mu_{Cold}(x) \rightarrow [0, 1], x \in X$

Cold = { $0.6/x_1 + 0.7/x_2 + 0.7.5/x_3 + 0.8/x_4 + 0.85/x_5$}

For instance "Rama has Cold" with fuzziness 0.8

Let A, B and C be the fuzzy sets. The operations on fuzzy sets are given as

Negation

If x is not A

$A' = 1-\mu_A(x)/x$

Conjunction

x is A and y is B → (x, y) is A x B

$A \times B = \min(\mu_A(x), \mu_B(y))(x,y)$

If x=y

$A \wedge B = \min(\mu_A(x), \mu_B(x))/x$

Disjunction

x is A or y is B → (x, y) is A' x B'

$A' \times B' = \max(\mu_A(x), \mu_B(y))(x,y)$

If x=y

$A \vee B = \max(\mu_A(x), \mu_B(x))/x$

Implication

if x is A then y is B

$A \rightarrow B = \min\{1, 1-\mu_A(x) + \mu_B(y)\}/(x,y)$

If x=y

$\rightarrow B = \min\{1, 1-\mu_A(x) + \mu_B(x)\}/x$

Composition

$A \circ R = \min_x \{\mu_A(x), \mu_R(y)\}/(x,y)$,

where $R=A \rightarrow B$

$A \circ R = = \min\{\mu_A(x), \mu_R(x,y)\}/y$

If x = y

$A \circ R = = \min\{\mu_A(x), \mu_R(x,x)\}/x$

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

Concentration

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

Diffusion

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

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III. PROPOSED METHOD OF FUZZY CONDITIONAL INFERENCE

There are many fuzzy conditional inference methods, among those Zadeh , TSK and Mamdani methods are popular for many applications.

Zadeh[9] defined fuzzy set A for fuzzy proposition of type " x is A" by

$A= \mu_A(x)/x$

TSK[5] fuzzy conditional inference is given by
if x is A then y= f(x) is B
if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then y is B
where $y=f(x_1,x_2,\ldots,x_n)$
The proposed fuzzy conditional inference for TSK is given in the bellowing

The fuzzy inference may be derived in the following
The additive mapping $f:R\rightarrow R$ is called derivation if
$f(x+y)=f(x)+f(y)$
t-norm is used in several fuzzy classification system
$t(x+y)<=max(t(x),t(y))$
$t(x*y)<=min(t(x),t(y))$
Substitute fuzzy sets A_1 and A_2 with x and y respectively
$ffA_1 + A_2)<=max(f(A_1),f(A_2))$
$f(A_1 * A_2)<=min(f(A_1),f(A_2))$
The fuzzy conditional inference is given by
if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then $B =f(A_1, A_2, \ldots, A_n)$
where $A_1 + A_2$ is $A_1 \vee A_2$, $A_1 * A_2$ is $A_1 \wedge A_2$
The proposed fuzzy conditional inference for TSK method is given by
if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then $B = f(A_1,A_2,\ldots,A_n) =min(A_1,A_2,\ldots,A_n)$

The proposed fuzzy conditional inference for TSK using Mamdani fuzzy conditional inference $A\rightarrow B=min\{A,B\}$ is given by
if x_1 is A_1 and x_2 is A_2 ….. and x_n is A_n then y is B
$=min\{ min(A_1,A_2,\ldots,A_n) , B\}$
$= min\{min(A_1,A_2,\ldots,A_n) \quad min (min(A_1,A_2,\ldots,A_n)\}$
$= min(A_1,A_2,\ldots,A_n)$
Where $B= min(A_1,A_2,\ldots,A_n)$

The proposed fuzzy conditional inference for TSK method is given by
if x_1 is A_1 and x_2 is A_2 ….. and x_n is A_n then y is B
$= min(A_1,A_2,\ldots,A_n)$
The proposed fuzzy conditional inference is given by
if x is A then y is B ={A}
The proposed nested fuzzy conditional inference "if x is A then if y is B then z is C" for TSK method is given by
$A\rightarrow(B\rightarrow C)= min\{\mu_A(x), \ min (\mu_B(y), \mu_C(z))\}$
$min\{\mu_A(x), \ min (\mu_B(y), \mu_C(z))\}$

Zadeh fuzzy conditional inference give by
if x is A then y is B= $min (1,(1- \mu_A(x)+ \mu_B(y)))$
$= min (1,(1- \mu_A(x)+ \mu_A(x)) =1$

The nested fuzzy conditional inference for"if x is A then if x is B then y is C" is given by $A\rightarrow(B\rightarrow C)$
$= min \{1,(1- \mu_A(x)+ \ min (1,(1- \mu_A(x)+ \mu_A(y))$
=1
Given fuzzy conditional inference is not known.
Hence, Zadeh fuzzy conditional inference is not suitable.

Mamdani[3] fuzzy conditional inference is given by
if x is A then y is B = $min (\mu_A(x),\mu_B(y)))$
The nested fuzzy conditional inference "if x is A then if x is B then x is C" for Mandani method is given as
$A\rightarrow(B\rightarrow C)= min\{\mu_A(x), \ min (\mu_B(x), \mu_C(zx)\}$
$min\{\mu_A(x), \ min (\mu_B(x), \mu_C(x))\}$

The nested fuzzy conditional inference
"if x is A then if x is B then x is C"
is equivalent to
if x is A and x is B then x is C"

Mamdani fuzzy conditional inference give by
if x is A then y is B= $min (\mu_A(x), \mu_B(y))$
$= min (\mu_A(x), \mu_A(x))= \{\mu_A(x) \}$
The proposed fuzzy conditional inference for Mamdani method is given by
if x is A then y is B= $\{\mu_A(x)\}$

The nested fuzzy conditional inference "if x is A then if y is B then z is C" for Mandani method is given by
$A\rightarrow(B\rightarrow C)= min\{\mu_A(x), \ min (\mu_B(y), \mu_C(z))\}$
$min\{\mu_A(x), \ min (\mu_B(y), \mu_C(z))\}$
$= min\{\mu_A(x), \ \mu_B(y)\}$
$= min\{\mu_A(x), \ 1\}$
$= \{\mu_A(x) \}$

The proposed nested fuzzy conditional inference for Mamdani method is given by
if x is A if y is B then z is C= $\{\mu_A(x)\}$

A. Composition

If some $R=A\rightarrow B$ relation between A and B is known and some value of Antecedent A', the Consequent B' is given by
$B=A'oR, \ R=A\rightarrow B$
$= min (\mu_{A'}(x), \mu_R(x))$
$= \quad min (\mu_{A'}(x), min (\mu_A(x), \mu_A(x))$
$= \quad min \{\mu_{A'}(x), \mu_A(x) \}$

The composition for nested fuzzy conditional inference is given by
$B=A'oR, \ R=A\rightarrow B\rightarrow C$
$= min (\mu_{A'}(x), \mu_R(x))$
$= \quad min \{\mu_{A'}(x), min (\mu_A(x), \mu_A(x), \mu_C(x)) \}$
$= \quad min \{\mu_{A'}(x), \mu_A(x) \}$

IV. FUZZY REASONING

The fuzzy reasoning is drawing conclusions from fuzzy prepositions . Zadeh [9] and Fukami [2] proposed fuzzy reasoning. In the following fuzzy reasoning is studied for proposed fuzzy conditional inference..

Zadeh fuzzy reasoning is given by

if x is A then y is B
x is A_1

---

y is A_1 o (A→B)

for instance A1 is very A, more or less A, not A etc.
Zadeh fuzzy reasoning is given by
if x is A then y is B
x is very A

---

y is very A o (A→B)

The fuzzy reasoning using proposed fuzzy conditional inference is given by

if x is A then y is B
x is A_1

---

y is A_1 o (A→B)

Consider Zadeh fuzzy conditional inference for the proposed conditional inference and is give by

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

if x is A then y is B
x is A_1

---

y is A_1 o (A→B)
$=A_1$ o (1)
$=A_1$

Hence the following fuzzy reasoning is satisfied.

if x is A then y is B
x is very A

---

y is very B

if x is A then y is B
x is more or less A

---

y is more or less B

if x is A then y is B
x is not A

---

y is not B

The nested fuzzy conditional inference

if x is A_1 if x is A_2 and … and if x is A_n then y is B

is equivalent to
if x is A_1 and A_2 and … and A_n then y is B

V. BUSINESS INTELLIGENCE

In the fuzzy databases, the data is represented as linguistic format with fuzziness.

The relational database is a Cartesian product of attributes and is represented as

$R=A_1 \times A_2 \times \ldots \times A_n$

Or

$R(A_1, A_2, \ldots, A_n)$
$t_i = (d_{i1}, d_{i2}, \ldots, d_{in})$, $d_{ij} \in A_i$

The fuzzy relation databases is defined as
$R= \{t, \mu(t)\}$

For instance

ino	Iname	Sales	μ
I105	Coffee	80	0.7
I107	Milk	60	0.6
I104	Tea	100	0.8
I108	Sugar	50	0.6

Fig.1 Fuzzy sales database

ino	Iname	price	μ
I105	Coffee	100	0.9
I107	Milk	50	0.5
I104	Tea	80	0.8
I108	Sugar	60	0.6

Fig.2Fuzzy Price database

The fuzzy reasoning is drawing conclusions.
Consider the fuzzy reasoning

If x is A then y is B
x is more A

---

y is more A o (A→B)

If x is sales then y is price
x is more sales

---

y is more sales o (sales →price)

ino	Iname	sales
I105	Coffee	0.7
I107	Milk	0.6
I104	Tea	0.8

I108	Sugar	0.6

Fig.3, Sales

ino	Iname	price
I105	Coffee	0.9
I107	Milk	0.5
I104	Tea	0.8
I108	Sugar	0.6

Fig.4. Price

ino	Iname	More price
I105	Coffee	0.94
I107	Milk	0.70
I104	Tea	0.89
I108	Sugar	0.77

Fig.5 More price

Zadeh fuzzy reasoning is given by

y is more sales o (sales →price)
= min{ more sales, min(1, 1-sales+price)}

ino	Iname	price
I105	Coffee	0.94
I107	Milk	0.7
I104	Tea	0.89
I108	Sugar	0.77

Fig.8

Mamdani fuzzy reasoning is given by
y is more sales o (sales →price)
= min{ more sales, min(sales, price)}

ino	Iname	price
I105	Coffee	0.7
I107	Milk	0.5
I104	Tea	0.8
I108	Sugar	0.6

Fig.6

Prposed fuzzy reasoning is given by
y is more sales o (sales →price)
= min{ more sales, sales}

ino	Iname	price
I105	Coffee	0.7
I107	Milk	0.6
I104	Tea	0.8
I108	Sugar	0.6

Fig.7.

Similarly for very less price may be studied.

VI. FUZZY EXPERT SYSTEMS

MYCIN[1] is an example of medical expert system. MYCIN is a Medical expert system developed for medical diagnosis [1]. The fuzzy information shall also be possible to define in empty MYCIN. EMYCIN is with empty knowledge base.

Consider the nested fuzzy rule in medical diagnosis

If the patient has Red Eye
and Purulent has Discharge
and matting has Eye Lashes
Then the patient is diagnose Conjunctivitis Eye

If the patient has Red Eye
If Purulent has Discharge
If matting has Eye Lashes
Then the patient is diagnose Conjunctivitis Eye

For instance, Fuzziness may be given as for symptoms
If the patient Red Eye (0.8)
If Purulent Discharge(0.7)
If matting Eye Lashes(.75)
Then the patient has Conjunctivitis Eye

The proposed nested fuzzy conditional inference may be interpreted in EMYCIN (empty MYCIN) as

(defun CF (cf1 cf2 cf3)
(min cf1 cf2 cf3)
(CF .8 .7 .75)
(defrule 10
If: Red-Eye
If: Purulent-Discharge
If: Matting-Eye
then : identity organism is Conjunctivitis-Eye (CF)
if the symptoms of rule with Red-Eye, Purulent-Discharge and Matting-Eye matches than EMYCIN diagnose identity organism is Conjunctivitis-Eye with 0.7.

VII. CONCLUSION

The fuzzy conditional inference and nested fuzzy conditional inference are studied. A method is studied for fuzzy conditional inference. The fuzzy conditional inference, nested fuzzy conditional inference and fuzzy reasoning are studied for proposed method. The Business Intelligence and Medical diagnosis are given as an example.

ACKNOWLEDGMENT

The Author express thanks to Reviewers for their valuable comments..

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