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№ 11762

Artificial Intelligence and Fuzzy Machine Learning with Python

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January 13, 2024

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***Abstract*—deep learning is identifying particular information from the problem. Neural network is useful for deep learning. Fuzzy deep learning is finding information from incomplete information. The fuzzy logic deals with incomplete information. In this paper, fuzzy neural networks are discussed for fuzzy deep learning. The single fuzzy membership function is not sufficient to deal with incomplete problems. The two fold fuzzy set will give more evidence than the single fuzzy membership function. Deep learning is studied using twofold fuzzy logic. Medical eye diagnosis is given as an example.**

Keywords—fuzzy logic, text processing, deep learning, medical expert systems

I. INTRODUCTION

Zadeh [11] propose single membership function to deal with incomplete information. Fuzzy Set with two membership functions will give more evidence to deal with the incomplete information. The Many-Valued Logic is considered to discuss the Fuzzy Logic with two membership functions. The fuzzy Word may be defined by two Fuzzy membership functions based on "Belief and Disbelief" to deal with incomplete, inconsistent, inexact and Incomplete information.

The AI problems may contain incomplete information. The KR is key factor to solve the AI problems. The KR is necessary to deal with incomplete problems. The FKR is studied to design incomplete problems. This FKR later used for logic programming to solve in complete AI problems.

II. FUZZY LOGIC

The possibility set may be defined for the proposition of the type "x is A" as

$\pi_A(x) \rightarrow [0,1]$
$\pi_A(x)=\max\{\mu_A(x_i)\}, x \epsilon X$

$\mu_A(x)=\mu_A(x_1)/x_1+\mu_A(x_2)/x_2+\ldots+\mu_A(x_n)/x_n$
$\mu_{bird}(x)=\mu_{bird}(x_1)/x_1+\mu_{bird}(x_2)/x_2+\ldots+\mu_{bird}(x_n)/x_n$

$\mu_{bird}(x)=\mu_{bird}(x_1)/x_1+\mu_{bird}(x_2)/x_2+\ldots+\mu_{bird}(x_n)/x_n$
$\mu_{bird}(x)=0.1/\text{Penguin} + 0.3/\text{Hen}+0.5/\text{Cock} + 0.6/\text{Parrot} + 0.8/\text{eagle} + 1.0/\text{flamingos}$

Let A and B be the fuzzy sets, and the operations on fuzzy sets are given below [13]

$A \vee B=\max(\mu_A(x), \mu_B(x))$ Disjunction
$A \wedge B=\min(\mu_A(x), \mu_B(x))$ Conjunction
$A'=1-\mu_A(x)$ Negation
$AxB=\min\{\mu_A(x), \mu_B(x)\}$ Relation
$A \circ B==\min\{\mu_A(x), \mu_B(x, x)\}$ Composition

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

$\mu_{very}(x) =\mu_A(x)^2$ Concentration
$\mu_{more\ or\ less}(x) = \mu_A(x)^{0.5}$ Diffusion

III. FUZZY NEWRAL NETWORK

The neural network concept is taken from the Biological activity of nervous system. The neuron passes information to other neurons. There are many models described for neural networks. The McCulloch-Pitts model contributed in understanding neural network and Zedeh explain that activity of neuron is fuzzy process [12].

The McCulloch and Pitt's model consist of set of inputs, processing unit and output and it is shown in Fig.2

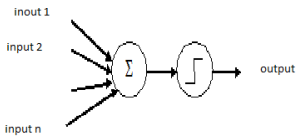

Fig2. McCulloch and Pitt's model

The fuzzy neuron model for fuzzy conditional inference for

if x_1 is A_1 and/or x_2 is A_2 and/or … and/or x_n is A_n then B may be defined as fuzziness and computational function.

Where $f(A_1,A_2,\ldots A_n,B)$ and $A_1,A_2,\ldots A_n,B$ are fuzzy sets.

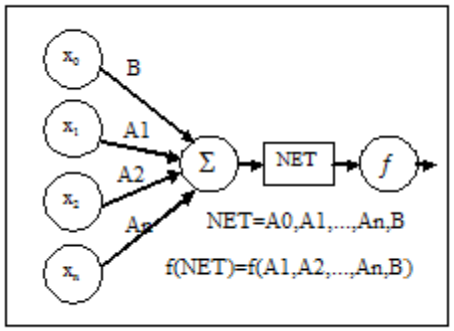

Fig.3.Fuzzy neuron model

The multilayer fuzzy neural network is shown in Fig.4

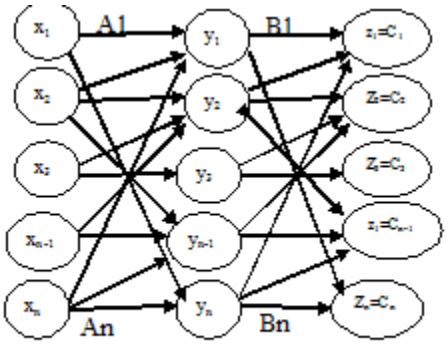

Fig.4. Multilayer fuzzy neural net

IV. METHODS FOR FUZZY CONDITIONAL INFERENCE

There are many fuzzy conditional inference methods, among those Zadeh[12] , TSK[5] and Mamdani[2] methods are popular for many applications like fuzzy control systems. These fuzzy conditional inferences shall be used for fuzzy medical expert systems. Consider the Zadeh fuzzy conditional inference.

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

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

=min{1,(1-min($\mu_{A1}(x_1)$,$\mu_{A2}(x_2)$,…,$\mu_{An}(x_n)$))+$\mu_B(y)$}

The fuzzy neuron for Zadeh fuzzy conditional inference is represented as in Fig.5

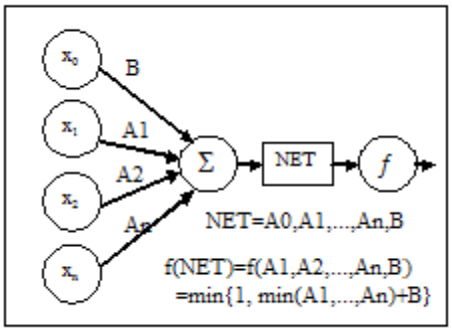

Fig.5. Zadeh method

Mamdani [5] proposed the inference for fuzzy conditional proposition in which prior information is also known for Consequent part. i.e., the relationship between president part and consequent part is known.

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

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

=min($\mu_{A1}(x)$, $\mu_{A2}(x)$, …, $\mu_{An}(x)$, $\mu_B(y)$)

(4.2)

The fuzzy neuron for fuzzy conditional inference is represented as in Fig.6

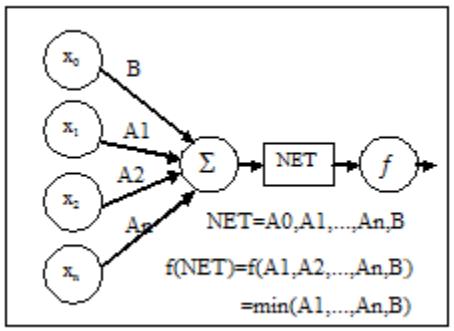

Fig.6. Mamdani method

The fuzzy inference needs prior information for the precedence part and consequent part. i.e., the relationship between president part and consequent part is known The modified method is proposed when relationship between president part and consequent part is not known.

The fuzzy conditional inference for TSK method is given as

if x_1 is A_1 and x_2 is A_2 ….. and x_n is A_n then $y=f(x_1,x_2,....,x_n)$ is B

The fuzzy conditional inference for Sugeno method is given as

if x_1 is A_1 and x_2 is A_2 ….. and x_n is A_n then $y=f(x_1,x_2,....,x_n)$ is $B=f(x_1,x_2,....,x_n)$

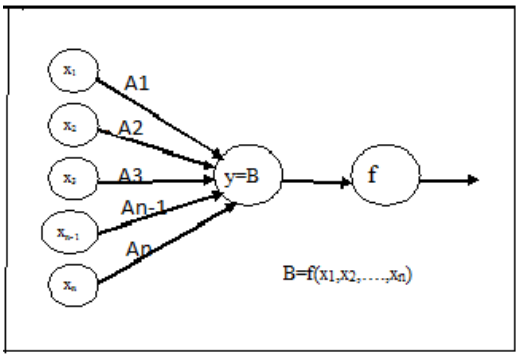

Fig.7a. TSK method

Considering fuzzy sets Instead of variable for fuzzy rule and the fuzzy rule may be given as

if x_1 is A_1 and x_2 is A_2 and … and x_n is A_n then y is B =f(A_1, A_2, …, A_n)

The fuzzy inference may be derived in the following way.

The additive mapping f:R→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

f(A_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 =min(A_1, A_2, …, A_n)

where A_1 + A_2 is A_1 or A_2 , A_1 * A_2 is A_1 + A_2

The fuzzy neuron for fuzzy conditional inference is represented as

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

The fuzzy conditional inference using Mamdani inference is given by

if x is A then y is B= min(A,A)=A

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

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

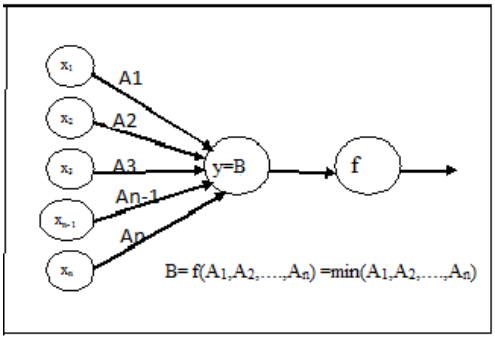

Fig.7b. Reddy method

V. FUZZY NATURAL LANGUAGE PROCESSING

Fuzzy logic not only computes with words also compute with the sentence.

Consider the sentences some context of medical diagnosis.

The doctor finds following theory. of natural language

Theory: the patient has fever . The patient has rash. The patient has body-ache . The patient has chills. The patient has headache. The patient has runny-nose. The patient has swollen-glands .The patient has sneezing. The patient has vomiting.

The diagnosis will be made from the theory.

The rules of the diagnosis are given by

If the patient has fever and rash and body-ache and chills Then the patient has chicken-pox .

If the patient has fever and headache and runny-nose and rash Then the patient has German-measles .

If the patient has fever and swollen-glands Then the patient has mumps .

If the patient has cough and sneezing and runny-nose Then the patient has whooping-cough.

If the patient has fever and vomiting and headache and rash and light Then the patient has meningitis.

The symptoms have to be extracted from the theory and interpreted in rules.

The backward reasoning is used for medical diagnosis.

Backward Reasoning: The backward reasoning try to match initial states for goal state.

Consider fuzzy rule

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

B will be fired after matches A_1, A_2 and … and A_n .

For example in the fuzzy rule

If the patient has fever and swollen-glands Then the patient has mumps.

The diagnosis mumps will be given after matching fever and swollen-glands.

VI. COMPUTIN WORDS WITH TWO FOLD FUZZY SETS

Zadeh considered a single Fuzzy membership function to define the Fuzzy word to deal the incomplete information.

The proposition " x is A" is defined by

A= $\mu_A(x)$, Where A is Fuzzy word and x Є X, $\mu A(x)$ is Fuzzy membership function.

The propositions " x is A" may represent the evidence with "Belief" and Disbelief" to deal the Incomplete information [8].

Given some Universe of discourse X, the proposition " x is A" is defined by its two Fuzzy membership functions

$\mu_A(x) = \{\mu_A^{Belief}(x), \mu_A^{Disbelief}(x)\}$

or

$A = \{\mu_A^{Belief}(x), \mu_A^{Disbelief}(x)\}$

$A =\{ \mu_A^{Belief}(x_1)/x_1 + \mu_A^{Belief}(x_2)/x_2 + \ldots + \mu_A^{Belief}(x_n)/x_n,$

$\mu_A^{Disbelief}(x_1)/x_1 + \mu_A^{Disbelief}(x_2)/x_2 \ldots + \mu_A^{Belief}(x_n)/x_n\}$

$\mu_A^{Belief}(x) + \mu_A^{Disbelief}(x) <=1,$

For example,

Consider the Fuzzy proposition "x has Cold" and The Fuzzy word 'Cold" may be defined

Cold = { $0.8/x_1 + 0.6/x_2 + 0.4/x_3 + 0.6/x_4 +0.75/x_5$, $0.4/x_1 + 0.5/x_2 + 0.5/x_3 + 0.4/x_4 +0.35/x_5$}

For instance , "Rama has Cold" with fuzziness {0.8, 0.4}.

The fuzzy certainty Factor FCF) may be defined with the "belief " and "disbelief "

.

Fuzzy certainty factor(FCF) is defined as the deference between belief [MB] and disbelief [MD] of probabilities.

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

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

where "belief" and "disbelief" are fuzzy sets.

$\mu_A^{FCF}(x)$ is single fuzzy membership function.

Consider the rule in medical diagnosis

If the patient has Red Eye

and Purulent Discharge

Then the patient has Conjunctivitis Eye

For instance, Fuzziness may be given for symptoms and diagnosis as

IF the patient has Red Eye (0.9, 0.2)

AND Purulent Discharge0(.7, 0.2)

THEN the patient has Conjunctivitis Eye (0.8, 0.2)

The FCF may be given as

IF the patient has Red Eye (0.7)

AND Purulent Discharge(0.5)

Then the patient has Conjunctivitis Eye Eye(0.6)

The fuzzy rule may be interpreted in EMYCIN (empty MYCIN) as using Mamdani [2] fuzzy conditional inference

(defrule 10
If: Red-Eye
and Purulent-Discharge
then : identity organism is Conjunctivitis-Eye (0.7)

VII. Fuzzy Deep Learning

Fuzzy logic not only computes with words also compute with the sentence.

Consider the sentences some context of medical diagnosis.

The fuzzy Corona expert systems are is problem solving systems using Fuzzy Corona reasoning with Fuzzy Corona facts and rules. These Fuzzy facts and rules are modulated to represent the Corona Knowledge available to the system. The Fuzzy Corona Expert System is independent component which performs Fuzzy reasoning in HFCES.
Consider the following fuzzy facts and fuzzy rules.

The fuzzy Corona rule are given by using MB and MD

if fever (0.8,0.1)
and Dry-Cough(0.95,01)
and Tiredness(0.9,0.3)
and Headache(0.9, 0.25)
and difficult to breath (0.9, 0.1)
Then the patient has Corona

The fuzzy Corona rule are given by using MB and MD
if fever (0.7)
and Dry-Cough(0.65)
and Tiredness(0.6)
and Headache(0.75)
and difficult to breath (0.8)
Then the patient has Corona

In Corona diagnosis, the consequent part is derived from precedent part[6].

If x is A_1 and x is A_2 and,…, and x is A_n then x is B
=min $\{A_1, A_2, \ldots, A_n\}$

if fever (0.7)
and Dry-Cough(0.65)
and Tiredness(0.6)
and Headache(0.75)
and difficult to breath (0.8)
Then the patient has Corona=
min{0.7,0.65,0.6,0.75.,0.8)=0.6

For rule-1, fuzzy expert system is given fever , Dry-Cough, body_ ache and Headache the system will reason diagnose Corona with fuzziness of 0.9.

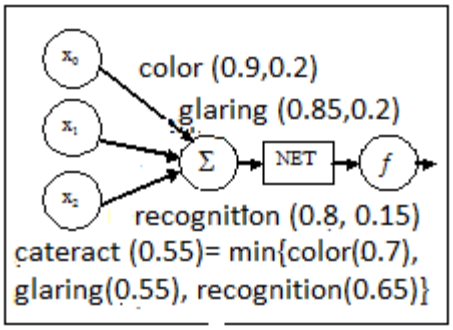

Fig9. Fuzzy neural net with twofold set

After symptoms are searching and matched from the text/case sheet, The diagnosis will give diagnosis cataract with fuzziness with 0.55..

Python programming may be given as

```
import string
import min

text = input('text: ')

symptoms = text.split()
symptom1='appreciating-colors'
symptom2='glaring'
symptom3='recognizing-faces'

if symptom1 in symptoms and  symptom2 in symptoms and  symptom3 in symptoms:
                print('patient diagnosed cataract')

# check if the number is negative, positive or zero
f1 = float(input("appreciating-colors: "))
f2 = float(input("glaring: "))
f3 = float(input("recognizing-faces: "))
f=min(f1,f2,f3)
print(f)

def min(a,b,c):
    if a<=b and a<=c: return a
    if b<=a and b<=c: return b
    if c<=a and c<=b: return b
”
```

VIII. Conclusion

Fuzzy deep learning finds particular information from incomplete information. Fuzzy neural network is used for fuzzy deep learning. The fuzzy words are extracted from fuzzy text. The fuzzy words interpreted in fuzzy rules and given inference using different methods. Python programming is given for fuzzy text processing.

Acknowledgment

The author thank to iFuzzy2020 Conference Chair for accepting this paper.

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