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Fuzzy Deep Learning in Text Processing: An Application to Medical Expert System

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ABSTRACT

Deep leering in natural language processing is an emerging area for text processing. Semantic analysis is used for natural language processing for deep learning. Fuzzy Natural language is languages which contain fuzzy rules with incomplete information. The fuzzy logic deals with incomplete information. In this paper, fuzzy neural networks are s discussed for fuzzy natural language processing. 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 diagnosis is given as an example.

Keywords: Fuzzy Logic; Fuzzy; Natural Language Processing; Deep Learning; Medical Diagnosis

Introduction

Various theories are proposed to deal with incomplete information. Most of the theories are based on probability and randomized. Fuzzy logic is dealing with commonsense and mind. Zadeh [1] proposes a 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 a key factor to solve the AI problems. The KR is necessary to deal with incomplete problems. FKR is studied to design incomplete problems. This FKR was later used for logic programming to solve complete AI problems.

Fuzzy Logic

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

$$\pi P(X) \to [0,1]$$

$$\pi_P(X) = \max\{\mu_P(X_i)\}, x \in X$$

$$\mu_P(X) = \mu_P(X_1)/X_1 + \mu_P(X_2)/X_2 + ...\mu_P(X_n)/X_n$$

$$\mu_{bird}(X) = \mu_{bird}(X_1)/X_1 + \mu_{bird}(X_2)/X_2 + ...\mu_{bird}(X_n)/X_n$$

$$\mu_{bird}(X) = \mu_{bird}(X_1)/X_1 + \mu_{bird}(X_2)/X_2 + ...\mu_{bird}(X_n)/X_n$$

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

Let P and Q be the fuzzy sets, and the operations on fuzzy sets are given below [2]

$$\text{PVQ} = \max\{\mu_P(X), \mu_Q(X)\} \quad \text{Disjunction}$$

$$\text{P} \wedge Q = \min\{\mu_P(X), \mu_Q(X)\} \quad \text{Conjunction}$$

$$P' = 1 - \mu_P(X) \quad \text{Negation}$$

$$PXQ = \min\{\mu_P(X), \mu_Q(X)\} \text{ Relation}$$

$$PoQ = \min\{\mu_P(X), \mu_Q(X, X)\} \text{ Composition}$$

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

$$\mu_{very}(X) = \mu_P(X)^2 \text{ Concentration}$$

$$\mu_{moreorless}(X) = \mu_P(X)^{0.5} \text{ Diffusion}$$

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 Zadeh explain that activity of neuron is fuzzy process [3]. The McCulloch and Pitt's model consist of set of inputs, processing unit and output and it is shown in Figure 1. 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 and shown in Figure 2.

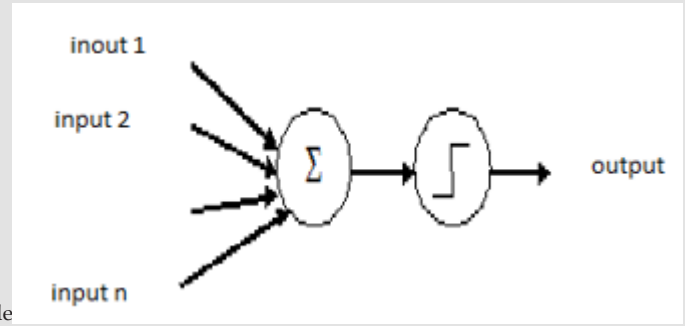

Figure 1: McCulloch and Pitt's mode

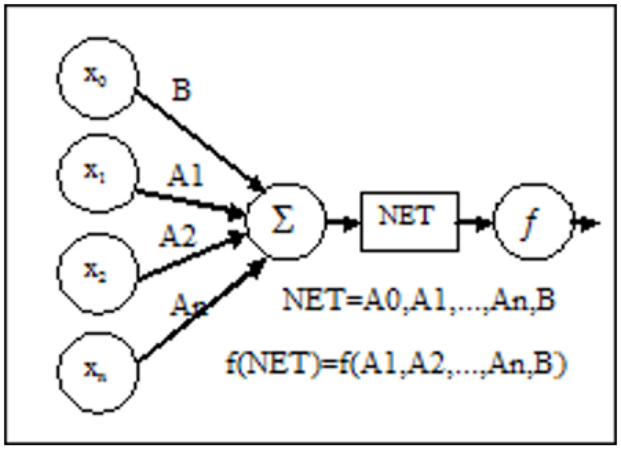

Figure 2: Fuzzy neuron model.

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

Methods for Fuzzy Conditional Inference

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

$$\text{if x is A then y is B} = \min\left(1, \left(1 - \mu_A(X) + \mu_B(Y)\right)\right)$$

Let A_1, A_2,..... A_n and B be the fuzzy sets. The fuzzy nested condition 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

$$= \min\{1, (1\text{-}\min(\mu_{A1}(X_1), \mu_{A2}(X_2), ...\mu_{An}(X_n) + \mu_B(y)\} \quad (4.1)$$

The fuzzy neuron for Zadeh fuzzy conditional inference is represented as in Figure 3.

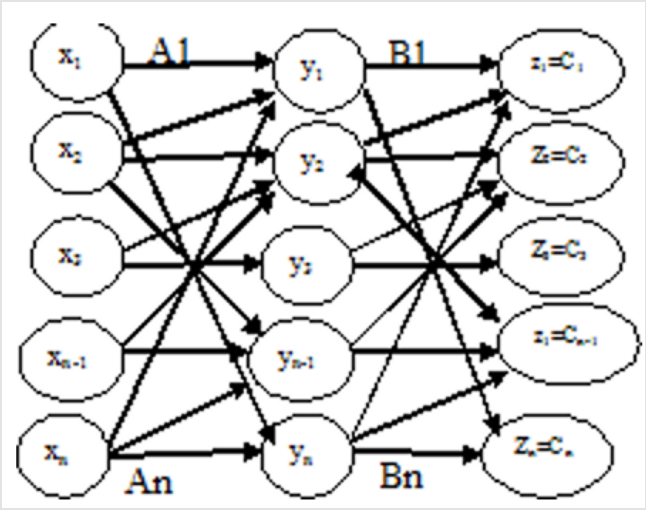

Figure 3: Multilayer fuzzy neural net.

Mamdani [4] 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.

$$\text{If x is A then y is B} = \min\left(\mu_A(X) + \mu_B(X),\right)$$

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

$$= \min\left(\mu_{A1}(X), \mu_{A2}(X), \ldots.(\mu_{An}(X) + \mu_B(y)\right) \quad (4.2)$$

The fuzzy neuron for fuzzy conditional inference is represented as in Figures 4 & 5.

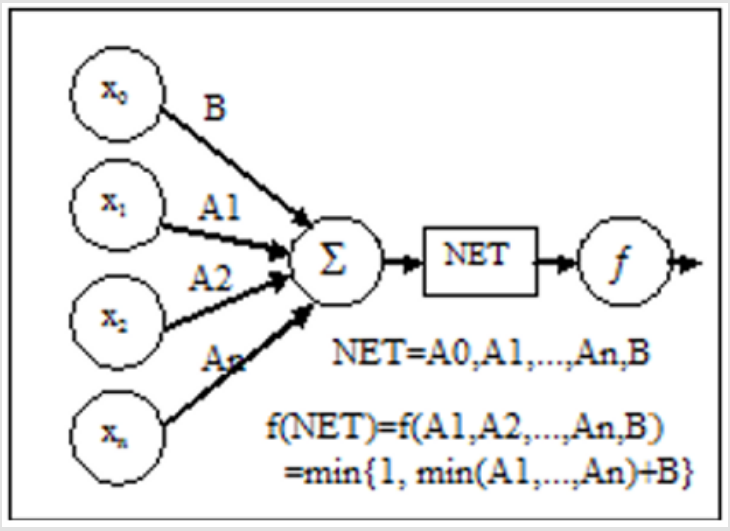

Figure 4: Zadeh method.

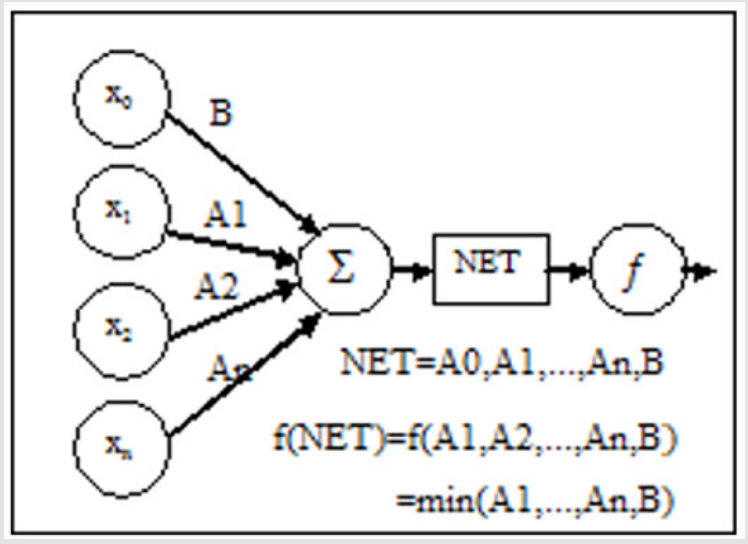

Figure 5: Mamdani method.

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 [5] is given as $B = f\left(X_1, X_2, ..., X_n\right)$ and is shown in Figures 6a & 6b.

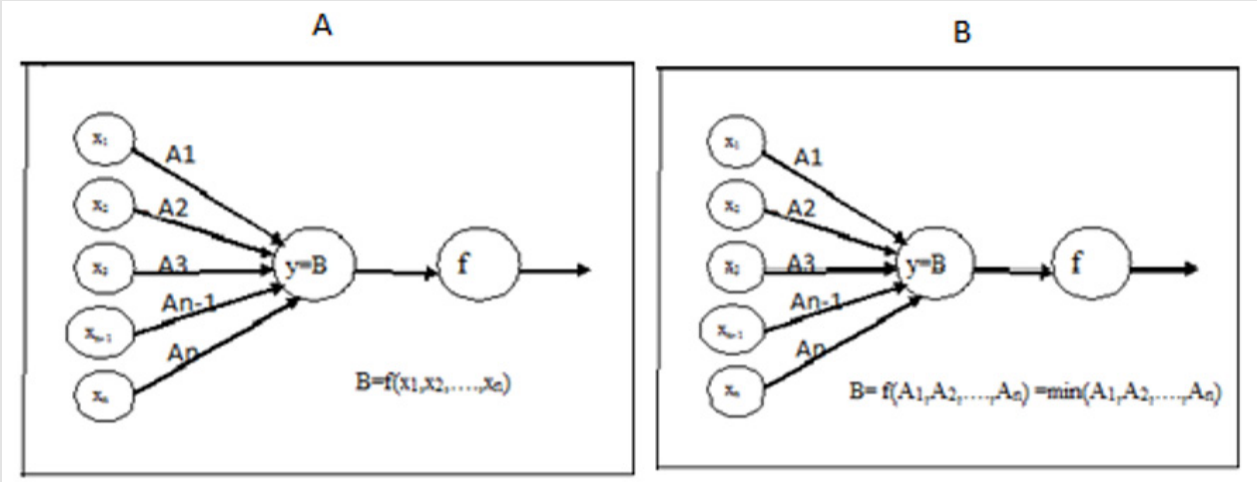

Figure 6:
A. TSK method.
B. Reddy method.

The TSK method is difficult to compute, and modified method is proposed instead of TSK method. The TSK model is difficult to compute.

Consider 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 An then B =f (A_1, A_2, ..., A_n)

The fuzzy inference may be derived in the following way. The additive mapping $f : R \to R$ 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 A1 and A2 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 =in (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

$$B = f(A_1, A_2, \ldots, A_n) = \min(A_1, A_2, \ldots, A_n) \quad (4.3)$$

and is shown in Figures 7 & 8.

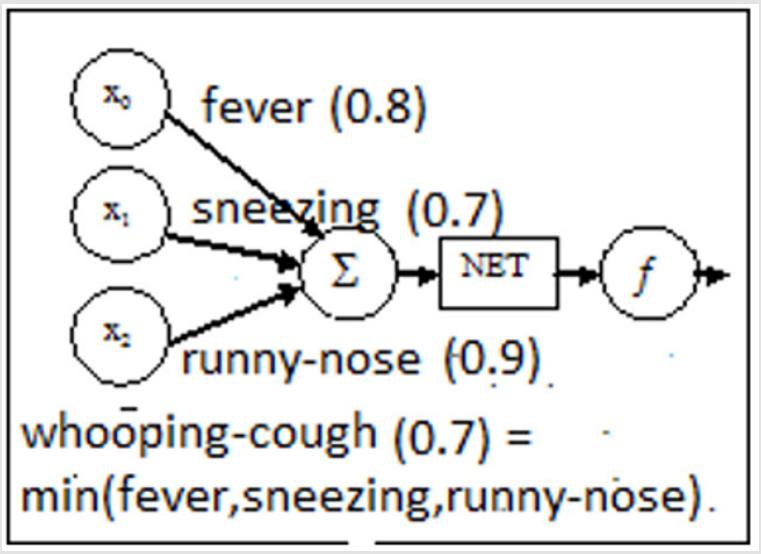

Figure 7: Fuzzy neural nets.

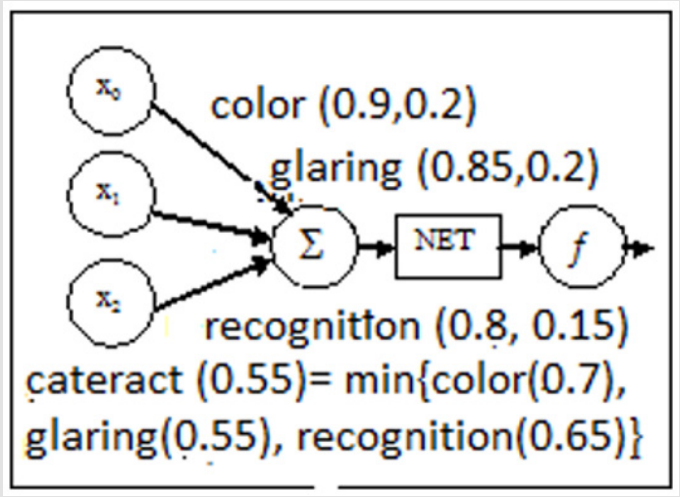

Figure 8: Fuzzy neural net with twofold set.

Fuzzy Natural Language Processing

Fuzzy logic not only computes with words but also computes with the sentence. Consider the sentences some context of medical diagnosis. The doctor finds the following theory. of natural language Theory: the patient has fever. The patient has a rash. The patient has a body-ache. The patient has chills. The patient has a headache. The patient has a 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.

Computing 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 $\forall X$, $\mu_A(X)$ 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

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

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

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

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 [6] fuzzy conditional inference

(defrule 10

If: Red-Eye

and Purulent-Discharge

then : identity organism is Conjunctivitis-Eye (0.7) [7-12].

Fuzzy Deep Learning in 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 the following theory. of natural language

Text

The patient has fever. The patient has a rash. The patient has a body-ache. The patient has chills. The patient has a headache. The pa-

tient has a runny nose. The patient has swollen glands. The patient has sneezing. The patient vomited.

- The following fuzzy rules of the diagnosis are deep learning from the above text.

- 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.

Consider Fuzzy Rule if the Cough and Sneezing and Runny-Nose then Whooping-Cough

By searching keywords and after matching, the diagnosis will be given whooping-cough with 0.7 will be given after matching cough, sneezing and runny-nose and fuzziness is given. Cough (0.8), sneezing (0.7) and runny-nose (0.9)

Consider the Test for Eye Diagnosis

The patient has difficulty in appreciating-colors, glaring and recognizing-faces. The patient has loss in vision field. The patient has poor vision and unable to see things properly The patient has increased blood flow due to congestion and eye is red color.

Consider Deep Learning of Fuzzy Rules from the Text

- **Rule-1:** If the patient has difficulty in appreciating colors, glaring and recognizing faces then the patient has cataract.

- **Rule-2:** If the patient has loss in vision field then the patient has glaucoma.

- **Rule-3:** If the patient has poor vision and unable to deep things properly then the patient has diminished vision.

- **Rule-4:** If the patient has increased blood flow due to congestion and eye is red color then the patient has redness of eye.

The symptoms of fuzzy rules are extracted from the text.

Consider Rule-1, Rule-1:If the patient has difficulty in appreciating colors (0.9,0.2) , glaring (0.85, 0.2) and recognizing faces (0.8.0.15) then the patient has cataract

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.
```

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