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FuzzProGePeNuNet: Fuzzy Protein Genetic Petri Neural Net: A Knowledge Representation Technique and Application to Fuzzy Medical Deep Learning

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Abstract: Learning methods play major role in AI problem solving. Deep Learning techniques need to be studied for incomplete problems particularly for medical expert systems. Usually incomplete information is fuzzy rather than likelihood. Learning methods are necessary to solve expert problems. Learning fuzzy conditional inference with individual methods using fuzzy logic, Genetic algorithms, Petri net, neural net and not sufficient for large problems. In this paper FuzzProePeNuNet method is studded by combining fuzzy logic, Neural nets, Petri nets, Genetic algorithms and Protein knowledge base for large problems of Fuzzy Expert Systems. The fuzzy medical diagnose is given an example.

Keywords: Medical Diagnosis, Deep Learning, Knowledge Representation, Fuzzy Logic, Protien Databases, Genetic Algorithms, Petri Nets, Neural Networks

1. Introduction

The learning methods play is key factor for AI problem solving particularly incomplete information. There are some methods are discussed for learning fuzzy conditional propositions for expert systems [3, 4]. There is need of methods for better understanding for incomplete information. There are individual methods fuzzy logic, neural nets, Petri nets, genetic algorithms, protein knowledge base. The combination of these methods is required for complete representation of conditional propositions of incomplete information. Zadeh [11] proposed fuzzy logic to deal with incomplete information. The fuzzy logic based on belief rather than likely hood. Zadeh [12], Mandani [2] and TSK [5] are proposed fuzzy conditional inference for incomplete information. Learning expert systems with fuzzy logic is not sufficient and required another method like Neral nets, Petri nets, Genetic algorithms and Protein knowledge base for incomplete information. The combination of these methods will sole AI problems efficiently.

In the following, the combination of fuzzy logic, Genetic algorithms, Petri net, Neural net and Protein knowledge base learning methods are studied. FuzzProGePeNuNet method is proposed by combining fuzzy logic, Genetic algorithms, Petri net, Neural net and Protein knowledge base for expert systems problems. The medical diagnosis is given as example. It is necessary to study basics of fuzzy logic.

2. Fuzzy Logic

Zadeh [11] 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,

$$\text{young} = 1.0/10 + 1.0/20 + 0.5/30 + 0.1/40 + 0/50$$

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

For example, young may be defined as

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

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 $\rightarrow$ (x, y) is A x B

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

If x=y

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

Disjunction

x is A or y is B $\rightarrow$ (x, y) is A' x B'

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

If x=y

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

Implication

if x is A then y is B

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

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

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

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

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

3. Proposed Fuzzy Conditional Inference

The Zadeh [10] fuzzy inference for if president part then consequent part" is given by

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

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

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

The Mamdani [5] inference is given by

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

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

$B = \min(\mu_{A1}(x_1),\mu_{A2}(x_2),\ldots,\mu_{An}(x_n)),\mu_B(y)$

The fuzzy conditional inference for TSK method is 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

where $y = f(x_1,x_2,\ldots,x_n)$

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 [2]

$t(x+y) <= \max(t(x),t(y))$

$t(x*y) <= \min(t(x),t(y))$

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 V A_2, $A_1 * A_2$ is $A_1 \Lambda A_2$

The 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 is given by

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

using Mamdani fuzzy conditional inference,

$A \rightarrow B = \min\{A,B\}$

it 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

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

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

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

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

When consequent part is not known, the fuzzy conditional inference 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

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

4. Fuzzy Neural Network

The neural network concept is taken from the Biological activity of nervous system. The neurons passes information through other neurons. There are many models described for neural networks. The McCulloch-Pitts model [1] contributed in understanding neural network. Zadeh explain that activity of neuron is fuzzy process [14].

The McCulloch and Pitt's model consist of set of inputs, processing and output. It is shown in Figure 1.

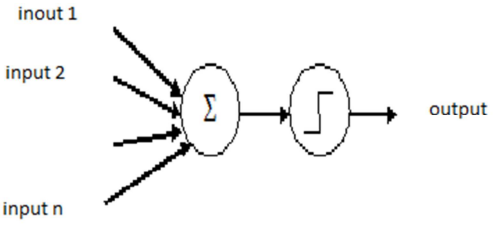


Figure 1. *McCulloch and Pitt's model.*

The fuzzy neuron model for Zadeh 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 y is B

is shown in Figure 2.

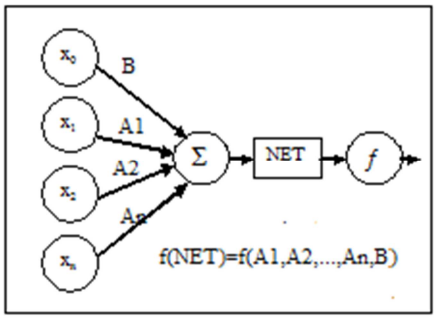


Figure 2. *Fuzzy neuron model.*

The fuzzy neural networks representation is unable to differentiate two fuzzy conditional inference

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

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

The combination of fuzzy neural networks and Petri nets representation will differentiate two fuzzy conditional inference.

5. Fuzzy Neural Petri Net

The Fuzzy Petri Neural net Representation will distinguish and/or containing in fuzzy rules. The Petri nets are Graphical representation to systems. The fuzzy Petri nets are Graphical representation to fuzzy rules of incomplete information. Several kinds of fuzzy Petri nets have been investigated for representation of rules in Knowledge Based Systems [3].

In the following, extended fundamental concept of fuzzy Petri nets to incorporate information.. The proposition of type "p=x is A"

Extended fuzzy Petri nets is defined by

EFPN=<P, D, T,μ>

Where P={p1,p2,…,pn} is set of positions

D={d1,d2,…,dn} set of propositions.

T={t1,t2,..,tn} set of transition.

μ is fuzziness of P.

The extended fuzzy Petri net (EFPN) is represented with three types.

Type 1: The fuzzy production rule "if p1 then p2"

Type 2: The fuzzy production rule "if p1 and p2 then p3"

Type 2: The fuzzy production rule "if p1 or p2 then p3

The EFNN model is s shown in Figure 1, Figure 2 and Figure 3

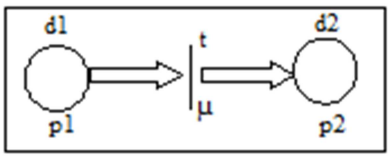


Figure 3. *Typ1 EFPN model.*

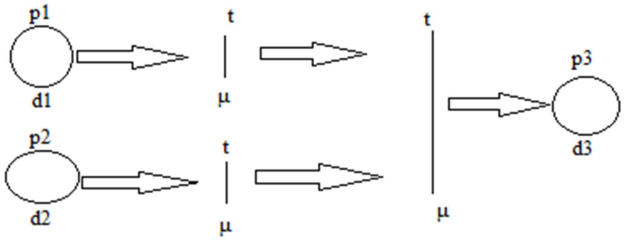


Figure 4. *Type2 EFPN model.*

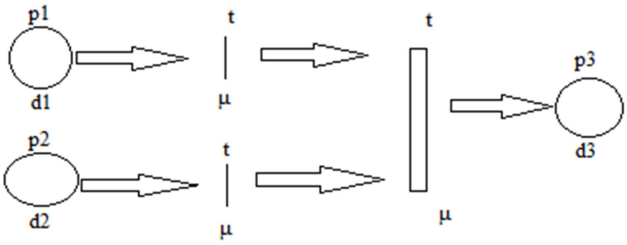


Figure 5. *Type3 EFPN model.*

The Fuzzy Petri Neural net is a Graphical representation of Fuzzy Petri net and Fuzzy Neural net.

Consider Mamdani fuzzy conditional inference

if d_1 and d_2 and ….. and d_{n-1} then d_n

$=\min(d_1, d_2, \ldots, d_{n-1}, d_n)$

The Graphical reorientation is shown in Figure 6.

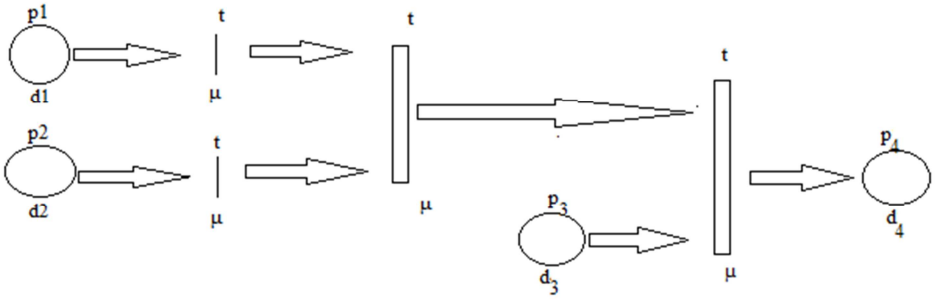


Figure 6. *Fuzzy Neural Petri Net.*

6. Fuzzy Genetic Petri Neural Net

Genetic Algorithms (GA) introduce by Darwin [3]. Genetic Algorithms are used to learn, match, search and optimize the problem [8]. There are four evaluation processes.

Selection
Reproduction
Mutation
Competition
Consider fuzzy proposition for pattern
if d_{i1} and d_{i2} and ….. and d_i n-1 then d_{in}
Consider fuzzy proposition for pattern of president part
P11: d_{11} and d_{12} and d_{13}
P21: d_{21} and d_{22} and d_{23}
P31: d_{31} and d_{32} and d_{33}
P41: d_{41} and d_{42} and d_{43}
Pattern#1 111 100
P11 P22
Pattern#2 111 111
P31 P42
The parent p11 and p22 match with crossover
The fuzzy conditional inference is given by
if x_{i1} is A_{i1} and x_{i2} is A_{i2}, and, ….. and x_{in-1} is A_{in-1} then x_{in} is A_{in}
p11 is precedent pat of fuzzy rule
d11 and d12 and d 13
i.e. 1 1 1
if the pattern to BE matched
111
Than fuzzy rule
If d11 and d12 and d13 then d1 will be fired
if the pattern to be matched
101
Than fuzzy rule will not be fired.
The Fuzzy Genetic Petri Neural net of fuzzy rule
if d_{i1} and d_{i2} and ….. and d_{in-1} then d_{in}
is given by

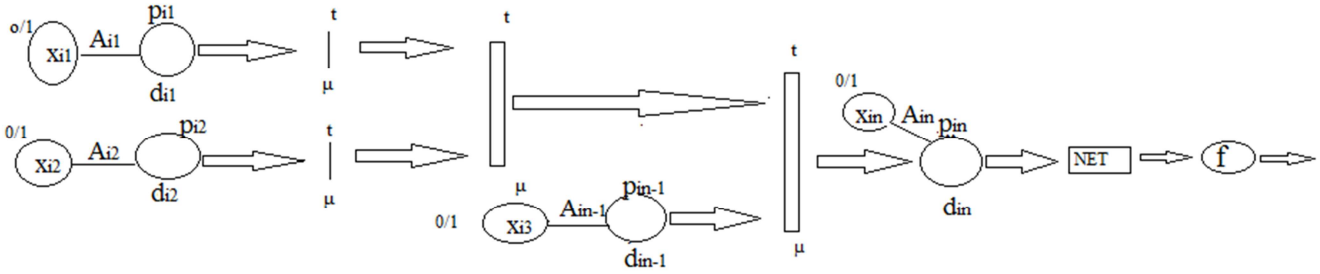


Figure 7. *Fuzzy Genetic Petri Neural Net.*

When the president part (111) is matched, than the inference is given by
f(net)= (1- min(d_{i1}, $d_{i2,}$….. d_{in-1} +d_{in})) Zadeh
f(net)= (d_{i1}, $d_{i2,}$….. d_{in-1}, d_{in}) Mamdani
when consequent part is not known, the fuzzy inference is given by
f(net)= (d_{i1},$d_{i2,}$….. d_{in-1})
The Graphical reorientation is shown in Figure 7.

7. Fuzzy Protein Genetic Petri Neural Net

The Chemistry of Proteins shall be used as learning method. The combination of Amino acids are the proteins.
The Graphical reorientation is shown in Figure 8.

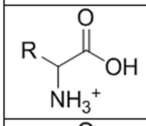
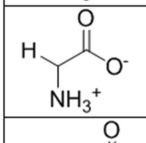
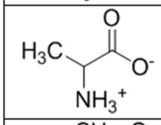
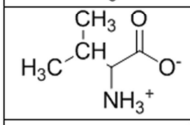
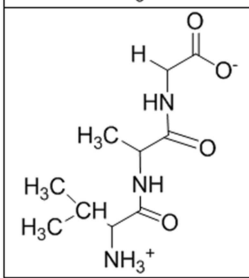
Structure	Name
	Amino acid
	Glycine(Gly)
	Alanine(Ala)
	Valine(Val)
	Gly-Ala-Val (Protein)

Figure 8. *Prottein Knowledge Base.*

The combination of Amino acids of Protein represents the knowledge base like if S1 and S2 and S3 then D"

If Gly and Ala and Val then Gly-Ala-Val

The Figure 9 will give one Protein knowledge base.

Consider the Protein knowledge base for medical eye diagnosis.

If

fever (0.7)

and

rash (0.6)

and

body ache (0.8)

Then

chickenpox (0.65).

The Graphical reorientation of net is shown in Figure 9.

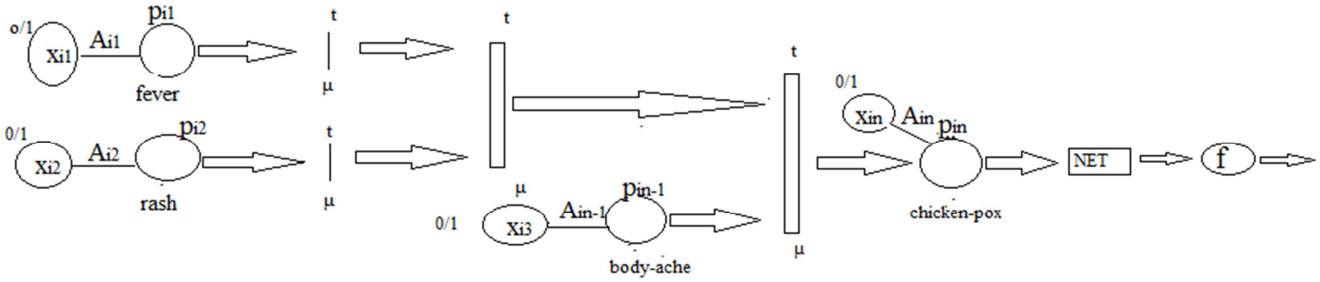


Figure 9. *Fuzzy Protein Genetic Petri Neural Net.*

If the fuzzy medical rule matches with pattern (1 1 1) than the above rule will be fired.

$$f(net) = \min(0.7,06,0.8), 0.65)=0.65$$

8. Conclusion

The Deep learning methods play major role in problem solving. The combination of learning will complete representation of problem particularly AI problem with incomplete information. Different methods fuzzy logic, neural nets, Petri nets, genetic algorithms and protein knowledge base are combined to learn the fuzzy conditional propositions of expert systems. The medical diagnosis is given as an example.

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