Neuro-Fuzzy Classification

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***Abstract*— The system proposed in this paper is the implementation of the neuro-fuzzy classification system. Feature wise degree of belonging of patterns to all the classes are obtained using fuzzification process. A fuzzification process will generate a membership matrix having elements equal to product of classes and features in the dataset. This matrx is then given as input to NN. Classification accuracy and KIA is used for performance measurement.The proposed system learns well even with lower percentage of training data that makes the system faster.**

***Keywords*: Neural Network, Fuzzy Logic, Classification, Fuzzification, Multi-Layer Perceptron, Defuzzification, KIA .**

INTRODUCTION

The neuro-fuzzy system is the classification of the hybrid systems. *Hybrid systems* combining fuzzy logic, neural networks, genetic algorithms, and expert systems are proving their effectiveness in a wide variety of real-world problems. This system includes the combination of neural networks and fuzzy logic system (FLS).

When performing the classification, uncertainties can arise at any stage resulting from imprecise/incomplete or vague input data , overlapping boundaries among classes and indefiniteness in defining features.Fuzzy systems are suitable for uncertain or approximate reasoning, especially for the system with a mathematical model that is difficult to derive. Fuzzy logic allows decision making with estimated values under incomplete or uncertain. Therefore, fuzzy logic system is used so that we get a scope to process such imprecise/incomplete data which gives accurate results.

Most important advantage of neural networks is their adaptivity. Neural networks can automatically adjust their weights to optimize their behaviour as pattern recognizers, decision makers, system controllers, predictors, etc. Adaptivity allows the neural network to perform well even when the environment or the system being controlled varies over time[2].

Fuzzy set theory is the extension of the classical set theory. We can explain the classical set theory as follows :

Classical set theory: A set is defined as a collection of similar elements. Consider a set A which can be defined to contain the following elements:

$A=\{a_1,a_2,a_3,.....,a_n\}$

If we define the belongingness of an element a_i to the above set A we have to define two conditions given below:

$A(x) \rightarrow [0,1]$

$A(x) = 1$, x is a member of A

$A(x) = 0$, x is not a member of A

This function is defined on a universal space X .It assumes

1) Value of 1 of those elements x which belong to set A.

2) Value of 0 of those elements x which do not belong to set A .

Fuzzy set theory : A fuzzy set theory uses the entire interval between 0 and 1.It has a capability to deal with approximate values rather than the precise values. The fuzzy set theory allows linguistic variables like “high”, ”medium ” and “low”.

To enable a system to deal with cognitive uncertainties in a manner more like humans, one may incorporate the concept of fuzzy logic into the neural networks[4].

The resulting *hybrid system* is called fuzzy neural, neural fuzzy, neuro-fuzzy or fuzzy-neuro network.

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I. PROPOSED SYSTEM

The main aim of the paper is to explore the degree of belongingness of each pattern to different classes.

The first step is to assign a memberships for each feature of a pattern to different classes forming a membership matrix. In a membership matrix number of columns and rows is equal to the number of classes and number of features respectively.

In the second step the membership matrix will be converted into a vector by cascading rows and columns , which will be the input to the NN thus number of input nodes to NN is equal to the product of feature and number of classes.The output of the NN is fuzzy in nature.

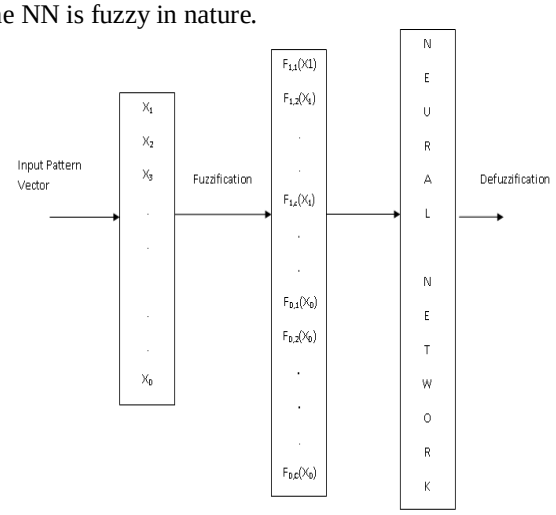

Fig 1 : Proposed Neuro-Fuzzy classification system.

The last step is defuzzification where MAX operation is used to defuzzify the output of NN.The patern is assigned to class 'c' with highest class membership value[1].

II. MODULES

A. *Fuzzification*

Fuzzification is the process of converting the crisp values into the fuzzy values. A membership function(MF) is required for fuzzification. Membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1.

There are various types of membership functions such as triangular membership function Gaussian membership function,∏-type MF[3]. The MF generates a feature-wise degree of belonging of a pattern to different classes by fuzzification.

The proposed system uses ∏-type of MF for fuzzification . This spline-based curve is so named because of its Π shape. The membership function is evaluated at the points determined by the vector x. The parameters *a* and *d* locate the "feet" of the curve, while *b*and *c* locate its "shoulders."

Syntax

Y=pimf(x, [a b c d])

Where,

a=Min value of the attribute

b=Mean(x) – [(Max(x)-Min(x)]/2

c= Mean(x) + [(Max(x)-Min(x)]/2

d=Max value of the attribute

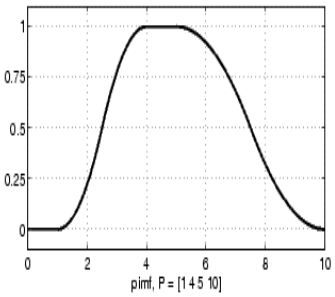

Fig 2: ∏ Type Membership function

The membership function is a product of smf (S-shaped membership function) and zmf(Z-shaped membership function) membership functions(http://www.mathworks.in) given by:

$$f(x;a,b,c,d)=$$

$$\begin{cases} 0, x \le a \\ 2\left(\frac{x-a}{b-a}\right)^2, a \le x \le \frac{a+b}{2} \\ 1-2\left(\frac{x-c}{d-c}\right)^2, c \le x \le \frac{c+d}{2} \\ 2\left(\frac{x-d}{d-c}\right)^2, \frac{c+d}{2} \le x \le d \\ 0, x \ge d \end{cases}$$

B. *Neural Network*

Tables Neural network is referred to a a network which consists of neurons and these neurons do some computation and processing and give the results so that the output can be obtained .They are of two types :

1) Biological neural network(BNN) : BNN are made up of real biological neurons that are connected or functionally related in a nervous system. In the field of neuroscience, they are often identified as groups of neurons that perform a specific physiological function in laboratory analysis.

2)Artificial Neural network(ANN) : ANN are composed of interconnecting artificial neurons (programming constructs that mimic the properties of biological neurons) for solving artificial intelligence problems without creating a model of a real system. . ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a **learning process**. Neural network algorithms abstract away the biological complexity by focusing on the most important information. The goal of artificial neural networks is good, or human-like, predictive ability.

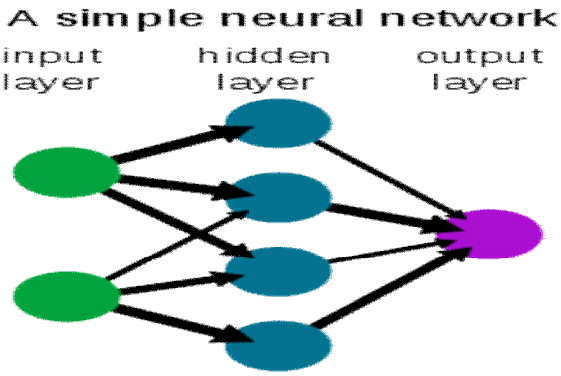

Fig 3: Neural Network

Where can neural network systems help?

- where we can't formulate an algorithmic solution.
- where we *can* get lots of examples of the behaviour we require.
- where we need to pick out the structure from existing data[5].

Proposed NN classification has been implemented using Feed Forward Multi Layer Perceptron (MLP) classifier having three layers:

1) Input layer : Input layer nodes can be calculated as the number of elements in the membership matrix.

2) Hidden layer: Hidden layer nodes can be calculated using the following formula:

$$\sqrt{number\ of\ inputs * number\ of\ classes}$$

3) Output layer : The number of nodes in the output layer are the number of classes.

C. *Defuzzification*

The task of Defuzzification is to find one single crisp value that summarises the fuzzy set that enters it from the inference block.The process of converting the fuzzy output is called defuzzification.The max will be calculated among the belongingness calculated to each of the class and accordingly the class will be allotted from the value which we assign to the class. The output of the process will finally be only one maximum value which will help us get the estimated value.

III. EXPERIMENTAL RESULTS AND ANALYSIS

For establishing the importance of the proposed model we considered fully labelled dataset(Pima-Indians-Diabetes).

- Title: "Pima Indians Diabetes"
- 768 instances.
- 8 attributes plus 1 binary class label.
- All attributes numeric values.
- Class is nominal,
  - 1:tested +ve for diabetes.
  - 0:tested –ve for diabetes.

Table 1. PIMA Indian Diabetes Dataset

No.	Attributes	Type
1.	Number of times pregnant	Numeric
2.	Plasma Glucose concentration	Numeric
3.	Diagnostic Blood Pressure	Numeric
4.	Tricep skin fold thickness	Numeric
5.	2 hour serum insulin	Numeric
6.	Body Mass Index	Numeric
7.	Diabetes pedigree function	Numeric
8.	Age	Numeric

Selection of training and test samples for all classes of fully labelled dataset have been made after dividing the dataset into two parts.1) Training data is taken for estimation of the parameters of the classifiers.2)Test data is taken for testing the performance.

Table 2. Classification of PIMA Indian Diabetes Dataset

No. of instances	Correctly classified	Incorrectly classified
768	456	312

IV. PERFORMANCE ANALYSIS

To evaluate the performance of the system we introduce few measures which can be mentioned by Kappa Index of Agreement (KIA).KIA value signifies better agreement of estimated data with true one. KIA can be calculated by using confusion matrix (CM).CM is a square matrix having rows and columns that represent number of sample patterns assigned to a particular class relative to a true class. This matrix produces statistical measures of class accuracy which includes overall classification accuracy and KIA.

Table 3. Performance Measures

Accuracy	KIA
59.375	0.59

V. CONCLUSION

We have proposed neuro-fuzzy model for classification and shown its effectiveness for classification of fully labelled dataset. The uses advantages of NN such as parallelism, robustness, and advantages of fuzzy system such as handling imprecise and uncertain data. The computational capacity of proposed model is high. And its learning ability with small % of training data makes it practically applicable for the problems with large number of classes and features

REFERENCES

[1] S. M Ashish Ghosh, B. Uma Shankar, Saroj K. Meher(2009):A novel approach to neuro-fuzzy classification.
[2] Robert Fuller(2001): Neuro-Fuzzy Methods for Modelling & Fault Diagnosis
[3] A Short Fuzzy Logic Tutorial(2010)
[4] RC Chakraborty(2010):Fuzzy Set Theory
[5] Prof. Leslie Smith Centre for Cognitive and Computational Neuroscience(2001): An Intoduction to Neural Network.