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A Fuzzy Based Classification – An Experimental Analysis

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Abstract: ***Soft Computing has become popular in developing systems that encloses human expertise. Imaging technologies and clinical cytology has improved in disease diagnosis. Exact detection is extremely important for proper treatment and cure of disease. Two soft computing technique Neural Network and Support Vector Machine are used for classification of Caridotocography data set. This paper clearly explains the advantages of hybrid technique, when Fuzzy is combined with Neural Network and Support Vector Machine it is clearly noticed that there is an increase in accuracy of classification rate.***

Keywords: Neural Network, SVM, Fuzzy Neural Network, Fuzzy SVM.

I. INTRODUCTION

Neural Networks(NN) are regression machines that associate i/ps with o/ps. The black box effect of Neural network contains an i/p of N values namely, $x_1,\ldots\ldots x_N$ which forms the characteristic vector **x** that suggests the class, group, pattern, and related output(o/p) vector **y** for the corresponding input(i/p) vector **x**. A trained NN is a computational machine that apply an algorithm which is specified by the i/p nodes, o/p nodes, hidden layers and the connecting lines between them, transforming node functions, and weight multipliers $w_1,\ldots\ldots w_R$, here, weights are denoted as vector **w**, then NN is given by

$$\mathbf{y} = f(\mathbf{x}\,;\,\mathbf{w}) \qquad (1)$$

Here **x** is any i/p vector and **y** is the resultant o/p vector that should match best a label $\mathbf{t}^{(q)}$ for some q.

One of the disadvantages of Neural Network is, learning of one weight tends to unlearn the other weights, so epochs are continued until the SSE is sufficiently small. Another problem is that the learned set of weights yields a local minimum, of which it has been shown that there are many [1] so that the learning is very likely to not be optimal. This reduces the accuracy when other feature vectors are put through the NN that have different noise values. Fusion of Fuzzy logic and neural network is very efficient.

SVM is a statistics based machine learning technique which is used for classification or regression analysis that aims to find the most optimal hyper plane. The important duty of SVM is to find an optimal solution and used as approximating functions and classifications at the current level of development. Decision-making process is quick and for this cause SVM can be used in real time applications.

Suppose [2] [3] [4]:

$$(u_1, v_1).....(u_n, v_n);\ u_i \in R^d;\ v_i \in (-1, 1) \qquad (2)$$

Sample components are obtained from two classes. The components of $x_i \in R^d$ from class A_1 then use $y_i = 1$, from class A_2 then use $y_i = -1$. Linearly separable training set contains elements of class A_1, and elements of class A_2 on both sides of hyper plane [2] [3] [4]

So ,we have

$$\langle u, \phi \rangle = c \qquad (3)$$

hyper plane is linearly separable, if

$$\langle u_i, \phi \rangle > c \quad \text{if } v_i = 1, \qquad (4)$$

$$\langle u_i, \phi \rangle < c \text{ , if } v_i = -1, \qquad (5)$$

Where $\phi \in R^d$ inner product between a and b is a unit vector and $c \in R$ ⟨a, b⟩. SVM examines the most optimal hyper plane continuously. Figure 1 show a SVM method. [2] [3] [4]

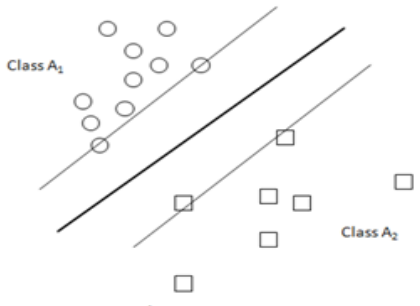

Fig. 1 SVM method

Figure 1 illustrates as, thin line means the boundaries or margins and thick line in the centre is called band limit. Support vectors are the points found on top of the margin. These support vectors are near to optimal hyper plane and separating hyper plane are far away from the sample points. [2] [3] [4] [5]

SVM has one detriment that is, its training stage is insubstantial to handle corrupt and existing outliers data[6].

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In reality, data set belongs to this category, to overcome this Fuzzy is being associated with SVM. In FSVM , fuzzy membership is associated to each data point [7]. The distance between fixed point and its fixed class centre is defined by membership function. However the class centre is very accessible to noise. Compare to SVM, FSVM performs better in confront to noises.

II. PREVIOUS WORK

In medical field, there are many studies related to hybrid technology in recent times. [8] Introduced a new training algorithm in FSVM, [9] created a FSVM with a new fuzzy membership function. A comparative study is made using Fuzzy Neural Network in diagnosing Thyroid and Breast cancer Disease. [11] gives A Novel Neuro- Fuzzy System for disease Classification [12] gives a comparative study of disease classification using Machine learning algorithms [13] A new method is developed for classification of Heart disease Prediction using ANFIS method.

III. FUZZY NEURAL NETWORK

Let F be a Fuzzy set represented as an ordered pair $(f, \mu_f(x))$, on a space X. where the membership function $\mu_f(x)$ is $\mu_f(x): 2^f \to [0,1]$ at given point $f \in X$. $\Re(X)$ represents the family of fuzzy sets in space X and each point of X is represented by f vector.

For fuzzy sets with membership function $\mu_f(x): 2^f \to [0,1]$ are defined by the following operations:

$$\otimes(\mu_1,\mu_2) = \min\binom{m}{j}(\mu_1,\mu_2) = \wedge\left(\mu_1\binom{m}{j}, \mu_2\binom{m}{j}\right);$$

$$\otimes(\mu_1,\mu_2) = \max\binom{m}{j}(\mu_1,\mu_2) = \vee\left(\mu_1\binom{m}{j}, \mu_2\binom{m}{j}\right);$$

where $\binom{m}{j}$ shows all j-sized subsets of m-sized set is always a subset of 2^f).

The primary operations are :

union: $P \cup Q,\ \mu_{P\cup Q}(x) = \oplus(\mu_P(x), \mu_Q(x))$

intersection: $P \cap Q, \mu_{P\cap Q}(x) = \otimes(\mu_P(x), \mu_Q(x))$

A fuzzy relation R on a Cartesian product $Z_1 \times Z_2 \times \ldots\ldots \times Z_n$ i.e. $R \in \Im(Z_1 \times Z_2 \times \ldots. \times Z_n)$ is defined by the membership function $\mu_R(x): 2^{(Z_1 \times Z_2 \times .. \times Z_i)} \to [0,1]$. The composition between the fuzzy set Z and the relation R is defined as

$$Z \circ R, \mu_{Z\circ R}(y) = \oplus(\mu(x) \otimes \mu_R(x,y)).$$

A fuzzy neural network can be defined as:

$$Z(i) = R_N(f_N(Z(i-1)), f_N(V(i))) \quad (1)$$

$$V(i) = R_L(f_N(Z(i), V(i), V(i-1)) \quad (2)$$

Where $Z(i)$, $Z(i-1)$ are fuzzy sets of neural network state defined in the space **Z** i.e.

$Z(i)$, $Z(i-1) \in \Im(X)$. $V(i) \in \Im(X)$ are the weights on the **i**-th learning phase. $\mathbf{R_N}$ is a fuzzy relation describing the activation function and $\mathbf{R_L}$ is a fuzzy relation describing the learning algorithm.

IV. FUZZY SUPPORT VECTOR MACHINE (FSVM)

Available information's in the real world problems are very often insufficient, vague and inaccurate. One of the important tool to handle these data is Fuzzy regression analysis, this is effectively applied in various real time problems. In this section, fuzzy hypothesis is joined with SVM regression method. The parameters which are fuzzified in SVM regression will make it more flexible. The given o/p data, denoted by $\tilde{P}_i = (p_i, c_i)$, are symmetric triangular fuzzy numbers, where p_i is a center and c_i is a width. The membership function of $\tilde{P}_i$ is given by

$$\mu_{\tilde{P}_i}(p) = 1 - \frac{|p - p_i|}{c_i} \quad (3)$$

For handling the fuzzified training data, bias term and weight of the components that are used in SVM regression model are also set as fuzzy numbers. Let Fuzzy weight vector be V ={v, e} and fuzzy bias term

B = {b, d}, V ={v, e} is the fuzzy weight vector, here each components within it are fuzzy numbers. Let this be denoted as $v = [v_1, \ldots\ldots, v_n]^t$, and $e = [e_1, \ldots\ldots, e_n]^t$, This means "approximation **v**" described by the center **v** and the width **e.** Likewise, B={b, d} is the fuzzy bias term, which means "approximation **b**", described by the center **b** and the width **d**. Fuzzy parameters used here are triangular membership function.

$$P = V_1\Psi(x)_1 + \ldots\ldots\ldots V_n\Psi(x)_n + B = V \cdot \Psi(x) + B, \quad (4)$$

membership function is defined as follows [10]:

$$\mu_P(y) = \begin{cases} 1 - \dfrac{\left| p - (w^t \Psi(x) + b) \right|}{e^t \left| \Psi(x) \right| + d}, x \neq 0 \\ 1 \qquad\qquad x = 0, y = 0 \\ 0 \qquad\qquad x = 0, y \neq 0 \end{cases} \tag{5}$$

where $\left|\Psi(x)\right| = \left[\left|\Psi(x)_1\right|,.....,\left|\Psi(x)_n\right|\right]^t$, n is the dimension of feature space, and $\mu_P(p) = 0$ when $e^t \left|\Psi(x)\right| + d \leq \left| p - (v^t \Psi(x) + b \right|$.

V. RESULTS AND DISCUSSIONS

Here, fuzzy set theory concepts are integrated into Neural Network and SVM. A fuzzy neural network gains implicit knowledge from experts which can easily included in fuzzy neural network, and this knowledge helps to learn from training samples which in turn enhances the accuracy of the o/p. The fuzzy neural network learns by training set which has an i/p values $X \in [0,1]$ and targets $t \in [0,1]$ with the primary weights $W \in [0,1]$. Alternatively, SVM regression model must recognize the parameters, that is components of weight vector and biased term that are fuzzy numbers. In addition to it the desired o/ps are also fuzzy number in the training sample. When the concept of fuzzy set theory is incorporated into SVM, it safeguards the goodness of SVM. Finally, the fuzzy Support Vector Machine and Fuzzy Neural Network may be very useful in classifying biological data. The data set cardiotocographic consists of 2126 instances with 23attributes is taken from UCI machine learning repository.

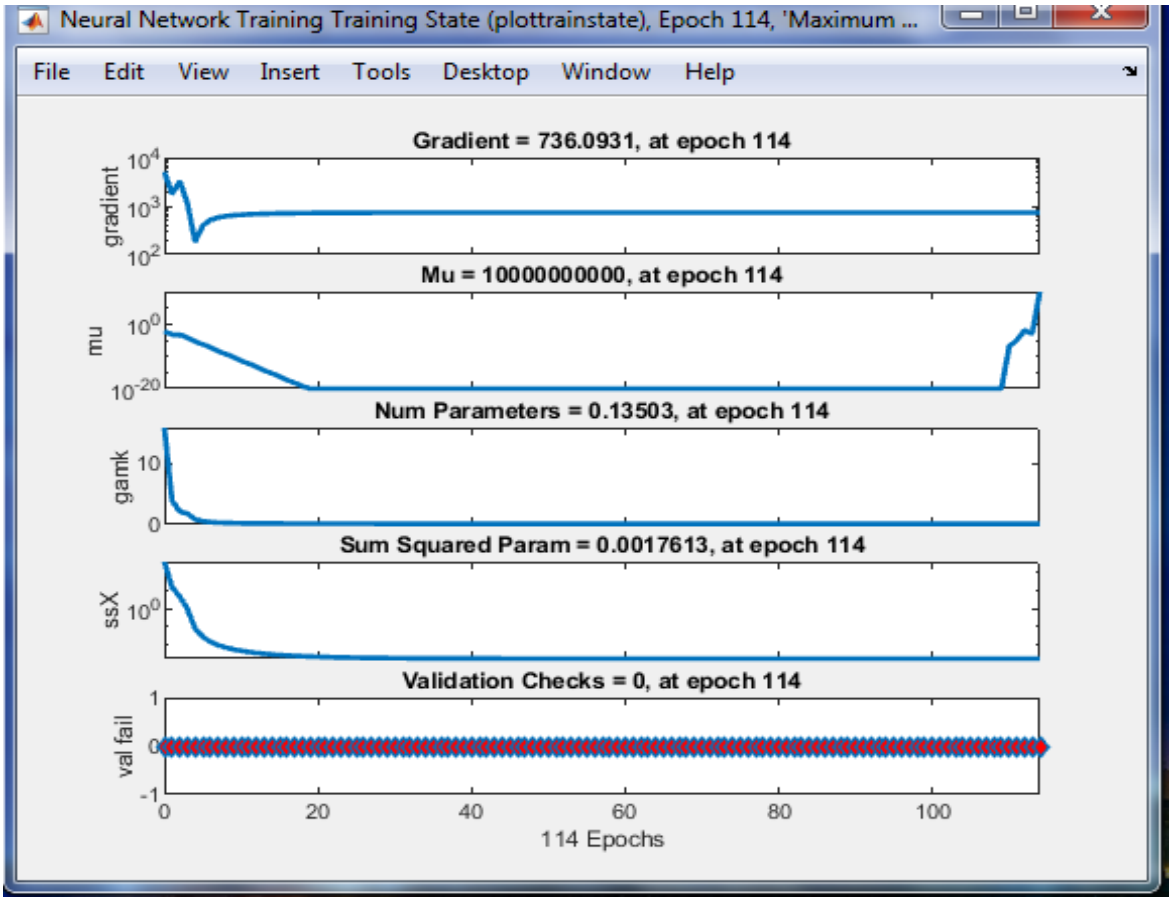

Fig. 2 Neural Network Training State

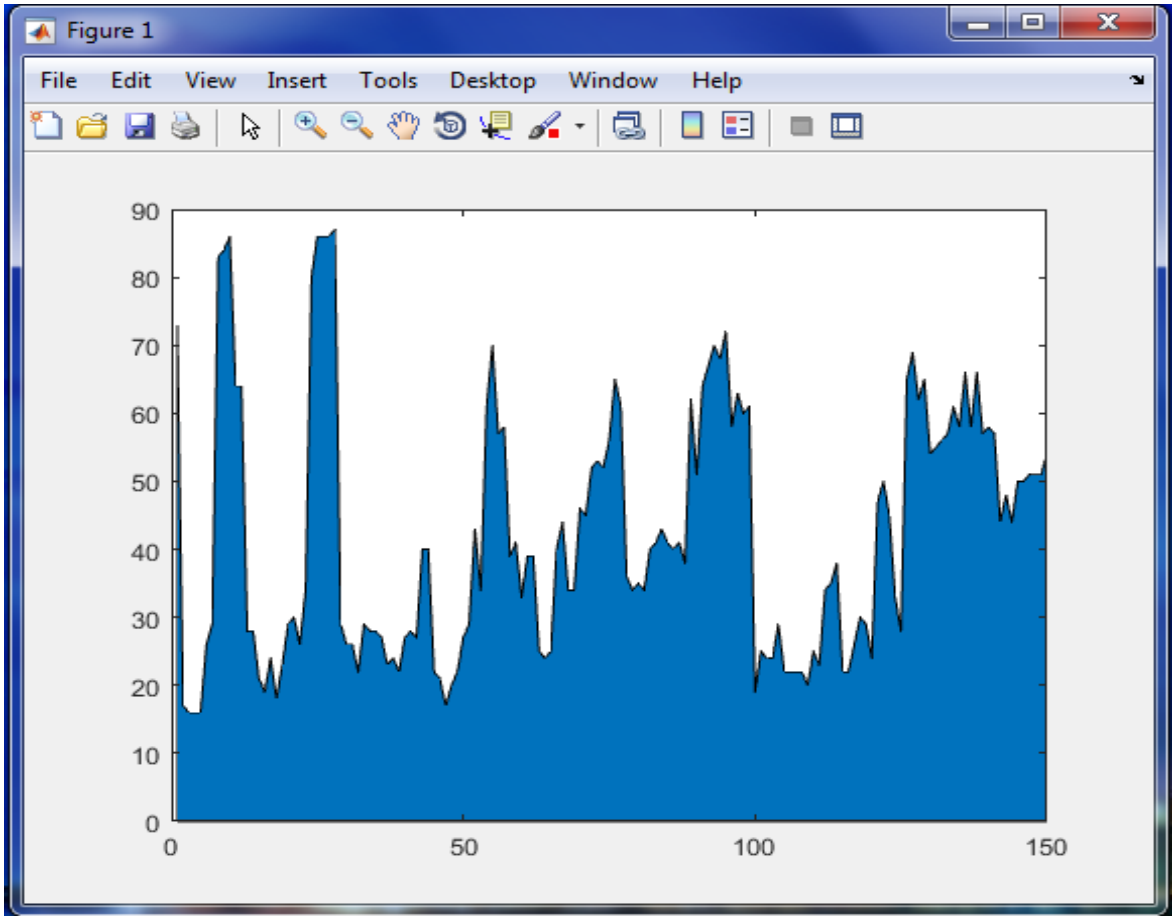

Fig. 3 SVM model

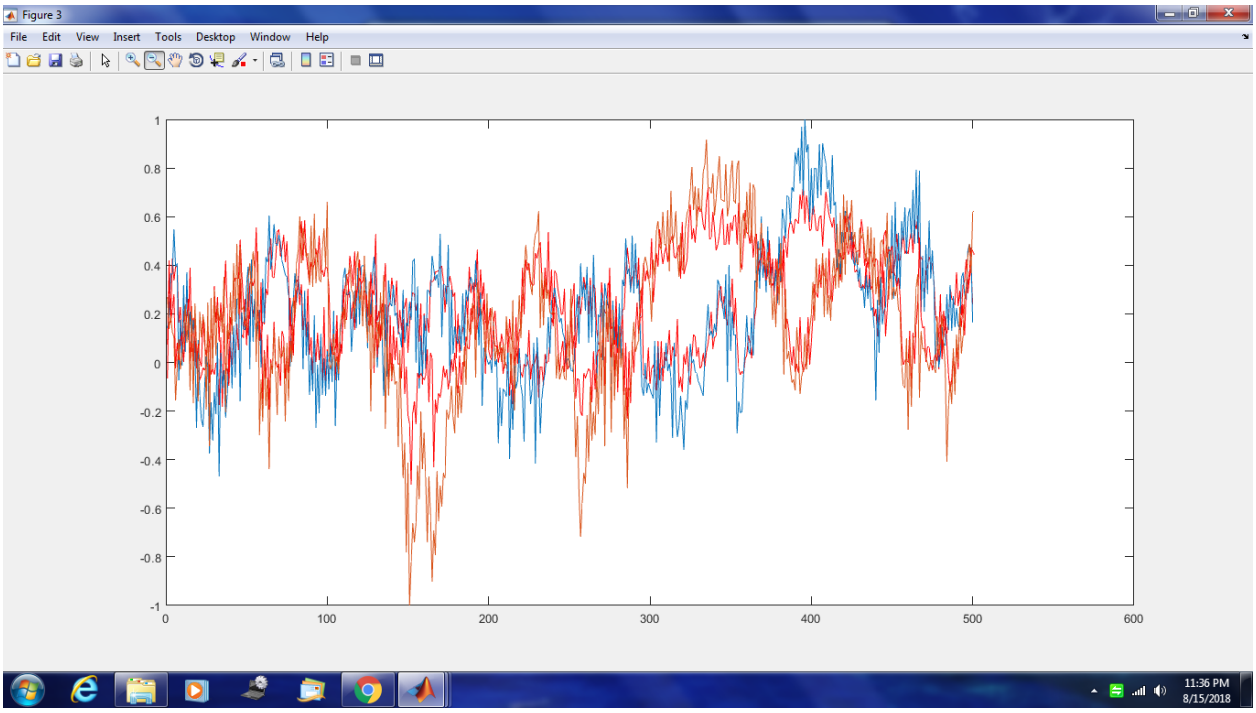

Fig. 4 FNN

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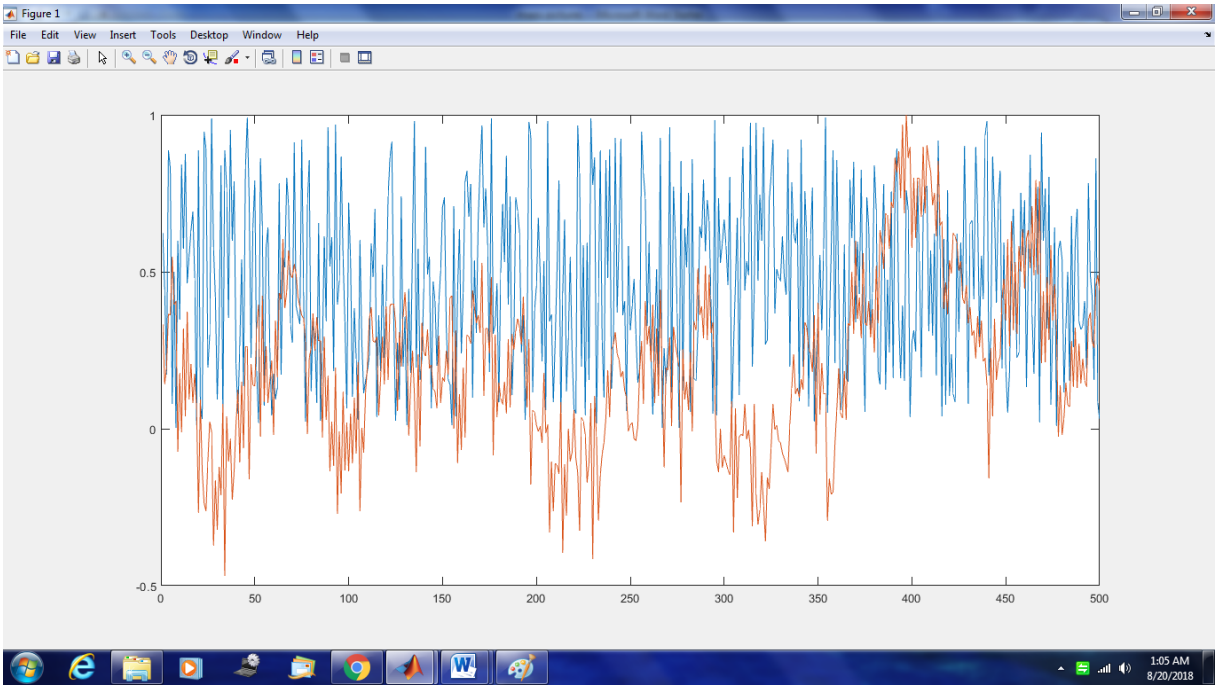

Fig. 5 FSVM

VI. CONCLUSION

This paper shows a comparative study of Fuzzy Neural Network and Fuzzy SVM technique for classification of cardiotocographic data set helping patients to predict and reliable diagnosis at the earliest. Fuzzy Neural Network has been used for classification which has both the advantages of fuzzy logic and neural network. In this, the data set shows a classification rate of 77% for Neural Network and 75 % for SVM. Investigational study of fuzzy neural network shows significantly improved classification of 96% and also speed over back propagation algorithm. So this neural network is very appropriate to be applied in training of large-sized neural networks. Similarly Fuzzy SVM shows an accuracy of 94% of classification compared to regression SVM, which are very satisfying. Therefore the results clearly show that hybrid technology has high accuracy and speed in classifying biological data set.

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