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A STEP FORWARD: FROM FUZZY TO NEURO-FUZZY

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ABSTRACT
The main objective of this paper is to discuss two soft computing techniques. We cannot directly compare the two techniques but we can find one which best suits our experiment for classification. The two techniques are fuzzy logic and neural networks.

KEYWORDS
classification model, soft computing techniques, fuzzy logic, artificial neural networks.

INTRODUCTION
Soft computing is a field of computer science that helps in modelling and analysing imprecise data and hence deals with uncertainity and imprecision. It is very closely related to biological processes and reasoning. Some of the soft computing techniques are fuzzy logic, neural networks, evolutionary algorithms, hybrid algorithms.

In this paper, two of these soft computing techniques will be discussed in relation to the experiments performed in Matlab7.0 using FIS(fuzzy inference system) and ANFIS(Adaptive networks based on fuzzy inference system). Datasets from UCI repository have been used.

The question that now comes to our mind is that, what exactly is classification? Since, soft computing techniques apply to machine learning, classification is an algorithmic procedure for assigning a given piece of input data(instance) into one of a given number of categories(classes). It is widely used in pattern recognition. Classification is supervised learning, meaning that it learns to classify new instances based on learning from a training set of instances that have been properly labelled with correct classes. The most widely used classifiers are maximum entropy classifiers, Naive Bayes classifiers, support vector machines(SVM), decision trees, perceptrons, neural networks, fuzzy classifiers, nearest neighbour classifiers and radial basis function classifiers.

FUZZY INFERENCE SYSTEM
Fuzzy logic is a multi-valued logic derived from fuzzy set theory that deals with reasoning which is uncertain(approximate). It was a consequence of fuzzy set theory by Lofti Zadeh[10]. It has been widely used in the field of artificial intelligence and machine learning. The real world data is crisp in nature, that is, it can take values, 0 or 1. The membership function maps the input data into fuzzy sets. This process is called fuzzification. The membership functions are linguistic variables. The fuzzy inference process requires membership values to be combined with logical connectors and finally making if-then rules for classification.

The decision to be made requires construction of rules of the form:

IF input is 'X', THEN output is 'Y',

Where 'input' is the attribute for 'X' membership function and 'output' is the class and 'Y' is the decision finally made. Thus, input is the antecedent part and output forms the consequent part. For, consequent to be true, the antecedent must be true. The output that we get is defuzzified(converted back into crisp data) for the outside environment.

The Matlab7.0 provides with two FIS toolboxes: mamdani[5] type and sugeno[8] type. These two differ in their output. The former expects the output membership functions to be fuzzy sets, whereas the latter gives a linear or constant membership function as output. Mamdani is easy to work with and with fuzzy logic and its FIS, mamdani has been used.

ARTIFICIAL NEURAL NETWORKS
It is usually called Neural Networks[4]. It is a mathematical or computational model inspired by the biological neural networks. It is similar in structure and functionalities. The network consists of an interconnected group of artificial neurons processing the information to compute the result. It is an adaptive system that changes its structure based on internal or external information that flows through it during the learning phase.

Classification[1] is possible because they model complex relationships between inputs and outputs by finding patterns. Artificial neurons[4] were first proposed by Warren McCulloch in 1943.

ANFIS is a 5 layer feedforward adaptive network having square and circle nodes. The square nodes are adaptive because they have parameters while the circle nodes have none and are fixed. We get the desired output by updating the parameters according to the given training data and a learning procedure(backpropagation or hybrid).

PROBLEM STATEMENT AND RELATED WORKS
Since we need to deal with imprecise data, we use fuzzy inference system to implement a classification model and to make it better with adaptability, we use ANFIS.

The classification model categorises the input into any of the output classes. It has been applied to real world data like Lenses dataset that helps the doctor to find which type of lenses suit the patient. Iris dataset has been used with both FIS and ANFIS.

Related works[2] have been carried out by many researchers.

WORKING DATASETS
IRIS DATASET
It has 150 instances, 4 attributes and 3 classes.

Attributes are-

- Sepal length(SL)(cms)
- Sepal width(SW)(cms)

- Petal length(PL)(cms)
- Petal width(PW)(cms)

Classes are-

- Setosa
- Versicolour
- Virginica

We have the following information:

TABLE1. ATTRIBUTE INFORMATION FOR IRIS DATASET

Attribute	Minimum value	Maximum value
Sepal Length	4.3	7.9
Sepal Width	2.0	4.4
Petal Length	1.0	6.9
Petal Width	0.1	2.5

With the FIS system, this dataset has been implemented using varying labels-3,5,7,9,11 and 13. The following table shows the membership functions for two attributes:

TABLE 2. VARIABLE LABELS FOR ATTRIBUTES OF IRIS DATASET

Label	SL	SW
3	L M H	L M H
5	VL L M H VH	VL L M H VH
7	VL ML L M H MH VH	VL ML L M H MH VH
9	PL VL ML L M H MH VH PH	PL VL ML L M H MH VH PH
11	ZL VL PL ML L M H MH PH VH ZH	ZL VL PL ML L M H MH PH VH ZH
13	ZL NL PL VL ML L M H MH VH PH NH ZH	ZL NL PL VL ML L M H MH VH PH NH ZH

Other two attributes, petal length and petal width have the same labels. The labels, 'L' for "Low', 'H' for 'High', 'M' for 'Medium', 'V' for 'Very', 'P' for 'Positive', 'Z' for 'Zero' and 'N' for 'Negative'.

Triangular membership functions have been used. 90 of 150 instances form the training dataset and the rest 60 are the testing dataset. For, FIS in Matlab7.0, 3 labels have been used and 16 rules were constructed.

Another way for classification is done by degree of weighted convenience[3]. But this method is possible only when numeric data is present.

The classification then has been improved by using ANFIS.

LENSES DATASET

It has 24 instances, 4 attributes and 3 classes.

Attribute Information-

- age of the patient(AP): (1) young, (2) pre-presbyopic, (3) presbyopic
- spectacle prescription(SP): (1) myope, (2) hypermetrope
- astigmatic(AS): (1) no, (2) yes
- tear production rate(TP): (1) reduced, (2) normal

Classes-

- the patient should be fitted with hard contact lenses(HR),
- the patient should be fitted with soft contact lenses(S),
- the patient should not be fitted with contact lenses(N).

The training dataset has 14 instances and the testing dataset has 10 instances. 14 rules have been formed. The classification model for this dataset has been implemented using both FIS and ANFIS.

TABLE 3: LABELS FOR LENSES DATASET

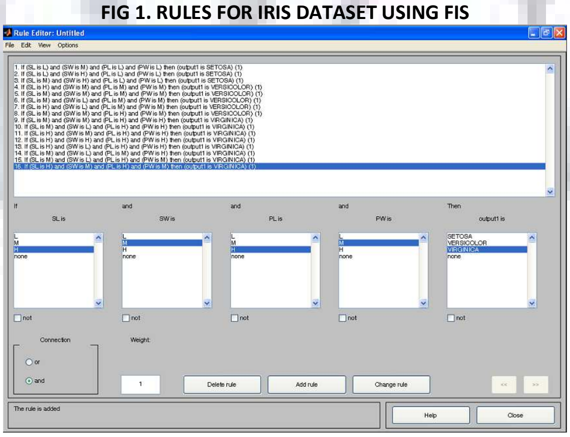
Attribute	Membership Functions(Labels)		
AP	L	M	H
SP	L		H
AS	L		H
TP	L		H

EXAMPLE

IRIS DATASET

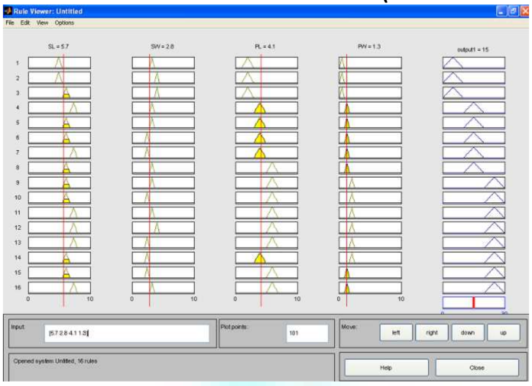
Using the Fis system of the MATLAB7.0, we get the following rules:

FIG 1. RULES FOR IRIS DATASET USING FIS



We can test the instances using the following snapshot:

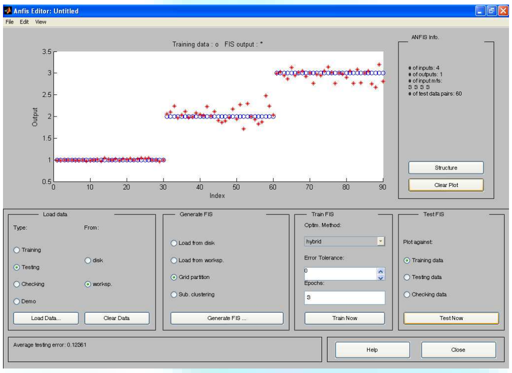
FIG 2: TESTING INSTANCE 100 OF IRIS DATASET(CLASS VERSICOLOR)



Using the method of weighted convenience[1] we find the weight of every definitive rule formed and then classify the input.

Incase of ANFIS, we load the training and the testing dataset and then compare the results of FIS and the generated output of ANFIS using the plots:

FIG 3: TESTING VS TRAINING



LENSES DATASET

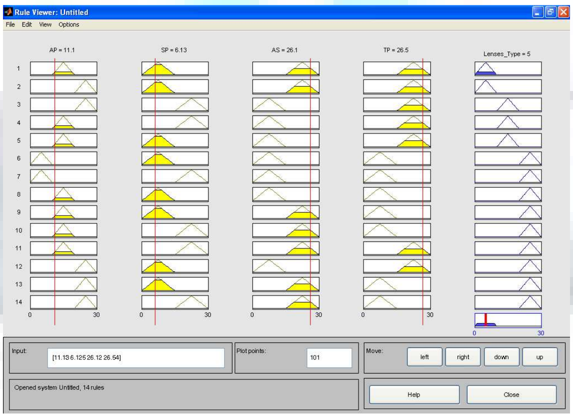
We can form the following rules:

TABLE4. RULES FOR LENSES DATASET

HR	S	N
{{M,L,H,H},1}	{{M,L,L,H},2}	{{L,L,L,L},3}
{{H,L,H,H},1}	{{M,H,L,H},2}	{{L,H,L,L},3}
	{{H,H,L,H},2}	{{M,L,L,L},3}
		{{M,L,H,L},3}
		{{M,H,H,L},3}
		{{M,H,H,H},3}
		{{H,L,L,H},3}
		{{H,L,H,L},3}
		{{H,H,H,L},3}

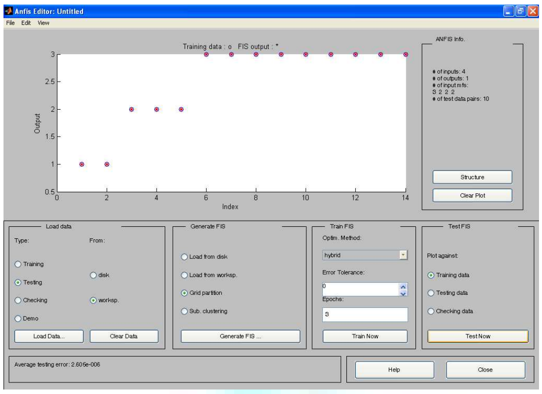
We use the mamdani FIS and for ANFIS we have the sugeno FIS.

FIG 4: TESTING VS TRAINING



We can implement this dataset using ANFIS and check the output of class 1:

FIG 5: TESTING VS TRAINING



CONCLUSION

From the above performed experiments, we can conclude that although fuzzy logic is a very strong concept for modelling a classification model, it can only be used better if we have numeric data. But for non numeric data like lenses data, 2 instances were not correctly classified and also we cannot increase the number of labels and perform the degree of weighted convenience method. Using the ANFIS toolbox of Matlab7.0, we can make a better classifier as the model becomes adaptive to the environmental parameters. The result using ANFIS is better than FIS. Thus, including neural networks, the model becomes better and more effective. Also, the epochs for training should be chosen according to the data because overtraining often increases the error rather than reducing it.

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