Annals of Microbiology and Infectious Diseases
Volume 3, Issue 3, 2020, PP 29-33
ISSN 2637-5346

Classification of Medical Datasets using a Modified Adaptive Fuzzy Inference System

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ABSTRACT

Recently, several approaches have been studied to address the classification problems that have faced researchers over the past years. In this paper, the Adaptive Neural Fuzzy Inference System (ANFIS) is modified to classify the data using the particle swarming optimization (PSO) algorithm, the optimization process passes through two basic stages, the first stage uses the (PSO) algorithm to adjust the parameters of the fuzzy inference system model. In the second stage, a fuzzy inference system model is made according to ideal standards obtained from the (PSO) algorithm. We obtained better results through the proposed PSO-AFIS algorithm to achieve effective results compared to the standard adaptive algorithm. (ANFIS)

Keywords:*Adaptive Neuro Fuzzy Inference System (ANFIS); Particle Swarm Optimization (PSO) algorithm; Classification*

INTRODUCTION

Using modern methods to conduct classification of a group of data, we expect to obtain better results according to the available classifiers, and the examiner may not be able to use the classification in which he is not an expert, for example training the accuracy of parameters, and to obtain more accurate parameters, this is limited to using the expertise of the expert,Thus there can be no complete realization that it is the best possible[2 ,1]

The artificial neural network, the fuzzy system and are the focus of researchers' attention, so the researchers worked to combine these two systems together to get one system called the Adaptive Nervous System for Fuzzy Inference (ANFIS). They obtained a system with distinctive characteristics that helped overcome many of the problems (flexibility, speed, adaptability) that existed in both systems, so they got better performance than the expert fog systems and the artificial neural network.[3, 4]

The focus of the researchers in (ANFIS) was to find A model capable of obtaining more accurate results through parameter training[5]. In spite of this improvement, sometimes we find there is a weak ability to find the best efficiency Therefore, the swarm algorithms were used to make the system more efficient and accurate [6, 7].

The remnant of this paper is organized as follows.The PSO in Section 2. ANFIS is presented in Section 3. The Proposed PSO-AFIS algorithm is explained in Section 4. Section 5 covers the 5.Experimental Results. Finally, in section 6, the conclusions are mentioned.

PARTICLE SWARM OPTIMIZATION (PSO)

The PSO algorithm is a simulation of the behavior of groups of fish, insects and birds that fly in search of food through co-operation between group members, which was applied by Kennedy and Eberhardt 1995[8]. The algorithm relies on a set of random values called particles. Each particle in the PSO is linked to the velocity and location of the object and can be modified. These particles move within the search space and the original algorithm of PSO is described as follows[9, 10]:

$$v_{id} = v_{id} + c1\,\mathrm{rand}\,()\,(p_{id} - x_{id}) + c2\,\mathrm{rand}\,()(p_{gd} - x_{id}) \ldots (1)$$

$$x_{id} = x_{id} + v_{id} \ldots (2)$$

where c_1 and c_2 are positive constants in Eq.(1), and rand() and rand() are two random functions (random numbers) in the range [0,1],$X_i = (x_{i1}, x_{i2}, \ldots, x_{iD})$ represents the ith particle ,$P_i = (p_{i1}, p_{i2}, \ldots, p_{iD})$ represents the best previous position (the position giving the best fitness value) of the ith particle.

The symbol g in Eq.(1) represents the index of the best particle among all the particles in the population, $V_i = (v_{i1}, v_{i2}, \ldots, v_{iD})$ represents the rate of the position change(velocity) for particle i.

The Eq. (1) explains how the velocity of the particles (birds, fish, insects, etc.) is updated dynamically and that Eq.(2) describes how the site is updated for particles [11, 12]

ADAPTIVE NEURAL FUZZY INFERENCE SYSTEM (ANFIS)

Neural networks play an essential role when there is a sufficient number of inputs to conduct the training without prior knowledge of the nature of the entered data. As for fuzzy systems, there must be a full knowledge of the rules on which the problem is classified as it is represented by (IF-THEN) rules, which is the phrase for conditional statements expressed in the formula[13]:

IF X then Y, where both X and Y are fuzzy sets.

The idea of ANFIS aims to integrate a neural network system with an adaptive fuzzy logic system,that is, we get a mysterious nervous system that combines the features of the neural network and the mysterious inference of the Sugenotype, which was developed in the early 1990s by Jean in order to reap the benefits available in both systems at the same time[14, 15].

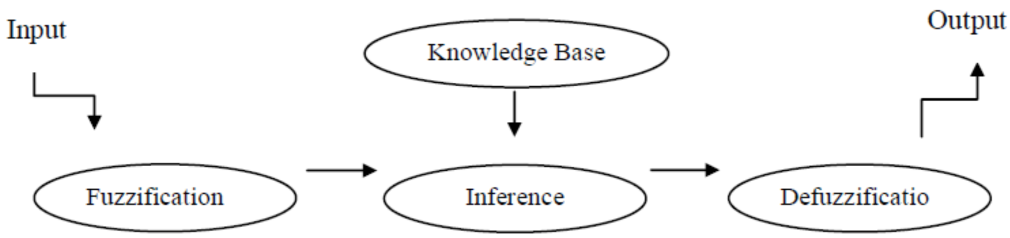

Figure1.*The adaptation ANFIS to conduct learning and training*

If we conduct the fuzzing on the obvious input variables, then can apply the rules to them, and then remove the fuzzing with an inverse process to get real values[16].

The general structure of ANFIS for Sugeno model (first rank) can be defined as :

$$\text{IF } X_n \text{ is } A_i \text{ AND } Y_n \text{ is } B_i \text{ THEN } F = P_i X_1 + q_i X_n + r_i \quad \ldots (3)$$

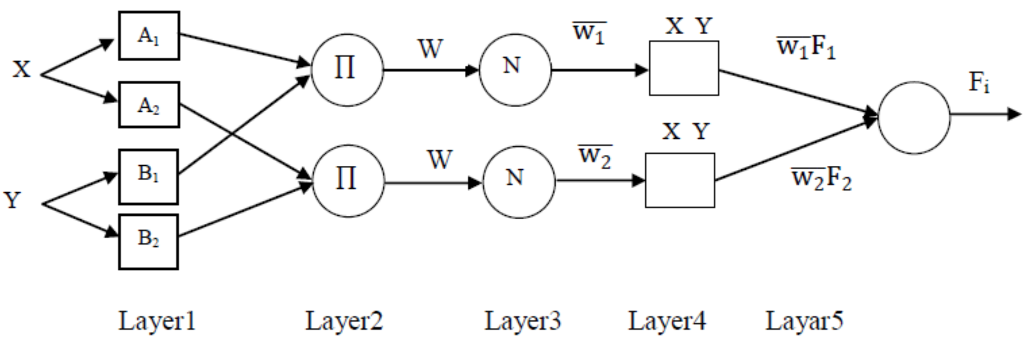

Figure2.*The general structure of ANFIS*

- The first layer represents the process of fuzzing and determining the degree of membership for each entry. Usually, the organic grades within the first cycle are not appropriate and the reason for this is the random representation of these membership functions until the adjustment process is carried out, where these degrees are represented as follows[17]:

$$Oi1 = \mu A_i(X), \mu B_i(Y) \ldots (4)$$

- The second layer is the nodes that are not adaptive as the rules are applied to them:

$$Oi2 = \mu A_i(X_1) * \mu B_i(Y_n) \ldots (5)$$

- The third layer, the excitation force on neurons is calculated through the normalization process and is as follows[18]:

$$\overline{w_i} = \frac{w_i}{\sum w_i} \ldots (6)$$

This represents the output for the third layer and is symbolized by O_i^3.

- The fourth layer in this layer, the fuzzing process is reversed, meaning results are easy to read and understandWhere this process takes place as follows[19]:

$$O_i^4 = Y_i = \overline{w_i}F_i = \overline{w_i}(p_iX_1 + q_iX_2 + r_i) \ldots (7)$$

Where p_i, q_i, and r_i are the parameters of the model in a given order because they deal with the part that was then in the ambiguity area.

- The fifth layer This layer represents the final output of the system (ANFIS) as it consists of one node and represents the sum of the outputs of the nodes in the previous layers. The calculation is as follows:

$$O_i^5 = \sum_i y_i = \sum_i \overline{w_i}F_i = \sum_i \overline{w_i}(p_iX_1 + q_iX_2 + r_i) \ldots (8)$$

The learning algorithm in ANFIS uses a hybrid learning, as it combines the two methods of rapid regression and the method of estimating the least squares, and the training in each epoch goes through two phases: the forward direction phase and the back direction phase[19, 20]

The Proposed Algorithm PSO-AFIS

The proposed PSO-AFIS method consisted of two basic stages. In the first stage, a particle swarming optimization (PSO) algorithm is used to determine optimal parameters of the fuzzy inference system (FIS) in the Sojeno model. In the second stage, the FIS model is constructed according to the optimal parameters found by the PSO algorithm, where these optimal parameters are entered into the inference system and the ideal model is formed according to the data set used. The proposed PSO-AFIS method was tested on three different data sets and classified according to the mean square error (MSE) criteria.

Algorithm: Steps of the proposed PSO-AFIS algorithm.
Step1: Set the initial parameters of FIS and PSO algorithm. **Step2:**Create FIS of Sugeno model using optional parameters.
Step 3: Set the initial velocities and positions using, Eq. (1) and Eq. (2)
Step 4: Evaluate dataset by fitness function.
Step 5: Set iteration i from 1 tomax of iteration.
Step 6: Update velocityand position according to Eq. (1) and Eq. (2).
Step 7: When i≤ Max_iteration stop satisfied and return get the best parameters of FS. **Step 8:**Insertion of the optimal parameters of FIS into the Sugeno model.
Step 9: Calculate the MSE criterion for the proposed CPSO-AFIS method.

Experimental Results

The proposed PSO-AFIS algorithm is evaluated by comparing the results with the ANFIS model. The purpose of the comparison is to verify the effectiveness of the proposed PSO-AFIS algorithm for solving classification problems. We selected two sets of medical data represented by Heart and Thalassemia.Table 1 shows the comprehensive description of data sets.

Table1.*Description of the datasets*

Dataset	# Samples	# Features
Data1=Heart	1199	2
Data2=Thalassemia	150	10

Table2. *Comparison of the MSE between ANFIS and PSO-AFIS for training datasets*

Datasets	Methods	Training (MSE)
Data1	PSO-AFIS	**1.0550e-01**
	ANFIS	1.1137e-01
Data2	PSO-AFIS	**7.3035e-03**
	ANFIS	8.0421e-03

Table3. *Comparison of the MSE between ANFIS and PSO-AFIS for testing datasets*

Datasets	Methods	Testing (MSE)
Data1	PSO-AFIS	**1.1907e-01**
	ANFIS	1.2506e-01
Data2	PSO-AFIS	**7.9334e-03**
	ANFIS	8.4812e-03

The training and testing dataset for the PSO-AFIS algorithm, achieved the best MSE, for instance, in Data1, the MSE of the testing dataset is 1.1907e-01by the FMI-BPSO which is lower than 1.2506e-01 by ANFIS, as shown in Table 3.

An implementation comparison shows that, compared to the ANFIS model, the proposed algorithm, PSO-AFIS, has a clear advantage in terms of MSE for classification and that ANFIS is worse than CPSO-AFIS through two sets of data.

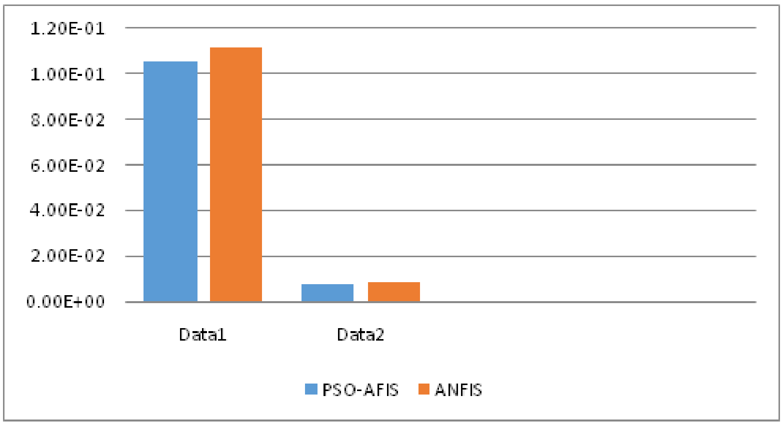

Figure3.*Represents the comparison of MSE between Training CPSO-AFIS & ANFIS in Data1 and Data2*

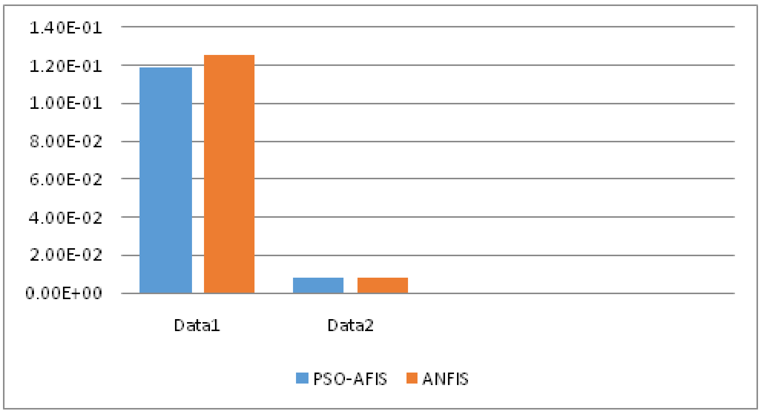

Figure4. *Represents the comparison of MSE between Testing CPSO-AFIS & ANFIS in Data1 and Data2*

Conclusion

In this paper, the PSO-AFIS method is proposed as a particleSwarm optimization (PSO) and fuzzy inference system (FIS) of the Sugeno model type to improve the classification performance of two data sets in Table 2. The proposed PSO-AFIS method was compared with the results of ANFIS for training, and through Table 3, the test results of the proposed CPSO-AFIS algorithm were compared with the results of ANFIS and Figures (3-4). The experimental results from the data sets in Tables 2 and 3 indicate that the proposed CPSO-AFIS method has Rating performance higher than ANFIS byMSE criteria.

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Citation: *Fatima Hashim Najim, Omar Saber Qasim, "Classification of Medical Datasets using a Modified Adaptive Fuzzy Inference System", Annals of Microbiology and Infectious Diseases 2020, 3(3), pp. 29-33.*