EEG Signals Classification Using a Hybrid Structure of ANN and PSO

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***Abstract*—In this study, Artificial Neural Networks and Particle Swarm Optimization (PSO) techniques designed in the form of a hybrid structure are used for diagnosis of epilepsy patients via EEG signals. Attributes of EEG signals are needed to be determined by employing EEG signals which are recorded using EEG. From this data, four characteristics are extracted for the classification process. 20% of available data is reserved for testing while 80% of available data is being reserved for training. These actions were repeated five times by performing cross-validation process. PSO is used for updating the weights during training ANN and a program is constituted for classification of EEG signals. Education and recording processes were performed with different parameters by means of the constituted program. The obtained findings show that the proposed method was effective for achieving accurate results as much as possible with the use of ANN and PSO, together.**

***Index Terms*—Artificial neural network, particle swarm optimization, epilepsy, EEG signals.**

I. Introduction

In the study of Hema et al. (2008), five different mental tasks from two subjects were studied and combinations of two tasks were used in the classification process. The obtained results validated the performance of the proposed algorithm for mental task classification [1].

In another study of Hema et al. (2008), a classification algorithm using a PSO Neural Principal component analysis was used to extract the features. These features were used for training and testing the neural network. Classification accuracies varied from 77.5% to 100 % for the 10 different task combinations for each of the subjects [2].

Skinner et al. (2007), investigated the efficacy of the genetic-based learning classifier system XCS, for classification of noisy, artefact-inclusive human EEG signals which are represented using large condition strings (108bits) [3].

In the study of Paulraj et al. (2007), a mental task classification algorithm using a PSO for a Radial basis Neural Network was proposed. Obtained results showed that average classification rated ranging from %74 to %94.87 [4].

In another study of Tezel et al. (2007), new neural network models with adaptive activation function (NNAAF) were presented to detect epileptic seizure. They achieved 100% average sensitivity, average specificity, and approximately 100% average classification rate for all the models [5].

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Chatterjee et al. (2005), showed the possible development of PSO-based fuzzy–neural networks (FNNs) that can be employed as an important building block in real robot systems. The developed model was controlled by voice-based commands [6].

Qiu et al. (2005), introduced a novel PSO algorithm in order to solve the EEG dipole source localization problem. The results showed that PSO is feasible and efficient for the source localization in EEG [7].

Bergh et al. (2004), presented a variation on traditional PSO algorithm, called Cooperative Particle Swarm Optimizer (CPSO), by employing cooperative behavior for significantly improving the performance of the original algorithm [8].

In the study of Gudise et al. (2003), a comparative study was made on the computational requirements of PSO and Back Propagation, as training algorithms for neural networks. Results were presented for a feed-forward neural network learning with a non-linear function [9].

II. Material and Method

EEG signals are observed via vibrations of the electrical potentials (oscillations) that occur during brain activity through electrodes placed on the skull [10]. EEG signals are often referenced for understanding the properties and the investigation of neurological and neuropsychological functions in the brain, today as well as for diagnostic and therapeutic purposes in many clinical [11].

A. Data Selection

In this study, EEG signals were taken from database described in Andrzejak et al. (2001) that is publicly available. Feature vectors are removed using 4097 data obtained from epileptic patients and healthy individuals. Min, max, average and standard deviation is carried out for extracting this feature vectors. Thus, 200 data has obtained consisting of four feature vector. From the obtained data, 20% was reserved for testing and 80% for training and these operations were repeated by 5 times by applying cross-validation.

B. Artificial Neural Networks Models

Neural networks are composed of many simple elements operating in parallel. These elements are inspired by biological nervous systems. The network function is largely determined by the connections between elements. Neural networks have been trained to perform complex functions in various fields [12].

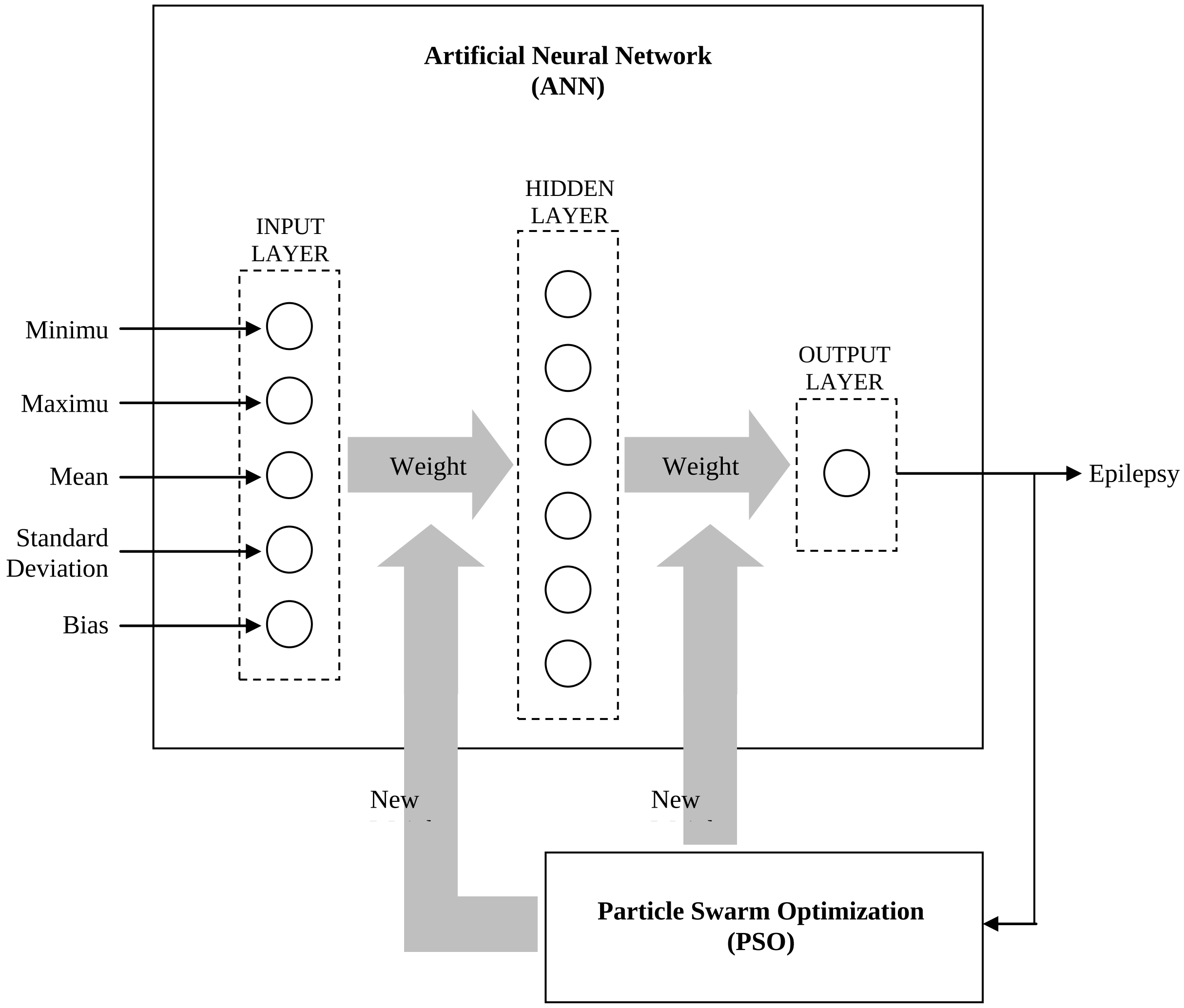

Fig. 1. Back- propagation multilayered neural network structure with PSO.

A. *Particle Swarm Optimization Models*

PSO algorithm is a recent addition to the list of global search methods. This derivative-free method is particularly suited to continuous variable problems and has received increasing attention in the optimization community. PSO is originally developed in [13] and inspired by the paradigm of birds flocking. PSO consists of a swarm of particles and each particle flies through the multi-dimensional search space with a velocity, which is constantly updated by the particle's previous best performance and by the previous best performance of the particle's neighbors [14].

III. DESIGN OF THE HYBRID MODEL

PSO are used for updating the weights after finding the value of output error in ANN model. Thus, a hybrid model was carried out with PSO. Fig.1 denotes the structure of hybrid model with back-propagation neural network and PSO.

The network input consists of four feature vectors and a bias. The output value is the state of presence or absence of epilepsy. Input values and hidden layer neuron number of the network consisting of one hidden layer determine the vector space (N) of PSO. The number of PSO vector space changes depending on the number of neurons in hidden layer. It is known that a starting position and velocities were determined for each particle in PSO. In this model, the initial position values are weights which are used in ANN. ANN and PSO are used in a hybrid structure for diagnosis of epilepsy disease. Sigmoud function is used to detect the output error values in feed-forward network structure. By means of the program written in Delphi language, finding the best weights and the optimal number of neurons in hidden layer have been attempted.

A. *Experiments and Results*

In this study, diagnosis of epilepsy via EEG signals has been tried by using ANN and PSO. The public database constituted by Andrzejak and colleagues has been employed for this purpose. The obtained results by entering different number of iterations and by entering different number of neurons in hidden layer have been provided in Table 1. A higher accuracy rate has been achieved by means of the used network parameters in training, namely with an increasing number of population and neurons in hidden layer. 96%, 98% and 99% accuracy rates have been obtained when the numbers of population are 10, 20 and 30, respectively. Furthermore the average success rate has been obtained as 98% from all of the test scores.

TABLE I: OBTAINED RESULTS FROM TEST DATA.

Test Set Parameters	**Neurons in Hidden Layer**	10	10	10	15	15	15	20	20	20	
	Iteration	100	100	100	100	100	100	100	100	100	
	Error Rate	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	
	Population	10	20	30	10	20	30	10	20	30	**Average (%)**
Results	**Result 1**	92%	100%	100%	100%	100%	100%	98%	100%	100%	99%
	Result 2	96%	94%	100%	94%	100%	98%	98%	100%	100%	98%
	Result 3	98%	100%	100%	94%	98%	100%	100%	98%	100%	99%
	Result 4	94%	100%	100%	96%	96%	100%	96%	100%	100%	98%
	Result 5	92%	94%	98%	90%	96%	98%	96%	100%	98%	96%
Average Success Rate (%)		98%									

The weights are updated and optimum weight values are tried to be determined with the structure of back-propagation by means of performed hybrid structure with ANN and PSO.

In this study, only the feed-forward network structure has been used in ANN model, PSO algorithm has only been used for updating the weights. Thus, the optimum weights have been obtained with less number of iterations by means of PSO while updating the optimal weights of network. It can be observed more quickly whether a person has epilepsy from EEG signals by means of the developed program that will take place in the future and will be computerized.

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