The Usage of Artificial Neural Networks Method in the Diagnosis of Rheumatoid Arthritis

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Abstract: In this study, artificial neural networks (ANN) method is used for the diagnosis of rheumatoid arthritis in order to support medical diagnostics. For the diagnosis of rheumatoid arthritis, backpropagation algorithm was examined in Matlab R2015b environment in artificial neural networks. With the system, the data in a data set, which are received from the patients with rheumatoid arthritis and from the people who are not suffering from rheumatoid arthritis, are classified successfully. Also, ANN backpropagation algorithm results and the results found by Perceptron algorithm are compared in terms of performance. Whereas %82 accuracy percentage is obtained with the Backpropagation method in performance tests in the data set, the accuracy percentage is calculated %71 with Perceptron method.

Keywords: Rheumatoid arthritis, disease diagnosis, artificial neural networks.

1. Introduction

Rheumatoid arthritis is a kind of long-term inflammatory rheumatism which symmetrically affects, most commonly, the small joints like the hands and the feet. It affects not only the small joints but also it can be seen in other large joints like shoulders. It comes at the very beginning of all kinds of inflammatory rheumatisms in the world. Of all types of rheumatisms, it is just one of them, which causes the greatest damage and the largest deformities of the joints. [1, 2]

The cause of rheumatoid arthritis is unknown. In spite of the fact that the hereditary predisposition is important, it is not true for all the patients. Although rheumatoid arthritis doesn't develop in all people who have hereditary disposition to it, disease may occur in the others who don't have any hereditary disposition. Hereditary predisposition shows only that these people with hereditary predisposition are more likely to develop the disease than do the other people without it. A number of physical and environmental factors, which we do not know for certain today, probably also play a role in the development of the disease or it probably triggers the disease. If we summarize what we can say about the cause of the disease today; rheumatoid arthritis is a disorder which may occur, with the involvement of some unknown environmental and physical factors, in individuals with a genetic predisposition. Sometimes the factor that triggers the disease may be an emotional trauma, depression, stress, infectious factors or some other factors, and sometimes there aren't any triggering factors for the disease. It is not a contagious disease. [1, 3, 4]

It can be seen in almost all age groups but it most commonly begins between the ages of 20 and 50. Women are about two or three times more likely to get rheumatoid arthritis than men are. It can be seen in people of any race and country. The incidence of the disease may be much in some races and less in the others. For example;

while this rate is 1/1000 for South African natives, it increases up to 5/100 in some Native American communities. Recently, the prevalence research of rheumatoid arthritis is continuing in the seven European countries, including Turkey. Studies in our country have been completed all around the country with the support of Physical Medicine and Rehabilitation (PMR) Clinics of many universities under the control of Turkish League Against Rheumatism (TLAR) and under the leadership of PMR Clinic of Mediterranean University, and also the incidence of this disease in our country will be published together with the other 6 European countries soon. Antalya region, as it is a region which gets immigration from all over Turkey, may reflect the general situation of our country in this respect. In a survey completed by Physical Therapy and Rehabilitation-Rheumatology Clinic of Mediterranean University in 2004, the prevalence of rheumatoid arthritis in Antalya was detected as 3.8/1000 (approximately one in every 260 people). [1, 4, 5]

Climatic conditions, does not affect the incidence or occurrence of rheumatoid arthritis. In the development of the disease, there is no effect of living in hot or cold regions or being in dry or humid environment. Climatic factors, probably does not affect the incidence of the disease but it may affect whether you feel the complaints more or less. For example; while regional hot treatment may raise the complaints in the swollen joints, on the contrary, cold treatment may reduce it. [1, 2, 5]

In the second part of the study; materials and methods used in the study are introduced, in the third part; the experimental results are examined and in the fourth part; the report is completed by comparing the results that are obtained.

2. MATERIALS AND METHODS

In this study, rheumatoid arthritis is diagnosed with Backpropagation algorithm, and the results are compared with the Perceptron algorithm, which is a kind of another classification algorithm. The data set used for the diagnosis of rheumatoid

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arthritis patients are obtained from Medical Faculty of Selcuk University.

2.1. Dataset

In this study, rheumatoid arthritis disease dataset, which is obtained from Medical Faculty of Selcuk University, is used. Data in this dataset is obtained from totally 69 real research subjects, 20 of them are patients with rheumatoid arthritis and 49 of them are people with no rheumatoid arthritis. In the dataset, some measurements are made on the research subjects for totally 11 characteristics and these characteristics are detailed in Table 1.

Table 1. Dataset of rheumatoid arthritis

Number	Information About the Characteristics
1	The age of the patient
2	C-reactive protein (CRP)
3	Iron (FE)
4	**Iron-binding capacity** (IBC)
5	Ferritin
6	Transferrin
7	Sedimentation rate
8	Hemoglobin (HGB)
9	Mean corpuscular volume (MCV)
10	Hepcidin
11	Prohepcidin

2.2. Artificial Neural Networks (ANN)

Artificial Neural Networks are an artificial intelligence approach which is trying to create a new system by imitating the functioning of the human brain [6, 9, 10]. This is one of the highly-preferred methods for the classification problems. ANN structure is formed on the basis of the structure of biological neurons in the human brain. In ANN, exactly as in our brain, there are some learning mechanisms and decision-making mechanisms which are based on the information that are learned. [7, 8, 13]

Today, there are many learning models of Artificial Neural Networks such as Perceptron, Adaline, Multilayer Perceptron Model (Backpropagation), Vector Quantization Problems, Hopfield Networks and Elman Networks [11, 12, 13]. Generally, in ANN, weight values are changed automatically, according to the specified learning rule, by giving output values corresponding to a given input set. After completion of the data training, trained network is able to predict the result of any given data set according to the latest state of the weight values. Also, in this study, Multilayer Perceptron Model is used. A multilayer, feed-forward backpropagation neural network model is shown in Figure 1.
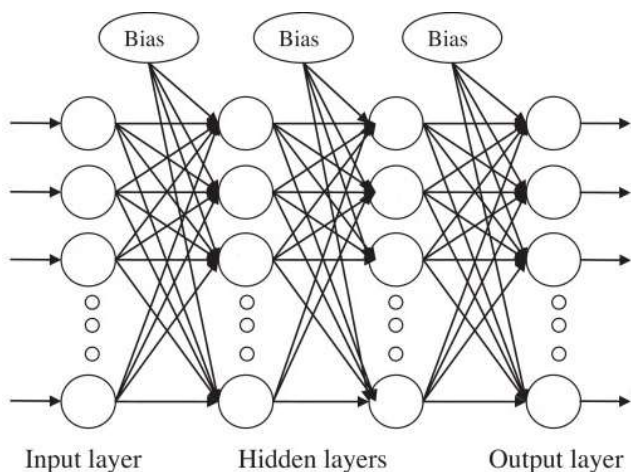

Figure 1. ANN Multilayer Perceptron Model

3. Experimental Studies

In the artificial neural networks, which are used in this study, classification is made for the diagnosis of a rheumatoid arthritis. The classification process which is done in artificial neural networks was conducted in Matlab environment. The number of hidden layers is determined as 1. Feed Forward Back Propagation algorithm is used as a learning method. In addition to these, the performance of the network is found according to the Mean Squared Error (MSE) and regression rules.

There are totally 69 examples, which belongs to the 20 patients with rheumatoid arthritis and 49 research subjects with no rheumatoid arthritis, in the dataset used in this study. %75 of this data has been used in the training phase of ANN, while the remaining %25 of it has been used as the test data. Details of the network structure which is improved for the system is given in Figure 2.
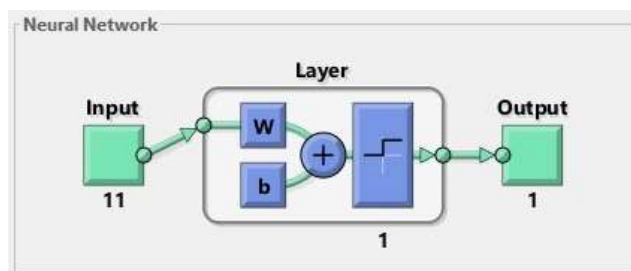

Figure 2. The network structure which is used for the system

At the end of the test process, "Accuracy Percentage" and "Error Percentage" criteria are considered as a basis to actualize the performance analysis. Successful results have been obtained for 1000 epoch in this study. Regression results for ANN are shown in Figure 3.
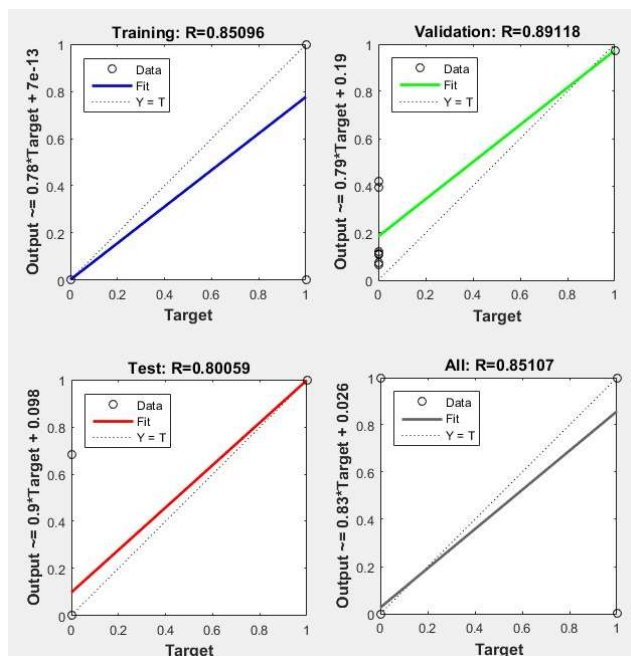

Figure 3. ANN Regression Results

Among the test data used in the study, totally 17 data were tested, including 14 accurately estimated and 3 misestimated data. The test data, values and predictions of the system according to the expected output are shown in Figure 4.
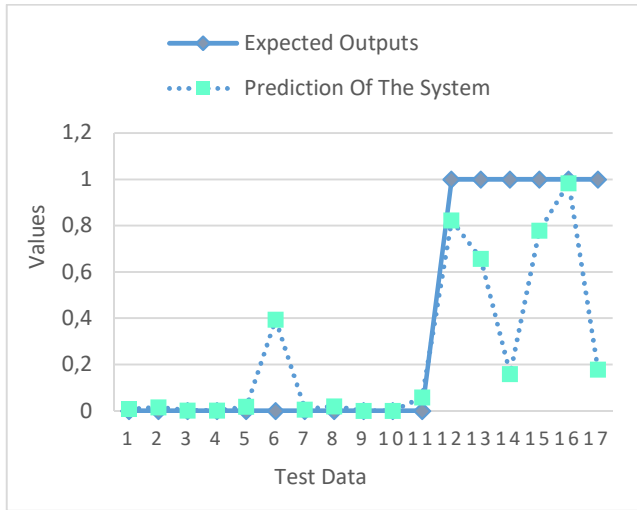
Figure 4. Test chart

At the end of the analysis while the percentage of correct detection is found as %82 with Backpropagation method, the percentage of false detection is found as %18. Also, this study is compared with Perceptron theorem, which is one of the classification techniques. With Perceptron algorithm, %71 accuracy percentage and 29% error percentage is obtained. According to these results, it has been shown to achieve the better performance results with ANN.

For both classification methods, accuracy and inaccuracy percentages, which are obtained as a result of 1000 epoch, are shown in Table 2.

Algorithm	Accuracy Percentage	Error Percentage
Backpropagation	82	18
Perceptron	71	29

Table 2. Performance percentages for 1000 epoch

The results of the performance percentages of the Backpropagation and Perceptron classification methods are shown on the graphic in Figure 5, and performance comparisons are made.
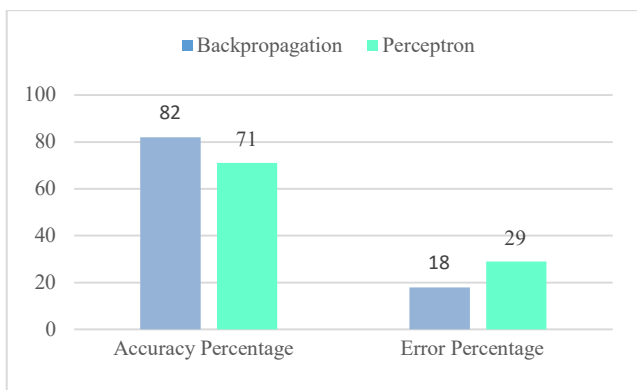

Figure 5. Performance percentages of the algorithms

4. Results

In this study, ANN-based classification is aimed to assist in the diagnosis of rheumatoid arthritis. While evaluating the success of classification methods, "Accuracy Percentage" and "Error Percentage" performance measurements are used.

While %82 accuracy percentage is obtained with the Backpropagation method in performance tests in the data set, on the other hand the accuracy percentage is calculated %71 with Perceptron method. In the diagnosis of rheumatoid arthritis with a set of available data, it was observed that ANN classifiers gave successful results in terms of training and testing performance.

In this study, different pre-processing techniques can be used to increase system performance in the future and the performance of this study can be evaluated with different classification methods.

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