

Rheumatoid Arthritis Diagnosis Based on Intelligent System

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KEYWORDS: Rheumatoid Arthritis, Artificial Intelligence, Disease Diagnosis.

Abstract

The Rheumatoid Arthritis (RA) affects many people targeting their joints, especially small joints, and it targets all ages which it is more common in women. This disease has many symptoms similar to other diseases. Therefore, it is very hard to detect. Also, the diagnostic tools are complex and uneconomical. In this paper, artificial intelligence network used for diagnosis and early detection of RA in accordance with criteria developed by the American College of Rheumatology. The best performance occurs with the minimum number of neurons required when the number of neurons is 6. So that, the performance is equal to 3.8968×10^{-10} . When reducing the number of neurons to 5 or increasing to 8, the result is 0.0041 and 1.0611×10^{-10} , respectively. However, all results can be consider acceptable and indicate that the best choice from this structure will be 6 neurons in the form of complexity and accuracy.

1. Introduction

Artificial intelligence was used to solve the problems related to the accuracy of diagnosis of diseases, [1]. RA is a common disease among different ages. Generally, RA is an autoimmune disorder due to tissue damage resulting in inflammation in young age or childhood, [2]. One of the strategies available for the diagnosis of rheumatoid arthritis is an American College of Rheumatism criteria which used in this paper to generate a database for the beginning detection of the RA. Artificial intelligence is one of the most effective methods used to simplify diagnosis, avoid errors and early detection rather than routine diagnostic procedures. Over the past years, a lot of information has become available in the detection of diseases using artificial intelligence such as: [3], have been proposed a sensory neural network based on the patient answer database, when each sensor has react related to specific questions. [4], applied the genetic algorithm to optimize the Artificial Neural Network (ANN) for heart disease diagnosis to accomplish best category, [5], proposed a computer system to detect rheumatoid arthritis disease via means of process variables to distinguish between infected and healthy people. [6], based on

thermal imaging technique to diagnose rheumatoid arthritis in the knee. [7], used artificial intelligence to detect gum disease and obtained 82% accuracy, using Levenberg-Marquardt algorithm (LM). [8], used chest medical images to train a deep convolutional neural network to diagnose chest diseases to get promising results. The general mathematical representation of the artificial intelligence algorithm that used in this research and the data standards used to construct the diagnostic system will present in the next sections.

2. Neural Network Technique

The machine learning is used in a regression, classification, and clustering, as a basic tool for learning emulation and do Prediction. In this section, the ANN mathematical model will present to use for the classification of the RA diagnosis. The human brain is the core of control unit which is managing for many activities. It contains approximately 100 billion neurons which linked to each other by interconnections (synapse) and the human brain approximately has more than 125 trillion synapses [9]. In many years, scientific people have tried to construct a computer simulation of the process of the brain. They have reached to build the first ANN. It consists of a combination of neurons connected by weighted links and their output bounded by activation function. The training rule is the major aspect of the ANN, which it is modifying the weights to eliminate the Mean Square Error (MSE). The general equations given as below:

$$y = f(net) \quad \dots(1)$$

$$net = w_1x_1 + w_2x_2 + w_3x_3 + \dots + w_n \quad \dots(2)$$

$$e = d - y \quad \dots(3)$$

Where: y is the output of the neuron, f is the activation function, x is the input signal, w is the weight, n is the number of inputs to neurons, e is a vector of network errors, k is the No. of output neuron and d is the output target vector.

There are many algorithms developed in artificial intelligence systems, which differ according to adjust the network weights. In this section, the LM algorithm used in this paper has weight adjustment as in equation (4):

$$w_{t+1} = w_t - [J^T J + \zeta I]^{-1} J^T e \quad \dots(4)$$

Where: J is the Jacobian matrix, ζ is combination coefficient and, [10]

3. Dataset Criteria for Rheumatoid Arthritis

The dataset that used to train the neural network is generated based on the American College of Rheumatology classification criteria for early detection of RA. This criterion is shown in the Table (1), [11] Table (1): Classification standard for RA, [11]

Standard	Outcome
A- Joint involvement	
1 major joint	0
2-10 major joints	1
1-3 minor joints (with or without involvement of major joints)	2
4-10 minor joints (with or without involvement of major joints)	3
>10 joints (at least 1 minor joints)	5
B- Serology:	
(-) RF and (-) anti-CCP	0
Low-(+). RF and low-(+). anti-CCP	2
High-(+) RF and high-(+) anti-CCP	3
C- Acute Phase reactants:	
Norm CRP and norm ESR	0
Abnorm CRP or abnorm ESR	1
D- period of symptoms	
6< weeks	0
6≥ weeks	1

Where the major joints included: shoulders elbows, hips, knees and ankles. And the mainor joints included: MCPs, PIPs, second-fifth MTPs, thump IPs and wrists. Low positive is less or equal than three times the maximum limit of normal. High positive is greater than three times the maximum of normal. If the total total is greater than or equal to 6 the person is infected. Figure (1) illustrates the general architecture of ANN with one hidden layer. The training to each neuron achieved by the Levenberg-Marquardt Back-Propagation (LM-BP) algorithm to produce the correct diagnosis.

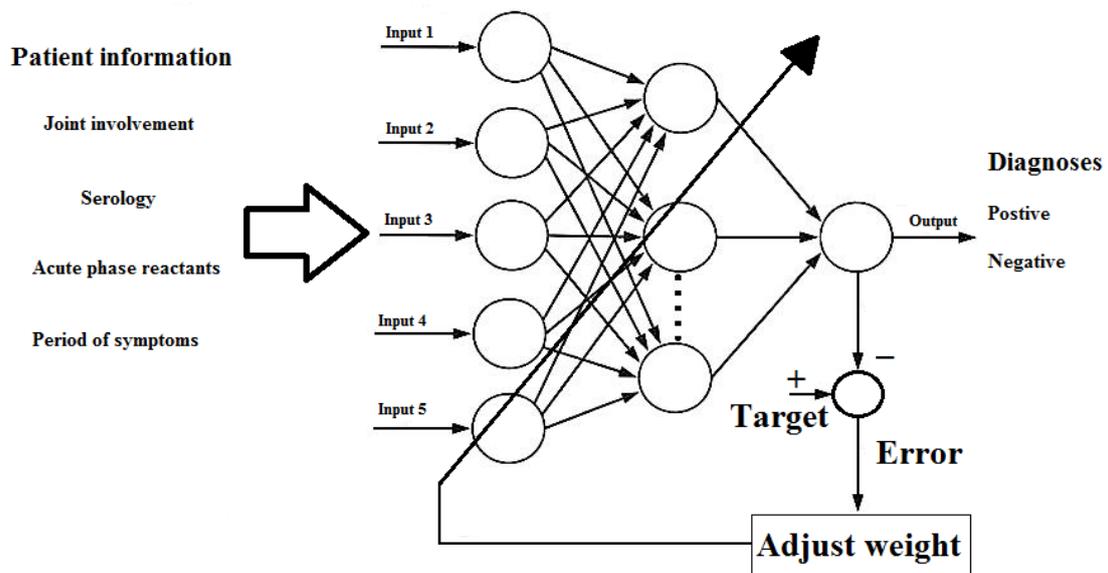


Figure (1): Schematic of ANN with LM-BP block diagram

4. Results and Discussion

The complete model that presented in the previous section has been tested in term of the accuracy according to the database that given in American College of Rheumatism to classify the Rheumatoid Arthritis. The results of the network model are obtained with LM algorithm that presented in previous section. The experimental environment is performed by dividing the data as follows: 15% validation, 15% testing, and 70% training with three structures of the neural network 5, 6 and 8. Figure (3) shows the performance curves (validation, testing, and training) to 3 different numbers of neurons to investigate the neural network behavior with changing the number of epochs. It can be seen that the network of 5 neurons gives a very poor performance equal to 0.0040629. Moreover, 6 and 8 neurons deliver the best performance equal to 3.8968×10^{-10} and 1.0611×10^{-10} respectively. However, the complexity of the 6 neurons is less than the 8 neurons and the performance difference between them is a very small. Thus, making it more suitable to build the system.

The Figure (2) shows the block diagram of the neural network for six neurons. The behavior curves in Figure (4) shows the correlation between actual and measured data to indicate effectiveness of the network.

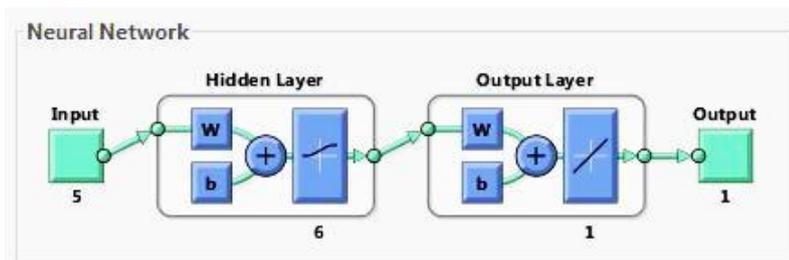


Figure (2): Block diagram of the 6 neurons network.

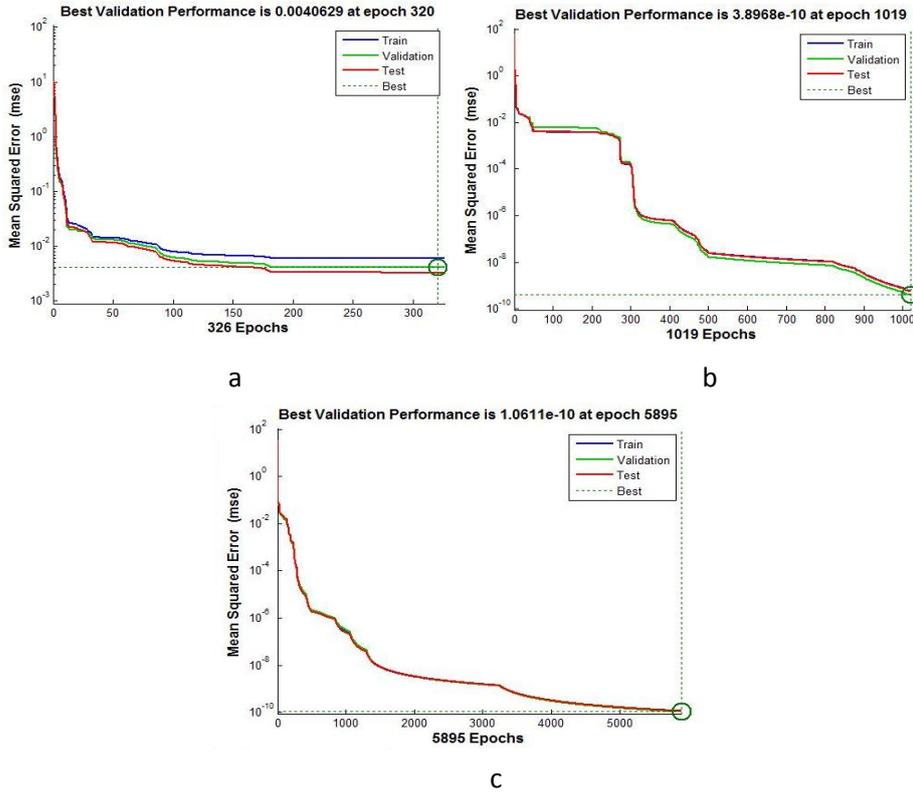


Figure (3): learning curve of the trained network at different number of neurons a: 5 neurons, b:6 neurons, c:8 neurons.

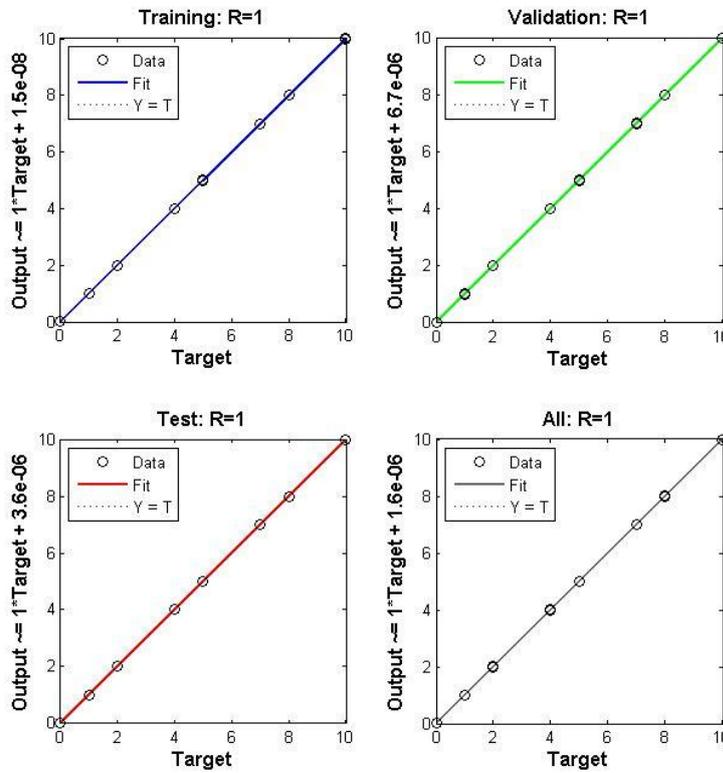


Figure (4): Regression curves of 6 neurons.

5. Conclusions

It has become clear that the software program has the advantage of shortening the time and accuracy to make a decision to help experts in various fields. In this study, we took the risk of RA disease to be detected by using LM-BP algorithm. The various structures of the network were trained in choosing the suitable one. A network of 6 neurons was relatively better in terms of minimizing error and simplicity in construction.

6. Reference

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تشخيص التهاب المفاصل الروماتويدي بالاستناد على نظام ذكي

الخلاصة

التهاب المفاصل الروماتويدي يؤثر على كثير من الناس مستهدفا المفاصل وخاصة المفاصل الصغيرة، ويستهدف جميع الأعمار حيث هو أكثر شيوعا في النساء. هذا المرض له العديد من الأعراض مشابهة لأمراض أخرى. لذلك، فمن الصعب جدا كشفه. كما أن أدوات التشخيص معقدة وغير اقتصادية. في هذا البحث، شبكة الذكاء الاصطناعي استخدمت لتشخيص والكشف المبكر عن التهاب المفاصل الروماتويدي وفقا للمعايير التي وضعتها الكلية الأمريكية للروماتيزم. أفضل أداء يحدث مع الحد الأدنى لعدد الخلايا العصبية المطلوبة عندما يكون عدد الخلايا العصبية هو 6. بحيث، فإن الأداء يساوي $10^{-10} \times 3.8968$. عند تقليل عدد الخلايا العصبية إلى 5 أو زيادة إلى 8، والنتيجة هي 0.0041 و $10^{-10} \times 1.0611$ ، على التوالي. مع ذلك، يمكن اعتبار جميع النتائج مقبولة و أن أفضل خيار لهذه التصاميم سيكون 6 خلايا عصبية من جانب التعقيد والدقة.

الكلمات المفتاحية: التهاب المفاصل الروماتويدي، كشف الامراض، الذكاء الصناعي.