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PATTERN RECOGNITION OF DEFECTIVE BONES X-RAY USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT:-Recently, the applications of Pattern Recognition involved in many fields, starting from scientific research, medicine, reaching to the crime recovery by pattern recognition of finger imprints. For any bones doctor, bones X ray represents very useful and important part in the diagnoses level, sometimes it should be the key in surgical operations. This paper merges the two fields (pattern recognition and bones medicine) by training simple artificial neural network using back propagation algorithm to recognize five normal and five defective bones X ray images and then evaluates the recognition accuracy. From the training of network, it's clear that a higher number of hidden neurons increase the processing time. The shape of images plays an important role in recognition process. It's obvious that the network should choose the minimum number of hidden neurons such that it still determines the maximum performance of the network.

1- INTRODUCTION

Work on Artificial Neural Networks, commonly referred to as “neural networks”, has been motivated right from its inception by the recognition that the human brain computes in an entirely different way from the conventional digital computer. The brain is a highly complex, nonlinear, and parallel computer (information-processing system). It has the capability to organize its structural constituents, known as neurons, so as to perform certain computations (e.g., pattern recognition, perception, and motor control) many times faster than the fastest digital computer in existence today. To be specific, the brain routinely accomplishes perceptual recognition tasks (e.g., recognizing a familiar face embedded in an unfamiliar scene) in approximately 100-200 ms, whereas tasks of much lesser complexity make take days on a conventional computer. For another example, consider the sonar of a bat. Sonar is an active echo-location system. In addition to providing information about how far away a target (e.g., a flying insect) is, a bat sonar conveys information about the relative velocity of the target, the size of the target, the size of various features of the target, and the azimuth and elevation of the target. The complex neural computations needed to extract all this information from the target echo occur within a brain the size of a plum. Indeed, an echo-locating bat can purse and capture its target with a facility and success rate that would be the envy of a radar or sonar engineer. How, then, dose a human brain or the brain of a bat do it? At birth, a brain has great structure and the ability to build up its own rules through what we usually refer to as “experience”. Indeed experience is built up over time, with the most dramatic development (i.e, hand-writing) of the human brain taking place during the first two years from birth, but the development continues well beyond that stage[1].

2-Neural Networks

Recently, neural network becomes more popular as a technique to perform character recognition. It has been reported that neural networks could produce high recognition accuracy. Neural networks are capable of providing good recognition at the present of noise that other methods normally fail

An Artificial Neural Network (ANN) is information processing paradigm that is inspired by the way biological nervous systems as figure (1), such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN showed in figure (2) is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well. Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyses.

3-Bones Defective

Bone defects are commonly encountered in revision total knee arthroplasty (TKA) and can affect implant alignment and the bone-implant interface. Bone loss can be caused by stress shielding, osteolysis, infection, and mechanical motion generated from a loose implant. It may also be iatrogenic at the time of implant removal. In revision TKA, bone defects must be addressed to restore the joint line and provide structural support for the new implant. There is no consensus on the classification and management protocol. An ideal classification system should be easy to use, enable accurate evaluation of bone loss for preoperative planning, facilitate comparison of results among surgeons, predict outcomes, and provide guidelines on treatment and rehabilitation.

4- Back Propagation Algorithm

Learning by back propagation has become the most popular method of training neural networks. The reason for the popularity is the underlying simplicity and relative power of the algorithm. The name back propagation actually comes from the term employed by Rosenblatt (1962) for his attempt to generalize the preceptor learning algorithm to the multilayer case[4,5]. The BPN is a kind of supervised learning neural network. it is one of the most frequently used learning techniques in neural networks. The principle behind the BPN involves using the steepest gradient descent method to reach a small approximation. A general model of the BPN has an architecture composed of three layers including input layer, hidden layer, and output layer. Two nodes of each adjacent layer are directly connected to one another, which is called a link. Each link has a weighted value which represents the relation degree between two nodes. A training process described by the following equations (including error equation and weight equation) updates these weighted values.

Rumelhart and McClelland define an error term that depends on the difference between the output values an output neuron is supposed to have, called the target value Tj, and the value it actually has as a result of the feed forward calculations, Oj. The error term represents a measure of how well a network is training on a particular training set [6].

Equation (1) presents the definitions for the error. The subscript p denotes what the value is for a given pattern

$$E_P = \sum_{j=1}^{r_j} (T_{Pj} - O_{Pj})^2 \qquad (1)$$

The aim of the training process is to minimize this error over all training patterns. The output of a neuron in the output layer is a function of its input, or Oj = f(Ij). The first derivative of this function, f '(Ij) is an important element in error back propagation. For output layer neurons, a quantity called the error signal is represented by Δj which is defined in equation (2)

$$\Delta j = f'(Ij)\,(Tj - Oj) = (Tj - Oj)Oj\,(1 - Oj) \qquad (2)$$

This error value is propagated back and appropriate weight adjustments are performed. This is done by accumulating the Δ's for each neuron for the entire training set, add them, and propagate back the error based on the grand total Δ. This is called batch (epoch) training [19]. There are two essential parameters that do affect the learning capability of the neural network. First, the learning coefficient η which defines the learning power of a neural network. Second, the momentum factor δ which defines the speed at which the neural network learns. This can be adjusted to a certain value in order to prevent the neural network from getting caught in what is called local energy minima. Both rates can have a value between 0 and 1[20]. Each weight has to be set to an initial value. Random initialization is usually performed. Weight adjustment is performed in stages, starting at the end of the feed forward phase, and going backward to the inputs of the hidden layer[21]

The weights that feed the output layer (Wjh) are updated using equation (3), This also includes the bias weights at the output layer neurons. However, in order to avoid the risk of the neural network getting caught in local minima, the momentum term can be added as in equation(4)

$$Wjh\,(new) = Wjh\,(old) + \eta\,\Delta jOh \qquad (3)$$

$$Wjh\,(new) = Wjh\,(old) + \eta\,\Delta jOh + \alpha\,[\delta Wjh\,(old)] \qquad (4)$$

Where δWjh (old) stands for the previous weight change.
The error term for an output layer is defined in equation of the hidden layer, it is not as simple to figure out a definition for the error term. However, a definition by Rumelhart and McClelland describes the error term for a hidden neuron as in equation (5) and, subsequently, in equation (6)[21].

$$\Delta h = f'(Ih) \qquad (5)$$

$$\Delta h\eta = Oh\,(1 - Oh) \qquad (6)$$

The weight adjustments for the connections feeding the hidden layer from the input layer are now calculated in a similar manner to those feeding the output layer [21]. These adjustments are calculated using equation (7)

$$Whi\,(new) = Whi\,(old) + \eta\,\Delta h\,\eta Oi + \alpha\,[\delta Whi\,(old)] \qquad (7)$$

The bias weights at the hidden layer neurons are updated, similarly, using equation (7)

5-Pattern Recognition of Bones X-Ray Images

This project representing a design of an Artificial Neural Network can recognize multi-form characters with and without defectives of the bones X-ray images, after that the program will be tested with another images with deferent shapes to test the trained neural network, the program was written in Matrices Laboratory programming language (MatlabR2008a) and using back propagation neural network algorithm to trained neural network.

6-Bones X- Ray Description

Below the block diagram of system, shows the three stages of program,

7- Database Obtaining Level

First the natural and defective bones x-ray images collected from internet and then cropped by Photoshop program then saved as a (.jpg) image, after that all images resized and that size was 200×200 pixel, here 5 forms of bones images are used in this paper 3 forms of them for training and the others 2 for testing the trained ANN. For the training images used are: the natural bones images, the rotated images to the right and the rotated images to the left. For the testing images used are: the defective bones images and the flipped defected ones to 180 degree, next some example of the characters which used to train and test ANN.

8- Modification Operation

This level was to modify images to feed it in Artificial Neural Network before input it and this operation has three parts, first is to resize all the images and second convert it to a binary shape (gray scale mode), this will give a facility to programming the work in Matrices Laboratory Program (MatlabR2008a) and then the third part is to justified the value of the pixels by divided the value of each pixel on 255 to fix the value of all pixels in image between zero and one.

9- Processing Operation

After collecting characters images and prepare it to be feed to Neural Network then i used as an aid a Matrices Laboratory Program language toolbox (Matlab R2008a) to train Neural Network by using Back Propagation learning algorithm using 3 type of training images. To train Artificial Neural Network we must first find the real components of the back propagation algorithm which i use in my paper as a learning algorithm and then we must determine an activation function, number of input and output neurons, there are some elements (Training elements) of learning algorithm such as error goal that the Neural Network tried to reach during training and learning rate that represent the intelligence of the Neural Network and momentum factor that represent the speed of training. Table (2) Show's all training elements that I used to train Artificial Neural Network for character recognition. As showed above in this paper Back Propagation Learning Algorithm used and this algorithm works by calculate the error between the actual output and the target, when the value of that error is equal or less than the desired output that the trainer put as this case i put (0.00001) as an error goal as table(2) showed. Now we have the trained Neural Network which was ready to be test with the testing images, in test stage the images input to Neural Network with feed forward Network without getting feed backward network and without propagate the error and this process was done just to see how the training of Artificial Neural Network. Finally the training accuracy and testing accuracy of Neural Network input and output value can be calculated.

Fig.4 bellow which represent the neural network of Bones X- Rays system, clarified all the required parameters of any neural network can be trained to perform a task. Those parameters are input layer which contain input neurons number, in my project is 40000 neurons it's come from 200×200 pixel it's the size of image, hidden layer which contain hidden neurons number and here fixed at 80 neurons according to network performance, and finally output layer which contain output neurons number and here is 5 which represent the number of training images.

10- Program Flow Chart

11- Results

As a results, Table (2) represents the essential elements for Back Propagation Neural Network training process, including all the fundamental elements and the most important one is learning rate and momentum factor. Figure (7) shows the process of proposed Neural Network training and the structure of this network. Figure (8) shows the performance plot of the network which is the relationship between the mean square error and the maximum number of epochs which is equal here 138 epoch. Table (3) clarify the results of paper which is the training and testing efficiency of each image used alone, and then the total efficiencies of training and testing process.

12- Conclusion

The back propagation neural network can be applied to many applications, such as pattern recognition, pattern classification, and function approximation. From this paper its concluded that to train a neural network successfully, we must choose a suitable learning algorithm and its found that the noise exposed for the database effect on the network performance, if the noise increase the network testing accuracy decrease so that if we continuing in increasing of noise the network cannot recognize the trained database like a person make the vision test, when the test symbols being smaller and smaller he cannot recognize it. During the processing level i get a training accuracy rate 98.54% and a testing accuracy rate 75.85% , this indicated the difference between the two cases, when the accuracy rate decrease to this value this didn’t mean that the ANN inefficient, logically its must be a difference between training and testing because of all effects and noise exposed for the database. From the training for networks of programs, it is clear that a higher number of hidden layer neurons increase the processing time. It is obvious that it should be chosen the minimum number of neurons such that it still determines the maximum performance of the networks. It is also obvious that by increasing the learning rate it can get a shorter processing time but the percentage of the pattern recognition decreases. By changing the parameters (learning rate, momentum factor, and hidden layer neurons number) it enhances the results of the program and eliminates the Local Minima which faced in the graph of iteration vs. error.

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Table.(1): The First & Last Image of Bones X- Ray Images as an Example of Usage Images

The First Image of System:				
For Training			For Testing	
Normal Shape	**Rotated Shape to Right by 90◦**	**Rotated Shape to Left by 90◦**	**Defected Shape**	**Rotated Shape by 180◦**
				
The Last Image of System:				
				

Table.(2). Essential Elements

Number of Input Neurons	40000
Number of Hidden Neurons	80
Number of Output Neurons	5
Learning Rate	0.16
Momentum Factor	0.41
Error	0.0001
Number Of Iteration	137
Maximum Iteration	10000
Training Time	1 Sce
Testing Time	0.0718 Sce
Training Accuracy	98.54 %
Testing Accuracy	75.85 %

Table.(3). Training and Testing Efficiency of the system

No.	Image	Image Accuracy	No.	Image	Image Accuracy
1	Image 1	0.9815	1	Image 1	0.9258
2	Image 2	0.9871	2	Image 2	0.3693
3	Image 3	0.9870	3	Image 3	0.9849
4	Image 4	0.9869	4	Image 4	0.9537
5	Image 5	0.9854	5	Image 5	0.6716
6	Image 6	0.9892	6	Image 6	0.9258
7	Image 7	0.9809	7	Image 7	0.3711
8	Image 8	0.9814	8	Image 8	0.9849
9	Image 9	0.9848	9	Image 9	0.9662
10	Image 10	0.9835	10	Image 10	0.4322
11	Image 11	0.9858			
12	Image 12	0.9871			
13	Image 13	0.9870			
14	Image 14	0.9869			
15	Image 15	0.9875			
Training Accuracy		98.54 %	Testing Accuracy 75.85 %		

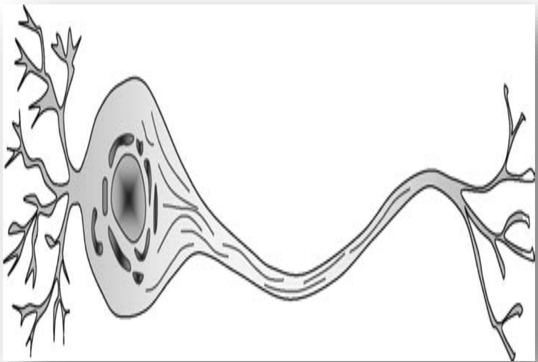

Fig. (1). Biological Neural Network

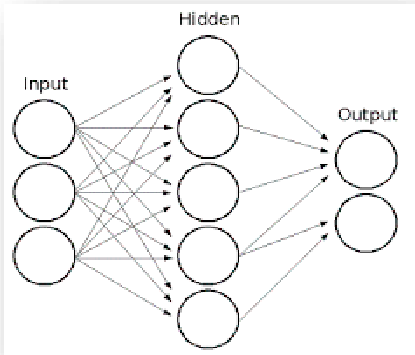

Fig. (2). Artificial Neural Network

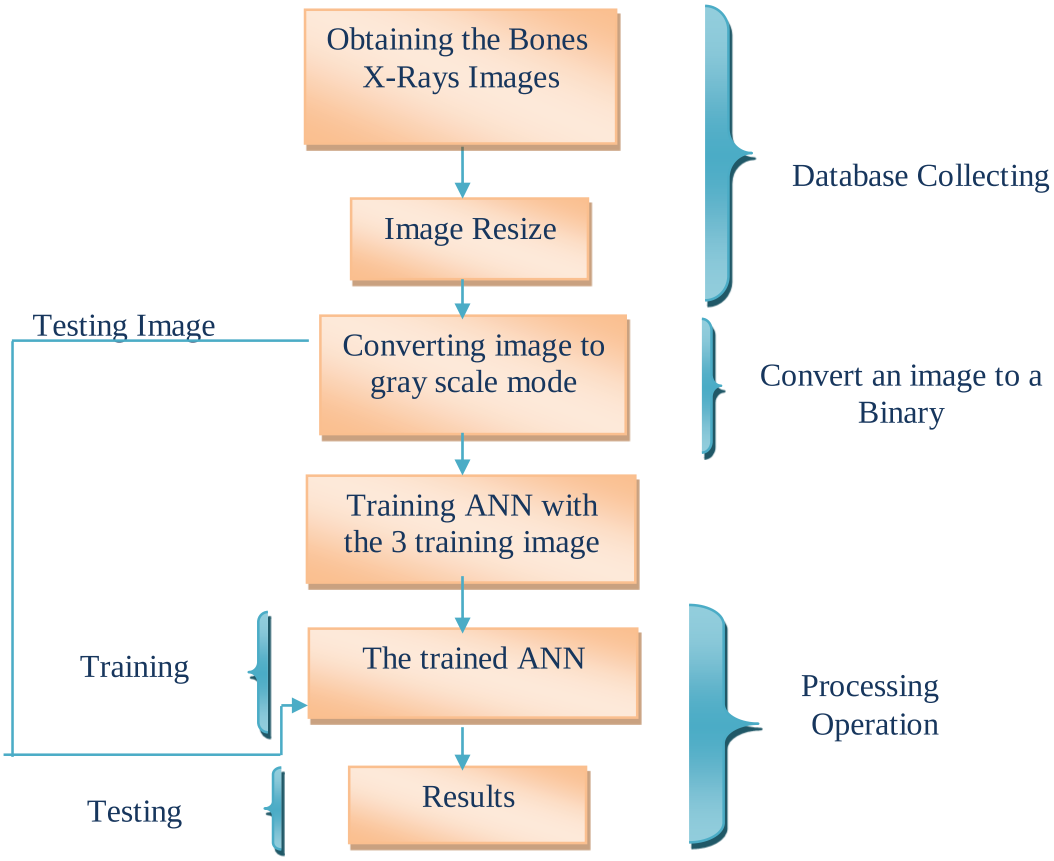

Fig. (3). Block Diagram of System

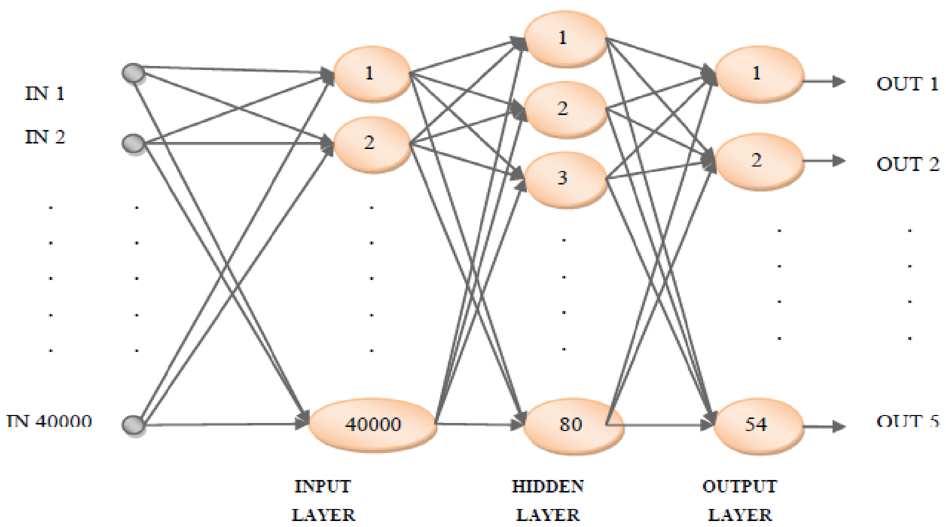

Fig.(4). Neural Network of System

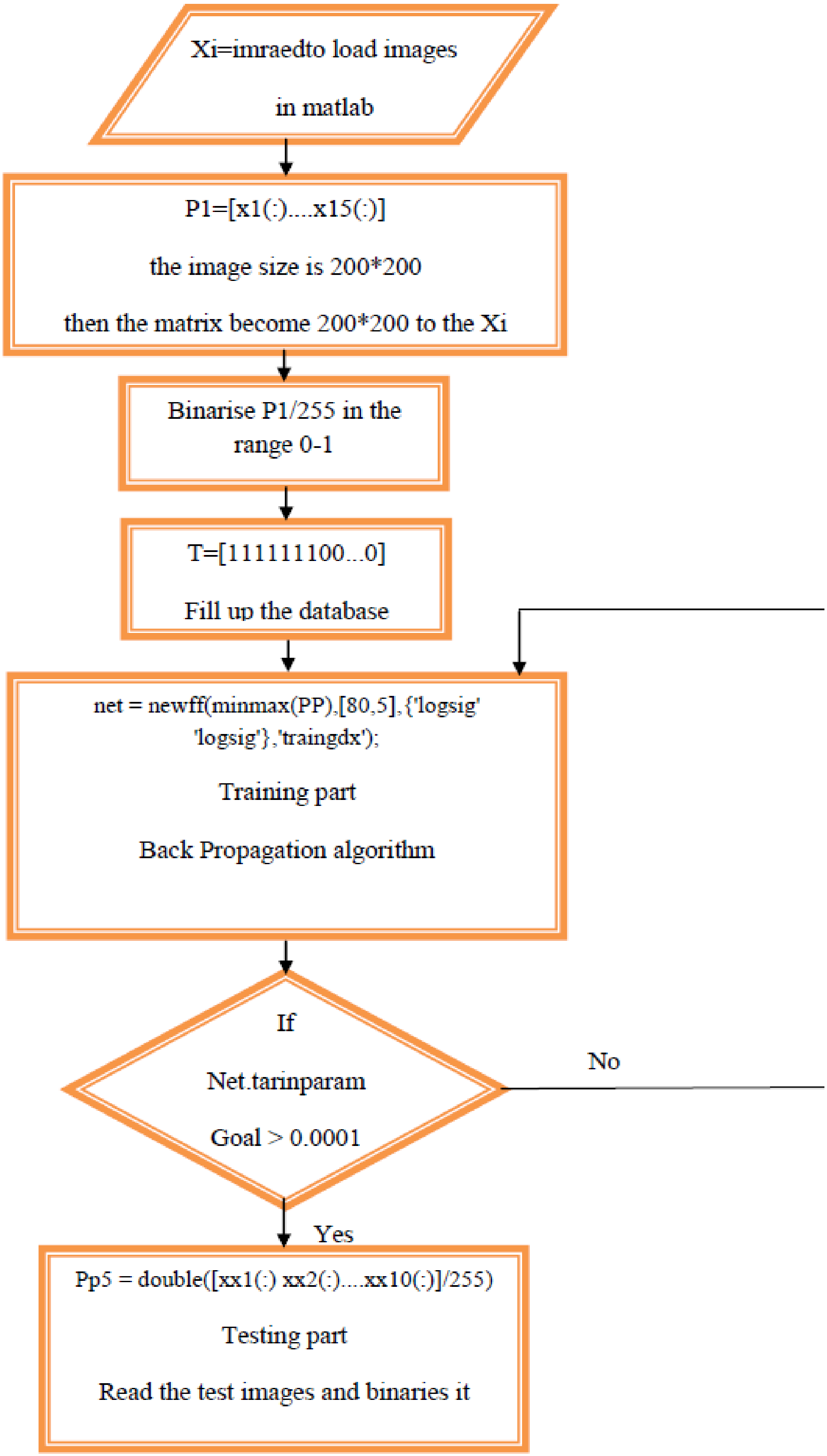

Fig.(5) Program Flow Chart

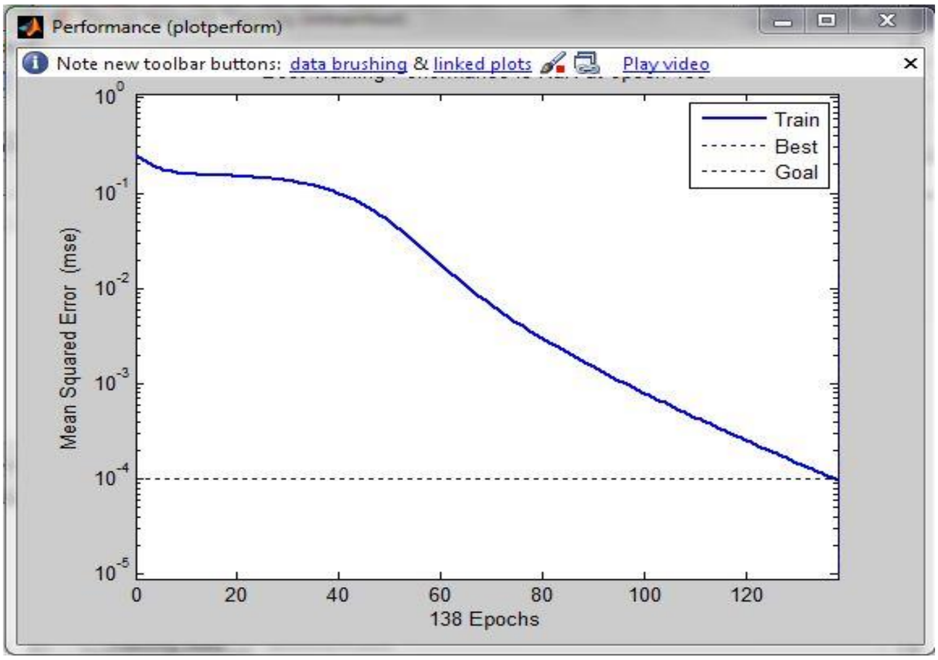

Fig.(6) The Proposed Neural Network

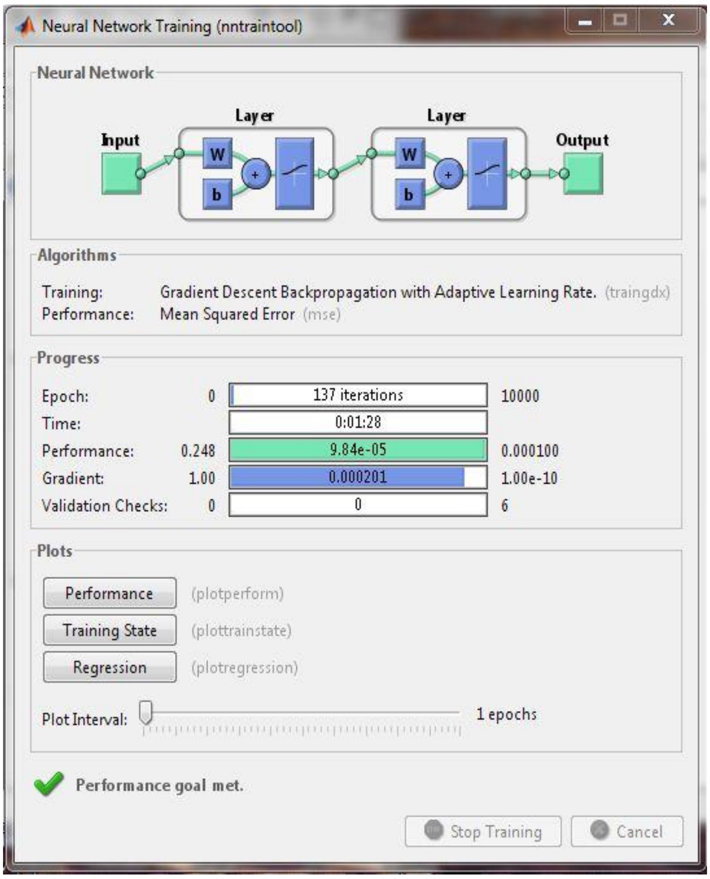

Fig.(7) Performance of the network

الخلاصة

في الآونة الأخيرة، استخدمت تطبيقات تمييز الانماط في العديد من المجالات، بدءا من البحث العلمي، والطب، و وصلت إلى اكتشاف الجريمة من خلال التعرف على بصمات الأصابع. في طب العظام، تعتبر الأشعة السينية جزء مفيد جدا ومهم في مستوى التشخيص ، وأحيانا تكون المفتاح في العمليات الجراحية. يدمج هذه البحث الحقلين (التعرف على الأنماط وطب العظام) عن طريق تدريب الشبكة العصبية الاصطناعية البسيطة باستخدام خوارزمية الانتشار العكسي لتمييز خمس صور اشعه سينيه لخمس عظام طبيعية وخمسة اخرى مشوهه وبعد ذلك تقوم الشبكة بتقييم دقة تمييز الانماط. من تدريب الشبكة ،اتضح أن استخدام عدد أكبر من الخلايا العصبية الخفية تزيد من وقت المعالجة. شكل الصور يلعب دورا هاما في عملية التمييز. ومن الواضح أن الشبكة يجب ان تحدد الحد اللازم لعدد الخلايا العصبية الخفية لكي يحدد أقصى أداء للشبكة.