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Effect of Neurons on the Performance of Microbend Optical Biosensor

Preeti Singh, Dr. H. M. Rai, Zile Singh

Abstract--- ***Osteoporosis is a very severe disease of bones. It leads to an increased risk of fracture. Existing biosensors need improvement to detect the early onset of osteoporosis. Fiber Optic microbend biosensor is being developed to achieve such an improvement. Microbend sensors are based on Microbend induced excess transmission loss of an optical fiber. Artificial Neural Networks (ANN) were a key development in the field of machine learning. They were inspired by biological findings relating to the behavior of the brain as a network of units called neurons. The basics of these neurons has been utilized to analyze the performance of ANN based simulink model in terms of mean square error (mse). The best validation performance in terms of mse is 0.044938 for one neuron. The percentage accuracy of the designed biosensor is obtained as 94%.***

Index terms--- **Artificial Neural Network, Biosensor, Epochs, Micobend, Neuron, Osteoporosis.**

I. INTRODUCTION

Osteoporosis is a very severe disease of bones. It leads to an increased risk of fracture. It is affecting a mass population and increasing day by day the cause may be one or the other. In osteoporosis the bone mineral density (BMD) is reduced, bone micro architecture is deteriorating, and the amount and variety of proteins in bone is altered. Work has been carried out towards the realization of a flexible, implantable sensor array for measuring surface strain on live bones [1]. Several methods to monitor the bone fracture healing process have been developed. Measuring the strain in an internal plate over times makes it possible using magneto elastic strain sensor [2]. Microbend sensors are based on Microbend induced excess transmission loss of an optical fiber to detect/measure displacement, pressure, strain, temperature etc. If a portion of fiber is deformed, the fiber would exhibit excess light loss [3],[4]. Such perturbation of fiber axis results in redistribution of guided power between modes of the fiber and also coupling of the fiber from one mode/mode group to another. The use of Supercomputers in orthopedic biomechanics research has been reported focus being on functional adaptation of bones [5].

Neural networks process information in a similar way the human brain does. Artificial Neural Networks were a key development in the field of machine learning. They were inspired by biological findings relating to the behavior of the brain as a network of units called neurons. The human brain is estimated to have around 10 billion neurons each connected on average to 10,000 other neurons. Each neuron receives signals through synapses that control the effects of the signal on the neuron. These synaptic connections are believed to play a key role in the behavior of the brain. Neural networks learn by example.

II. METHODS AND MATERIALS

Neural networks is composed of a large number of highly interconnected processing elements (neurons) working in parallel to solve a specific problem.

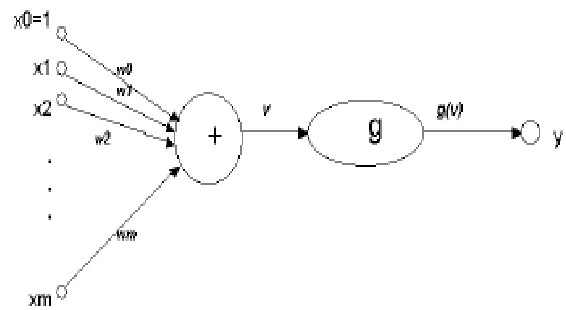

Fig 1: Basic Components of a Neuron

The fundamental building block in an Artificial Neural Network is the mathematical model of a neuron as shown in fig 1.The three basic components of the (artificial) neuron are:

1. The synapses or connecting links that provide weights, w_j , to the input values, x_j for j = 1, ...m;
2. An adder that sums the weighted input values to compute the input to the activation function where, w_0 is called the bias (not to be confused with statistical bias in prediction or estimation) is a numerical value associated with the neuron. It is convenient to think of the bias as the weight for an input x_0 whose value is always equal to one, so that
3. An activation function g (also called a squashing function) that maps v to g (v) the output value of the neuron. This function is a monotone function.

MATLAB has been used for simulation work. The ANN based test bench has been developed for optimization of fiber-optic biosensor for strain measurement in ortho applications using MATLAB and then subsequently iterations have been performed to analyze the performance of the simulink model by considering the concept of neurons.

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III. RESULTS AND DISCUSSION

Strain on bones can be measured more accurately with the improvement in biosensors. Such an improvement is being achieved with the design of fiber optic microbend biosensor model shown in fig 2 "to be published" [6]. A simulink model is being designed on the basis of system modeled shown in the fig 3. A strain vs. attenuation linear graph is obtained by tuning the modeled system.

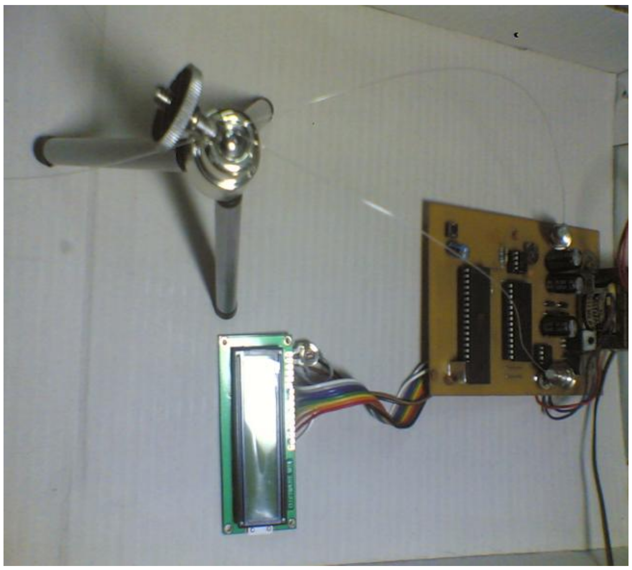

Fig 2: Photograph Of Biosensor Used For Taking The Readings

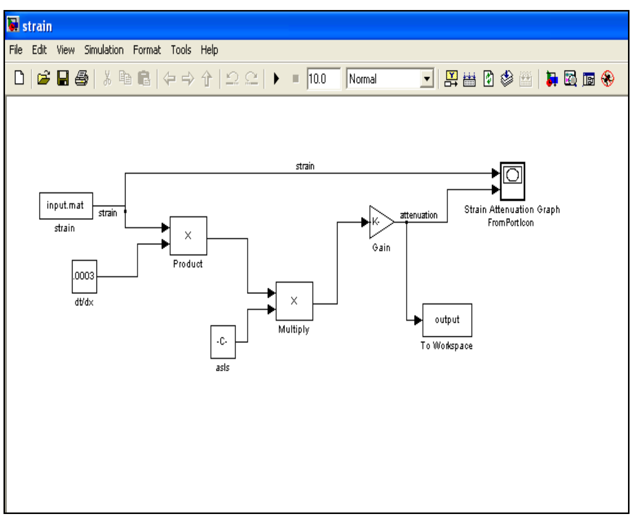

Fig 3: Simulink Model of Biosensor

A simulation of Artificial Neural Network based biosensor has been carried out using the concept of neurons on the basis of which the performance of the system is being analyzed. Analysis is being made with one neuron.

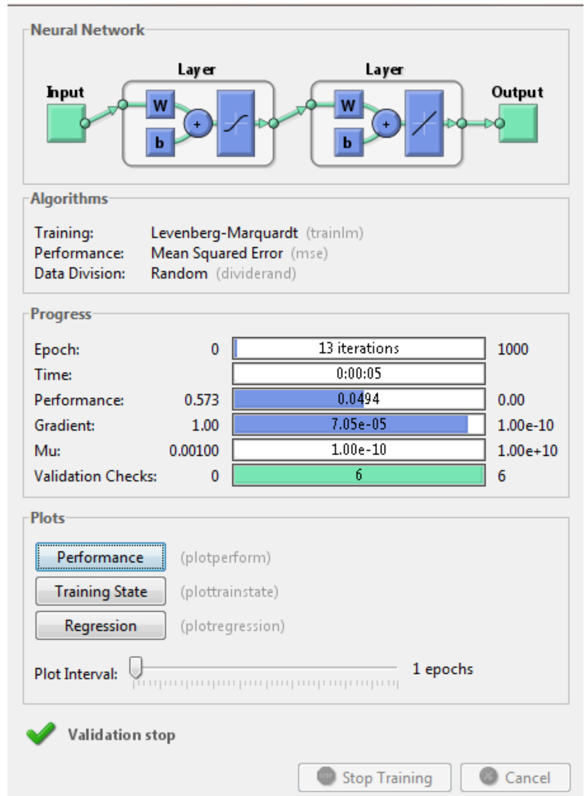

Fig 4: Neural Network Training Tool Showing With One Neuron Showing Various Parameters of Progress

Fig 4 shows the neural network training tool depicting the various sections of ANN simulation process i.e. neural network system, algorithms, progress and plots. Performance evaluation is made in terms of mean square error (mse).

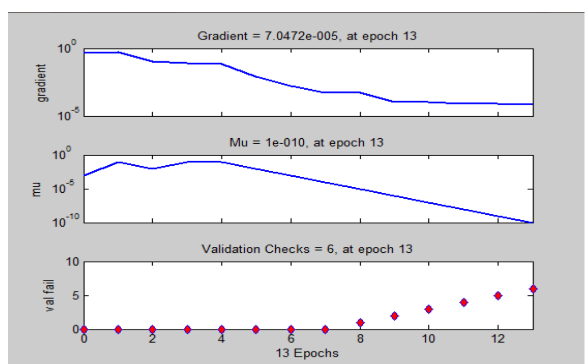

Fig 5: Number of Epochs vs. Training State Parameters

ANN based biosensor in the present research, is considered in terms of one neuron of neural network. Number of iterations (epochs) are being carried out. It has been observed that the number of iterations carried out for one neuron based neural network is 13.

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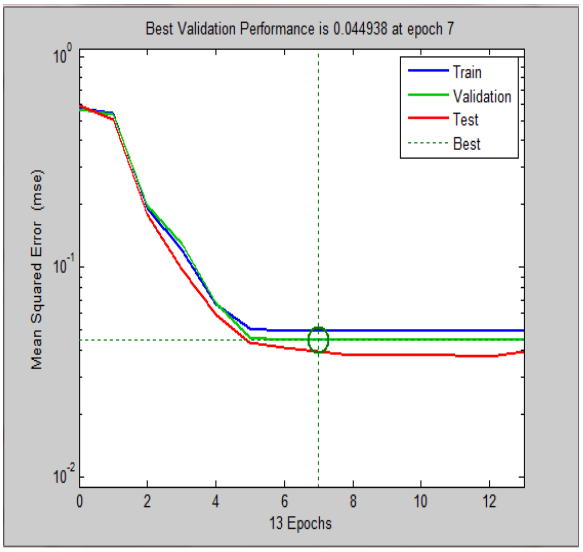

Fig 6: Number of Epochs vs. Mean Square Error

The respective values of gradient, Mu and validation check in the training state in 13 epochs are 7.0472e-005; 1e-010 and 6 respectively are shown in fig 5. The performance of the system is analyzed in terms of number of epochs versus mse as shown in fig 6. The graph is showing trends of trained, validation and test data in terms of epochs versus mse. It is clear that with the increase in number of epochs the mse decreases for all trained, validation and test data with slight difference in the slope. The best validation performance in terms of mse is 0.044938 at epoch 7. On the basis of parametric performance the percentage accuracy of the neural network based biosensor for one neuron system comes out to be 94%.

IV. CONCLUSION

The model of photometric microbend biosensor is designed to improve the performance of biosensor. Such improvement is analysed with Artificial Neural Network on the basis of neurons of the network. The trained, validated and test data is analyzed as number of epochs vs. mean square error (mse). The maximum mse at initial iterations is obtained as 0.573. With further iterations it is reduced to 0.044938 at epoch 7 i.e. the best validation performance in terms of mse. The percentage accuracy of the ANN based photometric strain biosensor trained using one neuron comes out to be 94%. The ANN based microbend biosensor shall be further analyzed by varying the number of neurons for better performance.

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AUTHOR BIOGRAPHY

Er. Preeti Singh, born in 1982, is B.Tech and M.Tech in ECE. She joined UIET, PU Chandigarh. She is Assistant Professor there. She is currently pursuing PhD in Electronics and Communication Engineering in NIMS University, Jaipur, India. Her main areas of interest are biosensors and fiber optic communication. She has published a number of technical research papers. She has guided 2 research scholars for M.Tech. At present she is guiding 3 research scholars for M.Tech. Email: *preets.singh.82@gmail.com*,

Dr. H.M.Rai Born on 1st August1943. He received the B.Sc. Engg.(Electrical), from Punjab University in 1963. M.E. from University of Roorkee in 1966 and PhD from Regional Engineering College, Kurukshetra University in 1992. He joined as lecturer in RECK in 1966. From there he retired as Professor in 2003. He has published a number of Technical papers and Text Books. His area of interest is Electrical Drives, Energy Systems, Instrumentation and control. At present he is Professor ECE, GIMT, and Kurukshetra. He has guided 5 research scholars for PhD. At present he is guiding 5 research scholars for PhD.