Biomedical Engineering Based Artificial Neural Network

Khadijeh karamzadeh, Hadis Askarifar, Hamid Moharrami

Abstract—In this paper, we will review the effect of artificial neural network in biomedical engineering. Efficacy of artificial neural networks demonstrated by use of a case study in this area. Artificial Neural Networks (ANNs) can solve many real world problems in the areas of pattern recognition, signal processing and medical diagnosis. Most of the medical data set is seldom complete. Complete set of data is needed for Artificial Neural Networks to achieve an accurate classification. The effectiveness of Artificial Neural Networks for diabetes mellitus is demonstrated.

Index Terms— Artificial intelligence, Artificial Neural Network, Back Propagation, Biomedical Engineering, Classification, Diabetes Mellitus, Multi Layer Perceptron .

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1 Introduction

Medical information systems in modern hospitals and medical institutions become larger and larger; it causes great difficulties in extracting useful information for decision support. Traditional manual data analysis has become inefficient and methods for efficient computer based analysis are essential. It has been proven that the benefits of introducing machine learning into medical analysis are to increase diagnostic accuracy, to reduce costs and to reduce human resources [1]. Biomedical Engineering is an interdisciplinary domain, which links many disciplines such as engineering, medicine, biology, physics, psychology, etc (Wolff 1970). This rapidly growing field must meet the needs of industrial, clinical, and scientific research communities. It involves the application of state-of-the-art technology to the creation of methodologies and devices for human welfare and for better understanding of human biological processes. Artificial neural network is one of the techniques that can be utilized in these applications [2]. Artificial Neural Network is currently the next promising area of interest. Already it could successfully apply to various areas of medicine such as diagnostic systems, bio chemical analysis, image analysis and drug development. The benefit of using Artificial Neural Networks is that they are not affected by factors such as fatigue, working conditions and emotional state [1]. This paper is organized as follows: In Section 2 we explain Artificial neural networks in general. Section 3 demonstrates efficacies of artificial neural networks by use of a case study in this area. The applications of artificial neural networks in biomedical engineering are showed in section 4. Finally, conclusions form the last section.

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2 Artificial Neural Network

Numerous advances have been made in developing intelligent systems, some inspired by biological neural networks. Researchers from many scientific disciplines are designing artificial neural networks to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control. Conventional approaches have been proposed for solving these problems. Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain. ANNs provide exciting alternatives, and many applications could benefit from using them [3].

2.1 Why Artificial Neural Network

The long course of evolution has given the brain many desirable characteristics not present in von Neumann or modern parallel computers. These include: massive parallelism, distributed representation and computation, learning ability, generalization ability, adaptively, inherent contextual information processing, fault tolerance, and low energy consumption. It is hope that devices based on biological neural networks will possess some of these desirable characteristics. Modern digital computers outperform humans in the domain of numeric computation and related symbol manipulation. However, humans can effortlessly solve complex perceptual problems at such a high speed and extent as to dwarf the world's fastest computer. Why is there such a remarkable difference in their performance? The biological neural system architecture is completely different from the von Neumann architecture. This difference significantly affects the type of functions each computational model can best perform.

Numerous efforts to develop "intelligent " programs based on von Neumann's centralized architecture have not resulted in general-purpose intelligent programs. Inspired by biological neural networks, ANNs are massively parallel computing systems consisting of an extremely large number of simple processors with many interconnections. ANNs models attempt to use some "organizational" principles believed to be used in the human let us consider the following problems of interest to computer scientists and engineers [3,8,9].

3 A Case Study

3.1 Diagnosis of Diabetes Mellitus Using Artificial Neural Networks

Diabetes mellitus is a lifelong disease resulted from the underproduction or reduced action of hormone insulin. This dysfunction of insulin results in blood glucose levels out of normal range, leading to many short and long-term complications [4,10]. Depending on the cause of this insulin insufficiency, two different types of the disease are distinguished. Type I diabetes mellitus and Type II diabetes mellitus. In this case, we deal about the classification of Type II diabetes [1].

Varieties of techniques have been applied to deal with the classification problems. Many previous research works shows that neural network classifiers have a better performance, lower classification error rate, and more robust to noise than other methods [6]. One type of neural network commonly used for classification is a Multi Layer Perceptron (MLP) a feed forward net with one or more layers of nodes and with back propagation for training [7]. Increasing both the number of hidden layers and neurons will make the network more flexible to the mapping to be implemented [5]. Moreover, increasing the number of hidden neurons increases the risk of over fitting.

To overcome these problems, [1] present two different approaches. The first approach attempts to construct the data sets with reconstructed missing values. It can achieve higher correct classification rates than the standard back propagation method. Reconstruction of missing values may shift input patterns, and the network may have to settle on a complicated solution to satisfy all reconstructed patterns. In contrast, the second approach attempts to reduce the actual learning time by using data pre-processing. Pre- processing can speed up the training time by starting the training process for each feature within the same scale. It is especially useful for modeling applications where the inputs are generally on widely different scales. In this study, various missing value analysis and pre-processing methods are analyzed. [1] Also investigates the reconstruction values with pre-processing and observes the results. This shows that the results are tremendously improved when applying these concepts.

The impact of the missing values can be assessed by taking the average of ten runs and measured in terms of classification accuracy (Table I). It shows that the accuracy was tremendously improved when using K-nearest neighbor and mean with PCA pre-processing method [1].

TABLE 1
Classification Accuracy

Missing value	Omit the samples	Replace with zero	Replace with mean	Replace with Knn
Accuracy	68.56	66.67	99.93	99.80

4 Application Of ANN In Biomedical Engineering Domain

Artificial Neural Networks are currently a 'hot' research area in medicine and it is believed that they will receive extensive application to biomedical systems in the next few years. At the moment, the research is mostly on modeling parts of the human body and recognizing diseases from various scans (e.g. cardiograms, CAT scans, ultrasonic scans, etc.) (Christos & Dimitrios 1996).

Table 2 below demonstrates that neural networks are ideal in recognizing diseases using scans since there is no need to provide a specific algorithm on how to identify the disease. Neural networks learn by example so the details of how to recognize the disease are not needed. What is needed is a set of examples that are representative of all the variations of the disease. The quantity of examples is not as important as the 'quality'. The examples need to be selected very carefully if the system is to perform reliably and efficiently (Christos & Dimitrios 1996) [2].

TABLE 2
Neural Networks In Biomedical Engineering Applications

Types Of Neural Network	Application
ARTMAP	Cancer (Downs et. al 1998)
	ECG (Suzuki 1995)
Bayesian	EMG (Cheng et. al 1992)
Feedforward, Backpropagation	Cancer (Ohno-Machado& Bialek 1998, Theeuwen et.al 1995)
	Cardiovascular System (Keller et. al 1995)
	ECG (Hu et. al 1992)
	Electromyogram (Hassoun et. al 1992)
	Human Gait Analysis (Rodrigues et. al 1999)
	Medical Image Analysis (Karkanis et. al 2000)
	Prescriptions/Drugs (Bryne et. al 2000)
Hopfield	Medical Image Analysis (Tsai et. al 1998)
Neuro-Fuzzy	Simulation of Elastic Tissue (Radetzky et. al 1998)
Resilient Propagation	Medical Image Analysis (Lasch et. al 2000)

5 Conclusion

In this paper, based on literature we conclude that Artificial neural network have a successful effect in biomedical engineering. Artificial neural networks can be applied in

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another field's of biomedical engineering such as: biomaterials, electrophysiology, biotechnology, modeling, instrumentation, rehab engineering, biomechanics, medical analysis, biosensors, prothetic, imaging, clinician, computers devices, informatics. In our case study, the experimental system achieves an excellent classification accuracy of 99%, which is best than before.

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