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Review Article

Artificial Neural Networks: Prediction of mortality/survival in gastroenterology

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ABSTRACT

Artificial Neural Networks have increasingly been used for building prognostic models in several medical domains. We discuss these networks along with their drawbacks and review their use in the prediction of survival and mortality compared to conventional models or gold standard disease scoring techniques in the field of gastroenterology. Our paper also emphasizes the development of web enabled multi-institutional neural network models based on two sets of variables for harnessing the potential of machine tools in the prognosis of patients.

1. Introduction

Survival of patients is the major concern both for their relatives as well as for their doctors and depends on a large number of risk factors viz., clinical features, age, sex, elective or emergency operations, comorbidities and length of stay in hospital. Premorbid factors, characteristics of the disease, the patient's preoperative condition, operative factors, and the surgeon's training are all associated with different surgical outcomes across different gastrointestinal operations which should be assessed when auditing.[1] Thus, predicting the survival and mortality is complicated and requires an intelligent model that takes care of the complex relationships between the response variables and a set of so-called predictor variables. A number of scoring techniques and conventional statistical models developed over the years have been extensively used in a variety of medical domains for the diagnosis and prognosis of patients. These methods have been successfully applied in many research studies because of their simplicity as well as ease in interpreting the results, but have failed to address the main issues often due to the inherent complex nature of the data. During the last two decades, artificial neural networks (ANNs) have become the models of choice in many medical data classification tasks and have shown an improved predictive ability over standard techniques. They have been successfully used in many areas of medicine and as evidence of health benefit in medical interventions.[2,3] ANNs, an advanced and effective artificial intelligence technique, can improve the classification accuracy and survival prediction of a number of gastrointestinal diseases.[4]

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Although, ANNs have become popular during the last three decades, they have been criticized as well owing to their "black box" nature showing little or no explanatory insight into the relative importance of input variables, "overfitting" problems with smaller data sets, difficulty in selecting input variables and the requirement of a long time for developing optimal models. Occasionally, they have also been criticized for their poor performance compared to traditional models. A comparison study of ANNs with other statistical approaches in medical data sets concluded that out of 28 studies, an ANN outperformed regression in 10 cases, underperformed in 4 cases, and was at par in the remaining 14 cases.[5] However, in 8 studies with sample sizes of over 5000, regression and ANNs were at par in 7 cases and in only one case did regression perform better than ANN. In view of these observations, we review critically the status of the applicability of ANNs and their performance *vis-a-vis* conventional models and scoring techniques especially with reference to survival/mortality prediction in the field of gastroenterology. The paper also discusses some of the shortcomings of ANNs for which they remain under criticism.

2. Artificial Neural Networks

2.1. *ANNs and network architecture*

Artificial Neural Networks are data mining tools, developed from biological inspiration and have been successfully applied in numerous fields viz., business, applied & basic research in medicine, engineering, agriculture, genomics, web searches and industry ANNs process information through artificial neurons(nodes), the way neurons in a human brain do and are capable of recognizing things like patterns, voices, images and odours etc. Today, neural networks have been developed ranging from a few to billions of neurons (nodes). Perhaps, the biggest neural network developed was by Andrew Ng and Stanford researchers which has 11.2 billion neurons, whereas a human brain has 100 trillion of neuron connections. This network is six times the size of Google's network developed to recognize cats on the internet.[6] Artificial Neural Networks are receiving increased attention in almost every discipline of medical sciences in the diagnosis of diseases, pattern recognition, predicting the survival/mortality of patients as well as for classification of cases. They have been successful in uncovering the complex nonlinear relationships and interactions present in the data and in predicting the response for a given set of predictor variables.

Many different ANN models have been proposed since the 1980s. Several types of neural networks have been designed already and new ones are being invented every week but all can be described by the transfer functions of their neurons, by the learning rule, and by the connection formula.[7] Unlike traditional models, they are made intelligent by way of supervised learning where the network is trained by presenting the correct output (e.g. to classify high-risk patients and discriminate them from low-risk patients) and the learning is supervised at each stage whether it is right or wrong. The supervised learning has a supervisor or teacher all the time to guide correct classification, whereas unsupervised learning doesn't have to do so. ANNs are also designed with unsupervised learning where no target results are provided to the input data and the network is supposed to find similar patterns and place the cases in appropriate clusters or groups.

A Multilayer Perceptron Feed Forward neural network trained with a back propagation algorithm is the most popular network and is widely used in many applications in medical science. The information in an ANN (Fig. 1) travels from the nodes of the input layer with varying signal strengths (weights), processed through hidden layer(s) nodes and finally passing through some activation (transfer) function reaches the nodes of the output layer as shown in the figure. These hidden nodes help in capturing the pattern in the data and make the network different from the conventional linear model. Most of the neural networks have been designed either with one or two layers with a varying number of nodes. The most tedious part of ANN is its designing followed by training and testing. Once the network is trained and tested it can be given new input information to predict the output. Below we discuss some of the problems that are encountered in developing an ANN model.

2.2. *Overfitting*

One of the common problems popularly known as "overfitting" occurs when the neural network is trained on comparatively smaller data resulting in a very small error. Such a network when further tested on the other part of the data set normally yields a large error. The reason being that the supervised learning makes the network familiarized with the examples fed during the training process but fails to generalize to newer data or situations while validating the network. There are number of approaches to overcome the problem of overfitting. However, the simplest approach is to either collect more data or to reduce the number of nodes in the network.

2.3. *Optimal model*

Unlike conventional models, finding an ANN optimal model is a tedious job and requires a lot of time. In general, networks with fewer hidden nodes are preferable as they usually have a better generalization ability and less overfitting problems.[8] As of today there is no structured method to identify the best architecture. It is trial-and-error approach adopted by researchers to find the best network. Although, considerable research has been done in the area of forecasting, yet, the

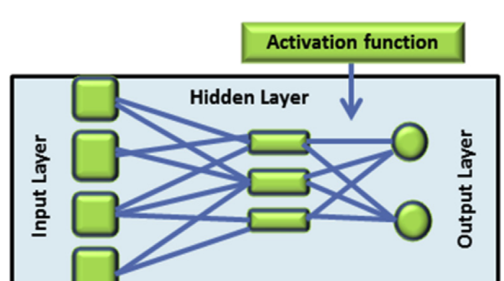

Fig. 1 – Neural network structure.