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Artificial Neural Networks to Predict Patient's Length of Stay

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Abstract

Hospitals determine the anticipated length of stay (LOS) based on the national benchmarks data. Those benchmarks are based on admitting diagnosis, Diagnostic Related Groups (DRGs), patients' age, sex, and other comorbidities. Providers are reimbursed based on these LOS calculations, since patients with similar DRGs/LOS are supposed to utilize comparable amount of hospital services. But unfortunately every patient is unique and every hospital is unique and the anticipated length of stay is far from accurate. We used large amount of historical data on our patients, compared the length of stay against their demographics, vital statistics and lab results. We attempted to use artificial neural networks (ANN), as a predictive modeling tool to learn this historical data and predict the length of stay for a new patient. We found that the neural network was able to predict the LOS 95% of the time within one day of error. We believe that ANN can be used to reliably predict the LOS at the time of admission

Keywords:
length of stay, artificial neural networks, prediction model

Introduction

Artificial Neural Network (ANN) is a computer algorithm that is modeled after the brain neural cell network. Scientists believe that humans learn new patterns by association. The human brain constantly looks for patterns in the real world, and associates these patterns with the outcomes. The brain cell network makes changes to the connections to store these patterns. After learning these large number of patterns and outcomes for those patterns, the brain cells will be able to predict an outcome for a pattern that is unique, based on the past experience. Thus an ANN can be trained using a large number of examples, to learn the implicit relationships between the variables that influence an outcome. Thus a trained ANN can be used to predict an outcome based on a set of variables that it has not seen before. We have referenced a few works in the past that have used this technology to predict LOS [1,2.3]. We attempted to use this technology to learn the influence of patients' demographics, vitals signs, and lab results in the total LOS, then use a trained network to predict the LOS based on those influencing factors that are available at the time of admission

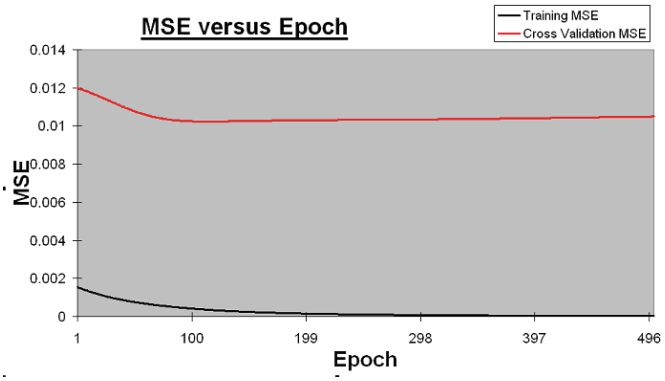
Materials and methods

We gathered the actual LOS data from our own patients, for the past 5 years. We tabulated these patients' demographics, such as age, gender, ethnicity, religion, city, state and active problems, vital statistics such as weight, height, blood pressure, respiration, pain score, and lab results such as chemeistry and hematology that are available at the time of admission. We were able to gather data from about 2000 patients without any missing elements. The population included all age groups from infants to all the way to the 90s and has a mix of all ethnic populations. We analyzed the data for any correlation between any of the above factors against the actual LOS.

We built a correlation matrix so that we will be able to filter any combination of the demographics components like city, gender, ethnicity etc, and visualize the effect of that on the LOS against any age groups.

We used the correlation model that was provided by the Neural solution plug-in for Microsoft excel. We couldn't find any consistent correlation using this tool.

Figure 1 - Shows the cross validation set with the MSE increasing after 100 epochs



We attempted to use artificial neural networks, as a predictive modeling tool to solve this problem. We were able to capitalize on the large amount of historical data available on our patients. We split the patient data into 3 parts, a training, validation a test set with 1000, 500, and 500 patients respectively. We tried different ANN architecture, learning parameters, and transfer function to determine the best architecture for this problem. We trained the network with the demographics data against the actual LOS on the training set and tested the accuracy of prediction by the

trained neural network on the test set. We found that the neural network was able to predict the LOS 95% of the time within one day of error. We are currently studying the value of feeding this anticipated LOS with additional parameters, like vital statistics and lab results to a series of trained networks, to fine tune the prediction accuracy.

Results

The artificial neural network learned demographic pattern to predict the LOS in the training set within 3000 epochs as shown in Figure 4 very accurately.

While training we used a cross validation set to compare the reduction in the mean square error (MSE) while learning, so as to stop the training when the MSE tend to increase in the cross validation set. That way the neural networks is prevented from over fitting the training set, but to make it more generalized so as to predict the test cases with a fair amount of accuracy.

Table 1 - The neural network learned the LOS very accurately as shown here within 3000 epochs. The LOS after 50, 250, 1000, and 3000 epochs are shown below

LOS	50	250	1000	3000
16	12.3	15.47	15.983	16.002
6	7.0	5.57	5.947	6.001
7	7.8	5.24	6.910	7.006
7	7.7	6.72	6.977	7.001
7	7.2	6.48	7.139	7.005
2	5.3	4.91	2.250	2.015
7	5.9	5.08	6.900	7.004
5	5.6	3.95	4.962	5.001
23	14.5	22.36	23.012	23.008
3	6.7	3.91	3.284	3.013
5	10.6	6.24	4.981	5.011
4	8.1	4.27	3.983	4.003
4	2.6	4.51	4.088	4.011
7	5.4	4.27	7.053	7.006
5	10.3	4.36	5.028	5.005
7	10.9	5.79	6.970	7.007
4	10.5	5.18	3.917	4.007
4	6.2	4.28	3.994	4.006
10	7.0	10.98	9.902	10.007
7	12.5	7.36	7.043	7.012
22	21.2	21.66	22.005	22.022
2	8.4	4.81	2.266	2.001

After the training we tried to use the trained neural network to predict LOS on a test set that the neural network has not seen before. The following table reflects the performance of the network.

The following table shows the prediction for LOS for all patients by trained network. The actual average LOS for all patients was 7.6 against the Neural Network that predicted the average to be 8.0. The current LOS prediction based on the national benchmarks data gives an average LOS value of 4.5. Thus the neural network prediction is very close to the actual since it is based on the local rather than the national aggregate data showing the value of local data in predicting the outcome since the local demographic mix and the local factors are more valuable.

Table 2 - Predicted Length of stay by NNW

	All		599pt
	LOS	Current	NN
Average=	7.6	4.5	8.0
Total=	4436	2607	4637

We were also able to train the NNW on a particular population of White Baptist, and then use the trained NNW to predict the LOS for that group. This will help us to predict outcomes even more accurately, if we have sufficient number of training data for that population.

Table 3 - Predicted LOS for White Baptist

	All		73pt
	LOS	Current	NN
Average=	7.2	5.1	7.7
Total=	512	361	545

We used the White Baptist since we had more patient data in that group than any other group.

Discussion

We believe that if a large number of historical data is available, an ANN can be used to reliably predict the LOS at the time of admission. Also as new evidence becomes available, like the vitals and lab results, those data could be used to continuously fine-tune the predicted length of stay. Once the care providers see the accuracy of predicted anticipated length of stay, and how it changes based on the accumulation of new evidence during the course of the patient stay, they would be able to fine tune their delivery of care to optimize the quality of the outcomes, enhance patient throughput and maximize reimbursement.

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