Chapter 5

RESULTS AND DISCUSSION

The data set of breast cancer patients were used in several experiments in order to model breast cancer survival. In this chapter, the results obtained from the neural network experiments using different algorithms, different pre-processing techniques and different neural networks are discussed.

5.1 Non-Parametric Survival Models of Breast Cancer

The results obtained from the Kaplan-Meier analysis from the nine-year analysis of 849 breast cancer patients seen at UMMC confirms the significance of factors such as stage, TNM classification, lymph node involvement, and grade as prognostic indicators. This is in agreement with the findings reported by Cheryl et al. (2000) and Rudan et al. (1994). Further discussions on the results of the Kaplan Meier Analysis can be found in Appendix B. We note that the Kaplan Meier Analysis carried out in this research was to confirm the significance of the mentioned variables as prognostic indicators. It is not within the scope of this research to carry out a comparison between the Kaplan Meier Analysis and with the predictions of the ANN. As has been shown by Abdul-Kareem et al. (2001), ANN produces a better estimate of survival time than statistical methods. Thus the focus of our research is in the application of ANN in the prediction of survival.

5.2 Neural Network Results

This section describes the results obtained from several experiments conducted using ANN technology to predict the survival prognosis of breast cancer. Several neural networks were created and trained using the same number of neurons, layers, epochs, performance goal and various training algorithms. A 17-15-1 network, with tansig-tansig-purelin was used. This parameter was chosen by trial and error as is usually done in the training of a neural network   Several experiments using different data pre-processing techniques, various training algorithms, and survival intervals are done to lend credibility to the entire exercise.

5.2.1 Percent Accuracy of Survival Using Different Pre-processing

Two backpropagation neural network models with different pre-processing methods namely, PCA and "One of N" representation were developed and trained to predict the survival of breast cancer patients. The neural network were reinitialised and retrained three times to produce better solutions (Demuth & Beale, 2000). Table 5.1 shows the results of training using different pre-processing methods. A discussion on PCA and "One of N" representation can be found in section 4.3.3.

Table 5.1: Percent Accuracy using different pre-processing

Survival Year	Pre-Processing	
	1 of N (%)	PCA (%)
1	86.44	88.14
2	72.88	64.41
3	71.19	66.10
4	76.27	74.58
5	84.74	76.27
6	89.83	84.75
7	96.61	93.22
8	98.31	96.61
9	98.31	98.31

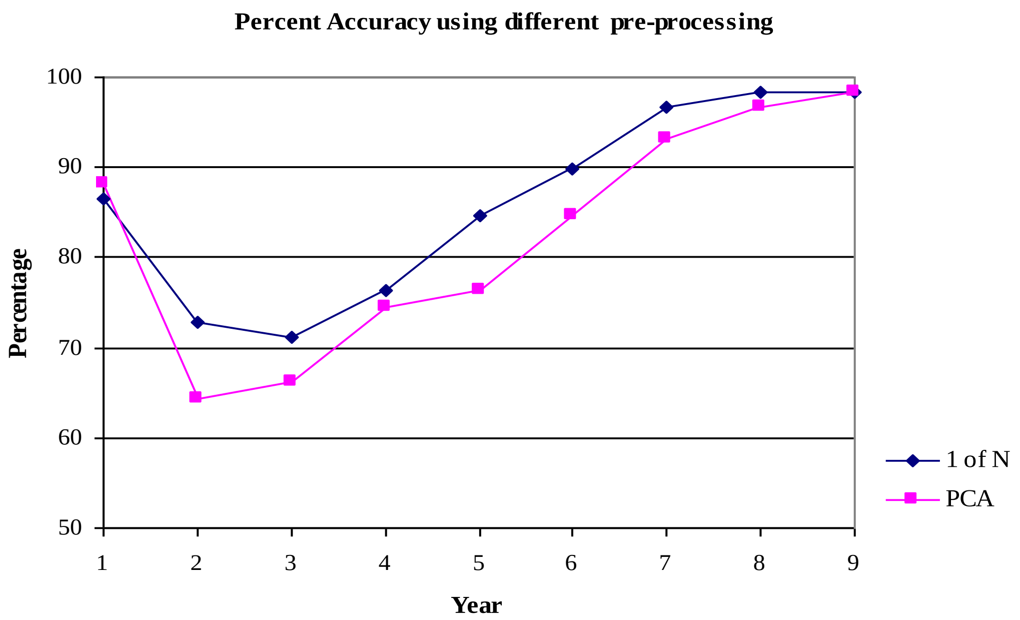

Figure 5.1: Percent Accuracy of neural network using different pre-processing

Figure 5.1 shows that the results of percent accuracy for the first year given by PCA is better than the "One of N" representation but this changes for the second year onwards, showing that the "One of N" representation gives better results than the PCA pre-processing techniques. As discussed in section 4.3.3.2, the "One of N" pre-processing results in binary data thus it seems that it is easier for the network to achieve convergence when the inputs and outputs are in "1s" and "0s".

However, the differences between the results obtained using the PCA and that using "One of N" pre-processing are not significant with p = 0.243 (p > 0.05). As mentioned in section 4.4.2, the hypothesis which states that there is no significant difference between one processing technique and the other is accepted if p > 0.05.

5.2.2 Percent Accuracy of Survival Using Different Algorithms.

Four different backpropagation neural network models were developed and trained using different training algorithms to predict the survival of breast cancer patients. The neural networks were also reinitialised and retrained three times. All algorithms used "One of N" pre-processing in the training. The results of percent accuracy after three times retraining for four different algorithms are shown in Table 5.2.

Table 5.2: Percent Accuracy using different algorithms

Survival Year	Algorithms			
	RP (%)	LM (%)	SCG (%)	OSS (%)
1	86.44	81.36	84.75	86.44
2	72.88	66.10	64.40	69.49
3	71.19	67.80	62.71	64.40
4	76.27	61.02	67.79	74.58
5	84.74	77.96	81.36	84.74
6	89.83	83.05	88.13	88.13
7	96.61	88.14	94.92	96.61
8	98.31	94.92	96.61	98.31
9	98.31	98.31	98.31	98.31

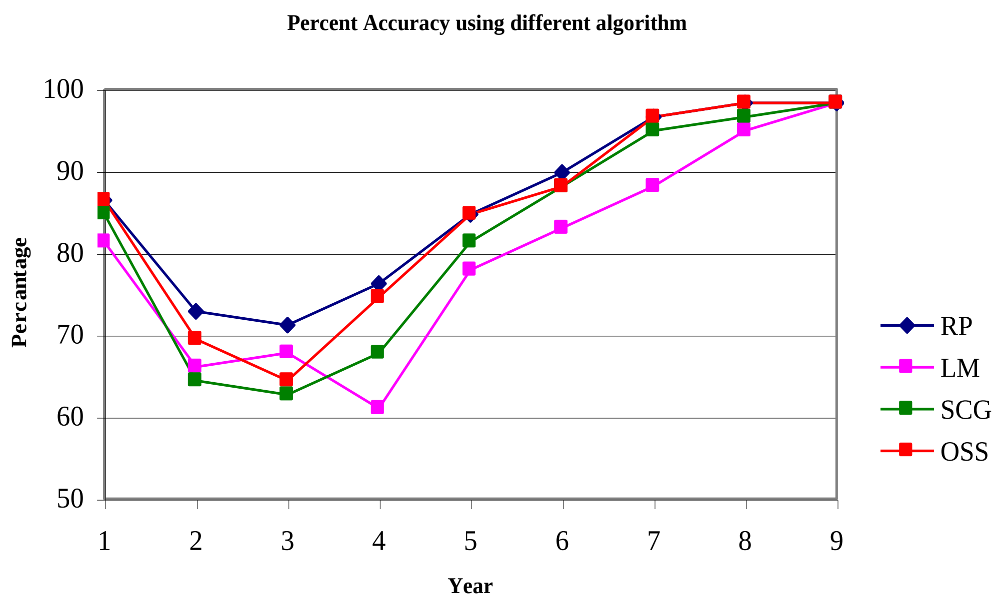

Figure 5.2: Percent Accuracy of neural network using different algorithms

Figure 5.2 shows the results obtained from all the training algorithms and indicates that Trainrp produces the best results. There is not much difference between Trainrp, Trainoss and Trainscg algorithms, and so they are suitable for use in training the survival data of breast cancer ($p>0.05$). This is in agreement with the findings reported by Abdul-Kareem et al. (2001), in the prediction of the survival of nasopharyngeal carcinoma (NPC). Although Trainlm produces reasonably good results (61%-98% accuracy), Trainlm took a long time in order to obtain convergence during the training stage.

5.2.3 Percent Accuracy of Survival Using Different Neural Network

Table 5.3 shows the results obtained using a feed forward backpropagation network and a recurrent (Elman) network. Both networks used the same number of neurons, layers, transfer functions, epochs, performance goal and pre-processing ("One of N" pre-processing).

Table 5.3: Percent Accuracy of Feed Forward and Elman neural network

Survival Year	Neural Network	
	Feed Forward (%)	Elman (%)
1	86.44	86.44
2	72.88	69.49
3	71.19	67.80
4	76.27	69.49
5	84.74	79.66
6	89.83	86.44
7	96.61	96.61
8	98.31	98.31
9	98.31	98.31

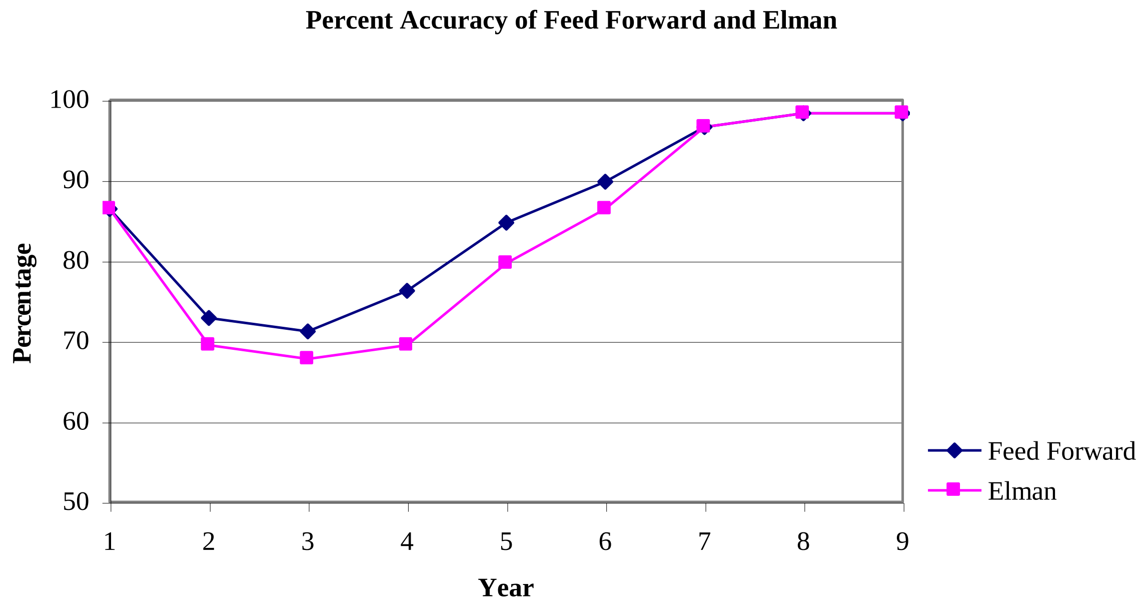

Figure 5.3: Percent Accuracy of Feed Forward and Elman Neural Network

Figure 5.3 shows the results of percent accuracy obtained from feed forward backpropagation and Elman neural network training. The percent accuracy obtained for the first year of survival for both models is the same with 86.44 %. In the second year until the sixth year of survival, the results show that the backpropagation network gives better results than the Elman network. The results for the seventh, eighth and ninth year of survival are the same for both the neural networks.

However, although we can conclude that the predictive performance of the backpropagation neural network is generally better than that of the recurrent network, the results of the first year of survival, and that of the seventh, eight and ninth shows no difference in the backpropagation and the recurrent network. The differences between the results obtained using the backpropagation and that using Elman neural network are not significant with $p = 0.120$ ($p > 0.05$). Thus, although most work in survival analysis has been involved with backpropagation neural networks (Burke et al., 1997) we would suggest that either one of these two networks could be used in other similar experiments.

5.2.4 Cross Validation

Cross Validation is a technique usually used to validate the data set. The description of the cross validation technique has been discusses in section 4.5. Cross validation technique was applied to make sure that there is no bias between the data taken for the generalization and overall data. Table 5.4 shows the result obtained with cross validation and non-cross validation using “One of N” pre-processing with Trainrp algorithm and backpropagation neural network models. A chi-square test shows that there is no statistical difference between the results obtained using cross validation and without cross validation with $p = 0.243$ ($p > 0.05$).

Table 5.4: Percent Accuracy of Cross Validation and Non Cross Validation

Survival Year	Cross Validation	Non-Cross
1	88.14	86.44
2	66.83	72.88
3	68.76	71.19
4	71.43	76.27
5	80.87	84.74
6	91.05	89.83
7	97.35	96.61
8	99.27	98.31
9	99.52	98.31

5.3 Summary

The results obtained from the neural network experiments are presented in this chapter. The results obtained from different pre-processing techniques indicate that “One of N” pre-processing is better than PCA pre-processing technique, however there were no significant differences between the results of the two techniques. The results using different training algorithms indicate that Trainrp gave a better result than the other algorithms and it can be used as the starting point for training survival data. The work done using feed forward backpropagation neural network was extensively carried out, but only a limited amount of work was done using the recurrent network. From the results obtained, there were no significant differences in the percent accuracy of the feed forward and recurrent network. We would suggest that the recurrent network could be used as an alternative in survival analysis experiments. The results produced after the data set was validated using cross validation technique are also presented in section 5.2.4 with no statistical difference between using cross validation and without cross validation.