



CHAPTER V

CONCLUSIONS AND FUTURE WORKS

5.1 Conclusions

Curl is one of the most important paper quality indexes in paper making industry. The research proves the robust bagging neural network-forecasting model for paper curl with fancy data preprocessing. The comparison of several previous sub-models training groups helps to choose the most suitable modeling focused on the detailed target in working environment of paper making factory which will benefit both paper curl testing and symptom controlling.

In this research, the source data from the paper factory database will be firstly preprocessed by several steps, and then the data will be separated into two different groups of data sets according to two different design methods. The preprocessed data will be firstly be normalized by max-min transformation. Then the data should be separated into three groups, training data, validation data and testing data. By some pruning methodologies, such as preliminary training, early stop, direct connection, the designed model can be shown in a very healthy performance. After that, two Newton-based learning algorithms will be used to train the models grouped with different preprocessed data sets, through setting several numbers of hidden units in the experiment. A best model will be chosen from the compared experiment result. The value of MSE shows that, for the middle scale size of source data in paper making field, the best model suitable for this research topic is the model that using Quasi-Newton algorithm with the source data set from PCA process setting in 8 hidden units. The selected model will be improved the performance by using the re-sampling method of bagging which is approximately same as bootstrap technology. After using bagging steps, the final value of testing data set MSE decreased from 0.00261968 to 0.000017593, which proves the efficiency of bagging technology. The detail of these steps is shown in Figure 5.1.

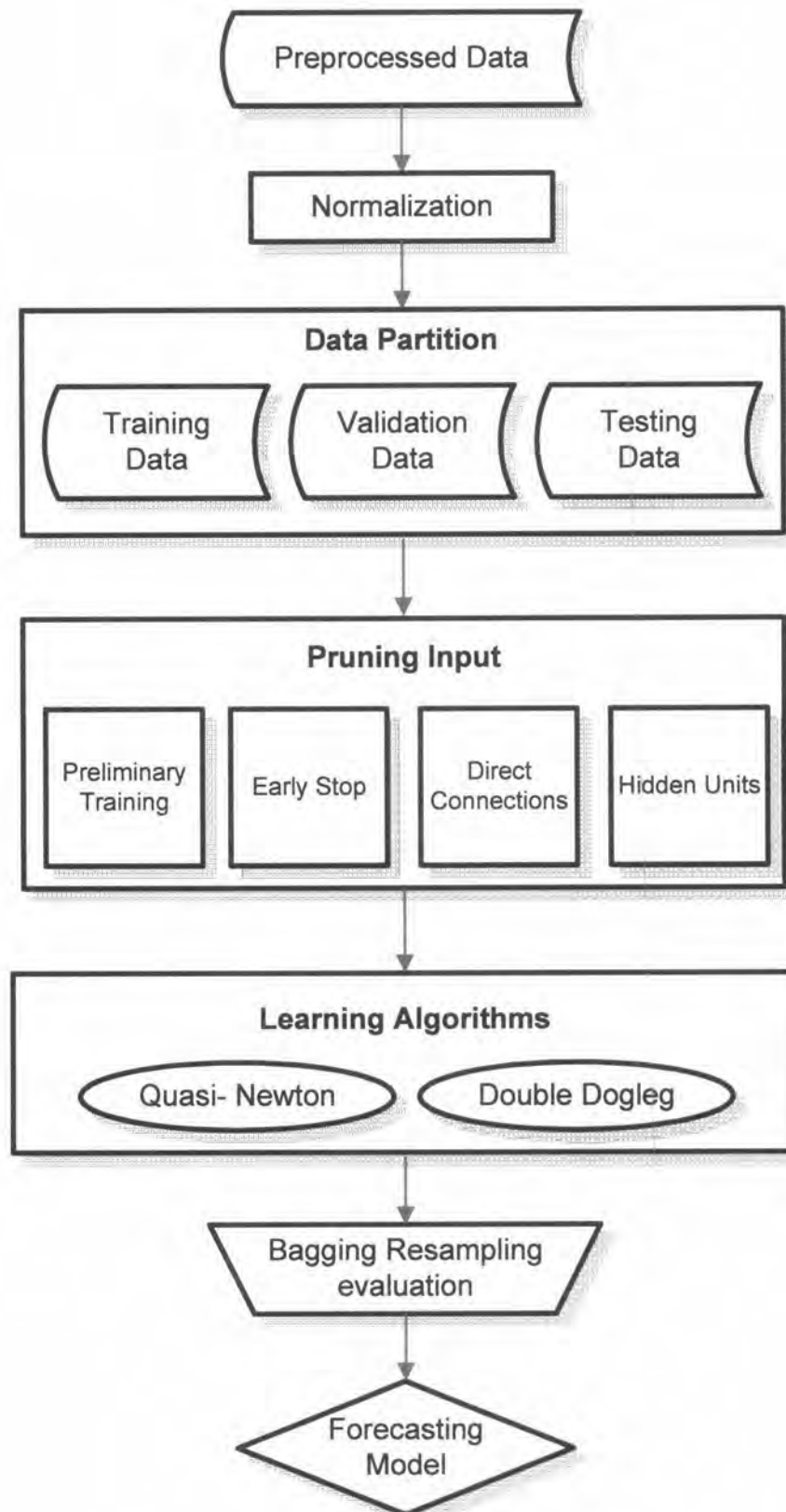


Figure 5.1: Detailed design layout.

The designed models may be used as a powerful tool for the reduction of

paper curl, thus enhancing paper quality and reducing production waste. It could be used in paper-making process together with the paper machine controlling system, to support operators and factory engineers to monitor and master the paper manufacturing situation in a good guarantee of the final quality indexes of paper products.

5.2 Discussions

In the forecasting and prediction area for paper making industry, the following issues should be highlighted when we design different models for individual environment:

- The source data selection to support different target output prediction
- The suitable preprocess step for source data for training preparation
- The trial of different learning algorithm according to different source data scale
- Linear relationship between the source data and target
- Evaluation step assess data in the binary format

In the design of the paper curl forecasting models, we use the technique of direct connection to solve the problem of the some linear relationships between the input data sets and output target. Some other methods can be used to try to resolve the situations. For example, a combination of neural network and regression could also be an ideal solution for this issue.

Furthermore, the selection of hidden units is also a tough task for neural network model. Normally there is no standard method in selecting the appropriate number of hidden units. In this research, we use traditional idea to set a hidden unit number first, and then change the value forth and back, finally compare the different results values to consider about the proper number of hidden unit for the neural network model. However, we can design more complicated neural network architecture to solve the instability of selection hidden units. For example, both cascade correlation and sequential network construction can appropriately solve this problem. Sequential network construction starts with one hidden unit and using the final weight estimates at each step as starting values in subsequent steps. Cascade correlation is basically fitting both a single hidden layer unit and a linear design. Frozen weights are used in this technology.

5.3 Future works

The designed models are abstracted in each ten minutes. However, the production process data of papermaking are time series. The related data are increasing all the time. How to design a suitable model in time series? How to move the experiment model from off-line to on-line prediction for improving its real-time function will be a challengeable task in the future. With on-line learning, we can not use pruning technique such as early stopping, cross-validation and bootstrapping, because it could not compute the objective function on the training set or the error function on the validation set for a fixed set of weights, since these data sets are not stored stably. This is a topic to move the research direction from supervised learning to unsupervised learning, which would need more related knowledge and profound background in paper making industry.

On-line forecasting model can be more useful and efficient to paper factory engineers and operators, to support their everyday job in a ad hoc state with continually enlarged input database. Therefore, design a suitable and reasonable on-line model for paper quality prediction is the target for the future works. It will bring more benefit for paper making industry.