Estimation of Word Recognition by Using Back-Propagation Neural Network

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Abstract:

In recent years, the studies on literacy and reading have been taken seriously. A lot of researchers mention that the key factor to improve the students' reading ability is word recognition. If teachers realize the ability of students' vocabulary, they can use remedial teaching to help the sub-standard students. This study uses the back-propagation neural network to establish an experimental model. The comparison of the literacy estimated results between the back-propagation neural network and the traditional statistical method is verified. This study proves that the back-propagation neural network has good credibility and extension, as well as the estimated results can be taken as the classified basis on students' literacy.

Keywords: Word Recognition, Reading Ability, Back-Propagation, Neural Network, Vocabulary Volume.

1. Introduction

Literacy is the foundation of reading and writing. If learners lack literacy skills or have a literacy problem, their future reading and learning may be both affected. They may waste a lot of time during reading and thus fail to engage in effective learning or affect their learning achievement [1]. Consequently, if the literacy skills children should possess can be understood, it is possible to provide the children who fail to meet the standard with remedial teaching. As a result, the test on vocabulary volume is particularly important. At present, there is no consistent estimation method used for assessing vocabulary volume in Taiwan. The difference in the chosen tools tends to lead to significant difference in estimation results. Therefore, it is a necessary procedure to use a standardized test for data identification or diagnosis [2]. However, a formal assessment is required for performing screening or growth monitoring. Taking vocabulary volume for example, if there is a test on vocabulary volume for a teacher can perform, calculate the score and perform several assessments within a year without spending too much time or disclosing its content, the objective of performing screening and growth monitoring can be achieved [3]The studies concerning vocabulary volume in Taiwan are mainly qualitative studies which seldom investigate statistical method for estimating vocabulary volume [4]. Artificial neural network is capable of learning and memorizing the inputs to the outputs, and back-propagation neural network is the most representative model commonly in practice. It is a supervisory learning network and is thus applicable to the application of diagnosis and prediction. Back-propagation neural network has been comprehensively applied to various fields. In recent years, it has frequently been applied to the financial prediction of stocks and futures. The purpose of this study was to use artificial neural network to predict vocabulary volume and to compare the result to the prediction result of vocabulary volume using traditional statistical method, as well as to verify that artificial neural network can be comprehensively promoted. Moreover, because artificial neural network possesses good learning and memory models, as the variables input in the network are increased or decreased, the target value can be calculated through the training of artificial neural network model. Therefore, it can be provided as an alternative estimation tool.

2. Problem Statement

The subjects of this study were elementary school students in a remote area in Miaoli County, Taiwan. Because grade 1 and 2 students are still at the stage of word decoding and recognition, this study selected grade 3 to 6 students as the subjects. To obtain more data, the first vocabulary volume test was performed on 46 grade 3 to 6 students in the second semester of 2010 academic year where the total sample size was 46. The second vocabulary volume test was performed on 37 grade 3 to 6 students in the first semester of 2011 academic year where the total sample size was 37. That is, the total sample size in this study was 83.The main purpose of this study was to investigate and compare the difference in the estimated vocabulary volume using artificial neural network and that using traditional statistical method. This study used the Self-edited Vocabulary Estimation Test compiled by Professor Jun-Ren Li [5] as the traditional statistical method to perform a test on vocabulary volume. The test results were input into the calculation template of Excel, and formula were used to calculate the estimated vocabulary volume. As for the application of artificial neural network, back-propagation neural network software Alyuda NeuroIntelligence was used to input the aforesaid result of vocabulary volume as the input value. The experimental model was established based on data training and

the output target value was the estimated vocabulary volume. This study compared the results of vocabulary volumes obtained from these two methods to verify that the neural network can be comprehensively applied.

3. Self-Edited Vocabulary Estimation Test

In 2010, Professor Jun-Ren Li at Department of Educational Psychology and Counseling, National Taiwan Normal University edited a test based on 5,021 word bank of Survey Report on Commonly Used Words by Elementary School Students issued by National Languages Committee (2002), classified words into three groups for random selection according to word frequency, and selected a total of 60 words as the test content. The test method was explained as follows:

3.1. Method for performing the test:

The test was performed on individuals one-on-one where the researcher read the test questions and the students verbally answered questions.

3.2. Time of the test:

The time of the test was not restricted, and there was no need to count the time. In general, it was estimated that each student could complete the test within 15 minutes.

3.3. Test method:

The students were requested to look at the test questions from the left to the left and from the top to the bottom and to make phrases for the words they knew in order. The students were all requested to answer the questions on the target words in the form of "X of XX." For example, for target word "affection," students should answer "affection of emotional affection." The students would be provided with examples before the initiation of the test to enable them to fully understand how to answer questions.

3.4. Scoring Principles:

(1) When a student makes a phrase or is able to point out the correlation, the answer will be deemed right.
(2) When a student fails to make a phrase or sentence, the answer will be deemed wrong and no score will be given.
(3) Two-word phrases, three-word phrases or proverbs are all acceptable. For example, dragon boat "racing."
(4) Names of people, such as Yat-Sen "Sun" will be deemed right.
(5) Buzzwords, such as having had "enough," will be deemed right as long as they are used correctly.
(6) Misidentification of target words will be deemed wrong. For example, for the target word "special," students answering "very of very special;" for the target word "health," students answering "very of very health." Such confusion will be deemed wrong.

3.5. Scoring method:

60 target words in the test were classified into three groups with the marks of ○, △, and □ at the bottom of Chinese letters. The number of correct phrases made would be in each group would be recorded in the score field at the bottom of record form.

3.6. Calculation of results:

The test results were input into the calculation template of Excel, and a formula was used to calculate the estimated vocabulary volume. The calculation formula was as follows:

(○ Number of correct answers ×1500÷24)+(△ Number of correct answers ×1500÷24)+(□ Number of correct answers ×2000÷12)=Estimated vocabulary volume (1)

4. Back-propagation Neural Network

Back-propagation neural network is the most representative model of comprehensive application among current artificial neural networks. Data training was used to establish the system model, and the system model could be applied to estimation, prediction, or diagnosis [6]. This study used back-propagation neural network to establish the experimental model and used the artificial neural network software Alyuda NeuroIntelligence to conduct the experiment. The procedures for establishing the model of artificial neural network were as follows [7]:

4.1. Date analysis:

This study collected data and transformed them into matrices to facilitate the input into the artificial neural network. In addition, the factors affecting estimation results were analyzed to determine the input value. The number of correct answers of the three groups ○, △, and □ (test results of vocabulary volume) were used as input variables.

4.2. Data pre-processing:

The analyzed data were processed. The data of input layer were reflected to [-1,1], and that of output layer were reflected to [0,1].

4.3. Designing the framework of artificial neural network:

It was very important to set up various parameters in the model of artificial neural network. The use of inadequate settings would lead to difficulty in convergence and early termination of network. The parameters required to be set up in the back-propagation neural network were as follows [8]:

(1) Number of hidden layers: in general, the convergence effect of one or two layers would be better. The excessive number of layers would lead to poor convergence effect. The lack of hidden layer would lead to the failure to reflect how units interact and affect one another, leading to larger error.

(2) Number of hidden layer processing units: there was no specific criterion on the number.

(3) Other parameters: e.g. learning rate, convergence target value, number of training cycles, etc. It was extremely hard to find out a universal principle for setting up artificial neural network under different circumstances. Therefore, this study used trial-and-error approach to test various parameters in an attempt to find out the optimal parameter combination.

4.4. Training artificial neural network:

The artificial neural network was operated by constantly adjusting weight values and threshold values through training. The optimal solution calculated by network would be used as target output.

4.5. Testing and analyzing performance:

This procedure made it possible to compare the difference between estimated value and actual value. Moreover, the accuracy could be understood based on correlation graphs. If the difference between training results was too large, procedures 1 to 4 should be repeated for training.

4.6. Assessment and verification:

The artificial neural network completing the training could be used to predict new cases. This study used the results of 20 vocabulary volume at other schools as test data to verify the accuracy of network and to amend it again.

5. Simulation Results

This study obtained a total of 83 effective sample data from Self-edited Vocabulary Estimation Test, and used the artificial neural network software Alyuda NeuroIntelligence to conduct the experiment.

5.1. Data analysis:

Vocabulary volume ○, vocabulary volume △, and vocabulary volume □ were used as dependent variables of input layer, while estimated vocabulary volume was used as the independent variable of output layer. After 83 data were arranged in order, the first 57 data were the training data for training the artificial neural model, 13 data were used as verification data, and 13 data were used as testing data.

5.2. Data pre-processing:

The input and output data used in this model were processed. The data of the input layer were reflected to [-1,1], and that of the output layer were reflected to [0,1].

5.3. Designing the framework of artificial neural network:

The parameters were different under different circumstances. After the testing, this study found that the optimal number of neurons of input layer was 3, the optimal number of neurons of hidden layer was 5, and the optimal number of hidden layers was 1, as shown in Figure 1.

5.4. Simulation training:

Seven algorithms could be used in the training model, and there was no significant difference among them. The users could choose the proper one according to the characteristics of the questions. After the testing, this study chose Limited Memory Quasi-Newton, the most effective one, and set up the number of training cycling as 500 times. After the simulation training was completed, the optimal convergence effect was achieved, as shown in Figure 2.

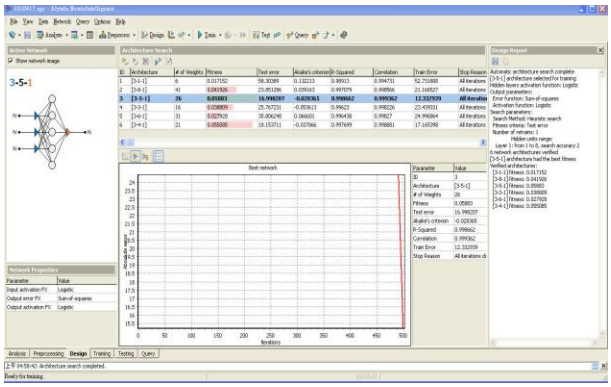

Fig. 1. Neural Network Architecture

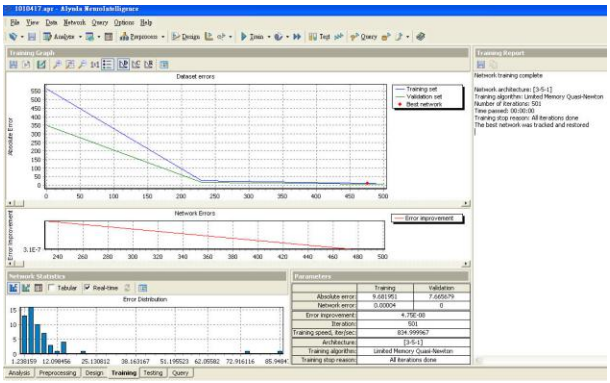

Fig. 2. Simulation Training

5.5. Testing and analyzing performance:

After the testing was completed, the comparison between the estimated values and actual values and result assessment were shown in Figure 3. According to the results, the comparison between the estimated value and actual value showed that the correlation was 0.999484, R-squared was 0.99845, and the error was small. The correlation was highly positive, suggesting that the vocabulary volume estimation model established in this study was feasible and accurate.

5.6. Assessment and verification:

This study obtained 20 vocabulary volume test results from other school as the testing data to verify the artificial neural network which completes the verification training can be used to predict new cases. The verification results showed that its predication was accurate and could be used for estimation of vocabulary volume, as shown in Figure 4.

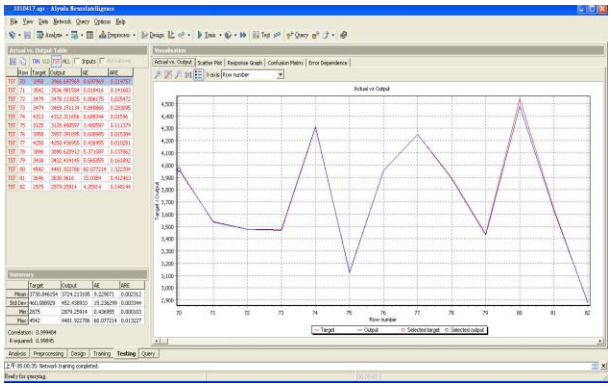

Fig. 3. Estimated Values and Actual Values

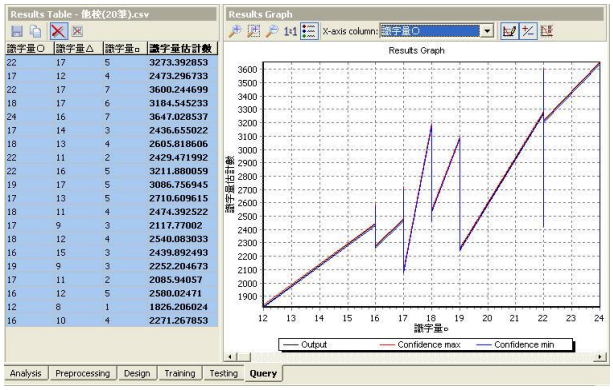

Fig. 4. Assessment and Verification

6. Conclusion

According to the simulation results of this study, 83 test results of vocabulary volume estimation of grade 3 to 6 students at Linsenes elementary school in Miaoli County were used as input values. With the training and learning of artificial neural network, the experimental model was established. Through simulation training, 20 data obtained from other elementary schools were used for verification to prove that the estimated results of artificial neural network were reliable. Comparing to the calculation template established by vocabulary volume estimation test using traditional statistical method, the error of output value from the model established by back-propagation neural network was extremely small, verifying that artificial neural network could be comprehensively applied to various estimations and predictions and be provided as an alternative as estimation tool. Moreover, artificial neural network possessed good learning and memory models. As other variables were decreased or increased, artificial neural network could replace the original statistical method to achieve great prediction effect.

References

[1] H. Catts, S. Adlof and S.E. Weismer. Language Deficits in Poor Comprehenders: A Case for the Simple View of Reading, JSLHR, Volume 49, pp. 278-293, 2006.

[2] R.P. Carver. Predicting Reading Levels in Grades 1 to 6 From Listening Level and Decoding Level: Testing Theory Relevant to the Simple View of Reading, Reading and Writing: An Interdisciplinary Journal, Volume 10, pp. 121-154, 1997.

[3] A. Lin, D.M. Podell and N. Rein. The Effects of CAI on Word Recognition in Mildly Mentally Handicapped and Nonhandicapped Learner, Journal of Specical Education Technology, Volume 11, Issue1, pp. 16-25, 1991.

[4] I. Mullis, M.O. Martin, A.M. Kennedy and F. Pierre. PIRLS 2006 International Report: IEA's Progress in International Reading Literacy Study in Primary Schools in 40 Countries, TIMSS & PIRLS, International Study Center, Chestnut Hill, MA: Boston College, 2007.

[5] J.R. Li. Phonological Awareness and Chinese Character Acquisition in Taiwan Children: A Reading Ability Control Design Research, Paper presented at the International Symposium on Cognitive Processes of Chinese Language, University of Hong Kong, Hong Kong, 1997.

[6] L. Fu and L.B. Kara. Neural Network-Based Symbol Recognition Using a Few Labeled Samples, Computers & Graphics, Volume 35, Issue 5, pp. 955-966, 2011.

[7] N.K. Kasabov, R.I. Kilgour and, S.J. Sinclair. From Hybrid Adjustable Neuro-Fuzzy Systems to Adaptive Connectionist-Based Systems for Phoneme and Word Recognition, Fuzzy Sets and Systems, Volume 103, Issue 2, pp. 349-367, 1999.

[8] J.H. Chiang. A Hybrid Neural Network Model in Handwritten Word Recognition, Neural Networks, Volume 11, Issue 2, pp. 337-346, 1998.