System of grading hand-written multiple-choice answer sheet based on neural network

Arief Hermawan
Informatics Engineering
Yogyakarta University of Technology
ariefdb@yahoo.co.id

Abstract: *The aim this study is to develop a system of grading hand-written multiple-choice answer sheets based on neural network. Through this system grading can be done by computer with high speed. The study was done by developing a software to read hand-written answers and to classify them into the answer A, B, C, D, or E. The neural network used is the Perceptron model. It is made with Borland Delphi 7 and Matlab. It was found out that the system could identify hand-written marks on the multiple-choice answer sheets with an accuracy level of 68%.*

Keywords: *grading system, multiple-choice, neural network, Borland Delphi, vector, Optical Mark Recognition (OMR), pattern-mapping, processing unit, binary value*

1. Introduction

Testing is a process measuring a person's ability based on the material studied. There are types of tests, one of which is the multiple-choice type. In the multiple-choice test the examinee choose one correct answer out of several options.

The multiple choice test can be done by crossing or circling one out of the available options on the provided answer sheet. The grading is done by matching the answer with the key answer; it can be done by making holes on the key answer sheet and putting it on the answer sheet to be graded. The correct answer is calculated by summing up the filled holes.

This grading system mentioned above has a limitation when the test is long aside from the human error factor.

In line with the development of computer technology, some systems have been developed to tackle the above problem. One of the systems is by means of the OMR (Optical Mark Recognition). Choosing the answer is done by blackening one of the circles on the answer sheet by using a 2B-type pencil. The grading of the answer sheets by means of OMR is done on the computer by comparing the selected answers of the examinees with the key answers. By using OCR the grading can be done faster and with high accuracy.

However, this system has a drawback, that is the OCR machine is expensive and the answer sheet must be of a specific kind of paper. Besides, the kind of pencil used will also determine the success of this system.

The researches on neural network show that it can be used to recognize handwriting with high accuracy. In the present study, a system of grading hand-written multiple-choice answer sheets by means of neuro network was developed.

This system has some advantage. First, it system is cheap and easy because this system does not need any OCR apparatus which is very expensive. It is done by using a common scanner. It does not need any specific kind of paper and the examinees do not have to use the 2B-type pencils to mark the answers. This system can recognize the handwriting from the patterns not from the level of blackening. Second, since this system is done on the computer, the grading can be done very fast with high accuracy.

2. Related Literature

2. Neural Network

The neural network used in this research is the Perceptron. Perceptron pattern-mapping architecture classifies patterns through supervised learning. The patterns it classifies are usually binary-value (0/1) vectors, and the classification categories are expressed as binary. The perceptron is limited to two layers of processing units with a single layer of adaptive weights between them. The element shown at the center of Figure I is the basic processing unit of the perceptron. Inputs arrive from the left, and each incoming interconnection an associated weight, w. The perceptron processing unit performs a weighted sum of its input values. The sum takes the form:

$$S_j = \sum_{i=0}^{n} a_i w_{ji}$$

where:
w_{ji} = the weight associated with the connection to processing unit f from processing unit t
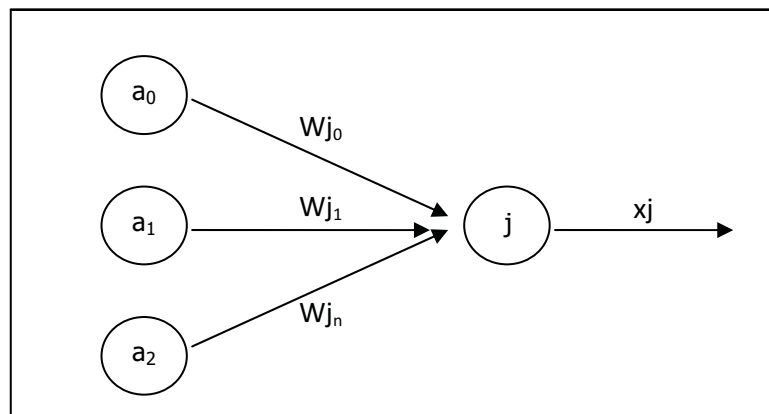a_i = is the value output by input unit t

Figure I: Perceptron processing unit.

The sum is taken over all of the units i that are input to the processing unit j. The special bias input depicted at the top left of Figure I behaves as an input unit that is always fixed at the value of $+1$. Its connection to unit j has a connection weight w_o, which is adjusted in the same way as all the other weights. The bias unit functions as a constant value in the sum (1) above.

The perceptron tests whether the weighted sum is above or below a threshold value, using the rule:

If $S_j > 0$ then $Xj = 1$
If $S_j d" 0$ then $X_j = 0$

where
X_j = the output value of processing unit f

The perceptron is trained by using a training set—a set pattern that is presented to the network repeatedly during training. Each pattern in the training set is a vector pair consisting of an input (pattern) vector, and an output (target value) vector. During training, each pattern in the set is presented to the network. When a pattern is input, the input layer assumes its values. The perceptron processing units then compute their output with the weighted sum and threshold. The network output are then compared to the desired output specified in the training set, the difference is computed, and then used to readjust the values of the connection weights. The readjustment is done in such a way that the network is—on the whole—more likely to give the desired response next time. Using the simplest perceptron learning rule, a constant is added or subtracted from the appropriate weights during learning:

$$W_{ji\,new} = W_{ji}\,old + C\ (t_{jp} - x_{jp})\ a_i$$

where :

C = a small constant (learning rate)
t_{jp} = the target value for output unit j after presentation of pattern p
x_{jp} = the output value produced by output unit j after presentation of pattern p
a_i = 1 or 0 , the value of input unit i

3. Research Methodology

To achieve the objective of the study, the following steps were need (see Figure III):
1) Designing the multiple-choice answer sheet, each sheet consisting of 100 answer items.
2) Developing software to be used to read the handwriting of the answer sheet, the software being developed by using Borland Delphi language Programming.
3) Developing neural network for classification of handwriting (see Figure II) showing the architecture of neural network used in this study.
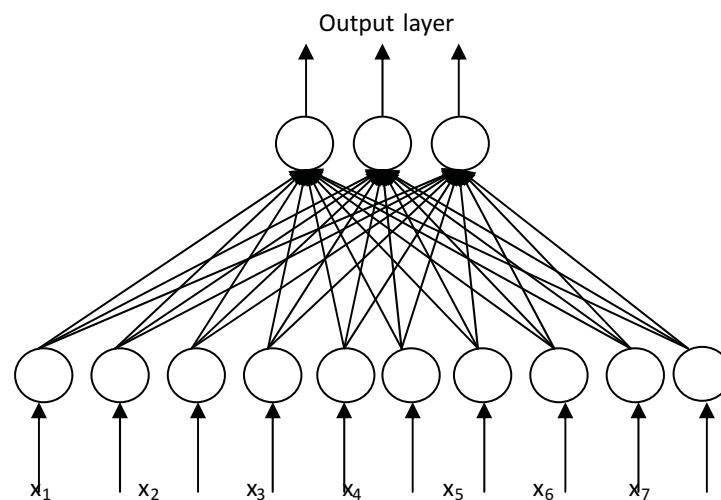

Figure II: The architecture of perceptron to identify.

The neural network consists of two layers. The first layer receives the input data by reading the image of the handwriting and the output layer presents the image as the letter A, B, C, D or E which is symbolized as follows:

a. 0 0 1 representing letter A
b. 0 1 0 representing letter B
c. 1 0 0 representing letter C
d. 1 0 1 representing letter D, and
e. 1 1 1 representing letter E

4) Training and testing neural network to recognize the pattern of handwriting of the answer A, B, C, D, and E.

The training was done with 3 people as a sample. Each subject was asked to write A, B, C, D, or E randomly on the answer sheet with the character of A, B, C, D, and E, each written 20 times. The training was conducted until neural network was convergent with an error below 0,1.

The testing of accuracy was conducted by counting the number of characters which were recognized correctly compared with whole answer on the answer sheet
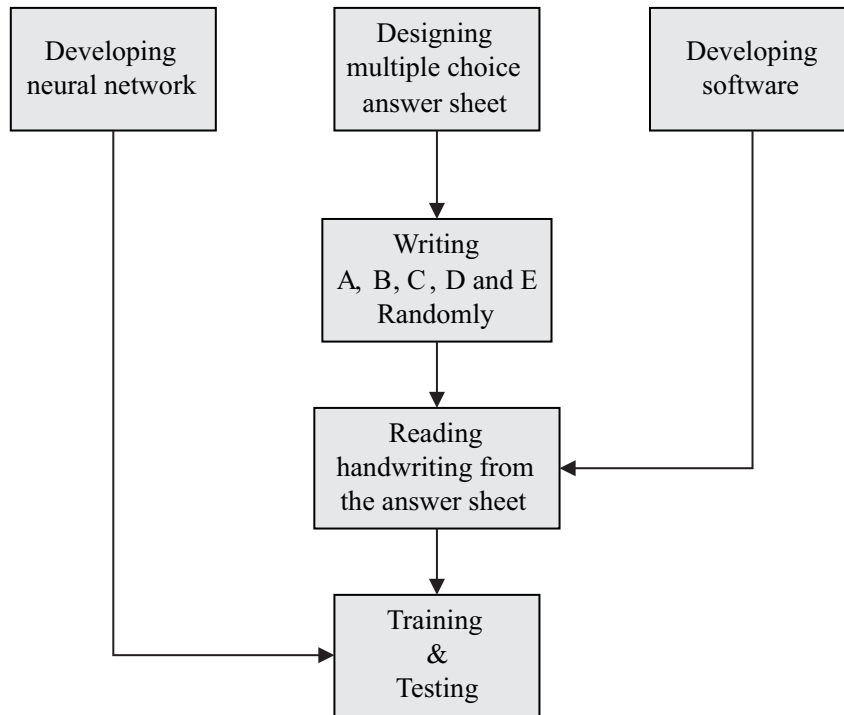

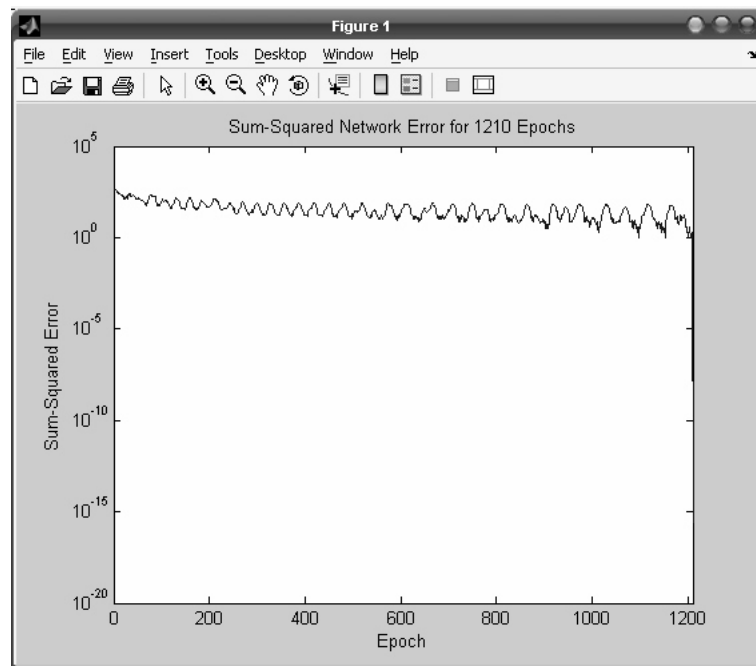**Figure III**: The research procedure

4. Result

Figure IV: The result of the try-out for three answer sheets.

Figure IV shows the results of three answer sheets (300 letters). The convergence of neural network is at the iteration of 1210. After the try out, the neural network could recognize 100% of the tried-out data (being able to recognize 300 letters well). The level of testing was conducted to recognize an answer sheet (100 letters). The results showed that it could recognize 62 letters well, but it failed to recognize 38 letters (wrong recognition). The table below shows the distribution of the mistakes in recognizing each letter.

Tabel 1. **Results of the try-out**

Letter	Correct items recognized	Wrong items recognized	Total no of items
A	16	4	20
B	11	9	20
C	11	9	20
D	12	8	20
E	12	8	20
			100

From the table above, it is seen that the best recognition by preception is on the letter A, and the poor recognition happens on the letters B and C.

5. Discussion

6. Conclusions and Recommentation

Based on the previous discussion, some conclusions are drawn and some suggestions are put forward.

1) The identification of multiple-choice hand-written answer sheet can be done by neuro network of the perceptron model. The input layer of perceptron consists of 143 cells which presents the results of reading the digital image of handwriting, and the output layer of perceptron consists of 3 cells which presents the answer A, B, C, D, or E.

2) Perceptron can recognize well all patterns tried out at the iteration number 1210. The accuracy of the patterns tried out is 100%, while at the testing level the perceptron could recognize the pattern with an accuracy of 62%. Use these recommentations based on your discussion of findings. How about more samples?

3) Further researches are needed to change the parameter of neuro network or neuro network model to improve the accuracy of recognition.

4) To apply this system easily, software is needed to be created to integrate the system of digital image reading with the pattern recognition system.

References

Alexander, I. Morton, H. (1990) *An introduction neural computing*. London: Chapman and Hall.

Bose. (1996). *Neural network fundamentals with graph, algorithms and application.* NY: McGraw Hill.

Dayhoff, J.E. (1990). *Neural network architectures*. NY: Van Nostrand Reinold.

Demuth, H. Beale, D. (1995). *Neural network toolbox for use with Matlab*. Massachussetts: The Math Work.

Rumelhart, D.E., McClelland, J.L. (1986). *Parallel distributed processing: explorations in the microstructures of cognition*, (Vol 1). London: MIT Press.

Schalkoff, R.J. (1992). *Pattern recognition: statistical, structural and neural approaches*. NY: John Wiley and Sons, Inc.

Widodo, D. (2000). Sistem pengenalan plat nomor mobil menggunakan pencocokkan pola dan jaringan saraf tiruan, http://vlsm.org/fusilkom-ui/fusilkom-00-s100abs.html

Wisna, G. (2001). Teknologi jaringan saraf tiruan, http://www.lp3b.or.id/Jaringan.htm,