Noise Removal on Batak Toba Handwritten Script using Artificial Neural Network

by Novie Theresia Br. Pasaribu, M. Jimmy Hasugian

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Novie Theresia Br Pasaribu and M. Jimmy Hasugian
Electrical Engineering Department
Maranatha Christian University
Bandung, Indonesia
novie.theresia@maranatha.edu, jhasugian@maranatha.edu

***Abstract*—This paper proposes the use of Artificial Neural Network (ANN) to remove background noise of Batak Toba handwritten script. Several artificial backgrounds are fused with the original script to reconstruct visual perception of manuscript text background. Experiments have been conducted on offline handwritten script cleaning process and show superior impact compared to threshold method and Gaussian filter. This is a seminal work on ancient Batak Toba manuscript recognition system as the primary research theme.**

Keywords—Batak Toba handwritten; artificial texture, image cleaning; ANN

I. INTRODUCTION

Offline handwritten script recognition is one of the most prominent research area due to its high variability. Among handwritten scripts, recognizing ancient manuscript is one of the most challenging problem due to several factors that degrade the manuscript quality i.e. dirty, faded, and irreparable damage. Meanwhile, material used in handwriting manuscript which is usually made of animal skin or wood, is also deteriorate the recognition process that absent in paper-based handwritten script (see Fig 1.)

However, handwritten recognition in ancient manuscript is prominent, since a lot of information inside the manuscript like guidance, rules, tradition, and medication [1] which is worthy to be conserved to enrich our knowledge and wisdom from our ancestor.

According to A.K. Jain, et al. [2] in designing a recognition system some issues should be taken care of i.e. definition of pattern classes, sensing environment, pattern representation, feature extraction and selection, cluster analysis, classifier design and learning, selection of training and test samples, and performance evaluation. It is also mentioned that to design pattern recognition system essentially involves three aspects: 1) data acquisition and preprocessing, 2) data representation, and 3) decision making. This paper focuses on data acquisition and preprocessing. This is a seminal work on recognition system of ancient Batak Toba manuscript, following the previous works [3], [4]. The objective of this work is to remove background noise in Batak Toba handwritten script with several artificial textures using ANN method.

Section 2 introduces the data acquisition and preprocessing steps, showing illustrative examples. Section 3 describes the proposed ANN topology and the experimental setup. The results and analysis are shown in Section 4. Finally, conclusions and further works are drawn in Section 5.

II. PREPROCESSING

A. Short Overview of Batak Toba Alphabet

The Batak Toba language with its alphabet is an Austronesian language that originates from northern Sumatra in Indonesia [5]. It is an *abugida* (combination between *syllabogram* and alphabet). As *abugida*, Batak Toba alphabet consists of consonant letters (*ina ni surat*) and vowel sounds (*anak ni surat*) as diacritic [1] as illustrated in Fig 2.

Batak Toba alphabet consists of 19 *ina ni surat* and 6 *anak ni surat* without any distinction between upper-case and lower-case letters. For preliminary information, some ancient Batak Toba manuscripts are provided by Logan Museum of Anthropology through their website [6].

B. Data Acquisition and Preprocessing

Batak Toba handwritten data used in this work is selected from handwriting of hundreds of students in school in Balige, North Sumatera, Indonesia. The students were asked to write a common poem in Batak Toba tradition in a piece of paper. Then these handwritings scanned with 300 dpi resolution.

Fig. 1. Ancient Batak Toba manuscript (source: TB Silalahi Center, Balige)

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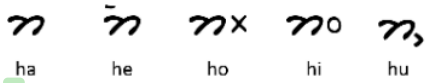

Fig. 2. The consonant letter 'ha' and the diacritics with Latin transliteration

Before any other preprocessing step, the scanned image is first cleaned and enhanced using threshold method [7] and used as target data sets for Artificial Neural Network (ANN) training process. In order to imitate the real ancient Batak Toba manuscript visualization, the scanned image $I_s(i,j)$ is combined with four paper texture images $I_t(i,j)$ to produce handwritten-script with artificial noisy-background $I_n(i,j)$. Later, these scripts are used as testing data sets. Fig 4. illustrates the process to produce image testing data sets.

Wavelet-based image fusion method [8] is used to combine the scanned image with 4 paper textures (see Fig 3.). Daubechies wavelet function with level 5 decomposition is used in the fusion process. This function is chosen because after several attempts, the image fusion gives the visual perception similar to the ancient Batak Toba manuscript text.

III. ANN Topology & Experimental Setup

To the best of our knowledge, several attempts in implementation of Artificial Neural Networks (ANN) in handwritten-text image cleaning are reported in [9] and [10]. Those papers show the benefits of using ANN in handwritten-text image cleaning and give significant impact in handwritten recognition.

What differ this work are in the process of creating training and testing data sets for the ANN and the topology as well. The overlap moving sliding-window (11 x 11 pixels) is fed to the ANN to clean the pixel at the center of the window. The ANN topology is described in Table I.

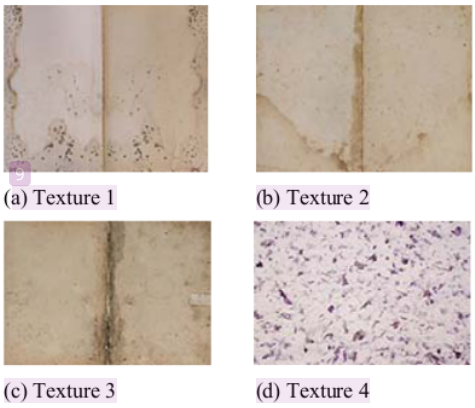

Fig. 3. Paper textures used as artificial-background

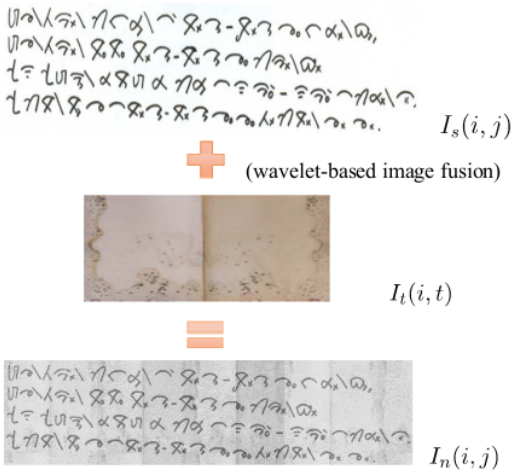

Fig. 4. Process to produce text similar to ancient manuscript using wavelet based image fusion

TABLE I. ANN Topology

Input Node	ANN Layer		
	Hiden Layer 1	*Hidden Layer 2*	*Output Layer*
(11x11)	48 neurons	16 neuron	1 neuron

The ANN has two hidden layers with 48 and 16 sigmoid units, and one output saturated-linear unit. Training was performed using backpropagation algorithm with gradient-descent momentum, using Mean Square Error (MSE) function.

Fig 5. describes the process of ANN Training. Training data used in this process is only one symbol (character) which has been fused with artificial texture 1. And as showed in the figure, the target image is also only one symbol relates to the training image. ANN performance is depicted in Fig 6. The system reach the performance goal, i.e. error 0.01. Diagram in Fig 7. shows the simulation process of ANN.

Fig. 5. ANN Training process

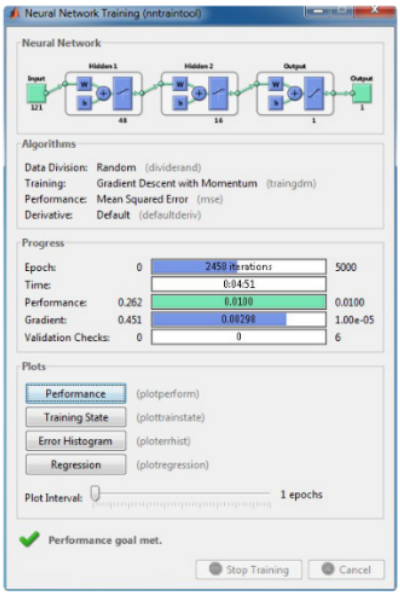

Fig. 6. ANN Training Performance

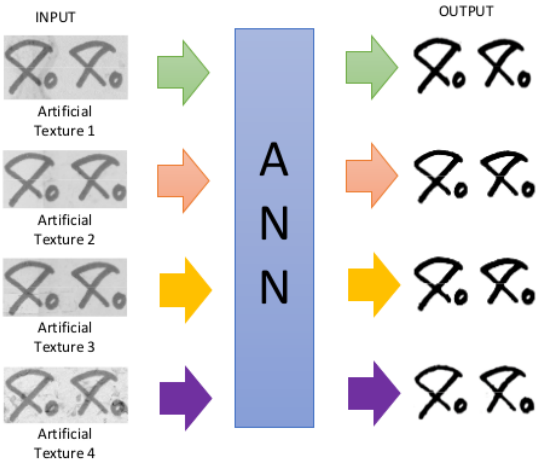

Fig. 7. ANN Simulation Process

By using the same scheme like illustrated in Fig 7., two other common methods i.e. threshold method and Gaussian filter (sigma parameter is equal to 0.5) is simulated also. Then the performance of ANN is compared with the other methods.

IV. Results

Due to the space limitation, the sample result of each method in the cleaning process with artificial background texture 1, is presented in Table II. In most image enhancement studies, the degradation modeled by additive noise is referred to in term of a metric called the PSNR (peak signal-to-noise ratio).

$$\mathrm{PSNR} = 10 \times \log_{10}\left(\frac{255^2}{\mathrm{MSE}}\right) \quad (1)$$

where MSE is the mean-squared-error of the binary image which is calculated as follows:

$$\mathrm{MSE} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left[I(i,j) - I_o(i,j)\right]^2 \quad (2)$$

where $I(i,j)$ is the pixel value of standard image created in the preprocessing step as described in Section II and $I_o(i,j)$ is the pixel value of the output of the each system, i.e. threshold method, Gaussian filter, and ANN.

Graphic in Fig. 8 shows the comparison of the average PSNR of the cleaning process using threshold method, Gaussian filter, and ANN for Batak Toba handwritten script with 4 different textures as artificial background. The results shows that PSNR using ANN method is significantly superior compares to the other methods, as noticeable in Table II the cleaning script using ANN is the clearest and more easily to read than the others (according to subjectively opinion of several respondents)

TABLE II. Output Comparison of Each System (Sample)

Input Image	Output Image		
	Threshold Method	*Gaussian Filter*	*ANN*

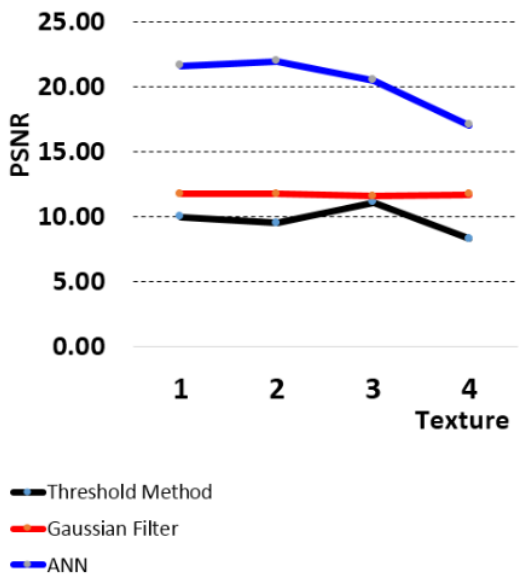

Fig. 8. PSNR Comparison of Each Texture

V. Conclusion

In this paper, Batak Toba handwritten script with artificial-textures, cleaning process based on ANN method is proposed, which is proved to have advantage over two traditional image enhancement methods. Furthermore, the results also satisfies human visual perception in reading a proper script.

This paper is a seminal work, and we expect the proposed method could be also used in the cleaning process of ancient Batak Toba manuscripts as it is proved for our further works.

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