A New Framework in Solving Tailing and Necking Problems of Thinned Binary Image

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Abstract. A framework for solving tailing and necking problem in thinned binary image (TBI) is proposed. Tailing and necking are some of the classical problems occurred in thinned binary image. Artificial Neural Network (ANN) approach has been selected to be implemented in this study for obtaining a better thinned binary image. The identified TBI with tailing and necking problem are represented in a n x n dimensions of matrix and will be undergo a training of different set of neural network models that have been develop by using multiple layer perceptron and back propagation algorithm with different numbers of hidden layers. The experimental works show promising results.

Keywords: Tailing, necking, thinning, neural network.

1 Introduction

Thinning is a fundamental preprocessing step in image processing. This process reduces a large amount of memory usage for structural information storage [1]. Not all objects can be thinned. Thinning is only useful for objects that consist of lines, not useful for objects with shapes that enclose a significant area [2].Thinning is also defined as the process of reducing the width of a line-like object from several pixels into one pixel thick. The resultant image is called thinned binary image (TBI) or skeleton. Thinning algorithms can be classified into two types which are sequential and parallel. Both categories use iterative approach, which mean the pixels on the pattern are deleted successively until only one pixel thick skeleton is obtained. In parallel algorithm, the deletion of pixels depend only on the results of the previous iterations. On the other hand, the sequential algorithms operate on a single pixel at a time, and the deletion of pixels depend upon the preceding processing result. However, there are few properties that need to be preserved while doing a thinning in order to get a good skeleton (TBI) which are:

i. The process does not remove the end points,
ii. The process does not break the line connectivity, and
iii. The process does not cause excessive erosion of the region

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Thinning is an important process, thus many algorithms have been developed since 1970's until present day. Many researches in thinning algorithm have been presented by many researchers. Stefanelli and Rosenfeld [3] investigated whether parallel thinning algorithm can be applied in digital pictures or not. The relative performance of the thinning algorithms was explained by Deutsch [4]. He compared three algorithms that had been applied to triangular, rectangular and hexagonal arrays. Zhang-Suen [5] enhanced the parallel thinning algorithm and came out with a faster parallel thinning algorithm than Stefanelli and Rosenfeld [3]. They used binary images as their application domain. In 1986, Lu and Wang [6] explored the study of parallel thinning algorithm in digital pattern and they improved the fast parallel algorithm by Zhang-Suen [5] and Stefanelli-Rosenfeld [3]. Many other researches have been conducted afterwards in order to get a better thinning algorithm by many researchers [7]. The application domains are not focused on digital patterns only but applied in differential domain like shape arrays, freehand sketch line, 3D object, fingerprint and the most popular application domain is handwritten character. One of the famous applications of thinning is character recognition, which is broadly used in the field of document analysis.

2 The Framework

In particular, the research concerns on the study of using ANN in solving tailing and necking problems of TBI. In this case, TBI of handwritten character are used as an input data. The TBI of handwritten character is obtained from a thinning process that has been conducted by Engkamat [8]. This input data is in the form of m x n matrix that consists of 0 or 1 which stand for binary image. Figure 1 shows the steps involved in each stage that are listed and explained in the remaining section.

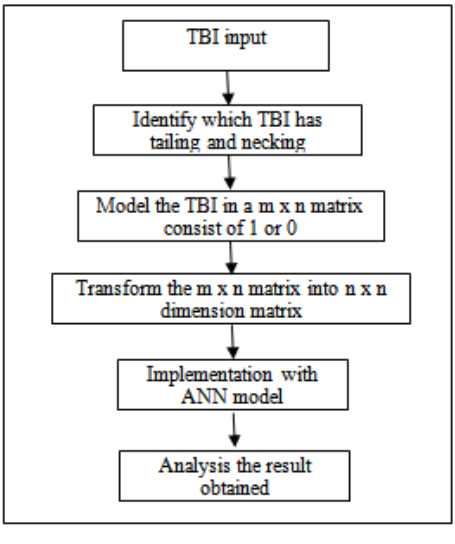

Fig. 1. The framework of the research

The first step is to identify the TBI of handwritten characters with tailing and necking and without tailing and necking. The identified handwritten characters will become the targets in the ANN training. The TBI with tailing and necking will be transformed from m x n matrix into n x n matrix dimensions in the next step. This process is to model the input training for ANN architecture. Figure 2 shows the design of input for ANN.

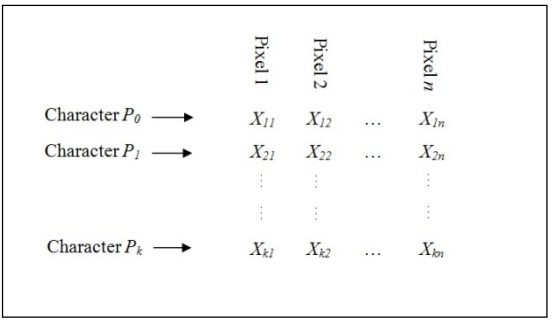

Fig. 2. Input data design

The next step is to implement the thinning algorithm in the ANN model by training the ANN model so it can fix the tailing and necking problems for each input data. The data are divided into three parts which are used for training, validating and testing in ANN learning algorithm. This algorithm is executed in MATLAB program.The training consists of a few different set of neural network models. These models use different numbers of hidden layers. The goal is set using Model Performance Evaluation (MSE) value. Figure 3 show the example of one of experimental results obtained from the training process.

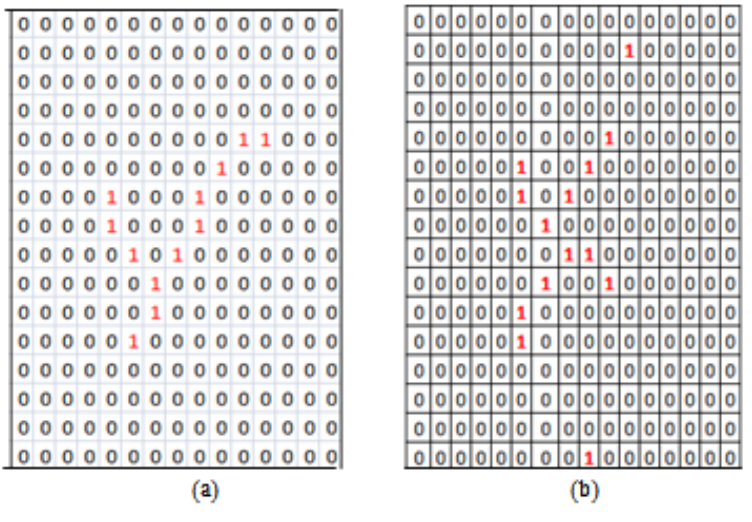

Fig. 3. (a) Original TBI with necking problem **(b)** Initial results of the proposed framework

From Figure 3, it can be seen that the trained ANN model has generated a new TBI from the original TBI with necking problem. In the example above, the necking problem in the original TBI is reduced. However, it produces separated pixels.The final stage of the research framework concerns on analyzing the result obtained. The result must be transform into *n* x *n* matrix first before we can change it back into *m* x *n* matrix which means the real form of binary image. The performance of the model is calculated by considering the percentage of accuracy of the result with target output. The performance of both experimental result and Engkamat's result will be compared based on the quality of final thinned binary image and processing time obtained.

3 Conclusions

In this paper we provide the discussion on the steps involved in modeling a handwritten character TBI, based on neural network approaches. Several other approaches highlighted by other researchers from previous works also been discussed in the beginning. The step of input modeling and training the input in ANN model are also outlined in this paper.

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