Back Propagation Neural Network Approach for Electricity Usage Meter Numeral Recognition

Andi Sudiarso, and Rierien J. Merischaputri

Abstract — Automatic meter reading has become a requirement of technology improvement for reading electricity usage meter automatically. Artificial intelligence method can be used to recognize numerical digits on a postpaid kWh meter. The purpose of this paper is to implement and to calculate the accuracy of artificial neural network method using back propagation algorithm through numeral recognition of electricity usage meter reading. The network was trained to learn by adjusting the interconnection strengths on every iteration. There are 33 samples that has been tested for this study. The back propagation algorithm is able to perform with 100% accuracy after some iteration processes. The results revealed that as the number of variation of samples increased, more accuracy is achieved by the trained network.

Keywords—Artificial neural network, backpropagation, electricity usage meter, image processing, numeral recognition.

I. INTRODUCTION

RECOGNITION of numeral images has been a popular research area because of its various potential applications. At this moment, the Indonesian electricity meter reading still use a repetitive and time consuming process that using a mobile phone to store the amount of electricity usage, a mobile phone camera to capture images of kWh usage, and a set of papers to record activities. Moreover, some human operators are not actually present to collect data and sometimes record wrong electricity usage deliberately [1]. This study presents an artificial neural network (ANN) method to automate numeral recognition of electricity meter reading using back propagation algorithm.

Numeral recognition is defined as an electronic translation process of images from handwritten, typewritten, or printed digit into a format understood by user for the purpose of editing, indexing/searching, and a reduction in storage size [2]. The related problems of numeral recognition are the existing noisy inputs, image distortion, and differences between typefaces, sizes, and fonts. For solving this problem, a back propagation (BP) algorithm of ANN approach is used. The very general nature of the back propagation training means that a back propagation network (a multilayer, feedforward network is trained by back propagation) can be used to solve problems in many areas. The purpose of this study is to implement BP and to calculate the accuracy rate of the algorithm for numeral recognition.

II. RESEARCH METHOD

A block diagram of the recognition system is shown in the Figure 1.

![Fig. 1 Block diagram of recognition system](image)

In the first step of research, it is required to determine the numeral samples as the inputs of network training. The training process will be completed when the correct targets has been achieved. For the best performance, an automated system needs an excellent image preprocessing stages including filtering and filling process. The preprocessing stage is one of the key successes of recognition system. Some of the steps follow a reference [3].

A. Numeral Samples

An observation has been made for 33 numeral type of Indonesian kWh meter at Yogyakarta district. The Indonesian kWh meter mostly used typewritten arial font. Numeral samples used are shown in Figure 2.

![Fig. 2 Numeral samples from 0 to 9](image)
B. Back Propagation (BP)

Backpropagation (BP) is a supervised training algorithm which looks for the minimum of the error function in weight space using the method of gradient descent. BP is a method for propagating information about errors at the output units back to the hidden units and input units. The architecture of BP is illustrated in the Figure 3. Although a single hidden layer is sufficient to solve any function approximation problem, some problems may be easier to solve using a network with two hidden layers or more. In such a network, the first hidden layers often serve to partition the input space into regions and the units in the second hidden layer represent a cluster of points [3]. Backpropagation is feed-forward and back propagation error evaluation which give more accurate outputs [4].

In the BP framework, each computation for each neuron requires the derivative of activation function. One cycle through the complete training set forms one epoch. The number of epoch elapsed while reaching the desired MSE convergence is counted. The BP training process ended when all the target performance have achieved. Strength of BP algorithm stands on its feed-forward and back propagation error evaluation which give more accurate outputs [4]. A neural network is well suited for such application because of its ability to learn adaptively.

The usual motivation to apply BP algorithm is to achieve a balance between correct responses to new input patterns, it is not beneficial to continue training until the total target of error achieved. The concept is the error computed by the training-testing method. As long as the error for the training-testing patterns decreases, training continues. When the error begins to increase, the network is starting to memorize the training patterns too specifically (and starting to lose its ability to generalize). Setting of optimum internal parameter used in the experiment is shown in Table I. Some of the settings follow previous experiments [6].

### III. Results and Analysis

A series of test has been performed on the system to recognize the numeral digits. The performance and reliability of the system is based on the error rate. Experiments carried with a set of inputs of size 10 x 300, where 10 is the number of classes and 300 is the feature vector length. The network is considered to have learned a pattern if all computed output values are within a specified tolerance of the desired values (0 or 1). For the result, the response of a unit was considered correct if its activation was no greater than the tolerance and the pixel (in the training pattern) corresponding to that unit was ‘off’. Sample size of 33 are taken for testing purposes. Figure 4 shows the example of ANN numeral recognition.

### Table I

<table>
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<tr>
<th>No</th>
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<th>Amount / Type</th>
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</thead>
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<tr>
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<td>Number of Nodes in Hidden Layer</td>
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</tr>
<tr>
<td>2</td>
<td>Activation Function in the Input Layer</td>
<td>Log Sigmoid</td>
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<tr>
<td>3</td>
<td>Activation Function in the Output Layer</td>
<td>Log Sigmoid</td>
</tr>
<tr>
<td>4</td>
<td>Training</td>
<td>Gradient Descent</td>
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<td>5</td>
<td>Number of Epochs</td>
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<tr>
<td>6</td>
<td>Number of Goal</td>
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<tr>
<td>8</td>
<td>Performance</td>
<td>MSE</td>
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</tbody>
</table>

Fig. 3 BP architecture (www.mathworks.com)

Fig. 4 BP numeral recognition
From 33 set experiments conducted, the BP algorithm had reached 100% accuracy rate. Proposed system recognizes 100% samples with average number of iterations is 3 times. The repetitive process of recognition caused by bad images which consist of glare and incomplete segmentation. Other character failures are caused by oblique, small, and shift characters. The example of image recognition and iteration shown in Table III.

### IV. Conclusion

The proposed method is mainly designed for real-time electricity usage reading on postpaid kWh meter. From the automated system built, the system could recognize the electricity usage correctly, with 100% accuracy. The repetitive iteration may be caused by bad images which consist of glare, oblique, small, shift characters and inappropriate shooting distance. Further research will focus on searching algorithm for integrated automated numeral recognition and billing calculation of electricity usage.

### REFERENCES


