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# An Automation of Electricity Usage Reading on Postpaid kWh Meter using Kohonen-Type Artificial Neural Network

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***Abstract*—**The automation of postpaid kWh meter reading has become a requirement for most energy suppliers in Indonesia to face the open market competition, customer's grievance, and human operator absenteeism. Nowadays, the tools used in the process of collecting data are mobile phone to store the amount of usage, camera of mobile phone to capture images as office validation, and a set of papers to record the amount of electricity usage in physical form. The system spent 60.90 sec/house that equal with 59 houses/hour. The automated system presents a new methodology, kohonen-type of artificial neural network, for avoiding the high construction and maintenance costs in the existing meter reading technology. Result of the automated design shows the data read-out has 48.76 seconds at the average process time that equal with 73 houses/hour. From the comparison, it shows that there is a significant difference between the methods of analysis. The automated system performs 14 houses (24%) more in an hour. This paper also addresses the optimum internal parameters of kohonen method for the electricity usage reading on postpaid kWh meter.

***Keywords*—** kWh meter, artificial neural network, kohonen, time of work, image processing.

## I. INTRODUCTION

ELECTRIC utilities, particularly in urban areas, continuously encounter the challenge of providing reliable power to end-users at excellent services. With the rapid developments in technology, there are many improvements in automating various industrial aspects such as electricity usage reading for reducing manual efforts. The Indonesian kilo watt hour (kWh) meter reading used mobile phone to store the amount of usage, mobile phone camera to capture images of kWh usage, and a set of papers to record in physical form. These processes are repetitive and time consuming. Moreover, some human operators absence to collect data and record wrong electricity usage deliberately [1]. It gives disadvantages to both of energy suppliers and end-users such as deficiency and overpayment. The proposed system avoids the opportunity of fraudulence. It allows with more control into the attendance of the human operator using automatic electricity usage reading by mobile phone camera.

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The automated system presents kohonen-type self-organizing maps (SOM) of artificial neural network to recognize the number of electricity usage. SOM method was developed by Teuvo Kohonen. SOM is an unsupervised training algorithm and commonly used to divide the input patterns into several groups. The input vector will provide training for the establishment of a network environment. Each new input will provide adaptation to each internal parameter. The proper allocation of unsupervised training indicates that the network has perfectly controlled. The result of SOM training is the closest group to the given input [2]. The purpose of this study is to compare the consumption time of manual system with automated system. The comparisons are done using manual system and SOM method.

## II. RESEARCH METHOD

The high level block diagram of the automated kWh meter reading system is shown in the Figure 1. In the first step of research, we need to determine the numerical character samples as the input of network training. Before trained, the samples have been labeled to distinguish each character input. Training will be completed when each numerical character sample has been grouped appropriately.

After training stage is done, we can do the recognition stage of electricity usage from kWh meter image database and real field. For the best performance, automated system needs an excellent image preprocessing stages

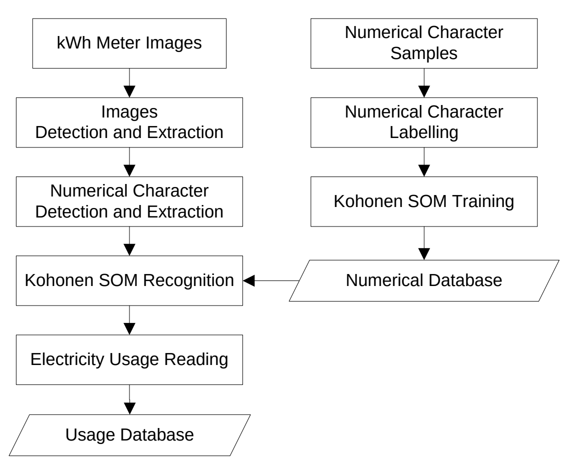


Fig. 1 Automated kWh Meter Reading System

The preprocessing stage is one of the key successes of SOM method. Some of the steps follow a reference [3]. These steps consist of automatic segmentation to detect and extract full image to an electricity usage location. The process will be repeated from an electricity usage location to the numeric characters which represent the number of electricity usage. After the recognition is done, the proposed system will input the data to excel-based automatically.

For SOM method, there were three types of analysis conducted, the performance analysis of optimum internal parameter, each numerical character of usage, and set of usage. After 56 observations, setting of optimum internal parameter used in the experiment is shown in Table I. Some of the settings follow a reference [4].

TABLE I
PARAMETER CONDITIONS USED IN THE EXPERIMENT

| No. | Setting Variable | Amount/Type |
|---|---|---|
| 1 | Matrix of Min and Max Values for input elements (PR) | 500 |
| 2 | Size of $i^{th}$ Layer Dimension (Di) | 4 3 |
| 3 | Topology Function (TFCN) | Hexagonal |
| 4 | Distance Function (DFCN) | Linkage |
| | | Box |
| 5 | Ordering-phase Learning rate (OLR) | 0.7 |
| 6 | Ordering-phase Steps (OSTEPS) | 1000 |
| 7 | Tuning-phase Learning Rate (TLR) | 0,06 |
| 8 | Tuning-phase Neighborhood Distance (TND) | 1 |

Data collection earned from energy supplier and direct observation. Energy supplier gave the postpaid kWh meter images that used as input in the SOM analysis of image database testing. Direct observation was used to analyze the time consumption and performance of existing and proposed system on the real field. Data collection of existing system was conducted 7 times at 3 locations of Yogyakarta, April 22nd to 30th, 2013.

Based on electricity usage reading framework, we calculate the average time by accompanying the human operator whom read electricity usage on postpaid kWh meter. Each observation was made in an hour. The data collection of SOM method was obtained by accompanying the third party (not us or human operator of energy supplier) whom read electricity usage. The assessment used third party to keep neutral calculation. The tool of SOM's data collection was laptop webcam connected with MATLAB.

## III. RESULT AND ANALYSIS

A series of test has been performed on the system to recognize the electricity usage on postpaid kWh meter. The performance and reliability of the system is based on the time and error rate.

### A. *Existing System Analysis*

To compare system with same weight, data with service and payment activities were eliminated. From 7 times observations obtained, data uniformity test were performed. Data were outside the upper and lower limits were removed. After the test, 308 samples were obtained and will be analyzed to get the average consumption time. The average time of data storage, image capture, and physical record were 5.7 seconds, 5.7 seconds, and 9.5 seconds respectively with 40 seconds of transfer time. At total average time of 60.9 seconds/house, the existing kWh meter reading system calculated as 59 houses/hour. Based on the final score, the longest time was physical record activities. The failure of the human operator was noted as much as 5 % on two observations.

### B. *SOM Analysis*

The SOM analysis was divided into two parts. The first part was assessing the electricity usage image from energy supplier's database. The second part was assessing system on the real field captured by laptop webcam. Figures 2 and 3 show the interface of proposed system.

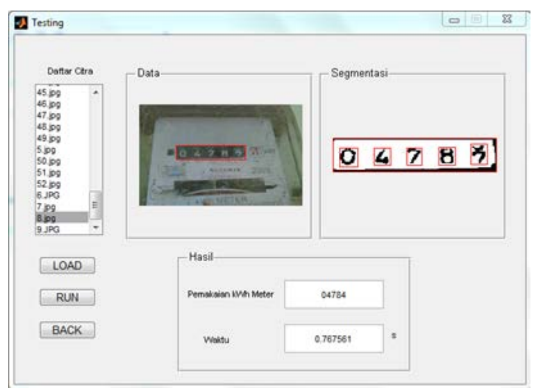


Fig. 2 Interface of Image Database Testing

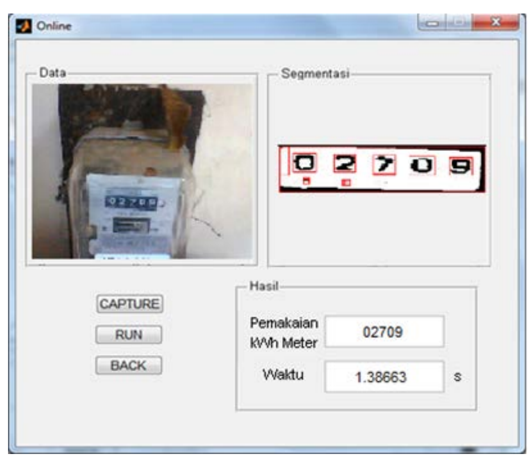


Fig. 3 Interface of Image Field Testing

To determine the level of accuracy, we conducted the set and individual calculation between the characters. For image database testing, there were 52 samples obtained. Proposed system recognizes 69% of upright character, 68% of blurred character, 80% of oblique character, 86% of blurred character of oblique image, and 40% of small character. The average level of system accuracy was 66%. The recognition of upright character shows low level of accuracy. It caused by bad image as an input which consisting glare and incomplete segmentation. For individual calculation, system performance is shown in Table II. Character 3 and 5 show low level of accuracy. It caused by frequent incomplete segmentation. Other character failure caused by oblique, small, and shift character.

TABLE II
CHARACTER RECOGNITION ON DATABASE TESTING

| **Number** | **Frequency** | **Legible Character** | **Accuracy (%)** |
|---|---|---|---|
| 0 | 40 | 37 | 93 |
| 1 | 25 | 21 | 84 |
| 2 | 19 | 16 | 84 |
| 3 | 18 | 11 | 61 |
| 4 | 17 | 17 | 100 |
| 5 | 19 | 12 | 63 |
| 6 | 13 | 12 | 92 |
| 7 | 21 | 20 | 95 |
| 8 | 23 | 19 | 83 |
| 9 | 10 | 9 | 90 |
| **Average** | | | **85%** |

Shift character example shown on Figure 2 (Last numeric character image, which is a shift in the character of 6 and 7). The database testing average time was 0.76 second without transfer time.

The proposed system was validated through image field testing. For image field testing, system performance is shown in Table III.

TABLE III
RECOGNITION ON FIELD TESTING

| Electricity Usage | Accuracy (%) | Iterations | Total Testing Time | Average Time(s)/ Iteration |
|---|---|---|---|---|
| 02709 | 100% | 22 | 8,84 | 0,40 |
| 02421 | 100% | 31 | 12,13 | 0,39 |
| 02717 | 100% | 6 | 2,47 | 0,41 |
| 02726 | 100% | 28 | 11,26 | 0,40 |
| 26046 | 100% | 24 | 9,12 | 0,38 |

The system spent an average of 0.39 seconds per iteration and 8.76 seconds per kWh meter without transfer time. From observation, we analyzed the placement of webcam and kWh meter played an important role for the successful reading. kWh meter lies on high ground with high glare, shift character, oblique image, and long distance kWh meter were some problems found in the observations.

Based on the results obtained, the average consumption time apart with transfer time compare on Table IV.

TABLE IV
COMPARISON OF AVERAGE CONSUMPTION READING TIME

| | SOM System | | Existing System |
|---|---|---|---|
| | Databas e | Field | |
| Average Time (s) | 0.76 | 8.76 | 20.9 |

With 40 seconds of a transfer time, the existing system performed as 59 houses/hour less than the automated system with field testing that was performing as 73 houses/hour. With significant differences generated by the automated system, productivity was able to improve.

## IV. CONCLUSIONS

Based on the results of this study, conclusion can be stated as follows.

1. The internal parameters of kohonen method for electricity usage reading have an optimum effect with OLR is 0.7, TLR is 0.06, layer topology is 4 and 3, topology function is hexagonal, and the distance function are linkage and box.
2. Comparison of the quality of the automated system to the existing system produces average electricity usage reading which is far above the readout of the existing system. By eliminating the manual data record and collecting process, the kohonen method read 14 houses/hour (24%) more than the existing one.

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