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Identification of Resistor Types Using Extreme Learning Machine Algorithms and Morphological Operations

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Abstract−Electronic components are the basic elements to form a series of electronic devices that are usually used in everyday life. For someone who studies the field of electricity, knowledge of electrical components is an important thing. One of the components whose use is most often found in electronic circuits is a resistor. However, some people do not know about these types of resistors. Especially for someone or a student who will learn about electronic components. This study aims to develop an image processing system that can identify transistor type images using the Extreme Learning Machine (ELM) algorithm. This algorithm performs integrated learning through a special form of feedforward perceptron which has one hidden layer. In order for the ELM algorithm to work properly, information about the features contained in the object to be identified is needed. So, in this study the ELM algorithm is combined with morphological characteristics through parameters such as area, perimeter, eccentricity, major axis length, and minor axis length. Based on these parameters, features will be obtained which will be input in the identification process. At the evaluation stage, the precision value was 87%, recall was 84.47% and accuracy was 85.5%.

Keywords: Image Identification; Image Processing; Extreme Learning Machine; Morphological Characteristics; Types of Resistors

1. INTRODUCTION

With the rapid development of today's technology in everyday life will require objects that are connected to electronics and it can be said that almost all devices will become an important goal in the performance of daily activities. Every electronic device used in everyday life can work properly because of the presence of electronic components. Electronic components are a basic element to form a series in electronic devices and will usually be packaged in discrete form at the connecting terminals [1]. For someone who studies the field of electricity, knowledge of electrical components is an important thing. Electronic components are the smallest elements in an electronic circuit. One of the components whose use is most often found in electronic circuits is a resistor. Resistors are basic electronic components that are used to limit the amount of electricity flowing in an electronic circuit [2]. Basically a resistor is a passive component that has a certain resistance value or resistance whose value determines the amount of electricity produced. Resistors function to limit and regulate the amount of electric current that will be used in other components in electronic circuits. Resistors can be made from a variety of component materials and films, even resistance wire (wire made from high resistivity alloys such as nickel-chromium) [3]. In general, resistors consist of several types, including: Fixed Resistor, Variable Resistor, Thermistor, and Light Dependent Resistor (LDR) [4]. However, some people do not know about these types of resistors. Especially for someone or a student who will learn about electronic components. Knowing the types of resistors becomes an important thing. Physically, each type of resistor has a different shape. So that resistors can be distinguished based on their shape. In order for someone who will learn about electronic components, especially about the type of transistor, it is necessary to have a system that can provide information about the type of transistor based on its image. Thus, digital image processing can be a solution to these problems.

Digital image processing can be interpreted as a field that examines how an image can form, manage and analyze it so as to produce information from the image that can be utilized [5]. From image processing, we can obtain information that can be useful to help human work [6]. One application of digital image processing that can be applied is image identification. Image identification is a process to describe an object based on the main properties of the object [7]. Identification of objects in digital images requires techniques and methods that are able to extract and identify the features contained in digital images. Through feature extraction in the image, the image can be identified and grouped into a certain class [8]. With image identification, it can help understand the diversity of objects in the image better [9]. Algorithm that can be used in image identification is Extreme Learning Machine (ELM). ELM is an integrated learning framework method from a special form of feedforward perceptron which has one hidden layer [10]. ELM is also known as a feedforward neural network with a single hidden layer or single hidden layer feedforward neural networks (SLFNs) [10]. This method has a faster learning speed than conventional artificial neural network methods such as backpropagation [11]. The ELM algorithm fixes the problems in the previous artificial neural network algorithms, especially in learning speed [12]. Several previous studies regarding the application of the ELM algorithm in digital image processing showed good accuracy results. Such as research on brain tumor classification based on Magnetic Resonance Imaging (MRI) images using the ELM algorithm [13]. In this study, the proposed model is able to produce an accuracy of 91.4%. Another study on the classification of melanoma skin cancer types using the ELM algorithm [14]. The test shows that the ELM algorithm has an accuracy of 97% using 11 features and 91% using 5 features. The next research is research on the application of X-Ray image algorithms for COVID-19 detection [15]. This research results produce the best accuracy of 91.21%.

This study aims to implement the Extreme Learning Machine (ELM) algorithm to identify the type of transistor. This algorithm was chosen because this method has a more effective and simpler mathematical model than a feedforward

artificial neural network. Thus, this method will work well if used in solving image identification problems. In order for the ELM algorithm to work properly, information about the features contained in the object to be identified is needed. So, in this study the ELM algorithm is combined with morphological characteristics through parameters such as area, perimeter, eccentricity, major axis length, and minor axis length. Based on these parameters, features will be obtained which will be input in the identification process..

2. RESEARCH METHODOLOGY

2.1 Research Stages

In order for the research carried out to achieve the objectives correctly, it is necessary to develop planned and structured research stages. The stages of the research carried out can be seen in Figure 1.

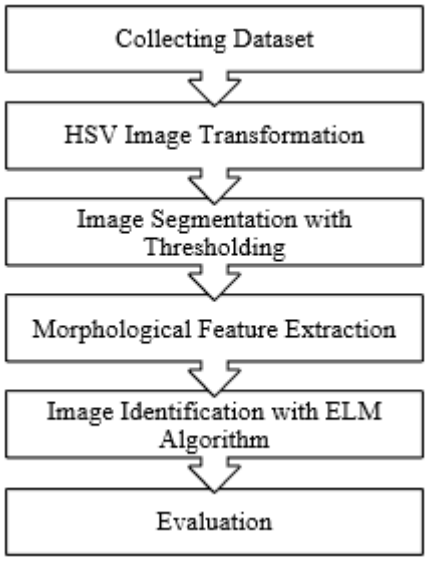

Figure 1. Research Stages

2.1.1 Collecting Dataset

At this stage, a dataset will be collected, which contains the image of the type of transistor that will be used for training and testing. The types of resistors used in this study include: In general, resistors consist of several types, including: Fixed Resistor, Variable Resistor, Thermistor, and Light Dependent Resistor (LDR). Transistor image data obtained from the internet based on the types of transistors. Approach in the distribution of data distribution The process of distributing data sets applies a trial-and-error approach [16], where the data for training and testing is divided equally, namely 50% and 50%. The distribution of data on the dataset used for both training and testing data with a certain amount will not provide fluctuating accuracy values [17]. For the manufacture of a prototype, a not too large amount of data can be used [18]. Thus, the number of datasets used in this study is 200 resistor images. So, for the distribution of image data used for training are 100 images and 100 image data are used for testing.

2.1.2 HSV Image Transformation

Image transformation is useful for adding information from the image to be identified. Then the original image will be transformed into the HSV color space. The HSV image will have a perceptual color space and contain cylindrical coordinates in three parts, including: hue, saturation, and value [19]. The HSV transformation stage is an important stage before carrying out the segmentation process.

2.1.3 Image Segmentation with Thresholding

The next stage is the image segmentation process, where at this stage to separate one object from another. Objects with the same arrangement will be separated based on their area boundaries. The output generated in the segmentation process is in the form of a binary image, where the image will be transformed into an image with values 1 and 0. In this study, the image segmentation method used is thresholding. Thresholding function is to find the appropriate threshold, so that the desired object in the image can be obtained [8]. Thresholding technique is similar to the quantization process which can be obtained through equations (1) and (2).

$$x = b * int\left(\frac{w}{b}\right) \quad (1)$$

$$b = int\left(\frac{256}{a}\right) \quad (2)$$

Where, w indicates the gray degree value before processing and x indicates the result after thresholding is performed.

2.1.4 Morphological Feature Extraction

An object will have different characteristics from other objects, then the feature extraction process is a process to explore these characteristics. The results of feature extraction will be important information for the identification process [20]. In this study, we will perform feature extraction based on its shape. Shape characteristics can be obtained by extracting morphological features through the parameters of area, perimeter, eccentricity, major axis length, and minor axis length. The area is obtained by counting the number of pixels of the object to be processed. The perimeter is obtained from the number of image elements that surround the object. While the length of the major axis is the diameter of an area and the length of the minor axis is the shortest diameter of an area. From the results of the major and minor axes will be calculated eccentricity. Eccentricity is the ratio of the length between the major and minor axes. To find the value of centricity obtained through the equation.

$$x = e = \sqrt{1 - \frac{b^2}{a^2}} \quad (3)$$

The symbol a is obtained based on the length of the major axis, on the contrary for b is obtained from the length of the minor axis.

2.1.5 Image Identification with ELM Algorithm

Extreme Learning Machine (ELM) is a type of artificial neural network with one hidden layer which is commonly called a Single Hidden Layer Feedforward Neural Network (SLNs) [21]. The ELM algorithm is able to overcome the problems in the previous approach, especially in the speed of learning [10]. Some of the factors that cause the ELM algorithm to have a better learning speed include:

1) In training using slow gradient-based learning.
2) The parameters in the network are obtained iteratively.

To carry out learning using conventional gradient-based learning algorithms, all parameters of feedforward neural network are obtained manually. These parameters include input weights and hidden layers. All parameters have a relationship at each layer, so it requires a fast learning pattern and what happens will be trapped at a local minimum. That does not happen in the ELM algorithm, because each parameter is chosen randomly. That is why the ELM algorithm is faster in learning and generalization will be more optimal [10].

The mathematical model of ELM is simpler and more effective. For the number of different input and target output pairs (x_i, t_i), where $x_i = [x_{i1}, x_{i2}, \dots, x_{in}]^T \in R^n$ and $t_i = [t_{i1}, t_{i2}, \dots, t_{in}]^T \in R^m$, standard SLFNs with N hidden nodes and activation function $g(x)$ can be modeled mathematically using equation (4).

$$\sum_{i=1}^{\tilde{N}} \beta_i g_i(x_j) = \sum_{i=1}^{\tilde{N}} \beta_i g_i(w_i \cdot x_j + b_i) = O_j, j = 1, 2, \dots, N \quad (4)$$

Where, $w_i = [w_{i1}, w_{i2}, \dots, w_{in}]^T$ is a weight vector that connects the i-th hidden node and the input nodes. $\beta_i = [\beta_{i1}, \beta_{i2}, \dots, \beta_{im}]^T$ is the weight vector connecting the i-th hidden node and the output nodes. b_i is the threshold of the i-th hidden node. $w_i \cdot w_j$ is the inner product of w_i and w_j.

Standard SLFNs with $\tilde{N}$ hidden nodes and activation function $g(x)$ are assumed to be able to estimate these N samples with an error rate of 0 which means $\sum_{j=1}^{N} \|o_j - t_j\|$, so that there are β_i, w_i, and b_i such that they form equation (5).

$$\sum_{i=1}^{\tilde{N}} \beta_i g_i(w_i \cdot x_j + b_i) = t_j, j = 1, 2, \dots, N \quad (5)$$

The above equation can be written simply as equation (6).

$$H\beta = T \quad (6)$$

Where H is the result of equation (7) and B is obtained from equation (8).

$$H = \begin{bmatrix} g(w_1 \cdot x_1 + b_1) & \cdots & g(w_{\tilde{N}} \cdot x_1 + b_{\tilde{N}}) \\ \vdots & \ddots & \vdots \\ g(w_1 \cdot x_N + b_1) & \cdots & g(w_{\tilde{N}} \cdot x_N + b_{\tilde{N}}) \end{bmatrix}, \quad (7)$$

$$H = \begin{bmatrix} \beta_1^T \\ \vdots \\ \beta_{\tilde{N}}^T \end{bmatrix} dan\ T = \begin{bmatrix} t_1^T \\ \vdots \\ t_{\tilde{N}}^T \end{bmatrix} \quad (8)$$

Where, H is the hidden layer output matrix equation in the neural network. While $g(wi \cdot xj + bi)$ is the output of the hidden neurons associated with the input xj. β is the matrix of the output weights and the matrix T of the target. In In the ELM algorithm, the weights of the input and hidden layers can be determined randomly, so that the output weights of the hidden layer can be obtained through equation (9).

$$\beta = H \dagger T \quad (9)$$

2.1.6 Evaluation

Evaluation serves to measure the performance of the developed model [22]. In addition, evaluation can be used as a test to ensure that the developed model has been running as it should [23]. In this study, the evaluation process is carried out by calculating the value of precision, recall, and accuracy through the confusion matrix. The model will be tested then the results of the test will be entered into the matrix. In the confusion matrix there are several parts, namely: true positive, false positive, true negative and false negative which will be used to get precision, recall and accuracy values [24]. Precision shows the accuracy between the requested data and the identification results. Recall is usually referred to as sensitivity describing the success of the model to retrieve information. While accuracy shows the level of accuracy of the model in correctly identifying. To get the value of precision, recall, and accuracy can be calculated through equation (10), (11) and (12).

$$Precision = \frac{TP}{TP + FP} \quad (10)$$

$$Recall = \frac{TP}{TP + FP} \quad (11)$$

$$Accuracy = \frac{TP}{TP + FP} \quad (12)$$

Where, TP (True Positive) is positive data that is correctly identified. TN (True Negative) is negative data that is correctly identified. FP (False Positive) is negative data identified as positive data. On the other hand, FN (False Negative) is positive data but identified as negative data.

3. RESULT AND DISCUSSION

To develop a resistor type identification system, the first step is to prepare a model for training. The dataset used is 200 resistor images with 100 training data and 100 test data. The training data will be used as training data for the model to be developed. Training and testing is carried out using Matlab software. To identify the resistor image, first the original image of the object to be identified is transformed into the HSV color space. This is done in order to obtain information from the colors contained in the image. Figure 2 below is the result of the HSV image transformation.

(a) (b)

Figure 2. (a) Original Image, (b) HSV Transformation

After the original image is transformed into HSV form, then the image will be segmented. This process aims to get the object needed, then the object to be identified will be separated from the background. The image segmentation

process uses the thresholding method. The result of image segmentation with thresholding is a binary image. The results of segmentation in the form of binary images are shown in Figure 3.

(a) (b)

Figure 3. (a) Original Image, (b) Segmentation Results with Thresholding

From the results of image segmentation to make it easier for the next process, the segmentation results will be improved through morphological operations. The results of the morphological operation can be seen in Figure 4.

Figure. 4. Morphological Operation Results

The next process is to perform feature extraction which aims to obtain values that distinguish one object from another. In this case, using feature extraction based on its shape through morphological characteristics. The morphological characteristics will look for the value of area, perimeter, eccentricity, major axis length, and minor axis length. The result of feature extraction is shown in Figure 5.

(a)

	Ciri	Nilai
1	Area	57717
2	Perimeter	2.5741e+...
3	Eccentrici...	0.9262
4	Major Axi...	654.3073
5	Minor Axi...	246.7646

(b)

Figure 5. (a) Morphological Operation Image, (b) Feature Extraction Results

After feature extraction, the values obtained will be input to the ELM algorithm for identification. The ELM algorithm performs integrated learning of a special form of feedforward perceptron which has one hidden layer. The ELM algorithm works by randomizing the input and hidden weight parameters, this makes the ELM algorithm have the ability to learn much faster and be able to generalize optimally. The stages of the ELM algorithm in the developed model are as follows:

Input : input data x_j and output is target $t_j, j = 1, 2, \dots, N$
Output : input weight w_i, output weight b_i and bias $b_i, i = 1, 2, \dots, N$
Step 1 : Find the activation function ($g(x)$) and the number of hidden nodes ($\tilde{N}$)
Step 2 : Randomly determine the value of the weights input w_i and bias $b_i, i = 1, 2, \dots, N$
Step 3 : Finding the value of the output matrix H on hidden layers
Step 4 : Finding the value of the output weight β by using $\beta = H\dagger T$

These steps are then implemented in Matlab software to build a GUI application to make it easier for users to run the system. The interface of the resistor type identification system with the ELM algorithm using Matlab is shown in Figure 6.

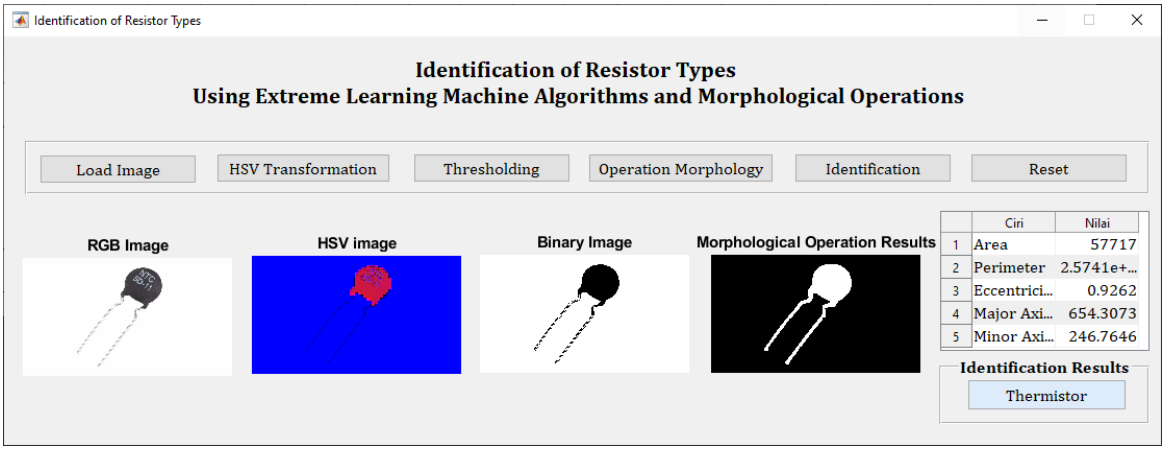

Figure 6. Resistor Type Identification System Interface

After the resistor type identification system has been implemented, an evaluation of the developed model will then be carried out. The evaluation process uses a confusion matrix, to get true positive, false positive, and true negative values which are used to find precision, recall, and accuracy values. The test uses 100 data for testing by measuring the performance of the model in identifying. The confusion matrix generated in the test is presented in Figure 7.

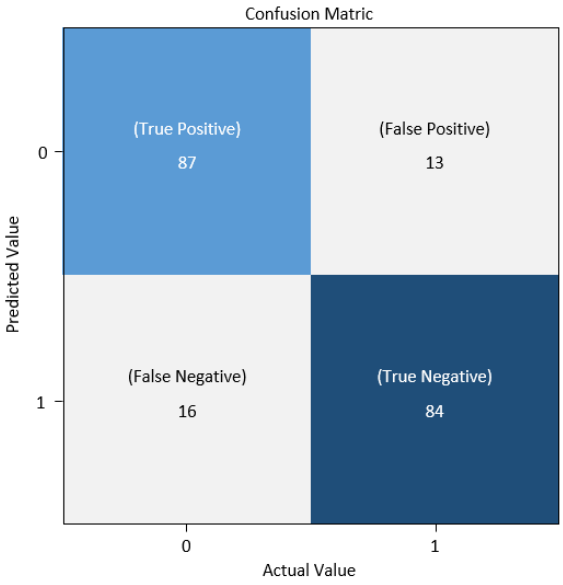

Figure 7. Confusion Matrix from Developed Model

From the value of the confusion matrix obtained, then look for the value of precision, recall and accuracy using equations (10), (11) and (12). The test results are presented in Table 1.

Table 1. Evaluation Result

Precision	Recall	Accuracy
0.8700	0.8447	0.8550

In Table 1, the results for precision are 0.8700 or 87%, recall gets a value of 0.8447 or 84.47% and accuracy gets a value of 0.8550 or 85.5%. Next, the test results will be converted based on the criteria based on the following values: Good, values ranging from 76% to 100%; Simply, the value ranges from 56% to 75%; Poor, the value ranges from 40% to 55%, Very Poor, if the value is less than 40% [25]. So the ELM model used to identify the type of resistor is in the good category.

Based on the evaluation, it shows that the model is able to identify the type of resistor well. However, the average error value from the accuracy test results shows a value of 14.5%. This can happen because there are factors that influence, namely: 1) The types of resistors have almost the same shape, so it is not enough to identify them based on their shape only; 2) The dataset used is still too small, it is necessary to increase the number so that the learning carried out by the system can be maximized; 3) Images of resistors with different positions will affect the identification results; 4) The image data used is an image with a single color background, the system is difficult to identify for various backgrounds.

4. CONCLUSION

In this study, a system was developed to identify the type of resistor using the ELM algorithm with operations and morphological features. With morphological characteristics, it is able to provide information about the characteristics of objects by calculating the values for the area, perimeter, eccentricity, major axis length, and minor axis length. The ELM algorithm works by integrating a special form of feedforward perceptron which has one hidden layer. The ELM algorithm has the ability to randomize parameters such as input and hidden weights, so that ELM can learn quickly and its generalization performance will be much better. The model was developed with Matlab software and produces a resistor type identification system that can perform HSV transformation, extraction of morphological features, morphological operations and image identification with the ELM algorithm. The evaluation was carried out using a confusion matrix and obtained a precision value of 87%, recall of 84.47% and accuracy of 85.5%. With these results it can be said that the type of resistor can be identified by the ELM algorithm model well. However, there are some suggestions from researchers as improvements for further research. For feature extraction, it is not enough just based on the shape, but can apply other feature extraction. In addition, to get optimal accuracy, deep learning methods can be applied. To get a good learning pattern, it is necessary to increase the number of datasets and use datasets taken independently.

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