CALCULATING RESISTANCE VALUE OF RESITOR USING TEMPLATE MACHING METHOD

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ABSTRACT

Resistor is a basic component of electronics that serves to limit the amount of current in a circuit. A common resistor type tube-shaped and there are several rings of color. Color code on resistors value indicates an obstacle on the resistor. Based on the results of previous research, which has the percentage of success in the calculation of the value of 57% of identified 30%, and 13% is not recognized. Thus, needed a study to create an application that calculates the value using the digital image processing. Template matching method is one of the applied method of engineering convolution. The principle of this method is to compare the image of the object that will be identified with the image of an existing template. When the image object has a value higher then the resemblance image of the object will be identified. Template matching method to implement the necessary image processing operations i.e. color classification HSV (Hue Saturation Value) that is used to detect the color of the resistor. After testing the system with the Black Box method can be drawn the conclusion that the program is functioning correctly. On the detection of objects has a 89% accuracy and the calculation for the value of the resistance of the resistor has a 69% accuracy rate.

Keywords: resistor, template matching, hue saturation value, resistance value, pattern recognition

1. INTRODUCTION

Resistor is a component of electronics which serves to inhibit the flow that goes on a series of electronics. A common resistor type tube-shaped and there are several rings of color. Ring resistor color code standard manufacturing released by the EIA (Electronic Industries Association) [1].

Color code on resistors value indicates an obstacle on the resistor. Reading the color code has some color on each ring. So have some combination of the colors and the number of rings. Error reading the color code resulted in the wrong in determining the value of the resistance of the resistor. The value of the obstacles that incompatible with the series will result in damage to electronic circuits. Based on the results of previous research, which has the percentage of success in the calculation of the value of 57% of identified 30%, and 13% not recognized [2]. Therefore, it takes a research to create an application that calculates the value using the digital image processing.

Image processing is a technique of manipulation digitally image that particularly using computers. For easy interpretation by humans and computers, then the digital image processing to be done by a variety of methods to achieve the appropriate image [3]. Digital image processing method using pattern matching to detect one of them with a template matching method.

Template matching method is one of the applied method of engineering convolution. Application of template matching method is relatively easy to implement on digital image processing techniques. The principle of this method is to compare the image of the object that will be identified with the image of an existing template. If the image object has a value higher then the resemblance image of the object will be detected. Conversely, when the image object has a low similarity value then the image of the object is categorized as unknown objects [2].

Next to be able to implement this method then need some digital image processing operations by the classification HSV color. Classification is used to detect HSV color code on resistors that will be tested. The profit that is simple in its programming and process quickly.

Based on the above exposure, the research is intended to apply the template matching method and classification of the color of the HSV resistance values to calculate the resistor in a series.

2. CONTENT OF THE PAPER

2.1 Review Literature

2.1.1 Resistor

Resistor is a component of electronics which serves to inhibit the flow that goes on a series of electronics. The unit of the value of the resistor is ohm (Ω) [1].

2.1.2 Template Matching

Template matching is one of the techniques in digital image processing that serves to match the right every part of an image with the image that became templates [7]. Basically the process done by pasting the image of a particular template are then compared with the image in the database.

2.1.3 Normalized Cross-correlation

Normalization process is one in which the preprocessing stage is done before entering into the process of detection object. The process used at the stage of this normalization using the concept of normalization in accordance with Normalized Cross-Correlation method, where in this stage include, calculating the average and standard deviation for the test image and image templates. The equation for calculating the average as follows:

$$\bar{x} = \frac{x1+x2+x3+\cdots+xn}{n} \quad (2.1)$$

While the equation to calculate the standard deviation as follows:

$$\hat{f} = \frac{\mathrm{f}-\bar{\mathrm{f}}}{\sqrt{\Sigma(\mathrm{f}-\bar{\mathrm{f}})^2}} \qquad \hat{\mathrm{g}} = \frac{\mathrm{g}-\bar{\mathrm{g}}}{\sqrt{\Sigma(\mathrm{g}-\bar{\mathrm{g}})^2}} \quad (2.2)$$

2.1.4 HSV Color Model

On the processing of image color, there are various models of color. Model RGB (red green blue) is a widely used model. On this model to represent images using 3 pieces of the color components. In addition there is a color model RGB HSV where this model there are three components namely the hue, saturation, and value. Hue is one of the size of the wavelength of the dominant color adopted by sight, while the saturation is a measure of the abundance of white light mixed in hue.

$$R' = \frac{R}{255} \quad (2.3)$$

$$G' = \frac{G}{255} \quad (2.4)$$

$$B' = \frac{B}{255} \quad (2.5)$$

$$H = \begin{cases} 0, & if\ max = min \\ 60° \ x\ \left(\frac{(G-B)}{max-min}\ mod\ 6\right) \\ 60° \ x\ \left(\frac{(B-R)}{max-min} + 2\right) \\ 60° \ x\ \left(\frac{(R-G)}{max-min} + 4\right) \end{cases} \quad (2.6)$$

$$S = \begin{cases} 0, & if\ max = min \\ \frac{max-min}{v} \end{cases} \quad (2.7)$$

$$V = max \quad (2.8)$$

2.1.5 HSV Color Quantization

Color quantization is the process of the reduction of the number of colors that represent an image. One of the combinations of dimension both in terms of performance as well as computational load that is light and often used i.e. 72 dimensions (8 dimensions for component 3 dimensional hue, saturation, and components for 3 dimensions for the components of the value).

$$H = \begin{cases} 0\ jika\ h\ \in [316-20] \\ 1\ jika\ h\ \in [21-40] \\ 2\ jika\ h\ \in [41-75] \\ 3\ jika\ h\ \in [76-155] \\ 4\ jika\ h\ \in [156-190] \\ 5\ jika\ h\ \in [191-270] \\ 6\ jika\ h\ \in [271-295] \\ 7\ jika\ h\ \in [296-315] \end{cases} \quad (2.9)$$

$$S = \begin{cases} 0\ jika\ s\ \in [0-0.2] \\ 1\ jika\ s\ \in [0.2-0.7] \\ 2\ jika\ s\ \in [0.7-1] \end{cases} \quad (2.10)$$

$$V = \begin{cases} 0\ jika\ v\ \in [0-0.2] \\ 1\ jika\ v\ \in [0.2-0.7] \\ 2\ jika\ v\ \in [0.7-1] \end{cases} \quad (2.11)$$

After getting the value 72 dimension, the value of HSV in normalizing to 1 vector equation

$$G = 9H + 3S + V \quad (2.12)$$

2.1.6 Convolution

Convolution is a process where the image manipulated with external mask (template) to generate a new image. Where template is expressed in the form of a matrix whose size is smaller than the size of the image [8]. Konvolusi on 2-dimensional operations can be defined in the following equation:

$$I'(\hat{\mathrm{g}}, \hat{\mathrm{f}}) = \sum_{i=-n}^{n} \sum_{j=-m-1}^{m} h(i,j) I(n,m) \quad (2.13)$$

Operation of convolution is done by sliding the mask pixel per pixel in the image. Starting from the initial pixel (0.0) to pixel (0.1) and so on until the end of the pixel. Results of convolution will be stored in the new matrix.

2.2 Analysis and Implementation

2.2.1 Method of Collecting Data

In this final project report writing, research methods is divided into 2 stages, stage of data collection and the development of the software.

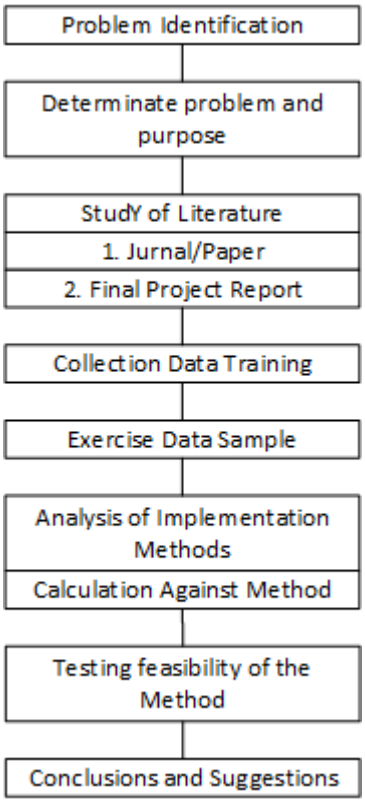


Image 1. Scheme Research

Data collection methods used in this study are as follows:

a. study of Literature

Method of collecting data related to the research that is in the form of books, papers, journals relating to template matching and HSV.

b. collection of Samples

At this stage the researcher collects data sample image in the form of a resistor which is at a PCB. The sample data used as the data for training while doing the training with a template matching method and model of HSV color.

2.2.2 Image Input

Image input used in the application, i.e. the image of the resistor with a .jpg picture format. In addition image color is also not dark so that applications can more optimally perform the introduction of resistors.



Image 2. Examples of Image Input

Image 2. is the image input data as a trainer. Here is a picture of a matrix of colors Red (R), Green (G), and Blue (B) of Figure 2.

R=85 G=120 B=87	R=129 G=164 B=131	R=76 G=92 B=66
R=147 G=182 B=149	R=137 G=172 B=139	R=57 G=73 B=47
R=81 G=120 B=89	R=67 G=106 B=75	R=21 G=39 B=17

Image 3. RGB Matrix of the Input Image

2.2.3 Image Trainer

Image trainer used in this application, i.e. the image of the resistor is located on the PCB with a .jpg picture format.



Image 4. Sample Image Trainer

Image 4. is the image data input data as a trainer. Here is a picture of a matrix of colors Red (R), Green (G), and Blue (B) of Figure 4.

2.2.4 HSV Color Modeling

In this process, the RGB color model changes done to the image to HSV color model input and image of the trainer. By using the equation (2.3), (2.4), (2.5), (2.6, 2.7, 2.8), then the results of modeling input image to HSV color are as follows.

H=123 S=0.331 V=0.498	H=123 S=0.213 V=0.643	H=97 S=0.283 V=0.361
H=123 S=0.192 V=0.714	H=190 S=0.235 V=0.702	H=97 S=0.356 V=0.286
H=132 S=0.325 V=0.471	H=132 S=0.368 V=0.416	H=109 S=0.564 V=0.153

Image 5. HSV Image Input

2.2.5 HSV Color Quantization

Space of HSV, each component has a range of great value. If you use a value of HSV directly. So it is better if the color model of HSV quantization in non-equal intervals, i.e. H: 8 parts, S: 3 parts and V: 3 parts. By using the equation (2.9), (2.10), (2.11) then the results for HSV color image quantization input as follows.

H=3 S=1 V=1	H=3 S=1 V=1	H=3 S=1 V=1
H=3 S=0 V=2	H=4 S=1 V=2	H=3 S=1 V=1
H=3 S=1 V=1	H=3 S=1 V=1	H=3 S=1 V=0

Image 6. HSV Color Quantization

After getting the value of the quantization, then merged into 8x3x3 and get the histogram vector 72 dimensions. A combination of values of h, s, v will be normalized to be 1 vector. With the equations (2.12) then the result yields the following vector 1.

H=3 S=1 V=1	H=3 S=1 V=1	H=3 S=1 V=1
H=3 S=0 V=2	H=4 S=1 V=2	H=3 S=1 V=1
H=3 S=1 V=1	H=3 S=1 V=1	H=3 S=1 V=0

Image 7. 1 Vector Quantization

2.2.6 Normalized Cross-correlation

Normalized cross-correlation method needs to perform normalization on both the image of the first. Normalization technique used in accordance with the stages of normalization on normalized cross-correlation.

Here are the steps for normalized cross-correlation:

1. Calculate the average of a second image with equation (2.1).
2. Calculate the standard deviation of the second image with equation (2.2).

0	0	0
-1	3	0
0	0	-1

Image 8. Matrix Image Template

2.2.7 Convolution

Convolution is a process where the image was manipulated using external mask (template) to generate a new image. The steps that is placing the template on the image pixel (0.0) and shifted to the end of pixel imagery with equations (2.13).

2.2.8 Matched Object

Matched object results or output of the convolution process that generates maximum value from the new value as the pixels that best approached with the image template on the image of the target.

2.2.9 Calculating of Value Resistance

In the calculating of value resistance of a resistor using HSV color modeling using. HSV color useful as modeling limit the color values used in detecting the color of each ring on the resistor. The following limit values of the HSV used as reference.

Table 1. Limit value of HSV from OpenCV

Color	Hue	Saturation	Value
Black	0-180	0-25	0-50
Brown	0-15	90-250	100-150
Red	11-15 atau 171-180	176-255 atau 65-250	161-255 atau 50-150
Orange	4-9	100-250	100-150
Yellow	20-30	130-250	100-160
Green	45-72	50-250	60-150
Blue	80-106	50-250	50-150
Purple	130-155	40-250	50-150
Gray	0-180	0-50	50-80
White	0-180	0-15	90-140

Based on table 1. range of values of Hue, Saturation, Value of each is 0-180 º, 0-255 and 255. Hence the need for changes in the value of the range of each component. The range of each component will be changed to 0-360 º, 0-1, and 0-1.

Table 2. Limit value of HSV

Color	Hue	Saturation	Value
Black	0-360	0-0.1	0-0.2
Brown	0-30	0.35-0.98	0.39-0.58
Red	11-30 atau 342-360	0.69-1 atau 0.25-0.98	0.63-1 atau 0.2-0.58
Orange	8-18	0.39-0.98	0.39-0.58
Yellow	40-60	0.5-0.98	0.39-0.62
Green	90-144	0.2-0.98	0.23-0.58
Blue	160-212	0.2-0.98	0.2-0.58
Purple	260-310	0.15-0.98	0.2-0.58
Gray	0-360	0-0.2	0.2-0.31
White	0-360	0-0.05	0.35-0.54

Here is a picture of a resistor which will count the value of resistance:



Image 9. Example of a Resistor

In Image 9. pixel value is the value of the captured HSV. The following matrix value of HSV in Image 9.

x/y	0	…	3	4	…	11
0	120 0.197 0.616	…	49 0.192 0.918	40 0.221 0.957	…	94 0.583 0.235
…	…	…	…	…	…	…
6	35 0.598 0.38	…	14 0.824 0.58	15 0.862 0.541	…	25 0.979 0.184
…	…	…	…	…	…	…
12	135 0.351 0.761	…	103 0.396 0.545	100 0.422 0.529	…	110 0.5 0.235
…	…	…	…	…	…	…
19	25 0.312 0.741	…	11 0.67 0.725	12 0.709 0.714	…	23 0.659 0.345
…	…	…	…	…	…	…
30	62 0.862 0.569	…	26 0.372 0.718	27 0.402 0.682	…	39 0.508 0.239

Image 10. Matrix Value of HSV

On the pixel (6.3) indicates the value of the Hue, Saturation, Value each was 14, 0.58 0824, and then shows the brown color in table 3.20. So does the value of HSV in pixel (12.3) worth 108, 0383, 0553 showed green color. And pixel (19.4), which is worth 12, 0709, 0.714 showed red.

The ring first, second, and third was declared as A, B, c. based on table 2. If Brown's first ring it will be given a value of 1, the second ring is green then rated 5, and the third ring is red then rated 102. The value of the resistance in Figure 9 is worth 1.5K Ohm.

2.3 Implementation

2.3.1 Hardware Implementation

Hardware implementation describes the hardware that is used.

Table 3. Hardware Implementation

No	Hardware	Specifications
1	Processor	AMD E1-2500 APU
2	Memory	6 GB DDR 3
3	VGA	AMD Radeon HD 8210 Graphics Card
4	Hardisk	500 GB
5	Monitor Screen	Resolution 1366x768 *pixel*

2.3.2 Software Implementation

Software used for the calculation of the value of the resistance of the resistor on the digital image can be seen in table 4.

Table 4. Software Implementation

No	Software	Specifications
1	Operating System	Windows 10 Pro 64-bit
2	Programming Language	Java
3	Supporting Device	Java Development Kit
4	Aplication Tools	Netbeans IDE 7.4
5	Modeling	Microsoft Visio 2013

2.3.3 Interface Implementation

Interface implementations to compute the value of the resistance of a resistor on the digital image has multiple interfaces. Here is the interface of the application.

1. Main Menu Display

The first display will appear when a program is executed that is either a main menu that consists of 2 buttons Select button i.e. PCB and Template matching.



Image 11. Main Menu Display

2. Input Image Display

The input menu is used to start the process of detection and calculation of the value of the resistance on the resistor.

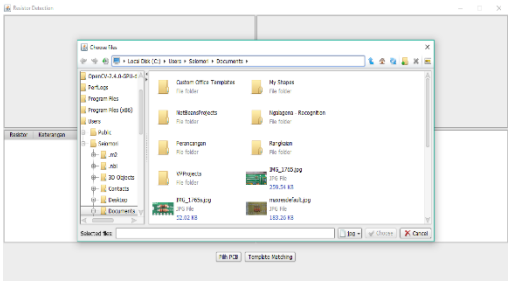


Image 12. Input Image Display

The image on the input file format jpg. Display the main menu after the input image can be seen in Figure 13.

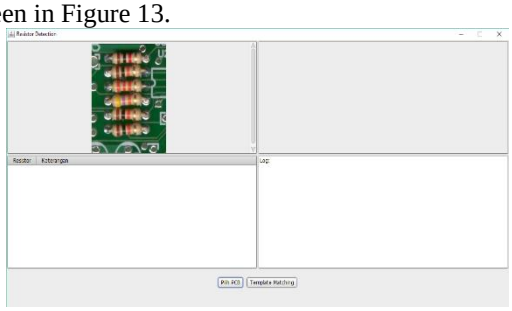


Image 13. Main Menu Display

3. Display of the Message have not selected Images

Display this message appear when users have not selected images. In Figure 14 is the display of a message have not selected images.

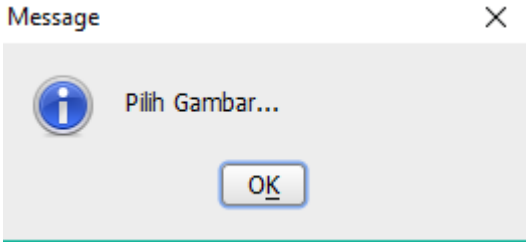


Image 14. Message Display

4. Output Display

Display of the output is the end result of the detection and calculation of the value of the resistor. In Figure 4.5 is the display of the results of the output of the program.

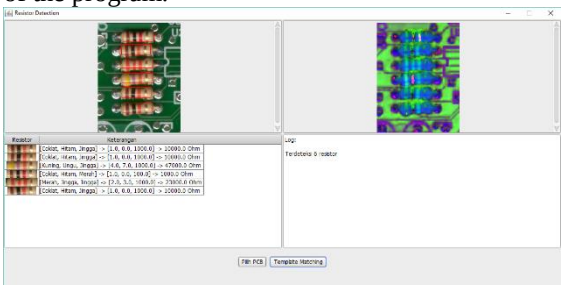


Image 15. Output Display

2.3.4 Testing the Program

This testing is done on the file image formats such as jpg. The image that was tested as a target can be seen in table 5.

Table 5. Image Test

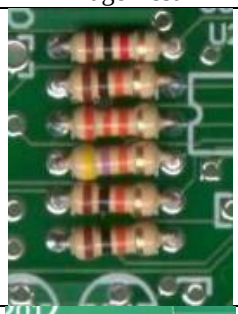
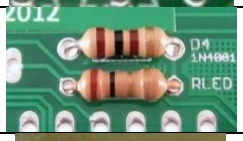
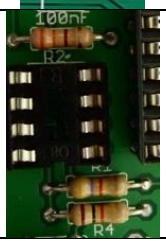
No	Image Test	Resolution
1		177x235
2		250x134
3		105x103
4		247x93
5		215x145

Image templates that will be in the jpg format mismatch on the target. In table 6 are some of the image templates.

Table 6. Image Templates

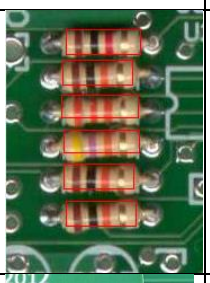
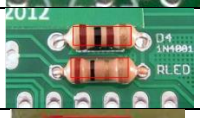
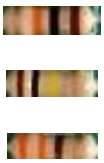
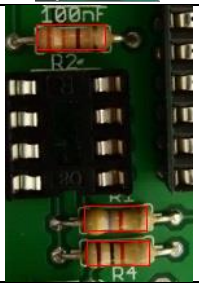
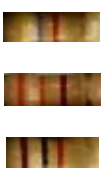
No	Image Templates	Resolution	Resistance Value
1		51x22	12k Ω ± 5%
2		66x22	1k Ω ± 5%
3		62x22	10k Ω ± 5%
4		68x20	23k Ω ± 5%
5		67x20	47k Ω ± 5%
6		17x51	330 Ω ± 5%
7		15x47	10k Ω ± 5%
8		16x52	47k Ω ± 5%

Table 6. Image Templates

No	Image Templates	Resolution	Resistance Value
9		11x40	100k Ω ± 5%
10		11x40	330 Ω ± 5%
11		12x41	10k Ω ± 5%
12		77x25	100 Ω ± 5%
13		76x26	3 Ω ± 5%

Following is the result of a test program that has been done using the test parameters such as calculating the accuracy of detection and calculation of value of resistance. In table 7. results of detection of the resistor.

Table 7. Detection Image Results

No	Image Test	Image Template	Description
1			Detected
2			Detected
3			Detected
4			Detected
5			Detected

From the results of testing of detection resistor can be obtained the following conclusions:

a. A lot of testing: 5
b. The overall number of resistors: 19
c. The number of detected images: 17
d. The percentage of accuracy: 17/19 x 100% = 89%

In table 8 is the result of the calculation of the value of the resistance of each resistor.

Table 8. Result of Calculating Resistance Value

No	Image Template	R 1	R 2	R 3	R 4	Detected	Conclusion
1		✓	✓	✓	✓	1k Ω ± 5%	Correct
2		✓	✓	✓	✓	10k Ω ± 5%	Correct
3		✓	✓	✓	✓	23k Ω ± 5%	Correct
4		✓	✓	✓	-	47k Ω	4th ring is not detected
5		✓	✓	✓	✓	200 Ω ± 5%	Correct
6		✓	✓	✓	-	3Ω	4th ring is not detected
7		✓	✓	✓	✓	12k Ω ± 5%	Correct
8		✓	✓	✓	✓	100k Ω ± 5%	Correct
9		✓	✓	✓	✓	330 Ω ± 5%	Correct
10		-	✓	✓	✓	300 Ω	Incorrect
11		✓	✓	✓	✓	330 Ω	4th ring is not detected
12		✓	✓	✓	✓	10k Ω ± 5%	Correct
13		✓	✓	✓	✓	47k Ω ± 5%	Correct

From the results of testing of the calculation of the value of the resistance of the resistor can be obtained the following conclusions:

a. A lot of testing: 5
b. Number of resistors: 13
c. Correct: resitor Number 9
d. Incorrect: resitor Number 1
e. Number of resistors that ring to 4 not detected: 3
f. Percentage accuracy: 69%

3. Closing

3.1 Conclution

Based on the results of the analysis, design, and implementation then it can be concluded that the results of testing, template matching can detect objects on the digital image generating accuracy of 89% and for the calculation of the value of the resistance on resistors of 69%.

3.2 Suggestions

Application of object detection and calculation of the value of the resistors, so that many shortcomings still need to be developed more. To improve the quality of accuracy and functionality of these applications, there are some suggestions to consider are:

1. Detection range will be better still if in detecting objects using a higher image resolution and quality images with the image format to another.
2. The application is better able to detect an object with a different template models such as the rotation of different templates with an image of the target.
3. Detection of objects have disadvantages, namely the value of the pixel the pixel values should resemble templates that exist on the target so that the object can be detected correctly.
4. Calculation of resistors would be even better if the detected color range is initialized properly.

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