IMPLEMENTATION OF THE TEMPLATE MATCHING METHOD FOR IMAGE RECOGNITION OF MOTORIZED VEHICLE NUMBER PLATE

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Abstract

The motorized vehicle number (TNKB) sign or commonly referred to as the police license plate is a plate made of aluminum that shows the sign of a motorized vehicle in Indonesia that has been registered with the Samsat Office. The motor vehicle number sign in the form of an aluminum plate consists of 2 (two) lines, the first line showing the area code (letters), police number (numbers), and the final code/series. This study uses 10 license plates of motorized vehicles as test data taken for each character and 3 data sets of letters AZ and numbers 0-9 number plates of motorized vehicles for each character as training data. The purpose of this study was to determine the level of accuracy of the method *Template Matching* on image recognition of motor vehicle numbers. The results of the implementation of the method *Template Matching* on the image recognition of motorized vehicle license plates is to produce an accuracy rate of 95.56%.

Keywords: *Template matching*, Motorized Vehicle Number Plates, Image Recognition

1. INTRODUCTION

Motorized vehicle registration number (TNKB) or commonly referred to as police license plate is a plate made of aluminum that shows the sign of a motorized vehicle in Indonesia that has been registered at the Samsat Office. Samsat or One-Stop Administration System is an integrated administrative system between the National Police, the Provincial Revenue Service and PT Jasa Raharja which provides motor vehicle registration services. The motor vehicle number sign is in the form of an aluminum plate consisting of 2 (two) lines. The first line shows the area code (letters), police number (numbers), and the final area code/series (letters), while the second line shows the month and year of validity. Police numbers are usually assigned according to the order in which the vehicle is registered. There are several colors of motorized vehicle markings based on the nature and ownership of the vehicle.

There are many methods that have been done in image recognition using motorized vehicle number plates. Based on previous research [3] which implemented an image recognition application for motorized vehicle numbers using the method *template matching*. By using a total of 30 sample data with a total of 238 characters, an accuracy of 80.25% is obtained. Then, a test was carried out that only used an ideal image of 22 sample data with a total of 176 characters, the results obtained an accuracy rate of up to 97.77%. The ideal sample data for this system is sample data that has a brightness value and with a data collection distance of 2 to 3 meters.

While research from [1] uses the algorithm *K-Nearest Neighbor* to detect and recognize Iraqi number plates. From 70 image data taken under different conditions and used to test the proposed method, an accuracy rate of 91.5% was obtained.

In research [2] which uses *K-Nearest Neighbor* (KNN) and *Support Vector Machine* (SVM) in recognizing vehicle number plate characters. From 20 tests, the accuracy of the SVM method is 95% and the accuracy of the KNN method is 80%. Then, research [4] using the method *Template Matching* and the Distance *Canberra* method obtained an accuracy rate the *Template Matching* of 90% for method and accuracy rate for the Distance method *Canberra* an 85%.

Based on the explanation mentioned above, there are differences in the level of accuracy of the methods used. So the method was chosen *Template Matching* to see how much accuracy the vehicle number plate image recognition has.

2. RESEARCH METHODOLOGY

The research methodology carried out in this study is as follows:

a. Data collection, research data taken is vehicle number plate image data that has been used in research [5] entitled "Implementation of Methods *Zoning* and *Neural Networks Backpropagation* for Police Number Plate Image Recognition Motor vehicle".
b. *Pre-processing*, in this step the initial processing is carried out, such as grayscalling, operator convolution roberts, binarization, gap filling, noise removal, character segmentation, resizing image, to image extraction.
c. Training Data and Test Data*,* training data in the form of 3 sets of image data 26 letters AZ and 10 numbers 0-9, so that the total training data obtained is 108 characters and 10 vehicle number plate images as test data, each of which has a test plate. 9 characters, so that the total test data obtained is 90 character images, with a resolution of each character of 11x21 pixels.
d. *Template Matching,* test data and training data that have been pre-processed will extract the pixel values using the Matlab GUI for each character, which then uses the method *Template Matching* to calculate the distance of each character between the test data and the training data. After the distance value is obtained, then the sorting is done in descending order.
e. Classification results, the distance value obtained using the method *Template Matching*, then classification is carried out based on the distance between the test data and the training data that is close to 0.
f. Accuracy Test, the classification results are added up by the correct class, which is then divided by the total number of test plate characters to find the level accuracy of the method *Template Matching*.

3. RESULTS AND DISCUSSION

3.1. Data collection The

Research data was taken from vehicle number plate image data that has been used in research by [5] entitled "Implementation of Methods *Zoning* and *Neural Networks Backpropagation* for Image Recognition of Police Number Plates for Motorized Vehicles"

Figure 2 Image Test Plate

3.2. Pre-processing

Pre-processing is done to get more accurate analysis results for complex imagedata problems. Pre-processing is also carried out to prepare test and training imagedata to be obtained so that the information system contained therein can make the data value smaller without changing the information already in the image data and suitable for processing in the next process. Things that are done in pre-processing, namely grayscalling, convolution operator roberts, binarization, gap filling, noise removal, character segmentation, resizing image, to image extraction.

3.3. Training Data

The training data used in the form of 3 sets of character data from 26 letters AZ and 10 numbers 0-9 taken from the existing plate image data, so that the total training data obtained is 108 characters. The training data used is only 3 sets of character data because of the 80 plate images obtained, there are several characters that are less than 5 and the lowest is 3. Here is one of the training data used:

Table 1 Character Training Data “B” (PLATLATIH_1.jpg)

No	1	2	3	4	5	6	7	8	9	10	11
1	0	1	1	1	1	1	1	1	0	0	0
2	1	1	1	1	1	1	1	1	1	0	0
3	1	1	1	1	1	1	1	1	1	1	0
4	1	1	1	1	1	1	1	1	1	1	0
5	1	1	1	1	1	1	1	1	1	1	0
6	1	1	1	1	1	1	1	1	1	1	0
7	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	0
11	1	1	1	1	1	1	1	1	1	1	0
12	1	1	1	1	1	1	1	1	1	1	0
13	1	1	1	1	1	1	1	1	1	1	0
14	1	1	1	1	1	1	1	1	1	1	0
15	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1

17	1	1	1	1	1	1	1	1	1	1	0
18	1	1	1	1	1	1	1	1	1	1	0
19	1	1	1	1	1	1	1	1	1	0	0
20	1	1	1	1	1	1	1	1	0	0	0
21	1	1	1	1	1	1	1	0	0	0	0

3.4. Test Data

The test data is in the form of 10 vehicle number plate images with each test plate having 9 characters, so that the total test data obtained is 90 character images. The following is one of the test data used:

Table 2 Test Data for “D” character (PLATLATIH_1.jpg)

No	1	2	3	4	5	6	7	8	9	10	11
1	0	0	1	0	0	0	0	0	0	0	0
2	0	1	1	1	1	1	1	1	0	0	0
3	0	1	1	1	1	1	1	1	1	1	0
4	1	1	1	1	1	1	1	1	1	1	0
5	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	0
18	1	1	1	1	1	1	1	1	1	1	0
19	1	1	1	1	1	1	1	1	1	1	0
20	0	1	1	1	1	1	1	1	1	0	0
21	0	1	1	1	1	1	0	0	0	0	0

3.5. Template Matching

Template Matching is the process of finding an object (template) on all objects in an image. The template is compared with the entire object and if the template matches (close enough) to an unknown object in the image then the object is marked as a template. Ideally, the template is said to match the object in the image if r = 0. The formula used is as follows:

$$r = \frac{\sum_{k=1}^{n} (x_{ik} - \bar{x}_i) \cdot (x_{jk} - \bar{x}_y)}{\sqrt{\sum_{k=1}^{n} (x_{ik} - \bar{x}_i)^2 \cdot \sum_{k=1}^{n} (x_{jk} - \bar{x}_y)^2}}$$

The following are the steps for calculating *Template Matching* to obtain thedistance or r value:

a. Test Data

1. Calculating the value of $\bar{x}$

The value of $\bar{x}$ is the average pixel value in the test data. The value of $\bar{x}$ can be obtained by dividing the amount of training data by the number of data. The following formula is used to find the value of $\bar{x}$:

$$\bar{x} = {}^{1}/_{n} \sum_{k=1}^{n} x_{ik}$$

To get the amount of test data ($\sum_{k=1}^{n} x_{ik}$) enter all pixel values in the testing data in table 3 and do the sum as the following:

$$\sum_{k=1}^{n} x_{ik} = 0 + 0 + 1 + 0 + 0 + \cdots . + 0 + 0 + 0 + 0 + 0 = 202$$

Then to get the number of data (n), multiply the rows and columns of the test data used , such as 11x21, then a lot of data (n) = 231. After getting the number of test data and a lot of data, the results are:

$$\bar{x} = \frac{202}{231} = 0{,}874458874$$

2. Calculating the value of $x_{ik} - \bar{x}$

value of x_{ik} is the pixel value in the data test, so that $x_{ik} - \bar{x}$ obtained by x_{ik} minus the average pixel value of the training data ($\bar{x}$) , where the calculation process is carried out from the first row and column to the last row and column. The following is the result of calculating the value of $x_{ik} - \bar{x}$:

Table 3 Results of the value of $x_{ik} - \bar{x}$

No	1	2	3	...	9	10	11
1	-0.88	-0.88	0.13	...	-0.88	-0.88	-0.88
2	-0.88	0.13	0.13	...	-0.88	-0.88	-0.88
3	-0.88	0.13	0.13	...	0.13	0.13	-0.88
...	...	...	...	...	...	...	...
19	0.13	0.13	0.13	...	0.13	0.13	-0.88
20	-0.88	0.13	0.13	...	0.13	-0.88	-0.88
21	-0.88	0.13	0.13	...	-0.88	-0.88	-0.88

3. Calculating the value of $\sum_{k=1}^{n} (x_{ik} - \bar{x})^2$

Is the sum of all test data values from $x_{ik} - \underline{x_i}$ squared. This calculation process is carried out from the first row and column to the last row and column. The following is the result of calculating the value of $(x_{ik} - \bar{x})^2$:

Table 4 Results of the value of $(x_{ik} - \bar{x})^2$

No	1	2	3	...	9	10	11
1	0.76	0.76	0.02	...	0.76	0.76	0.76
2	0.76	0.02	0.02	...	0.76	0.76	0.76
3	0.76	0.02	0.02	...	0.02	0.02	0.76
...	...	...	...	...	...	...	...
19	0.02	0.02	0.02	...	0.02	0.02	0.76
20	0.76	0.02	0.02	...	0.02	0.76	0.76
21	0.76	0.02	0.02	...	0.76	0.76	0.76

After the calculation results of $(x_{ik} - \bar{x})^2$ obtained, then add up all the values of $(x_{ik} - \bar{x})^2$ in table 6 as follows:

$$\sum_{k=1}^{n} (x_{ik} - \bar{x})^2 = 0{,}76 + 0{,}76 + 0{,}02 + \ldots + 0{,}76 + 0{,}76 + 0{,}76 = 25{,}36$$

b. Training Data

1. Calculate $\bar{x_j}$

The $\bar{x_{j\,value}}$ is the average pixel value in the training data. The value of $\bar{x_j}$ can be obtained by dividing the amount of training data by the number of data. The following formula is used to find the value of $\bar{x_j}$:

$$\bar{x} = {}^{1}/_{n} \sum_{k=1}^{n} x_{jk}$$

To get the amount of training data ($\sum_{k=1}^{n} x_{ik}$), enter all the pixel values in the training data in table 4 and do the summation like this:

$$\sum_{k=1}^{n} x_{ik} = 0 + 1 + 1 + \ldots + 0 + 0 + 0 = 205$$

Then to get a lot of data (n), multiply the rows and columns of the training data used, such as 11x21, then a lot of data (n) = 231. After getting the amount of testing data and a lot of data, then we get results:

$$\bar{x} = \frac{205}{231} = 0{,}89$$

2. Calculating the value of $x_{jk} - \bar{x}$

value of x_{jk} is the pixel value in the training data, so $x_{jk} - \bar{x}$ obtained by x_{jk} minus the average pixel value of the training data ($\bar{x}$) , where the calculation process is carried out from the first row and column to the last row and column. The following is the result of calculating the value of $x_{jk} - \bar{x}$:

Table 5 Result of the value of $x_{jk} - \bar{x}$

No	**1**	**2**	**3**	**…**	**9**	**10**	**11**
1	-0.89	0.11	0.11	…	-0.89	-0.89	-0.89
2	0.11	0.11	0.11	…	0.11	-0.89	-0.89
3	0.11	0.11	0.11	…	0.11	0.11	-0.89
…	…	…	…	…	…	…	…
19	0.11	0.11	0.11	…	0.11	-0.89	-0.89
20	0.11	0.11	0.11	…	-0.89	-0.89	-0.89
21	0.11	0.11	0.11	…	-0.89	-0.89	-0.89

3. Calculating the value of $\sum_{k=1}^{n} (x_{jk} - \bar{x}_y)^2$

is the total value of the training data from $x_{jk} - \bar{x}$ (can be seen in table 10) squared. This calculation process is carried out from the first row and column to the last row and column. The following is the result of the calculation of $(x_{jk} - \bar{x})^2$:

Table 6 Result of the value of $(x_{jk} - \bar{y})^2$

No	1	2	3	...	9	10	11
1	0.79	0.01	0.01	...	0.79	0.79	0.79
2	0.01	0.01	0.01	...	0.01	0.79	0.79
3	0.01	0.01	0.01	...	0.01	0.01	0.79
...	...	...	...	...	...	...	...
19	0.01	0.01	0.01	...	0.01	0.79	0.79
20	0.01	0.01	0.01	...	0.79	0.79	0.79
21	0.01	0.01	0.01	...	0.79	0.79	0.79

After the calculation results of $(x_{jk} - \bar{y})^2$ obtained, then add up all the values of $(x_{jk} - \bar{y})^2$ in table 4 as follows:

$$\sum_{k=1}^{n} (x_{jk} - \bar{y})^2 = 0{,}79 + 0{,}01 + 0{,}01 + \ldots + 0{,}79 + 0{,}79 + 0{,}79 = 23{,}07$$

a. Calculates the value of $\sum_{k=1}^{n} (x_{ik} - \bar{x}) . (x_{jk} - \bar{y})$

$\sum_{k=1}^{n} (x_{ik} - \bar{x}) . (x_{jk} - \bar{y})$ Is the sum of all the results of the multiplication between the values $(x_{ik} - \bar{x})$ from the test data and the value $(x_{jk} - \bar{y})$ from the training data. This calculation process is carried out from the first row and column to the last row and column. Here is the result of $(x_{ik} - \bar{x}) . (x_{jk} - \bar{y})$

Table 7 Result Value $(x_{ik} - \bar{x}) . (x_{jk} - \bar{y})$

No	1	2	3	...	9	10	11
1	0.78	-0.10	0.01	...	0.78	0.78	0.78
2	-0.10	0.01	0.01	...	-0.10	0.78	0.78
3	-0.10	0.01	0.01	...	0.01	0.01	0.78
...	...	...	...	...	...	...	...
19	0.01	0.01	0.01	...	0.01	-0.11	0.78
20	-0.10	0.01	0.01	...	-0.11	0.78	0.78
21	-0.10	0.01	0.01	...	0.78	0.78	0.78

After the calculation results $(x_{ik} - \bar{x}) . (x_{jk} - \bar{y})$ obtained, then add up all the values of $(x_{ik} - \bar{x}) . (x_{jk} - \bar{y})$ in table 14 as follows:

$$\sum_{k=1}^{n} (x_{ik} - \bar{x}) . (x_{jk} - \bar{y}) = 0{,}78 + (-0{,}10) + 0{,}01 + \cdots + 0{,}78 + 0{,}78 + 0{,}78 = 13{,}74$$

To calculate the distance(r) the formula is used *template matching*. The following formula is used.:

$$r = \frac{\sum_{k=1}^{n} (x_{ik} - \bar{x}) . (x_{jk} - \bar{y})}{\sqrt{\sum_{k=1}^{n} (x_{ik} - \bar{x}_i)^2 . \sum_{k=1}^{n} (x_{jk} - \bar{x}_y)^2}}$$

Given $\sum_{k=1}^{n} (x_{ik} - \bar{x}) . (x_{jk} - \bar{y}) = 13{,}74$, $\sum_{k=1} (x_{ik} - \bar{x})^2 = 25{,}36$,

$\sum^{n}$ ^{2}

= 23,07 , so that it is entered into the formula as follows:

$$r = \frac{13.7}{\sqrt{25.36 \cdot 23.07}} = 0.567847586$$

Table 8 Results of Value r

Data Test	Data Training	$\sum_{k=1}^{n}(x_{ik} - \bar{x}_i).(x_{jk} - \bar{x}_j)$	$\sum_{k=1}^{n}(x_{ik} - \bar{x}_i)^2$	$\sum_{k=1}^{n}(x_{jk} - \bar{x}_j)^2$	r
D	0-1	16.61039	25.35931	23.84416	0.675492
D	0-2	16.61039	25 ,35931	23,84416	0.675492
D	0-3	17,35931	25,35931	25,37662	0,6843
D	1-1	-1.17316	25,35931	54.70996	-0.0315
D	1-2	0.943723	25 ,35931	57,17749	0.024784
D	1-3	3,212121	25,35931	48,78788	0.09132
D	2-1	-0.30736	25,35931	57,35931	-0.00806
D	2-2	-3,06061	25.35931	57.69697	-0.08001
D	2-3	4.307359	25.35931	57.35931	0.112938
D	3-1	9.69697	25.35931	56.42424	0.256351
D	3-2	7.692641	25 ,35931	57,35931	0,201699
D	3-3	7,064935	25,35931	57,66234	0.184754
D	4-1	3.311688	25,35931	57,74026	0,086545
D	4-2	4,818182	25,35931	57.27273	0.126427
D	4-3	4.948052	25.35931	56.1039	0.13118
D	5-1	5.082251	25.35931	51.98268	0.139977
D	5-2	-1.05195	25.35931	56 , 1039	-0.02789
D	5-3	3,805195	25,35931	56,96104	0,10012
D	6-1	9,220779	25,35931	71,37662	0,216731
D	6-2	11.84848	25.35931	38, 60606	0.378675
D	6-3	7.714286	25.35931	44,41558	0.229858
D	7-1	-1,19048	25,35931	57.61905	-0.03114
D	7-2	-4.45022	25.35931	55 ,35931	- 0.11877
D	7-3	-0.32468	25.35931	55.55844	-0.00865
D	8-1	11.84848	25.35931	38.60606	0.378675
D	8-2	19.5974	25.35931	39.74026	0.617326
D	8-3	18.08658	25.35931	49.17749	0.512159
D	9-1	11.71429	25.35931	47.14286	0.338797
D	9-2	13.71429	25.35931	47.14286	0, 39664
D	9-3	13.5974	25.35931	39.74026	0.428324
D	A-1	8.571429	25.35931	56.57143	0.226301
D	A-2	8.450216	25.35931	55.35931	0.22553
D	A-3	7.324675	25.35931	55.55844	0.195139
D	B-1	13.73593	25.35931	23.07359	0.567848
D	B-2	13.48918	25.35931	18.2684	0.62671
D	B- 3	12,47619	25,35931	35,61905	0,415119
D	C-1	5,056277	25,35931	57,17749	0.132785
D	C-2	6,056277	25,35931	57,17749	0.159047
D	C-3	13 ,44589	25,35931	56,70996	0,354561
D	D-1	16,10823	25,35931	26,83983	0,617432
D	D-2	12,99134	25,35931	14,89177	0,668516
D	D-3	16,11255	25.35931	20.70996	0.703082
D	E-1	-0.15152	25.35931	38.60606	-0.00484
D	E-2	-0.56277	25.35931	57.74892	-0.01471
D	E-3	- 1.31602	25.35931	57.5671	-0.03444
D	F-1	-0.44156	25.35931	57.50649	-0.01156
D	F-2	-0.7013	25.35931	54.93506	- 0.01879
D	F-3	6.186147	25.35931	57.72294	0.161688

D	G-1	7.186147	25.35931	57.72294	0.187825
D	G-2	12.33766	25.35931	48.38961	0, 352199
D	G-3	10.08225	25.35931	51.98268	0.27769

D	H-1	1.324675	25.35931	55.55844	0.035291
D	H-2	5.688312	25.35931	57.74026	0.148654
D	H-3	4.073593	25.35931	55.93074	0.108164
D	I-1	-2.80952	25.35931	57.61905	-0.0735
D	I-2	6.186147	25.35931	57.72294	0.161688
D	I-3	6.437229	25.35931	57.74892	0.168213
D	J1	1.051948	25.35931	56.1039	0.027889
D	J2	3.051948	25.35931	56.1039	0.080912
D	J3	4.056277	25, 35931	57,17749	0.106524
D	K1	8.939394	25.35931	57.69697	0.233702
D	K2	1.943723	25.35931	57,17749	0.051045
D	K3	7,584416	25,35931	50.64935	0.211625
D	L1	3,419913	25,35931	53,17749	0,093128
D	L2	2,168831	25,35931	52,5974	0,059385
D	L3	0,922078	25,35931	54,23377	0,024864
D	M1	5,333333	25,35931	51,33333	0,147819
D	M2	5.701299	25.35931	54.93506	0.15275
D	M3	7.082251	25.35931	51.98268	0.195062
D	N1	3.839827	25.35931	46,70996	0.111568
D	N2	3 ,839827	25,35931	46,70996	0.111568
D	N3	8,709957	25,35931	50,29437	0,243886
D	O1	17,22944	25,35931	31,74892	0.607209
D	O2	17,35931	25,35931	25,35931	0.684534
D	O3	16,35931	25,35931	25, 35931	0.645101
D	P1	8.95671	25.35931	52.29437	0.245953
D	P2	10.45455	25.35931	53.45455	0.283951
D	P3	6.320346	25.35931	56.83983	0.166474
D	Q1	13, 48485	25,35931	24,60606	0,539829
D	Q2	-1.4E-14	25,35931	24,60606	0,539829
D	Q3	17,96537	25,35931	46,2684	0,524475
D	R1	7,108225	25,35931	26 ,83983	0.27246
D	R2	6.593074	25,35931	43,93074	0.197531
D	R3	4,467532	25,35931	44,41558	0.133116
D	S1	6,683983	25,35931	57,5671	0.174936
D	S2	5 ,30303	25,35931	56,42424	0.140192
D	S3	9,450216	25,35931	55,35931	0,252219
D	T1	-3,94372	25,35931	57,17749	-0.10357
D	T2	5,922078	25,35931	54 ,23377	0.159687
D	T3	-1.57143	25.35931	56.57143	-0.04149
D	U1	4.445887	25.35931	56.70996	0.117236
D	U2	3.66997	25.35931	56.42424	0.097734
D	U3	8,95671	25,35931	52,29437	0,245953
D	V1	1,558442	25,35931	57,50649	0,04081
D	V2	4,424242	25,35931	55,15152	0.118302
D	V3	6,454545	25,35931	53 ,45 455	0.175309
D	W1	4.688312	25.35931	57.74026	0.12252
D	W2	2.437229	25.35931	57.74892	0.063688
D	W3	4.458874	25.35931	50.99567	0.123991
D	X1	1, 437229	25.35931	57.74892	0.037557
D	X2	3.428571	25.35931	56.57143	0.09052
D	X3	2.199134	25.35931	55.74892	0.058488
D	Y1	7.935065	25.35931	57.66234	0 ,207508
D	Y2	0.038961	25.35931	49.55844	0.001099
D	Y3	1.294372	25.35931	52.89177	0.035342

D	Z1	-1.81385	25.35931	57.72294	-0.04741
D	Z2	-0 ,42857	25,35931	56.57143	-0.01132
D	Z3	-0.12114	25.35931	103.8376	-0.00236

In table 8, it can be seen that the overall result of the r value in the character test data for the letter "D" (PLATUJI_1.jpg) The training data used are 3 data sets for each character of the letter AZ and numbers 0-9. After the value of r is obtained, then the sorting is done in descending order or sorting from large to small. This is done because in template matching, the value of the correlation coefficient or r has a value between -1 and +1, which if the correlation coefficient has a value between 0 to -1 then the similarity results obtained will be far. If the correlation coefficient has a value between 0 to +1, then the similarity results obtained will be close. The following is one of the distance values in the "D" character test data (PLATUJI_1.jpg) which has been sorted in descending order,

No.	Test Data	Training Data	r
1	D	D-3	0.703082
2	D	O2	0.684534
3	D	0-3	0 ,6843
4	D	0-1	0.675492
5	D	0-2	0.675492
6	D	D-2	0.668516
7	D	O3	0.645101
8	D	B-2	0.62671
9	D	D-1	0.617432
10	D	8-2	0.617326
11	D	O1	0.607209
12	D	B-1	0.567848
13	D	Q1	0.539829
14	D	Q3	0.539829
15	D	8-3	0.524475
16	D	9-3	0.512159
17	D	B-3	0.428324
18	D	9-2	0.415119
19	D	6-2	0.39664
20	D	8-1	0.378675
21	D	C-3	0.378675
22	D	G-2	0.354561
23	D	9- 1	0.352199
24	D	P2	0.338797
25	D	G-3	0.283951
26	D	R1	0.27769
27	D	3-1	0.27246
28	D	S3	0.256351
29	D	U3	0.252219
30	D	P1	0.245953
31	D	N3	0.245953
32	D	K1	0.243886

33	D	6-3	0.233702
34	D	A-1	0.229858
35	D	A-2	0.226301
36	D	6-1	0.22553
37	D	K3	0.216731
38	D	Y1	0.211625
39	D	3-2	0.207508
40	D	R2	0,201699
41	D	A-3	0.197531
42	D	M3	0.195139
43	D	G-1	0.195062
44	D	3-3	0.187825
45	D	V3	0.184754
46	D	S1	0.175309
47	D	I-3	0.174936
48	D	P3	0.168213
49	D	I-2	0.166474
50	D	F-3	0.161688
51	D	T2	0.161688
52	D	C-2	0.159687
53	D	M2	0.159047
54	D	H-2	0.15275
55	D	M1	0.148654
56	D	S2	0.147819
57	D	5- 1	0.140192
58	D	R3	0.139977
59	D	C-1	0.133116
60	D	4-3	0.132785
61	D	4-2	0.13118
62	D	W3	0.126427
63	D	W1	0.123991
64	D	V2	0 ,12252
65	D	U1	0.118302
66	D	2-3	0.117236
67	D	N1	0.112938
68	D	N2	0.111568
69	D	H-3	0.111568
70	D	J3	0.108164
71	D	5-3	0.106524
72	D	U2	0,10012
73	D	L1	0,097734
74	D	1-3	0,093128
75	D	X2	0,09132
76	D	4-1	0,09052
77	D	J2	0,086545
78	D	W2	0,080912
79	D	L2	0 ,063688
80	D	X3	0,059385
81	D	K2	0,058488
82	D	V1	0,051045
83	D	X1	0,04081
84	D	Y3	0,037557
85	D	H-1	0,035342
86	D	J1	0,035291
87	D	L3	0 ,027889

88	D	1-2	0.024864
89	D	Y2	0.024784
90	D	Q2	0.001099
91	D	Z3	-0.00236
92	D	E-1	-0.00484
93	D	2-1	-0.00806
94	D	7 -3	-0.00865
95	D	Z2	-0.01132
96	D	F-1	-0.01156
97	D	E-2	-0.01471
98	D	F-2	-0.01879
99	D	5-2	-0.02789
100	D	7-1	-0.03114
101	D	1-1	-0.0315
102	D	E-3	-0.03444
103	D	T3	-0.04149
104	D	Z1	-0.04741
105	D	I-1	-0.0735
106	D	2-2	-0.08001
107	D	T1	-0 ,10357
108	D	7-2	-0.11877

3.6. Classification Results

From the distance value (r) that has been obtained by calculating the method *Template Matching* and having been ordered in order *descending*, the results of the classification of all test data are obtained as shown in table 9 as follows:

Table 9 Following are the results of the classification of all test plates.

Test data	Character	Training Data	Class	Description
PLATUJI_1	D	D-3	D	True
	A	A-3	A	True
	6	6-2	6	True
	1	1-2	1	True
	7	7-2	7	True
	6	6-2	6	True
	A	A-2	A	True
	A	A-2	A	True
	I	I-1	I	True
PLATUJI_2	D	B-1	B	True
	A	A-3	A	True
	6	6-2	6	True
	5	5-2	5	True
	3	3-3	3	True
	9	9-1	9	True
	P	P2	P	True
	C	C-1	C	True
	W	W2	W	True
PLATUJI_3	D	D-1	D	True
	A	A-3	A	True
	6	6-2	6	True
	9	9-1	9	True
	6	6-2	6	True
	9	9-3	9	True
	F	F-1	F	True
	B	B-3	B	True

	D	B-3	B	False
PLATUJI_4	D	B-3	B	False
	A	A-1	A	True
	6	6-2	6	True
	4	4-1	4	True
	7	7-2	7	True
	2	2-1	2	True
	A	A-3	A	True
	A	A-3	A	True
	A	A-3	A	True
PLATUJI_5	D	D-1	D	True
	A	A-3	A	True
	6	6-2	6	True
	1	1-2	1	True
	2	2-1	2	True
	2	2-2	2	True
	K	K2	K	True
	A	A-2	A	True
	V	V2	V	True
PLATUJI_6	D	D-1	D	True
	A	A-3	A	True
	6	6-2	6	True
	3	3-1	3	True
	7	7-2	7	True
	1	1-2	1	True
	P	P-2	P	True
	B	B-3	B	True
	H	H-1	H	True
PLATUJI_7	D	D-1	D	True
	A	A-3	A	True
	6	O-2	O	False
	3	3-1	3	True
	2	2-3	2	True
	2	2-1	2	True
	B	L-2	L	False
	B	B-2	B	True
	S	S3	S	True
PLATUJI_8	D	D-2	D	True
	A	A-3	A	True
	6	6-2	6	True
	2	2 -1	2	True
	3	3-1	3	True
	2	2-1	2	True
	A	A-3	A	True
	A	A-3	A	True
	P	P1	P	True
PLATUJI_9	K	K1	K	True
	H	H-3	H	True
	5	5-1	5	True
	8	8-2	8	True
	2	2-2	2	True
	9	9-1	9	True
	E	E-2	E	True
	K	K2	K	True
	K	K2	K	True

PLATUJI_10	K	K3	K	True
	T	T1	T	True
	5	5-1	5	True
	5	5-1	5	True
	8	8-2	8	True
	6	6-2	6	True
	L	L1	L	True
	Z	Z1	Z	True
	Z	Z2	Z	True

3.7. Accuracy Test

Based on the classification results that have been obtained using the method *Template Matching* of 10 test data plate images that have a total number of characters letters and numbers of 90 character images, the number of correct predictions is 86 characters, ma The accuracy level is obtained as follows:

$$Accuracy = \frac{86}{90} x100\% = 95.56\%$$

From the calculation of the accuracy results, it can be concluded that the implementation of the method *Template Matching* for vehicle number plate image recognition has an accuracy rate of 95.56%.

4. CONCLUSION

Based on the results of the research and discussion that has been done, From the research that has been done using *the Template Matching Method*, it can be concluded that the level of accuracy for the implementation of the method *Template Matching* on vehicle number plate image recognition has an accuracy rate of 95.56%.

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