License Plate Detection and Recognition for Indonesian Cars

Priyanto Hidayatullah, Ferry Feirizal, Hadi Permana, Qori Mauluddiah, and Andhika Dwitama

Computer Engineering and Informatics Department
Bandung State Polytechnic, Bandung, Indonesia
priyanto@polban.ac.id, ffeirizal@gmail.com, hpermana1@gmail.com,
mauluddiahqori@gmail.com, andhikadwitama92@yahoo.com

Abstract: License Plate Recognition (LPR) is an application in the study of Image Processing and Pattern Recognition. Unfortunately, development of LPR is hampered by several technical problems such as specular reflection, blurry image, noises and other disturbing objects. There are a lot of LPR methods available. However, those methods are tested for samples outside Indonesia. In this paper, an LPR method for Indonesian cars is presented. This method consists of two main phases: plate localization and character recognition. Plate localization is performed by combining the modified horizontal edge processing, modified vertical edge processing, region of interest extraction and short object elimination. The character recognition is done by a modified template matching algorithm with some improvements in noise removal. From 80 samples used in the experiments, there are 63 successfully detected plates (78.75%). In the recognition phase, from all detected plates, the average Jacaard similarity index is 85.87% and the average remaining noise is 0.25. These results are considered to be good based on a Likert scale.

Keywords: License Plate Recognition, Optical Character Recognition, template matching, noise removal

1. Introduction

LPR is an application in the study of Image Processing and Pattern Recognition. LPR is developed to detect the location of the license plate in an image and recognize its characters. Researchers have developed a lot of LPR methods. Naikur Bharatkumar Gohil [1] has developed a plate localization prototype that successfully detects Californian car plates. The method uses horizontal and vertical edge processing. C´esar Garc´ıa-Osorio et.al.[2] used so-called artificial vision system to recognize Spanish car license plate numbers. This system is designed to be independent of the distance between the car to the camera, the size of the license plate, the inclination and the surrounding illumination conditions. Some other researchers used neural network and its variance for LPR. [3][4][5]

Serkan and Ergun [6] developed a method for Turkish license plate identification. It consists of three major parts: plate region extraction, segmentation of characters and recognition of the characters. They used edge detection and smearing algorithms for plate region extracting. Smearing algorithms, filtering and some morphological algorithms are used for segmentation. Statistical based template matching is used for recognition of plate characters. P. Anishya. et.al. [7] developed VNPR that has many applications in traffic monitoring system in India, including controlling traffic volume, ticketing vehicle without human control, vehicle tracking, policing, security, etc. The results showed that the performance of the canny edge detector far surpassed the other three operators.

Mohd Firdaus Zakaria and Shahrel A. Suandi [8] proposed a method that normally utilizes template matching and color information to perform the recognition. Unfortunately, they did not detect plate location automatically. Instead, they cropped plate images from the original images and did some preprocessing before performing recognition.

Diego Barragán Guerrero [9] developed a template-matching-based OCR which is actually

Received: October 1st, 2013. Accepted: January 20th, 2016
DOI: 10.15676/ijeei.2016.8.2.7

can be used not only for LPR, but also for handwriting recognition. This is a simple yet effective method. One of state of the art OCR is Tesseract OCR [10]. This method is then improved by Google Inc and become one of the most used methods for commercial applications.

Those methods mentioned above are mostly used for a specific country outside Indonesia. Each country has its own license plate color, size, format and font type. These factors are very important for having a good plate detection and character recognition accuracy [11].

Californian license plates used by Naikur[1] have white background, blue characters, the word "California" written in red and a sticker with different color in accordance to the year of issue. In the other hand, Indonesian license plates have black background and white characters. As we reviewed the template-based OCR method used by Diego [9], we found that the font type is very different to the one used in Indonesian license plates. We also realized that Indonesian license plates have a specific format: It always starts with one or two alphabets, then uses numbers from one to four digits and ended with one to three alphabets. The original Diego OCR is not adapted to this format which probably leads to low accuracy for Indonesian license plates. Based on these findings, for the case of Indonesian license plate, we believe that there should be some improvements and modifications to get good results.

2. General Overview of License Plate Recognition

The first step in License Plate Recognition is localization of the plate itself. Plate localization is a way to locate the position of a car license plate. The simplest approach to detect the license plate is by using histogram. By finding the maximum value of vertical and horizontal histogram, the intersection of both maximum values is the license plate location (Figure 1). One implementation of this approach is a method by Naikur Bharatkumar Gohil [1]. The flowchart of the method is shown in Figure 2.

The next step is character recognition. Recognition of characters on a car license plate can be done automatically using technologies such as Optical Character Recognition (OCR). OCR is a technology to recognize handwriting or printed text. The input of OCR is an image and the output is a string/text. One of the approaches of OCR is template matching. Basically, the plate image is cut into pieces that will be compared with all templates to find the most similar template, as illustrated in Figure 3 and Figure 4. The flowchart of the method is shown in Figure 5.

Figure 1. The license plate localization using histograms

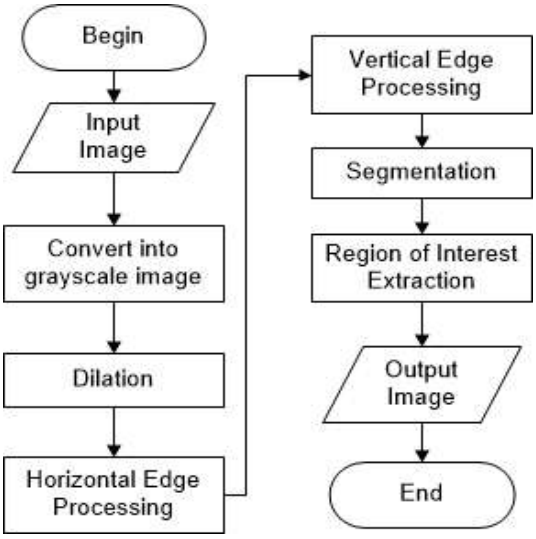

Figure 2. Flowchart of Naikur Bharatkumar Gohil method

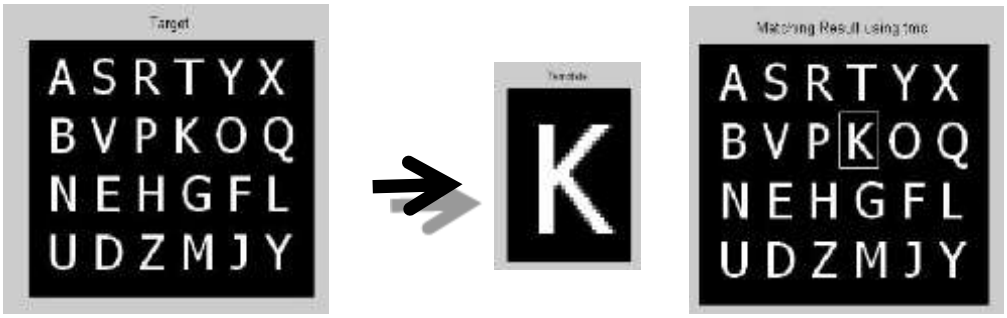

Figure 3. Illustration of template matching algorithm

Pattern of letter “K” on a more detailed level can be illustrated in the figure below:

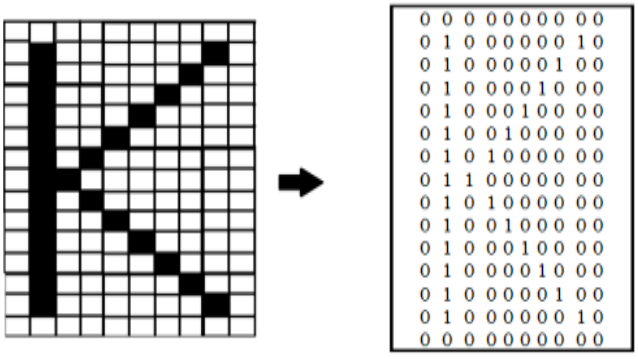

Figure 4. Illustration of a letter pattern

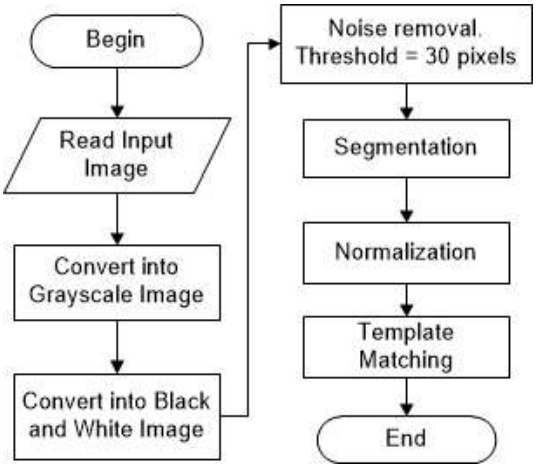

Figure 5. Flowchart of Diego method

3. The Proposed Method

In this paper, we propose to use histograms for license plate localization. Template matching is the method we use for recognition. The flowchart of the proposed method is shown in Figure 6.

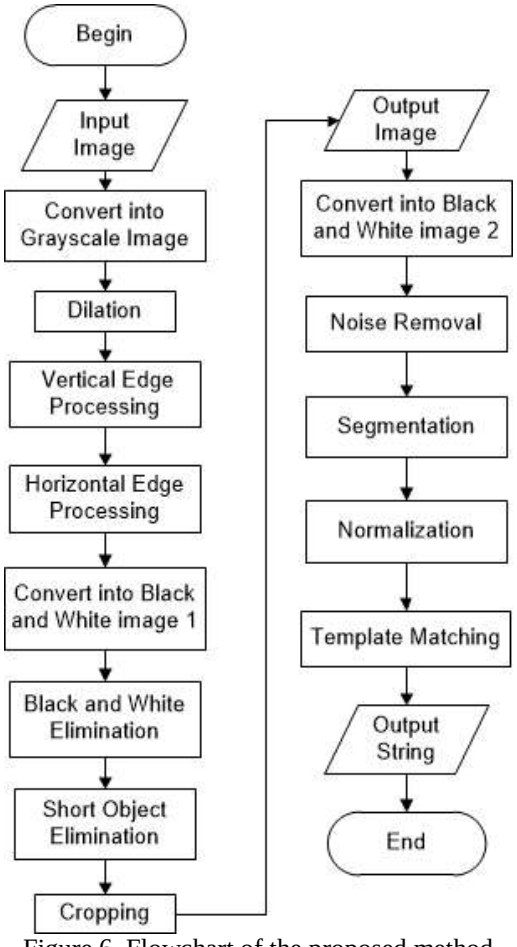

Figure 6. Flowchart of the proposed method

The input image should be a Red-Green-Blue (RGB) image. The RGB image will first be converted into a grayscale image using Equation 1 [12]. The dilation process is then applied to the image to make the characters in the image thicker. The dilation is carried out according to the code [1] below, which is generally taking the highest pixel value between a pixel and its left and right neighbor.

```
ImageOut ← ImageIn
For i ← 1 to rows , i++
  For j ← 2 to cols-1 , j++
    temp ← max(ImageIn.pixels[i,j-1], ImageIn.pixels[i,j])
    ImageOut.pixels[i,j] ← max(temp, ImageIn.pixels[i,j+1])
  Endfor
Endfor
```

$$Y = Lum(R,G,B) = \omega_R * R + \omega_G * G + \omega_B * B \quad (1)$$

where

ω_R = 0.299

ω_G = 0.587

ω_B = 0.114

Y = Grayscale value

The next step is vertical edge processing, which will scan the image vertically and produces a vertical histogram. This histogram represents the sum of the differences of grayscale values between neighboring pixels within each row of an image. The image parts that have a vertical histogram value below the average value will be eliminated, so the image will be segmented into several rows (Figure 7). After that, the remaining parts of the image that is located at the top or bottom of the image will be removed (Figure 7x) because the sample-capturing configuration ensures that the license plate is not located at the top or bottom of the image. Then the most probable row candidate will be chosen by selecting the row which has the maximum value of the vertical histogram (Figure 7z). The result is illustrated in Figure 8.

Figure 7. Vertical Edge Processing

Figure 8. Result of vertical edge processing

The next process is horizontal edge processing. It will scan the image horizontally and produces a horizontal histogram. This histogram represents the sum of the differences of grayscale values between neighboring pixels within each column of an image.

As in the vertical histogram, the image parts that have a horizontal histogram value below the average value will be eliminated (Figure 9). The image is then segmented into several columns (Figure 10). After vertical and horizontal edge processing, the image will be converted into black and white image using Otsu threshold. Black and white difference elimination is applied to remove the area that relatively has more white pixels.

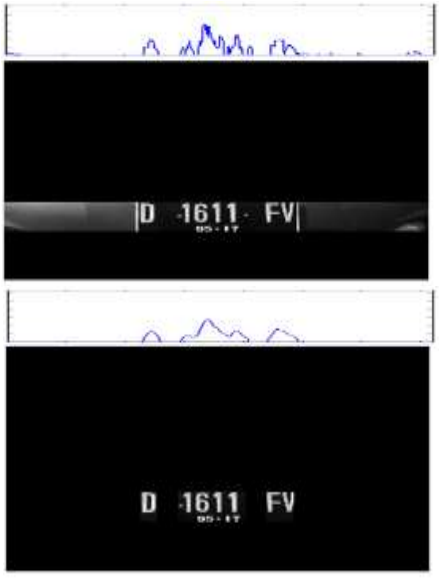

Figure 9. Horizontal edge processing

Figure 10. Result of horizontal edge processing

The process continues with short object elimination to remove detected objects that is shorter than the half of the plate's height. For the example given, the numbers that show the expiration month will be eliminated because they are shorter than half of the plate's height. The illustration is given in Figure 11.

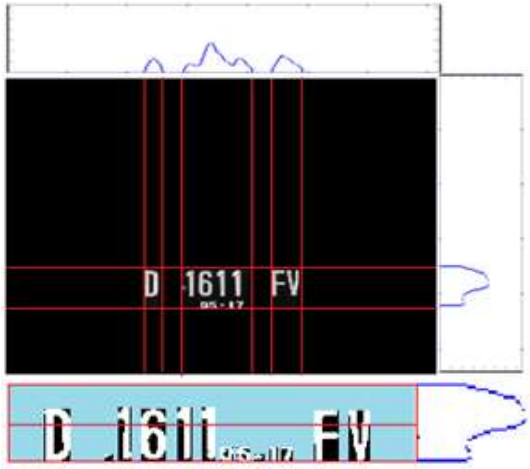

Figure 11. Short Object Elimination

After some noises are removed, the remaining area is used as a base to crop the grayscale image in the first step. We now have extracted the license plate from the image. The extracted plate image is shown in Figure 12.

Figure 12. Cropped Image

The license plate image is then converted into a binary image. Noise removal is then applied. The noise removal process is divided into several steps. The first step is median filtering to remove salt and pepper noise which often appears on the plate because of dust. The filter uses a 3x3 mask. The second step is eliminating objects which size are considered impossible to be a character. This is carried out by removing objects that have size below threshold based on Equation 2. The equation is based on an Indonesian car license plate that is 430 mm wide and 135 mm high (Figure 13).

$$Th = (h * l) * c \tag{2}$$

if $\sum px \geq Th$, then the object is considered as a character

if $\sum px < Th$, then the object is considered as noise

where
Th = threshold
h = height of the image
l = length of the image
c = constant
px = object size

The value of c is 0.007. The results of experiments show that 0.007 is the most optimum value.

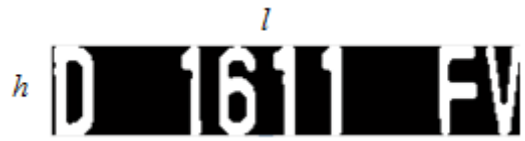

Figure 13. Noise Removal

Figure 14. Segmentation

The third step of noise removal is to eliminate objects that exceed 1/8 length of the image (l). The first object in the image will be labelled so that the object can be identified. After that, each object is checked for its length. If it exceeds 1/8 length of the image, then the object will be eliminated.

The last step of noise removal is to check whether an object is parallel to other objects or not. The characters on a license plate are usually nearly parallel. Therefore, if an object is not parallel to other objects, then the object is not a license plate character. The result is shown in Figure 13.

The next step is segmentation. Each object in the image will be cut starting from the leftmost object (Figure 14). After that, the segmented objects are normalized. They are resized to the size of the template which is 42 x 24 pixels.

The last step is template matching. The Indonesian license plate has some rules. The first part is the area code which is always one or two alphabets. The second part is the number of the vehicle. This part always consists of numbers from one to four digits. The last part is one to three additional alphabets (Figure 15). In this process, each piece of the license plates is grouped based on the rules above. Each part is compared to its template group. This is to avoid the possibility of mixed up letters with numbers or otherwise. The result of the template matching process is a string/text.

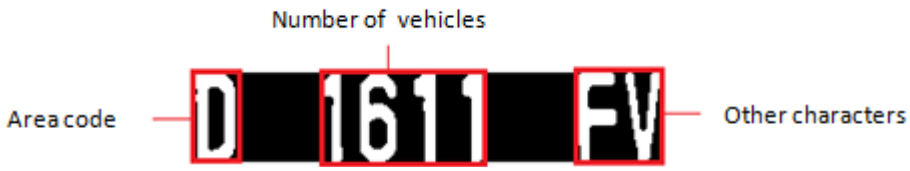

Figure 15. Indonesian License Plate Number Format

To sum up, the key ideas that improve the license plate detection method of Naikur Baratkumar Gohil is the sample capture configuration which influences the size of the license plate on the image. Switching the sequence of the vertical edge processing with horizontal edge processing is also very important because the Naikur method sometimes removed the license plate from the image by putting the horizontal edge processing at the beginning. We also put a substantial addition to remove as much noise as possible by adding short object elimination (Figure 9), removing objects with size below a threshold based on Equation 2, and removing very long objects which length is much larger than the length of a character.

In the optical recognition process, compared to Diego original template matching method, the improvements are the usage of a font type of Indonesian license plates for the template and the comparison of a character to a more specific template group based on license plate format shown in Figure 15.

4. Results and Evaluation

Sample quality is very important in getting a good localization and recognition result. The aim is to minimize noise that occurs in the samples, such as specular reflection, inclination and so on. Therefore, some camera configurations are tested to get desired samples. We have taken pictures of license plates from a distance of 1 m, 1.5 m and 2 m and from a height of 55 cm, 1 m and 2 m. The camera position is always perpendicular to the license plate to avoid specular reflections. The samples are taken using a digital camera which gives 720 x 540 pixel size images.

The license plate image samples are then processed using the proposed method. For comparison, the samples are also processed using the Naikur Bharatkumar Gohil original method for plate localization. In the character recognition process, Diego Barragan Guerrero original template matching method and Tesseract OCR are both tested.

The assessment uses Likert scale to account for percentage of successful results of the detection phase, the average similarity percentage in the recognition phase and the average value of remaining noise [13]. The scale is given in Table 1 and Table 2. Table 1 is used to determine the meaning of the localization test results and used to determine the meaning of the average value of similarity in the recognition test. It has a range of 0% - 100%. Table 2 is used to determine the meaning of recognition test results for the average of remaining noise. Range 0-7 is based on the number of characters that still exist at the end of the proposed LPR process.

Table 1. Meaning of Successful Localization and The Average value of Similarity in Recognition

Range of Percentage	Meaning
81-100	Excellent
61-80	Good
41-60	Adequate
21-40	Poor
0-20	Inadequate

Table 2. Meaning of Average Noise in The Recognition

Range of Percentage	Meaning
5.61-7	Inadequate
4.21-5.6	Poor
2.81-4.2	Adequate
1.41-2.8	Good
0-1.4	Excellent

There are 80 samples obtained. The samples show that license plate object taken from a distance of 1 m and a height of 55 cm from the ground gives the best samples. A distance of more than 1 m between the camera and the license plate makes the license plate appear too small in the sample image. Camera height of 55 cm gives the best samples because most Indonesian license plates are located 55 cm from the ground. This height makes the camera perpendicular to the license plate. The comparison is illustrated in Figure 16.

The proposed method is implemented using MATLAB. Some code parts of the Naikur Bharatkumar Gohil and Diego Barragan Guerrero are included into the prototype. The screenshot of the application is shown in Figure 17.

(a) Capturing distance 2 m

(b) Capturing distance 1.5 m

(c) Capturing distance 1m, camera height 55cm

(d) Camera height 2 m

(e) Camera height 1m

Figure 16. Comparison of sample-capturing configurations

Figure 17. Screenshots that showed recognition of license plate

A. Testing for License Plate Detection

From all samples, there are 63 successfully detected samples (78.75%) while original Naikur Bharatkumar Gohil method detected 28,75% of the samples. The license plate is successfully detected if it covers all characters. The successfully detected plate examples are shown in Figure 18 and Figure 19.

Figure 18. A plate number object that is successfully detected-1

Figure 19. A plate number object that is successfully detected-2

The samples that were unable to be detected are those whose image are cut or exceeded the license plate area. Some samples that failed to pass detection are shown in Figure 20 - 22. From the Figure 20 - 22, we can see that specular reflection is one of the causes of the failure. The reflection was counted as white, therefore resulting in a large black and white grayscale value difference. This reflection was considered as characters by the system.

Figure 20. License plate cut

Figure 21. License plate area exceeded

Figure 22. License plate cut and area exceeded

B. Testing of Character Recognition

The 63 successfully detected samples were then subjected to character recognition process using the modified proposed method, the original template matching algorithm and Tesseract OCR. The similarity between detected strings and the factual numbers are then calculated using the Jacaard Similarity Index [14][15] which equation is shown in Equation 3. The remaining noise is calculated based on the noises that still appeared after carrying out the proposed noise removal.

The proposed method average similarity is 85.9%. This result is better than the original template matching by Diego Barragan Guerrero which achieves 49.17% similarity and Tesseract OCR which gives 83.45% similarity. The detailed results are shown in Table 3.

At first, the process failed to detect D1685XT and F1024WM samples. The reason is because dirt in those cars made too much noise, so that the characters joined together and hard to recognize. The D1685XT sample was able to be recaptured in a clean condition which makes the license plate successfully detected (Figure 23). The F1024WM sample was not able to be recaptured because we could not find the car.

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} \tag{3}$$

Figure 23. Dirty plate (top image) and clean plate (bottom image)

Table 3. The Experiment Results

Factual Police Number	The Proposed Method Results	Original Template Matching Result	Tesseract Result	% Similarity			Remaining Noises	
				The Proposed Method	Original Template Matching	Tesseract	The Proposed Method	Original Template Matching
DK1118IL	DK1118IL	DKJJ48IL	UK 1118 IL	100.0	62.5	71.0	0	0
DK1118IL	DK1118IL	DK33J8IL	DK1118 IL	100.0	62.5	100.0	0	0
DK1193ES	DK1193ES	DKVJJUBAWJES	DK 1193 ES	100.0	30.8	100.0	0	4
BA464RI	BA464RI	BAX6N4R1	BA 46!. RI	100.0	55.6	75.0	0	1
AD9136VE	AD9136VE	AD49T3BYVE	M39136 VE	100.0	50.0	67.0	0	2
A1896CS	A1996CS	HAF3996CS	A 1896CS	85.7	50.0	100.0	0	2
KT1379AO	KT3379AD	KTT379AD	KT I379 AO	66.7	66.7	100.0	0	0
B1963ZFF	B1953ZFF	TUB3ZFF	B 1953 ZFF	75.0	44.4	75.0	0	0
KT61TA	KT81TA	KTBJTA	KT 61 TA	66.7	42.9	100.0	0	0
D1354ND	D1354ND	D3354NDJ	D 1354 ND	100.0	71.4	100.0	0	1
D1072GC	D1072DC	D307ZGC	D 1072 GC	85.7	55.7	100.0	0	0
T1566TC	T1588TC	T358BIC	I 1566 TC	66.7	33.3	83.3	0	0
D1611FV	D1611FV	D3O833FV	D 1511 FV	100.0	37.5	66.7	0	1
D1493NG	D1493NC	D91493NG	D 1493 NG	75.0	100.0	100.0	0	1
D1132AL	D1132AL	DJ33ZAL	D 1132 AL	100.0	50.0	100.0	0	0
B8772IS	B8772IS	B877Z1SH	B 8772 IS	100.0	44.4	100.0	0	1
D1397XB	D1397XB	D3397XB	D 1397 XB	100.0	85.7	100.0	0	0
D1459TH	D1459TH	00Z345F9TH	D 1459 TH	100.0	45.4	100.0	0	3
D1707BOE	D1707BOE	D37D7B8E	D 1707 BGE	100.0	44.4	75.0	0	0
D1760EO	D1780EO	D91780AEB	P 1760 EW	75.0	45.4	55.6	0	2
D1302UD	D1302UD	D33O2UD	D 1302 UD	100.0	57.1	100.0	0	0
D1838UC	D1838UC	PD3B38UC	D 1838 UC	100.0	62.5	100.0	0	1
D1081ON	D1081BN	D33D83BN	D 1081 GN	71.4	37.5	71.4	0	1
D1842JW	D1842JW	D3B4ZJ4W	U 1842 JW	100.0	40.0	100.0	0	1
D1885UI	D1885UI	D3885U1	D 1885 UI	100.0	71.4	100.0	0	0
D1773UC	D1773UC	D3773UC	D 1773 UC	100.0	83.3	100.0	0	0
D1547TE	D1547TE	ZDT54ZTE	D 1547 TE	100.0	62.5	100.0	0	1
D1244OQ	D1244OO	D3244DU	D 1244 BU	83.3	37.5	50.0	0	0
D1832AAF	D1832AAF	0T83ZAAFF	D 1832 MF	100.0	40.0	75.0	0	0
D1523QA	D1523OA	D8T5Z310A	D 1523 UÂ	75.0	45.4	75.0	0	2
D1481UK	D1481UK	D34B3UK	m 1481 UK	100.0	50.0	71.4	0	0
D1818XT	D1819XT	D3838XT	D 1818 XT	83.3	66.7	100.0	0	0
D1235SP	D1235SP	D3Z35SP	U 1235 SP	100.0	62.5	100.0	0	0
D1190UJ	D1190UJ	D339DUJ	U 1190 UJ	100.0	57.1	100.0	0	0
D811CJ	D811CJ	100833CJ	D 811 CJ	100.0	57.1	100.0	0	2
D1662RB	D1662RB	D3662RB	D 1662 RB	100.0	71.4	100.0	0	0
D1384UJ	D1384UJ	D33B4UJ	D 1384 UJ	100.0	62.5	100.0	0	0
D1732WG	D1732UD	D373ZVUG0	D 1302 UD	62.5	36.4	44.4	0	2
D1321AAD	D1321AAD	03323AAO0	U 1321 MD	100.0	42.7	57.1	0	1
D1572UH	D1572UH	D357ZUH	D 1572 UH	100.0	66.7	100.0	0	0
D1774MQ	D1774HD	D4VV4M9U	D 177K. VIU	57.1	33.3	27.3	0	1
D1778QB	D1778OB	D377870B	U 1778 HB	71.4	50.0	50.0	0	1
D403LL	D403LL	U4D3LL	|l] 403 LL	100.0	66.7	50.0	0	0
D1279PI	D1279PI	03Z79P1	D 1279 PI	100.0	40.0	100.0	0	0
D1258SV	D1258SV	03258SV	D 1258 SV	100.0	55.6	100.0	0	0
D1861OB	D1861DB	D03BBJ9DB	D 1861 UB	83.3	20.0	71.4	0	2
D1218XZ	D7218XZ	J1Z384XZ1	U 1218 Xl	85.7	44.4	71.4	0	2
D1343UB	D1343UB	03343UB	D 1343 UQ	100.0	57.1	71.4	0	0
D1142UE	D1142UE	0334ZUE	D 1142 UE	100.0	33.3	100.0	0	0
D1276FV	D4270HV	4U1ZZULV	U lčlb PV	40.0	18.2	8.3	0	1
D1013QR	D1033OR	043D13OR	D 1013 UR	71.4	62.5	71.4	0	1
D1819JN	D1819JN	L0JT8394JN	D 1819 JN	100.0	36.4	100.0	0	3
D1623XS	D1623XS	L0A3BZ3TXS	D 1623 XS	100.0	23.1	100.0	0	3
D1673PD	D1673PO	HPL03B73P0	E 1673 PD	85.7	30.0	85.7	0	3
D1638MR	D1838HR	03838HR	D 1638 MR	62.5	33.3	100.0	0	0
D1584TY	D1584TY	D35BXTX	D 1584 TY	100.0	30.0	100.0	0	0
D1337UU	D1887UU	DV3JJ714UU	U 1337 UU	66.7	62.5	100.0	0	3
D1108PO	D1108PO	OAW33D8W7P8	D 1108 PB	100.0	40.0	71.4	0	4
D1335TH	D7335TH	L70Z3402354F949THI	D 1535 TH	71.4	26.7	100.0	0	11
D1685XT	D1685XT	TP3M104516XTT	D1685XT	0.0	41.7	100.0	7	6
F1024WM	Not detected	PF13DO72436WH	Empty page	0.0	35.7	0.0	7	6
D1713JT	D1TTS	F003A7O6791370JLAFJ	D 1713	42.9	30.8	66.7	2	12
D1435RJ	D1435RJ	UJ0P3405345390RJJ	U 1435 RJ	100.0	45.4	100.0	0	10
Average				**85.87**	**49.29**	**83.45**	**0.25**	**1.56**

5. Conclusions

The proposed method consists of two main phases which are plate localization/detection and character recognition. The Indonesian license plate has its unique characteristics so that any LPR method used has to be modified and improved to have a good result. For the detection phase, we used modified vertical edge processing and horizontal edge processing and some additional improvements to remove noises. Those improvements were black and white difference elimination and short object elimination. In the recognition phase, we used the template matching algorithm whose accuracy was improved using Indonesian license plate font and format. Some noise removal method is also added to remove objects that were considered impossible to be a character based on their size.

The proposed method was implemented and tested using 80 samples. From the test results, we can conclude that the proposed license plate detection method gives better results compared to original license plate detection method of Naikur Bharatkumar Gohil. There are 63 successfully detected plates (78.75%) while Nikur Bhartkuar Gohil successfully detected 28.75% of the samples. According to Likert scale, the proposed method result is good.

The recognition phase test was done using the successfully detected samples from the detection phase. The proposed method achieved 85.87% average similarity using the Jacaard Similarity Index while Tesseract achieved 83.45% and original template matching algorithm achieved 49.49% average similarity. According to Likert scale, the proposed method similarity is very good.

In term of noise reduction, the proposed method resulted in less remaining noise. The proposed method average remaining noise was 0.25 while noise from original template matching algorithm was 1.56. According to Likert scale, the proposed method remaining noise is good.

In respect to license plate sample capture configuration for Indonesian cars, we found that a distance of 1 m from the camera to the plate and a distance of 55 cm between the camera and the ground resulted in the best result. We also propose an equation based on the Indonesian license plate size that effectively removes noise (Equation 2). From the experiments we found that the most optimal constant (c) is 0.007.

Aside from improvements that are mentioned above, some failures still occur. We summarize that these failures appeared because of specular reflection that disturbed the localization and recognition of license plate, tilted plate characters which make the characters hard to recognize, blurry images and dirty car samples which make the characters joined together and hard to recognize, the sample image was taken too close which disturbs the difference black and white elimination, and the plate character was printed similar to another character.

6. Acknowledgements

We would like to express our gratitude to Mrs Transmissia Semiawan, Mrs Fitri Diani, Mr Dewa Gede Parta, Mr Bambang Wisnuadhi and Mr Haryadi for meaningful feedbacks. This research is partly funded by Penelitian Pemula Research Grant DIPA Polban.

7. References

[1]. Gohil, Naikur Bharatkumar. 2010. Car License Plate Detection. Sacramento: California State University.

[2]. C´esar Garc´ıa-Osorio, Jos´e-Francsico D´ıez-Pastor, Juan J. Rodr´iguez, and Jes´us Maudes." *LICENSE PLATE NUMBER RECOGNITION*, New heuristics and a comparative study of classifiers" No year.

[3]. C.N. Anagnostopoulos, I. Anagnostopoulos, V. Loumos, and E. Kayafas, "A license plate recognition algorithm for Intelligent Transportation System application*", T-ITS-05-08-0094*, 2005.

[4]. Leonard G. C. Hamey, Colin Priest, "Automatic Number Plate Recognition for Australian Condition", no year.
[5]. Osslan Osiris Vergara Villegas, Daniel González Balderrama, Humberto de Jesús Ochoa Domínguez, and Vianey Guadalupe Cruz Sánchez. "License Plate Recognition Using a Novel Fuzzy Multilayer Neural Network", 2009.
[6]. Serkan Ozbay, Ergun Ercelebi, "Automatic Vehicle Identification by Plate Recognation", *World Academy of Science, Engineering and Technology* 9, 2005.
[7]. P. Anishiya, S. Mary Joans, "Number Plate Recognition for Indian Cars Using Morphological Dilation and Erosion with the Aid of Ocrs", 2011 *International Conference on Information and Network Technology IACSIT Press*, Singapore.
[8]. Mohd Firdaus Zakaria and Shahrer A. Suandi, "Malaysian car Number Plate Detection System Based Template Matching and Colour Information", *International Journal on Computer Science and Engineering* Vol 02. No. 04. 1159-1164, 2010.
[9]. http://www.matpic.com/esp/matlab/ocr.html, accessed on 3 September 2012
[10]. Ray Smith, "An Overview of the Tesseract OCR Engine", Google Inc.
[11]. P. Hidayatullah, N. Syakrani, I. Suhartini, and W. Muhlis, "Optical Character Recognition Improvement for License Plate Recognition in Indonesia," Computer Modeling and Simulation (EMS), 2012 Sixth UKSim/AMSS European Symposium on. pp. 249–254, 2012.
[12]. Burger, Wilhelm, Mark J. Burge. 2008. Digital Image Processing An Algorithmic Introduction Using Java. New York: Springer.
[13]. Jr, Harry N. Boone, Deborah A. Boone. 2012. Analyzing Likert Data. Journal of Extension. 50(2).
[14]. Paul Jaccard. Etude comparative de la distribution orale dans une portion des Alpes et des Jura.In Bulletin del la Socit Vaudoise des Sciences Naturelles, volume 37, pages 547-579.
[15]. Jacob Bank, Benjamin Cole, "Calculating the Jaccard Similarity Coeficient With Map Reduce for Entity Pairs in Wikipedia", 2008.

Priyanto Hidayatullah was born in Garut, Indonesia in 1981. He received a Bachelor degree from Bandung Institute of Technology in 2004 and a double degree Master of Science from Universite Jean Monnet France and University of Eastern Finland in 2010. Currently he is a lecturer, book writer and researcher in Computer Engineering and Informatics Department, Bandung State Polytechnic, Indonesia. His research interests are image processing, computer vision, machine learning and especially Biomedic.

Ferry Feirizal was born in Cimahi, Indonesia in 1959. He received a Bachelor degree Major in Computer Science from Western Kentucky University, United State of America in 1990. Currently he is a lecturer, writer and researcher in Computer Engineering and Informatics Department, Bandung State Polytechnic, Indonesia. His research interests are image processing and microcontroller programming using Arduino for automated monitoring in agriculture.

Hadi Permana was born in Bandung Indonesia in 1992. He obtained a Diploma degree from Computer Engineering and Informatics Department, Bandung State Polytechnic, Indonesia in 2013. Currently he is a Java programmer in Customs and Excise, Ministry of Finance Republic of Indonesia.

Qori Mauluddiah was born in Bandung, Indonesia in 1989. She obtained a Diploma degree from Computer Engineering and Informatics Department, Bandung State Polytechnic, Indonesia on 2013. Currently, she is a developer in IT Consultant and student of Maranatha Christian University for Bachelor Program.

Andhika Dwitama was born in Bandung, Indonesia in 1992. He obtained a Diploma degree from Computer Engineering and Informatics Department, Bandung State Polytechnic, Indonesia in 2013. Since his graduation, he was involved on several software engineering projects as a programmer at PT Bee Solution Partners. In 2015, he continued his studies to get a bachelor's degree of Informatics at Widyatama University, Bandung.