IN REVIEW

INDONESIAN LICENSE PLATE RECOGNITION USING YOLOV3 AND OPTICAL CHARACTER RECOGNITION

FINAL PROJECT

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DEPARTMENT OF INFORMATICS
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JAKARTA
2020

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FINAL PROJECT

Submitted to Complete Terms
Completed a Computer Bachelor Degree

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JAKARTA
2020

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	Submitted/Published on:	Journal Name	: International Journal on Electrical Engineering and Informatics		
		ISSN	: 2085-6830		
2	Working Sheet, Is the result of research material as a complete Journal Article. Consist of (minimum 4)	Literatur Review			[✓]
		Analysis & Application Design Result			[-]
		Source code			[✓]
		Data set			[✓]
		Experiment Stages			[✓]
		Whole Experiment Result			[-]
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This thesis has been examined and tried as one of the requirements to obtain a Bachelor's degree in the Informatics Engineering Study Program, Faculty of Computer Science, Universitas Mercu Buana.

Jakarta, 12th February 2020

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This Final Project has been examined and defenced as one of the requirements for obtaining a Bachelor's degree in the Informatics Engineering Study Program, Faculty of Computer Science, Universitas Mercu Buana.

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ABSTRAK

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Abstrak: Sistem Transportasi Cerdas (STC) adalah penerapan teknologi tingkat lanjut terhadap sistem transportasi untuk menghadapi ragam permasalahan transportasi. Beberapa teknologi yang diidentifikasikan sebagai STC adalah Automatic License Plate Recognition (ALPR), Advanced Traffic Signal Control Systems (ATSCS), Electronic Toll Collecting System (ETCS), Bus Information Management System (BIMS). STC telah menjadi hal yang difokuskan oleh pemerintah hingga sekarang untuk menghadapi transformasi digital di Indonesia. Oleh karena itu, penulis melakukan kontribusi terhadap perpindahan sistem konvensional ke digital melalui penelitian ini. Penulis menggunakan sistem YOLOv3 convolutional network untuk mendeteksi plat kendaraan dilanjutkan dengan penerapan Otsu's thresholding dan Tesseract OCR untuk mengenali karakter. Dari dataset gambar plat kendaraan sejumlah 1000, metode yang diterapkan menghasilkan nilai mAP@0.5 IoU sebesar 88.87% dan akurasi pengenalan karakter sebesar 80,2%.

Kata kunci:
License plate recognition, YOLOv3, Tesseract OCR.

ABSTRACT

Name	:	Edra Kevin Oktaviano
Student Number	:	41516010055
Counsellor	:	Dr. Ida Nurhaida, MT
Title	:	Indonesian License Plate Recognition using YOLOv3 and Optical Character Recognition

Abstract: Intelligent Transportation System (ITS) is implementation of advanced technology towards transportation system to encounter various transportation problems. Several technologies identified as ITS including Automatic License Plate Recognition (ALPR), Advanced Traffic Signal Control Systems (ATSCS), Electronic Toll Collecting System (ETCS), Bus Information Management System (BIMS). Until now, ITS becomes main focus of Indonesian government to encounter digital transformation. Thus, Author tries to give contribution on transformation of transportation system to digital through this paper. Author uses YOLOv3 convolutional network to detect license plate followed by Otsu's thresholding and Tesseract OCR to recognize characters. From 1000 license plate image as dataset, implemented method has resulting mAP 88.87 percent and character recognition 80,2 percent.

Keywords:
License plate recognition, YOLOv3, Tesseract OCR.

PREFACE

Thank you for the presence of Allah SWT and the visit of His Highness the Prophet Muhammad as his role model and lover, who has given so much grace and provided many opportunities for authors to complete thesis report well. This report was prepared to obtain a Bachelor degree (S1) in Informatics Department, Universitas Mercu Buana. The author is fully aware that the preparation of thesis report cannot be separated from the support, enthusiasm and guidance of various parties. Therefore, the author would like to express my gratitude as much as possible to:

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The writing of this thesis report was prepared as well as possible, but the author realizes that there are still many shortcomings and is not perfect yet, therefore constructive criticism and suggestions from all people are expected. Hopefully this thesis report is useful and useful for readers and can increase knowledge for involved parties. Finally, the author would like to say thank you for all the guidance, and support and this great opportunity, may we all always be protected by Allah SWT.

Jakarta,

Edra Kevin Oktaviano

Indonesian License Plate Recognition Using YOLOv3 and Optical Character Recognition

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Abstract: Intelligent Transportation System (ITS) is implementation of advanced technology towards transportation system to encounter various transportation problems. Several technologies identified as ITS including Automatic License Plate Recognition (ALPR), Advanced Traffic Signal Control Systems (ATSCS), Electronic Toll Collecting System (ETCS), Bus Information Management System (BIMS). Until now, ITS becomes main focus of Indonesian government to encounter digital transformation. Thus, Author tries to give contribution on transformation of transportation system to digital through this paper. Author uses YOLOv3 convolutional network to detect license plate followed by Otsu's thresholding and Tesseract OCR to recognize characters. From 1000 license plate image as dataset, implemented method has resulting mAP 88.87 percent and character recognition 80,2 percent.

Keywords: License plate recognition, YOLOv3, Tesseract OCR

1. Introduction

Intelligent Transport System (ITS) is implementation of advanced communication, information, and electronic technology to solve various transportation problems such as traffic jam, security, efficiency, and environmentally friendly [1]. This system has started developing in Indonesia to encourage digital transformation. ITS has various technologies such as Automatic License Plate Recognition (ALPR), Advanced Traffic Signal Control Systems (ATSCS), Electronic Toll Collecting System (ETCS), Bus Information Management System (BIMS). ALPR, a vision-driven ITS [2] is used to identify, count vehicles, and distinguish each vehicle as a unique entity by recognizing characters on a license plate [3]. ALPR is expected to be intelligent system to detect rules violation, odd-even rules, and traffic surveillance.

License plate is an essential part in identifying vehicle. In some cases, license plate can be deliberately altered in fraud situations or replaced (e.g., with a stolen plate). Thus, ITS is relying heavily on LPR strength [4]. On the initial process, machine will detect license plate from collected data. Then, processing is focused on recognizing detected character on license plate with decent accuracy. Thus, accuracy has to be well maintained despite the quality of image, perspective distortion, and light reflection on license plate surface.

This paper is aimed to detect license plate from Indonesia using convolutional neural network and recognize character using Optical Character Recognition (OCR). Convolutional neural network used is You Only Look Once (YOLO) v3, a state-of-the-art method on object detection. While OCR method used is Tesseract OCR. This paper is expected to have a great accuracy and speed result in detecting and recognizing license plate.

Author has performed a series of literature study on researches about license plate recognition, especially Indonesian license plate due to significant differences between other license plate. One example of research about license plate on vehicle image has been done by [5]. The author used Hough Transformation to detect candidate of horizontal line on plate's edge. This license plate detection resulting 90% of accuracy.

Another research also performed to recognize character on Indonesian license plate. The research is performed by [6]. They use Tilt correction and Faster R-CNN as their method on detecting license plate. Various stages of image processing such as grayscaling, planar homography, and canny edge detection used to cleanse and detect the object on license plate. Result shows 82,14% accuracy of character recognition on license plate.

Similar research has been studied to understand further about Indonesian license plate detection Algorithm. The research is performed by [7], they implement image processing as their method. Algorithm of the research including edge detection, image contouring, segmenting and distance calculation are used to detect license plate before sending result to character recognition. The algorithm results produced 100 milliseconds of time processing, but encountering a serious problem which affecting result. The problem he encountered is algorithm has chance to false detect car's grill as a character on license plate.

2. Methods

Following figure is a diagram of research's proposed method. First stage is data collection related to this research. Next stage is performing image pre-processing to improve detection rate. Then, training and testing process is performed using object detection algorithm. After finished testing process, detected image then will be cropped based on its acquired bounding box. Cropped image will be sent to thresholding process to segment between object and background to ease character recognition on final stage.

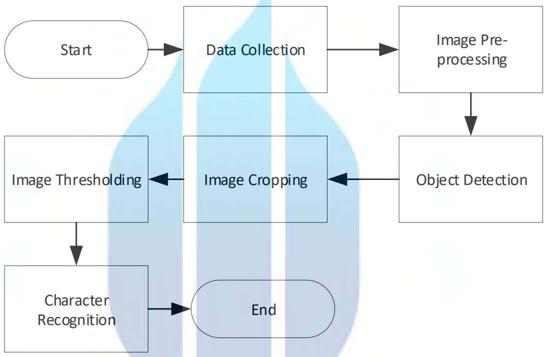


Figure 1. Proposed Method

A. *Data Collection*

Data obtained for training and testing resources are taken from:

1. Google Image Search
2. Indonesian Plate Number dataset from Kaggle

Data obtained using google image search through crawling technique is 500 images and data obtained from Kaggle dataset is 500 images. Dataset from Kaggle contains license plate originated from Cirebon, West Java. Collected data on this research should contain license plate.

To create image label file for training and testing purpose, Author uses LabelImg application. The output of application will be saved as annotation in text file with identical name with the labelled image. YOLO based annotation file format for image label is *class_no, x, y, width, height*. Whereas *class_no* is index of given class, *x* is float values relative to width, *y* is float values relative to height, *width* is float value of object width divided with image width, *height* is float value of object height divided with image height. Figure 2 is the example of data.

Figure 2. License plate dataset

B. *Image Pre-Processing*

In this stage, author performs a series of image processing algorithm to convert color to monochrome and to distribute color density evenly on image histogram [8]. First, author performs grayscaling to change color intensity into monochrome. It will ease thresholding at further stage due to lesser color range. To calculate color conversion, author uses standard color conversion called CCIR 601, as described on following formula:

$$Y' = 0.299\,R' + 0.587\,G' + 0.114\,B' \qquad (1)$$

Where:

Y' = Achromatic value
R' = Red value
G' = Green value
B' = Blue value

Following image is a result example of grayscaling process:

(a) (b)

Figure 3. Before (a) and after grayscaling (b)

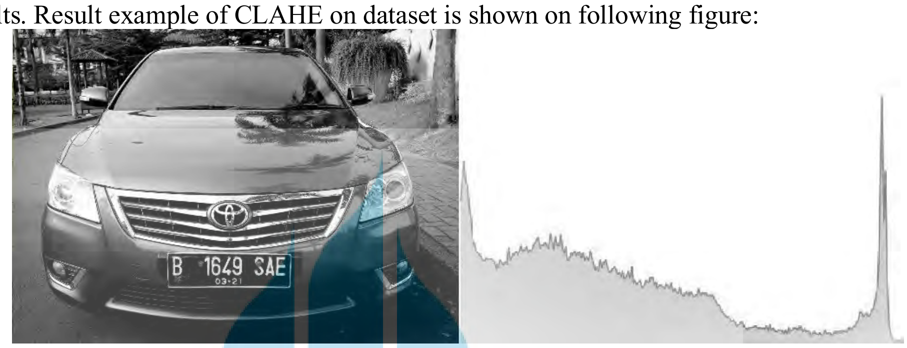
After finished on grayscale, author performed image enhancement. Image enhancement is used to improve the appearance of an image and make it suitable for human visual perception or subsequent machine learning [9]. Technique used in Image Enhancement is Contrast Limited Adaptive Histogram Equalization (CLAHE). CLAHE technique to enhance the visibility of local details of an image by increasing the contrast of local regions [9].

Refer to [10], first stage of CLAHE is segmenting on non-overlapping image into regions. Then clip limit calculation is performed to clip histogram. Then, histogram will be redistributed in such a way that its height does not go beyond clip limit. Clip limit β is described below:

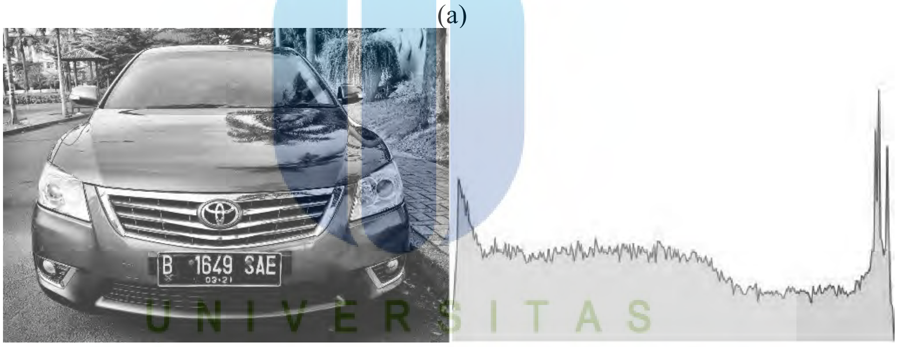
$$\beta = \frac{M \times N}{L}\left(1 + \frac{\alpha}{100}(S_{max} - 1)\right) \quad (2)$$

Where:
M × N = Total pixels of a region
L = Total grayscale pixels
α = *clip factor*
S_{max} = Maximum allowed slope

On the Final stage, cumulative distribution functions (CDF) from histogram will be determined for grayscale mapping. Pixels will be mapped linearly from four nearest regions results. Result example of CLAHE on dataset is shown on following figure:



(a)



(b)

Figure 4. Comparison of CLAHE and Histogram Equalization. a) Grayscaled image. b) CLAHE image

C. Object Detection

Author uses YOLOv3 to perform object detection. YOLOv3 is a fast and accurate object detection [11], and also successor of YOLOv1 [12] and YOLO9000 [13]. Various researches implemented YOLOv3 as their object detection such as Autonomous Driving [14], airplanes [15], electronic components [16], and cephalometric landmarks [17]. Object detection on YOLO produces bounding box coordinates and probability of each category directly through regression operation. This process gives significant improvement on object detection [18].

On training process, [19] explains YOLO divides input image into S x S grid. A grid will detect an object when its center falls on its grid. Each grid can be only associated to an object and predict fixed number of B boundary box. Every boundary box has a box confidence score. There are 5 information contained in every bounding box, those are *x,y,w,h,confidence_score.* Following formula is used to predict tensor of dimension:

$$S \times S \times (B * 5 \mid C) \tag{3}$$

YOLOv3 Architecture can be seen on figure 5. YOLOv3 has 53 convolutional layers called Darknet53, with additional elements such as residual blocks, skip connections and upsampling [20]. YOLOv3 Architecture can be constructed deeper, hence accuracy detection will be increased [16].

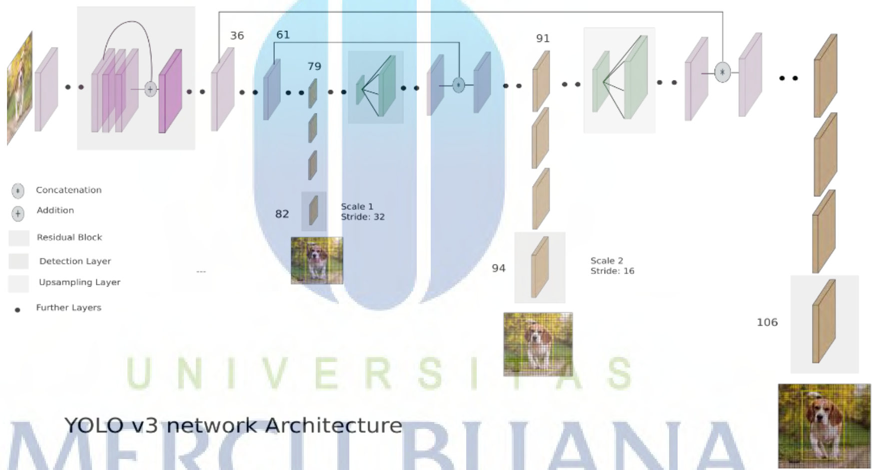


Figure 5. YOLOv3 network architecture

On previous YOLO networks, YOLO is hardly able to detect small objects. Using three times scaling where on the last scale the feature map is downsampled into 8x, enabling YOLO to detect small objects better [21]. It is expected to be useful for author's dataset where license plates are relatively placed remotely located on the picture.

Following figure is example of the output using testing dataset:

Figure 6. Training result

Evaluation will be executed after data is trained. Evaluation will be consisted of precision, recall, and AP calculation. Precision is ability to identify only for relevant object in form of correct prediction percentage, whereas recall shows ability to find relevant object on every positive prediction that could have been made. Recall is true positives percentage on every ground-truth [16].

Following equations are used to calculate Precision dan Recall:

$$Precision = \frac{TP}{TP + FP} = \frac{TP}{all\ detections} \qquad (4)$$

$$Recall = \frac{TP}{TP + FN} = \frac{TP}{all\ ground\ truths} \qquad (5)$$

Average Precision is precision/recall curve defined as precision average consists of 11 same-length recall level [0, 0.1, 0.2, 0.3,..., 1][22]. AP formula is defined as follows:

$$AP = \frac{1}{11} \sum_{r \in [0,0.1,0.2,\ldots,1]} Pinterp(r) \qquad (6)$$

Where,

$$Pinterp(r) = \max_{\tilde{r}:\tilde{r} \geq r} p(\tilde{r}) \qquad (7)$$

D. Image Cropping

In this stage, author crops image based on bounding box information on the testing data output using Python programming language.

(a) (b)

Figure 7. Uncropped image (a) is cropped with provided bounding box (b)

E. Image Thresholding

On Image Thresholding stage, author performed Otsu’s method. This thresholding technique originated from the name of its inventor is a global thresholding technique proved of its effectivity [23]. In Otsu's method, image will be divided into two class, background and object. Following equation explains Otsu's method [24] in dividing object and background class variant:

$$\begin{cases} \sigma^2 = P_o \, . \, (M_o - M)^2 + P_b \, . \, (M_b - M)^2 \\ M = P_o \, . \, M_o + P_b \, . \, M_b \\ P_o + P_b = 1 \end{cases} \tag{8}$$

$$t^* = Arg \max_{a \le t \le b} \{ P_o \, . \, (M_o - M)^2 + P_b \, . \, (M_b - M)^2 \} \tag{9}$$

Where:

σ^2 = Varian for background or object classes
Po = Pixel value probability as object class
Pb = Pixel value probability as background class
Mo = Average pixel value for object class
Mb = Average pixel value for background class
M = Average for whole classes
t* = Threshold value

Following image is thresholding result executed in Python:

(a) (b)

Figure 8. Before (a) and after thresholding (b)

After finished thresholding, author invert the image color to imitate image with written text on white paper.

F. Character Recognition

In this last step, author uses character recognition on license plate using Tesseract OCR engine. Following diagram is the Tesseract OCR procedure:

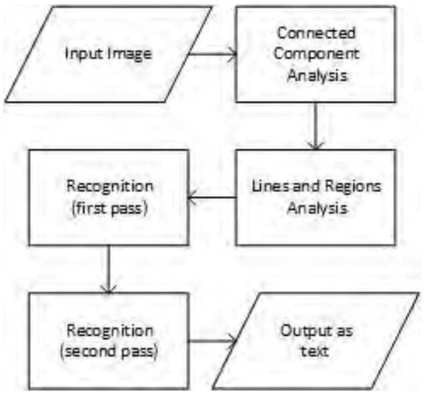


Figure 9. Tesseract OCR steps diagram

On first step, inputted image will be analyzed to generate text outline. Outlines will be connected to create Blobs. Next, Blobs will be arranged into word rows and analyzed to fix pitch or generate proportional text. Recognition will occur in two passes, whereas first pass will recognize each word and fetch to adaptive classifier as training data, and second pass will be re-recognized if classifier found something useful after passing the text [25].

3. Result and Discussion

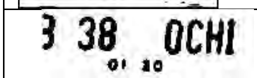
After training and testing data have finished, evaluation is performed to discover performance of object detection toward dataset. Evaluation result trained using YOLOv3 network shown on figure 10.

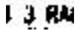
```
 calculation mAP (mean average precision)...
100 <- testing data
 detections_count = 355, unique_truth_count = 130 <- objects detected
class_id = 0, name = license, ap = 88.87%        (TP = 83, FP = 4)

 for conf_thresh = 0.50, precision = 0.95, recall = 0.64, F1-score = 0.76
 for conf_thresh = 0.50, TP = 83, FP = 4, FN = 47, average IoU = 68.78 %

 IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
 mean average precision (mAP@0.50) = 0.888656, or 88.87 %
Total Detection Time: 3 Seconds
```

Figure 10. Precision, recall, and mAP@0.5 IoU

Data on figure 10 is evaluation of testing images with ratio 90:10 from total 1000 images. Class on this dataset only consists of vehicle license plate denoted as “license”. On figure 10, Confidence threshold denoted as *conf_thresh* is probability of detected bounding box. For confidence threshold value of 0.5, author obtain value of *precision*= 0.95*, recall= 0.64, F1-score*= 0.76. On evaluation, mAP also generated to discover the average of AP for all classes. Result of mAP percentage with 0.5 IoU 88.87%, indicating a good object detection on proposed dataset.

Table 1. Image enhancing and text recognition result example

Image	Predicted Text	Actual Text	Processing Time	Percentage
	B 1549 RFS	B 1549 RFS	0.3435546 sec	100%
	3 38 OCH	B 38 OCHI	0.318021 sec	71%

	461 ML	L 461 ML	0.3197079 sec	83%
	tee TF	2568 T	0.3279512 sec	0%
	| 3 Aa	B 3 RAK	0.3012207 sec	40%

Result example from image processing from thresholding to character recognition is described on table 1. On the table, correct percentage is displayed as result of total characters predicted using character recognition divided with total actual character. Accuracy percentage falls below 50% if file size is too small and/or lamination of an image is way too high or too low, hence character will be hardly recognized. Implementation of character recognition on 100 testing data generating 80,2% accuracy percentage with processing time <0.4 second. It is indicating good accuracy and speed for real-time usage.

4. Conclusion

According to process of system design, implementation, and dataset testing on this research, can be concluded that YOLOv3 Network is able to decently perform object detection and OCR could recognize the character well. mAP result from testing is 88.87%. Accuracy on character recognizing is 80.2% followed with <0.4 second processing time. With current processing time and accuracy, this method is expected to solve real-time plate recognition problem in Indonesia.

5. Suggestions

Suggestion given by Author to improve or enhance result of this research are:

1. Performing improvisation and/or parameter tuning on object detection technique.
2. Performing technique comparation on object detection such as using ResNet and/or SSD.
3. Performing technique comparation in image processing with different thresholding or edge detection as additional technique to compare time processing or accuracy difference on character recognition.

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