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Indonesian Vehicle License Plate Identification Using YoloV5 and OCR

[1]Herlambang Kurniawan, [2]Enny Itje Sela
[1,2]Fakultas Sains dan Teknologi , Universitas Teknologi Yogyakarta
Email: herlambangkurniawan111@gmail.com[1], ennysela@uty.ac.id[2]

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Abstract. In response to escalating urbanization and vehicular density, this research addresses the imperative for public safety and traffic management. The relationship between public safety and traffic control highlights the importance of strong identification systems. This research aims to make a licence plate identification by using the YOLOv5 for adept object detection and complementing it with Optical Character Recognition (OCR), the study enhances license plate recognition precision. The result of this research on a dataset of 100, through the utilization of this approach, the research achieved a perfect accuracy rate of 100% in identifying vehicle plates, while the accuracy rate for character recognition on vehicle plates was at 90%.

1. INTRODUCTION

As the number of vehicles in Indonesia continues to rise, so does the incidence of crimes, particularly motor vehicle theft. This criminal activity has become well-organized, with a sophisticated network in place [1]. The constraints faced by legal authorities, particularly the police, in eliminating or identifying motor vehicle crime in Indonesia pose a significant issue. The police's duty is often complicated by factors such as scarce resources, insufficient manpower, and expansive territories. Furthermore, the insufficient training in vehicle crime investigations might also impede the capacity of law enforcement officials to address these illicit operations [2]. License plates are crucial for the identification of a vehicle. The Identification process can be performed by utilizing digital equipment such as cameras, telephones, CCTV and by applying image processing techniques [3].

Several related studies that have been carried out to identify vehicle number plate detection are research conducted by [4] who conducted research on two-wheeled vehicle number plate detection using the edge detection method showed that Sobel and Prewitt operators had an accuracy rate of 60% and 63% according to the confusion matrix, but both still had weaknesses in detecting more than two objects and there is excessive light reflection. Next is research conducted by [5] whereby taking images using IP CCTV and image processing, especially using the Optical Character Recognition (OCR) method, the researcher succeeded in achieving an accuracy of detecting the location of the number plate of 83.33% and reading the character of the number plate of 80%. %, with all characters correctly identified. Subsequently, a study conducted by [6] sought to extract the number plate region of motorcycles using mathematical morphological operations in four stages: image pre-processing, edge detection using the Sobel operator, plate area identification through morphological operations (dilation, filling, opening), and labeling and segmentation of the plate regions. Through the examination of 50 vehicle photos, it has been demonstrated that the morphological operation was effectively executed, resulting in an 80% success rate in the extraction of number plate images. Next, a study conducted by [7] focused on developing an autonomous vehicle number plate detection system using YOLOv3. The study utilized a dataset of 700 pretrained data for training the system. The online and API-based system demonstrates a perfect accuracy rate of 100% for number plate detection. The OCR findings achieved a commendable accuracy of 92.32% using Tesseract, successfully detecting all the characters on car and motorbike plates, which typically consist of 7-8 characters.

Based on research that has been carried out previously in this research used image processing techniques, specifically YoloV5, to segment images of car license plates. Additionally, the OCR approach was utilized to accurately recognize the characters included on the license plates. Upon entering the segmentation step with Yolo, the picture will go through preprocessing, which includes image cropping, grayscaling, edge detection, angle repositioning, image rotation, and then proceed to the identification stage using OCR. Once the characters are acquired, the subsequent step is removing any undesirable characters that may be present. The dataset used in this study contains 100 instances of images obtained from vehicles, which are categorized into two-wheeled and four-wheeled vehicles.

Furthermore, testing of this method itself is carried out by carrying out tests based on the level of success of the system in identifying existing vehicle plates or by using a method based on accuracy.

2. METHOD

The stages of this research on vehicle number plate detection begin with the collection of a dataset consisting of images of vehicle number plates. This dataset is then used to train and test the detection model. During the image processing stage, different methods such as grayscaling, edge detection, and angle repositioning are used to enhance the quality of the dataset. Subsequently, during the system design phase, researchers provided a comprehensive description of the structure and specifications of the number plate detection model. This encompasses the creation of algorithms for detecting and recognizing license plates. Finally, the evaluation stage entails a comprehensive examination of the system's overall performance. The research framework can be seen in **Figure 1.** Research Framework.

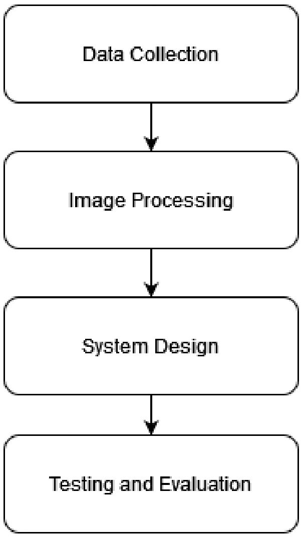

Figure 1. Research Framework

Data Collection

This research collected data from primary sources by directly capturing images using a mobile phone camera. The device use is the Realme 3 Pro, with a 25-megapixel camera. The information was acquired from several locations, including university parking lots and mall parking lots. The dataset collection takes place in the afternoon, specifically between 15:30 and 17:00, on weekdays. This research utilizes a total of 100 vehicle image datasets, encompassing both two-wheeled and four-wheeled vehicles. The datasets include images of automobiles with black and white license plates. The samples of data can be seen in **Figure 2.** Dataset Sample.

Figure 2. Dataset Sample

Image Processing

Image cropping

Image cropping is a method used to selectively remove or take out specific portions of an image that are deemed significant or captivating. The primary objective is to enhance concentration on specific regions, enhance visual arrangement, and/or modify image dimensions and clarity [8]. The sample of image cropping process can be seen in Figure 3. Image Cropping.

Figure 3. Image Cropping

Grayscaling

Grayscaling refers to the transformation of a colored image into a grayscale image. Color images often employ the RGB (Red, Green, Blue) color mode, where each pixel is typically encoded using three color values: red, green, and blue. Grayscaling simplifies an image by eliminating color data, retaining only the gray level or light intensity [9].

$$I = (0.299\, x\, R) + (0.578\, x\, G) + (0.114\, x\, B) \quad (1)$$

The provided equation is utilized for determining the intensity value (I) within the RGB (Red, Green, Blue) color model during the process of converting to grayscale. The formula utilizes R, G, and B to denote the intensity values of red, green, and blue, respectively, at a specific pixel in a color image. The coefficient values (0.299, 0.578, 0.114) represent the relative significance of each color in generating a grayscale representation of the entire image devoid of color [10]. The result of grayscaling image can be seen in **Figure 4. Grayscaling**

Figure 4. Grayscaling

Edge Detection

Edge detection is an image processing approach that seeks to identify the boundaries or edges separating distinct objects within the image. These edges correspond to notable variations in pixel intensity and can aid in comprehending the structure or form of an object. An instance of edge detection is the Canny detection technique. The Canny Edge Detection technique is a sophisticated approach for detecting edges, known for its ability to generate smooth and precise edge boundaries [11]. The result of edge detection image can be seen in Figure 5. Edge Detection

Figure 5. Edge Detection

Angle Repositioned

The HoughLines transformation is an image processing technique employed for the purpose of identifying straight lines inside images. This technique is advantageous for identifying lines that may pose challenges when using conventional edge detection methods. The HoughLines transform enables the identification of straight lines in an image without the need for prior information about the line's length or orientation [12].

$$x\, cos(\theta) + y\, sin\,(\theta) = \rho \quad (2)$$

In this given context, x and y represent the Cartesian coordinates of a point in a two-dimensional plane, whereas θ denotes the angle formed between the positive x axis and the line specified by the equation. Furthermore, ρ represents the magnitude of the distance between the point and the origin in the polar coordinate system [13].

Image rotation

Image rotation involves the act of rotating an image around a specific central point. This technique is commonly employed in image processing to facilitate picture correction or transformation [14]. Image rotation uses the concept of 2D matrix rotation which can be seen in the equation below, which is used to rotate a vector in two-dimensional space as far as an angle θθ. By multiplying this rotation matrix by the vector $\boldsymbol{V} = \begin{bmatrix} x \\ y \end{bmatrix}$ R rotation results can be obtained, giving a new vector $\boldsymbol{R} = \begin{bmatrix} x\prime \\ y\prime \end{bmatrix}$. Valuable in the context of geometric transformations and computer graphics applications, as it allows for the alteration of vector positions inside a two-dimensional plane [15]. The result of image rotation process can be seen in Figure 6. Image rotation

$$M = \begin{bmatrix} cos(\theta) & -sin\,(\theta) \\ sin\,(\theta) & cos(\theta) \end{bmatrix} \tag{3}$$

Figure 6. Image rotation

System Design

YoloV5

The YOLOv5 framework has five pre-trained models of different dimensions, ranging from the smallest YOLOv5s to the largest YOLOv5x. The rapid detection speed of YOLO is a crucial factor that influenced the decision to use YOLOv5. The YOLO method employs trained evaluations of blocks of pixels, considering both colour and form, for the purpose of detection [16]. The YoloV5 architecture can be seen in Figure 7. YoloV5 architecture.

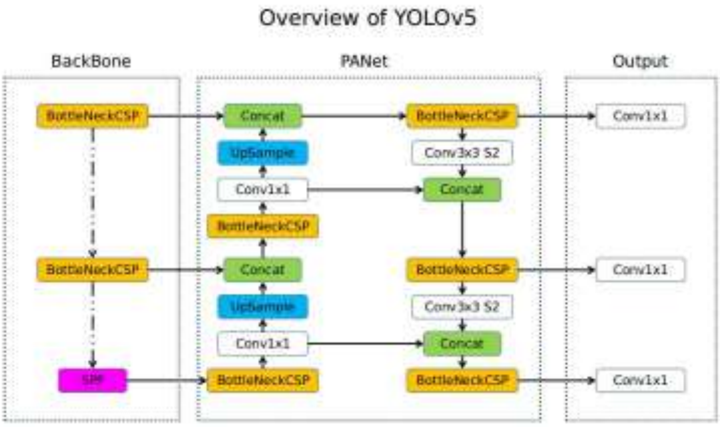

Figure 7. YoloV5 architecture

The figure below depicts the outcome of segmentation achieved by the implementation of the Yolov5 technique. When a car plate object is present in this image, it will be enclosed within a bounding box. The Yolo system provides accurate information by displaying confidence scores for object detection as numerical values ranging from 0 to 1. The result of segmentation using Yolov5 can be seen in Figure 8. License Plat Detection.

Figure 8. License Plat Detection

Testing and Evaluation

Evaluation of results using accuracy is a method commonly used to measure the extent to which a model or system can predict correctly all the data being evaluated. Accuracy is calculated by dividing the number of correct predictions (true positives) by the total amount of data evaluated. Mathematically [17], the accuracy formula is as follows:

$$Accuracy = \frac{True\ Positive}{Total\ data} \tag{4}$$

3. RESULTS AND DISCUSSION

Testing is done under different situations in order to achieve the most suitable research outcomes. The initial test involved evaluating a two-wheeled vehicle equipped with a black license plate. Subsequently, a second test was conducted using a two-wheeled vehicle featuring a white license plate. The third test involved assessing a four-wheeled vehicle with a black license plate, while the fourth test involved evaluating a four-wheeled vehicle with a white license plate.

Test with two-wheeled black license plate

Based on the Figure 9. (a) Success recognize character ; (b) Failed recognize character, image (a) depicts a car plate that has been accurately recognized or identified by the characters displayed on the plate. picture (b) is a picture where the system has not accurately detected the character.

(a) **(b)**

Figure 9. (a) Success recognize character ; (b) Failed recognize character

According to the

Table **1.** Two-wheeled black license plate accuracy, it seems that 25 number plates for two-wheeled vehicles were inputted into the detection system, and all of them were correctly identified. Out of these results, a total of 20 were accurately identified. The success rate or accuracy of detecting two-wheeled number plates is 80%. The value is derived by dividing the count of accurately recognized number plates (20) by the total count of number plates inputted into the detection system (25), and then multiplying the result by 100 to obtain the percentage.

Table 1. Two-wheeled black license plate accuracy

	two-wheeled black license plate				
No	**Jumlah Data**	**Plat Terdeteksi**	**Karakter Benar**	**Plat acc**	**Karakter acc**
1	25	25	24	100%	96%

Test with two-wheeled white license plate

Based on the Figure 10. (a) Success recognize character ; (b) Failed recognize character, image (a) depicts a car plate that has been accurately recognized or identified by the characters displayed on the plate. picture (b) is a picture where the system has not accurately detected the character**.**

(a) **(b)**

Figure 10. (a) Success recognize character ; (b) Failed recognize character

According to Table 2. Two-wheeled white license plate accuracy data, it seems that 25 number plates for two-wheeled vehicles were inputted into the detection system, and all of them were correctly identified. Out of these results, a total of 20 were accurately identified. The success rate or accuracy of detecting two-wheeled number plates is 80%. The value is derived by dividing the count of accurately recognized number plates (20) by the total count of number plates inputted into the detection system (25), and then multiplying the result by 100 to obtain the percentage.

Table 2. Two-wheeled white license plate accuracy

	two-wheeled white license plate				
No	**Jumlah Data**	**Plat Terdeteksi**	**Karakter Benar**	**Plat acc**	**Karakter acc**
1	25	25	24	100%	96%

Test with four-wheeled black license plate

Based on the Figure 11. (a) Success recognize character ; (b) Failed recognize character, image (a) depicts a car plate that has been accurately recognized or identified by the characters displayed on the plate. picture (b) is a picture where the system has not accurately detected the character**.**

(a) **(b)**

Figure 11. (a) Success recognize character ; (b) Failed recognize character

According to Table 3. four-wheeled black license plate accuracy data, it seems that 25 number plates for two-wheeled vehicles were inputted into the detection system, and all of them were correctly identified. Out of these results, a total of 20 were accurately identified. The success rate or accuracy of detecting two-wheeled number plates is 80%. The value is derived by dividing the count of accurately recognized number plates (20) by the total count of number plates inputted into the detection system (25), and then multiplying the result by 100 to obtain the percentage.

Table 3. four-wheeled black license plate accuracy

No	Jumlah Data	Plat Terdeteksi	Karakter Benar	Plat acc	Karakter acc
		four-wheeled black license plate			
1	25	25	20	100%	80%

Test with four-wheeled white license plate

Based on the Figure 12. (a) Success recognize character ; (b) Failed recognize character, image (a) depicts a car plate that has been accurately recognized or identified by the characters displayed on the plate. picture (b) is a picture where the system has not accurately detected the character

(a) **(b)**

Figure 12. (a) Success recognize character ; (b) Failed recognize character

According to Table 4. four-wheeled white license plate accuracy data, it seems that 25 number plates for two-wheeled vehicles were inputted into the detection system, and all of them were correctly identified. Out of these results, a total of 20 were accurately identified. The success rate or accuracy of detecting two-wheeled number plates is 80%. The value is derived by dividing the count of accurately recognized number plates (20) by the total count of number plates inputted into the detection system (25), and then multiplying the result by 100 to obtain the percentage.

Table 4. four-wheeled white license plate accuracy

No	Jumlah Data	Plat Terdeteksi	Karakter Benar	Plat acc	Karakter acc
		four-wheeled white license plate			
1	25	25	22	100%	88%

Based to the experimental findings mentioned earlier, all the data pertaining to the vehicle's license plate was correctly recognized, resulting in a 100% accuracy rate for the current plate detection system. However, during the character detection phase, there were still certain characters that did not correspond to the plate number. Among the two-wheeled cars bearing black and white license plates, there remains a single image with inaccurate character identification. On automobiles with black and white plates, there are 5 incorrect images of black plates and 3 incorrect photographs of white plates. Based on the computation below, the overall accuracy achieved for both vehicle plate detection and character appropriateness detection with the plate number is 100 % and 90 % correspondingly.

$$Plat\ acc\ total = \frac{100 + 100 + 100 + 100}{400}\ x\ 100 = 100\%$$

$$Character\ acc\ total = \frac{96 + 96 + 80 + 88}{400}\ x\ 100 = 90\%$$

4. CONCLUSION

The vehicle number plate detection system plays a crucial role in the future for the prevention of law infractions and other illegal activities associated with automobiles. This study employed the Yolov5 technique to develop a system for detecting vehicle number plates. The system accurately segments the plate section of a vehicle and using Optical Character Recognition (OCR) to identify the characters in the plate image. Through the utilization of this approach, the research achieved a perfect accuracy rate of 100% in identifying vehicle plates, while the accuracy rate for character recognition on vehicle plates was at 90%. The research is limited by the absence of diverse data, which hinders the system's ability to accurately recognize objects when there are variations, such as differences in the distance between the camera and different vehicle objects. As a result, the system's performance is not yet optimal. Hence, future research endeavors should focus on augmenting the dataset with a wider range of data variations and exploring advanced techniques like Yolov8 and other supplementary approaches for preprocessing, such as adjusting light intensity using the gamma method.

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