Indonesian License Plate Detection and Identification using Deep Learning

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Abstract— License plate is the unique identity of the vehicle, which serves as proof of the legitimacy of the operation of the vehicle in the form of a plate or other material with certain specifications issued by the police and contains the area code, registration number and validity period and installed on the vehicle. License plates are often used in automated parking systems and vehicle identification in case of traffic violations. So, it is necessary to build a system for detection and identification of license plates. The proposed license plate detection and identification system is divided into three main processes, namely license plate detection, character segmentation, and character recognition. The detection process uses transfer learning techniques using Faster R-CNN Inception V2. The segmentation process uses traditional computer vision with morphological operations and contours extraction. Then the character recognition process uses the MobileNet V2 transfer learning technique as an architecture for character classification. The recognition accuracy compared between MobileNet V2 and Tesseract-OCR shows that MobileNet V2 is superior with an accuracy rate of 96%, while Tesseract-OCR has a poor accuracy of 59%.

Keywords— Deep Learning, Convolutional Neural Network, License Plate Detection, Character Segmentation, Character Recognition.

I. INTRODUCTION

Vehicle plate detection and recognition is an important technology in traffic systems. This technology utilizes image processing to identify a vehicle from a license plate image. The variety of conditions in the field which is not necessarily ideal in the identification process poses a challenge in accuracy such as weather conditions, license plate quality and differences in intensity due to lights or the environment which can cause problems during license plate recognition. Each country has a license plate standard that is different from one another. For Indonesia, license plates have several types of background color and text color, besides that there is also information on the validity period of the license plate itself.

On the edge of the license plate there is an edge that is the same color as the text of the license plate. The following are the types of license plates in Indonesia [1]:

- Black background color with white text is personal or rental vehicle.
- Yellow background with Black text is for public transportation.
- The red background color with white text is for Government vehicles.
- The white or red background color with black text is for foreign diplomatic corps vehicles.
- Black background color with white text consisting of 5 digits and country code numbers printed smaller with sub-section format is intended for vehicles of foreign diplomatic corps operational staff.

Figure 1. Various types of Indonesian vehicle license plates

Several studies on Automatic License plate Recognition (ANPR) have been carried out using various methods. The current method that is widely used for license plate detection is the method based on image processing [2], [3] and deep learning based methods [4]–[6]. Conditions in Indonesia are certainly different from other countries, such as differences in vehicle types, differences in the shape and color of license plates, and additional information in the form of the validity period of the license plates. Due to the different types of vehicles, the shape of the license plate color and the presence of a frame on the edge of the license plate and other variations, it is difficult to find a public dataset that is the same as the field conditions in Indonesia. Most publicly available datasets generally have a white background color and black text.

Dataset is made in accordance with the state of license plates in Indonesia by collecting license plate images of various types of vehicles, plate colors, shooting angles, light, weather, and resolution. The license plate detection technique uses the Faster R-CNN model architecture [7], then character segmentation using image processing [8], [9], CNN [10] is performed to read segmented characters. The contribution of this research is proposing another method for improvisation to the adjustment of conditions in Indonesia when the detection process uses a dataset of Indonesian license plate vehicles and performs morphological operations and filter contour [11] when segmenting the required characters.

II. RELATED WORKS

There are many system developments that follow Computer Vision's example, such as object detection [12], [13], image recognition [14], [15], as well as certain pattern recognition. The development of this system becomes a functionality that can facilitate work in various fields. The development of deep learning [16] this is very appropriate and effective to be used to solve these problems. This cannot be separated from the research in this field. Previous research on deep learning using convolutional neural networks has been carried out by researchers on various kinds of objects.

A. Transfer Learning

Transfer learning (TL) [17], [18], is a learning enhancement technique in dealing with new tasks through the transfer of knowledge from related tasks that have been previously studied. The use of transfer learning itself is currently becoming very popular to be combined with neural networks, especially in the field of computer vision. this is because the neural network requires large data and large computing capabilities, so that combined with transfer learning can ease the computational burden, cope with large data needs, and save time during learning. The quality of a transfer learning is greatly influenced by the quality of the dataset used. Although there are no clear rules regarding the best dataset topology, the use of various objects such as dynamic object scaling and translation, randomized positioning, variable lighting, and camera angle, pose estimation, distractor noise etc.

B. Automatic License Plate Recognition (ALPR)

Image processing-based methods have previously been carried out with the proposed method which is a method consisting 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. Another method proposed is using image processing, which consists of six main processes in this system. In pre-processing, the system will enhance frame by using top hat and bottom hat transformation. It will detect and crop the plate by using integral protection. After getting the plate position, segmentation in each character then a feature extraction combined with Artificial Neural Network get the character of the vehicle registration number.

The deep learning-based method was previously carried out with the Front-View Detection stage where the detection was initially carried out to identify the front view of the vehicle then the license plate detection was carried out. The license plate that has been detected is then carried out for character identification. Another method proposed is the initial process of directly detecting the license plate, after the position of the license plate is detected, the filter process is carried out so that the detected license plate is truly precise. The filtered license plates are then identified as the final stage. Another method uses the transfer learning object detection API using the Faster R-CNN Inception V2 architecture, then the recognition process uses Tesseract OCR [19].

III. PROPOSED METHOD

This section describes in detail the proposed approach to detection and identification of license plates in Indonesia, divided into three main stages, namely license plate detection, character segmentation [20], [21], and character identification [22], [23]. License plate detection is done to find the location of the license plate on an image. Character segmentation aims to separate and filter characters on the license plate that have been detected. Characters that have been separated and filtered are then identified so that the letters and numbers listed on the license plate are known.

Figure 5. Total Loss of License Plate Detection

In the character identification section, the training process uses transfer learning from the MobileNet V2 architecture with pre-trained weight. The model results show an accuracy of 95% after 5 epochs and when the training process is complete, the accuracy is 99% as shown in the graph of Figure 6.

Figure 6. Training and Evaluation Accuracy

The technique of measuring the accuracy of number plate character recognition uses a comparison between the expected characters and the predicted characters. Test uses images of various types of vehicles and color license plate.

$$CR\ Similarity = \frac{Total\ Identified\ Characters}{Total\ Factual\ Characters} \times 100$$

The following formula is to calculate the average of character identification accuracy between MobileNet V2 and Tesseract OCR 4.1.1.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n \frac{CI_i}{CT_i} \times 100\%$$

The following are the details of the calculation results of each accuracy of the number plate and then determine the average of the entire sample tested. The test results are shown in the Table 1.

Table 1.
Character Recognition Test Results

No.	License Plate	Factual Plate Number	Proposed Method Result	Tesseract OCR Result	% Similarity	
					Proposed Method	Tesseract OCR
1		D1511V	D1511V	none	100%	0%
2		B234KIL	B234KIL	B234KIL	100%	100%
3		Z7665TA	Z7665TA	77669THI	100%	57%
4		F1949KI	F1949KI	none	100%	0%
5		P841XX	P841XX	P841XX	100%	100%
6		L1488IU	L1488IU	L1488IU	86%	100%
7		B1759POH	B1759POH	B1759POH	100%	100%
8		A669U	A669U	none	100%	0%
9		BG1348UI	BG1348U1	BG1328UI	87%	87%
10		B1228CMU	B1228CMU	B1228CMU	100%	100%
11		B2850XZL	B2850XZL	none	100%	0%
12		T1228HL	T1228HL	T4228HL	100%	85%
13		B2101UFK	B2101UFK	B2101UFK	100%	100%
14		B1709TIE	B7709TIE	B09TIE	87%	75%

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15		PA1391JB	PA1391JB	0822	100%	0%
16		N348VR	N348VR	none	100%	0%
17		B152RFS	B152RFS	B152RFS	100%	100%
18		B1739BAH	B1739BAH	none	100%	0%
19		B17ANR	B17AW	B	67%	17%
20		B1307UJQ	B1307UJQ	B1307UJQ	100%	100%
21		B1429ES	B1429ES	Ir1429ES	100%	86%
22		BB1741FP	BB1741FP	BB1741FP	100%	100%
23		B17PSD	B17PSD	B17PSD	100%	100%
24		BG1ST	BG1ST	GAST	100%	50%
25		B1286FES	B1286FES	B1286FES	100%	100%
26		N888B	N888B	none	100%	0%
27		B1308RFO	B1308RFO	B1308RFO	100%	100%
28		B1DKI	B1DKI	none	100%	0%
29		B1478TTD	B1478TTD	81478TTD	100%	87%
30		B1664OC	BH664QC	B1664QC	87%	100%
31		BG1242IE	BG1242IE	eG1242IE	87%	87%
32		D1965EB	D1965	none	71%	0%
33		KT1649DL	KT1649DL	KT1649OL	100%	87%
34		BD7224CV	BD7224	none	75%	0%
35		B2248SYW	B2248SYW	ip7208StoOee	100%	25%
36		DK46S	DK46S	none	100%	0%
37		BE2298JI	BE2298JI	BE2298JI	100%	100%
38		L1469NH	L1469NH	L1469NH	100%	100%
39		PA1345RZ	PA1345PZ	none	87%	0%
40		L1025HB	L1025HB	L1025HB	100%	100%
41		BK8672CV	BK8672CV	none	100%	0%
42		L1184CC	L1184CC	L11ECC	100%	71%
43		B2860BFC	B2860BFC	82860BFC	100%	87%
44		B9005HW	B9005HH	none	86%	0%
45		L1798XN	L198N	L1798XN	71%	100%
46		B1418SGD	B1418S6D	none	87%	0%
47		Z1445DZ	Z1445DZ	Z1445OZ	100%	86%
48		B1041RFZ	B1041RFZ	B1041RFZ	100%	100%
49		B1257UJH	B1257UJ	none	87%	0%
50		DP1129AW	DP1129AH	OP1129AW	87%	87%
51		L1652SH	L1652SH	L1652SH	100%	100%
52		B1658PVE	B1658PVE	B1658PVE	100%	100%
53		L162TJ	L162TJ	LEE18J	100%	50%
54		BM1439TP	BW1439TP	BY1740539TP	87%	75%

55		B2805UZ	B2805UZ	none	100%	0%
56		B1699SEC	B1699SEC	B1699SEC	100%	100%
57		B1582BOH	B1582BOH	B1582BOH	100%	100%
58		B1980YY	B1980YY	none	100%	0%
59		AD9021AL	AD9021AL	AD9027AL	100%	87%
Average Similarity					96%	59%

V. CONCLUSION

Research on the detection and identification of Indonesian number plates has been carried out using deep learning. The dataset used for detection of Indonesian vehicle number plates is 295 files that have been annotated with number plate data from various types of vehicles, weather conditions, light conditions, license plate conditions, vehicle position, resolution, and image quality. While the dataset used for character identification is 34,575 images which are divided into 36 characters of various shapes, orientations, and thicknesses.

The number plate identification and detection process use three main stages, namely License Plate Detection (LPD), Character Segmentation (CS), Character Recognition (CR). The LPD process uses object detection technology by means of transfer learning using the Faster R-CNN Inception V2 architecture which has a balance between accuracy and processing time. The CR process uses traditional computer vision, namely by performing morphological operations and extract contours to filter the expected characters. Then the CR Process tries to compare between Tesseract OCR 4.1.1 and image classification technology by means of transfer learning using MobileNet V2.

The result of the comparison between MobileNet and Tesseract OCR in the character identification process proves that MobileNet V2 is far superior. Tesseract OCR has a weakness if the position of the license plate is tilted, or the camera position is not straight resulting in inaccurate results.

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