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Vehicle Type Detection and Classification System To Determine Parking Rates Based On Image Recognition

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Abstract

This study aims to develop a system for detecting and classifying vehicle types using the Convolutional Neural Network (CNN) model YOLO V5 based on image recognition. This research consists of several stages, from the potential and problem stages, needs analysis, literacy studies, prototyping, system design, and system testing. The collected datasets were taken using smartphone cameras and webcams with a total of 800 image datasets, divided into two categories: training data and validation data. System testing is carried out in day and night conditions. The classification test results in daytime conditions obtained an accuracy of 93, an accuracy of 80%. The system's design for detecting and classifying vehicle types for determining parking rates based on image recognition works well. Each type of vehicle can be seen and ranked by the system.
Keywords: Classification, Vehicles, Raspberry Pi 4, CNN, YOLOV5

Abstrak

Penelitian ini bertujuan untuk mengembangkan sistem pendeteksi dan pengklasifikasian jenis kendaraan dengan menggunakan Convolutional Neural Network (CNN) model YOLO V5 berbasis image recognition. Penelitian ini terdiri dari beberapa tahap, mulai dari tahap potensi dan masalah, analisis kebutuhan, studi literatur, pembuatan prototipe, perancangan sistem, dan pengujian sistem. Dataset yang dikumpulkan diambil menggunakan kamera smartphone dan webcam dengan total 800 dataset gambar yang dibagi menjadi dua kategori yaitu data training dan data validasi. Pengujian sistem dilakukan pada kondisi siang dan malam hari. Hasil pengujian klasifikasi pada kondisi siang hari diperoleh akurasi sebesar 93, dengan tingkat akurasi sebesar 80%. Perancangan sistem untuk mendeteksi dan mengklasifikasikan jenis kendaraan untuk penentuan tarif parkir berdasarkan image recognition bekerja dengan baik. Setiap jenis kendaraan dapat dilihat dan diurutkan oleh sistem.
***Kata-kata kunci**: Klasifikasi, Kendaraan, Raspberry Pi 4, CNN, YOLOV5*

1. Introduction

A parking lot is an element of transportation system infrastructure that cannot be separated from the transportation network system. Parking is when the vehicle is not moving because the owner has parked it temporarily or for a limited time. An organized parking system can provide a feeling of comfort for vehicle users when they want to go to a particular place [1]. A well-managed parking system is needed so that parking service users can more easily access parking lots. Effective and efficient parking management requires the support of all components of the parking system itself, from parking attendants to existing parking facilities. The parking facility is a computerized system that facilitates parking for parking service users.

Along with current technological developments, more and more companies are implementing automatic parking systems. An automatic parking system is a parking system that operates automatically without human intervention [2]. The automated parking system is activated when the vehicle enters the parking area from the parking entrance to the exit. The application of an automatic parking system aims to minimize human resources work so that the system is expected to avoid errors or human errors. Constraints or limitations that arise as a result of human-caused mistakes can be minimized by implementing an automatic parking system.

Automated parking systems are generally widely applied to crowd center parking lots, such as hotel parking systems, shopping centers, airports, office buildings, etc. Several companies in Indonesia have used an automatic parking system, one of which is using an e-money card as a tool for access to and from the parking lot. However, some companies set parking rates according to the type of vehicle. Meanwhile, e-money cards cannot determine the type of vehicle used by parking users. Hence, the operator still needs to know the type of vehicle used to set parking rates, or parking attendants still do it manually. However, this method can result in a buildup of cars at the exit when drivers simultaneously leave the parking lot. Therefore, we need a system that can automatically detect the type of vehicle drivers use to determine parking rates quickly to avoid vehicle stagnation at the parking exit. Modern parking bars usually operate automatically with mechanical and electrical systems. The components that make up the parking barrier are the arms, motors, control boards, and main logic controllers [3].

Using artificial intelligence, image recognition is a technology for automatically recognizing objects, people, places, and actions in images. Image recognition performs tasks such as image tagging, content search, and driver assistance systems. Image recognition applications include object recognition, facial recognition, gesture recognition, image analysis, security, and surveillance. Image recognition works much like the human eye, viewing images as a collection of signals and interpreting them with the visual cortex. Image recognition identifies and detects objects or features in digital images or videos. This concept performs many machine-based visualization tasks, such as labeling image assets with meta tags, searching for image assets, and guiding self-propelled robots, self-driving cars, and accident prevention systems [4].

The deep neural network is the most effective tool for image recognition, especially the convolutional neural network (CNN) algorithm. CNN is an architecture designed to efficiently process, relate, and understand large amounts of data contained in high-resolution images. The CNN algorithm is an efficient artificial neural network architecture in the image classification process. The central concept of the CNN algorithm itself lies in its convolution operation. This operation will extract images for each feature to form several accessible classification models. This technique enables a more efficient implementation of the image pattern training function.

Many supporting studies have been related to vehicle-type detection systems, such as those by Irfan et al. [5]. Using the multi-layer perceptron method, the system can classify vehicles with digital image processing. The test results for vehicle detection show an accuracy value of 92.67%. Meanwhile, the classification process is carried out with a trial and error stage to evaluate the parameters that have been identified. The results of this study indicate that the classification system produces an average accuracy value of 87.60%. Subsequent research detects the type of vehicle on the road using Open CV [6]. This study aims to calculate the number of cars based on the type of vehicle that passes through traffic using the OpenCV library. This study produces an average accuracy rate of 77.8% for quiet road conditions, 47.5% for normal road conditions, and 28.2% for congested road conditions. Subsequent research by Manajang et al., 2020 [7] classification of types of motorized vehicles using the TensorFlow object detection framework. This research produces a system that can detect and count the number of cars passing through the road based on the type of vehicle. Accuracy testing for detecting vehicle objects based on the classification of vehicle types carried out on 5 test video files has an average accuracy of 90.8% for counting the number of vehicles every 5-second interval. The type of vehicle that passes through the road is even less effective for its implementation.

Companies in Indonesia have widely used the use of automatic parking access as an effort to reduce working human resources, so it is expected that the system is free from errors or human errors, one of which is using an e-money card as access to and from the parking lot. Using an e-money card cannot set parking rates according to the type of vehicle, so it still requires an operator, or it is done manually. However, this method can cause a buildup of cars at the exit access of the parking lot. Therefore, the authors will develop a system for detecting and classifying vehicle types to determine parking rates based on image recognition. Types of vehicles that will be detected and classified include cars, trucks, and buses. The data generated is in the form of parking fee data based on the type of vehicle. This system was created using image recognition using the Yolo V5 Convolution Neural Network (CNN) method.

2. Method

The development process in this study consists of 6 stages: literature study, preparation of tools and materials, development process, validation, testing, and revision. If the revision process runs smoothly without any problems, then the process has been completed. The development procedure can be described as follows. The development procedure can be seen in **Figure 1**.

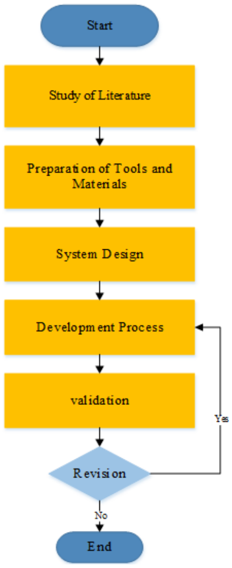

Figure 1. Research Stages Workflow

Study of literature: at this stage, the researcher conducted a literature study from the developed research. In this case, the work was carried out to obtain further information about the vehicle type recognition system for determining parking rates based on image recognition. Preparation of Tools and Materials: After conducting a literature study, the research concluded what tools and materials are needed to develop a vehicle-type detection system to determine parking rates based on image recognition. System Design and Design: at this stage, the researcher builds a prototype by making a temporary design that focuses on serving parking service providers. Designing and conducting tests on a vehicle-type detection system to determine parking rates based on image recognition is done in stages to produce output according to the plan and the theory that supports it. The process of designing a vehicle type detection and classification system to determine parking rates based on image recognition made in the form of a flowchart is as follows. The flowchart system can be seen in **Figure 2**.

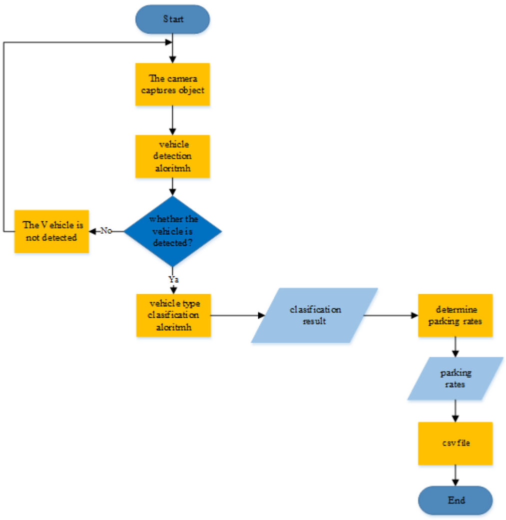

Figure 2. System Flowchart

This vehicle-type detection and classification system is based on image recognition using the Yolo V5 Convolution Neural Network (CNN) method to detect objects through a camera. This system uses a Raspberry Pi 4 as a microcontroller, and the webcam is designed to turn on in a real-time when the system is running. The architecture of the vehicle type detection and classification system can be seen in **Figure 3**.

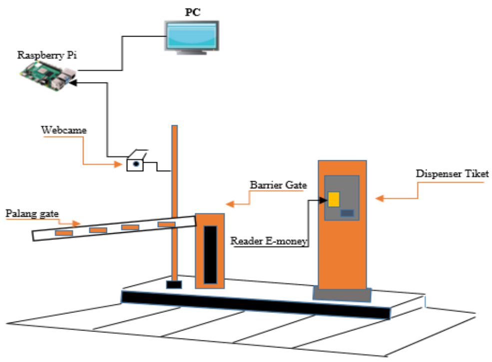

Figure 3. System Architecture

Development Process: In this study, there are two development processes, namely, the hardware development process and the software development process. The system development process can be seen as follows. Hardware Design, hardware or vehicle-type detection system development based on image recognition using a webcam camera. The webcam will be the basis for detecting the type of vehicle, which functions to retrieve vehicle image data when paying a parking fee before passing through the portal. Raspberry Pi operates to process data and is connected to a PC. Software Development Process In designing software in this study, there are several stages to achieve the desired result. These processes include image acquisition, labeling, dataset distribution, training using the Yolo V5 Convolution Neural Network (CNN) model, and testing.

Validation: at this stage, tool validation is carried out to ensure the functioning of all tool components. Can the Raspberry Pi 4 be used for digital image processing via a webcam Camera? As well as whether webcam cameras can be applied to vehicle type detection and classification systems to determine parking rates based on image recognition. Trial: The system testing process is carried out as black box testing at the trial stage. This stage aims to check the system's ability to detect and classify vehicles based on their type. In the revision, based on the conclusions from the validation and the tool as a whole, this stage contains adjustments and improvements if there are tools that cannot work with the proper functions described earlier.

The system for detecting and classifying vehicle types to determine parking rates based on image recognition uses a mini-computer, a Raspberry Pi 4. System coding uses the Python programming language and uses a prototype development model. This study collected a dataset of 800 image data consisting of 3 object classes, namely cars, buses, and trucks. Dataset collection was carried out using a webcam camera and a smartphone.

This study used data from systematic testing as a data collection technique. The collected data is then presented in a table. After the data collection process is carried out, the next step is to analyze the data. The data obtained from the data collection results must be immediately processed and interpreted to show whether the research objectives have been achieved. This study used descriptive qualitative data analysis techniques, and the data analyzed is data obtained from the system testing results and presented in tabular form. The analysis of image data processing performance to get vehicle type identification and classification accuracy can be calculated using the formula:

$$Weight\ percentage = \sum_{i}^{n} \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions} \times 100\%$$

Information:

i = Number of correct predictions

n = Total number of predictions

The Confusion Matrix is a collection of prediction results for a classification problem [10]. The Obfuscation Matrix compares the total number of structured bins for events that occurred in positive (TP) and true (TN) events with the overall classification of events that occurred in positive (FP) and true (FP) events.

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F1\ Score = 2 \times \frac{Precision \times Recall}{Precision + Recall}$$

Information:

TP = Actual is positive and predicted is positive

FP = Actual is negative and predicted is positive

FN = Actual is positive and predicted is negative

3. Results and Discussion

3.1 Presenting the Results

At this stage, the researcher collects data. The data collected in this study were 1500 images of each vehicle data type, the data has been divided into training and validation. Vehicle image data was taken directly from parking lots and roads by researchers using smartphone cameras. The data was taken from August to September. The more data obtained, the greater the accuracy of the results. **Figure 3** is a dataset that researchers have collected.

Annotation or Object Annotation is the process of placing an annotation on an image by providing a bounding box along with the class name of the object. Object labels are classified into three classes, namely cars, buses, and trucks. Labeled objects are displayed on the front, back, and sides. Image annotation process using Labeling software. These tags use annotations in the YOLO annotation format. The result of the annotation is data that contains information about the position of the bounding box and its label in .txt file format.

At this stage of the training process, it aims to train the system so that it can understand the pattern of the desired object. This study uses the Jupyter Notebook software for the data training process. The duration of the training process depends on the size of the data set or database that has been prepared. The more images prepared, the longer the training process will take, but the more accurate the results will be. The training process Requires uploading image data along with the annotation results, i.e., a txt file. zip format. The file is then opened to access a label file folder named training_data. on the calculation graph from the training data process that generates the weights file. The weight results from this training process produce mean average precision (mAP) parameters. The mAP value is the average precision value obtained from each relevant item's precision value generated, and it uses a value of 0 for relevant items not caused by the system. The graph training data results can be seen in **Figure 4**.

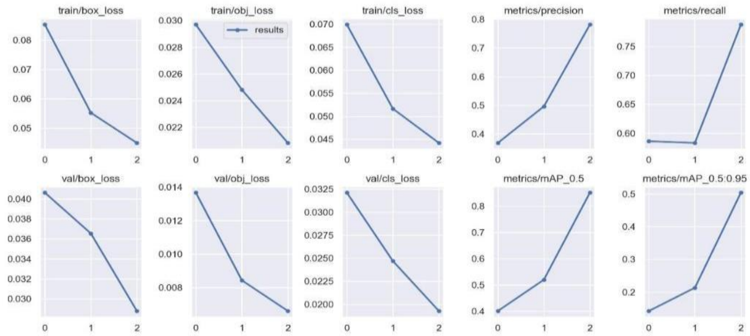

Figure 4. Evaluation Results of the Training Dataset

The detection program is designed to test the accuracy of detecting vehicle types using real-time testing. The data will be processed using the Convolution Neural Network (CNN) method, and the architecture used is YOLO V5, with the training data reference parameters in the form of training weights. The output of this program is the results of vehicle detection and classification based on their type. The result of detecting the type of vehicle is the final result of processing the type of vehicle detection in this system. After the recognition processes have been successfully processed, the image is marked with a border and a bounding box. The results of the detection and classification of vehicle types can be seen in **Figure 5**.

Figure 5. The Results of The Detection of the Type of Car Vehicle

At this stage, the system will determine the parking fee that the driver must pay. After the system has successfully detected and classified the type of vehicle, it can set parking rates according to the type of vehicle. The author has previously set parking rates for each type of vehicle. The car tariff is IDR 5,000, buses are IDR 10,000, and trucks are IDR 12,000.00. Based on these rates, if what is detected is a car, then the rate that will appear is IDR. 5,000. If what is detected is the type of bus vehicle, then the rate that will appear is IDR. 10,000, and if what is detected is the type of truck, then the rate that will appear is IDR 12,000. Data on parking costs or rates can be stored in Microsoft Excel, so we will be able to develop the system easily.

In testing, the accuracy of the classification of vehicle types is used to determine whether the process of detection and classification of vehicle types can run well or not. This classification process determines the type of vehicle the system detects. In testing the accuracy of this classification, there are three scenarios, namely:

a. Testing Based on Scenario One

Testing scenario one involves finding the optimal distance. It is done to determine the system's accuracy in detecting the type of vehicle at a certain distance. Two tests were carried out at two distances, namely at 5 meters and 10 meters. The space is calculated from the camera's location to the vehicle object. Experiments were carried out 15 times at each distance, 5 (five) times for cars, 5 (five) times for buses, and 5 (five) times for trucks. Testing the accuracy of the classification of vehicle types at a distance of 5 meters is presented on **Table 1**.

Table 1. Testing the Accuracy of The Classification of Vehicle Types at A Distance Of 5 Meters

Predictions / Actual	Car	Buses	Trucks
Car	5	0	0
Buses	0	5	0
Trucks	0	0	5
Not Detected	0	0	0

Based on the Confusion matrix in Table 1, the values of True Positive (TP), False Positive (FP), False Negative (FN), F1 Score, Precision, and Recall can be calculated.

True Positive = 5 + 5 + 5 = 15

False Positive = 0

False Negative = 0

$$Precision = \frac{TP}{TP + FP} = \frac{15}{15 + 0} = 1$$

$$Recall = \frac{TP}{TP + FN} = \frac{15}{15 + 0} = 1$$

$$F1\ Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} = 2 \times \frac{1 \times 1}{1 + 1} = 1$$

So in the test with a distance of 5 meters for each type of vehicle, namely cars, buses, and trucks, with 15 trials or 5 (five) trials for each type of vehicle, a TP of 15 is obtained, which means that 15 vehicles have been successfully predicted into the correct vehicle class, FP equal to 0, which means that there are no vehicles that are expected to be wrong, and FN = 0, which means that there are no vehicles that were not successfully detected. Vehicle type detection test with a distance of 10 meters is presented on Table 2.

Table 2. Vehicle Type Detection Test with a Distance of 10 meters

Actual \ Predictions	Car	Buses	Trucks
Car	3	0	2
Buses	0	5	0
Trucks	0	0	5
Not Detected	0	0	0

Based on the Confusion matrix, the values of True Positive (TP), False Positive (FP), False Negative (FN), F1 Score, Precision, and Recall can be calculated.

$True\ Positive$ = 3 + 5 + 5 = 13

$False\ Positive$ = 2

$False\ Negative$ = 0

$$Precision = \frac{TP}{TP + FP} = \frac{13}{13 + 2} = 0{,}86$$

$$Recall = \frac{TP}{TP + FN} = \frac{13}{13 + 0} = 1$$

$$F1\ SCore = 2 \times \frac{Precision\ \times\ Recall}{Precision + Recall} = \ 2 \times \frac{0{,}86 \times 1}{0{,}86 + 1} = 0{,}92$$

Based on testing at a distance of 10 meters between the camera and the object, a TP value of 13 is obtained, meaning that 13 vehicles have been correctly predicted in the vehicle class. The FP value is 2, meaning that two vehicles are expected incorrectly. The FN value is 0, meaning that there are no vehicles that cannot be detected.

b. Testing Based on Scenario Two

The test results are based on scenario one, namely, to get the optimal distance. Then, they are used to determine the system's accuracy in detecting the type of vehicle at a certain position and angle. This test is carried out after obtaining the optimal distance between the camera and the object. In this test, testing was carried out at a camera angle of 35° and 50° at the same height of 1.7 meters. Testing the detection of vehicle types at a camera height of 1.7 meters and an angle of 35° is presented on **Table 3**.

Table 3. Testing The Detection of Vehicle Types At A Camera Height Of 1.7 Meters And An Angle Of 35°

Actual \ Predictions	Car	Buses	Trucks
Car	3	0	0
Buses	0	5	0
Trucks	0	0	5
Not Detected	2	0	0

Based on the Confusion matrix, the values of True Positive (TP), False Positive (FP), False Negative (FN), F1 Score, Precision, and Recall can be calculated.

$$True\ Positive = 3 + 5 + 5 = 13$$

$$False\ Positive = 0$$

$$False\ Negative = 2$$

$$Precision = \frac{TP}{TP+FP} = \frac{13}{13+0} = 1$$

$$Recall = \frac{TP}{TP+FN} = \frac{13}{13+2} = 0{,}86$$

$$F1\ Score = 2 \times \frac{Precision \times Recall}{Precision+Recall} = 2 \times \frac{1 \times 0{,}86}{1+0{,}86} = 0{,}92$$

Based on testing at a camera position of 1.7 meters from the ground and located at an angle of 35° for each type of vehicle, namely cars, buses, and trucks, for 15 trials or 5 trials for each type of vehicle, a TP value of 13 is obtained, meaning 13 vehicles were successfully detected in the correct vehicle class. FP is 0, meaning that no vehicles are detected incorrectly. FN is 2, which means 2 (two) vehicles are not detected. Testing for the detection of vehicle types at a camera height of 1.7 meters and an angle of 50° is presented on **Table 4**.

Table 4. Testing For the Detection of Vehicle Types At A Camera Height Of 1.7 Meters And An Angle of 50°

Actual \ Predictions	Car	Buses	Trucks
Car	5	0	0
Buses	0	5	0
Trucks	0	0	5
Not Detected	0	0	0

Based on the Confusion matrix in Table 4 the values of True Positive (TP), False Positive (FP), False Negative (FN), F1 Score, Precision, and Recall can be calculated.

$True\ Positive\quad = 5 + 5 + 5 = 15$

$False\ Positive\quad = 0$

$False\ Negative\quad = 0$

$$Precision = \frac{TP}{TP+FP} = \frac{15}{15+0} = 1$$

$$Recall = \frac{TP}{TP+FN} = \frac{15}{15+0} = 1$$

$$F1\ Score = 2 \times \frac{Precision \times Recall}{Precision+Recall} = 2 \times \frac{1\times1}{1+1} = 1$$

So in testing with the camera position 1.7 meters from the ground and located at an angle of 50° for each type of vehicle, namely cars, buses and trucks, 15 trials or 5 trials for each type of vehicle a TP of 15 is obtained, meaning that there is 15 vehicles that were successfully detected in the correct vehicle class. FP is 0, meaning that no vehicle has been detected incorrectly. The FN value is 0 which means that there are no undetected vehicles.

c. Testing Based on Lighting Conditions

After getting the optimal distance and position, further testing will occur in day and night conditions. The distance and position of the camera from the object is adjusted to the optimal distance and position that have been tested before. The maximum speed of the vehicle when exiting the parking portal access is 20 km/h. Testing in daytime conditions was carried out at 11.00-14.00 WITA and at night conditions from 19.00-21.00 WITA. Tests were carried out to determine the system's accuracy in detecting the type of vehicle according to the lighting conditions. Tests under daytime conditions is presented on **Table 5**.

Table 5. Tests Under Daytime Conditions

Predictions / Actual	Car	Buses	Trucks
Car	5	0	0
Buses	0	5	0
Trucks	0	0	4
Not Detected	0	0	1

Based on the Confusion matrix in Table 5, the values of True Positive (TP), False Positive (FP), False Negative (FN), F1 Score, Precision, Recall, Accuracy can be calculated.

$True\ Positive\quad = 5 + 5 + 4\ = 14$

$False\ Positive\quad = 0$

$False\ Negative\quad = 1$

$$Precision = \frac{TP}{PTP+FP} = \frac{15}{15+0} = 1$$

$$Recall = \frac{TP}{TP+FN} = \frac{15}{15+1} = 0{,}93$$

$$F1\ Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} = 2 \times \frac{1 \times 0{,}93}{1+0{,}93} = 0{,}96$$

$$Accuracy = \frac{TP}{Total\ Percobaan} = \frac{14}{15} \times 100\% = 0{,}93 \times 100\% = 93\%$$

Based on testing under daytime conditions for each type of vehicle, namely cars, buses, and trucks, for 15 trials or 5 trials for each type of vehicle, a TP of 15 was obtained, meaning that 15 vehicles were successfully detected in the correct vehicle class. The FP value is 0, meaning no vehicles have been detected incorrectly. The FN value is 1 which means that there is 1 vehicle that is not detected. Testing at night conditions presented on **Table 6.**

Table 6. Testing at Night Conditions

Predictions / Actual	Car	Buses	Trucks
Car	5	0	0
Buses	0	4	0
Trucks	0	1	3
Not Detected	0	1	1

Based on the Confusion matrix in Table 6, the values of True Positive (TP), False Positive (FP), False Negative (FN), F1 Score, Precision, Recall, Accuracy can be calculated.

$True\ Positive = 5 + 4 + 3 = 12$

$False\ Positive = 1$

$False\ Negative = 1+1 = 2$

$$Precision = \frac{TP}{TP+FP} = \frac{12}{12+1} = 0{,}92$$

$$Recall = \frac{TP}{TP+FN} = \frac{12}{12+2} = 0{,}85$$

$$\text{F1 } Score = 2 \text{ x } \frac{Precision \times Recall}{Precision + Recall} = 2 \times \frac{0{,}92 \times 0{,}85}{0{,}92+0{,}85} = 0{,}88$$

$$\text{Accuracy} = \frac{TP}{Total\ Percobaan} = \frac{12}{15} \times 100\% = 0{,}8 \times 100\% = 80\%$$

Based on testing under night conditions for each type of vehicle, namely cars, buses and trucks for 15 trials or 5 trials for each type of vehicle, a TP of 12 was obtained, meaning that 12 vehicles were successfully detected in the correct vehicle class. The FP value is 1, meaning there is 1 wrongly detected vehicle. The FN value is 2, which means that 2 vehicles are not detected.

The system for detecting and classifying vehicle types to determine parking rates based on image recognition is made using a mini-computer, Raspberry Pi 4. System coding uses the Python programming language and uses a prototype development model. The prototype development model consists of two stages: gathering needs and building a prototype. This system was developed to provide convenience to parking attendants by allowing them to classify vehicle types and determine parking rates automatically.

The detection program is designed to test the accuracy of detecting vehicle types using real-time testing. The data will be processed using the Convolution Neural Network (CNN) method, and the architecture used is YOLO V5 with the training data reference parameters in the form of training result weights. The output of this program is the results of vehicle detection and classification based on their type. The results of the vehicle type detection are the end result of processing the vehicle type detection in this system. After all the recognition processes have been successfully processed, and the image is marked with a border and a bounding box. The system will set a parking fee that must be paid by the driver.

Lazaro (2017), in his research entitled Detection of Types of Vehicles on the Road Using Opencv. Vehicle types can be classified based on the area of the rectangle that marks the vehicle object. The optimal maximum time limit for vehicle objects to pass through the detection zone is 35 ms. This reduces the risk of detecting the same vehicle object multiple times. Features such as hair can be used to detect vehicle objects.

Manajang (2020), in his study of the Implementation of the Tensorflow Object Detection Framework in the Classification of Types of Motorized Vehicles. The Tensorflow Object Detection API framework can be applied to construct a system capable of detecting and counting the number of vehicles of any type passing along a road. The classification of the types of vehicles that cross the road, which is carried out every five seconds in the video, is not as effective as it is implemented. The pre-training model used in this study is the YOLO v3 pre-training model, and the classification of the vehicles used is still not in accordance with the classification of vehicles used in Indonesia, so research is needed to build target vehicles that are suitable for these vehicles. classification in Indonesia.

4. Conclusion

Based on the research that has been done based on the results of designing a vehicle type detection and classification system to determine parking rates based on image recognition, it is considered to work well. Each type of vehicle can be detected and classified by the system. The test results of the vehicle type detection and classification system to determine parking rates based on image recognition in daytime conditions obtained an accuracy of 93%, for determining rates of 93%. Meanwhile, at night an accuracy value of 80% is obtained, and the determination of rates is 80%. In the future, it is expected to increase the image dataset with several variations, such as image resolution, camera angles, and shooting conditions, especially during the day or night.

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