Classification and Counting of Moving Vehicle at Night with Similarity of Rear Lamp

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Abstract. Congestion is caused by a large number of vehicles exceeding road capacity. If we know the amount of the average density of vehicles passing by, it can be a consideration of infrastructure development. Therefore, the authors made a study to classify and calculate vehicles at night using the similarity of vehicles rear lamp. The technique used by authors is to pair each vehicle's rear lamps that have been detected which have the same characteristics, in this case, we used the similarity of pixels for the pairing process. After that, the pair of rear lamps will be calculated and classified as the type of motorbike or car. This study resulted in a calculation that in Video 1 with not-so-busy traffic conditions able to detect 79 of 88 motorbikes and 32 of 35 cars with accuracy 90.24%. Video 2 with fairly quiet conditions was able to detect 52 of 56 motorbikes and 9 of 11 cars with accuracy 91.04%. Video 3 with crowded traffic conditions can detect 63 of 71 motorcycles and 23 of 29 cars in actual conditions with accuracy 86.00%.

1. Introduction
Congestion is a situation or state of stalled or even stopped traffic caused by the number of vehicles exceeding the road capacity. According to data obtained from the National Police Headquarters, the number of vehicles registered in Indonesia as of January 1, 2018, reached 111 million, or more precisely 111,571,239 units of vehicles. This figure includes the number of motorbikes that contributed the most by 82% or 91,085,532 units of motorcycles. Following private cars with a contribution of 12% or as many as 13,253,143 cars. The remaining contributions are from buses, freight cars, and special vehicles. [1] Referring to the number of vehicles in Indonesia, the average density of traffic and types of vehicles that pass in each region can be used in the construction of appropriate infrastructure that can significantly reduce the level of congestion.

The average density of traffic or vehicles passing on the highway can be determined in various ways. So far, in Indonesia still uses manual methods, namely by assigning a surveyor to observe the passing vehicles and count them. This makes it possible for human error to occur due to the overcrowding of the number of vehicles passing by. It is undeniable that the environmental influences or the internal conditions of the surveyors result in an inaccurate calculation process.

Intelligent Transportation System (ITS) is the application of technology, information, and communication in the field of transportation. ITS can provide benefits to transportation system improvement such as knowing the information in real-time. Through the implementation of ITS, it can overcome transportation problems effectively and efficiently. Research related to the detection and calculation of vehicles by implementing ITS has been conducted by researchers. A study conducted by G. Salvi in 2012 entitled "An Automated Vehicle Counting System Based on Blob
Analysis for Traffic Surveillance." [2] Testing of this study gained an accuracy of up to 98%. However, this study was conducted during the daytime where light sensitivity is better than at night and this study has not been able to classify the types of vehicles.

Based on the explanation above, the authors chose to research on systems that can classify and count vehicles at night using the rear lights as the object of detection and for the process of detecting the color of the vehicle rear lights reference a study by Nur Khamdi in 2017 entitled "Detection of Ball Objects with the Color Method HSV Filtering on Humanoid Soccer Robots". [5] The author also uses the method in a study conducted by G. Salvi to design a vehicle counting system at night, which uses the blob tracking method to combine adjacent colors after going through the Color Detection process. Then for the pairing technique, this study uses a similar method to the rear lights of the vehicle.

2. Related Work

Previous research on the detection and calculation of the number of vehicles on the highway was conducted by G. Salvi, an Italian researcher in 2012 entitled "An Automated Vehicle Counting System Based on Blob Analysis for Traffic Surveillance." [2] This study uses Blob Analysis to detect and count vehicles with an accuracy rate of up to 98%. This research uses the Blob Detection method. However, this research was conducted during the day and has not been able to classify the type of vehicle.

Research at night was conducted by Gery Dias Claudio in 2017 entitled "Detection and Calculation of Moving Vehicles at Night" [3]. In this research, an accuracy rate of 33.33% was calculated and 20 out of 12 vehicles were detected for the first video, an accuracy rate of 96% and 26 of 25 vehicles were detected for the second video, and an accuracy rate of 73.68%, detected 14 out of 19 vehicles. This research uses headlights as a detection object. Then the research conducted by M. Rohit and Mitul M. Patel in 2015 entitled "Nighttime Vehicle Tail Light Detection in Low Light Video Frames Using Matlab" [4] This study uses the RGB color format of the backlight as the object of detection and the symmetry check method for the pairing process. Both of these studies are only capable of detecting only cars and cannot classify vehicle types.

The author uses a study conducted by Nur Khamdi in 2017 entitled "Detection of Ball Objects with the HSV Color Filtering Method on Humanoid Soccer Robot" [5] as a reference for detecting red lights on the vehicle's backlights. In this research, the detection of balls with certain colors through color detection using HSV color components.

3. Proposed Method

Video Extraction
At this stage, the input data in the form of video footage that has been taken previously carried out a scanning process that is the process of breaking video or extracting video into a series of frames.

Pre-processing
This stage is carried out in the process of improving the image or frame to get a better image quality before the next process is carried out. Some of the pre-processing stages are brightness and contrast enhancement, RGB to HSV conversion, color filtering, and morphological operations.

Determine ROI
Then determine the ROI (Region of Interest) as a detection area for moving vehicles. This is done to reduce computing time and reduce unwanted disturbances in the process of classification and calculation of vehicles, such as traffic lights, lights that turn on other than car lights and so on.

Vehicle Detection
The next process is the vehicle detection stage using two methods, color detection, and blob detection.
Pairings
The pairing stage is determined by the similarity of the rear lights utilizing the Manhattan Distance method. In addition to using the similarity of the backlight pixels by this method, several similarity processes were added to improve the accuracy of the classification and calculation of the vehicle i.e. the wide similarity of the blob and the similarity of the y-axis coordinates on the centroid blob.

Vehicle Classification and Counting Vehicle
The classification and calculation process is done by counting the number of lights, in this case as a pair of the blob that has been through the pairing process. Then the length of the new bounding box is
calculated after the pairing process, which fulfills a certain length threshold and when passing the final ROI is calculated as one vehicle and the type of vehicle is identified.

4. System Design
4.1. Preliminaries
4.1.1 Brightness and Contrast Enhancement
Brightness is another word to describe the intensity of light in an image. Contrast is to state the spread or appearance of light and dark in an image. Low contrast images can be characterized by most image compositions being bright or mostly dark. Suppose the pixel \( f(i,j) \) is the original pixel intensity at coordinates \((i,j)\) and \( g(i,j) \) is the intensity of the resulting pixel with \( \alpha > 0 \) is the gain parameter (contrast) and \( \beta \) is the bias parameter (brightness) then the process Contrast and Brightness Enhancement are defined:

\[
g(i,j) = \alpha \cdot f(i,j) + \beta
\]

4.1.2 HSV and RGB
Convert RGB to HSV values using a formula based on [6]. The value of each HSV (Hue, Saturation and Value) color ranges from 0-1.

Equations to determine \( H \):

\[
H := \begin{cases} 
0 , & \text{if } \text{delta} = 0 \\
(6 + \frac{(G - B)}{\text{delta}}) \mod 6 , & \text{if } \text{maxColor} = \text{value of } R \\
2 + \frac{(B - R)}{\text{delta}} , & \text{if } \text{maxColor} = \text{value of } G \\
4 + \frac{(R - G)}{\text{delta}} , & \text{if } \text{maxColor} = \text{value of } B \\
0 , & \text{otherwise}
\end{cases}
\]

Then

\[ H_{\text{HSV}} = \frac{H}{6} \]

Equations to determine \( S \):

\[
S := \begin{cases} 
\frac{\text{delta}}{\text{maxColor}} , & \text{if } \text{maxColor} \neq 0 \\
0 , & \text{otherwise}
\end{cases}
\]

Equations to determine \( V \):

\[
V := \frac{\text{maxColor}}{255}
\]

Where \( \text{maxColor} \) is the maximum value of RGB, \( \text{minColor} \) is a minimum value of RGB and \( \text{delta} \) is the difference between \( \text{maxColor} \) and \( \text{minColor} \).

4.1.3 Image Morphology
Morphological operations depend on the order in which the pixels appear, not paying attention to the numeric values of the pixels so that the morphological techniques are suitable when used to process binary images and grayscale images. In binary images, the set in question is a member of the 2-dimensional integer \( Z^2 \) space where each set element shows coordinates \((x, y)\) with \( x, y \in Z \) white pixels in an image [7].
4.1.4 Dilation Operation.
The process in dilation is "growth" or "thickening" in a binary image. Each pixel from the background that matches the size and shape of the structuring element so that it touches the object pixels is converted into object pixels, this makes the object more "thick". If A and B are members of \( \mathbb{Z}^2 \), the dilation between A (representing the object of an image) and B (structuring element) is expressed:

\[
A \oplus B = \{ a + b, a \in A, b \in B \}
\]

4.1.5 Erosion Operation.
The process of erosion is "depletion" in binary imagery. Erosion will produce objects in the image to become thinner or eroded. If A and B are members of \( \mathbb{Z}^2 \), the dilation between A (representing the object of an image) and B (structuring element) is expressed:

\[
A \ominus B = \{ z \mid (B)_z \subseteq A \}
\]

Erosion A by B is all sets of \( z \), i.e. a translation from B by \( z \), written \( (B)_z \) \( z \), found in A.

4.1.6 Similarity
Similarity or commonly known as Similarity Measurement is the process of measuring the similarity of an object to other objects. In Similarity Measurement distance measurement will be done, where the more distance between two objects, the more different the two objects, distance is usually a measure of dissimilarity. (Rencher, A. C., 2002)

The similarity Measurement method used in this study is Manhattan Distance. This method is one of the most widely used measurements by adding up the absolute differences of the variables. This procedure is called an absolute block or better known as city block distance. The use of Manhattan Distance is better if applied to find similarities between two objects that are visually the same. Manhattan distances can be calculated:

\[
d(x, y) = \sum_{i=1}^{n} |x_i - y_i|
\]

Where \( d(x, y) \) distance between object \( x \) and object \( y \) in \( i \) pixel and \( n \) is number of pixels on the object.

4.2. System Design
4.2.1 Design of Vehicle Detection Process
Vehicle detection is done after the image is pre-processed. The vehicle detection process in this study uses the concept of color detection and blob detection to detect vehicle lights. In the previous process, a binary image has been obtained in which the color component consists of two colors namely black and white. To make it easier to detect vehicle lights, a color filter is used for binary imagery where if the white color in the image means that it shows the vehicle's rear lights and if black means it is not the vehicle's backlight or also called the background image. Pixel coordinates in white are saved while pixel coordinates in black are not saved. Examples of color detection methods in binary images can be seen in the illustration in Figure 2.
After the white pixel coordinates are detected then a blob detection process is carried out. Blob Detection is an algorithm to determine a group of pixels that are interconnected or not. This algorithm is used to identify separate objects or count the number of objects from an image. Blob Detection is used in merging neighboring pixels. Pixels that are considered as neighbors are pixels that are less than 10 centimeters from the detected pixel. The blob detection process is illustrated in Figure 3, and an explanation of calculating the distance of each pixel detected using Euclidean Distance is presented in Table 1.

![Figure 3. Blob Detection Process](image)

Euclidean Distance for the blob detection process can be seen with the following equation:

\[
d_{ab} = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}
\]

Where \(d_{ab}\) distance between object \(a\) (detected object) and object \(b\) (detected object previously) with \(x\) coordinate and \(y\) coordinate.

### Table 1. Calculation Distance of each pixel

| No | \((x_i, y_i)\) detected | \(d_{ab}\) | \((x_{\text{min}}, y_{\text{min}})\) | \((x_{\text{max}}, y_{\text{max}})\) | Update centroid \((x_b, y_b)\) |
|----|-------------------------|-------------|-----------------|-----------------|------------------|
| (a) | (when nothing has been detected yet) | null | null | null | null |
| (b) | (4,2) | 0 | (4,2) | (4,2) | (4,2) |
| (c) | (5,2) | 1 | (4,2) | (5,2) | (4,5,2) |
| (d) | (3,3) | \(\sqrt{3.25}\) | (3,2) | (5,3) | (4,2,5) |
| (e) | (6,6) | 4 | (3,2) | (6,6) | (4,5,4) |

#### 4.2.2 Design of Pairing Process

After getting a blob that has been bound in a box in the vehicle detection process, then the blob is paired or a pairing process is carried out to get a partner who will be more easily identified based on the type of vehicle. The pairing process carried out in this study uses similarity by utilizing the Manhattan Distance method.

If greater the value of \(d(x, y)\), smaller the level of similarity between blobs. In this study, the centroid technique is used so that blob \(x\) and blob \(y\) can be done in the Manhattan Distance calculation process because the calculation requirement is the two calculated objects must have the same number of elements. The centroid technique is shown in the illustration in Figure 4.
Figure 4. (a) initial blob, (b) taken \( \left( \frac{n}{2} \right) \) pixels around the centroid, (c) a new bounding box is formed then a similarity process is performed by comparing the pixels of the two blobs. Manhattan Distance Calculation between blobs in Figure 5 can be seen in Table 2. If it is known that the values of \( d(x, y) > \) threshold then blob \( x \) and blob \( y \) are not a pair of the blob, but if \( d(x, y) \leq \) threshold then blob \( x \) and blob \( y \) are paired into a new bounding box. Then from the results of trials that have been conducted to find the value of \( d \), the authors take the threshold value \( d = 36 \) as the maximum limit of two objects said to be similar or the same which is then said to be one pair. Then the data in Table 2 qualifies as a blob pair.

![Figure 5](image)

**Figure 5.** (a) the explanation related to the pixels used, (b) the value of the blob

| Blob | Pixel | \( d(x, y) \) |
|------|-------|---------------|
|      | 1     | 2             | 3     | 4     | 5     | ……   | \( n-1 \) | \( n \) |
| \( x \) | 0     | 1             | 1     | 1     | 0     | ……   | 1     | 0     |
| \( y \) | 0     | 0             | 0     | 0     | 0     | ……   | 1     | 1     |
| \( ||x_i - y_i|| \) | 0     | 1             | 1     | 1     | 0     | ……   | 0     | 1     | 4     |

**Table 2.** Container Loading List Capacity

The next step, add two stages of similarity of various components are added to support the improvement of vehicle classification and calculation accuracy.

**Similarity centroid y-axis coordinates**

In this process, each blob is checked for centroid than the centroid of blob 1 and centroid of blob 2 on the y-axis coordinates are compared. It can be seen in the illustration in Figure 6.
Figure 6. Centroid similarity process coordinate y-axis

The given threshold value is 3 because each paired blob (identified as a car) has lights that are symmetrical/parallel to the y axis and at least there is a maximum error of 3 pixels.

$$|y_1 - y_2| \leq 3$$

Where $y$ mean location of the $y$ –axis coordinate.

Similarity length and width of the blob

Then check the length and width of the lump together. It can be seen in the illustration in Figure 7. If there are clumps in pairs (meaning cars) then they have lengths and widths of clots that are not much different or even the same. In this study, the value of length and width is 3 pixels.

Figure 7. Similarity length and width of the blob

Known that the length of blob 1 = 5 and the length of blob 2 = 5 and the width of blob 1 = 5 and the width of blob 2 = 4, where the difference in length and width between blob 1 and blob 2 $\leq 3$ means that the two blobs have similarity of length and the width of the blob.

After going through several similarity processes, the blobs that have the previous conditions of similarity then bound to a new bounding box. Takes values $(x_{min}, y_{min})$ and $(x_{max}, y_{max})$ from two blobs that have similarity conditions to be used as a new bounding box size. The way to form a new bounding box is shown in Figure 8.

Figure 8. The process of forming a new bounding box

All bounding boxes are detected in every different frame in the video and to determine whether the bounding box in the first frame is the same as the bounding box in the second frame and so on, the checking process is carried out by tracking. The illustration of the tracking process is shown in Figure 9.
The tracking process utilizes the Euclidean Distance method to detect the position (coordinates) of objects in finding the bounding box distances in the i-th frame and (i + 1) frame.

4.2.3 Design of Classification and Counting Process
The classification and calculation process is done by counting the number of lights, in this case as a pair of the blob that has been through the pairing process. Then the length of the new bounding box is calculated after the pairing process, which fulfills a certain length threshold and when passing the final ROI is calculated as one vehicle and the type of vehicle is identified. The classification process is done by finding the length (x axis) of the bounding box. The bounding box length calibration process is determined in Table 3.

Table 3. Calibration of bounding box length

| Transportation type | bounding box length |
|---------------------|---------------------|
| Car                 | > 30                |
| Motorcycle          | ≤ 30                |

Vehicle calculation is done at the centroid of the bounding box regarding the upper limit \(y_{\text{min}}\) of the ROI line. It should be noted that if a video is a collection of frames, a tolerance limit is performed to identify that the bounding box is about the upper limit of the ROI line. In this study, the author uses a threshold of 2 pixels for the maximum distance of the object centroid approaching \(y_{\text{min}}\). Bounding boxes that have been detected past the ROI line are counted as one object and classified as a car or motorcycle.

5. Results and Discussions
Testing on the program in this study was conducted on * .mp4 videos. The trial video has been stored in computer storage and was obtained from the recording. The video used has 1280x720 pixels with a minimum frame rate of 50 frames/sec. The list of testing inputs is presented in Table 4.

Table 4. Testing Data List

| No. | Video Name | Duration | Place | Characteristic |
|-----|------------|----------|-------|----------------|
| 1   | Video 1    | 105 second | Pedestrian Bridge Darmo Trade Center (DTC) | Medium - (congested and close together at a time) |
| 2   | Video 2    | 120 second | Pedestrian Bridge Jl. Raya Darmo | Quiet with a lag time between the oncoming vehicles |
| 3   | Video 3    | 60 second | Pedestrian Bridge Delta Plaza | Relatively crowded even (causing congestion) |
Testing Result

Measuring the performance of the system/method is by calculating the precision and recall that refers to the journal [8]. Precision is the level of accuracy between the information requested by the user and the answers provided by the system. While the recall is the success rate of the system in finding back information.

False-positive = the sum of data that is not a vehicle but a vehicle detected by the system.
False-negative = the sum of data that is a vehicle but is not detected by the system.

\[
\text{recall} = \frac{\text{detection result} - \text{wrong classification} - \text{false positive}}{\text{amount of vehicle}} \times 100\%
\]

\[
\text{precision} = \frac{\text{detection result} - \text{wrong classification} - \text{false positive}}{\text{amount of vehicle} - \text{wrong classification}} \times 100\%
\]

Then in measuring the performance of detection displayed by the level of detection (accuracy) which shows the percentage of data detected by the system, the level of error of detection which shows the percentage of errors detected by the system and the detection ratio that shows the percentage ratio of many vehicles detected by the system against many vehicles in fact.

\[
\text{detection rate} = (1 - \frac{\text{false negative}}{\text{amount of vehicle}}) \times 100\%
\]

\[
\text{error detection rate} = \frac{\text{false positive}}{\text{amount of vehicle}} \times 100\%
\]

\[
\text{detection ration} = \frac{\text{detection result}}{\text{amount of vehicle}} \times 100\%
\]

1. Testing on Video 1

Detailed results of the classification and calculation of vehicles in Video 1 are presented in Table 5.

| Video Width | Classification | Amount of Vehicle | Detection Result | False Negative | Wrong Classification | False Positive |
|-------------|----------------|-------------------|------------------|-----------------|----------------------|----------------|
| 10 pixels   | Motorcycle     | 88                | 83               | 26              | 6                    | 15             |
|             | Car            | 35                | 38               | 4               | 0                    | 6              |
|             | **Total**      | **123**           | **122**          | **31**          | **6**                | **24**         |
| Video 1     | Motorcycle     | 88                | 86               | 18              | 8                    | 10             |
|             | Car            | 35                | 38               | 3               | 0                    | 6              |
|             | **Total**      | **123**           | **124**          | **21**          | **8**                | **16**         |
| 50 pixels   | Motorcycle     | 88                | 93               | 9               | 3                    | 11             |
|             | Car            | 35                | 38               | 3               | 2                    | 4              |
|             | **Total**      | **123**           | **131**          | **12**          | **5**                | **15**         |
| Video  | ROI width | Classification  | Recall (%) | Precision (%) | Detection Rate (%) | Error Detection Rate (%) | Detection Ratio (%) |
|--------|-----------|----------------|------------|---------------|-------------------|--------------------------|-------------------|
| Video 1 | 10 pixels | Motorcycle     | 70,45      | 75,61         |                   |                          |                   |
|        |           | Car            | 91,43      | 91,43         |                   |                          |                   |
|        | Total     |                | **80,94**  | **83,52**     | 75,61             | 17,07                    | **98,37**         |
|        | 20 pixels | Motorcycle     | 77,77      | 85,00         |                   |                          |                   |
|        |           | Car            | 91,43      | 91,43         |                   |                          |                   |
|        | Total     |                | **84,35**  | **88,21**     | **82,83**         | **13,01**                | **100,81**        |
|        | 50 pixels | Motorcycle     | 89,77      | 92,94         |                   |                          |                   |
|        |           | Car            | 91,43      | 96,97         |                   |                          |                   |
|        | Total     |                | **90,60**  | **94,96**     | **90,24**         | **12,20**                | **106,50**        |

Present the line diagram that related to ROI width and recall, precision, and accuracy values in Figure 10.

![Line Diagram](image)

**Figure 10.** Line Diagram

From the results above, those with recall, precision, and accuracy values are found at an ROI width of 50 pixels. For trials on the next video carried out at a width of ROI 50 pixels to see the maximum calculation.

According to Table 4, it can be concluded that at ROI width of 50 pixels the number of motorcycles that can be detected by the system is 79 motorbikes from 88 motorbikes in actual conditions and the number of cars that can be detected by the system is 32 cars out of 35 cars in actual conditions.

2. Testing on Video 2
   Details of the results of the classification and calculation of vehicles in Video 2 are presented in Table 5.
### Table 6. Classification and Calculation Results on Video 2

| Video | ROI Width | Classification | Amount of Vehicle | Detection Result | False Negative | Salah Classification | False Positive |
|-------|-----------|----------------|-------------------|------------------|-----------------|----------------------|----------------|
| Video 2 | 50 pixels | Motorcycle | 56 | 58 | 4 | 0 | 6 |
|        |           | Car         | 11 | 13 | 2 | 0 | 4 |
|        |           | **Total**   | **67** | **71** | **6** | **0** | **10** |

| Video | ROI Width | Classification | Amount of Vehicle | Detection Result | False Negative | Detection Rate (%) | Error Detection Rate (%) | Detection Ratio (%) |
|-------|-----------|----------------|-------------------|------------------|-----------------|---------------------|------------------------|---------------------|
| Video 2 | 50 pixels | Motorcycle | 92,86 | 92,86 | 81,82 | 81,82 | **Total** | **87,34** | **87,34** | **91,04** | **14,93** | **105,97** |

According to Table 6, it can be concluded that at ROI width of 50 pixels the number of motorbikes that can be detected by the system is 52 motorbikes from 56 motorbikes in actual conditions and the number of cars that can be detected by the system is 9 cars out of 11 cars in actual conditions.

3. Testing on Video 3

Detailed results of the classification and calculation of vehicles in Video 3 are presented in Table 7.

### Table 7. Classification and Calculation Results on Video 3

| Video | ROI Width | Classification | Amount of Vehicle | Detection Result | False Negative | Salah Classification | False Positive |
|-------|-----------|----------------|-------------------|------------------|-----------------|----------------------|----------------|
| Video 2 | 50 pixels | Motorcycle | 71 | 75 | 8 | 1 | 11 |
|        |           | Car         | 29 | 26 | 6 | 0 | 3 |
|        |           | **Total**   | **100** | **101** | **14** | **1** | **14** |

| Video | ROI Width | Classification | Amount of Vehicle | Detection Result | False Negative | Detection Rate (%) | Error Detection Rate (%) | Detection Ratio (%) |
|-------|-----------|----------------|-------------------|------------------|-----------------|---------------------|------------------------|---------------------|
| Video 2 | 50 pixels | Motorcycle | 88,73 | 90,00 | 79,31 | 79,31 | **Total** | **84,02** | **84,66** | **86,00** | **14,00** | **101,00** |
According to Table 7, it can be concluded that at ROI width of 50 pixels the number of motorbikes that can be detected by the system is 63 motorbikes from 71 motorbikes in actual condition and the number of cars that can be detected by the system is 23 cars out of 29 cars in the actual condition.

6. Conclusion and Future Work
Based on an analysis of the results of the testing program, the following conclusions are:

1. Classification and calculation of moving vehicles have been successfully carried out using the backlight similarity with stages: pre-processing (brightness and contrast enhancement, RGB to HSV conversion, color filtering, and morphological operations), vehicle detection (color detection and blob detection), pairing and classification and calculation stages. The pairing process uses the similarity of vehicle taillights with the Manhattan Distance method can be used to detect vehicles so that vehicle lights can be classified as motorbikes or cars.

2. The classification and calculation of the number of vehicles give good enough results that can be seen based on the detected light object. The results of calculations are on Video 1 with traffic conditions that can detect 79 of 88 motorcycles and 32 of 35 cars with an accuracy of 90.24%. Video 2 with fairly quiet conditions was able to detect 52 out of 56 motorcycles and 9 out of 11 cars with an accuracy of 91.04%. Video 3 with traffic conditions that tend to be evenly distributed was able to detect 63 of 71 motorcycles and 23 of 29 cars in actual conditions with an accuracy of 86.00%.

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