Counting the Number of Moving Vehicles by Its Type Based on Computer Vision

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***Abstract*— Traffic jam, lack of adequate information of the traffic low used for development of road infrastructure to reduce traffic jam, and possibility of human error in the execution of a heavy traffic survey become the primary background of this study. By using information technology, open up an opportunity for the development of monitoring system computer vision based. This study will calculate the total amount of moving vehicles based on its type with computer vision based with staged: ROI selection, image segmentation with Gaussian Mixture Model method, filtering process, blob detection and tracking, and vehicles classification with Fuzzy Clustering Means. Implementation of an application using visual studio 2010. The output comprises result of classification and total amount vehicles based on its type. The test application divided into a few test scenarios, namely test 1, test 2, test 3 and test 4. The accuracy obtained on each test are 36.27%, 50.47%, 60.75%, and 67.00% respectively.**

Keywords*— computer vision, digital image processing, fuzzy clustering means, gaussian mixture model, vehicles calculation.

I. INTRODUCTION

Motor vehicles are a means of transportation whose number continues to increase, especially for land transportation in the Banjarbaru City area, South Kalimantan. The number of motorized vehicles, both four-wheeled and two-wheeled in the city of Banjarbaru, South Kalimantan, has increased every year. The increase in the number of motorized vehicles from 2012 to 2013 occurred in each wheeled vehicle where the percentage increase was above 6.67% where two-wheeled vehicle get an increase of 13.76% per year [1]. Data on the increasing of motorized vehicles from 2010 – 2013 in units can be seen in Table I below. As a result of the increasing number of vehicles that are not matched with adequate road facilities and capacity, traffic problems arise.

One of the problems that require special attention from the government today is related to traffic, namely traffic jams everywhere, especially during rush hours. Congestion has a great influence on business performance processes, distribution of goods, time efficiency, business success, safety levels, and other work activities [2]. One of the government's efforts to reduce congestion is by establishing special lanes for motorized vehicles, both two, four or more wheels, and by implementing a policy of certain times for motorized vehicles such as trailer trucks, large trucks, large buses and others. However, what happens in the field, there are still many violations because the driver does not know the applicable rules and other causes [3]. Then, another alternative to overcome road congestion is to build road infrastructure. In the construction of road infrastructure, traffic density data is needed [2]. And until now, to obtain traffic density data, it is done manually, which is assigning several people to survey the field and counting the number of each passing vehicle and divided based on certain times, namely in the morning, afternoon and evening [4]. The implementation of the survey has the possibility of human error in the calculation process due to too heavy traffic, environmental influences and internal conditions. In order for road infrastructure development to be effective and in accordance with road capacity, a video-based traffic density monitoring system is needed that provides vehicle classification information accompanied by a calculation of the number of vehicles by type.

By utilizing information technology, this can be done especially by using digital image processing techniques that can process information from images or videos (moving images). The development of video sensors, video processing software and hardware opens opportunities for the development of computer vision-based monitoring systems because they are able to provide more detailed information for traffic volume analysis needs [5].

Vehicle type classification systems based on video processing and digital image processing techniques have been widely developed, one of which is in research conducted by Bagus Pribadi and Muchammad Naseer [3] namely the Vehicle Type Classification System Through Digital Image

TABLE I. MOTORIZED VEHICLE INCREASE IN BANJARBARU CITY

No.	Vehicle Type	Year			
		2010	2011	2012	2013*
1	Passenger Car	155,611	165,445	181,179	192,953
2	Bus	91,620	91,789	92,055	92,275
3	Truck	151,550	160,342	171,274	182,379
4	Motorcycle	1,143,986	1,293,943	1,476,514	1,675,773
Total		1,542,767	1,711,519	1,921,022	2,143,380

Processing Techniques, in this study the system is able to detect and classifying the type of vehicle on the input data in the form of one-way CCTV recordings, but in this study the level of accuracy achieved is not clearly stated and cannot show the number of vehicles because it is not accompanied by the relevant algorithm.

Furthermore, there is a study conducted by Wisnu Rizky Kurniawan [6]. In this study there were 4 videos that were used as input data with different conditions, in video 1 road conditions one direction (one way) which in the video only shows four-wheeled vehicles, in video 2 it is still with one-way (one-way) road conditions and in the video two-wheeled and four-wheeled vehicles are seen, in video 3 the condition of two-way roads at night with minimal street lighting and video 4 night conditions with good street lighting, the test results show an accuracy rate of 90% but only on video 1 conditions, but in this study the classification system and the calculation system for the number of vehicles have not been integrated with each other, as well as the calculation algorithm in this study this under certain conditions still has the possibility of counting one object to be le more than one.

Another research using one of the relevant methods was carried out by Zamroji Hariyanto [2]. This study used the Gaussian Mixture Model (GMM) method in video data analysis, and the results of application testing can classify vehicles into three types. vehicles, namely motorcycles, cars, and trucks/buses with an accuracy rate of 94.27% with video data taken in the afternoon, but in this study the program has not been able to distinguish the types of buses and trucks correctly. And research with one of the same methods was also carried out by Fitroh Amaluddin, et al [7]. In this study, the average accuracy obtained was 70% on each time condition, namely the accuracy of video recording in the morning conditions 81.82%, during the day 88.24%, in the afternoon 91.3% and at night 86.49%, but in this study, there is no mention of video data used in road conditions.

Based on the problems and related studies mentioned, this study will apply the Gaussian Mixture Model (GMM) which has high accuracy on detecting moving object combined with Fuzzy Cluster Means (FCM) methods in classifying moving vehicles and calculating the number of vehicles based on their type. It is hoped that this method can be applied to road conditions in Banjarbaru with many traffic flows in the opposite direction, because in several related studies, the traffic flow data used is only on one-way roads.

II. Proposed Method

In this study, the data used in the form of CCTV footage of traffic flow on several two-way highways in Banjarbaru downloaded from the Banjarbaru Pantau website with a video

Fig. 1. Frame Example from CCTV Footage

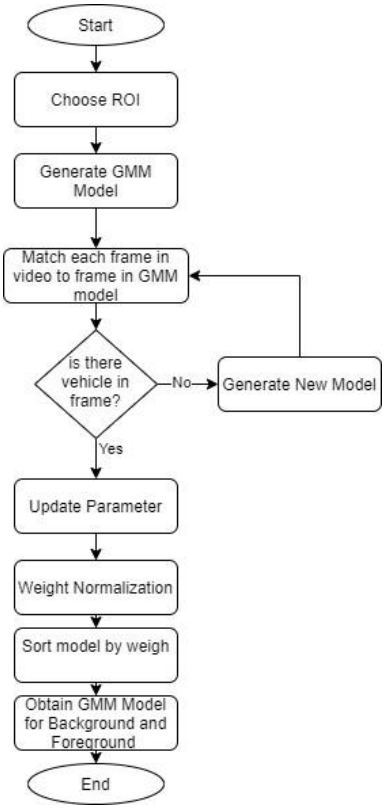

Fig. 2. Flow of Data Processing using GMM

recording resolution of 360 x 640 pixels and a frame rate of 30 frames per second (fps). The frame example from CCTV footage is shown in Fig. 1.

In data processing, data is divided into three types, namely input data, process data and output data. The input data is in the form of video recording of traffic flow, process data is data that contains the parameters that will be used by the Gaussian Mixture Model (GMM) and Fuzzy Clustering Means (FCM), the output data is information about the number and classification of vehicles by type detected in the application.

Before the data is classified using the Fuzzy Clustering Means (FCM) method, there are several previous processes that must be carried out on moving object image data (video) using digital image processing techniques involving the Gaussian Mixture Model (GMM) filter method. The flow of data processing stages using the Gaussian Mixture Model (GMM) filter method can be seen in Fig. 2.

The steps on data processing using GMM are as follow.

a. Determine the ROI (Region of Interest) on the video recording which is the calculation area for classification.
b. Scanning to get every frame of the video.
c. Background Subtraction with GMM method for segmentation of each frame based on the background object (background) with the foreground object.
d. Shadow removal and filtering in order to make the moving object image free from noise.
e. Detection of objects in the foreground, then proceed with the tracking process to determine whether the objects in the *t* frame with *t+1* frame are the same.
f. These objects can be calculated and classified using the Fuzzy Clustering Means (FCM) method.

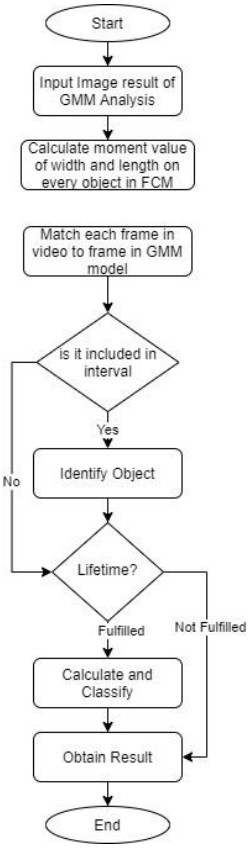

Fig. 3. Flow of Calculation and Clustering Vehicle using FCM

Next step is vehicle clustering and calculation using the Fuzzy Clustering Means (FCM) method which can be seen in Fig. 3. The steps are as follows [17].

a. Input the resulting image from the GMM process.
b. Calculates the length and width values in pixels of each object.
c. Calculating the cluster value which is initialized randomly at first iteration of FCM.
d. Adjusts the object's length and width (interval) values with the class label.
e. Grouping objects by cluster.
f. Classifying objects then counts the number of objects that have been clustered.

III. Result And Discussion

A. Result

In the implementation stage, this research refers to one of the related studies conducted by Zamroji Hariyanto [2]. The implementation includes the implementation of video input, implementation of ROI area selection, implementation of the GMM process, implementation of image filtering, and implementation of blob detection. The implementation of Fuzzy Clustering Means is the result of a direct design from the author which is inserted into the application as a function.

The programming language used is C# using visual studio 2019 IDE and OpenCV library to assist the image processing step. The proposed method implemented into desktop application. An overview of the implementation of the results of the application made can be seen in Fig. 4.

Fig. 4. Implementation of the Proposed Method

B. Discussion

To find out the results of the application and how much accuracy is obtained from the application of the algorithm used in detecting objects, counting and classifying objects in moving images (video) then the testing phase is carried out. This trial includes testing on vehicle classification parameters, then proceeding with vehicle classification trials in several test scenarios, the calculation and classification data from the program will be compared with the calculation of the number of vehicles by surveyors, then the vehicle detection accuracy level from the program will be calculated using (1).

$$Accuracy = \frac{JP}{JS} \times 100\% \quad (1)$$

Where:

Accuracy = Percentage of successful classification
JP = Number of vehicles detected correctly
JS = actual number of vehicles in video

The total number of vehicles in CCTV footage used for testing can be seen in Table II. At the testing stage, the application is tested into several test scenarios, and the following results are obtained. The clustering distribution result on each test scenario is shown in Fig. 5.

a. Test scenario 1, an experiment was conducted by giving the cluster a label identity, namely c1 motorcycle, c2 car, c3 truck, and c4 bus. The accuracy results obtained in test scenario 1 above are 36.27% with max iteration 3. From the results obtained, it can be concluded that the type of cluster cannot be determined at the beginning, because the value of cluster membership in FCM is done randomly.
b. Test scenario 2, label identity is carried out after the cluster process is complete. The accuracy results obtained in test scenario 2 above are 50.47% with a max iteration of 3. In test scenario 2, the cluster results obtained are adjusted to the original data on the inputted CCTV footage.
c. Test scenario 3, perform the same experiment as scenario 2, with increased iterations and an enlarged ROI area. The accuracy results obtained in test scenario 3 above are 60.75% with a max iteration of

TABLE II. Vehicle Number on CCTV Footage

Groundtruth Data	
Vehicle Type	**Number**
Motorcycle	6
Passenger Car	3
Truck	2
Bus	2
Total	1

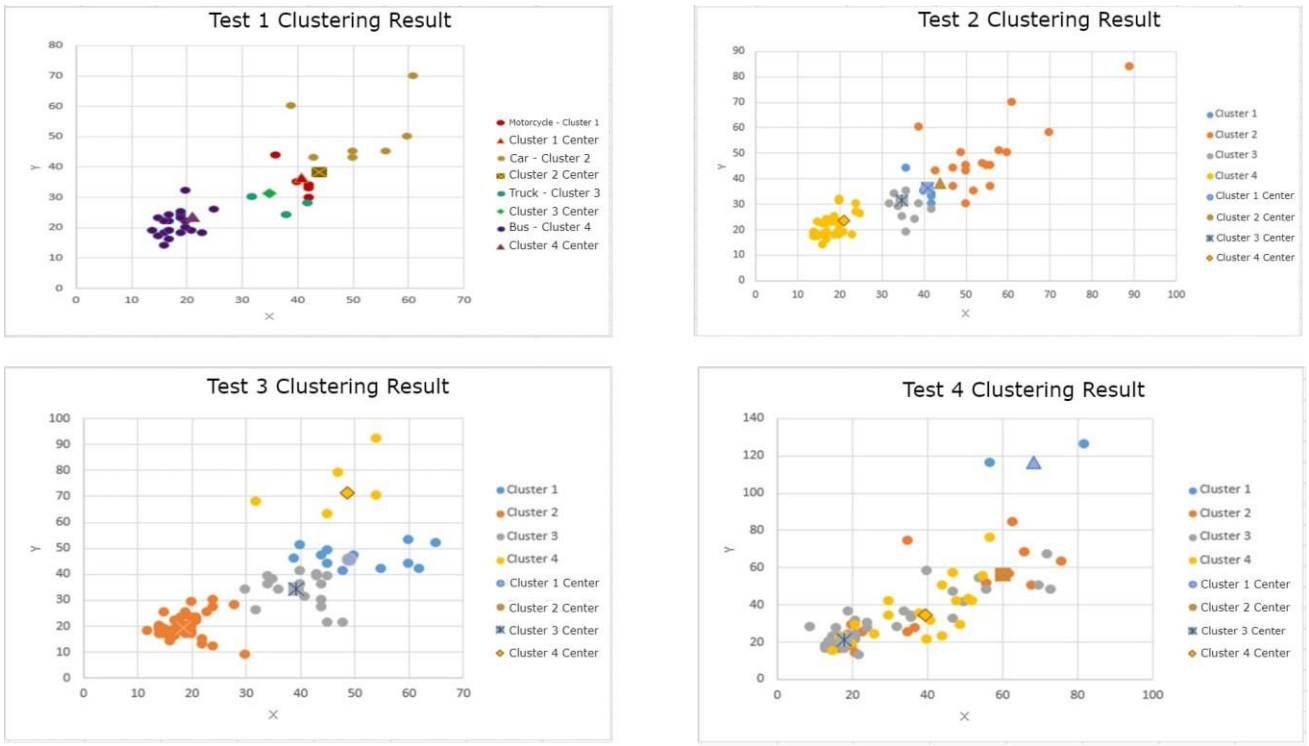

Fig. 5. Cluster Results from Each Scenario, Scenario 1 (Top Left), Scenario 2 (Top Right), Scenario 3 (Bottom Left), Scenario 4 (Bottom Right)

10. In test scenario 3, the ROI area is enlarged so that more objects can be detected.

d. Test scenario 4, improve scenario 3 then iteration is increased again by using another video. The accuracy results obtained in test scenario 4 above are 67.00%. In this test scenario 4, the ROI area is still enlarged and the max iteration is increased to 50.

The result obtained from the test scenario conducted is overall under 70% accuracy. A few issues that has been identified from the test result are as follows:

- Some vehicles in the video footage are moving very fast. It resulted the GMM method failed to identify it as an object in clustering process.
- ROI size is affecting the number of vehicles object that can be identified. The bigger the ROI size used, the more vehicle type can be identified, such as truck and bus which has big size in video footage frame.
- FCM parameter configuration is affecting the clustering result. Optimization problem can be addressed in future research.

IV. Conclusion

From the research conducted on Counting the Number of Moving Vehicles by Type with the Gaussian Mixture Model (GMM) and Fuzzy Clustering Means (FCM) Methods Based on Computer Vision, it was found that from several test scenarios carried out, the varying levels of accuracy obtained due to the speed of the vehicle affecting the process of object detection in the application. The faster the speed of the vehicle, the harder it is for the application to detect moving objects.

In previous studies that also used the GMM and FCM methods, extraction was still done manually, namely changing the video into many frames, then cutting each result obtained from the GMM process, image filtering, and blob detection for each object that was detected.

In contrast to this research which has been done semi-auto. The process is carried out directly by the application obtained from previous research sources, then entering the FCM function. At the output of the application, the data generated is data from live video that has been clustered, then the data is entered into excel for calculation and accuracy tests, so that the results of the GMM and FCM calculations are obtained.

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