Real-Time Traffic Classification and Volume Count using Automated Image Processing

Intan Bahri, Anas Ibrahim, Tey Li Sian. Kuan Woei Keong, Ahmad Kamaruddin, Noryani Yahaya, Ahmad Ismail.

The 13th International Conference on Computer Engineering and Mathematical Sciences 2024 (ICCEMS 2024)

11th - 12th July 2024

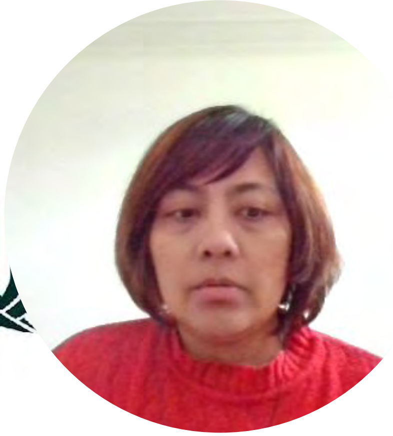
Overview of Traditional Traffic Data Collection Method

Manual counting:

- Involves human enumerators
- Record the number of vehicles
- Use tally counters or clickers
- Classify them into categories

Limitations:

- Labour intensive
- Fatigue and inattention
- Human error
- Limited coverage
- Temporal limitations



Literature Review

Previous studies by *Wieclawek & Pietka (2004), Suryatali & Dharmadhikari (2015), Seenouvong et al., Memon et al. (2018), Wu et al. (2016), Bas et al. (2007), Tursun & Amrulla (2013),* and *Lei et al. (2008).*

Objective: Implement a system able to detect the movement, classification, and number of vehicles through analysing fixed camera video footage with the help of image processing techniques.

- Classifies vehicles into three categories
- Uses adaptive approach with Python and OpenCV, implementing Gaussian Mixture Model technique
- Validates with real traffic camera footage

Methodology Overview

The methodology entails three stages:

(a) Vehicle detection

(b) Classification

(c) Counting

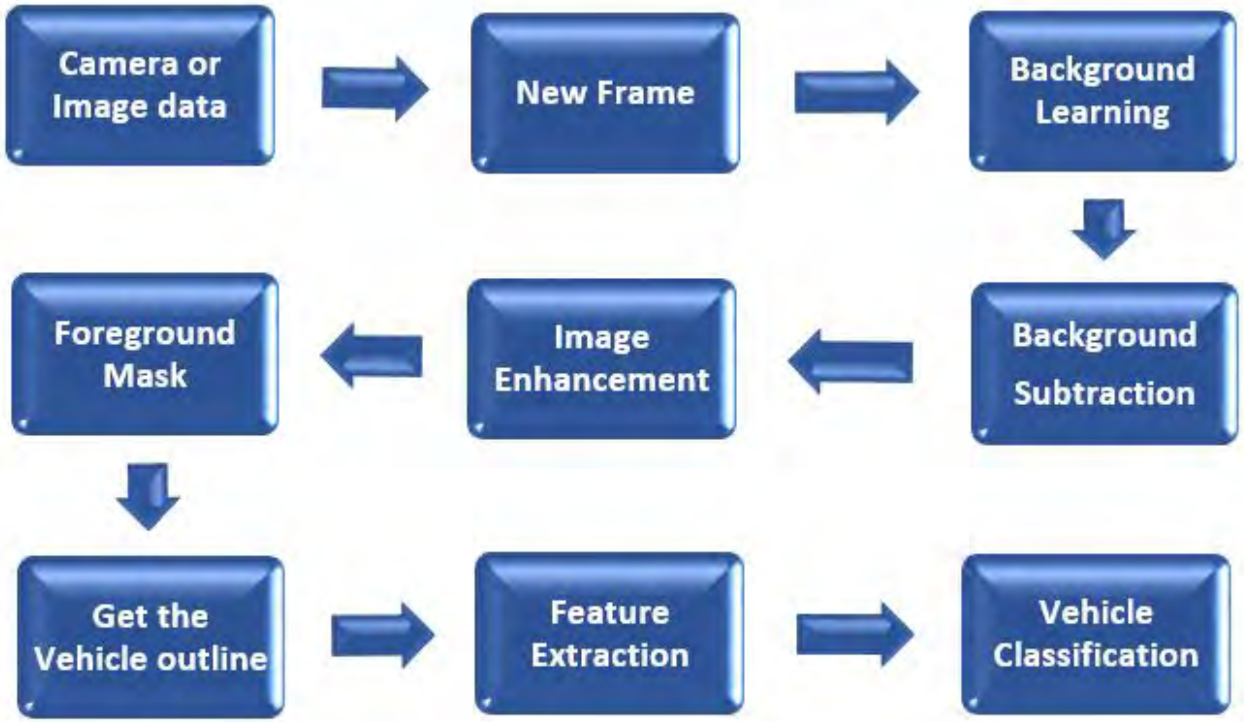


Fig. 1: Main components in traffic volume counting system

Stage 1 - Field Traffic Data Collection

- Field data is collected using a Video Collection Unit (VCU)
- VCU is strategically positioned above the road, angled downward
- Vehicle counting occurs via both VCU and manual methods for comparison.
- Data collection spans four 30-minute intervals between 5:00 p.m. and 7:00 p.m

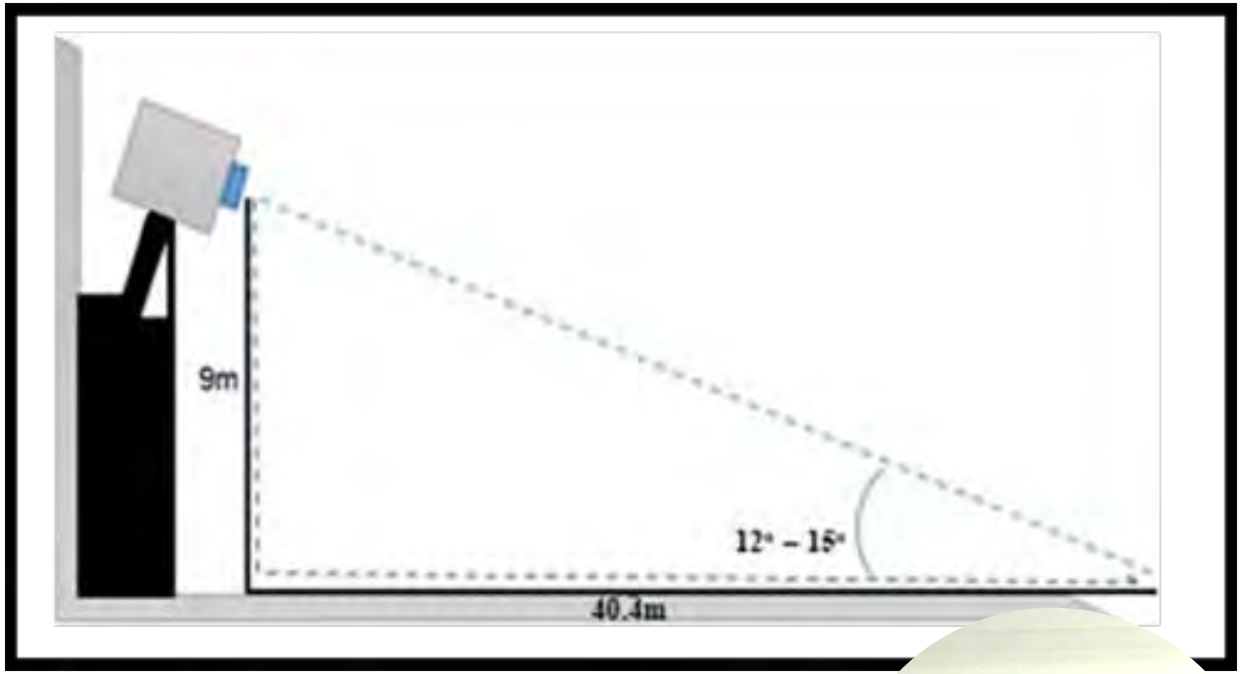
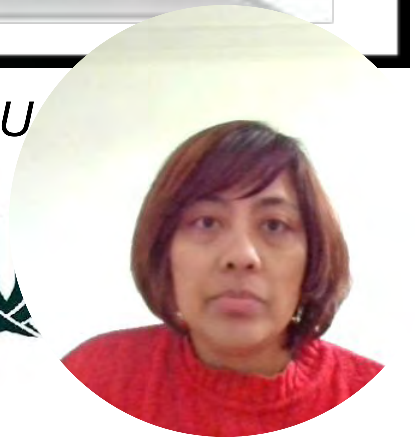


Fig. 2: Optimum angles of VCU



Stage 2 - Background Subtraction and Foreground Extraction

- Utilised to identify or trail vehicles (moving objects) in the video frame
- Involves isolating the foreground image from the background recognition
- Method: Gaussian Mixture Model (GMM)

(a) Image background (b) Original image (c) Background subtrac

Fig. 3: Background subtraction processes

Stage 3 - Vehicle Classification and Counting

(a) Classification

- Vehicles are classified into LTV, MTV, HTV
- OpenCV module in Python extracts centroid, aspect ratio, area, size, solidity of detected vehicles
- Compare the contour properties of solidity and area for LTV, MTV and HTV with the detected objects.

Fig. 4: Camera footage includes a boundary line (red line), shape detection (green box) centroid (red dot).

Stage 3 - Vehicle Classification and Counting…cont.

(b) Counting

- Checking if the centroid of a vehicle touches or crosses a reference line in the image
- Once the centroid of a vehicle in an image crosses the reference line, the system counts the vehicle
- The reference lines are indicated in red and blue in both directions

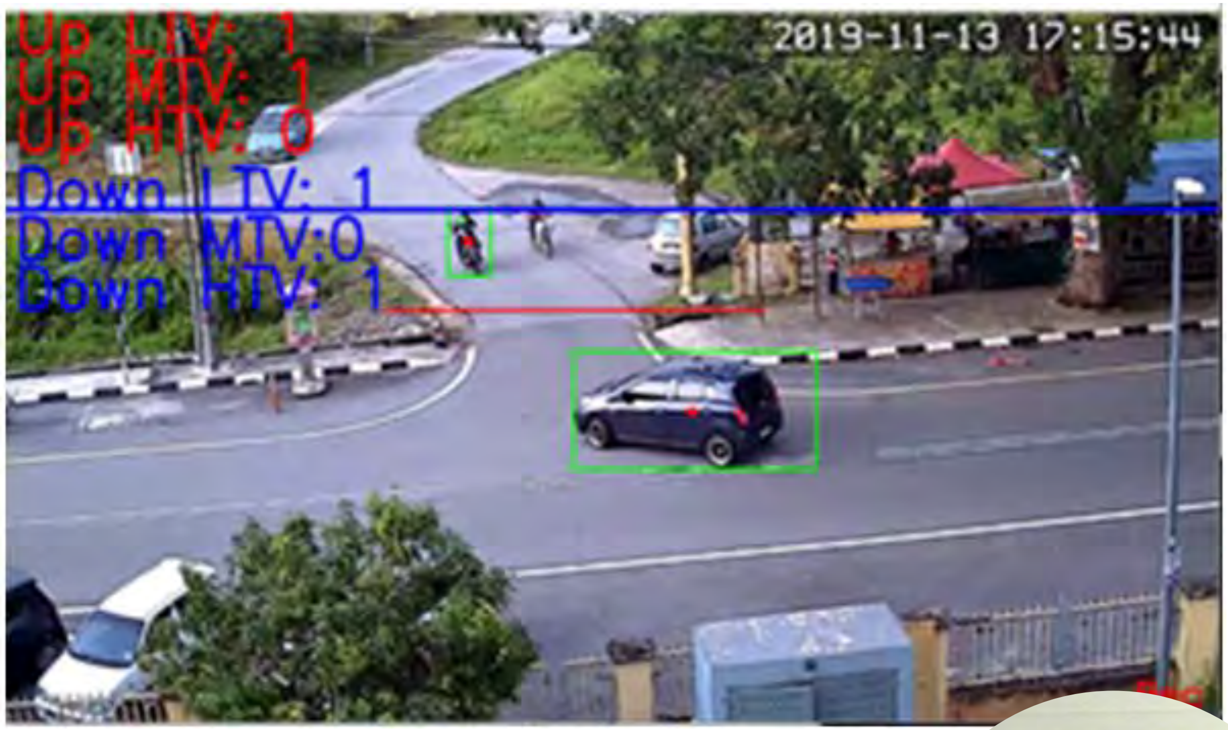


Fig. 4: Camera footage includes a boundar line (red line), shape detection (green box centroid (red dot).

Results and Discussion

Comparison of manual and automated counts:

- Four sample videos recording different traffic scenes were compared to the results of the proposed method.
- The automatic method was observed to have no error counts with true values relating to the first 30-minute interval, and only a small discrepancy relating to the 2nd, 3rd & 4th 30-min. intervals.
- The smallest variation against actual count is during the 1st 30-minute interval, and the highest variation during the 3rd 30-minute interval.

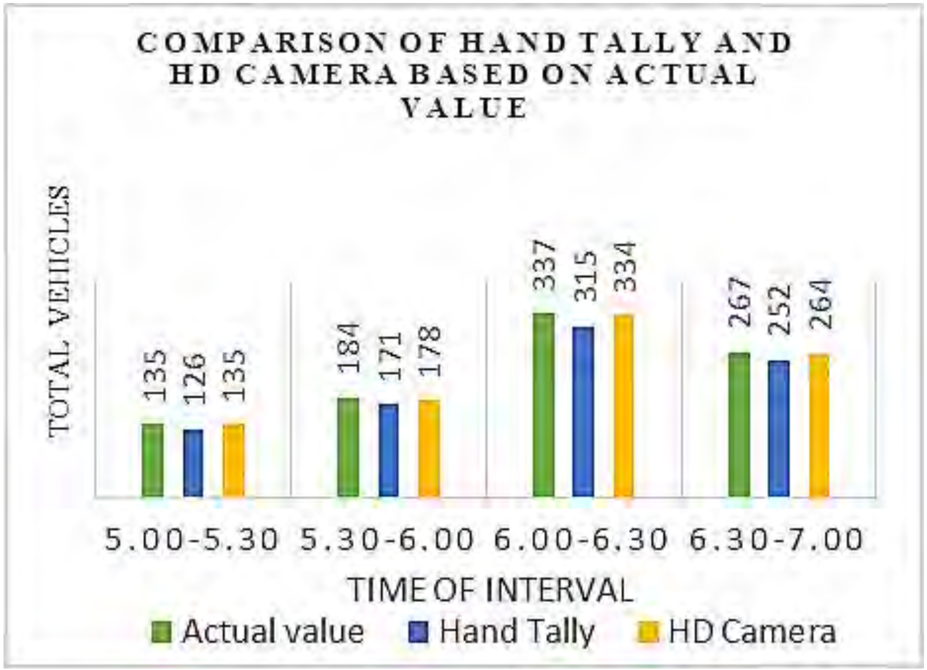


Fig. 5: Comparison of actual cou… count, and automatic count f… interval

Results and Discussion…cont.

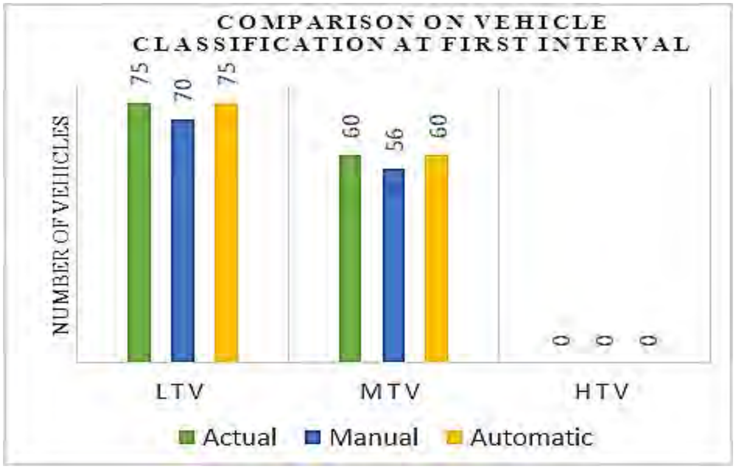


Fig. 6: Vehicle classification comparison, 5.00 p.m & 5.30 p.m

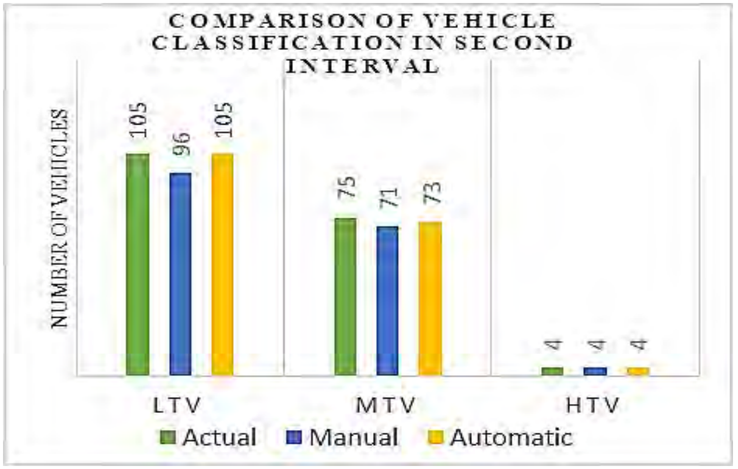


Fig. 7: Vehicle classification comparison, 5.30 p.m & 6.00 p.m

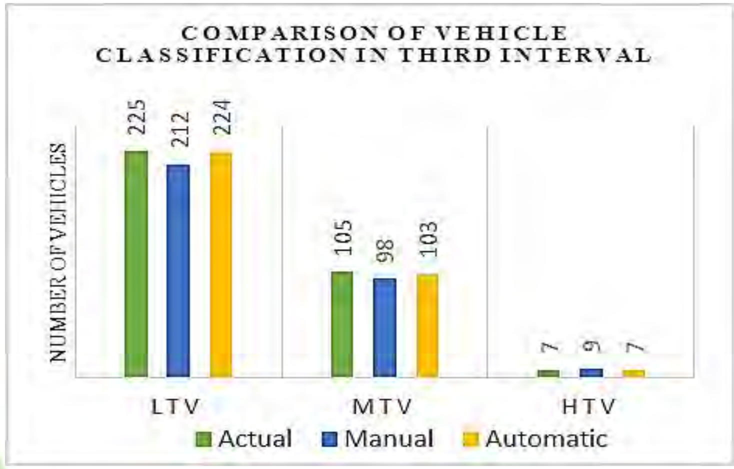


Fig. 8: Vehicle classification comparison, 6.00 p.m & 6.30 p.m

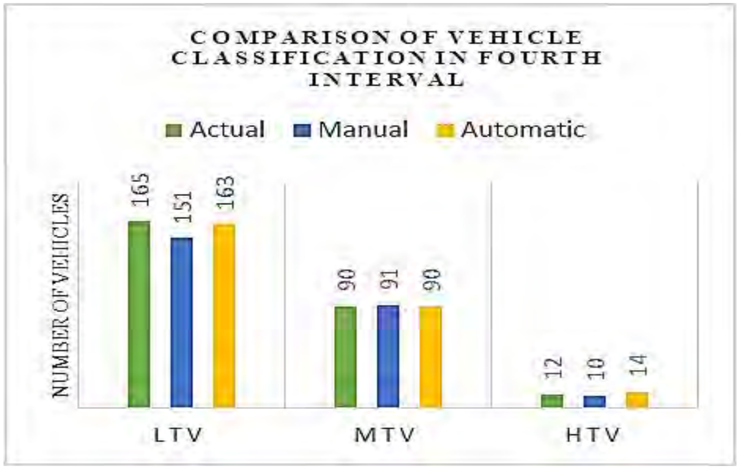
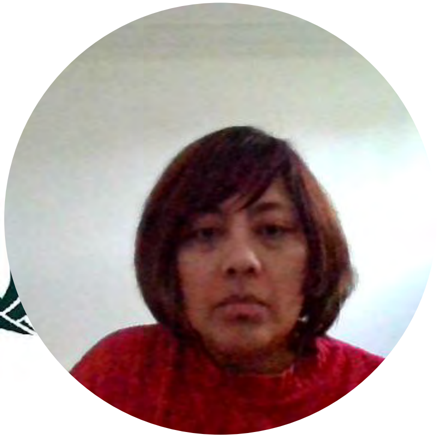


Fig. 9: Vehicle classification comparison, 6.30 p.m & 7.00 p.m

The results show only a small error in vehicle classification using the proposed automated counting system versus the actual counts.



Accuracy Comparison

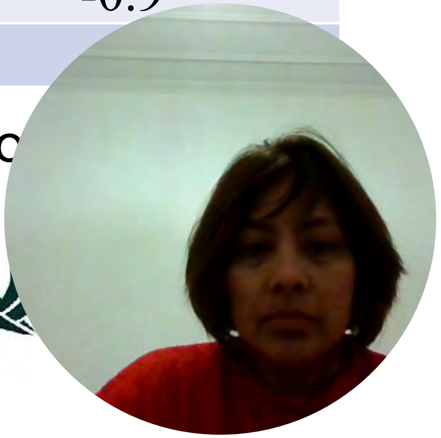
Error rates: Manual vs. Automated image processing.

The automated counting system is shown to have greater accuracy than the traditional manual tally counter method.

Table 1: Comparison of percentage accuracy

		Total Truth Count (Actual)	Percentage Error (%) of Actual and Manual	Percentage Error (%) of Actual and Automatic
Count	Total Count (2 hour)	923	-6.4	-1.3
Classification	5.00 p.m. - 5.30 p.m.	135	-6.7	0
	5.30 p.m. - 6.00 p.m.	184	-7.0	-3.3
	6.00 p.m. - 6.30 p.m.	337	-6.5	-0.9
	6.30 p.m. - 7.00 p.m.	267	-5.6	[illegible]

The value of Passenger Car Unit (PCU) conversion factors was based on Geo
Road Design Guideline 8/86 from Public Works Dept Malaysia (2015)



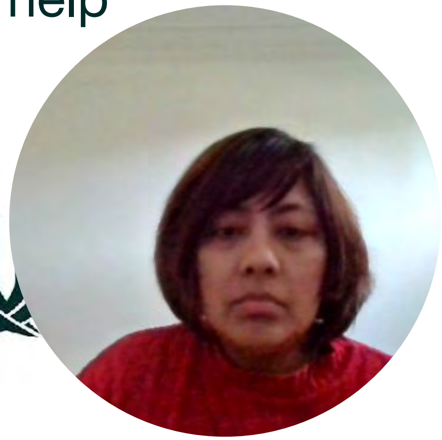
Conclusion

Summary of findings

This study has demonstrated the capability and reliability of video collection unit (VCU) and algorithm-based image processing methods for the effective detection, classification and counting of vehicles traveling on roadways.

Benefits of the automated system over manual methods

- The automated counting system (with OpenCV code bindings in Python) outperforms the traditional manual tally counter method–in the accuracy of both vehicle classification and count.
- Proposed automated counting system and machine learning algorithm (AI) will help optimise traffic control operations in urban centres



Challenges and Improvements

- Issues with small object detection
- Lighting conditions at intersections must be improved
- Adjustments for camera angles during times of high traffic volume

THE END