

PERFORMANCE OF COMPUTER VISION METHOD FOR OVER-HEIGHT VEHICLE DETECTION

Twk. Mohd. Iqbal*¹, Ridha Ilahi², Munandar³, Reza Irhamna⁴

^{1,4} Universitas Bina Bangsa Getsempena, Banda Aceh, Indonesia

² Universitas Islam Negeri Ar-Raniry, Banda Aceh, Indonesia

³ STMIK Indonesia, Banda Aceh, Indonesia

* Corresponding email: twk.mohd.iqbal@gmail.com

ABSTRACT

Prevention of accidents for over-height vehicles that will pass through tunnels or underpasses is very necessary. This prevention is done by providing an early warning to over-height vehicles. Early warning is carried out using a system that is able to detect oversized vehicles from the tunnel or underpass height allowed to be passed. This system must have high accuracy and be resistant to various environmental conditions. Interference in detection can occur due to rain, wind, lack of light, night time, various backgrounds such as walls, trees, and two-way roads. This research examines the durability of computer vision-based over-height vehicle detection methods against environmental condition influences. The methods used are Gaussian Mixture Model (GMM) and blob detection. Samples were taken in 3 different location conditions and detected in 5 frame variations. The results of this research show that GMM and blob detection is excellent performance and resilience against environmental conditions. This method can detect over-height vehicles with an accuracy reaching 100% with the number of frames at 5 and 7. It is expected that this detection method can provide more accurate early warnings for over-height vehicles, thereby increasing road user safety.

Keywords : *over-height vehicle detection, Gaussian Mixture Model (GMM), blob detection, performance detection*

INTRODUCTION

Accidents in tunnels or bridge columns (underpasses) can occur because the vehicle height exceeds the permitted limit. This causes vehicles to collide with tunnels. In environmental factors, there are several things that cause accidents such as uphill, downhill, or curved roads, including tunnels and bridge columns (underpasses). Such conditions can result in material losses, casualties, structural damage to bridge columns (underpasses), and also cause traffic to slow down or become congested.

To prevent such accidents, an over-height vehicle detection system is needed. This system will detect the height of vehicles passing through the underpass. If the vehicle height exceeds the permitted threshold, the system will provide a warning to the driver to stop immediately or take an exit route (Massoud, 2013).

Previous research related to over-height vehicle detection has used digital image processing methods (Massoud, 2013) (Dai, Park, & Brilakis, 2015). Previous research on over-height vehicle detection systems using digital image processing used various methods, namely blob detection and Kanade Lucas Tomase (KLT) methods (Khorramshahi, Behrad, & Kanhere, 2008), blob detection and Histogram of Oriented Gradients (HOG) methods (Dai, Park, & Brilakis, 2015), KLT detection methods, KLT and SURF detection methods (Nguyen & Brilakis, 2018), and methods using Gaussian Mixture Model (GMM) features and blob detection (Iqbal, Arnia, & Muharar, 2021).

The results of previous digital image processing-based studies using various methods show varying accuracy levels. In research using blob detection and Kanade Lucas Tomase (KLT) methods, the vehicle detection accuracy reached 92.2% (Khorramshahi et al, 2008). Meanwhile, blob detection and Histogram of Oriented Gradients (HOG) methods produced a vehicle detection accuracy of 95.83% and over-height vehicle detection accuracy of 95.77% (Dai et al., 2015). Research with KLT detection methods produced a vehicle detection accuracy of 68.7% and over-height vehicle detection accuracy of 83.3%. KLT and SURF detection methods yielded a vehicle detection accuracy of 83.3% and over-height vehicle detection accuracy of 96.6% (Nguyen & Brilakis, 2018). And lastly, the Gaussian Mixture Model (GMM) and blob detection method achieved a vehicle detection accuracy of 100% and over-height vehicle detection accuracy also reaching 100% (Iqbal, Arnia, & Muharar, 2021).

These research results show that Gaussian Mixture Models (GMM) and blob detection can produce high accuracy in detecting vehicles and over-height vehicles. This high accuracy level became the basis for researchers to choose the Gaussian Mixture Models (GMM) and blob detection methods to examine the accuracy detection resilience against environmental conditions. It

is hoped that this research can provide high accuracy in vehicle detection to provide accurate early warnings.

METHODS

The Over Height Vehicle Detection System (OHVDS) is a system for detecting vehicle height and providing warnings to drivers. (Dai, Park, & Brilakis, 2015). The system will activate an alert if a vehicle exceeds the permitted height for passing through a tunnel or underpass. This warning can prevent traffic accidents.

One method of vehicle detection is based on digital image processing (Nguyen et al., 2016). With digital image processing, besides detecting vehicle presence, it can also be used to detect height, speed, and vehicle movement direction (Khorramshahi, Behrad, & Kanhere, 2008). The method used for detecting vehicle presence and height is the Gaussian Mixture Model (GMM)

Gaussian Mixture Models (GMM) is a Gaussian function component forming a density model type from various thresholds. This feature separates foreground and background (Goyal & Singhai, 2018) in video. The separation is done by comparing images from one frame to the next. If a density group shifts, it will be grouped as foreground and others as background, represented in a binary matrix. Detected foreground objects are considered vehicles. The system then determines the vehicle height. If the vehicle height exceeds the permitted threshold, the system will trigger a warning to the driver, such as through sound, lights, and warning boards.

Blob detection is the detection of bright or dark pixels in an image, working quickly and accurately. This concept works by representing the image in a matrix with a certain number of pixels across several rows. An image is converted to grayscale, and then a threshold value is determined. This threshold value is used to determine bright and dark areas. The bright areas become blob areas (Islamadina, Pramita, Arnia, Munadi, & Iqbal, 2018).

The research was conducted by recording video datasets at three locations: Simpang Surabaya, Pango Bridge, and Lamcot. Simpang Surabaya location has traffic characteristics with a concrete wall background and sunlight. The Pango Bridge location has traffic characteristics with a background of small plants, grass, trees, and traffic from different flow directions, and sunlight. The Lamcot location has traffic characteristics with a background of trees, office buildings, traffic from different directions, and street lamp lighting.

Vehicle detection was performed by determining object duration and direction on frames. This method aims to reduce vehicle detection errors. In this study, there are five frame variations in vehicle detection: 3, 5, 7, 9, and 11 frames. Meanwhile, over-height vehicle detection was conducted under three conditions: first, without determining ROI (Region of Interest) and

without detecting vehicle movement direction; second, with ROI and without detecting vehicle movement direction; and third, with ROI and detecting vehicle movement direction.

Dataset recording at Simpang Surabaya and Pango Bridge was done during the day with a frame rate of 30 frames per second (fps) and recording was done in cloudy and slightly rainy environmental conditions. Dataset recording at the Lamcot location was done at night with a frame rate of 9 fps and recording was done on a bright night with street lighting. Recording duration was 7 minutes and 54 seconds, using a resolution of 640x480 pixels.

RESULTS AND DISCUSSION

The over-height vehicle detection research used Gaussian Mixture Model (GMM) features and blob detection. The research was conducted at three locations: Simpang Surabaya, Pango Bridge, and Lamcot. The analysis method was conducted in 3 conditions: first, without ROI and without vehicle direction detection. Second, with ROI and without vehicle direction detection. Third, with ROI and with vehicle direction detection. And all conditions were studied in 5 frame variations: 3, 5, 7, 9, and 11 frames. The results from the trial videos are shown in Table 1, Table 2, and Table 3.

Table 1. Video Testing Data in *Simpang Surabaya, Banda Aceh*

Condition	Frame					actual
	3	5	7	9	11	
<i>Without ROI and without direction detection</i>	12	9	8	8	6	2
<i>ROI and without direction detection</i>	5	4	4	4	4	
<i>ROI and direction detection</i>	2	2	2	2	2	

Table 2. Video Testing Data at *Pango Bridge, Aceh Besar*

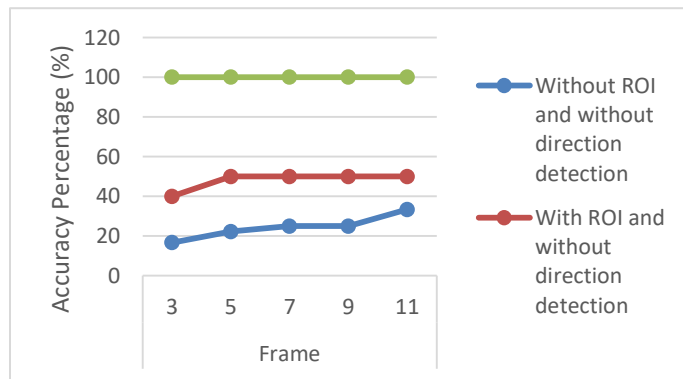
Condition	Frame					Actual one direction	Actual two direction
	3	5	7	9	11		
<i>Without ROI and without direction detection</i>	34	23	19	19	16	2	6
<i>ROI and without direction detection</i>	15	10	8	8	7		
<i>ROI and direction detection</i>	4	2	2	1	1		

Table 3. Video Testing Data at *Lamcot, Aceh Besar*

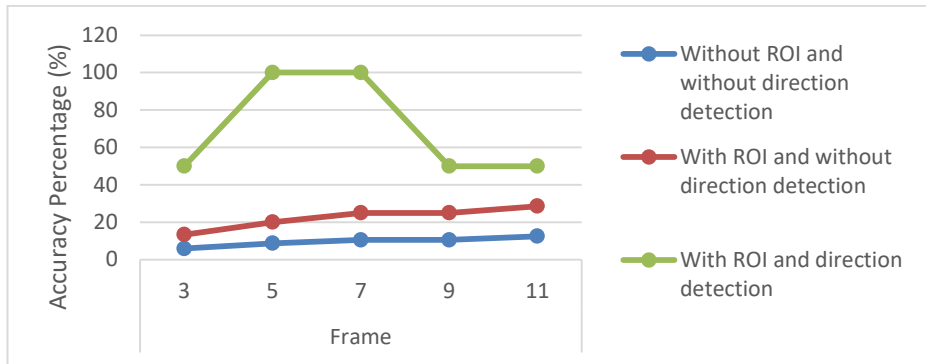
Condition	Frame					Actual one direction	Actual two direction
	3	5	7	9	11		
<i>Without ROI and without direction detection</i>	38	27	15	11	10	1	1
<i>ROI and without direction detection</i>	20	7	5	4	4		
<i>ROI and direction detection</i>	4	1	1	0	0		

The experimental results show that accuracy improvement is influenced by the use of ROI and detecting vehicle movement direction. Using ROI is to focus object detection in a specific area. The detected object is examined for its movement direction in the next frame. If the detected object moves consistently in one direction, it is considered a vehicle. And if the detected object moves inconsistently, it is not considered a vehicle. Thus, using ROI and detecting vehicle movement direction can reduce errors in vehicle detection.

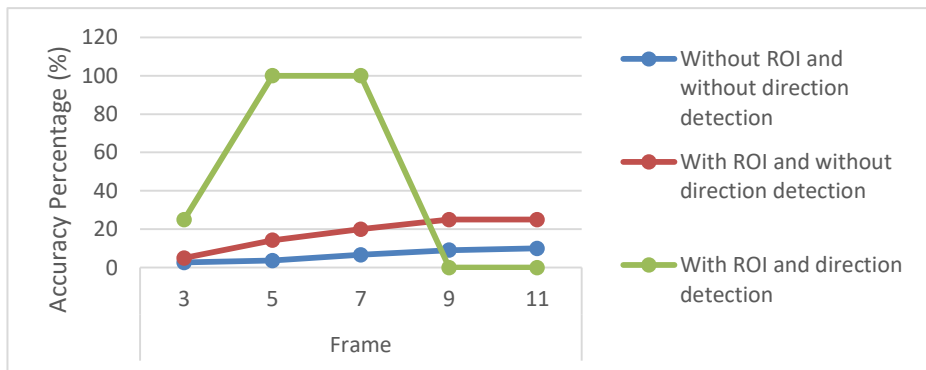
The over-height vehicle detection is done by determining the object's duration and movement direction in the frame (Nguyen & Brilakis, 2018). Over-height vehicle detection at 3 frames showed low accuracy results. This is because it could not yet reduce detection errors. While at 5 and 7 frames, there was an accuracy increase. At 9 and 11 frames, there was a decrease in accuracy level. The accuracy level graphs for each location are shown in Figure 1, Figure 2, and Figure 3.



Graph 1. Accuracy level at in experiments at *Simpang Surabaya*.



Graph 2. Accuracy Levels in Experiments at *Pango Bridge*



Graph 3. Accuracy level in experiments at *Lamcot*

CONCLUSION

This research shows that the GMM and blob detection method that has excellent performance and resilience against environmental conditions. This method can detect over-height vehicles with an accuracy reaching 100% with the number of frames at 5 and 7 in three different environmental condition characteristics. The first location had traffic characteristics with a concrete wall background and sunlight. The second location had traffic characteristics with a background of small plants, grass, trees, and different traffic flow directions, along with sunlight. The third location had traffic characteristics with a background of trees, office buildings, different traffic flow directions, and street lamp lighting.

The use of ROI and number of frames in detecting over-height vehicles influences accuracy improvement. The frame numbers with the highest accuracy are 5 and 7 frames. This indicates that the GMM and blob detection method, combined with ROI usage and frame number detection, has good resilience in maintaining high accuracy.

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