Journal of Engineering and Applied Sciences 12 (17): 4500-4503, 2017
ISSN: 1816-949X

Vehicle Detection on Images from Satellite using Oriented Fast and Rotated Brief

[1]Joko Lianto Buliali, [1]Chastine Fatichah, [1]Darlis Herumurti, [1]Diagnosa Fenomena,
[2]Hera Widyastuti and [3]Mark Wallace
[1]Department of Informatics,
[2]Department of Civil Engineering, Institute of Teknologi Sepuluh Nopember, Surabaya, Indonesia
[3]Faculty of Information Technology, Monash University, Melbourne, Australia

Abstract: Traffic density data plays important role in traffic management, road planning as well as urban land use planning. Several efforts have been used to gather this data, mainly by detecting and counting vehicles in roads by processing images from CCTV placed in certain positions in roads. The main disadvantage of this approach is that it is only possible to detect and count vehicles effectively in a relatively limited area of the roads due to limited height and camera resolution. By using satellite images or images taken from drones, the coverage area of the roads can be increased significantly, however problems of false detection due to objects looking similar to vehicles also increases. This reseach uses Template Matching methos by using correlation equation, haar cascade classification, keypoint detection using maximally stable extremal region and Oriented FAST and Rotated BRIEF (ORB) feature extraction method. The highest recall and precision value using MSER and ORB are 100 and 75%, respectively.

Key words: Satellite images, vehicle detection, feature extraction, recall, MSER, classification

INTRODUCTION

Traffic jam is a common problem in big cities which results in ineficiency and substantial economic losses. Traffic management is one of possible efforts to reduce traffic jams. Efforts have been used to gather this data, mainly by detecting and counting vehicles in roads by processing images from CCTV placed in certain positions in roads (Suppatoomsin and Srikaew, 2011; Patil and Nandyal, 2013). The main disadvantage of this approach is that it is only possible to detect and count vehicles effectively in a relatively limited area of the roads due to limited height and camera resolution. The vehicles that are relative near to the camera look big in size while those are relative far to the camera look very small and often overlapped each other, causing wrong detection. Cities with complex road architecture such as those with many turns, makes CCTV image vehicle counting method less effective.

Such limitation can be alleviated by using devices that can capture images that is perpendicular to the road or vehicles. Images from weather baloon, drones or satellites are such examples in which size distortion in the capetured image due to the position of vehicles are minimized. Additional advantages of such images include the ability to capture roads in a relatively wide area, ability to cope with complex road architecture such as those with many turns mentioned above. In this research, images from a satellite are used as the case studies.

MATERIALS AND METHODS

The main processes in this research include grayscale conversion, feature extraction, feature matching, template matching and classification. The latter three processes (feature matching, template matching and classification) can be executed in parallel. Overall process is shown in Fig. 1.

Detection using haar cascade classification

Haar-cascade classification consists of three stages: Information extraction on positive samples and negative samples, training and classification. For training stage, Adaboost method is used to select Haar feature and to train the classifier. Figure 2 shows 25 images from 527 positive samples and 25 images from 502 negative samples.

To increase the speed of Haar feature calculation, images are first converted into integral image (summed area table) which are images in which the intensity of every pixel is the accumulation of the value of adjecent pixels. After the process, Adaboost chooses Haar feature.

Corresponding Author: Joko Lianto Buliali, Department of Informatics, Institute of Teknologi Sepuluh Nopember, Surabaya, Indonesia

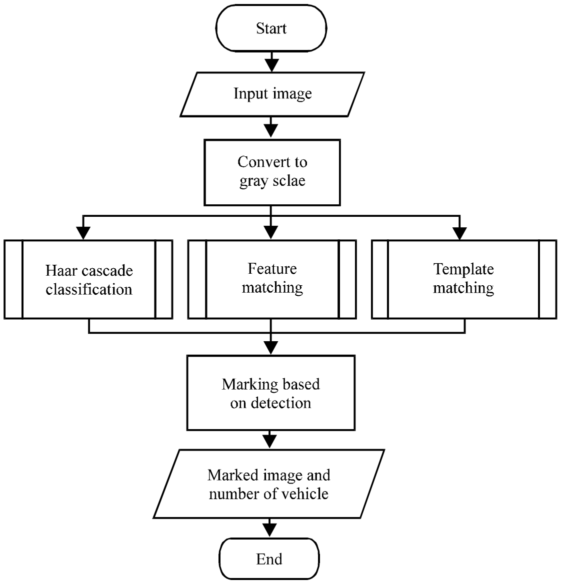

Fig. 1: Flowchart of the overall process

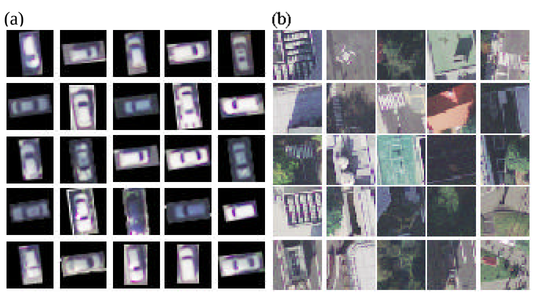

Fig. 2: a) 25 images from 527 positive samples and b) 25 images from 502 negative samples

Next in classification process, labeling is determined by the window in certain areas. If labeling produces negative value then classification process is over and window location is moved to the next location.

Detection using template matching: If labeling produces positive value then classification process is started by carrying out Template Matching process. This is a method to find areas in the Input image (I) that matches or resembles Template images (T). To find appropriate areas, sliding window technique is carried out by sliding the Template (T) 1 pixel at a time until all Input image (I) is covered. While sliding window technique is carried out, matching value between area Input image (I) covered by window with the Template (T) is calculated by using Eq. 1, so that matching matrix (R) is obatained:

$$R(x,y)=\sum_{x',y'}T(x',y')\times I(x+x',y+y') \quad (1)$$

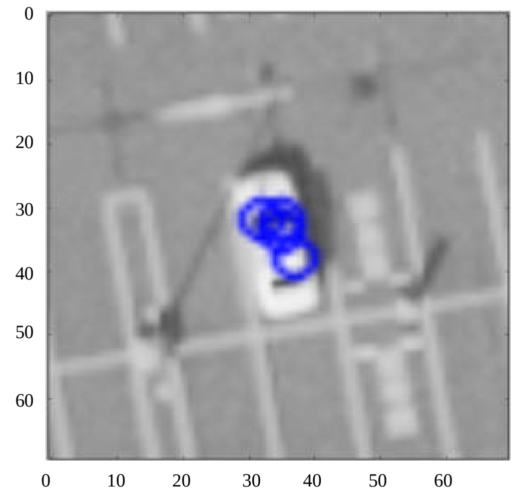

Fig. 3: Feature point of an input image

Where:

R (x, y) = The matching value of matching matrix (R) at (x,y) index

T(x', y') = The grey level on template image T dan I(x+x', y+y') the grey level on input image I

After that thresholding is carried out on matching matrix R. If the value of R (x,y) is greater that a threshold value t then R (x,y) is regarded as appropriate.

Detection using feature matching: Feature matching is used to find fitur point (keypoint) in input image that matches smaller size images (template images). Feature matching can be used when an input image has undergone linear tranformation and when template image has strong feature.

The first step in feature matching is to find feature point of every input image by using keypoint detection in Maximally Stable Extremal Region (MSER) (Soo, 2014) and Oriented FAST and Rotated BRIEF (ORB) (Hinz *et al.*, 2003). The method in finding feature point in MSER is by using extremal region and the method in finding feature point in ORB is by using corner points (called corner detection). The process of finding feature point of an input image is shown in Fig. 3.

Based on the feature point that has been obtained, feature extraction is done by using Oriented FAST and Rotated BRIEF (ORB). Feature that is obtained is in the form of BRIEF binary descriptor which stores grey level intensity feature and the orientation of the keypoint. Hamming distance is used to calculate the matching value between an input image and a template. After that KNN classification is used to obtain k-pair matching feature. From those pairs, the best pair is selected by carrying out ratio test (Rublee *et al*., 2011). The formula for ratio test is shown in Eq. 2 where r is the ratio, m and n are 2 distances of a pair of feature produced by KNN. A pair of feature is regarded as good match if it satiesfies Eq. 2:

$$r < \frac{m}{n} \tag{2}$$

RESULTS AND DISCUSSION

Testing is carried out by calculating recall and precision values based on the following:

- True positive: a tag with a car object inside the tag
- False negative: a car object without a tag
- False positive: a tag without a car object

To measure time of each process, a notebook with the following spesification is used: Intel®Core™ i7-3517U CPU@1.90GHz (4 CPUs) prosesor, RAM 4GB and running on Windows 10 operating system.

A tag on an image is classified as true positive when the position of a car object inside the tag. When there are more than one tag on a car only one tag is classified as true positive. Five tests have been carried out:

- Detection by using template matching
- Detection by using haar cascade classification
- Detection by using ORB feature matching
- MSER feature matching
- ORB and MSER feature matching

Haar cascade classification is carried out to compare performance of each detection process using feature matching. ORB and MSER feature matching is carried out to measure the effect of keypoint detection in feature matching process. All tests use the same 30 image dataset each with the size of 1000×1000 pixels. Table 1 shows the results of the tests. The results of the tests using 5 methods are shown in Table 1.

It can bee seen from Table 1 that all tests using feature matching show better results as compared with template matching and Haar cascade classification methods. This is due to the characteristics of feature matching method which is immune to rotation or the difference in a car's orientation on the image and in the template. In the latter three tests, feature matching is done by using three different keypoint detection methods.

Table 1: Results of testing using 5 methods

Methods	Precision (%)	Recall (%)	Time (sec)
Template matching	3.84	14.06	9.60
Haar cascade classification	1.96	15.19	5.17
Feature matching ORB	6.83	24.17	0.21
Feature matching MSER	4.83	8.55	0.76
Feature matching ORB dan MSER	10.71	42.51	0.88

Table 2: Results of testing using different image sizes

Image sizes/Methods	Precision (%)	Recall (%)
250×250 pixel		
Template matching	1.43	4.00
Cascade classification	12.50	28.00
Feature matching	13.10	44.00
1000x1000 pixel		
Template matching	0.00	0.00
Cascade classification	26.92	28.00
Feature matching	8.33	16.00

Table 3: Results of testing using image with only cars and roads

Methods	Precision (%)	Recall (%)
Template matching	36.36	33.33
Cascade classification	87.50	53.85
MSER ORB feature matching	100.00	75.00

Combination of ORB and MSER method shows the highest performance among the three. This is due to the method's ability to detect car object with bright colors as well as those with dark colors.

Further testing is done by using images with smaller sizes to see the performance of the system due to different image sizes. Table 2 shows the results of this testing. In the testing, there is an increase in the result of detection (in either template matching and feature matching) after cutting the image. This is due to the fewer detected objects. While, in cascade classification method, cutting the image results in the increase of false alarm.

The next testing is carried out on images on areas that contain only cars and roads. This is done to check the performance of each method to detect cars on images that do not contain objects other than cars and roads. The result of the test is shown in Table 3.

In this testing, there is increase in the average values of recall and precision when compared to the the average values of recall and precision on images with various objects. This is due to the fact that there are no other objects such as buildings detected as cars.

CONCLUSION

Based on the results of testings, several conclusions can be drawn. Testings using feature matching show better results as compared with template matching and haar cascade classification methods. This is due to the characteristics of feature matching method which is immune to rotation or the difference in a car's orientation on the image and in the template.

Combination of ORB and MSER method shows the highest performance among the three methods (Template Matching ORB feature matching and MSER feature matching). This is due to the method's ability to detect car object with bright colors as well as those with dark colors.

If images are cut on areas that contain only cars and roads, there is increase in the average values of recall and precision when compared to the the average values of recall and precision on images with various objects. This is due to the fact that there are no other obhects such as buildings detected as cars.

Feature Matching methods produce higher average recall when compared to Template Matching and Haar Cascade. Feature Matching also considerably faster than the two methods.

ACKNOWLEDGEMENT

This research is supported by the grant from and Directorate General of Higher Education, Ministry of Education and Culture, Republic of Indonesia and Research Center of Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia in the year of 2015 and 2016.

REFERENCES

Hinz, S., C. Schlosser and J. Reitberger, 2003. Automatic car detection in high resolution urban scenes based on an adaptive 3D-model. Proceedings of the 2nd GRSS/ISPRS Joint Workshop on Remote Sensing and Data Fusion over Urban Areas, May 22-23 2003, Berlin Germany, pp: 167-171.

Patil, P. and S. Nandyal, 2013. Vehicle detection and traffic assessment using images. Int. J. Comput. Sci. Mobile Comput., 2: 987-1000.

Rublee, E., V. Rabaud, K. Konolige and G. Bradski, 2011. ORB: An efficient alternative to SIFT or SURF. IEEE Proceeding of the International Conference on Computer Vision (ICCV), November 6-13, 2011, Barcelona, pp: 2564-2571.

Soo, S., 2014. Object detection using haar-cascade classifier. Master Thesis, University of Tartu, Tartu, Estonia.

Suppatoomsin, C. and A. Srikaew, 2011. 2DPCA for vehicle detection from CCTV captured image. Proceedings of the IEEE International Conference on Information Science and Applications (ICISA 2011), April 26-29, 2011, IEEE, Jeju Island, South Korea, ISBN:978-1-4244-9222-0, pp: 1-5.