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Performance Comparison between SVM and K-Means for Vehicle Counting

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Abstract. Support vector machine (SVM) and K-means have been two well known methods used in classification. Choosing an accurate classifier for good features to differentiate between the foreground and background has a significant effect in increasing the accuracy of the detection. This paper presents and analyzes performance comparison between SVM and K-means classifiers for vehicle counting targeted for intelligence transportation systems (ITS) application. In particular, precision and recall have been used for the comparison between the two methods. Five videos from different weather conditions have been used for the testing purposes. SVM shows a better performance in terms of precision and recall.

1. Introduction
The development of intelligent transportation systems (ITS) that extracts information from the traffic surveillance systems plays an important role in traffic management. With the ever-increasing vehicles on the road, it is crucial to develop a robust and reliable traffic surveillance system to increase safety, to direct traffic flow, to improve the control of traffic in urban congestion speed and to check the rules of traffic and traffic signals [1].

Customarily in any ITS, vehicle detection is the first step in the traffic monitoring system [2] and this is even more so important for vehicle counting, speed estimation and traffic flow. Hence, increasing the accuracy of the vehicle detection process will result in enhancing the efficiency of traffic control.

Additionally, this will lead to improving the accuracy of the further steps in the traffic surveillance systems such as vehicle tracking, vehicle movement pattern, and behavior understanding [3]. There are many technologies for computing the traffic measurements such as inductive loop detector, traffic radar and microwave detectorsin addition to video cameras [4]. Presently, the most common form of detector used is the inductive loop sensor [5]. However, video camera has many advantages over the other technologies such as [6]: Less costly for maintenance and installation, nonintrusive, able to provide more information on the entire traffic scene, easily upgradable, and scalable in its design and functionality by changing the system algorithm. Moreover, the advances in camera sensing and computational technologies makes the vehicle detection using video camera becomes an extremely active research area in the traffic surveillance systems [7].

In this paper, two features will be extracted and applied to two classifiers, support vector machine (SVM) and K-means in order to compare the performance (precision and recall) between these classifiers. The rest of this paper is organized as follows: Section II gives a survey of the existing feature based method for vehicle counting. Section III demonstrates the general idea of the vehicle counting, along with the basic operation of SVM and K-means. Section IV presents the results and discussion, and finally, the conclusion is discussed in Section V.

2. Related Works

Different vehicle detection methods using video cameras were discussed in [8]. Currently, these methods can be categorized as frame differencing, background subtraction, optical flow and feature based extraction methods.

In [9], Mohamed et al. presented vehicle detection based on Haar-like feature extraction and neural network. The experimental results show that the best number of neurons is 150 neurons, which gives detection accuracy rate of 91.3%. The main drawback of this method is the computational time increases proportionally with number of neurons.

Another algorithm based on feature extraction was proposed in [10]. This algorithm consisted of three layers. The first layer is to extract the image features. The second layer is to fuse the image features to detect the vehicle features (Headlights and Windshield). Finally, vehicle features are fused to detect the vehicle accurately. This algorithm is able deal both during the daytime and nighttime. The algorithm has been evaluated on highway and urban with different weather and traffic conditions. The algorithm achieved average accuracy above 80% at false alarm rate of 10%. Haar-like feature and histogram of oriented gradient (HOG) are suitable features for vehicle detection but HOG has more computational complexity [11].

In [12], El-khoreby and Abu-Bakar proposed a vehicle counting method based on approximate median filter background modeling combined with triangle threshold method. The main problem in this method is in setting the appropriate number of frames to be used to model the background. They realized that this number is influenced by the frame rate and the amount of the movement.

3. Feature Based Method For Vehicle Counting

As mentioned in Section II extracting the features from the image can be performed by different methods such as Haar-like feature and HOG. After extracting the features from the image, a classifier will be applied to differentiate between the foreground and background for counting the number of vehicles. In this paper, two features are extracted from the image as shown in Fig.1. These features are area and edge. Next, two classifiers (SVM and K-means) will be applied so to compare their performance. Points nearer to the origin are noise while points towards the right side of the axis are valid vehicles.

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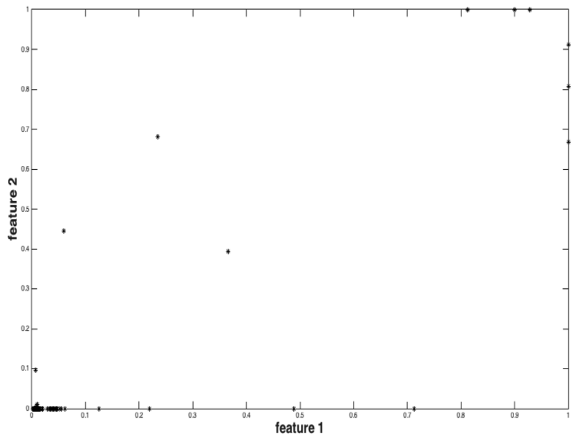

Figure 1. Positions for 2D feature vectors

3.1. SVM

SVM is a supervised machine-learning algorithm which can be used either for classification or regression problems. The basic idea in SVM is to construct a hyperplane or set of hyperplanes in a high or infinite dimensional space, which can be used for classification, regression or other tasks. The objective of the support vector machine algorithm is to find a hyperplane in an N-dimensional space (N—the number of features) that distinctly classifies the data points.

3.2. K-means

K-means clustering is a type of unsupervised learning approach, which is useful in the presence of unlabelled data (i.e., data without defined categories or groups). The goal of this algorithm is to find groups in the data, with the number of groups represented by the variable *K*. The algorithm works iteratively to assign each data point to one of *K* groups based on the features that are provided. In our case *K* equals two which are foreground and background. As shown in Fig. 2, K-means differentiate between foreground and background. The red dots refer to background while the blue ones refer to foreground.

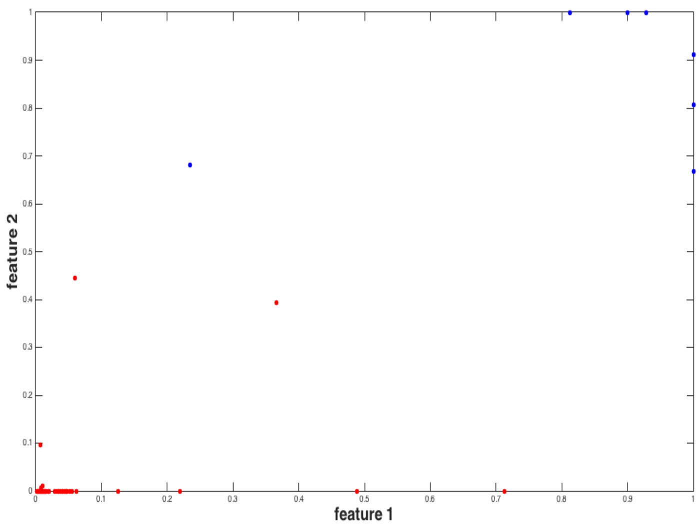

Figure 2. Results after applying K-means

4. Results And Discussions

The proposed method was implemented using MATLAB (R2015a) on a laptop with Intel i5 core processor, 2.3 GHz speed and 4GB RAM. The testing was carried out using our own collection of five urban traffic video sequences under rainy and normal weather conditions. The details of these videos are shown in Table 1 (these videos are publicly available. Please email to the corresponding author for full access).

Table 1. The details of the videos used on the test

Video sequence	Resolution	Duration (s)	Weather
Video 1	1920*1080	32 s.	Rainy
Video 2	1920*1080	34 s.	Heavy rain
Video 3	1920*1080	27 s.	Heavy rain
Video 4	1920*1080	32 s.	Rainy
Video 5	1920*1080	32 s.	Normal

The performance of the proposed method is evaluated by calculating the precision (P) and recall (R) as given in Eq. 1 and Eq. 2 respectively.

$$\text{Precision (P)} = \frac{\text{TP}}{\text{ND}} = \frac{\text{TP}}{\text{TP+FP}} \qquad (1)$$

$$\text{Recall (R)} = \frac{\text{TP}}{\text{NR}} = \frac{\text{TP}}{\text{TP+FN}} \qquad (2)$$

where ND is the number of detected vehicles, NR is the actual number of vehicles or the ground truth, true positive (TP) is the number of detected vehicles that are correct, false negative (FN) is the number of the vehicles that are not detected and false positive (FP) is the number of detected vehicles that are incorrect.

Table 2 shows the average precision and recall values for the five videos for the (K-means and SVM). The average precision and recall values for SVM are better than K-means.

Table 2. Comparison between k-means and SVM

	K-means	SVM
Precision	94.6	95.02
Recall	88.02	95.72

5. Conclusion

In this paper a comparison between K-means and SVM were presented. Both classifiers were applied over 2D feature vector. The results show that SVM has better performance than K-means in terms of precision and recall values. The average precision value for SVM over five videos in different weather conditions is 95.02% while it is around 94.6% in k-means. The average recall value for SVM is 95.72% while it is around 88.02% in k-means.

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References

[1] Asaidi, H., A. Aarab, and M. Bellouki. "Shadow elimination and vehicles classification approaches in traffic video surveillance context." *Journal of Visual Languages & Computing* 25.4 (2014): 333-345.

[2] Dedeoglu, Yigithan. *Moving object detection, tracking and classification for smart video surveillance*. Diss. bilkent university, 2004.

[3] Wang, Yang. "Joint random field model for all-weather moving vehicle detection." *IEEE Transactions on Image Processing* 19.9 (2010): 2491-2501.

[4] Mandellos, Nicholas A., Iphigenia Keramitsoglou, and Chris T. Kiranoudis. "A background subtraction algorithm for detecting and tracking vehicles." *Expert Systems with Applications* 38.3 (2011): 1619-1631.

[5] Dubey, Pooja P., and PrashantBorkar. "Review on techniques for traffic jam detection and congestion avoidance." *Electronics and Communication Systems (ICECS), 2015 2nd International Conference on*. IEEE, 2015.

[6] Arróspide, Jon, Luis Salgado, and Massimo Camplani. "Image-based on-road vehicle detection using cost-effective Histograms of Oriented Gradients."*Journal of Visual Communication and Image Representation* 24.7 (2013): 1182-1190.

[7] Sivaraman, Sayanan, and Mohan ManubhaiTrivedi. "Looking at vehicles on the road: A survey of vision-based vehicle detection, tracking, and behavior analysis." *IEEE Transactions on Intelligent Transportation Systems* 14.4 (2013): 1773-1795.

[8] Buch, Norbert, Sergio A. Velastin, and James Orwell. "A review of computer vision techniques for the analysis of urban traffic." *IEEE Transactions on Intelligent Transportation Systems* 12.3, 2011, pp. 920-939.

[9] Mohamed, Atibi, et al. "Real-time detection of vehicles using the haar-like features and artificial neuron networks." *Procedia Computer Science* 73, 2015, pp. 24-31.

[10] Robert, Kostia. "Video-based traffic monitoring at day and night vehicle features detection tracking." *2009 12th International IEEE Conference on Intelligent Transportation Systems*. IEEE, 2009.

[11] Van Pham, Huy, and Byung-Ryong Lee. "Front-view car detection and counting with occlusion in dense traffic flow." *International Journal of Control, Automation and Systems* 13.5 (2015): 1150-1160.

[12] El-Khoreby, Mohamed A., and Syed AbdRahman Abu- Bakar. "Vehicle detection and counting for complex weather conditions." *2017 IEEE International Conference on Signal and Image Processing Applications (ICSIPA),* pp. 425-428, 2017.