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Morphology Based Composite Method For Vehicle Detection From High Resolution Aerial Imagery

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Abstract.

This paper introduces a comparative study of automatic Vehicle detection from high resolution aerial images. The approach is based on morphological operation that describes the detection using structure based representation. Furthermore, vehicle shape and intensity of a vehicle's area are included as basic features. During extraction, the study compares the two basic morphological operations like Top-Hat and Bottom-Hat. The experimental result shows promising result using proposed method and gives precise detection of vehicles.

Key Words: Vehicle detection, Morphological processing, Top-Hat Operation, Bottom-Hat Operation, Structuring element, Aerial image.

1. Introduction.

Vehicle Detection is one of the most important applications in various fields specifically in Remote Sensing, Machine vision and many more. With accelerated development of remote sensing technologies, we have proposed a novel approach for vehicle detection from Aerial Imagery. The use of high resolution cameras installed on satellites like IKONOS, Worldview, QuickBird, GeoEye-1 and 2 provided by business-related companies like DigitalGlobe, GeoEye and RapidEye having resolution ranging from 0.15 meters[11]. This has formed the need to detect vehicle for variety of applications like as traffic management, military, urban and rural highways management [10]. Research on this topic is motivated from different fields of application: road planning, estimation or simulation of air and noise pollution, etc.In recent years, many researchers continuously working on vehicle detection, as a result of it many approaches are exist. In these approaches Morphological approach is covenant and proficient for vehicle detection, especially with Aerial images.

The whole morphological process of Automatic vehicle Detection is divided into four small stages of pre-processing; mask creation (Structuring element selection), morphological processing and masking of image .Pre-processing techniques to eliminate noise like road

strips and other objects are done by using median filter. Structuring element selection is done according to the approximate vehicle size. Morphological processing finds the exact vehicles by finding the edges of vehicles and Masking of image counts the vehicles by fetching the square around the vehicles.

In morphological approach, Top-Hat operation and Bottom-Hat Operation are majorly used for automatic vehicle detection. This study compares Top-Hat operation and Bottom-Hat operation for finding the better method among these two. In this research paper result of these two methods are tested on authorized images which are taken from authorized dataset [11]. The applicability and efficiency of better method depend upon the correct and robust detection of vehicle from high resolution aerial image. This study is carried out on road sites of highways whose ground sampling distance is 0.15m.

Paper is organized as follows. Section 2 discusses related work on automatic vehicle detection and counting from high resolution aerial imagery. The vehicle detection algorithm will be developed in Sect. 3. Sect. 4 discusses results achieved by these two approaches. Then, Sect.5 concludes the study and outlines the Future work.

2. Related Work.

Many researchers worked on vehicle detection from satellite image/aerial image [2][4][6]. According to the study of these research papers, vehicle detection are divided into the 2(Two) major type of vehicle modeling. (1) An appearance-based implicit model, (2) an explicit model. The implicit model typically consists of intensity or texture features computed using a window that surrounds a given pixel. Detection is performed by checking feature vectors of the surrounding image pixels. Ruskone et al. utilized aerial imagery with 0.3–0.4 m resolutions [2] and_exploited a two-step analysis strategy which was composed of vehicle detection followed by the validation through line clustering. A multilayer perceptron analyzed the intensity values of a pixel's neighborhoods for vehicle detection and classification. Then perceptual grouping theory was used to group the vehicles into lines for validation. Papageorgiou and Poggio presented a trainable system for vehicle detection from aerial imagery views taken from a stationary camera[3]. A Harr wavelet transform was used to describe the object classes in terms of local, oriented, and multi-scale intensity differences around adjacent regions. The vehicle model was derived by training a support vector machine classifier using a large set of positive and negative examples. Despite the early efforts, it has been noted that the implicit vehicle model was either derived through direct spatial or statistical analysis on the neighborhood of each pixel, or learned by training the features on a set of positive and negative samples. A few authors have proposed the use of explicit models for vehicle detection. Here, a vehicle is usually described by a box or wire-frame representation. Detection is carried out by either matching the model "top- down" to the image or by grouping low-level features "bottom-up" to construct structures similar to the model. Burlina et al. and Moon and Chellappa represented a vehicle as a 3D box with width, length, and height. Site models were used to constrain vehicle detection to parking lots or roads [1][5]. For the reasons listed above, this paper uses morphological pre-processing method to identify candidate vehicle pixels.

Morphological approach for detection of vehicle is introduced by a Zezhong Zheng, Xiaoting Wang, Guoqing Zhou and Ling Jiang. In the research paper, they discuss an approach which is dependent on the most basic topics of image processing top hat approach and bottom hat approach. They demonstrate this methodology on 0.15 m high resolution images. This approach provides a vehicle detection system which dependent on intensity of vehicles which are present on highways [10].

3. Methodology

Basic steps for TOP-HAT Processing and BOTTOM-HAT Processing as described below.

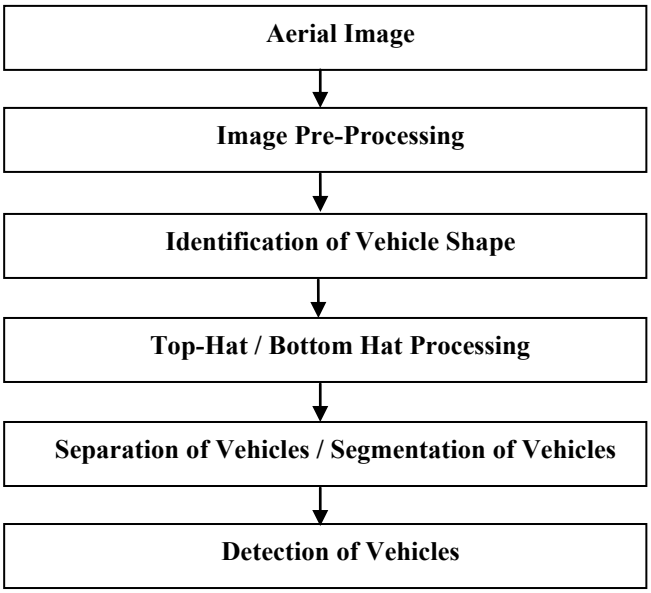

Figure. 1 Vehicle Detection Flowchart for TOP-HAT/Bottom Hat Operation.

3.1 Pre- Processing

Image pre-processing can significantly increase the reliability of a visual inspection. Several filter operations which intensify or enhance certain image details enable easier or faster evaluation. In vehicle detection approach pre - processing techniques are used to eliminate noise like road strips and other objects. Pre-processing is done by median filter; it shows the significant result related to noise reduction.

3.2 **Identification of Vehicle Shape.**

Before separation of vehicles, it is necessary to have information about vehicle size from image (in pixels), radius of vehicle etc. For that basis we crop a vehicle from the original image set shown in Fig.2.

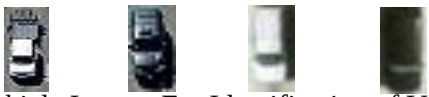

Figure. 2 Sample Vehicle Images For Identification of Vehicle Shape.

Cars which are in use for the detection is cover 17 pixels * 39 pixels in our aerial image (see Fig 2), because the car is symmetrical. Original image shown in Fig.3 (A).

3.3 Morphological method (Top Hat / Bottom Hat Processing)

Basically opening operation and closing operation are two basic operation used for highlighting vehicle information from the input image. Opening and closing operation extensively used in Top Hat operation and Bottom Hat Operation; result of Top-Hat (TH) operation and Bottom Hat (BH) operation is converted in to binary image.

$$Top - Hat: TH = img - img \circ se \quad (1)$$

$$Bottom\ Hat: BH = img \circ img - se \quad (2)$$

Where *se* is the structure element and *img* is the binary image of original image. After the processing of Top hat operation the resultant image is further processed using *se*, which is of shape square of 10 pixels and the final processed result is superimposed on original image, which shows fig 3 (F) & (G) .

3.4 Separation Of Vehicles / Segmentation of Vehicles

An edge in an image is a boundary or outline at which a significant change occurs in some physical aspect of an image, such as the surface reflectance, illumination or the distances of the visible surfaces from the Capturing device. Changes in physical aspects manifest themselves in a variety of ways, including changes in intensity and shape. Detecting edges is very useful in a no of contexts. For example in a typical image understanding task such as object identification.

In aspect of vehicle detection edge detection is the initial step for segmentation of vehicles. *Canny* Edge detection method used for the finding the edge of vehicles, after finding the disjoint objects (Vehicles) masking creation operation is performed on resultant image(Fig.3.D&E). Mask is superimposed on the original image shown in Fig.3.G.

3.5 Vehicle Detection.

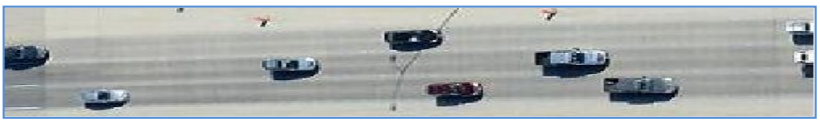

Figure .3 (A) Original Image.

Figure. 3 (B) Top Hat Image.

Figure.3 (C) Bottom Hat Image

Figure. 3 (D) Masking of Top-Hat Image.

Figure. 3 (E) Masking of Bottom-Hat Image.

Figure. 3 (F) Vehicle Detection Using Top-Hat Operation.

Figure. 3 (G) Vehicle Detection Using Bottom-Hat Operation.

4 Experiments And Disscusstion.

4.1 Data Sets

In this research, image taken from five highway subsets. The dataset was acquired from Rapid Eye, skysat 2, worldview 1, worldview 2 and rapideye from website satimagingcorp's gallery (www.satimagingcorp.com/satellite-sensors/other-satellite.../**rapideye**/)[11]. The ground sampling distance is about 0.15 m. Therefore, a car is supposed to consist of 17×39 pixels.

4.2 Precision estimating

Result plays important role in comparison; Result decides the efficiency and correctness of these two existing approaches, for calculating the result we need to form a formula to testing. Here following formula is apply for testing,

Calculate Detection percentage:

$$POD = DV * 100 / TNV \quad (3)$$

Calculate False detection/Null detection:

$$PND = FDV * 100 / TNV \quad (4)$$

1 FOD = False Detected Vehicles.
2 DV=Detected Vehicles.
3 TNV=Total No. Of Vehicles.
4 POD=Percentage of Detection.
5 PND=Percentage of Non Detection.
6 NDV=Non Detected Vehicles.

5. Discussion

As the figure shows in section 3.3, total 9 numbers are cars present. In the vehicle detection figure 10 in section 3.3, total vehicle detected are 9 using Top-Hat processing and Bottom-Hat processing. All the testing result from the above formula is apply on 5 highways. Result of Top-Hat processing as follows,

Table 1. Top-Hat Method Result of Detection.

S.No	Sample Image	TNV	DV	FOD /NDV	POD	PND
1	Road10.jpg	09	09	00	100 %	00 %
2	Road4.jpg	10	16	06(False)	40 %	60 %
3	Road9.jpg	07	07	00	100 %	00 %

4	Road3.jpg	06	06	00	100%	00 %
5	Road5.jpg	25	25	00	100%	00 %

Table 2. Bottom-Hat Method Result of Detection

S.No	Sample Image	TNV	DV	FOD /NDV	POD	PND
1	Road10.jpg	09	10	01(False)	88.88 %	12.12 %
2	Road4.jpg	10	07	03(Non)	70 %	30 %
3	Road9.jpg	07	02	05(Non)	28.57 %	71.43 %
4	Road3.jpg	06	07	01(False)	83.33%	16.67 %
5	Road5.jpg	25	41	16(False)	36%	64 %

6. Conclusion And Future Work.

This paper identifies a proficient and robust method for automatic vehicle detection from highway aerial images among two significant morphological operations (Top-Hat & Bottom-Hat). We use morphological methods as image pre-processing, Top/Bottom Hat processing, Identification of Vehicle shape, Segmentation of vehicles to identify candidate vehicles. From This study we are going to conclude that Top-Hat operation is the efficient and robust method for vehicle detection. Experimental results show that the applicability and the superiority of our study among the two methods.

The system can be improved and extended in the following ways:

1. Classification of vehicles from shape of vehicle.
2. Avoid the cropping of road from image and detecting the vehicles from the whole image set.
3. Vehicle detection of Vehicles from Videos.

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