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Connected Component Based Segmentation Technique for Vehicles Detection from High Resolution Satellite Images

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Abstract**:** ***Satellite images are used for various applications like geographical, weather and geological applications. The forecasters used the low-resolution satellite images to predict the atmospheric changes. The high resolution satellite images are used in more applications especially for object segmentation and detection. The research on the high resolution satellite image is a challenging task. Less research is performed on high resolution satellite imagery as it is a challenging task. Traffic monitoring is a challenging task in developing countries. Automatic vehicle detection is very much useful for the traffic monitoring system. Vehicle images appear in miniature size in high resolution satellite images which is very difficult to extract from the images. Many researchers are working in these areas for the past few decades and most of the research is based on various types of sensor data. In sensor images, complete road network cannot be captured. In this paper, automatic detection of vehicles from high resolution satellite is proposed. Connected component based algorithm for automatic vehicle detection in high resolution satellite images is proposed in this paper.***

Index Terms**:** ***Adaptive global thresholding, Connected component analysis, Morphological operator, Vehicle detection.***

I. INTRODUCTION

Vehicle detection and tracking are mainly used in many real time applications such as urban planning, traffic monitoring and control etc. Vehicle segmentation is used to find out the number of vehicles, the speed of the vehicle, and classification of the vehicles. In urban areas, traffic monitoring and controlling is the most needed task [1]. Vehicles details are necessary for traffic management, assessment of fuel requirement, traffic emissions control and control the air pollution [2]. Image processing approaches and investigation tools used for vehicle detection is given in this section. In this paper, a brief outline of image processing techniques and tools used to detect the vehicles which are used to develop the traffic surveillance systems is proposed. Automatic vehicle detection is most needed for traffic monitoring and surveillance system to control the traffic flow [3]. In the traffic monitor system, rather than the traditional method, high resolution satellite images are mainly used because of its compatibility, cost and accuracy [4]. The performance of vehicle segmentation is influenced in various areas such as urban planning, transport planning, evaluation of air and noise pollution levels in the atmosphere etc. Thus, an automatic approach of vehicle detection is essentially needed to solve the traffic-related issues and town planning.

The rest of the paper is arranged as follows. Section 2 gives the literature survey on vehicle detection. The proposed methodology of vehicle detection using connected component based approach is presented in section 3. Section 4 provides the results and discussion of the proposed algorithm and conclusion of the paper is present in section 5.

II. LITERATURE SURVEY

An important property of the vehicle image detection method is its ability to extract accurate vehicle images, and much literature on vehicle segmentation has been published in the past decades. Some of these works are stated here.

Noorpreet proposed vehicle detection method from high resolution satellite images [5]. This algorithm applied Otsu thresholding method to get a binary image, edges of the images are extracted with the help of canny operator after that blob analysis is applied to identify the vehicles objects in the image. Leitloff has presented a vehicle segmentation approach in very high resolution satellite images of urban zone [6]. This approach consists of four main processes. The region of interest (ROI) is determined by preprocessing steps, and then adaptive boosting classifier is applied. Then, the grouped vehicles and single vehicles are categorized. The location of vehicles is identified and reliability is measured in this paper.

Qu has introduced an automatic vehicle detection approach, which is based on Binary Normed Gradients (BING) and convolution Neural Network (CNN) [7]. This model consisted of two stages; Binary Normed Gradients (BING) is applied to extract region proposals. Convolution Neural Network (CNN), which combines feature extraction and classification, is used to enhance the robustness and improve the accuracy rate. Aaron presented an algorithm for 3D object centred change detection in satellite image [8]. This paper implanted the integrated cartographic modelling with image processing to utilize various government and commercial image data and geospatial data.

Kembhavi et al. [9] proposed a model based on multi-scale HOG features. Thus it can effectively detect vehicles in different sizes and scales.

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Grabner [10] proposed a car detection system using the robust boosting method. In [11], edges are detected then thresholding is applied to detect the changes in an image. This method is applied to simulated background images. Image subtraction is applied to detect the changes in the image. Viangteeravat proposed low-rank matrix decomposition based multiple target vehicles recognition along with classification. Results of the work are proved in military and civilian vehicles [12]. In this work, Hamming window function and FFT used to create Harmonic Line Frequency Sets (HLFS) matrices. Eigenvectors and values of HLFS matrices are measured using singular value decomposition. The classification is done using particle Filtering and results are given. Kharghanian proposed a Morphological based approach is used for vessel extraction from the retinal image [13]. Submit your manuscript electronically for review.

III. PROPOSED METHODOLOGY

Automatic vehicle extraction from high resolution satellite image is proposed in this paper. Connected component and morphological operators are used for this proposed extraction.

The workflow of this vehicle detection method is shown in Fig. 1. This workflow consists of RGB to Gray conversion followed by adaptive global thresholding technique; after that connected component approach is applied to segment the vehicle objects in the satellite image, the morphological closing operation is used to fill the holes in segmented regions and the final output image is consist of segmented vehicle images.

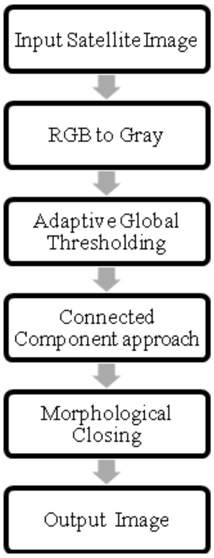

Fig. 1. The overall block diagram of the system

A. RGB to Gray Scale Conversion

Image acquisition is the first step in any vision system. After the input image is acquired, various processing methods are used to carry out the different vision tasks. The input image RGB is converted into a grayscale image for further processing.

B. Adaptive Global Thresholding

Adaptive global thresholding is used to segment the desired region from the converted gray image. The threshold value is identified from the histogram of the image[15]. The region which contains the vehicles is extracted by using an adaptive global thresholding method [14]. The vehicle regions are labelled to the value one and remaining regions are assigned to zero value. The output of this thresholding is a binary image

C. Connected Component-Based Approach

The group of pixels which are connected to a particular pixel is known as connected component [16]. Any group of pixels which is not divided by a boundary is known as connected pixels. The image is divided into sub-images by using connected component extraction technique.

With the help of morphological image operator these connected components are segmented. Connected component (A) of the image (I) is extracted using equation (1).

$$Y_j = (Y_{j-1} \oplus E) \cap I \qquad j=1, 2, 3 \ldots \qquad (1)$$

The symbols $\oplus$ represent image dilation, $\cap$ represent intersection, E is suitable structuring element and Y_j denotes the first nonzero pixel in image I. If $Y_j = Y_{j-1}$ then the algorithm has stopped.

The connected component approach is essentially applied to various automated image processing applications [17]. Connected components of an image are extracted by using morphological operations. The image is assigned as I and connected components in an image are represented as I(1), I(2), I(3),…. The first non-zero pixel in an image (I) is denoted as Y_0. Equation (1) is applied to extract the connected pixels with Y_0. That Y_0 is dilated by structural element E and dilated output is intersected and the image and it is represented as Y_1. Iteration is repeated till $Y_1 \neq Y_0$, if $Y_1 = Y_0$ then iteration is closed and Y_1 is the first set of the connected component. Till all non-zero pixels are grouped, the above process is continued.

The connected component output gives the labelled region of connected objects in the image. Region properties of each connected objects are measured. Since the images of the car are rectangular in shape, all the rectangular shaped objects are extracted from the image. In the segmented output, areas of the objects are checked to identify whether it is a car object or not.

D. Morphological closing

Mathematical morphology operator is based on set theory and it is developed by Matheron & Serra. Morphology is mostly used for segmenting image components used is boundaries, skeleton and convex hull extraction. Digital images can be processed using morphological operators along with structuring element [14]. Dilation and erosion are the most essential operator in image processing [14, 17]. Morphological dilation is applied to grow or thickens objects in a binary image. The thickening is managed by structuring element.

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The dilation of image I by structuring element E is given in equation (2).

$I \oplus E = \{z | (\hat{E})_z \cap I = \Phi\}$ (2)

$\hat{E}$ is reflection set of E and it is calculated as in equation (3).

$\hat{E} = \{s | s = -b \text{ for } b \in E\}$ (3)

$(E)_z$ is translation of E calculated using equation (4).

E. $(E)_z = \{c | c = b+z \text{ for } b \in E\}$ *(4)*

Φ is null set. In binary image, objects can be shrinked using erosion operation which is managed by the structuring element (E). It is given in equation (5).

$I \ominus E = \{z | (E)_z \in I$ (5)

Morphological opening and closing are derived from dilation and erosion and these operators are used in many image processing applications. Equation (6) denotes the closing operation.

$I . E = (I \oplus E) \ominus E$ (6)

The connected component method gives the image which consists only the vehicle objects. Tree shadows and some other noises create holes on that image which can be filled using morphological closing. The region properties of the output image give the number of vehicles in the output image.

IV. EXPERIMENTAL RESULTS

The performance of the algorithm is proved on various satellite images and results are given in Fig. 2. The results are in line with the expected output. The accuracy rate of the proposed work is calculated for satellite images and those values are given in Table I. The performance of the work is proved from this result.

Original Images Gay to binary conversion Segmented Vehicles

Fig. 2. Result of the proposed work

Table I. Accuracy rate of proposed work

Image	Total no of vehicles	Detected no of vehicles	Accuracy rate %
Image 1	11	10	90%
Image 2	13	12	92%
Image 3	11	9	82%
Image 4	6	4	67%
Average			83%

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V. CONCLUSION

The automatic detection of vehicles from satellite image is presented in this work. Connected component based morphological operation is used for this proposed automatic vehicle detection. The proposed work comprises the subsequent steps such as RGB to gray conversion; segmentation of vehicle image regions using adaptive global threshold method; the connected component algorithm is applied to extract vehicle image pixels from the segmented region. Morphological closing is used to remove the unwanted holes in the detected regions. The performance of the algorithm is proved on various images. The results are in line with the expected output. The accuracy rate of the proposed work is calculated for satellite images. The average accuracy rate is 83% and those values are proved the performance of the work.

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