Vehicle Detection from Satellite Images in Digital Image Processing

STUDY ORIENTED PROJECT REPORT

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By

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I’ve also tried to implement this research paper myself using OpenCV3 and Scikit-Image in Python (Jupyter Notebook).

Jupyter Notebook File Name: VehicleDetection.ipynb in the enclosing folder.

VehicleDetection.html file also enclosed for easy-read only viewing.

Link to paper: http://www.iosrjen.org/Papers/Conf.ICCIDS-2018/Volume-4/6.%2034-39.pdf

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Vehicle Detection from Satellite Images in Digital Image Processing

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Abstract: *Nowadays, a new agenda of extracting small scale objects as vehicles from high resolution satellite images have been evaluated. Less research is performed using high resolution satellite imagery as it is a challenging task. Though various studies have been performed, still there is a need to develop a fast, robust, and suitable approach. The approach described in this paper gives out the accuracy rate of vehicles captured from satellite images. It simply workout the full numbers of vehicles within the desired space in the satellite image and vehicles are shown underneath the bounding box as a small spots.*
Keywords: *Image Enhancement, Morphological Image Processing, Segmentation, Otsu Threshold, Edge Detection*

I. Introduction

Traffic data is laid low with higher changes in satellite resolution & object-oriented detection methodology in satellite pictures; it may be even quicker as well as newly obtained within the large area images from satellite instead of the traditional data obtaining method. Two thresholding techniques are used for this: initial is pixel level and second is Otsu method. With this approach better thresholding technique may be distinguished.

Because of difficulty created by factors like chaos, illumination, weather, & shadow disturbance vehicle detection from the real satellite image becomes tough. So, toboost the vehicle identification rate and once the detection must be good, there is an associate degree urgency of enhancing the acquisition of the satellite pictures before the vehicle extraction [1][9]. Essentially this theory uses the sharpening process as well as the histogram equalization processing of image enhancement method. Histogram has the key goal of building the centralized gray zone of the initial image histogram into the uniform distribution among all of the gray scale [2]. As an answer to the present stretching the image nonlinearly and reconstructs the image pixel values will be done. As per this manner, the amount of pixels within a convinced range of gray can be roughly similar.

II. Related Work

As a primary step Semantic analysis of changes in satellite imagery needs the detection of changes [12]. Most notable of those kind rely on background modeling. In this category, a variety of images of the scene are used to learn what the normal background look of the scene ought to appear so that given a brand new image, the pixels with abnormal look can be detected as changes. Relatively less researched field in pc vision is 3-d change modification. Earlier approaches used manually made 3-d website models to form correspondences between pictures so that modification detection algorithm rule is applied [3] [4]. For this sort of approach to be utilized in modern applications and therefore the overhead of constructing 3-d geometry is unworkable. Heller et al. use stereo pairs of satellite pictures to reconstruct 3-d pure geometry of the scene and then compare reconstructed pure geometry from totally different pairs of pictures to find 3-d changes to the scene [5]. This algorithmic rule is additional applicable but is also relied on having stereo pairs and it cannot find appearance changes on the surfaces of the scene like moving vehicles and shadows. Frequently, a brand new approach that joints the ability of Stauffer-Grimson style appearance modeling with machine driven 3-d geometry discovery has been projected [5]. This volumetric appearance modeling (VAM) approach is better for modification detection from satellite imagery for varied reasons.

III. Proposed Approach

1. Image Enhancement

A brief distribution of enhancement technique will be as under [7]:

1. Spatial domain strategies, that is direct affected to the pixels.
2. Frequency domain strategies, in image it works on the Fourier rework

Introduction

Nowadays, a new agenda of extracting small scale objects as vehicles from high resolution satellite images have been evaluated.

The amount of research being done on high resolution satellite imagery is very less as it is a challenging task.

There is an urgent need to develop fast, robust and suitable approach to detect objects/usual information from high resolution satellite imagery.

The aforementioned goal can cater to many future questions in terms of automation.

How many vehicles are currently present on the road?
What is the geological weather like in a certain area?
How is the vegetation in a certain area? and various others.

We now try to propose an algorithm to detect objects from an high resolution RGB image.

Methodology

i. Image Acquired

Initial stage of any vision system is to acquire and load any image data/dataset into memory.

Functions **imread()** in Open-CV can be used to read image into 3D array [for RGB] or 2D array [for gray scale image].

Acquired Image

ii. RGB to Gray Scale Conversion

The algorithm described in the paper mainly relies on the gray level values of the image, hence it is necessary to convert the RGB image to gray scale.

RGB to Gray Scale conversion is achieved as follows:

for every i,j in RGBimage [i][j][3]:

$$\textbf{Grayimage}\ [i][j] = \frac{(\ \textbf{RGBimage}[i][j][1] + \textbf{RGBimage}[i][j][2] + \textbf{RGBimage}[i][j][3]\ )}{3}$$

RGB to Gray Scale Image

iii. Binary Conversion

A binary image is stored as an array of 1's and 0's only. The above image contains values 0-255 (8 bit at input). Hence using appropriate thresholding we convert the image to binary.

The method suggested here was to use Otsu Threshold (k*).

Otsu Threshold:

The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal.

$$\begin{aligned}
\text{Within Class Variance} \quad \sigma_W^2 &= W_b\,\sigma_b^2 + W_f\,\sigma_f^2 \quad \text{(as seen above)} \\
\text{Between Class Variance} \quad \sigma_B^2 &= \sigma^2 - \sigma_W^2 \\
&= W_b(\mu_b - \mu)^2 + W_f(\mu_f - \mu)^2 \quad (\text{where } \mu = W_b\,\mu_b + W_f\,\mu_f) \\
&= W_b\,W_f\,(\mu_b - \mu_f)^2
\end{aligned}$$

Logic used for binary image conversion:

```
for every i,j in image[i][j]:

    if ( image[i][j] > k*):
            image[i][j] = 0;
    else
            image[i][j] = 1;
```

Gray to Binary Image

iv. Canny Edge Detection

Edge detection is an important technique to fetch useful structural data from different vision objects and reduce the volume of data to be processed.

Canny Edge Detection is an algorithm which detects edges and also reduces the noise using 5x5 Gaussian Filter.

According to the algorithm the image is first smoothened using 5x5 Gaussian Filter, and then it is filtered with a Sobel Kernal in both horizontal and vertical direction to get first derivative in horizontal (G_x) and vertical direction (G_y)

From this information edge gradient and direction is found for each pixel as

$$Edge\_Gradient\ (G) = \sqrt{G_x^2 + G_y^2}$$
$$Angle\ (\theta) = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

The image is fully scanned again to remove any unwanted pixels that may not contribute in an edge. Each pixel is checked if it’s a local maximum in its neighbor in the direction of gradient or not.

As of now our image will have many edges, to filter out useful edges, we use minVal and maxVal for hysteresis Thresholding.

Any edges with intensity gradient more than maxVal are sure to be true edges.
Any edges with intensity gradient below minVal are sure to be false positives, so discarded.
For the edge intensities between minVal and maxVal, if the edges are connected then they are kept otherwise discarded.

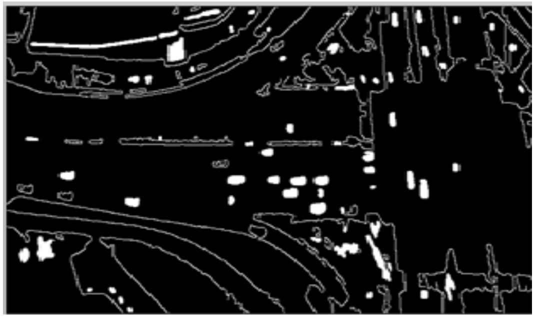
Canny Edge Detection

v. Filling Holes

After canny edge detection, the holes created in the images need to be filled to objectify / detect the solid objects (vehicles in this case).

We use Morphological Close Operation to perform the filling of holes.

Closing is opening performed in reverse. It is defined simply as a dilation followed by an erosion using the same structing element for both operations in morphological operations.



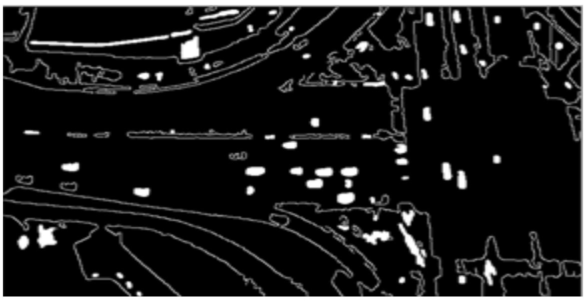
Filling Holes in the Image

vi. Filtrating using High Pass Filter

Sharpening of image is achieved by high pass filtering.
There isn't any specific high pass filter but we can design them using low pass filters.

If $\mathbf{L_p}$ **is a low pass filter** in fourier domain, we can create $\mathbf{H_p}$ **as high pass filter** as –

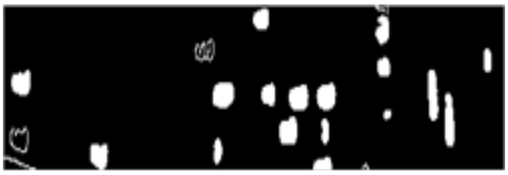
$$\mathbf{H_p = 1 - L_p}$$



High Pass Filtering

vii. Cropping the area

The resultant images many other noisy areas containing blobs of filled holes. We try to extract only those regions where the maximum amount of holes are present by cropping. This choice seems logical as there would be a specific region only (i.e. road / highway / lane) where all vehicles would be present.



Cropped Image

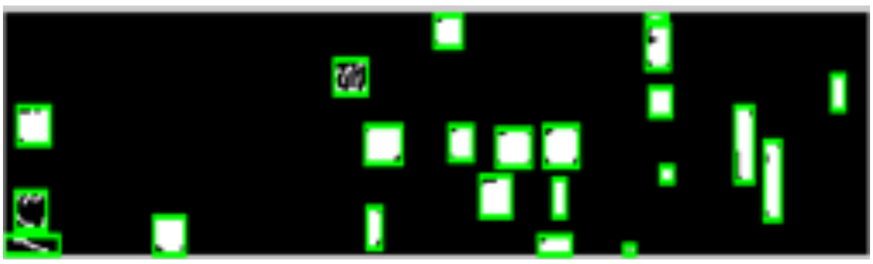
viii. Detected Vehicles using Blob Analysis

Blob analysis can be achieved by finding contours in the image.

Contours are curves joining all the continuous points (along the boundary) having same color or intensity.

Using **findContours()** in OpenCV we can calculate all the contours in the image.
Using **drawContours()** we can overlay the contours over the original image.

Hence the green enclosing boxes are the contours of this cropped image.



Blob Analysis Detection of Vehicles

Conclusion

Vehicles are evaluated from the proposed algorithm as follows:

Table1: Accuracy rate of detected vehicle

Road	*No. of vehicles*	*Detected*	*Missed*	*Accuracy rate*
Road 1	176	165	11	93.75%
Road 2	89	77	12	86.51%
Road 3	145	132	13	91.03%
Road 4	115	101	14	87.82%
Road 5	93	81	12	87.09%
Road 6	132	120	12	90.90%

These are the results for a dataset of satellite imagery.

We can see the proposed algorithm had achieved an average of ~89.5% accuracy for 6 roads.

The accuracy is pretty good but has scope for improvement. We can use advanced any complex edge and blob detection algorithm to increase the accuracy of the data.

Satellite imaging has been used with success for geographical weather and geological applications in the recent few decades.

With the advancement of technology and new refined sensors that offer higher resolution, this field of satellite imagery object detection has lots of applications and bounds to explore.

Segmentation techniques can be used to extract highway and vehicles information.

Color properties can used to extract vegetation information in areas.