



Application of Deep Learning technique in Image Morphology

Mr. Akshay Jagtap

Assistant Professor,

Dr. D. Y. Patil Arts, Commerce and Science College Akurdi, Pune, Maharashtra.

Corresponding Author – Mr. Akshay Jagtap

DOI - 10.5281/zenodo.17317547

Abstract:

Counting vehicles along the busy road of Pune plays an important role in making the decision for traffic control and management purposes. Nowadays, an intelligent vehicle management system uses modern AI deep learning and Image processing techniques. The paper discussed the implementation of vehicle detection algorithms using image morphological operation. This process removes the noise present in the captured image data and detects the moving vehicle. Continuous tracking the detected vehicle along the segmented road helps to count the number of vehicles.

Keywords: *Vehicle detection, an Intelligent Vehicular Management system, vehicle count, Image Processing*

Abbreviations: *CCTV, camera; HD, High Definition; JM Road, Jangali Maharaj Road.*

Introduction:

In recent years, the population of Pune city has increased. In 2020, the population of Pune city has been reaching 6,62,900 which is 2.7 percent than previous year's population (2019). Similarly, there is a significant increase in the vehicles that are moving in the central parts of Pune city. As per the statistics published by the Pune Regional Traffic Department (MH-12), there are nearly 3.62 million registered vehicles in the city. Therefore, the city suffers heavy traffic congestion across major locations in the city.

Traffic congestion occurs due to limited road infrastructure such as an increase in the number of vehicles on roads and poor road development. It is not possible to fulfill the demand of constructing new roads with the limited availability of the land. An Intelligent vehicular management system consists of various applications which are used to process,

analyze and improve the traffic management system.

Digital image processing techniques play a crucial role in real time applications such as object detection in vehicle detection system [1,3]. Some of the important applications using image processing techniques include identification and counting of the number of vehicles moving along the road, Number of vehicles parked in parking spaces and many more. The vehicle detection technique helps to design systematic vehicle parking spaces and to determine the congestion levels in the city.

Automatic vehicle detection and counting of vehicles requires images or video data generated from the CCTVs and cameras installed on roads which are used to monitor the traffic flow [2]. Image processing algorithms can perform the mathematical manipulations on these recorded data and

provide the detection and counting the number of vehicles present along the road.



Figure1. JM Road Pune Traffic Congestion

Image Morphology In Vehicle Detection:

Morphology is an image processing technique that has non-linear operations which are related to morphological features or shapes of an image.

This technique works on the relative order of the pixel values and thus it is best suited for binary image processing. The Morphology operation uses set theory [5, 6, and 8]. In the binary morphological process, an image does assume to have only two intensity pixels that are white and black. The white pixel represents the foreground portion of an image and black represents the background of an image.

The foundation of the Morphological process is nothing but the geometry such as circles, sphere, fruits, vehicles, etc. which is present in an image [2]. It is necessary to have probes with some shape and size. These probes have a matrix called “structuring element” that recognized the pixel in an image. This also recognizes nearby pixels present in an image. It is then positioned to all possible locations in an image. It is also compared with nearby pixels.

Morphological operation has two basic components which are called as “Dilation” and “Erosion”. Dilation refers to expansion and erosion refers to compression. The structuring element determines the extent of expansion and compression.

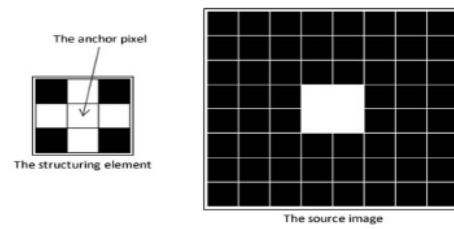


Figure 2. Binary Morphological pixels and Structuring Element

A. Dilation and Erosion in Morphology:

Dilation process is primarily used to expand or widen the shape of an object. Structuring element controls the size of the shape. It is also used to extract and eliminate feature vectors from an image.

In this operation, the image features are considered as feature vectors. These vectors combine and move throughout the image. Let “A” and “B” be the set in “N” space with ‘i’ and ‘j’ be its corresponding elements.

The vectors $i = (i_1, \dots, i_N)$ and $j = (j_1, \dots, j_N)$ be the N-tuples of co-ordinates. These co-ordinates are used to specify the locations of foreground pixels of an image.

The structuring element “B” dilates an image “A”. These sets of available vectors combine all element pairs. The dilation operation is given as $A \oplus B = \{b \in N | b = i + j \text{ for some } i \in A \text{ and } j \in B\}$.

Erosion is exactly reverse operation of dilation. This process strips down the boundaries of shapes in images. Erosion also acts like a linear LPF which is used to remove the noise if present. The assigned element used for the reduction and probing the object’s shapes are present in images. Erosion is modeled by set theory operation. The process is given as

$$A \ominus B = \{Z | (B_z) \cap A^c = \emptyset\}$$

B. Edge Detection in Morphology based vehicle Detection:

The edge detection [3] is a technique where the images are segmented into varying

grey levels. The edges in an image are the groupings of connected pixels which result in the boundaries for an object [8, 10]. Applications where the edge detection principle used are pattern recognition, Morphology and feature extraction.

-1	0	+1
-2	0	+2
-1	0	+1

H_x

+1	+2	+1
0	0	0
-1	-2	-1

H_y

Figure 3. Sobel Convolution Kernel

There are two types of edge detection operators: Gradient [14] and Gaussian.

- **Gradient based Edge Detector Operator:**

This operator computes the first order derivatives in an image. Prewitt, Sobel and Robert operator are some of the available edge detector operators.

A. Sobel operator is also known as fast and efficient discrete differentiator [5, 6, 7]. It is used to compute the gradient approximation for the intensity levels of an image in edge detection. At the computation stage, the sobel operator produces a gradient vector which then convolved with the input image.

Generally, Sobel Operator is used for measurement for 2-D spatial gradient, and it works on high frequency regions that consist of edge of an object in the image. This operator has a pair of 3x3 convolutional matrix kernels. This pair includes one basic kernel, and one is its 90-degree rotational version as shown in figure 3.

Convolution is performed using these kernels that generate the edges [8]. The convolution is performed in the horizontal and vertical direction. In this process, oinrnel moves along the horizontal direction, and its 90-degree counterpart moves along the vertical direction. A horizontal and vertical kernel

generates two gradient components. The combinations of these two gradients are used to find:

- An absolute magnitude of the gradient of each pixel points.
- Provides orientation of that gradient.

Let H_x and H_y be the gradient calculated along “x” and “y” direction. Following equations gives the magnitude of the gradient.

$$G = \sqrt{(H_x)^2 + (H_y)^2} \text{ ---- (1)}$$

$$|G| = |H_x| + |H_y| \text{ --- (2)}$$

The equation for the rotational angle of the gradient is calculated as (3).

$$\theta = \arctan\left(\frac{H_x}{H_y}\right) \text{ ---- (3)}$$

B. Prewitt operator is used to detect magnitude and orientation of an image [16]. It generally detects horizontal and vertical edges present in an image. Such Operator is mainly used to produce the sum of the square of differences between nearby pixels with the help of a discrete differentiator.

Gaussian based Edge Detector: This operator computes second order derivatives in an image. These operators are the canny edge detector and Laplacian of Gaussian operator.

- Detection using the canny edge detector is the multi-stage process. This process has the following steps: Gaussian filter kernel is used for the noise removal. Size of this kernel depends on the blurring effect. The equation for The Gaussian filter kernel for the size $(2m+1) \times (2m+1)$ is given in equation (4)

$$H_{-}(i,j) = 1/(2\pi\sigma^2) \exp \left(\frac{(1-(m+1)^2) + (1+(m+1)^2)}{2\pi\sigma} \right) \text{ ---- (4)}$$

Where $i \leq j, j \leq (2m + 1)$

- Gradient calculation: Gradient detection is used for measuring intensities of an object edges and the direction of the gradient of an image.
- Non-maximum Suppression The edge detection algorithm performs the calculation of gradient intensity and process moves toward the pixel points that have maximum values of gradient.
- Double Threshold: It is used to find strong, weak and non-relevant pixels in an image. In this high threshold is used to find the strong pixel and Low threshold is used to calculate the weak pixels.

Laplacian of Gaussian is used to locate edge points. This operator uses Laplace of the second derivative of an image. A canny edge detector is used to extract the feature in an image. This operator detects the edges of objects based on low error rate, accurately localized edge points in the images.

Object recognition using various edge detection techniques has been published in paper [9]. An image is segmented using sobel, Otsu [8], Canny and Genetic algorithm [5,7]. Result shows that the object boundaries shape has been generated from sobel edge detector than genetic algorithm and Otsu algorithm.

Proposed Methodology:

The objective of this proposed methodology is to identify and count the number of vehicles moving along the JM road Pune India. The JM Road is the prime location in Pune city and has observed the daily heavy traffic congestion in business hours.

To reduce the traffic congestion level and to utilize the available parking spaces along this road, an intelligent vehicle management system is needed.

To study the amount of flow of vehicles on this road, image processing-based morphology technique has been implemented.

For this purpose, vehicles data are needed. Quality image sensing devices are required to collect this data. The quality of this data depends on the type of sensing devices, light, illumination and weather conditions. CCTV and HD cameras are mounted on the road to record image and video data of moving vehicles.

- In a vehicle detection process, image sensing device positioning plays a crucial role. Image sensing devices like video recorders or cameras are used. This video camera is used for recording vehicle data from the road at specific time duration. The recorded video is then broken into the number of frames at specific time intervals. These frames are then individually given to an image enhancement step where the process of noise reduction is carried out.
- The recorded video frames are then converted into grey levels. The binary forms of these images are obtained using thresholding function. Series of thresholding operations are performed to generate multiple binary images.
- In edge detection step, sobel edge operator is used to produce edges. Series of morphological dilation is performed in horizontal, vertical and 45-degree directions. The results obtained from sobel operator are shown in figure 7.
- Binary filling process: Filling of holes results in the separation of background from an image. The foreground image present in an image is like shape of an object.

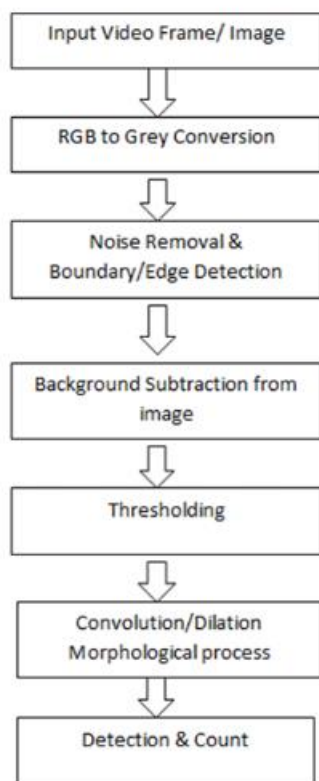


Figure 4. Flow Diagram

Results:



Figure 1. a. Input Video Frame



Figure 1. b. RGB to Grey Conversion



Figure 1.c Thresholding Effect



Figure 1.d Sobel Operator output

Table 1. Vehicle Count at Time Interval

Vehicle Count every after 12 second	
Time Interval	Vehicle detected
12 sec	1
24 sec	1
36 sec	1
48 sec	1

Conclusion:

Intelligent Vehicle management system consists of various technological design implementations. Some of the implementations are based on morphological image processing techniques. Accurate counting of the number of vehicles that are moving along the JM road in Pune city is achieved using object detection algorithm using morphological image processing.

Future Scope:

The vehicle detection and counting the number of vehicles moving on the road using deep learning is an important application. This can be used in the smart city development system for analyzing traffic congestion and to improve the intra city transportation system. Future work should concentrate mainly on better efficiency and improvement in the

proposed technique. The technique should use other available edge detectors like canny, laplacian edge detectors. Results of each should be comparable and effectively used to implement object detection systems. Best quality High resolution camera must be used to collect video data. The proposed implementation can be extended for vehicle tracking purpose on the highways.

Acknowledgement:

The authors would like to express gratefulness towards Dr. Mohan Waman sir Principal, Dr. D. Y. Patil Arts, Commerce and Science College Akurdi Pune, India for supports.

References:

1. Bhaskar Prem Kumar, Suet-Peng Yong; Image Processing Based Vehicle Detection and Tracking Method; 978-14799-0059-6/13/2014 IEEE
2. Ajmal Aisha, Hussain Ibrahim M.; Vehicle Detection Using Morphological Image Processing Technique; MCIT 2010
3. Kaur Jaspreet; Implementation of Smart Parking using Artificial Intelligence; International Journal of Scientific Development and Research (IJS DR); ISSN 2455-2631, August 2019
4. Cai Bill Yang, Alvarez Ricardo, Sit Michelle, Duarte Fabio and Ratti Carlo; Deep Learning Based Video System for Accurate and Real-Time Parking Measurement; IEEE Internet of Things Journal: Special Issue on Enabling a Smart City: Internet of things met AI, 20 Feb 2019
5. Pruthi Y M, Anuradha S G; Morphological Image Processing Approach of Vehicle Detection for Real-Time Traffic Analysis; International Journal of Engineering Research and Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 5, May - 2014.
6. Frias-Velazquez Andres, Jorge Nino-Castaneda Jorge Oswaldo, Jelaca Vedran, Pizurica Aleksandra and Philips Wilfried; A Mathematical Morphology based Approach for Vehicle Detection in Road Tunnels; Ghent University-TELIN-IPI-IBBT, Sint-Pietersnieuwstraat 41, B-9000 Ghent, Belgium
7. Qian S, Weng G. R.; Research on Object Detection based on Mathematical Morphology; International Conference on Information Technology and Management Innovation (ICITMI 2015)
8. Khurana Khushboo, Awasthi Reetu; Techniques for Object Recognition in Images and Multi-Object Detection; International Journal of Advanced Research in Computer Engineering and Technology (IJARCET), Volume 2, Issue 4, April 2013
9. Pei Soo-Chang, Lai Chin-Lun; A morphological approach of target detection on perspective plane; Elsevier Science, Signal Processing, 81 (2001) 1975-1984
10. Muthukrishnan R, M. Radha; Image detection technique for Image segmentation; International Journal of Computer Science and Information Technology (IJCSIT) Volume. 3, No 6, Dec 2011
11. Hussin R, Rizon Juhari M, Kang Ng Wei, Ismail R.C., Kamarudin A.; Digital Image Processing Techniques for Object Detection From Complex Background Image; International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012)
12. Parihar Rajvardhan Singh; An Hybrid Data Mining Approach to detection and classification of Health Care Data;

- International Journal of Electrical, Electronics and Computer Engineering 6(1):150-157(2017)
13. Sharma Fani Bhushan, Sharma Ajay, Sharma Nirmala; Fuzzy logic applications for traffic control an optimum and adaptive controlling application; International Journal on Emerging Technologies,1(1): 41-45 (2010)
14. Jain Ms. Khushbu, Burse Mrs. Kavita, Mishra Mrs. Rachna; Contrast Enhancement of Remote Sensing Images Using Optimal Edge Detection Technique; International Journal on Emerging Technologies 5(2): 51-57(2014)
15. Alam M. Zahid, Mishra Dr. Ravi Shankar; A Novel wavelet based threshold selection technique for Image Denoising; International Journal on Emerging Technologies 3(2): 52-55 (2012)