Traffic Analysis on Highways based on Image Processing

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***Abstract*-A steady increase in population, and the exponential increase in the number of vehicles, leads to traffic jam often during peak hours. Traffic analysis becomes a challenging problem as well as the needed one to control the traffic in decent and safe manner. Normally the traffic signals are operated on predefined fixed program, based on the time of day. In case if there is no vehicle in the allotted road, the time will lapsed for the other vehicles who are all waiting on the other side, which leads congestion. To rectify this issue, this paper presents an approach for analysis and detecting vehicles in highways traffic images by means of image processing techniques such as background differencing, Otsu's thresholding and morphological filters. To count the detected vehicle region properties are used. The result can then be used to control the traffic signals. The whole work has been developed using MATLAB environment.**

Keywords- Morphological operation, Median filter, Thresholding.

I. INTRODUCTION

Traffic system plays a vital role in this civilized world and many aspects of life that relies on it. The reason of traffic is an inefficient controlling of traffic signals that affects the traffic flow. This phenomenon requires finding methods of optimizing traffic flow, especially during rush hours. Most of the city traffic is controlled by sensors and cameras shall be installed in big highways and streets. Vehicle counts are typically used to gather data for determination of vehicle hourly patterns, daily or seasonal variations and growth trends, or annual traffic estimates. The most common use for the traffic image data collection is signal timing. Traffic signal preemption or prioritization allows the normal operation of traffic lights to be preempted. The most common use of these systems is to manipulate traffic signals in the path of an emergency vehicle, halting conflicting traffic and allowing the emergency vehicle right-of-way, to help reduce response times and enhance traffic safety. This problem can be controlled by the proper analysis of traffic, proper adjustment in the controlling of traffic management.

One of the methods to overcome the traffic problem is to develop a traffic analysis by measuring the traffic density on a road using images processing techniques. In recent years, the image processing techniques in traffic signal control has been investigated by several researchers. Various image processing operations like segmentation, filtering, object analysis are performed on the input image to analyse the traffic. In this proposed work, two source images are taken, one is blank road image and the other is its corresponding road image with vehicles. The absolute difference of these two source images will be considered as the new source image. The new image undergoes a series of image processing operations such as preprocessing, image enhancement, segmentation and morphological operation to detect the vehicles. The region property in image analysis helps to find the centroid of the vehicle and thereby count the number of vehicles in the image. The result message is shown to inform the number of vehicles in highway. The vehicle count decides the traffic.

The rest of this paper is organized as follows: Literature survey is discussed in section II, proposed system with block diagram is discussed in Section III, which is followed by test results and discussions in Section IV and the conclusion in Section V.

II. LITERATURE REVIEW

Many researches and works have been done on traffic analysis using image processing techniques. E.Atkociunas et al. [1] has proposed an approach to road monitoring and traffic problem, such as vehicle tracking, speed measurement, jam detection and number-plate recognition. Vehicle tracking based on Contour extraction; it is extracted for edge linking process. At last geometric centre is calculated for tracking the vehicle. Speed measurements were achieved by motion detection method and number-plate is recognized by neural network technology.

Bharathi Sharma et al. [2] has proposed automated vehicle detection based on average filter to reduce the noise effect, also discussed differential morphological closing profile for vehicle segmentation and shape detection. Thresholding value is applied to remove the unwanted objects other than the vehicle. Finally to extract the target vehicle shape index thresholding has discussed. Penjman Nikasaz et al. [3] has proposed to render automate control system for traffic on highways and streets based on contour extraction and motion detection. The methods used for automate control system is background subtraction or background elimination, it removes all background factors and detect the foreground and also Gamma correction were used for image contrast adjustment. Active contour and contour linking for edges and morphological operations like hit-or-miss are also proposed. James G. Harran et al. [4] proposed algorithms for the detection of road and environmental conditions and adapted to analyze images from curved road positions by using secondary Hough Transform. James G Harran also discussed the conversion of the grayscale image into a black and white image through a process called thresholding. This process involves the selection of a threshold value in the grayscale range which acts as a cutoff for determining which pixels should be converted to white or black in the resulting image(Binary Image) based on Otsu's global thresholding technique.

Pratishtha Gupta et al. [5] discussed a model to count the traffic load by some parameters such as edge detection, histogram equalization, labeling and removing the noise with the help of median filter. To get smooth image and sharp boundaries Pratishtha Gupta proposed median filter. Benjamin Coifmana [6] proposed vehicle detection and tracking system that is designed to operate under various challenging conditions (daylight, twilight and nighttime conditions). Instead of tracking entire vehicles, vehicle features are tracked, which makes the system less sensitive to the problem of partial occlusion. And also discussed image segmentation techniques which was done by active contour, it segment image into foreground and background. Active contour segments the 2-D grayscale image into foreground (object) and background regions using active contour based segmentation. The output image is a binary image where the foreground is white (logical true) and the background is black (logical false). Suresh Babu Changalasetty et al. [7] has proposed to automate the process of traffic monitoring system by making identification and classification of moving vehicles on road. The system uses LABVIEW for image processing of vehicle sample images to extract the features (area, perimeter, width, length). Suresh Babu Changalasetty also discussed neural network classification technique of data mining for the classification of vehicle as big or small. New VIs in LABVIEW are added to vehicle classification system for calculating traffic counting and density. Swaraj Raman M et al. [8] discussed labeling algorithm to count the object, which has the ability to distinguish certain overlapping objects.

Keerthana Gunesekaran et al. [9] has proposed the techniques used in the night time vehicle detection. White Top Hat Transform method used to modify the contrast of the image but the false regions can also be removed. Multilevel Thresholding has determined the optimal threshold by the maximizing the class variance of dark and bright regions. To identify the vehicle for further analysis, methods such as support vector machine classification, Rule based component analysis and symmetric based identification are used. Dharani S.J. et al. [10] suggested algorithm to determine the number of vehicles on the road and to control the traffic by calculating density only on the target area. Dharani discussed the region of interest; instead of working the whole image, only the region of interest is focused by applying image cropping method. Binary image having the same dimension are created with the reference image, then the road area has been shaded white, and the leftover region as black. The multiplication of the reference image with the cropping black and white image results in the final desired target area.

Prutha Y M and Anuradha S G [11] have proposed real time vehicle detection based on background differencing, morphological operations and edge detection. Threshold techniques are applied to calculate traffic parameters such as counting the number of vehicles and speed of the cars. Naveen Chintalacheruvu and Venkatesan Muthukumar[12] have proposed an efficient video based vehicle detection system based on Harris-Stephen corner detection algorithm. They implemented the video based detection system on embedded computer platform. Prabhakar Telagarapu et al. [13] described a vision based pedestrian and car tracking system which is able to distinguish between car and pedestrian using morphological and Blob analysis. Zhushao-Ping and Fan Xiao-Ping [14] have presented an effective approach for detecting and tracking moving vehicles in nighttime traffic scenes. They extracted SIFT features using SIFT feature extraction algorithm, which is used to characterize moving vehicles in night time. Then MILBOOST model is used for the on-road detection of vehicles at night time.

III. PROPOSED METHOD

The main objective of this work is to detect vehicle and count them in order to analyse the traffic. Figure. 3.1 depicts sequence of image processing techniques applied in order to analyse the traffic. To detect and count the vehicle two images are taken, first one is kept as reference image (road without vehicle) and the second image is road without vehicle. First, two RGB images are converted into gray scale image and then these images are subtracted using absolute difference operation. The enhanced image is filtered using, median filter to reduce the noise. Filtered image is then converted into binary image using Otsu's gray scale threshold. Differential morphological operations are used to segment the shape of vehicles.

Proposed algorithm, automatically detects the shape of vehicles by setting some initial parameters like a series of opening and closing operations of disc-shaped structure sizes to implement the morphological profile.

Finally Centroid of the segmented shapes is calculated and then the length of centroid is used to count the number of vehicles in the image.

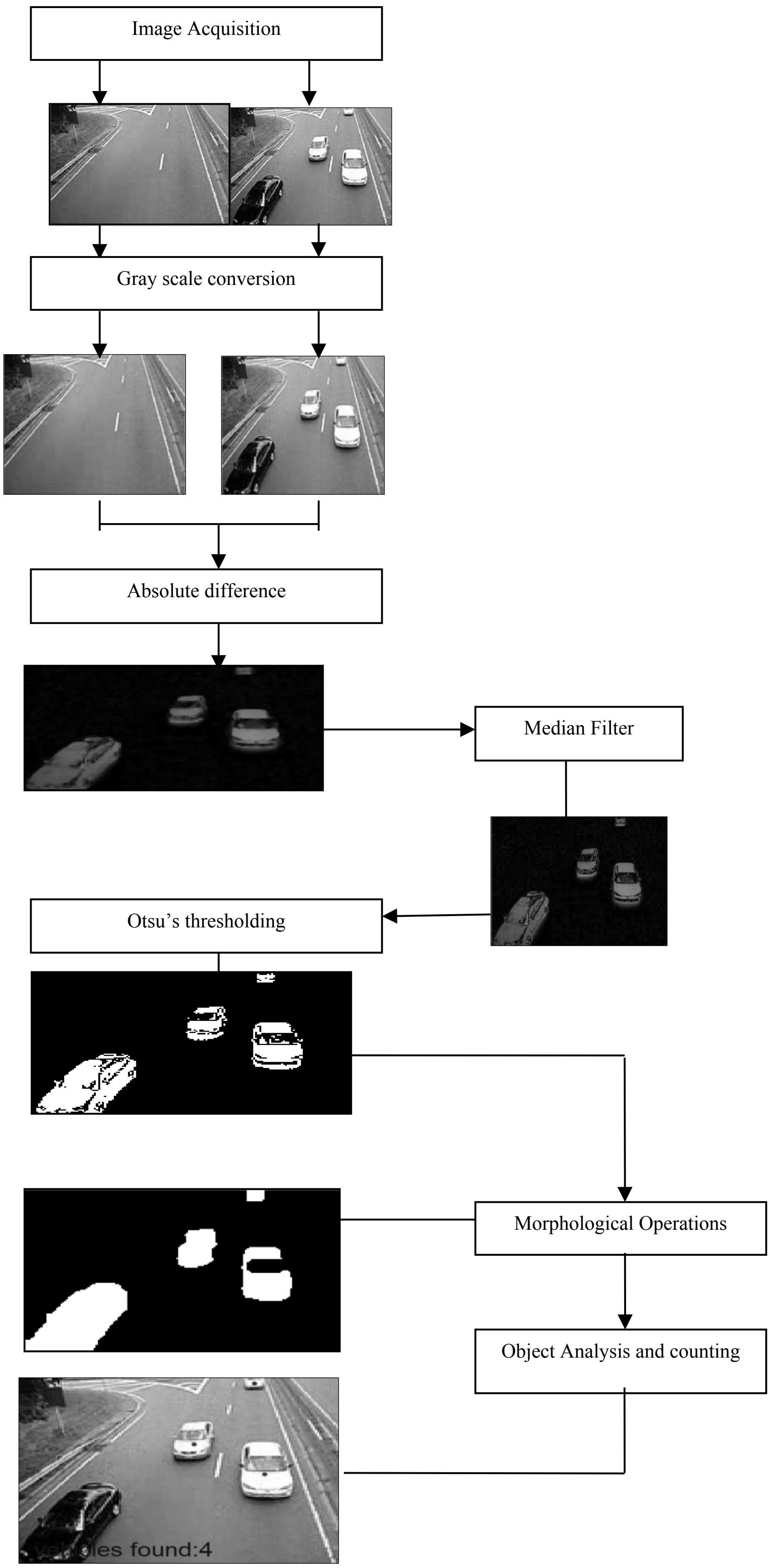


Figure 3.1 Steps to analyse traffic images

A. Image Acquisition

Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. The first step in this process is image acquisition, to acquire a digital image. To do so, it requires an image sensor and the capability to digitize the signal produced by sensor. For this purpose existing closed-circuit television (CCTV) or special cameras specifically designed for the task may be used. Images are captured by Fixed camera is shown in Figure. 3.2 and Figure. 3.3

Figure 3.2 Road image without vehicles

Figure 3.3 Road image with vehicle

B. Image Preprocessing

Preprocessing images commonly involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. Image preprocessing is the technique of enhancing data images prior to computational processing. The initial task of vehicle detection is to convert true color input image into gray level image. This is achieved using equation (1).

$$I_g = 0.2989 * R + 0.5870 * G + 0.1140 * B \quad (1)$$

where R represents the red color, G represents green color and B represents blue color; I_g , represents gray scale intensity. Figure 3.4 and Figure 3.5 shows the gray scale image of the source RGB images which is represented in Figure. 3.3 and Figure. 3.4.

Figure 3.4 Gray scale image without vehicles

Figure 3.5 Gray scale image with vehicles

C. Image Enhancement

The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for detecting objects. The enhancement does not increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that object can be detected easily. In this proposed work two enhancement techniques namely absolute difference and filtering are used.

a) Absolute Difference

Image arithmetic is the implementation of standard arithmetic operations, such as addition, subtraction, multiplication, and division, on images. Image arithmetic has many uses in image processing both as a preliminary step in more complex operations and by itself. Image subtraction can be used to detect differences between two or more images of the same scene or object. For this process two images are needed. First one is the reference image (road image without vehicles) and another one is its corresponding road image with vehicles. This process is achieved by equation (2)

$$g(x, y) = | h(x,y) - f(x,y) | \quad (2)$$

where h(x,y) denotes the gray scale road image without vehicles and f(x,y) denotes gray scale road image with vehicles. It subtracts each element in array f(x, y) from the corresponding element in array h(x, y) and returns the absolute difference in the corresponding element of the output array g(x, y). h (x,y) and f (x,y) are real, nonsparse numeric arrays with the same class and size. g has the same class and size as h (x,y) and f (x,y). If h (x, y) and f (x, y) are integer arrays, elements in the output that exceed the range of the integer type are truncated. Figure. 3.6 shows the absolute difference of Figure. 3.4 and Figure. 3.5.

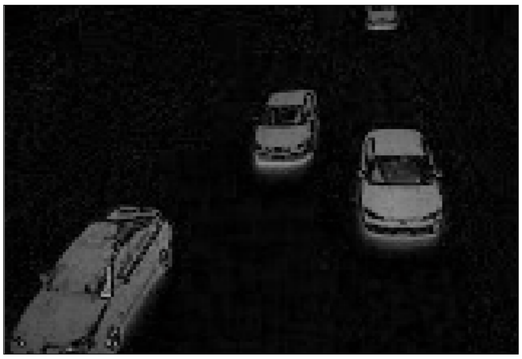


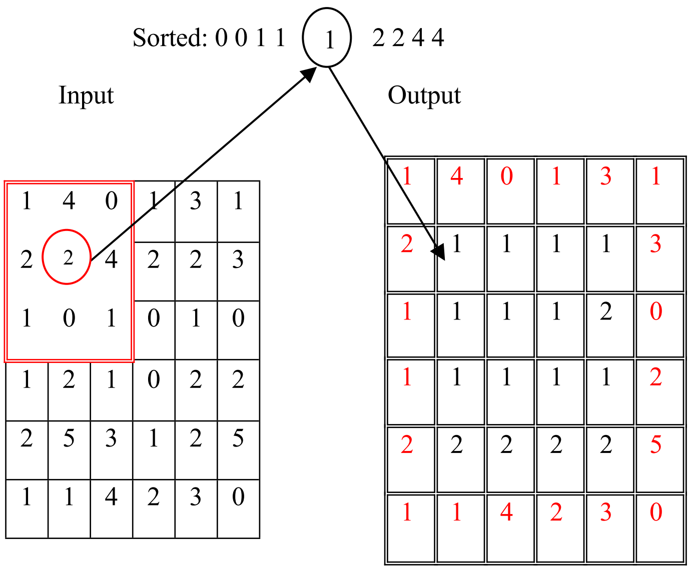
Figure 3.6 Absolute difference of image

b) Filtering

After pre-processing, image enhancement is done. Image enhancement operations namely median filter, wiener filter, averaging filter, smoothing filter, adaptive noise removal filtering, cross correlation can be used to improve the quality of an image. In this work median filter is used.

In median filtering, the neighboring pixels are ranked according to brightness (intensity) and the median value becomes the new value for the central pixel. Median filters can do an excellent job of rejecting certain types of noise, in particular, "shot" or impulse noise in which some individual pixels have extreme values. Median filter can be used to improve image contrast and brightness characteristics, reduce its noise content or sharpen its details. The algorithm for median filtering requires arranging the pixel values in the window in increasing or decreasing order and picking the middle value.

2D median filtering example using a 3*3 sampling window: Border values not changed.



Steps for 2D-median filtering:

1. Construct a window of size [x , y]
2. Sort the values in the window
3. Find the median value
4. Keep the border values unchanged
5. Replace the remaining values in the window with median value

6. Slide the window

Median filtering is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. Median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges.

Smoothing is often used to reduce noise within an image or to produce a less pixelated image. Most smoothing methods are based on low pass filters. A low pass filter is the basis for most smoothing methods. An image is smoothed by decreasing the disparity between pixel values by averaging nearby pixels. Using a low pass filter tends to retain the low frequency information within an image while reducing the high frequency information. Some specific smoothing and filter types are: Kalman filter, Kolmogorov–Zurbenko filter, Digital filter and so on.

In particular, compared to the smoothing filters, a median filter does not shift boundaries, like conventional smoothing filters (a contrast dependent problem) and also the median is less sensitive than the mean to extreme values (outliers), those extreme values are more effectively removed. Figure. 3.7 shows the image enhancement using median filter. It reduces noise and smoothes the image to preserve edges.

Figure 3.7 Median Filtering

D. Image Segmentation

Image segmentation has become an indispensable task in many image and video applications. This work proposed an image segmentation method based on the modified edge-following scheme where different thresholds are automatically determined according to areas with varied contents in a picture, thus yielding suitable segmentation results in different areas.

The simplest method of image segmentation is called the thresholding method. This method is based on a threshold value to convert a gray-scale image into a binary image. The technique behind this method is to select the threshold value (or values when multiple-levels are selected). Several popular methods are used in industry including the maximum entropy method, Otsu's method (maximum variance), and K-means clustering.

a) Otsu's Binarization

In this work Otsu's Binarization[15] or gray level thresholding is applied on the enhanced image to label the vehicles. Otsu's thresholding converts the gray level image into binary image.

Otsu's method is the most successful global thresholding method. It automatically performs histogram shape-based image thresholding for the reduction of a gray-level image to a binary image. The algorithm assumes that the image for thresholding contains two classes of pixels (e.g., foreground and background) and then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. It exhaustively searches for the threshold that minimizes the intra-class variance, defined as the weighted sum of variances of the two classes. Global thresholding, using an appropriate threshold T:

$$n(x, y) = \begin{cases} 1, & \text{if } g(x, y) > T \\ 0, & \text{if } g(x, y) \leq T \end{cases} \quad (3)$$

where n(x,y) represents the binary image. The result of the computation displays binary image. Figure. 3.8 shows the Gray threshold-Otsu's method.

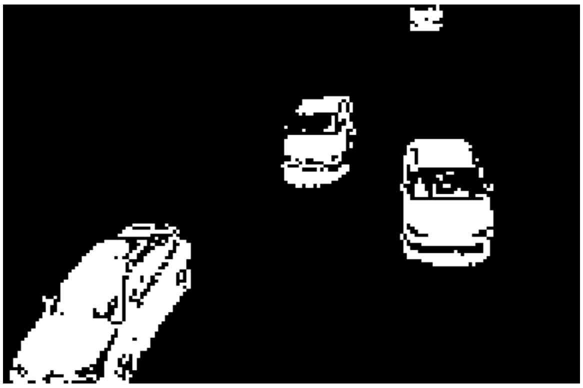


Figure 3.8 Otsu's thresholding

E. Morphological Operations

The segmented image undergoes a series of morphological operations to detect the exact shape of the object. Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations are affecting the form, structure or shape of an object, applied on binary images (black & white images – Images with only 2 colors: black and white). It can be used in pre or post processing (filtering, thinning, and pruning) for getting a representation or description of the shape of objects/regions (boundaries, skeletons convex hulls).

The dilation process is performed by laying the structuring element on the image. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel. If the origin of the structuring element coincides with a 'black' in the image, make black all pixels from the image covered by the structuring element. The erosion process is similar to dilation, but here pixels are turned to 'white', not 'black'. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel. If the origin of the structuring element coincides with a 'black' pixel in the image, and at least one of the 'black' pixels in the structuring element falls over a white pixel in the image, then change the 'black' pixel in the image (corresponding to the position on which the center of the structuring element falls) from 'black' to a 'white'.

a) Opening

Opening consists of an erosion followed by a dilation and can be used to eliminate all pixels in regions that are too small to contain the structuring element. In other words, foreground structures that are smaller than the structure element will disappear.

Figure 3.9 Morphological Open

b) Closing

Closing consists of a dilation followed by erosion and can be used to fill in holes and small gaps. Closing can also be used to remove pepper noise in images. It is normally applied to binary images. Closing is the dual of opening, *i.e.* closing the foreground pixels with a particular structuring element, is equivalent to closing the background with the same element.

To extract the targeted vehicle, shape index or structuring element is computed. A structuring element is simply a binary image (or mask) that allows us to define arbitrary neighborhood structures. In this work disk-shaped structuring element is used. Binary image area open and closing Morphological operations are used to segment the vehicle. Binary image area open operation removes small objects that are smaller than the pixels and it produce another binary image. In that binary image closing operation is performed. Figure. 3.9 and Figure. 3.10 show morphological open and close operation.

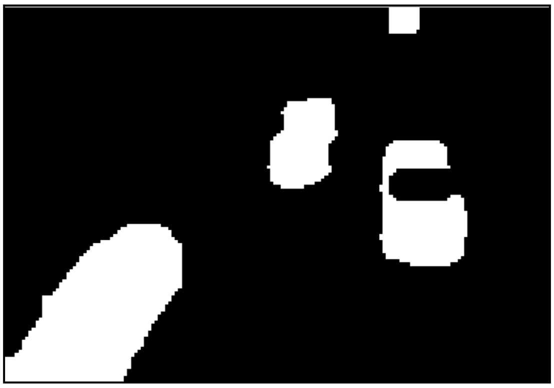


Figure 3.10 Morphological Close

F. Object Analysis

Region and image Properties are used to analyse the number of objects in an image. A region property can compute the 'area', 'centroid', 'bounding box' measurements and so on. To get region properties information about the objects in an image, centroid of the detected vehicle is computed. Using centroid points, number of objects is counted and displayed. The centroid of the object is determined as,

$$m(x,y) = \left(\sum_i x_i / i, \sum_i y_i / i \right) \quad (4)$$

where the centroid is denoted as m(x,y). The result is shown in Figure. 3.11. The red color dot represents the centroid of the detected vehicle. The length of the centroid points are counted to display the number of vehicles in the image or vehicles found in an image. Then the result is used to control the traffic.

Figureure 3.11 Vehicle Count

IV. RESULTS AND DISCUSSION

The proposed method tested on the road image which is taken from internet – Matlab videos. Finally this work having tested for 6 images and the count accuracy was perfect. In this proposed work 2D median filters used to remove the noise present in the respective images. Test was conducted on different filters, among them the best suited filter are: for Gaussian noise the wiener filter is best, Salt and Pepper noise is effectively removed by median filter. Differential morphological filters (area open and close) are used to segment the shape of vehicle. Proposed algorithms, automatically detects the vehicles by setting some initial parameters like a series of closing operation of different structure sizes to implement the differential profile. By extracting the features (area, centroid, length) the detected vehicles are counted easily using Mat lab environment.

The test image used disc-shaped morphological structure with the radius step size 5. Threshold value 20 is applied to morphological binary image open operation. Total vehicles visible in Figure. 3.11 are four. The algorithm is tested on the traffic images. The proposed system has better detection and counting than previous methods. In previous methods vehicles are detected using background subtraction, edge detection, and morphological operation and finally the histogram based on thresholding techniques determines the traffic flow. The result of the proposed methods is shown in Figure. 4

Table I: PERFORMANCE OF THE PROPOSED ALGORITHM

Images	Manual count	Algorithmic count	Accuracy
Image1	4	4	100
Image 2	3	3	100
Image 3	8	7	87.5
Image 4	3	3	100
Image 5	8	8	100
Image 6	3	3	100

The number of vehicles detected based on proposed method and the number of vehicle based on manual count depicted in Table I. It shows the accuracy of number of vehicles detected based on equation (5). This proposed method outperforms all other methods available in the literature.

$$Accuracy = \frac{Number\ of\ vehicles\ detected(Algorithmic\ count)}{Number\ of\ vechiles\ in\ the\ image(manual\ count)}\ \text{X } 100\% \quad (5)$$

Figure a. Vehicle count of Image 1

Figure b. Vehicle count of Image 2

Figure c. Vehicle count of Image 3

Figure d. Vehicle count of Image 4

Figure e. Vehicle count of Image 5

Figure f. Vehicle count of Image 6

Figure 4. The vehicle count of 6 traffic images after performing Image Processing techniques.

V. CONCLUSION

The proposed work helps to control the traffic jams in highways. This work presents the survey of vehicles during peak hours and in normal time which can be very useful to control the traffic. The proposed method is technically feasible to implement with low cost and with optimum accuracy. It is very important to recognize the type of a detected object (vehicles, pedestrian) in order to track and analyze its activities correctly. Further extensions are needed to classify the type of detected object. These classification coupled with detection techniques can increase the accuracy and efficiency of the proposed method.

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