

Ghost Vehicle and Shadow Removal Approach for Traffic Surveillance and Monitoring at Various Intersections Using Computer Vision

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Abstract

As traffic surveillance technology continues to grow worldwide vehicle detection, counting, tracking and classification are gaining importance. This paper proposes computer vision based real time vehicle detection, tracking and classification at urban intersections. Firstly, foreground extraction using double subtraction method is proposed, which increases the accuracy of blob detection. Classification based on the geometrical attributes of the vehicle and also quadrant division of the junction is put forward. Setting up dynamic ROIs is discussed, which increased the scope of traffic surveillance for different types of junctions. The proposed system is implemented using Intel Open CV library for image processing and video processing applications. The Practical implementation of the algorithm is made with C++ and computer vision. Several junction surveillance videos are used to evaluate the performance of the traffic surveillance system. In this paper, detection, tracking and classification of objects in with removal of shadow and ghost vehicles at different junction in video surveillance .Proposed work elaborated computer vision approach for Traffic monitoring in traffic surveillance application. Test results in the performance of the proposed algorithm in detection, classification and counting and proved the effectiveness of the traffic surveillance system. Obtained results showed a better performance in terms of accuracy.

Keywords: *Computer vision; double subtraction method; foreground extraction; dynamic, ROIs; vehicle detection; tracking; classification*

1. Introduction

Now-a-days, traffic surveillance and monitoring have been a crucial part in infrastructure development and transportation. Visual based vehicle tracking and traffic surveillance have received considerable attention during the last two decades. One of the main tasks in this surveillance is to track and detect a vehicle and obtaining real-time information. ITS (Intelligent Transportation System) have emerged as an efficient and cost-effective approach to solve the transportation-related problems. In traffic surveillance several parameters like: vehicle detection, tracking, counting, classification and flow of traffic are considered. Although radars and magnetic loops are used in some places, they have several limitations. It cannot give us the trajectory of any vehicle, classification, and they are difficult and costly to put up. On the other hand, computer vision based technology is highly beneficial as it can give us more information about the parameters, easy to install and maintain and has got wide-range operation.

There are many problems associated with it like: illumination variation, shadows of moving vehicles, occlusion of two vehicles, camera destabilization, etc. Due to these

problems, improper tracking of vehicles occur which in turn decreases the accuracy in tracking and detection. Occlusion is the major problem in the real-time surveillance at intersections. Due to bad weather, strong winds, humidity, improper focus setting or improper installation of the camera, camera destabilization may take place which creates a lot of noise in frames. Illumination problems are too frequent in case of cloudy areas and with trees on either side of lanes, which makes tracking very difficult.

There have been many techniques on vehicle detection and tracking. In this paper, foreground is extracted using our proposed double subtraction method. Using blob analysis, we have successfully tracked the moving objects. We have dealt the problem of shadows with shadow removal technique. In this method, a dynamic ROI method is proposed, which will be useful for setting extra ROIs wherever the user wants. A simple and robust technique is suggested to classify the vehicles into cars, bikes and buses. The paper is organized as follows: Section 2 reviews the related works. Section 3 gives an overview of the methodologies used in the algorithm. Section 4 describes the proposed algorithm. Section 5 briefs the practical implementation of the algorithm. Experimental and mathematical results are presented in Section 6. Finally, conclusions and future work are discussed in Section 7.

2. Related Work

Many works have been published related with vehicle detection, tracking and classification. There are several methods for detecting moving vehicles taken from video. Generally, they are categorized into three groups: background subtraction, frame by frame differencing and optical flow approaches. Tracking of moving vehicles in video sequences has been an active research topic in the field of computer vision. The main idea of the tracking processes is to keep track of identity of each detected vehicle over the whole sequence of the video. Thus, it eliminates possible multiple counts in the vehicle counting stage. Zhang, Ying et al. and Li, Juan *et al.*, presented several vehicle tracking algorithms [1, 2]. Paulraj, M. P. *et al.*, discussed Neural Networks and Time domain approach of the moving vehicle detection and classification [3]. Detection of the vehicle is done by using the noise emanated from the vehicle. However, we are interested to solve the problem in computer vision based approach. Kanitkar, Aditya et al. proposed vehicle detection using self-shadows and structural edge features [4]. This one is useful only where there are high resolution cameras. Furthermore, at junctions like T-intersections shadows are barely seen. Classification of the vehicle by the movement of the skeletal features is proposed by Yo-gameena, B. *et al.*, [5]. The star skeletonization algorithm is performed on the segmented objects to obtain skeleton features. Based on the signatures derived from the bottom section of the partitioned RMI using skeleton features, the object is classified into people and vehicles. Chai, C. *et al.*, introduced vehicle classification based on geometric features, height, and width [6]. Vehicle types are identified by calculating the length and width of each vehicle. In a similar work, a feature-based vehicle flow analysis and measurement system is proposed by Huang, Deng-Yuan et al. [7]. To increase the accuracy of vehicle classification, the temporal correlation of moving objects tracked between video frames is taken into consideration. In addition, the velocity of each vehicle and the vehicle flow through the field of vision are calculated by analyzing the features of vehicles. Rabiou, Habibu et al. discussed background subtraction and Kalman's filter algorithms are used to detect and track individual vehicles throughout the detection zone [8]. The detected vehicles' blob-area is used to trigger the segmentation unit which in turn extracts the vehicle while at a point closest to the camera. Setting up of ROIs at heavily crowded junctions to count the vehicles is proposed by Hashmi, M. F. *et al.*, [9], [10]. Statistical approach of the ROIs has been proposed in this work. The vehicle at the entry point must exit at one of the exiting ROIs. Ambardekar, Amol A *et al.*,

discussed background modeling and foreground object detection [11]. Optical flow algorithms estimate the motion of each pixel between two image frames and movement of blobs. Buch, Norbert *et al.*, introduced a comprehensive review of computer vision based techniques for analysis of traffic systems, with a high consideration on urban traffic [12]. Chong, Yan-wen *et al.*, introduced vehicle detection based on various vehicle features (such as vehicle shadows, rear lights, luminance entropy and edges). Proposed work can be used for the development of driver assistance system and autonomous vehicle systems. The proposed method is based on the vehicle shadow and detection is obtained by using shadow features of vehicles in a defined ROI [13]. Attard, Leanne *et al.*, discussed implementation of a Vision based Surveillance System. This system is capable to detect and classify vehicles at single lane or normal surveillance videos with high accuracy. The proposed work based on the static background subtraction method [14]. However, this system is not applicable for the vehicle detection and classification for junctions and intersection's videos surveillance system at heavy urban traffic.

Even though, a great deal of research has been done on object detection and classification in single lanes and highways not much work is done on traffic near crowded junctions. Classification of vehicles near intersection is done using geometrical approach discussed by Yogameena, B. *et al.* in [5], but the intersections discussed were not crowded which is different from Indian traffic. Many of the works proposed based on a model base features does not give accurate results near crowded junctions. This model-based classification relies on sets of 3D models that coarsely describe the shape of each vehicle type. Perhaps the most serious disadvantage of this model based approach is the need to represent various shapes of vehicles of same class with a single model [13].

3. Methods and Materials

In order to have effective tracking, counting and classification of vehicles the image should be noise-free and of good quality. Generally images have a lot of noise and disturbances, which makes the tracking and classification very difficult. In these methods shadow removal, creating ROIs, detection, classification and counting are discussed. In order to obtain an image with good quality for proper tracking and classification, some methods are applied, which are described in brief below:

3.1 Gray Scaling

A gray scale image has only one channel, and thus it is easy to operate as compared to RGB image. Any edge detection or feature detection operation is easily applied on a gray-scale image.

3.2 Morphology

The images obtained after gray scaling may suffer from extreme disturbances. To overcome such as problems 5x5 smoothing and morphological operations are applied. By using 5x5 average filter speckled or salt-pepper noise can be removed effectively. By using morphological operations like opening, dilation and erosion takes place simultaneously, where the brighter regions get isolated and smaller brighter regions vanish, which gives precise edge detection.

$$Dilation \quad I \oplus H = \{ (p + q) \mid p \in I, q \in H \} \quad (1)$$

$$Erosion \quad I \ominus H = \{ (p - q) \mid p \in I, \text{ for every } q \in H \} \quad (2)$$

Opening of an image is dilation of eroded image.

$$\text{Opening } I \circ H = (I \ominus H) \oplus H \quad (3)$$

3.3 Shadow Removal

One of the challenging problems in traffic surveillance is shadow removal. Usually shadow moves along with the vehicle which gets identified as a part of vehicle and gets recognized as foreground in turn causes detection problems. A simple shadow removal algorithm is proposed and discussed in equation 4.

Suppose if a pixel in the current frame is denoted as $C(x,y)$ and the corresponding pixel in the background frame is $B(x,y)$, then the foreground pixel values corresponding to that position is the absolute difference between the current frame and the background frame, $|C(x,y)-B(x,y)|$ which actually consist of vehicles and shadows. In shadow removal, we compare this value with shadow value threshold range say, $T1$ and $T2$ which are lower and upper limits of the shadow pixel range respectively as predefined by the user.

$$F(x, y) = 0 \quad \text{when } T1 < |C(x, y) - B(x, y)| < T2$$

$$|C(x, y) - B(x, y)| \quad \text{otherwise} \quad (4)$$

3.4 Moving Vehicle Detection- Foreground Extraction

The motion of an object is detected by comparing successive frames i.e. taking difference of the successive frames and extracting the foreground. The presence of an object is then detected by performing thresholding operation. In high motion detection, with normal background subtraction, back part of the vehicle and vehicle in the previous frame appears, which may tamper the result. This method proposes an effective way of removal of these errors.

3.5. Edge Detection

Canny edge detection is applied to get edges to which contours detection is applied. It's an optimal edge detector which has got good detection (mark as many real edges in the image as possible), good localization (detected edges should be as close as possible to the real edges) and minimal response (a given edge must be identified only once). Because of these advantages, canny edge detection is mostly preferred.

3.6 Object Detection and Tracking

The moving vehicles are obtained through double subtraction algorithm and are detected as blobs. After applying the canny edge detection to the foreground frame contours are found which are approximated to polygon, and then approximated to bounding boxes, which will bind them. The bounding box gives parameters of that particular vehicle like: point(x, y) starting point, height, width and area etc. of bounding box, which are used to track and classify them.

3.7 Classification

The classification of vehicles is done as small, medium and large based on area. The classification is maintained to be independent of variations in the video. The small vehicles are classified as bikes and cars based on their height/width ratio which helps us to increase our accuracy further more. We took a sample of 50 vehicles of different types and calculated the mean and variance of these samples. We used the combined width/height value for the classification purpose. In figure 1, the classification of vehicles is done as bikes, cars; autos etc. are shown as described below.

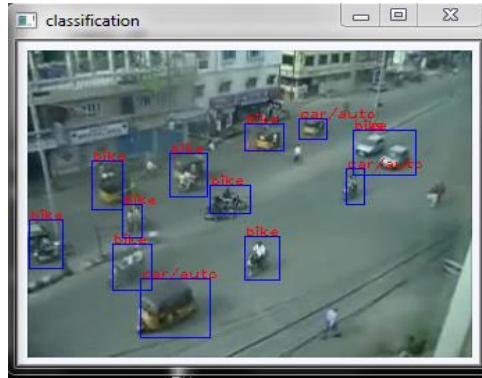


Figure 1. Classification of Vehicles at T-Junctions

3.8 ROIs Selection

An ROI (Region of Interest) can be simply defined as a selected subset of samples within a data set identified for a particular purpose. ROI plays an important role in giving the traffic parameters. We are creating dynamic ROIs through ROS by giving user freedom to choose ROI anywhere in the frame thus making it user friendly. These ROIs are used to count the number of vehicles going through that particular ROI. These ROIs are set with the help of mouse-pointer, where by dragging mouse, we can set dynamic ROIs. In figure 2(a) three ROIs are set at the outgoing paths of the road through which vehicles are exiting from the frame which will help us track the number of vehicles exiting. In figure 2 (b) two ROIs are set at the incoming paths of the road through which vehicles are entering the frame which will help us track the number of vehicles entering.



a) ROI at outgoing path (T-int)



b) ROI at incoming path (T-int)

Figure 2. ROI Selection for Various Junctions

3.9 Counting

A simple way to count the number of vehicles that are passing through a certain ROI is suggested. The vehicle passing through it gets classified and counting vehicles like small, medium, bus or car, etc. is also done. An effective and simple method has been proposed to see whether the bounding box has passed through it or not. The accuracy of the count is high, and this will be helpful in judging the path through which traffic is heavy. Counting of vehicles is shown in the Figure 3. The vehicle count is shown based on classification and ROI selected.

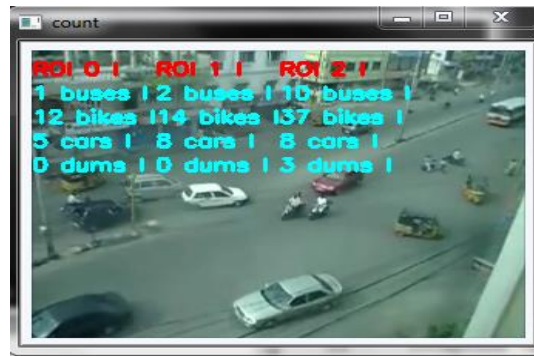


Figure 3. Showing the Counting of Vehicles

4. Proposed Algorithm

For determining the count and classification of vehicles at intersections this algorithm is proposed. The parameters taken into consideration include the observed count of vehicles passing through each ROI, classification of vehicles and counting based on statistical parameters. In this algorithm, first the video is converted into frames from where the gray scaling of each frame is done. Then morphological operations and smoothing is done to remove any stray noises. Shadow of moving vehicle is removed by proposed shadow removal technique. Then this sequence of frames is applied to the proposed foreground extraction method where we can obtain the moving vehicle precisely. Then canny edge detection is applied giving us the outline of vehicle. Contours are detected and polygon approximation is done, then the moving vehicle is bounded by a bounding box. The parameters of the bounding box are also obtained like starting position of box, height, width of the bounding box. The tracking of vehicles is done by this bounding box. The ROIs in this case can be set by the user, i.e. dynamic ROIs. Then using these parameters the classification of vehicles is done properly by checking the quadrant in which the vehicle is located and its corresponding area. The counting of vehicles passing through ROIs is done by checking whether the bounding box center has passed through that particular ROI or not. The flowchart of the proposed algorithm is as shown in above figure 4.

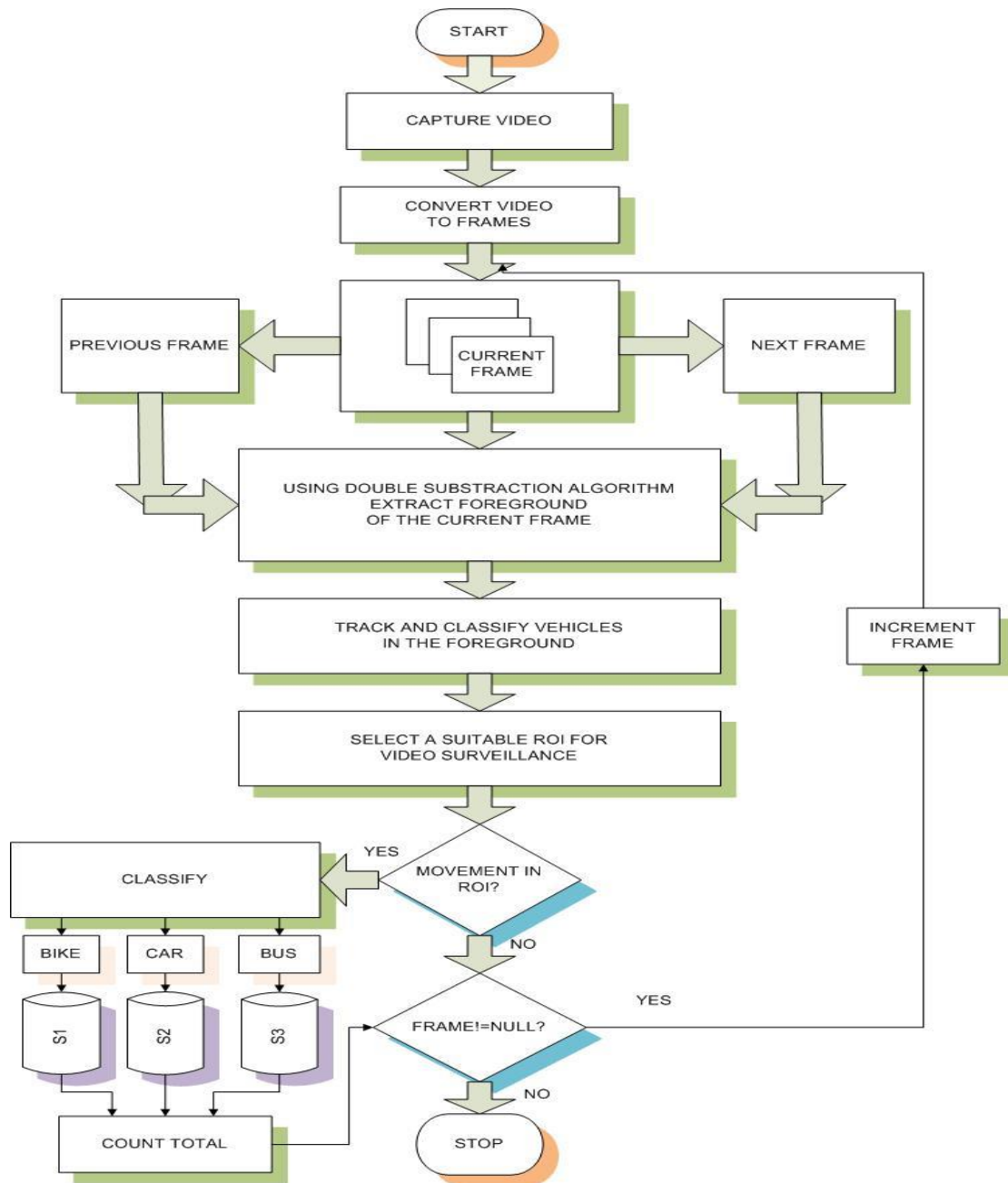


Figure 4. Flow Chart for Proposed Algorithm

5. Practical Implementation of Proposed System

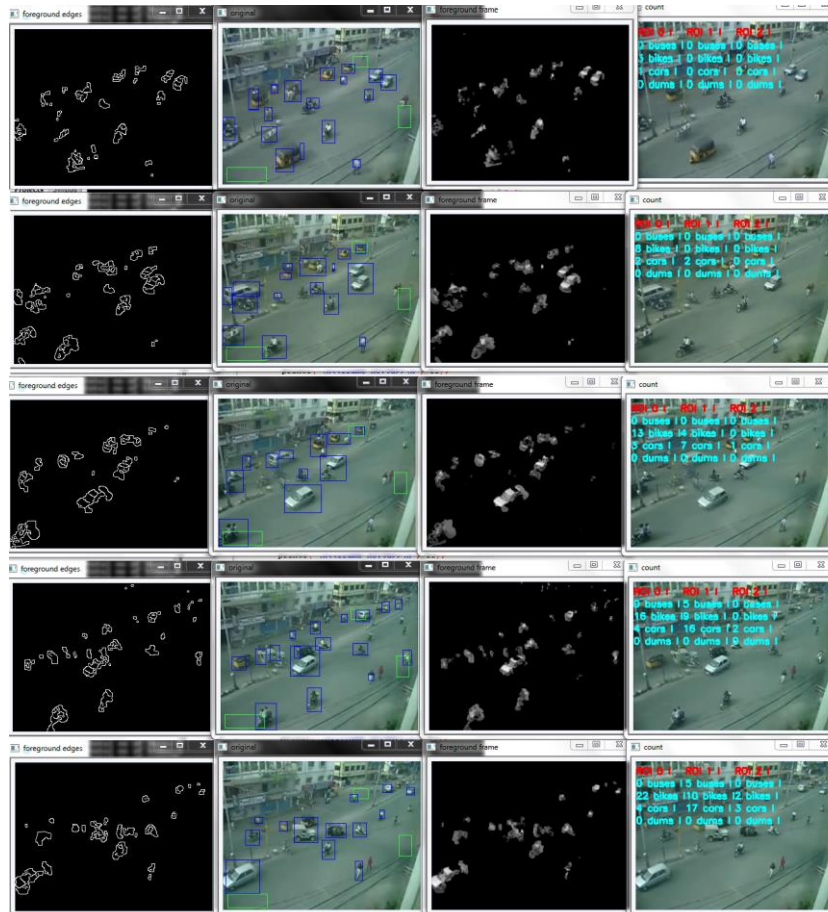


Figure 5. Results for Various Video Frames for Proposed System

The proposed method is implemented on a PC based hardware platform with Intel core i5 processor. Open CV library is used to speed up the development process and improve the execution and efficiency. In order to observe traffic at T-intersections in urban areas where heavy traffic density makes it impossible for detection and counting, we take a video footage set up on a rooftop overlooking a T-intersection which is taken in New Delhi.

Five videos are taken, which consist of various junctions like T-intersections, one way road and five junction roads with various traffic conditions and timings. The real-time video sequence lasts for 30 seconds. ROI selection is the most important phase. Improper selection of ROI may result in improper counting of vehicles and misprediction of the traffic flow. For one of the two T-intersections, three ROIs are taken at the entry points of the lanes and for the other one, a set of two ROIs are taken at the exit points of the lanes. For the other two videos, appropriate ROI setting is done and classification of the vehicles the quadrant division should be properly done by taking the statistical parameters of the video. The vehicle count and classification are shown separately in other dialog boxes. Results for various video frames for proposed system is as shown in figure 5.

6. Experimental Results and Discussions

6.1 Normal Background Subtraction Vs Double Subtraction Method

In normal background subtraction method, the difference of current frame and previous frame is obtained. Sometimes the vehicle which is in the previous frame also appears in the foreground which is not required. Figure 6 shows the detection of the ghost vehicle in the foreground which is detected as third vehicle whereas by proposed algorithm third vehicle doesn't appear because proposed method uses both previous as well as future frames.

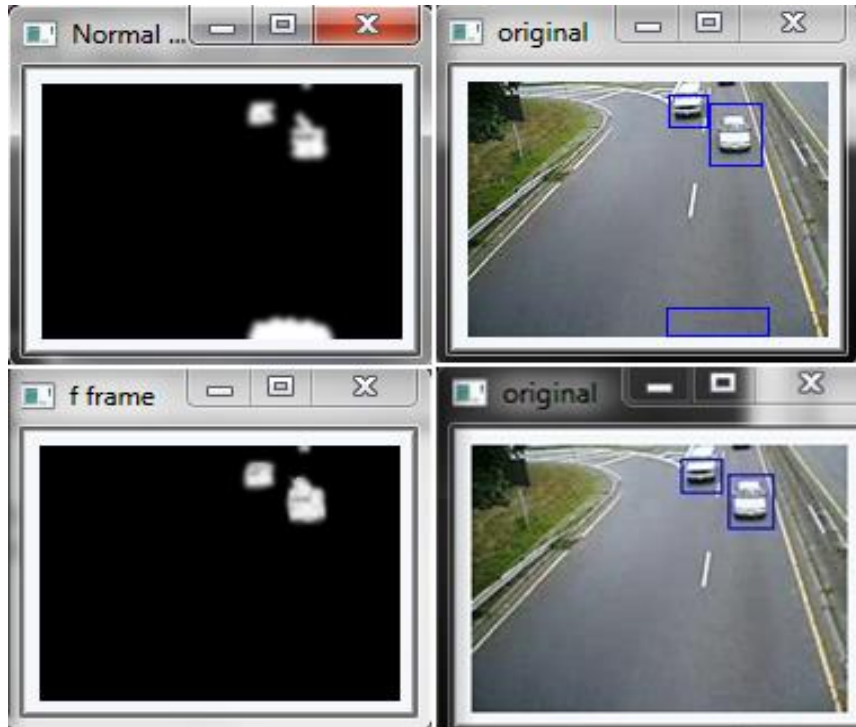


Figure 6. Normal Background Subtraction Vs Double Subtraction Method

6.2 Detection of Vehicles

Performance of any system can be tested and evaluated in terms of Precision, Recall and Accuracy. Precision or Positive predicted value (PPV) relates to the ability of the algorithm to detect a moving object detected correctly according to the outcomes. Recall or hit rate relates to the ability of the algorithm to determine moving object detected correctly according to the condition. Hence a high value of Precision and Recall proves better performance of the system. Precision and Recall are calculated for a set of five videos, which are of 92.39% precise rate and 91.07% recall rate. Parameter's calculation and estimate for vehicle detection and counting at various junctions is shown Table 1. We define the following terms for evaluate the performance of the system [15] [16]:

TRUE POSITIVE: moving vehicle is detected correctly

TRUE NEGATIVE: unmoving part of the frame is not detected

FALSE POSITIVE: unmoving part of the frame is detected as a vehicle

FALSE NEGATIVE: moving vehicle is not detected correctly

Precision: This gives us how precisely the algorithm can identify/detect vehicles.

$$PRECISION = \frac{TP}{TP + FP} \quad (5)$$

Recall: This almost gives us the accuracy of the algorithm i.e. the ability to identify the vehicles.

$$RECALL = \frac{TP}{TP + FN} \quad (6)$$

Table 1. Parameter's Calculation and Estimate for Vehicle Detection and Counting at Various Junctions

Sample Videos	TP	TN	FP	FN	Recall (%)	Precision (%)
Video1 (T-int)	84	-	9	8	91.30	90.32
Video2 (T-int)	68	-	6	7	90.67	91.89
Video 3 (T-int)	46	-	3	6	88.46	93.87
Video 4 (5 junc.)	82	-	10	11	88.66	89.58
Video (1 lane)	26	-	1	1	96.29	96.29

True Negative, which is the parameter for non-detection of stationary objects, includes road, buildings and background, *etc.*, which cannot be calculated.

6.3. Comparative Study of the Previously Proposed Work

With reference to the attributed works in the field of traffic surveillance, the paper [17, 9, 10] is referred. In this paper, different vehicle detection algorithms are proposed. In this paper, background frame is updated every time. In this paper counting of vehicles is not done. This paper was proposed to work on a single lane road. However, in our paper, a much more appropriate algorithm is proposed, which gives us better foreground images thus making detection much more accurate. Setting up of dynamic ROI is discussed in our paper, which increases not only the scope of vehicle counting but is also applicable in any type of junction. This paper's algorithm showed maximum success rate of 90% for vehicle detection. We claim to have an average success rate of 93.92, which is much better than this paper. Quadrant division is also proposed, which gives greater accuracy in vehicle detection and counting, though it has its own limitations. As this paper specifically deals with intersections, its success rate is less in vehicle classification. Given a single lane, our detection would have been higher. The comparative analysis of traffic parameters of vehicle detection and classification and their success rates are shown in figure 7 respectively.

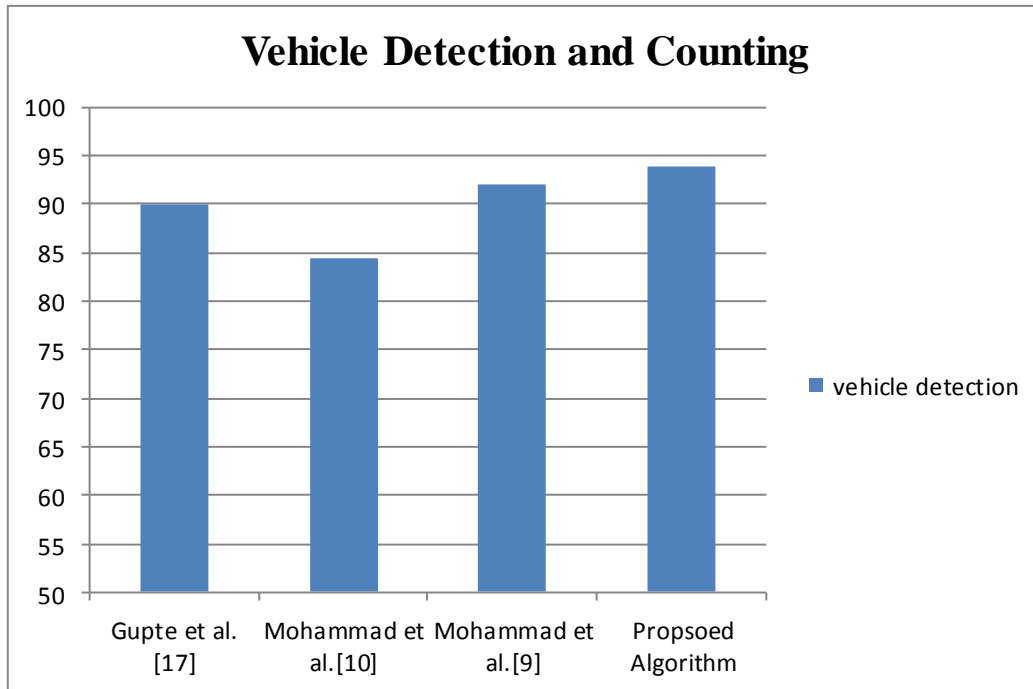


Figure 7. Comparative Analysis of Success Rate for Vehicle Detection and Counting

7. Conclusion and Future Scope

The paper presents an effective method for vehicle detection, tracking and classification using geometric attributes of the vehicles. The proposed work guarantees a high accuracy in case of heavily crowded urban intersections. This particular algorithm specifies in traffic flow monitoring using a dynamic ROI concept. The practical implementation of the algorithm gives us almost 93% accuracy in vehicle detection and counting respectively. This type of algorithm has quick, reliable and highly accurate performance in all possible conditions. Double subtraction method and blob analysis are used to detect and track the vehicles. The results indicated a promising trend in the vision based vehicle detection and classification. Although the proposed system demonstrated robustness in the vehicle detection, tracking and classification, further work is still required to help resolve the occlusion issues, camera destabilization, illumination effects, Random selection of ROIs depending upon the movement of vehicles and geometry of the junction, introducing appearance attributes in classification. Other parameters such as color, number plate, speed, trajectory of the vehicle can be calculated and lane's detection can also be done effectively. Further future work involves achievement of one of the above-mentioned challenges, working in high-density regions and comparative study of existing algorithms.

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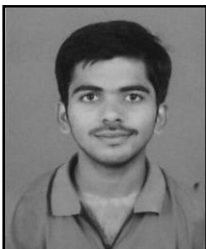
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