Vision Based Intelligent Traffic Management System

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ABSTRACT- **Vision based intelligent traffic management system is a robust framework that manages the on road traffic flow in real time by estimating traffic density near traffic signals. We have proposed a simple yet efficient algorithm to calculate the number of vehicles at various signals on a road to efficiently manage the traffic by controlling traffic signals to avoid congestion and traffic jam. The proposed system works by detection of vehicles in video frames acquired by cameras installed on roads and then perform accurate counting of vehicles at the same time. Dynamic background subtraction technique and morphological operations for vehicle detection have been used to achieve better detection efficiency. In order to attain accurate vehicle count in least possible time, we have used Region of Interest based method for vehicle calculation. The proposed framework is designed and implemented in several simulation test cases. It is expected that this work will provide an insight into the design and development of traffic signaling based system and also serves as a basis for practical implementation of a computer vision technology in real-time environment. Furthermore, this work also contributes to new design schemes to increase traffic signaling system's intelligence.**

I. INTRODUCTION

Traffic management has become one of the most illusionist issues now days. Conventional signaling systems use timing circuitry that is; they are time dependent, also, they turns to red and green without any estimation of traffic which creates the problems over the areas which possess dense traffic ratio in one direction as compared to other. Moreover, it creates the problem during peak hours, so an efficient system is needed that could manage the traffic flow at a certain point. We have proposed a system that overcomes these problems and estimates traffic density at a certain point on the basis of acquired vision through optical sensors like video cameras. The proposed system offers better reliability and low communication mechanism for crowded and dense traffic areas. Vision based techniques have improved the controlling mechanism, detection of events and organizational information in an efficient manner. The proposed system is equally intelligent as an individual traffic warden that manages the traffic flow when fixed timing based signals cause congestion on those sides of the roads that have higher traffic load than others. In addition to that, when these systems are installed on all the traffic signal point of a particular road and traffic density is analyzed by a central server that receives density information from individual traffic signals, then, the central server can make dynamic decisions regarding each signal point by considering the traffic density at pervious signal point and at the next signal point to keep traffic density even on all signals. This can really help to avoid traffic congestion on one signal point or on the whole long road. Since, the field of Computer vision is vast and proficient now days, therefore the transferring of conventional traffic signaling system over this process would be a useful progress in this technology era.

In this paper, a complete and smart traffic management framework has been presented. The basic working of the systems is based on vehicle detection and density estimation. A dynamic background subtraction method has been used to enhance detection efficiency in real time scenario, whereas traffic density is estimated on the basis of defined "region of interest".

The paper is organized in following portions: After a review of related work, proposed framework is described in three main steps; vehicle detection, vehicle density estimation and traffic management. Experimental results are then presented and thoroughly discussed. Finally, conclusion remarks and future enhancements are proposed in last portion.

II. RELATED WORK

A great deal of work has been carried out for vehicle detection and density estimation from an image sequence in computer vision. A very common method is vehicle tracking and background differencing technique. In [8] the tracking has been done by using kalman filter [3]. Moreover, they have applied the occlusion removal algorithms for detecting proper shape of vehicle by merging or dividing the image if there is any overlapping between two or more detected objects.

In the system proposed by [2], learning based method has been used for object detection. They trained their system on a labelled dataset in order to detect the objects. This is quite an interesting and useful method but it requires different sets of labelling and these training sets make it inefficient in terms of processing time as it cannot work well in real time scenario.

Static subtraction has been used for the detection of moving objects in an image or video sequence [11]. This has been done by constructing a reference image and current image will be subtracted from that reference image to acquire the moving objects. A detection

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rate is initially selected by determining an appropriate rate of threshold. This is a very useful approach but it can only work well in non varying intensity and light effects. Median background subtraction is also applied for separating static background with a moving foreground [1]. In [12] an algorithm is proposed for vehicle detection by applying dynamic background using robust information fusion. Passing vehicles can also be detected on the basis of motion information, several methods based on this technique have been reported in literature [5],[7] and [9]. These methods work well in absence of any noise or illumination changes.

Video based vehicle detection and classification system has also been presented for calculating the number of vehicles [4]. In this technique a vehicle is classified as short or long on the basis of its pixels length. Moreover, background updating mechanism is used in order to grasp the environmental changes. However, this technique requires high computational power that makes it less suitable for real time scenario.

Detection can also be performed by pixel wise model of the background and observing the significant variations from it as the moving object enters into the frame [10]. In this technique background model is updated after each frame. Temporal colour changes are detected and then filter is applied in order to form a foreground image. This approach does not give accurate results in case of merged vehicles or in the presence of other moving objects in the frame.

Vehicle classification has also been done by using wheel features. In [6] the classification algorithm consists of vehicle wheel baseline approach. As all vehicles have wheels and their texture is almost similar. So the algorithm consists of this information in the form of wheel detector.

III. PROPOSED METHODOLOGY

We have used the dynamic background subtraction method for vehicle detection in a video sequence. For density estimation, we have defined a region of interest in which the system calculates no. of vehicles in that particular frame.

A. *Vehicle detection*

As described above that we have implemented Dynamic background subtraction for vehicle detection. In this method we use to extract the first frame of the video and consider it as our background then this background is dynamically updated according to the formula given in (1);

$$bg_n = (gray * v) * (bg_{n-1} * (1-v)) \qquad (1)$$

In Equation (1) ‘bg_{n-1}’ is previous background image, ‘bg_n is updated background, ‘gray’ is original video frame and ‘v’ is dynamic background constant.

The value of ‘dynamic background constant’ is adjustable and ranges from 0 to 1. The value of background constant is tuned according to

a. For v = 0.2

b. For v = 0.5

c. For v = 0.9

Figure 1. Dynamically Updated Backgrounds for various values of background constant ‘v’.

different working scenarios. If the value of background constant is adjusted near 0, the updated background has increased impact of previous frames with a certain weight and vice versa. The elaboration of this background constant is shown in figure 1.

This background subtraction mechanism can also be done by using static background i.e. by using a constant background image, but this technique is overturn by intensity changes as light is the major factor for effecting the image brightness and quality. So this factor has been efficiently overcome by dynamic enhancement of background image. As the background updates with every incoming frame, so, it easily compensates for light fluctuations and weather conditions. This updated background is subtracted from current frame to identify the moving object in a certain frame.

Moreover, by applying different morphological operations we clarify the detected object and plot a rectangle along the object. The aspect ratio and area of the rectangle is used to classify it as a vehicle or non-vehicle.

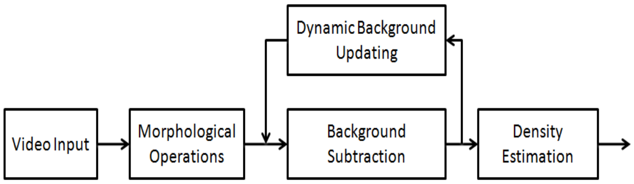

Figure 2. Background subtraction flowchart.

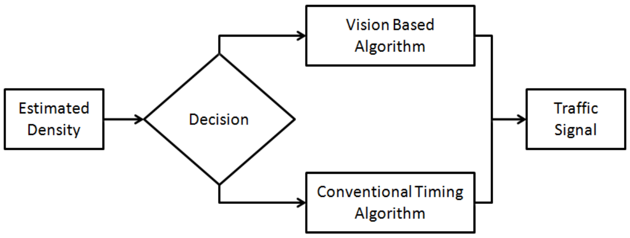

Figure 3. Traffic Management flowchart.

The important parts of traffic management algorithm are discussed as.

a. *Pre Processing*

Incoming video frames are pre-processed and enhanced in order to remove noise i.e. salt and pepper noise. This noise is voided by using morphological operations. This step is really important as it decreases the chances of false detection.

b. *Background Subtraction*

Background subtraction is an important part of our algorithm because at this vehicle is detected from an image sequence. Background subtraction is carried out by taking the difference of pre-processed video frame from dynamically updated background. The dynamically updated background is used for each video frame to achieve high detection efficiency.

B. *Density Estimation*

Vehicle counting has been done for those vehicles that pass through a defined area of interest. This requires less processing as the system does not need to process whole frame for counting vehicles. When an object is detected in that area of interest, an indicative rectangle is plotted around it. When a detected object enters in the defined region of interest, another indicative rectangle is plotted at its boundary vehicles counter is incremented. An important reason for carrying out this step is to avoid multiple counting of a single vehicle in a video frame.

C. *Traffic management*

The vehicle count value is updated at the processing hardware after a regular interval of time. Signal controlling algorithm works on the basis of updated vehicle count. It controls the electronic traffic

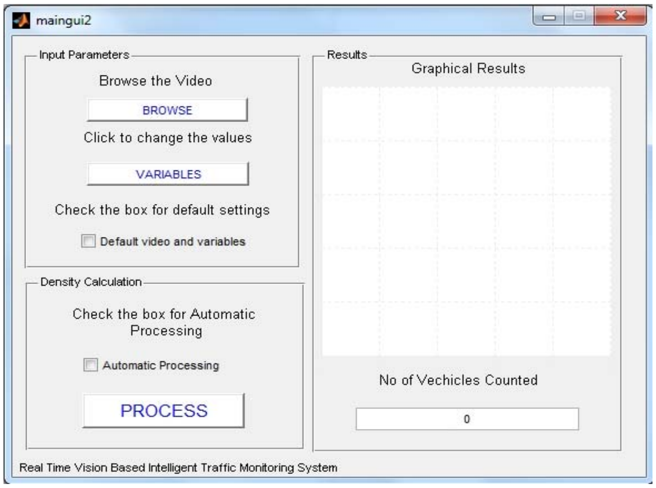

Figure 4: Graphical User Interface

signals according to number of vehicles on all roads, connecting at a specific central point like a square.

Fault detection capability is also incorporated in this system. There may be an occasion when camera might fail or due to very poor lighting or weather condition the captured video is not good enough to get processed for traffic density estimation. In these cases system detects irregular traffic patterns or it looks for no vehicle detection in the frames for a longer period of time. If this situation occurs, the system shifts all electronic signals to fixed times and traffic signals work in conventional way.

IV. EXPERIMENTS AND RESULTS

We have examined our proposed methodology on a limited collection of videos. As no standard database exists for experimentation on traffic related videos so we've recorded these videos in different scenarios. A few videos have also been acquired by the software in which we have implemented our algorithm.10 videos have been recorded in varying environment on different highways and streets. The videos are available online at: http://www.youtube.com/user/mianhassanaslam?feature=mhsn#p/u

A Graphic user interface is created for testing the videos so that testing of system becomes easier. The pictorial view of our designed Graphical User Interface is shown in figure 4.

The results obtained over a video sequence have been discussed hereby. First frame of the video is considered as reference background according to the methodology described in III; afterwards this background is kept on updating according to the above mentioned formula in (1). Subtracted image is obtained by subtracting the dynamically updated background from the incoming frames of the video sequence. This identifies the objects in the frame. The results may not be understandable and our system may not be able to understand the detected objects at this point as shown in figure 5.

Figure 5: Subtracted Image

Figure 6: Morphological operations

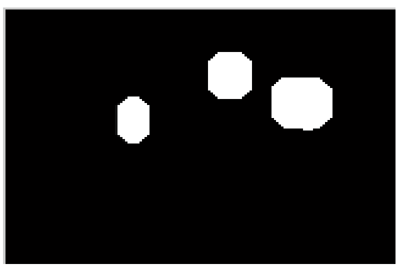

Figure 7: Threshold Image for blob detection

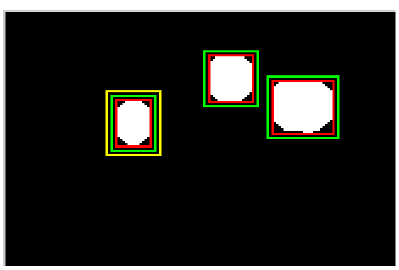

Figure 8: Rectangles, highlighting the detected blobs (binary)

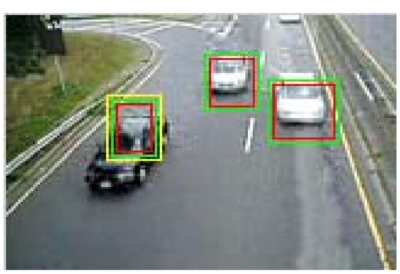

Figure 9: Detected Vehicles in a video frame (Coloured)

Figure 10: Dynamically Updated Background

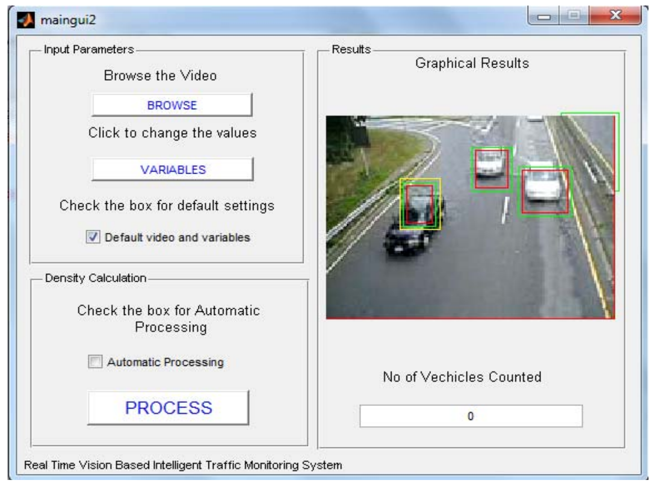

Figure 11: Graphic User Interface

Morphological operations are applied to enhance the results. The results of morphological operations are shown in figure 6.

In order to form a blob of detected objects, thresholding is applied to enhance the detected blob. In thresholding process the pixels that have values greater than the defined threshold are set to white and those that have values less than defined threshold are set to black, as a result the clear blob is formed. Figure 7 shows the blob detection results. The blobs are highlighted by plotting rectangles around them as shown in figure 8 and figure 9.

Dynamic background updating is shown in figure 10. Here the value of background constant is set to 0.5.

Figure 11 shows the working of graphical user interface in correspondence to a video scenario in which three cars are being shown on the road.

We have kept our algorithm simpler in such a way that it does not require any process for classification of vehicles and directly counts the density of traffic without classifying the type of vehicle and objects. The system is implemented on a general purpose PC with a specific interface to the software. The perspective software program calculates the traffic density.

Table 1: Detection results of proposed system on various videos

Video No.	Vehicles Calculated *(manually)*	Vehicles Detected	Vehicles Miscalculated	Detection Accuracy (%)
1	10	10	0	100
2	17	18	1	94.45
3	14	13	1	92.85
4	23	26	3	88.46
5	14	12	2	85.71

Table 2: Comparison of proposed system with other existing techniques

Method	Detection Accuracy (%)
Guohui Zhang [3]	91.53%
Roya Red [4]	91%
Zhen Jia [7]	95.3%(for crossing areas)
Our proposed method	92.30 %

The average vehicle detection accuracy is *92.30%*.

In addition to that, we have observed that smaller the size of video, lesser is the processing time and similarly larger the size of video greater is the processing time. We have tested the system methodology on different videos. The size of video frames varies from 120x160 to 240x320. We have observed from results that the video with smaller frame size has shown accurate results as compared to the videos that have bigger frame sizes..

Table 1 presents the results of proposed frame work on 5 selected videos. The comparison of proposed framework with other methods is given in Table 2. The comparison has been done in terms of correct detection accuracy percentage. It can be seen that our proposed system achieves higher detection accuracy as compared to other methods.

V. Conclusions

In this paper we proposed an algorithm of vehicle detection and traffic density estimation which leads to an efficient traffic management system, we have applied our algorithm in certain simulations and different video sequences. The proposed system is promising and has shown good real time performance. Although certain shortcomings; such as occlusion and shadow overlapping exist in this algorithm. However, these problems can be handled by applying efficient shadow removal and occlusion removal techniques.

VI. References

[1] A.Prati, I. Mikic, R.Cucchiara and M.M Trivedi, Analysis and detection of shadows in video streams, *IEEE Computer Vision and Pattern Recognition Confrence,*Volume:2, 8-14 December, 2001.

[2] C.Papageorgiou and T.Poggio. A trainable system for object detection, *Int Journal of Computer Vision,* 38:15-33, 2000.

[3] Grewal, M.S., Angus, P.A., 1993, Kalman filtering and practice, Printince Hall, Upper Saddle River, NJ, USA.

[4] Guohui Zhang, Ryan P.Avery, Yinhai Wang, A Video based vehicle detection and classification system for real-time traffic data collection using uncalibrated video camera,*TRB Annual Meeting,* 2007.

[5] M. Betke, E.Haritaoglu and L.S. Davis, Real time multiple vehicle detection and tracking from a moving vehicle, *Machine Vision and Applications,* 2000

[6] Ofer Achler, Mohan M. Trivedi. Camera based vehicle detection, tracking and wheel baseline estimation approach, *Computer Vision and Robotics Research Laboratory University of California,San diego.*

[7] P. Batavia, D. Pomerleau, and C. Thorpe, Overtaking Vehicle Detection Using Implicit Optical Flow, *Proc. IEEE Transportation Systems Conf,* 1997

[8] Roya Red, Mansur Jamzad. Real time classification and tracking of multiple vehicles in highways , *Communicated by E.Baker,*2004.

[9] S. Carlsson and J.Eklundh, Object Detection using Model Based Prediction and Motion Parallax, *European Confrence on Computer Vision,* 1990.

[10] Sung Chen Lee, Ram Nevatia, Speed performance improvement of vehicle blob tracking system, *University of Southern California,* 2006.

[11] Thanarat Horprasert, David Harwood, Larry S.Davis ,A robust Background Subtraction and Shadow Detection, *Computer Vision Labortary,* 1999

[12] Ying Zhu, Dorin Comaniciu, Martin Pellkofer, Thorsten Koehler, Passing vehicle detection from dynamic background using robust information fusion, *Siemens Corporate Reseach Inc,Princeton USA and Regensburg, Germany.*

[13] Zhen Jia, Zhipeng li, Fuqiang Liu, Jianwei Zhao, Pei-Yuang Peng, Jie Shao. Journal of Multimedia , Vol 6, No:1, Feb 2011