Traffic Monitoring and Signal Management System on Highways

A.Kannan[1], S.Manipriya[2]

[1]*College of Engineering, AnnaUniversity*
Guindy,Chennai,India

[1]kannan@annauniv.edu
[2]mani_priyam@yahoo.co.in

***Abstract*— In this work, an intelligent system for tracking various moving objects in the available traffic visuals of highways and provide dynamic traffic signal modification at the road junction has been designed and implemented. This system provides features for traffic monitoring based on a network of vehicle tracking units installed with cctv cameras for each road joining a junction. These units capture the images of movable objects in the highways, process the images and provide information of each of the moving objects in the scene. This includes position of the object, target id, velocity and its classification (car,bike e.t.c.). A traffic signal processing unit which receives the information provided by the vehicle tracking unit, merges the information received and prepare a synchronized real-time statistical output (alerts, accidents, road signs, lane changes etc). Since this system is flexible, it can be dynamically applied to broad fields of application.**

***Keywords*— vehicle tracking unit, road junction, traffic signal processing unit.**

I. Introduction

In recent years, with the latest technological advancements, of the-shelf cameras became vastly available, producing a huge amount of content that can be used in various application areas. Among them, traffic surveillance receives a great deal of interest. Until recently, video surveillance was mainly a concern only for military or large-scale companies. However, most agencies and organization including government and private are interested in video surveillance for effective monitoring and security. In the current road scenario, increased traffic demands the use of intelligent systems for monitoring, controlling and managing the traffic. Improved traffic management is necessary for avoiding congestion and also for providing safety measures. However, robust and accurate detection and tracking of moving object is a difficult problem for computer vision applications due to the illumination of background changes, occlusion problem etc. Therefore, it is necessary to develop an intelligent traffic monitoring system which can detect moving objects effectively. In this work, an intelligent traffic monitoring system, whose fundamental goal is to design a moving target tracking system, has been designed and implemented.

Many commercial and research systems use videoprocessing, aiming to solve specific problems in traffic monitoring. The traffic monitoring system for tunnels TRAVIS[1]is was supported by the General Secretariat of Research and Technology Hellas under the InfoSocAn efficient application for monitoring and surveillance used in the system called AVITRACK, which monitors airplane servicing operations [2]. An example of a commercial system for monitoring and controlling road traffic is Autoscopew Solo Wide Area Video Vehicle Detection System [3], which was also used in the FP5 INTERVUSE project [4], for the development of an artificial vision network-based system for monitoring the ground traffic at airports. Other commercial products for road traffic monitoring are VisioPad , VideoTrak 910, TraffiCam , Vantage Iteris Monitoring Video Detection System and ABT2000. In Vitus-1 study, more video-based systems especially for tunnel

In this paper, we present a novel camera video surveillance system, which supports functionalities such as detection, tracking and classification of objects moving within the supervised area. Whereas the majority of existing commercial and research traffic surveillance systems have been designed to cope with specific scenarios, the proposed system is applicable to a broad field of traffic surveillance applications. Its main advantages are extensibility, parameterization and its capability to support various image processing and data fusion techniques so as to be easily adaptable to different traffic conditions.

II. SYSTEM ARCHITECTURE

The proposed system consists of a network *of vehicle detection unit (VDU)*for each road joining a junction that uses a video sensor to capture images, detect the foreground objects within the region of interest and provide results to the *traffic signal processing unit(TSPU).* The TSPU is responsible for providing signals for each road in the junction and collecting statistical information about the scene and alerts during specific situation are detected. The system architecture is illustrated in Fig.1

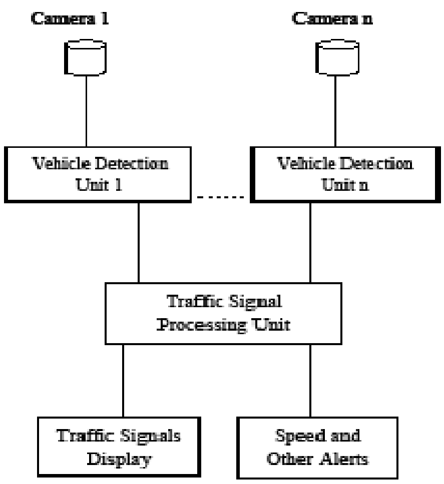

Fig. 1 The Architecture of the Proposed System.

The video sensors are standard CCTV cameras, not necessarily of high resolution, equipped with a casing appropriate for outdoor use and telephoto lenses for observation from a large distance. We also consider that they are static with fixed field of view and pre-calibrated using a procedure that is briefly summarized in the following section.

III. VEIHCLE DETECTION UNIT

Detecting changes in image sequence of the same scene is of significant interest due to increased traffic congestion. Traffic surveillance is among the important applications, which require reliable detection of changes in the scene. There are several different approaches for such a detection problem. The VDU automatically deals with background changes. It detects the moving object in the scene irrespective of day or night

Each VDU obtains frames of the region of interest from a fixed cctv camera. This region of interest includes a part of the road from a distant view a few meters before the junction. Each Vehicle detection unit consists of the following modules:

A. Background Extraction

Each pixel is represented by its maximum intensity value, minimum intensity value and intensity difference values between pixel in consecutive frame. The limitation of such a model is its susceptibility to illumination changes. By Yi wang et al [8], for each frame of the video sequence (referred to as current image), the difference between the current image and the current background is given as the difference image. The difference image is thresholded to give a binary object mask. The object mask is a binary image such that all pixels that correspond to foreground objects has the value 1, and all the other pixels are set to value 0.

The moving connected objects alone are identified from this method of background estimation as shown in Fig.2

B. Foreground Estimation

The entire connected component obtained from background extraction in the previous section is labelled to identify the individual foreground objects. This labelling is a tedious task as only those objects of importance alone have to be identified and labelled. Objects are labelled by finding the centroid for the object of interest in each frame. The small structures are removed in order to focus on the moving objects.

C. Feature Extraction

Specifically, 9 features are extracted from foreground objects of the previous section like height width etc., these feature are threshold in order to overcome exceptions.

D. Classification

A set of classes of moving objects (e.g. “person”, “car” etc) using the feature attributes is initially defined for each application. Then, each object is classified by calculating its membership to each class.

The classification based on the vehicle detection unit when compared with that of manual estimation

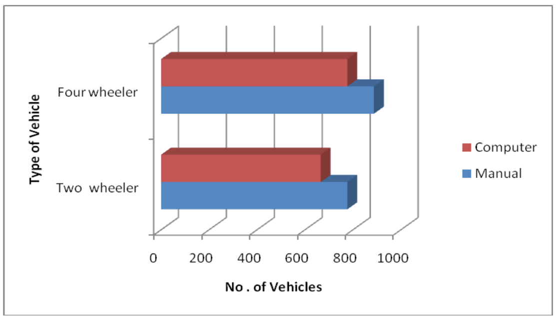

Fig.2 The result of vehicle detection unit.

IV. TRAFFIC SIGNAL PROCESSING UNIT

Measuring traffic movements of vehicles for junction signal such as number of vehicles is very important for the analysis of cross section traffic conditions and adjusting traffic signals. Various parameters are identified for monitoring the signals across the junction. Previous research work for the traffic signal modification parameter is based on a full-frame approach, which requires more computing power and, thus, is not suitable for real-time applications.

A. Vehicle Count Calculation

We use a method for counting vehicles at the key regions before the junctions by using the results obtained from vehicle detection unit. To count the number of vehicles passing the region of interest, a status vector is created. In this manner, for each frame, if a vehicle is detected in the visual, a "one" is stored at the status vector; otherwise, a "zero" is stored at the status vector. The group of one's corresponds to a vehicle, and a group of zeros corresponds to the distance between two vehicles. A one alone could be considered as a motorcycle or a fast moving car. This method is used to automatically and simultaneously compute the count for all the roads joining the junction.

B. Speed Limit Observation

To measure the speed, the time between the passages of vehicles in the frames is detected. The distances between the frames are fixed. Therefore, by the methods of TMJ[9]after computing the status vector for frames, the information about the number of frames (F_n) it takes for the passage of each vehicle until it enters and leaves the region of interest is recorded. This information is used to compute the speed of vehicles as shown in (1).

$$V(speed) = \frac{D \times F}{F_n} \qquad (1)$$

where
D - Physical distance between of region of interest;
F - Frame rate;
F_n - Number of frames taken for the passage of the vehicle;

The result is calculated simultaneously for all the roads to the junction and compared with the threshold to provide alerts.

C. Signal Updating Section

Let n be the number of roads joining the junction hence n set of signals. Based on the various parameter encountered in the previous section the signal is modified. In order to provide signal to the 1^{st} and n^{th} road signal is made default. The algorithm makes sure that all the roads get their time for green signal without much time to wait.

The execution times for each section of this unit is shown in the Fig.3

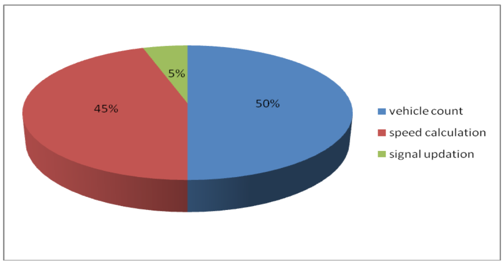

Fig. 3 Execution times in TSPU modules

V. Experimental Results

Preliminary results of the system have been obtained using as input a stereo traffic monitoring sequence. Original images are shown in Fig. 4(a-b) and the estimated background maps are presented in Figures 4(c-d) respectively.

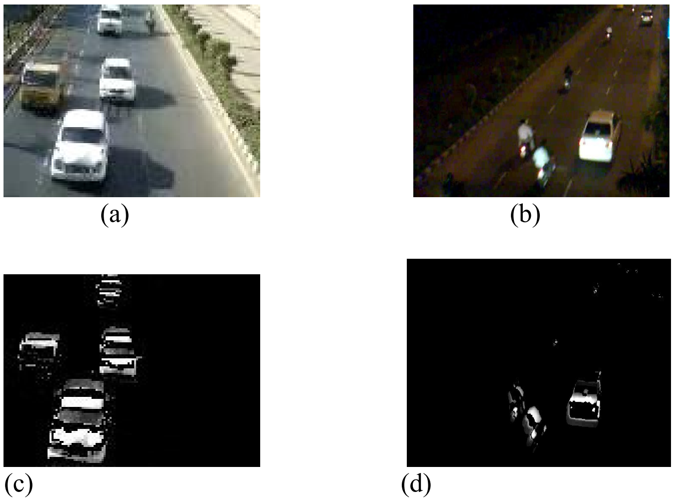

Fig.4 (a) Snapshot from traffic video 1 (b) Snapshot from traffic video 2(c) Snapshot after background estimation (d) Snapshot after background estimation

The Fig.5 provides the overall picture of final result that has been developed for signal modification for road junction.

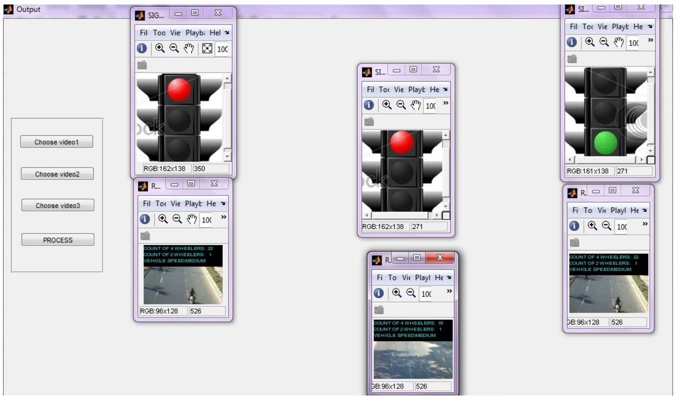

Fig. 6 Final Prototype for the proposed system

VI. CONCLUSION

A novel vehicle-detection technique based key region processing has been introduced in this paper. The information extracted by the vehicle-detection algorithm has been used for measuring other traffic parameters such as volume, speed, and other junction monitoring parameters. The algorithm has been implemented on a Pentium-based microcomputer system. The system is operational and works in real time. This low-cost vision-based system can be used for monitoring, controlling, and managing the whole traffic system and has the potential to be used for applications such as electronic road pricing, car park management system, detecting stolen vehicles, etc.

References

1. T. Semertzidis K. Dimitropoulos A. Koutsia N. Grammalidis: 'Video Network for Real-Time Traffic Monitoring and Surveillance', Published in IET Intelligent Transport Systems, Vol. 4, Issue 2, 2010 pp. 103–112.

2. Thirde, D.; Borg, M.; Ferryman, J.; Fusier, F.; Valentin, V.; Bremond, F.; Thonnat, M..: 'A Real-Time Scene Understanding System for Airport Apron Monitoring'. Proc. Fourth IEEE International Conference on Computer Vision Systems, January 2006,pp 26-26.

3. Panos G. Michalopoulos: 'Vehicle Detection Video Through ImageProcessing: The Autoscope System'IEEE Transactions on Vehicular Technology, Vol.40**,** 1991,pp 21-29.

4. Pavlidou, N.; Grammalidis, N.; Dimitropoulos, K.; Simitopoulos, D.; Strintzis, M.; Gilbert, A.; Piazza, E.; Herrlich, C.; Heidger, R.;.: 'Using Intelligent Digital Cameras to Monitor Aerodrome Surface Traffic', IEEE Intelligent System, 2005, vol.20, issue (3), pp. 76–81.

5. Dimitropoulos, K.; Grammalidis, N.; Simitopoulos, D.; Pavlidou, N.; Strintzis, M.; 'Aircraft Detection and Tracking Using Intelligent Cameras'. IEEE International Conference on Image Process, 2005, vol.2, pp. 594–597.

6. YI WANG., MENTORS: PIETRO PERONA., CLAUDIO FANTI.: 'Foreground-Background Segmentation of Video Sequences'. 19th British Machine Vision Conference. Vol. 24, 2008, pp 473-482.

7. Piccardi, M.; "Background subtraction techniques: a review." Systems, Man and Cybernetics, 2004 IEEE International Conference, Vol 4, 2004, pp.3099-3104.

8. Stauffer, C.; Grimson, W.E.L.; "Adaptive Background Mixture Models for Real-Time Tracking." Proc. IEEE Conference. CVPR, Vol. 1, pp 22-29, 1999.

9. Fathy.M and Siyal.M.Y; "A Window-Based Image Processing Technique or Quantitative and Qualitative Analysis of Road Traffic Parameters". IEEE transactions on Vehicular technology, VOL. 47, NO. 4, NOVEMBER 1998