Traffic Signal Time Control using Vision based Traffic Flow analysis

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Abstract – *Traffic monitoring plays an important role in intelligent transportation systems (ITSs). In this paper a traffic signal time control system is presented. This system depends on the traffic flow analysis using computer vision. Road intersection is monitored using cameras and fast image processing is used to analyze the video stream. Background subtraction is used to detect the motion of vehicles then a segmentation module is used. Some heuristic and rules are used to classify the objects and count the traffic on each direction. The time of green light is increased for the more crowded directions. Fast and accurate results are obtained using the proposed model.*

Key Words: intelligent transportation systems(ITS), vehicle counting, vision systems, traffic signal control (TSC) .

1.INTRODUCTION

The timing of traffic signal has a direct impact on the utilization of available infrastructure. There are two mode of traffic signals operation , pre-timed traffic signals, and actuated or controlled traffic signals. In pre-timed mode a control circuits provide a repetitive cycle and split timing. This timing is repeated over and over regardless of the absence or presence of traffic demand as shown in fig.1. The controlled traffic signals use vehicle sensors or detectors to measure the traffic in the different directions and adjust the timing of the traffic signals based on these measurements. This can achieve a large improvement in traffic flow, fuel consumption, pollution ,…etc. There are many technologies to sense and detect vehicles. Inductive-loop traffic detectors, can be used to detect vehicles at a specified location. RADAR and LIDAR technologies also can be used.

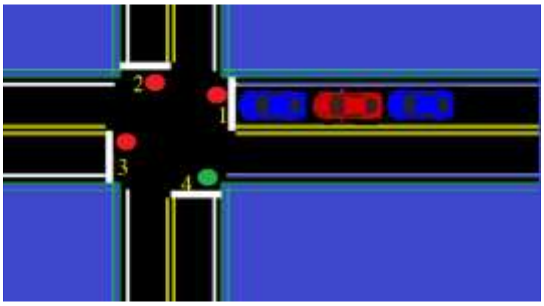


Fig.1: pre-timed traffic signal

In this paper we focus on computer vision techniques to detect vehicles and measure the traffic in the different roads and directions. Vision based techniques are flexible , cheap , and can be installed easily. Vision systems can cover wide area using a single camera. Fig.2 shows the field of view of a single camera fixed and directed to a single direction. A single intersections needs at least four cameras to monitor the traffic in all directions. Omnidirectional cameras have a wider field of view but needs more processing to rectify the captured images. The rest of the paper is organized as follows: section 2 gives related work. The vision system used in this work is discussed in section3 . Experimental setup and results are illustrated in section4. Conclusion is given in section 5.

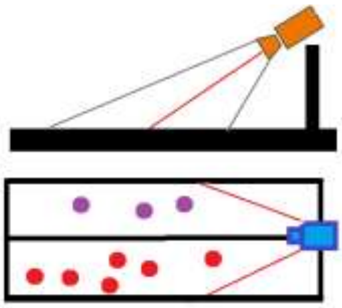


Fig.2: Camera Field of view

2. Related Work

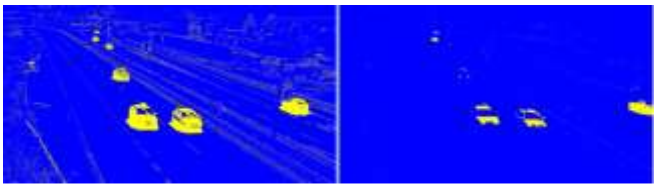
Recently, more and more researchers investigated the real time vision based transportation surveillance system[2][4][7]. Stefan et.al worked in a Vision-Based system to Collision

Prediction at Traffic Intersections[2]. They Monitor traffic at intersections in real time and predict possible collisions. This system was able to perform in real time on videos with (320 × 240) resolution under various weather conditions. Chowdhury et.al have developed a Real Time Traffic Density Measurement using Computer Vision. They measure the traffic density at the intersections by real time video. A video sample was collected. A mixture of Gaussian algorithm was used for background subtraction method . An automated traffic monitoring system using computer vision have been developed by Poddar .et.l[13]. They have implemented a system which measures the number of vehicles and checks for speed limit violation. They have achieved an accuracy of 98.96% for vehicle count detection and an accuracy of 98.14% for speed violation detection. Li ,et.al. developed a real-time detection, tracking, and counting system for moving vehicles[9]. They implemented the system using OpenCV. Malhi, .et.al have worked in vision based intelligent traffic management system[11]. They have proposed a simple and efficient algorithm to calculate the number of vehicles at various signals on a road to efficiently manage the traffic. Dynamic background subtraction technique and morphological operations for vehicle detection have been used to achieve better detection efficiency. A vision based adaptive traffic signal control system was developed by Deng, Lawrence Y., et al [5]. They used vision based techniques such as object segmentation, classification, and tracking get real time measurements in urban road. According to the real time traffic measurement, they derived the adaptive traffic signal control algorithm to adjust the red–green time of traffic lights. A survey of vision-based traffic monitoring of road intersections can be found in [4]. A dataset called ParalleEye consists of a large collection of virtual images for traffic vision research can be found in [10]. More systems related to vision based traffic management can be found in [1][3][6][13].

3. Vision System for Traffic monitoring

In this system, the traffic is measured in 4 directions and based on these measurements the time of green light is changed to give best capacity of the intersection. The four direction in this system are given numbers for simplicity from 1 to 4. Number 1 represents East-West direction ,2 for North-South ,3 for West-East, and finally 4 for South-North direction. The vision system starts with receiving a video stream then the analysis and information extraction is applied to this stream. The first step is background subtraction to detect the vehicles in a special region represents the area of road to be analyzed.

a)Background b)Frame



c) subtraction with different threshold values.

d) Region of Interest

Fig.4: background Subtraction

In Fig.4 the background subtraction process is illustrated with different values of threshold. A small values of threshold clarify the object to be detected but add noise to the image. Increasing the threshold value remove noise but can discard some important objects. The region of interest indicated in fig.4 (d) represents the area where objects should be considered. Objects detected outside this region are neglected. The background subtraction is implemented using the following equation

$$S(i,j)= \begin{cases} 1 & \text{if } |Fr(i,j) - Bk(I,j)| > Thresh \\ 0 & \text{otherwise} \end{cases}$$

where S is the result image , Fr is the frame image , and Bk is the background image.

After background subtraction , the segmentation process is applied. In the segmentation process the related pixels are grouped into objects. Many challenges are found during this process. Sometimes single object is divided into two segments, or two objects are connected and looks like a single object.

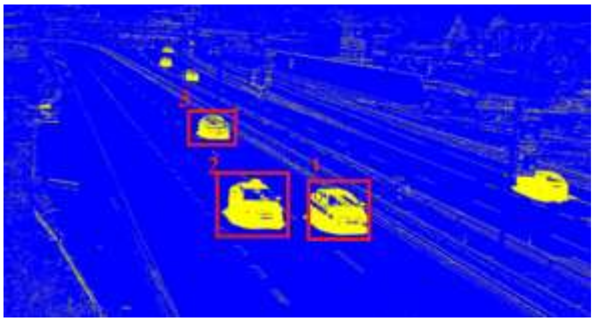


Fig5: Segmentation and Counting

Each detected segment is checked and verified to remove noise from counting. The count of pixels, the location and the features of the object indicate if it is a vehicle or it is just a noise.

4. Experimental Setup and Results

A software system is developed to detect car and analyze traffic. This system depends on the four phases traffic signal timing model[6][8]. In this model the timing of the traffic signal is divided into four phases, where each phase represents the time of green light for one direction. The directions are given numbers from 1 to 4. The green light time is increased if the car count is large for this direction. The source video can be captured from camera or loaded from video for testing. Fig.6 illustrates the system. For a resolution of 640 X 480 a speed of 5 ms is obtained for background subtraction. This time is increased for higher resolutions. Table-1 shows the time taken for background subtraction for different resolutions. The time for segmentation and counting also is shown in Table-1 which indicates the real time speed of the system.

Fig.6: Traffic Signal time control system

Table -1: Processing speed

Frame resolution	Back. Subtraction	Segmentation and Counting
1920 x1080	20 ms	23 ms
800×600	7 ms	8 ms
640×480	5 ms	6 ms

5. CONCLUSION

Vision based traffic monitoring is very important in the intelligent transportation systems. The proposed model of the vision system consists of background subtraction followed by segmentation and counting achieves very good results and high speed. The system fails in some situation where cars are very closed. This system can be improved by the addition of model based car detection add counting.

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