

A Novel Scheme for Real Time Road Traffic Control System

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Abstract

This paper primarily aims at the new technique of video image processing used to solve problems associated with the real-time road traffic control systems. There is a growing demand for road traffic data of all kinds. Increasing congestion problems and problems associated with existing detectors spawned an interest in such new vehicle detection technologies. But the systems have difficulties with congestion, shadows and lighting transitions. Problem concerning any practical image processing application to road traffic is the fact that real world images are to be processed in real time. Various algorithms, mainly based on back ground techniques, have been developed for this purposes since back ground based algorithms are very sensitive to ambient lighting conditions, they have not yielded the expected results.

This paper will give a general overview of the image processing technique used in analysis of video images, problems associated with it, methods of vehicle detection and tracking, pre-processing techniques and the paper also presents the real-time image processing technique used to measure traffic queue parameters. Finally, general comments will be made regarding the extensibility of the method and the scope of the new queue detection algorithm will be discussed.

Index Terms — Traffic control, monitoring vehicle, road traffic, Traffic surveillance and control, traffic management, road safety and development of transport policy.

1. INTRODUCTION

In normal traffic light system, the traffic signals are changed in the predetermined time. This method is suitable when the no of vehicles in all sides of a junction are same (fig 1). But when there is an unequal no of vehicles in the queues (fig 2) this method is inefficient. So we go for the image processing techniques using queue detection algorithm to change the traffic signals.

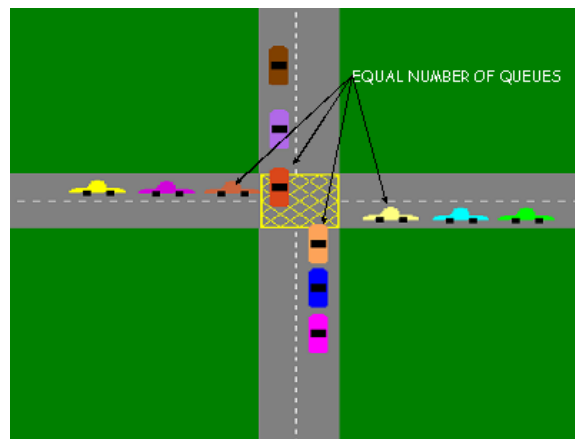


Fig 1

1.1 SCOPE OF TRAFFIC CONTROL

- ✓ Increasing demand for road traffic data of all sorts
- ✓ Variation of parameters in real-world traffic
- ✓ Aimed to measure queue parameters accurately
- ✓ Algorithm has two operations : vehicle detection and motion detection
- ✓ Operations applied to profiles consisting sub-profiles to detect queue

- ✓ Motion detection is based on applying a differencing technique on the profiles of the images along the road.

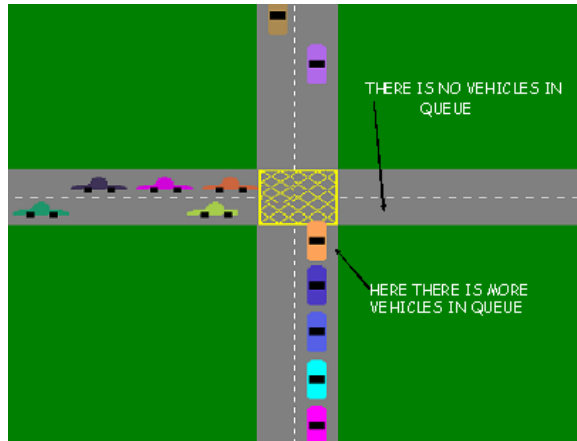


Fig 2

2. IMAGE PROCESSING APPLIED TO TRAFFIC

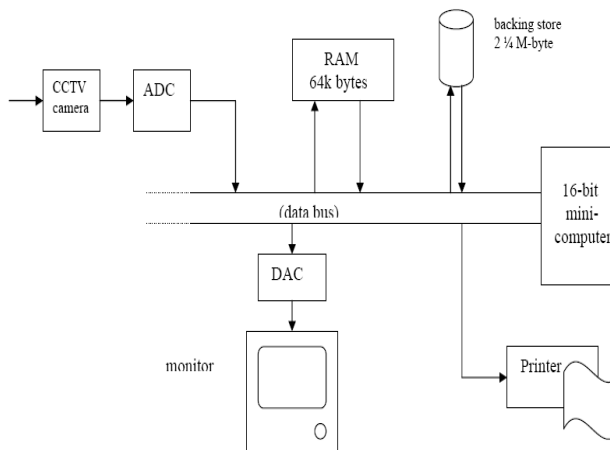
2.1 NEED FOR PROCESSING OF TRAFFIC DATA

Traffic surveillance and control, traffic management, road safety and development of transport policy.

2.2 TRAFFIC PARAMETERS MEASURABLE

Traffic volumes, Speed, Headways, Inter-vehicle gaps, Vehicle classification, Origin and destination of traffic, Junction turning.

2.3 IMAGE ANALYSIS SYSTEM STRUCTURE



2.4. STAGES OF IMAGE ANALYSIS

Image sensors used: Improved vision cameras: automatic gain control, low SNR

ADC Conversion: Analog video signal received from video camera is converted to digital/binary form for processing

Pre-processing: High SNR of the camera output reduces the quantity of processing enormous data flow.

To cope with this, two methods are proposed:

1. Analyze data in real time - uneconomical
2. Stores all data and analyses off-line at low speed. Pipeline Preprocessing does this job

3.1 STAGES IN PIPELINE PREPROCESSING

Spatial Averaging – contiguous pixels are averaged (convolution)

Subtraction of background scene from incoming picture.

Threshold – Large diff.s are true ‘1’, small diff.s are false ‘0’

Data Compression – reduces resulting data.

Block buffering – collects data into blocks.

Tape Interface – blocks are loaded onto a digital cassette recorder Preprocessed picture is submitted to processor as 2-D array of no.s.

TWO JOBS TO BE DONE

Green light on - determine no. of vehicles moving along particular lanes and their classification by shape and size.

Red light on - determine the backup length along with the possibility to track its dynamics and classify vehicles in backup.

4. METHODS OF VEHICLE DETECTION

Background frame differencing: -grey-value intensity reference image

Inter-frame differencing: -incoming frame itself becomes the background for the following frame

Segmentation and classification: -Sub division of an image into its constituent parts depending on the context

4.1 QUEUE DETECTION ALGORITHM

Approach described here is a spatial-domain technique to detect queue - implemented in real-time using low-cost system .For this purpose two different algorithms have been used.

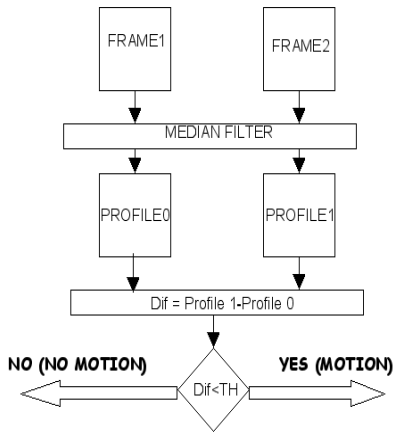
4.1.1 Motion detection operation, Vehicle detection operation

Motion detection is first – as in this case vehicle detection mostly gives positive result, while in reality, there may not be any queue at all. Applying this scheme further reduces computation time.

5. MOTION DETECTION OPERATION

BLOCK DIAGRAM:

The vehicle detection is based on applying edge detection on these profiles



- a) Differencing two consecutive frames.
- b) Histogram of the key region parts of the frames is analyzed by comparing with the threshold value.
- c) Key region should be at least 3-pixel-wide profile of the image along the road.
- d) A median filtering operation is firstly applied to the key region (profile) of each frame and one-pixel-wide profile is extracted.
- e) Difference of two profiles is compared to detect for motion.
- f) When there is motion, the differences of the profiles are larger than the case when there is no

motion. The motion can be detected by selecting a threshold value.

5.1 MOTION DETECTION ALGORITHM

THEORY BEHIND

The profile along the road is divided into a number of smaller profiles (sub-profiles) The sizes of the sub-profiles are reduced by the distance from the front of the camera. Transformation causes the equal physical distances to unequal distances according to the camera parameters.

Knowing coordinates of any 6 reference points of the real-world condition and the coordinates of their corresponding images, the camera parameters (a11, a12...a33) are calculated. The operations are simplified for flat plane traffic scene - (Zo=0).

$$\begin{pmatrix} X_o & Y_o & 1 & 0 & 0 & 0 & -X_o & -Y_o & Y_o \\ 0 & 0 & 0 & X_o & Y_o & 1 & -X_o & -Z_1 & Y_o \end{pmatrix} \begin{pmatrix} a_{11} \\ a_{12} \\ a_{13} \\ a_{21} \\ a_{22} \\ a_{23} \\ a_{31} \\ a_{32} \\ a_{33} \end{pmatrix} = \begin{pmatrix} X_1 \\ Y_1 \end{pmatrix}$$

Solving matrix equation for camera parameters

Above equation is used to reduce the sizes of the sub-profiles - each sub profile represents an equal physical distance.

No. of sub profiles depend on the resolution and accuracy required. The length of sub-profile should be about length of the vehicle - both the detection algorithms work accurately then.

6. VEHICLE DETECTION ALGORITHM

Following the application of the motion detection operation, a vehicle detection operation is applied on the profile of the unprocessed image. To implement the algorithm in real time, two strategies are often applied: key region processing and simple algorithms. Most of the vehicle detection algorithms developed so far are based on a background differencing technique, which is sensitive to variations of ambient lighting. The method used here is based on applying edge detector operators to a profile of the image – Edges are less sensitive to the variation of ambient lighting and are used in full frame applications (detection).

Edge detectors consisting of separable medium filtering and morphological operators, SMED (Separable The)Morphological Edge Detector) are applied to the key regions of the image. (SMED approach is applied (f) to each sub-profile of the image and the histogram of each sub-profile is processed by selecting Dynamic left-limit value and a threshold value to detect vehicles.

SMED has lower computational requirement while having comparable performance to other morphological operators. SMED can detect edges at different angles, while other morphological operators are unable to detect all kinds of edges.

7. LEFT-LIMIT SELECTION PROGRAM

This program selects a grey value from the histogram of the window, where there are approx. zero edge points above this grey value. When the window contains an object, the left-limit of the histogram shifts towards the maximum grey value, otherwise it shifts towards the origin. This process is repeated for a large no. of frames(100),and the minimum of the left-limit of these frames is selected as the left-limit for the next frame

8. THRESHOLD SELECTION PROGRAM

The no. of edge points greater than the left limit grey value of each window is extracted for a large no. of frames (200) to get enough parameters below and above a proper threshold value. This nos. are used to create a histogram where it's horizontal and vertical axes correspond to the no. of edge points greater than left limit and the frequency of repetition of these numbers for a period of operation of the algorithm (200 frames). This histogram is smoothed using a median filter and we expect to get two peaks in the resulted diagram, one peak related to the frames passing a vehicle and the other related to the frames without vehicles for that window.

However, as it can be seen in the figure given below, there are other numbers of edge points (32-40) between peaks 20 & 60, which are related to those vehicles in each profile. We use statistical approach based on selecting a point on the horizontal axis, where the sum of the entropy of the points above and below this point is maximum. This point is selected as the threshold value for the next period.

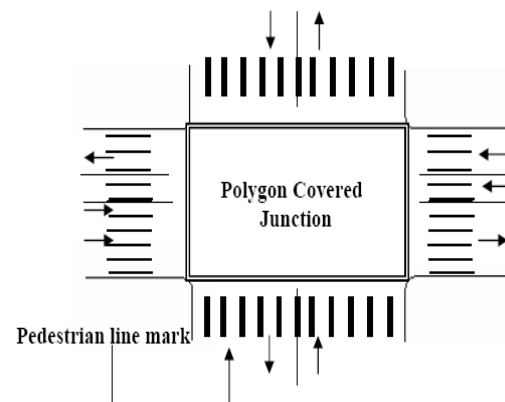
9. TRAFFIC MOVEMENTS AT JUNCTIONS (TMJ)

Measuring traffic movements of vehicles at junctions such as number of vehicles turning in a

different direction (left, right, and straight) is very important for the analysis of cross-section traffic conditions and adjusting traffic lights. Previous research work for the TMJ parameter is based on a full-frame approach, which requires more computing power and, thus, is not suitable for real-time applications. We use a method based on counting vehicles at the key regions of the junctions by using the vehicle-detection method.

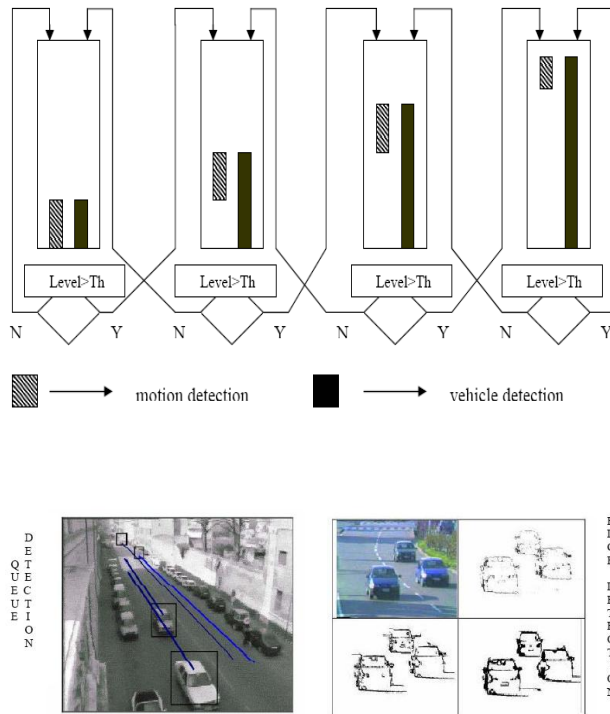
The first step to measure the TMJ parameters using the key region method is to cover the boundary of the junction by a polygon in such a way that all the entry and exit paths of the junction cross the polygon. However, the polygon should not cover the pedestrian marked lines. This step is shown in the figure given below. The second step of the algorithm is to define a minimum numbers of key regions inside the boundary of the polygon, covering the junction. These key regions are used for detecting vehicles entering and exiting the junction, based on first vehicle –in first-vehicle-out logic. Following the application of the vehicle detection on each profile, a status vector is created for each window in each frame.

If a vehicle is detected in a window, a “one” is inserted on its corresponding status vector, otherwise, a “Zero” is inserted. Now by analyzing the status vector of each window, the TMJ parameters are calculated for each path of the junction.



10. RESULTS AND DISCUSSIONS

The main queue parameters we were interested in identifying were the length of the queue, the period of occurrence and the slope of the occurrence of the queue behind the traffic lights. To implement the algorithm in real-time, it was decided that the vehicle detection operation should only be used in a sub-profile here we expect the queue will be extended. The procedure is as follows:



11. CONCLUSION

Algorithm measuring basic queue parameters such as period of occurrence between queues, the length and slope of occurrence has been discussed. The algorithm uses a recent technique by applying simple but effective operations. In order to reduce computation time motion detection operation is applied on all sub-profiles while the vehicle detection operation is only used when it is necessary. The vehicle detection operation is a less sensitive edge-based technique. The threshold selection is done dynamically to reduce the effects of variations of lighting. The measurement algorithm has been applied to traffic scenes with different lighting conditions. Queue length measurement showed 95% accuracy at maximum. Error is due to objects located far from camera and can be reduced to some extent by reducing the size of the sub-profiles.

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