International Journal of Research in Engineering, Science and Management
Volume-3, Issue-1, January-2020
www.ijresm.com | ISSN (Online): 2581-5792

Traffic Density Estimation in Traffic System Using Image Processing

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***Abstract*: Due to the increase in the number of vehicles day by day, traffic congestions and traffic jams are very common these days. In the modern world urban centres are growing at a very high rate especially traffic jams have become routine. One method to overcome the traffic problem is to develop an intelligent traffic control system which is based on the measurement of traffic density on the road using real time video and image processing techniques. In this paper, a simple and elegant approach for estimating the road traffic density during daytime using image processing the video data collected is first broken into frames which is then processed in a series of steps finally the vehicle are detected and extracted from the images and counted. Then the traffic density is obtained as the number of vehicles per unit area of the road section. The proposed approach was implemented in MATLAB R2015a and average vehicle detection accuracies of 96.0% and 82.1% were achieved for fast moving and slow moving traffic scenes respectively. The theme of this is to control the traffic by determining the traffic density on each side of the road and control the traffic signal intelligently by using the density information. This paper presents the algorithm to determine the number of vehicles on the road. The density counting algorithm works by comparing the real time frame of live video by the reference image and by searching vehicles only in the region of interest (i.e. road area). The computed vehicle density can be compared with other direction of the traffic in order to control the traffic signal smartly. The use of traffic monitoring techniques based on image processing could be very useful. In this paper you will know the system that estimates the rates at an urban crossroad by processing the sequence of images taken by a video camera is presented. This type of estimation is segmentation, and moving object tracking techniques are used thus the system will automatically estimate the traffic density of each road which will help to determine the duration of each traffic light. An intelligent traffic signal control system with the proposed traffic density estimation technique will be far better than the conventional timer based system image captured with cameras will be used for the detection of traffic density for the intelligent traffic control system. As populations as well as number of vehicles are increasing in the cities and towns, traffic congestion has become a major problem for the time being. Delays, fuel consumption and air pollution are some of the problems arise from traffic. In this paper, we proposed a system to overcome some these problems by providing an alternate route for the vehicles by predicting a possible congestion ahead of that road.**

Many traffic light systems operate on a timing mechanism that changes the lights after a given interval. An intelligent traffic light system senses the presence or absence of vehicles and reacts accordingly. The idea behind intelligent traffic systems is that drivers will not spend unnecessary time waiting for the traffic lights to change. An intelligent traffic system detects traffic in many different ways: Millions of vehicles pass via roads and cities every day. Various economic, social and cultural factors affect growth of traffic congestion. The amount of traffic congestion has major impacts on accidents, loss of time, cost of money, delay of emergency, etc. Due to traffic congestions there is a loss in productivity from workers, people lose time, trade opportunities are lost, delivery gets delay, and thereby the costs goes on increasing. To solve these congestion problems, it is better to build new facilities and infrastructure but at the same time make it smart.

***Keywords*: Traffic density estimation, Image processing.**

1. Introduction

Traffic lights play an important role in traffic management. In 1868, the traffic lights only installed in London and today these have installed in most cities around the world. Sometime the vehicles on the red light side have to wait for green signal even though there is little or no traffic. It results in the loss of valuable time. Several attempts have been made to make traffic light’s sequence dynamic so that these traffic lights operate according to the current volume of the traffic. Most of them use the sensor to calculate current volume of traffic but this approach has the limitation that these techniques are based on counting of the vehicles which means it considers a small vehicle (such as motorcycle) and a big vehicle (such as truck) as the same count and so provides similar pass through time(green signal) for small as well as big vehicles.

The system using image processing has been implemented where upon the density or fraction of area of road covered by vehicles is estimated and then time for green signal light is controlled accordingly. Technically, this system is based on computers and cameras. The project components includes: (A) hardware model (B) software model.

Our project focuses primarily on the following objectives:

- To design a system which will detect and track vehicles via camera and neglect objects which are not vehicles?
- To develop an algorithm for the above mentioned concept.
- To develop a communication interface between the control unit and traffic signals.

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2. Proposed methodology

A. Procedure

1) Phase-1

Initially image acquisition is done with the help of video camera. First image of the road is captured, when there is no traffic on the road. This empty road's image is saved as reference image at a particular location specified in the program. RGB to gray conversion is done on the reference image. Now gamma correction is done on the reference gray image to achieve image enhancement. Edge detection of this reference image is done thereafter with the help of horizontal and vertical filters and normalization.

2) Phase-2

Images of the road are captured. RGB to gray conversion is done on the sequence of captured images. Now gamma correction is done on each of the captured gray image to achieve image enhancement. Edge detection of these real time images of the road is now done with the help of horizontal and vertical filters and normalization.

3) Phase-3

After edge detection procedure both reference and real time images are matched and traffic lights can be controlled based on percentage of matching (Effective density). If the matching is between 0 to 10% - green light is on for 90 seconds. If the matching is between 10 to 50% - green light is on for 60 seconds. If the matching is between 50 to 70% - green light is on for 30 seconds. If the matching is between 70 to 90% - green light is on for 20 seconds. If the matching is between 90 to 100% red light is on for 60 seconds.

B. Operations

1) Image acquisition

The first stage of any image processing operation is the image acquisition stage. Acquired images are shown in Fig1, Fig. 2, Fig. 3, Fig. 4 & Fig. 5. After the image has been obtained, various methods of processing can be applied to the image to perform the many different tasks required today. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement. Digital image acquisition is the creation of digital images, typically from a physical scene. The term is often assumed to imply or include the processing, compression, storage, printing, and display of such images. The most usual method is video camera but other methods are also employed.

Fig. 1. Road with no traffic

Fig. 2. Road traffic status at time t1

Fig. 3. Road traffic status at time t2

Fig. 4. Road traffic status at time t3

Fig. 5. Road traffic status at time t4

2) Image Enhancement

The acquired image in RGB is first converted into gray. Now we want to bring our image in contrast to background so that a proper threshold level may be selected while binary conversion is carried out. This calls for image enhancement techniques. The objective of enhancement is to process an image so that result is more suitable than the original image for the specific application. There are many techniques that may be used to play with the features in an image but may not be used in every case. Listed below are a few fundamental functions used frequently for image enhancement.

1. Linear (negative and identity transformations)
2. Logarithmic (log and inverse log transformations)
3. Power law transformations (gamma correction)
4. Piecewise linear transformation functions

The third method i.e., power law transformation has been used in this work.

$$S=C\gamma \quad (1)$$

The power law transformations have the basic form Where S is output gray level, r is input gray level, c and γ are positive constants.

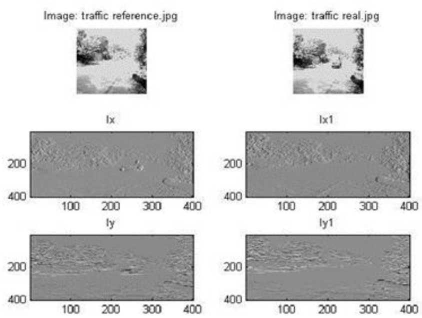


Fig. 6. Grey scale conversion and edge detection

3) Edge detection

Edge detection is a fundamental tool in image processing and computer vision, particularly in the areas of feature detection and feature extraction, which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The same problem of finding discontinuities in 1D signal is known as step detection. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. It can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond to,

1. Discontinuities in depth,
2. Discontinuities in surface orientation,
3. Changes in material properties and
4. Variations in scene illumination
5. Image matching

Edge based matching is the process in which two representatives of the same objects are paired together. Any edge or its representation on one image is compared and evaluated against all the edges on the other image. Then these edge detected images are matched and accordingly the traffic light durations can be set. Fig 6 & 7 shows the edge detected images. These cameras will take frames of the four ways at time t1, t2…etc. And these frames will be given to an image processing tool to find out the effective density of each frame and based on this result traffic light will be controlled. In this work instead of four videos we are considering video of a single road. At time t1, we are having frame number 1 and its effective density is calculated by image processing. We have selected a threshold for effective traffic density.

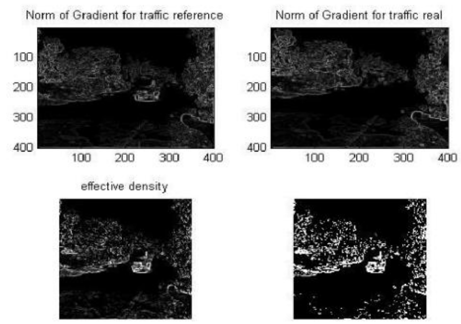


Fig. 7. Effective traffic density on the road

- Read video from camera or file (let the user decide the input).
- Colour space converter to convert the image from RGB to intensity format.
- Detect foreground using Gaussian mixture models.
- Analyze frames to segment vehicles in the video.
- Write the number of vehicles being tracked.
- Define region of interest (ROI)
- Remove the effect of sudden intensity changes due to camera's auto white balancing algorithm.
- Based on dimensions, exclude objects which are not vehicles. When the ratio between the area of the blob and the area of the bounding box is above certain percentage. (to be calculated later) classify it as a vehicle.
- Draw bounding rectangles around the detected vehicles.
- Display the number of vehicles being tracked.
- Provide User interface setting to adjust the traffic light according to number of vehicles on the road.
- Also provide maximum time on green light irrespective of the number of vehicles. (To be adjustable by user).

3. Processing unit

- Send out DTMF signal through audio port of pc/laptop. The DTMF signal from audio port is connected to DTMF receiver.
- The output from DTMF receiver circuit is connected to one of the input/output port of Atmega 16 microcontroller.
- Atmega 16 is programmed in such a way as to control the traffic light time according to area of traffic at a lane of intersection.

4. Foreground segmentation

Motion is a particularly important cue for computer vision. In such cases, it is common for moving objects to be referred to as the foreground and stationary objects as the background.

A classic example from the literature is automatic traffic flow analysis [4] in which motion is used to differentiate between vehicles (the foreground) and the roadway (the background). In image analysis, foreground segmentation is the first step of many different image analysis applications, such as automated visual surveillance, video indexing, and human machine interaction. A typical approach to Foreground segmentation is background subtraction which has very low computational cost. However, one drawback of traditional background subtraction is that it is vulnerable to environmental changes. One of the popular approaches, Gaussian Mixture Models (GMM) proposed by Stauffer and Grimson [5] is robust to gradual illumination as well as moving background regions. However, it is not robust to sudden illumination changes, foreground objects could be integrated into the background model if they remain static for a long period of time, and it has a relatively higher computational cost.

5. Results and discussion

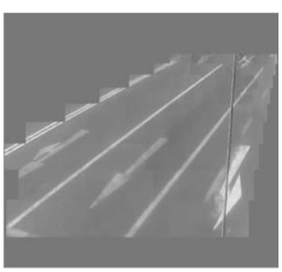
A. *Traffic Density Estimation*

The first part of the proposed analysis is background construction. The performance of the algorithm is measured by the accuracy of the constructed background image. Some experiments have been done on the lane of the intersection controlled by a traffic light. The algorithm meets the best result when the signal light is green.

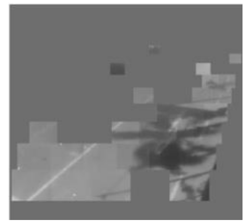
Fig. 4 shows the background image result of the intersection lanes shown in Fig. 1

Lane 1

Lane 2



Lane 3



Lane

Fig. 8. The background image result

The background images are accurately constructed on Lane 1, 2, and 3. When vehicle move on green time, the distance between vehicles is larger than the ROI size. On Lane 3, the tree shadows and any static object appear on camera are introduced as background images. Meanwhile, in a heavy traffic of Lane 4, the majority of the distance between vehicles is smaller than ROI size. In the later case, the background images are not constructed in entire ROI and the traffic of the lane is concluded to the congestion state.

6. Gaussian mixture model

In statistics, a mixture model is a probabilistic model for representing the presence of subpopulations within an overall population, without requiring that an observed data set should identify the sub-population to which an individual observation belongs. Formally a mixture model corresponds to the mixture distribution that represents the probability distribution of observations in the overall population. However, while problems associated with "mixture distributions" relate to deriving the properties of the overall population from those of the sub-populations, "mixture models" are used to make statistical inferences about the properties of the sub populations given only observations on the pooled population, without sub-population identity information.

A Gaussian Mixture Model (GMM) is a parametric probability density function represented as a weighted sum of Gaussian component densities. GMMs are commonly used as a parametric model of the probability distribution of continuous measurements or features in biometric system. GMM parameters are estimated from training data using the iterative Expectation-Maximization (EM) algorithm or Maximum a Posteriori (MAP) estimation from a well-trained prior model [6]. Let X is a random variable that takes these values. For a probability model determination, we can supposed to have mixture of Gaussian distribution as the following form

7. Experiment results

Experiments are carried out and depending upon the intensity of the traffic on the road we get the following results regarding on time durations of various traffic lights.

The study showed that image processing is a better technique to control the state change of the traffic light. It shows that it can reduce the traffic congestion and avoids the time being wasted by a green light on an empty road. It is also more consistent in detecting vehicle presence because it uses actual traffic images. Overall, the system is good but it still needs improvement to achieve a hundred percent accuracy. The table shows the effective traffic density at different times t1, t2, t3 and t4. Based on this effective traffic density signal decision can be made so that congestion is avoided.

Table 1
Effective density at four different

Frame number	Effective density
1)	11.0262
2)	11.3631
3)	8.8963

8. Conclusion

In the present work, a new image processing technique was developed to estimate the traffic density of the road. Those comprehensive works can be concluded as follows:

1. The background image can be constructed by detecting the image area containing static object lying in front of or behind the image area contain of moving object. The image area edge detection is used to verify the image area as the part of background image.
2. Traffic density can be estimated by calculating the ratio between the number of the ROI containing object and the total number of ROI.
3. The developed image processing technique is able to estimate the traffic density with higher accuracy and more time-efficient than any other techniques based on macroscopic approach.

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