Image Processing Based Traffic Density Estimation and Control at Intersection

Saima Beg, Krishna Chandra Shukla, Archana Yadav

***Abstract*— 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.**

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 [1].

***Index Terms*— Traffic density count, image processing, intelligent controlling of traffic.**

I. 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 [2, 3].

Our project focuses primarily on the following objectives:

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

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II. PROPOSED METHODOLOGY

[Refer to figure 1]

- 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).

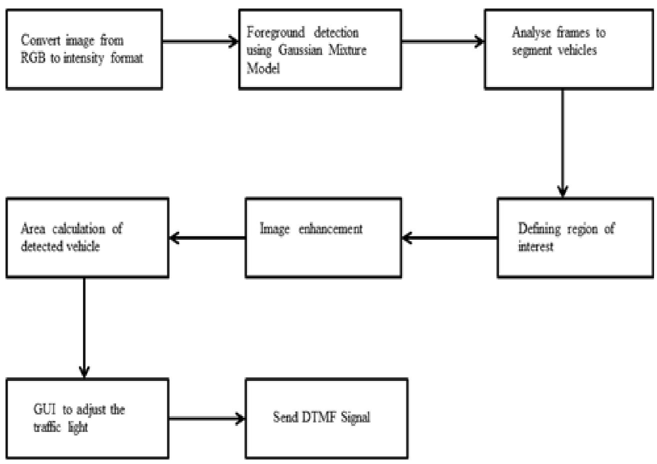


Fig.1 Image

III. .Processing Unit

[Refer to figure 2]

- 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.

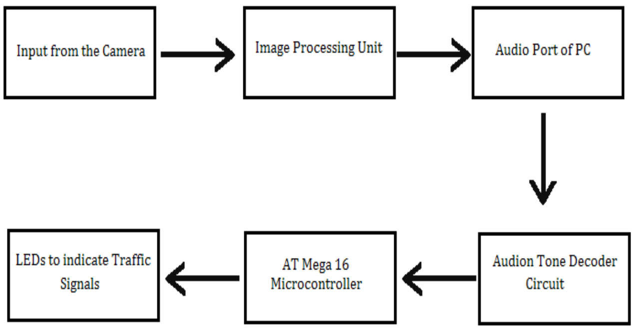


Fig.2 General Block Diagram

IV. 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.

V. 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 suppose to have mixture of Gaussian distribution as the following form

$$f(x) = \sum_{i=1}^{k} p_i \, N(x|\mu_i, \sigma_i^2) \qquad (1)$$

Where k is the number of regions and pi > 0 are weights such that $\sum_{i=1}^{k} p_i$ =0 (Refer eq. 1),

$$N(\mu_i, \sigma_i^2) \frac{1}{\sigma\sqrt{2\pi}} exp \frac{-(x-\mu_i)^2}{2\sigma_i^2} \qquad (2)$$

Where μ_i and σ_i are mean, standard deviation of class i (Refer eq. 2). For a given image X, the lattice data are the values of pixels and GMM is our pixel base model. However, the parameters are

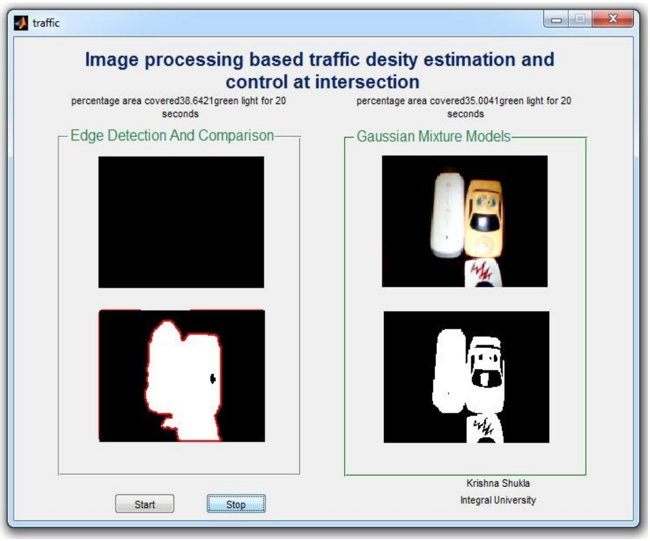
$$\theta = (p_1, \dots, p_k, \mu_1, \dots, \mu_k, \sigma_1^2, \dots, \sigma_k^2)$$

and we can guess the number of regions in GMM by histogram of lattice data.

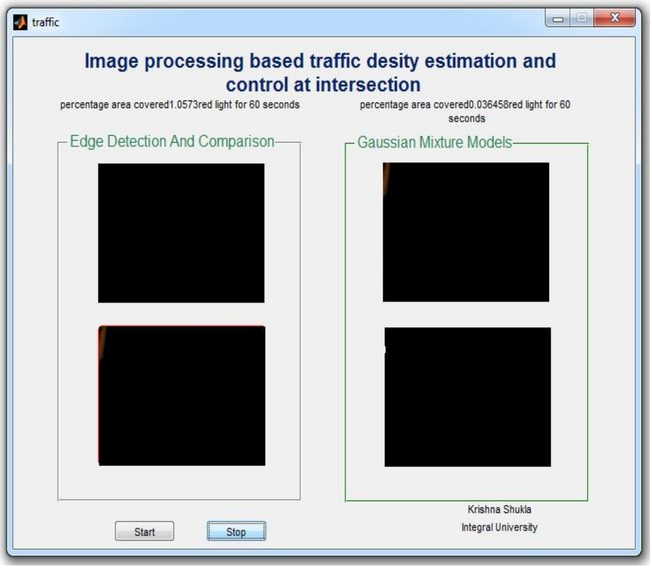
VI. EXPERIMENT RESULTS

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 varioustraffic lights.

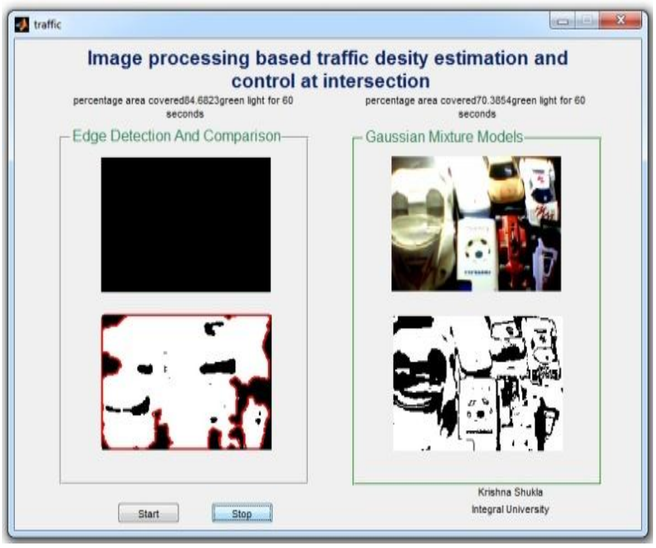
RESULT1



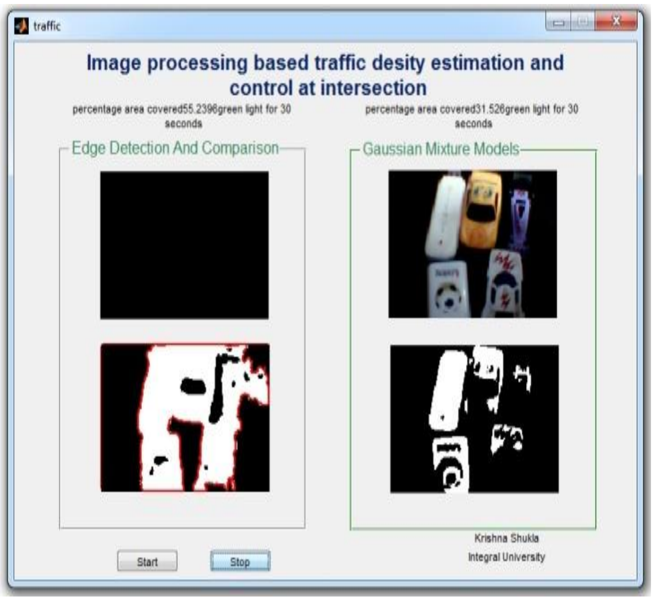
RESULT2



RESULT3



RESULT4



VII. SUMMARY AND CONCLUSIONS

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.

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