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Traffic Control System Based on Density of Vehicles Using Image Processing

Kamalam Balasubramani
Associate Professor/Department of ISE
Atria Institute of Technology, Bangalore

Ranganath R
Student/Department of ISE
Atria Institute of Technology, Bangalore

***Abstract*—In this paper we propose a method that determines the traffic congestion on the roads based on the total area occupied by the vehicles. Generally, every traffic signal in the junction will be assigned a constant green signal time. It is possible to propose a dynamic time-based coordination scheme where the green signal time of the traffic lights is set based on the current traffic conditions. We calculate the density from the total area of vehicles on the road based on which green light signal time can be set to fit the traffic environment at any junction.**

Index terms – Traffic Congestion, Vehicles, Density, Traffic light.

I. INTRODUCTION

Traffic congestion has become a major problem in the entire world. The problem of traffic on the roads creates a hectic environment. Hence, controlling the traffic is challenging task. Alsothere will be a lot of time as well as fuel wastage of the vehicles on the road. The most common reason of traffic congestion in all the countries is an inefficient traffic signal controlling system which affects the traffic flow.

For the reliable transportationsystem it is more important to have an intelligent traffic control system. In recent days image processing techniques [1] has been very promising topic to deal withtraffic related problems because of its ability to deal with the real time condition.The very first step goes with acquiring traffic information. Different techniques [2] to [5] have been proposed to acquire traffic information. Most ofthe work either propose a constant green light time to be set for any traffic conditions, or detects the edges of the vehicles and counts the numberof vehicles on the road. However, the first method is not a good approach to deal with varying traffic on the road and the disadvantage in second method is that counting the number of vehicles may give incorrect results (i.e.when the space between the vehicles on the road is smaller, then both the vehicles will be treated as one object).

In this paper we propose a system for controlling the traffic light using image processing techniques. The system will detect vehicles through images instead of using electronic sensors embedded in the flagstone. A camera will be installed alongside the traffic light. It captures images. We employa new method that finds total amount of pixels in the image which corresponds tothe amount of area occupied by the vehicles on the road ratherthan finding number of vehicles. The greater the area occupied by vehicles on the road the greater is the traffic congestion. In this way every kind of vehicles canbe accounted for traffic density. Using this information we set the signal time to vary according to the requirements.

II. SYSTEM MODEL

Traffic information is extracted in the form of images. A web camera placed at appropriate position is employed for image acquisition. The camera captures the images of the roads. Two types of images are used for processing, one is the foreground image and other one is the background image. The foreground image is the image of the road with vehicles and background image is the image of the same road without vehicles.The architecture diagram of the proposed system is shown in Figure 1.

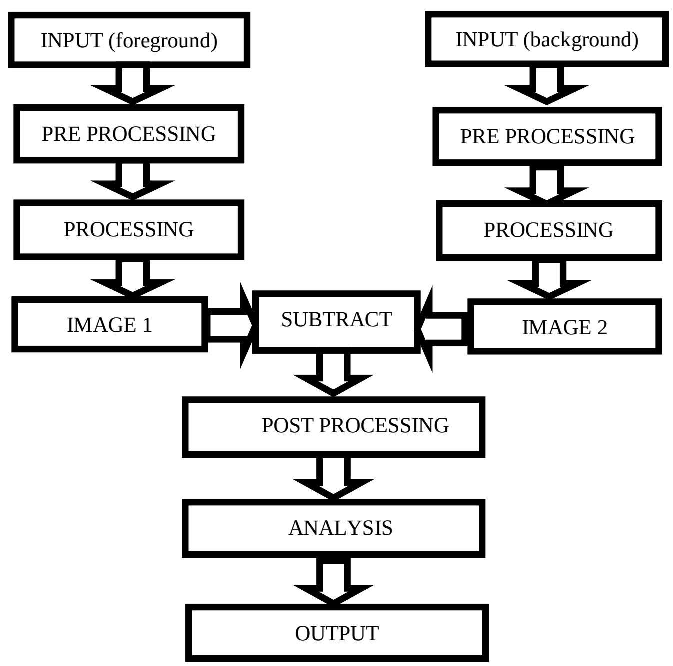


Figure 1: Proposed system architecture

The working of proposed system is given below:

A. *Input module*

The colored foreground and background images are captured by placing camera at a particular location[6]. The background image which is captured will be fixed for any particular junction and foreground images are captured whenever there is need to monitor the traffic. The foreground and background images are shown in figure 2(a) and 2(b) respectively.

B. Pre-processing module

The input foreground and background images are resized to reduce the processing complexity. These RGB (color) images are then converted to its grayscale equivalent using equation (1).

$$I = 0.33 * R + 0.33 * G + 0.33 * B \quad \ldots\ldots\ldots\ldots\ldots (1)$$

In equation (1) the R, G and B variables represent red, green and blue value of each pixel respectively. To improve the quality of input images wiener filter is used. Wiener filter [10][13]has the ability to remove the additive noise and invert the blurring simultaneously.Wiener filter is an adaptive noise-removal filter. It uses a pixel-wise adaptive Wiener method based on statistics estimated from a local neighborhood of each pixel.The resulting Foreground and Background images from this module are shown in Figure 2(c) and Figure2(d) respectively.

C. Processing module

Segmentation of the objects (vehicles) is carried out by detecting the boundaries of theobjects[8]. Sobel edge detecting[7] technique is used to perform edge detection. In this method, edges are detected using the Sobel approximation to the derivative. It returns edges at those points where the gradient of image (I) is maximum. It performs two dimensional gradient measurement using convolution kernel. If the input image is I, horizontal and vertical gradient is measured with equations (2) and (3) respectively. The final gradient is calculated using equation (4). This gives us processed foreground image FGp as shown in Figure 3(a). The same operations are performed to the background image which gives processed background image BGp as shown in Figure 3(b).

$$Sx = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} * I \ldots\ldots\ldots\ldots\ldots (2)$$

$$Sy = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * I \ldots\ldots\ldots\ldots\ldots (3)$$

$$BGp = \sqrt{Sx^2 + Sy^2} \ldots\ldots\ldots\ldots\ldots (4)$$

D. Subtraction module

This is the crucial step in the system. To accomplish this task background subtraction method [9] is used. The background subtraction method is particularly suitable for detecting a foreground objects on fixed background. Here basic mathematical subtraction is performed as shown in equation (5), where the background image is subtracted from the foreground image to detect the foreground objects. In addition, subtracting a fixed value will reduce the small intensity pixels from the resulting image (containing foreground objects) as shown in equation (6). The output of this module is the image with vehicles on the road. The output of the subtraction method is shown in Figure 4.

$$Obj = FGp - BGp \quad \ldots\ldots\ldots\ldots\ldots (5)$$

$$Obj = Obj - 0.007 \quad \ldots\ldots\ldots\ldots\ldots (6)$$

E.Post-Processing module:

This step includes following operations

a) Morphological closing
b) Flood filling
c) Binary conversion

The morphological closing operation [11]is used to close the objects detected from the subtraction module. An appropriate structuring element is chosen to close the objects. Morphologicalclosing essentially performs dilation of image followedby erosion of the same image using the same structuring element for both. It closes thegrayscale image with the structuring element. Structuring element must be a single, as opposed to an arrayof objects. Image can be any numeric or logical class and can be of any dimension, and must be non-sparse. If the image is logical, then structuring element must be flat.Mathematically this operation can be represented by equation (7).

$$I\_filled = Obj * S = (Obj + S) - S \quad \ldots\ldots\ldots\ldots\ldots (7)$$

Here (+) represents dilation and (-) represents erosion on the image. Sis a 6 * 6 matrix having all elements equal to 1. The resulting closed image is shown in Figure 5.

In case of any holes being unclosed in morphological closing technique can be closed using the flood filling operation[12]. If there is any gap within the closed boundary object it can be filled by using flood fill method, we then convert this image into binary image using suitable threshold. Otsu’s method [14] is used to obtain the threshold T needed to convert grayscale image to binary image. But to enhance the binary image quality we multiply the threshold by a factor found by equation (8). Then binary image is obtained using equation (9) and the image is shown in Figure 6.

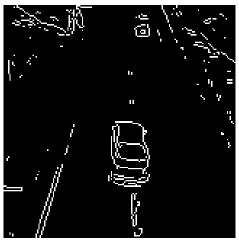
$$factor = \begin{cases} 0.8 & if\ Max(I\_filled) \geq 0.5 \\ 0.2 & else \end{cases} \quad \ldots\ldots\ldots\ldots\ldots (8)$$

$$I_{\_binary} = \begin{cases} 1 & if\ pixelvalue \geq T \times factor \\ 0 & else \end{cases} \quad \ldots\ldots\ldots\ldots\ldots (9)$$

Figure2(a) Figure 2(b)

Figure2(c) Figure 2(d)

Figure 2(a) Input Foreground image, Figure 2(b) Input Background image, Figure 2(c) pre-processed Foreground image Figure2(d)pre-processed Background image.



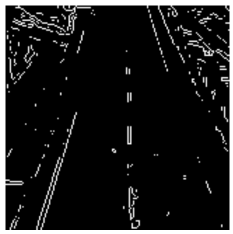
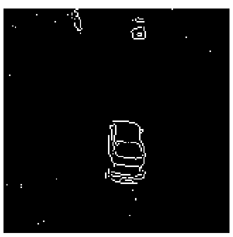


Figure 3(a) Figure 3(b)

Figure 3(a), Edge detected foreground image Figure 3(b), Edge detected background image



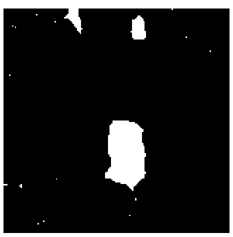


Figure 4 Figure 5 Figure 6

Figure 4, Image containing only vehicles on the road (subtraction module).

Figure 5, Morphologically closed image. Figure 6, Binary image.

F. Analysis

The binary image consists of only two values, ones and zeros. This helps to obtain the density of the objects on the road. We now calculate the total amount of white pixels(WP) in the image(that corresponds to number of ones in the binary image) using equation (10). And also we calculate the total amount of pixels (TP) in the image (that corresponds to total pixels including both zeroes and ones in the binary image). Now we find the total density(TD) of the objects in the image as given in equation (11).

$$WP = \sum_{i=1}^{R} . \sum_{j=1}^{C} I\_binary \ldots\ldots\ldots\ldots (10)$$

Where R is the number of rows in I_binary image and C is the number of columns in the I_binary image.

$$TD = (WP) / (TP) \quad \ldots\ldots\ldots\ldots\ldots (11)$$

G. Output

After calculating the density of the image we set time limit of the green signal (Gs) based on the density obtained in equation (11). Green Signal Time (Gs) is the total time required for one full completion of the green signal light at any traffic point. This signal time is taken as a function of total traffic density (TD) of vehicles represented as (12).

$$Gs = f(TD) \quad \ldots\ldots\ldots\ldots\ldots (12)$$

The output is set by performing simple multiplication. For example, if the density obtained is D%, and maximum green light time that can be allowed (set ON) on any side of the road is G seconds. Then the green light time of that road is calculated as given in equation (13).

$$Gs = (D \times G) \div 100 \quad \ldots\ldots\ldots\ldots\ldots (13)$$

Also the green light signal time is directly proportional to the density calculated. The denser the traffic, longer is the green signal time. This method is applied for longer duration when there is more traffic (as in peak hour) so that more vehicles can pass at a time. When there is less traffic, the green signal time is shortened so that vehicles on the other end need not have to wait for a longer period of time in signal transitions.

III. RESULTS AND DISCUSSION

The proposed system is simulated using MATLAB R2011b [15].Traffic images (both background and foreground images) captured at different junctions using an USB based camera is used as input and Traffic Density and Green Signal Time are the output generated by the system. Simulated GUI, designed to fit the real time signaling system is shown in Figure 8.

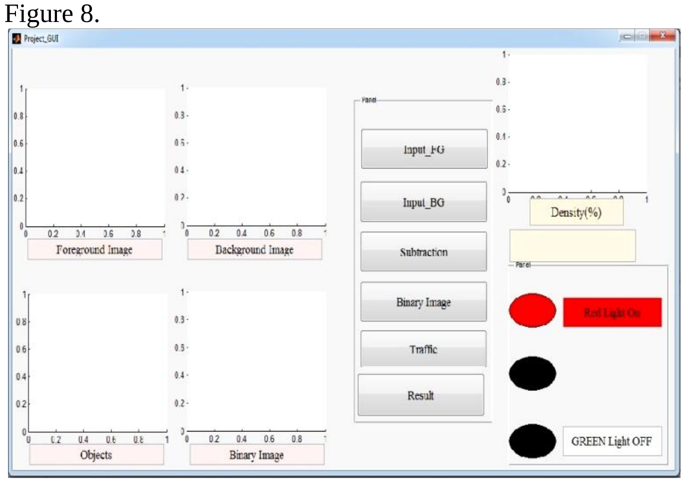


Figure 8, GUI design to match the real time system

In Figure 8, theInput_FG button and Input_BG button are used to read the Foreground and background images respectively, which are displayed on suitable axes in the GUI. The subtraction button reflects the output showing only objects. Binary_Image displays the binary equivalent of the subtracted image after post processing operation. Finally the Traffic button computes and displays the density, and a click on Results button will simulate the traffic lights as shown in Figure 9.

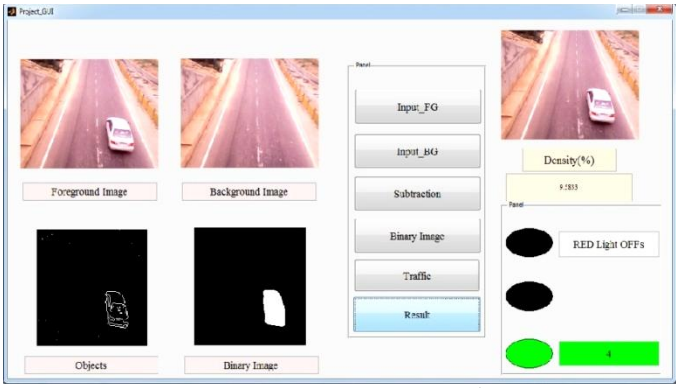


Figure9, GUI representing the output of the system

Figure 9 shows the density on the road of around 10% for the car and the maximum green light signal time to be set as 4 seconds which decreases to zero and red light switches ON as shown in Figure 8.

IV. Performance Evaluation

Table 1, Performance of the existing system v/s proposed system

System Performance			
Number of vehicles	**Existing System Green Light Time(in seconds)**	**Proposed System**	
		Green Light Time (in seconds)	**Density**
2	60	8	13.33%
4	60	16	26.66%
7	60	28	46.66%
15	60	60	100%

Performance is evaluated by comparing the traffic signal time with different number of vehicles in the existing and proposed system and is shown in Table 1. In the existing system, irrespective of the number of vehicles, the traffic green signal is ON for 60 seconds but in the proposed system, green signal time is set based on the density of vehicles.

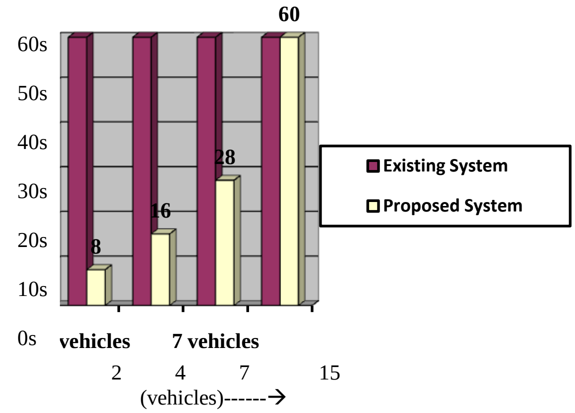


Figure 1[illegible]al time.

Figure 10, shows the graph comparing green signal time set in the existing and proposed method based on the number vehicles on the road. In existing system, no matter whatever be the number of vehicles the signal time is constant, say for 60 seconds. Whereas in proposed system the signal time depends on the number of vehicles. It increases with increase in number of vehicles. Thus we can maintain longer cycle for denser traffic and shortened cycle for lighter traffic.

V. Conclusion

In the existing traffic controlling system,generally each traffic light in thejunction is assigned a constant green signal timewhich leads to traffic congestion. The proposed system usesforeground image (with vehicles) and the background image (without vehicles) of the road to calculate density on the road. This dynamic time-based coordination scheme helps to set the green signal time of the traffic light based on the current traffic conditions. Hence, the time being wasted by a green light for an empty road can be avoided and thus can clear the traffic congestion on the other side of the road.This model could be extended to incorporate a large number of interconnected traffic junctions by using their traffic densities to adjust adjacent junction's time allocation.

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Authors Profile

Kamalam B, Associate Prof., Dept of ISE, Atria Institute of Technology,Bangalore. Her reasearch interest includes Image Processing,Swarm Intelligence.

Ranganath.Rreceived the **B.E.** degree in Information Science engineering from the Atria Institute of Technology, Bangalore, VTU,Belagavi,India, in 2015. His research interest includes image processing, Mobile Ad hoc networks ,ComputerNetworks.