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A Methodology to Control Traffic Signal Based On Image Processing Technique

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ABSTRACT:
Urban intersections are a primary concern for traffic engineers; they are the location of many accidents and the cause of most urban delay. There is fixed time slot for each intersection, so there is unnecessary waiting time for the vehicles even though there is less traffic density or no vehicles on other intersections. The aim of this paper is to minimize the waiting time at traffic signals (4-leg intersection and Pedestrian Crossing) resulting in time loss and wastage of fuel, thus it is significant to control the traffic signals in an effective manner. This paper concentrates on Model/Solution for traffic management at T intersection (Three and multiple legged intersections).
KEYWORDS: Dilation, erosion, imsubtract, imread, imerode, imdilate, MATLAB®, Sobel operator

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I. INTRODUCTION

As the number of vehicle in urban areas is ever increasing, it has been a major concern of city authorities to facilitate effective control of traffic flows in urban areas. Especially in rush hours, even a short period of poor control at traffic signals may result in a long-time traffic jam causing a chain of delays in traffic flows. The total amount of accumulated delay time in a city due to waiting at signal stops is enormous if it is counted on an annual basis. As the population of the modern cities is increasing day by day due to which vehicular travel is increasing which lead to congestion problem. Traffic congestion has been causing many critical problems and challenges in the major and most populated cities. The increased traffic has lead to more waiting times and fuel wastages. Due to these congestion problems, people lose time, miss opportunities, and get frustrated.
Traffic load is highly dependent on parameters such as time, day, season, weather and unpredictable situations such as accidents, special events or constructional activities. If these parameters are not considered, the traffic control system will create delays. To solve congestion problem new roads are constructed. The only disadvantage of making new roads on facilities is that it makes the surroundings more congested. So, for that reason there is a need to change the system rather than making new infrastructure twice. A traffic control system can solve these problems by continuously sensing and adjusting the timing of traffic lights according to the actual traffic load is called an Intelligent Traffic control System. The advantages of building Intelligent Traffic Control System which reduce congestion; reduce operational costs; provide alternate routes to travelers, increases capacity of infrastructure. One such traffic control system can be built by image processing technique like edge detection to find the traffic density, based on traffic density can regulate the traffic signal light [1].
The edge detection methods based on difference operation are used widely in image processing. It could detect the variation of gray levels, but it is sensitive to noise. Edge detection is an important task in image processing. It is a main tool in pattern recognition, image segmentation, and scene analysis. An edge detector is basically a high pass filter that can be applied to extract the edge points in an image [2]-[3]. This paper discusses the approach to reduce waiting time of vehicles at four way intersection. Approach explains image processing using edge detection and calculate the count of vehicles in an image based on which traffic timer controller fluctuate its time.

II. EXISTING SYSTEM

The following are the existing system used to control the traffic and their drawbacks are discussed below: A Microcontroller is a device that control most things around us. The control of traffic lights is well known region where this kind of control system is incorporated, which controls the four arrangements of activity lights at the activity crossing. But, the control isn't adaptable, in view of the state of traffic at the intersection. Or maybe, the on and off eras are settled for the red, green and orange lights. These planning lengths are varied according to the day, the day of the week and so forth. The traditional Vehicle-Actuated Control of isolated intersections attempts continuously to adjust green times. The main disadvantage is that the control algorithm looks only at the vehicles on green while not considering the number of vehicles waiting at red. The simplest type of vehicle-actuated installation has a detector located at a distance A ahead of the stop line at an intersection approach, and a controller sensitive to signals sent by the detector. Simple traffic-actuated signals suffer from some of the same weakness as those of fixed-timed signals. They will work well if the actual traffic flow matches the flow assumed when the unit extension of green was selected. The present traffic control system (TCS) in the metro urban areas of India is inefficient due to randomness in the traffic density pattern throughout the day. The traffic signal timers have a settled era to switch movement between various directions. Due to this, the vehicles have to wait for a long-time span even if the traffic density on another direction is null or very less. On the off chance that the traffic signal timer (TST) can be customized to be controlled with the constantly changing activity thickness, the issue of movement blockage can be diminished to an essentially bring down levels. The conventional signal timing process is tedious and requires considerable measures of physically gathered trac information. Customary time-of-day flag timing designs don't oblige variable and capricious trac requests. This outcome in client protestations, baffled drivers, overabundance fuel utilization, expanded deferrals, and debased security.

III. RESEARCH METHODOLOGY

3.1. Objective of the study

In the past control measures planned to limit postpone for all vehicles utilizing the road system. With increasing concern in the green/environmental issues a range of objective functions must be put forward:

1. Minimize overall delay to vehicles.
2. Minimize delays to public transport.
3. Minimize delays to emergency services.
4. Minimize delays to pedestrians.
5. Equitable distribution of delays between competing traffic.
6. Maximize reliability, i.e. minimize unpredictable variations in journey time for vehicle users.
7. Maximize network capacity.
8. Minimize accident potential for all users.
9. Minimize environmental impact of vehicular traffic (noise, atmospheric pollution, visual intrusion).
10. Energy efficiency.

3.2. Proposed Solution

The proposed framework adjusts the traffic signal timer as per the random traffic density using image processing techniques. This model uses high determination cameras to detect the changing traffic patterns around the traffic signal and controls the signal timer likewise by triggering the signals to the timer control system. The expansion and lessening in traffic congestion straightforwardly relies on the control on the flow of traffic, and henceforth, on the traffic signal timer. Because of this marvel, the vehicles need to confront an unpredictable postponement amid travel in the urban territories. At show, the traffic control systems in India, need knowledge and go about as an open-circle control framework, with no input or detecting system. The point in this work was to enhance the traffic control system by presenting a detecting system, which gives a criticism to the current system; with the goal that it can adjust the changing traffic density patterns and gives essential signs to the controller continuously task. The goal is to plan a smart traffic control system calculation with the utilization of detecting devices and image processing systems. The captured images were to be handled continuously utilizing an image processing toolkit, for example, MATLAB®, and different parameters must be figured to evaluate the density of vehicle traffic in each of the four bearings. The controller needs to execute the created calculation on the traffic signal timer to fluctuate its time.

This independent control system comprises of four noteworthy elements:

1. High resolution image capturing device.
2. Image processing tool e.g. MATLAB®.
3. Microcontroller based traffic light timer control.
4. Wireless transmission of signals.

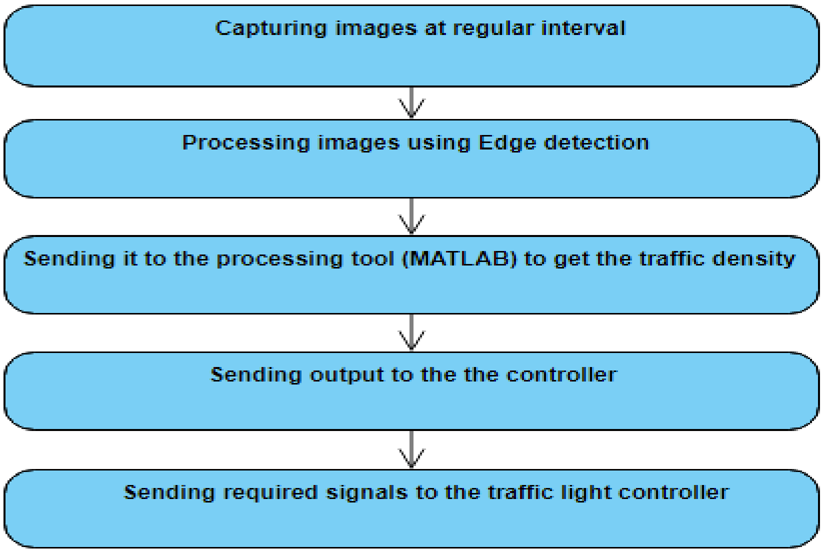

Figure 1. Activity flow of proposed system

3.2.1. Workflow of the System:

Step 1: Edge detection:

An edge in an image is a boundary or contour at which a significant change occurs in some physical aspect of an image, such as the surface reflectance, illumination or the distances of the visible surfaces from the viewer. Changes in physical aspects manifest themselves in a variety of ways, including changes in intensity, color, and texture [4]. Edge is a part of an image that contains significant variation. The edges provide important visual information since they correspond to major physical, photometrical or geometrical variations in scene object. Physical edges are produced by variation in the reflectance, illumination, orientation, and depth of scene surfaces. Since image intensity is often proportional to scene radiance, physical edges are represented by changes in the intensity function of an image Therefore, it should be mandatory to find out the occurrence in perpendicular to an edge [5]. The edge of foreground objects in a digital image is a subset of pixels of that image which does belongs to the objects and is adjacent to the background pixels. The edges extracted from a two-dimensional image of a three-dimensional scene can be classified as either viewpoint dependent or viewpoint independent. A viewpoint independent edge typically reflects inherent properties of the three-dimensional objects, such as surface markings and surface shape. A viewpoint dependent edge may change as the viewpoint changes, and typically reflects the geometry of the scene, such as objects occluding one another [6]. There are many methods for edge detection, but most of them can be grouped into two categories, search-based and zero crossing based. The search-based methods detect edges by first computing a measure of edge strength, usually a first order derivative expression such as the gradient magnitude, and then searching for local directional maxima of the gradient magnitude using a computed estimate of the local orientation of the edge, usually the gradient direction. The zero-crossing based methods search for zero crossings in a second-order derivative expression computed from the image in order to find edges, usually the zero-crossings of the Laplacian or the zero-crossings of a nonlinear differential expression. As a pre-processing step to edge detection, a smoothing stage, typically Gaussian smoothing, is almost always applied [5]. The main objective of edge detection in image processing is to reduce data storage while at same time retaining its topological properties, to reduce transmission time and to facilitate the extraction of morphological outlines from the digitized image. Edge Based System deals mainly with the performance study and analysis of various vehicle density detection methods and design of a new method for counting the number of vehicles from still image. The main work done here is that detecting and counting vehicles in day environment by using real time traffic flux through differential techniques and using lane dividing methods to effectively identify and count vehicles. The result of vehicle counting system can be used to track vehicles in high occlusion areas. Vehicle density at different illuminations can be found to an extent. The Architecture of the system is as shown below [7].

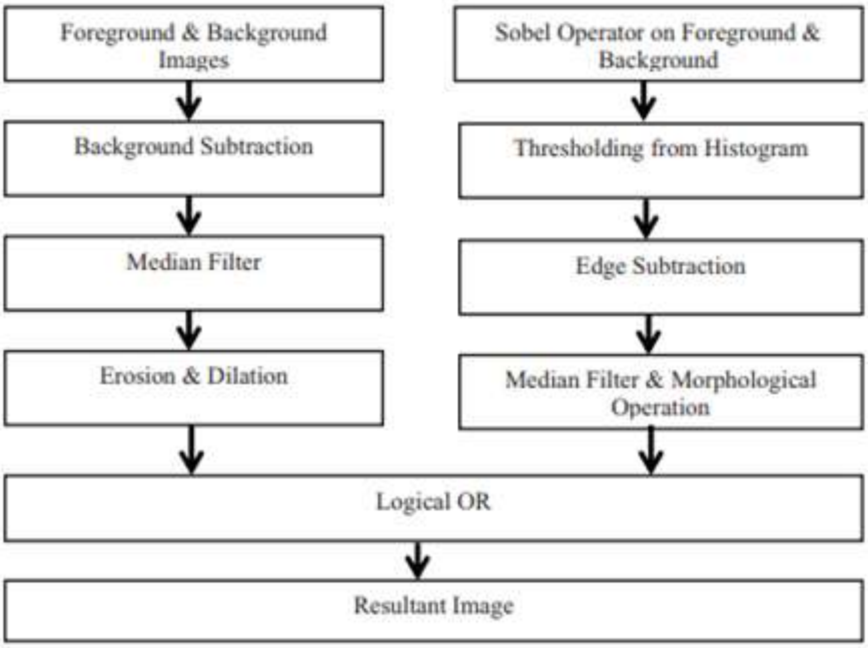

Figure 2. Architecture of Traffic Density Estimation using Edge Detection

In this work, Sobel edge detection operator was chosen since it gave better results than other edge detection operators such as Canny and Roberts during the preliminary tests were carried out. A threshold is applied first on foreground and background images based on the threshold value calculated from the histogram of the foreground and background images. Then background edge image is subtracted from the foreground edge image. Logically the resultant image will have edges of vehicles only with some noise. Again erosion and dilation applied to the detected edge of both the images. Here both erosion and dilation uses the same structuring element i.e. circle shaped structuring element. Then once again erosion is performed using a square shaped structuring element. Finally Logical OR is performed on the resultant images of background subtraction of images and the edge detected on the foreground image. Then the detected vehicles on the images are to be counted.

Algorithm:
1. Initially image acquisition is done with the help of still camera.
2. Background image is subtracted from foreground image.
3. Median filter is applied on the result to remove noise.
4. Morphological erosion is applied on the result with a circular structuring
5. Sobel operator is applied to find the edge images of both foreground and background images.
6. Calculate Histogram for both the foreground as well as the background images. From the histograms, intensities with highest frequencies are found.
7. The above found intensities are applied as threshold on edge images.
8. The resultant background edge image is subtracted from foreground edge image.
9. Median filter is applied to smoothen the result and erosion followed by dilation is applied.
10. Logical OR is applied between the above result and the result of background subtraction.
11. Object counting algorithm is applied on the result to count the number of vehicles in the image.

Step 2: Image Processing and Counting of objects in MATLAB:
1) imsubtract method:
Subtract one image from another or subtract constant from image
Syntax:
Z = imsubtract(X,Y)

Description:
Z = imsubtract(X,Y) subtracts each element in array Y from the corresponding element in array X and returns the difference in the corresponding element of the output array Z.
If X is an integer array, elements of the output that exceed the range of the integer type are truncated, and fractional values are rounded [8].

2) Morphological Erosion and Dilation:

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours. By choosing the size and shape of the neighbourhood, you can construct a morphological operation that is sensitive to specific shapes in the input image [8].

The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image [8].

We can also perform erosion and dilation sequentially.

Erode the image with the structuring element. This removes all the lines, but also shrinks the rectangles [8].

```
BW1 = imread('image.png');
imshow(BW1)

BW2 = imerode(BW1,SE);
imshow(BW2)
```

To restore the rectangles to their original sizes, dilate the eroded image using the same structuring element, SE.

```
BW3 = imdilate(BW2,SE);
imshow(BW2)
```

3) Label Block

The Label block labels the objects in a binary image, BW. The background is represented by pixels equal to 0 (black) and objects are represented by pixels equal to 1 (white). At the Label port, the block outputs a label matrix that is the same size as the input matrix. In the label matrix, pixels equal to 0 represent the background, pixels equal to 1 represent the first object, pixels equal to 2 represent the second object, and so on. At the Count port, the block outputs a scalar value that represents the number of labeled objects [8].

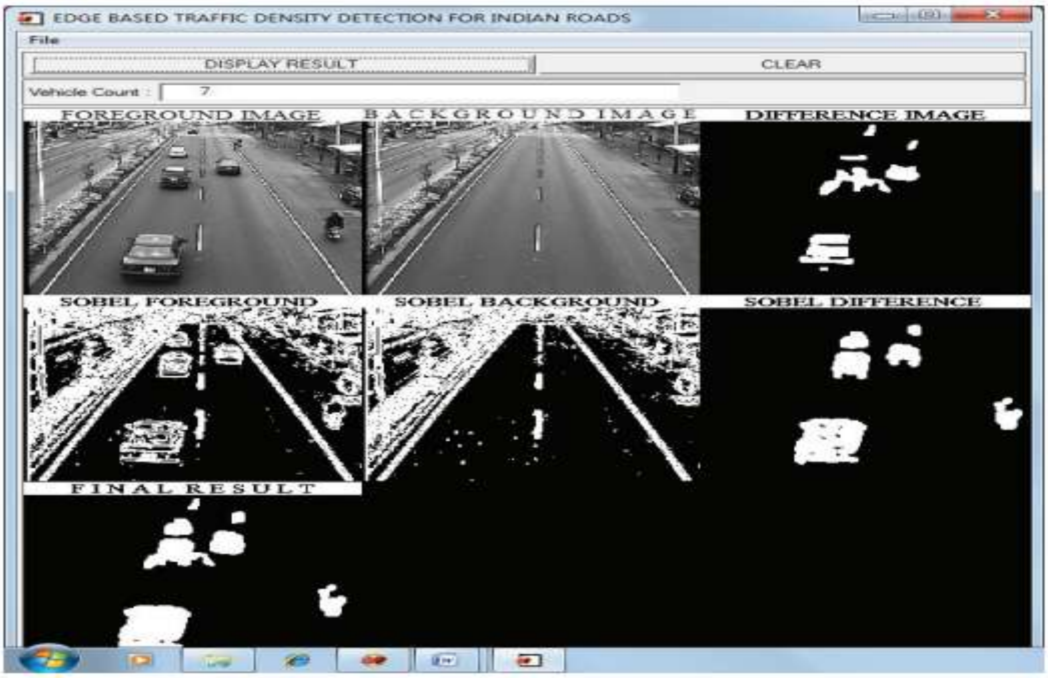

Figure 3: Experimental Result of Medium Traffic Using Edge Detection

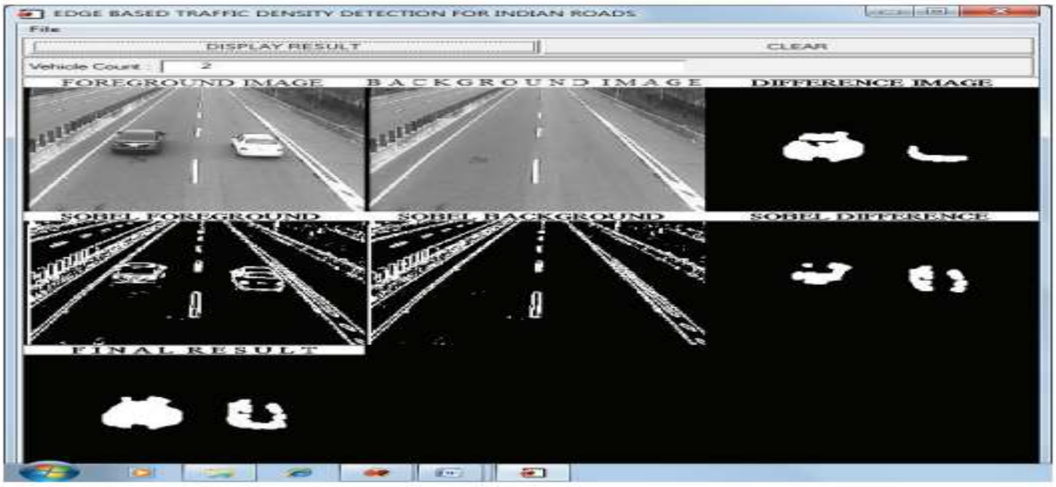

Figure 4: Experimental Result of Low Traffic using Edge Detection.

Step 3: Timing controlling by traffic timer controller

The traffic density is calculated and its value is send to controller for further calculations and timer manipulation As shown in Figure 4, traffic density is low (Count of vehicle is 2) so add 5 seconds more to remaining time period (suppose remaining time period is 15 sec). Due to this waiting time of these 2 vehicles i.e. 30+30=60 seconds can be saved.

	Traffic Density	Conventional System waiting time	Adaptive System	Saved time
Road 1	20	60 sec	30 sec	-
Road 2	30	20 sec	10 sec	-
Road 3	15	40 sec	30 sec	-
Road 4	5	10 sec 5 sec	15 sec (10+5) 5 sec	300 sec (5*60)

Table 1. Timing cycle at 4 way intersection

The table shows the timing cycle at 4 way intersection. At road 4, traffic density is low. As per the conventional system after 10 sec those vehicles have to wait for next 60 seconds. But according to the adaptive system if traffic density is low then add 5 seconds more in order to pass those vehicles, so waiting time of 60 seconds of each vehicle can be saved.

IV. CONCLUSION

In this paper discussed about existing traffic control system and their drawback. We came across different problems faced by the conventional traffic control and tried to overcome those problems can build a flexible traffic light control system based on traffic density. To find traffic density image processing techniques can be used, which ensures free traffic flow, reduced noise pollution, increase in fuel economy, reduction in accident rate and thus contributing to the appraisal of Indian economy.

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