A Survey: Smart Traffic Signal Control System

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ABSTRACT

Traffic congestion is a severe problem in many major cities across the world and it has become a nightmare for the commuters in the cities. Conventional traffic light system is based on fixed time concept allotted to each side of junction which cannot be varied as per varying traffic density at real time. Junction timings allotted can be fixed or varied manually. Sometimes higher traffic density at one side of a junction demands longer Green Light as compared to standard allotted time. There are various methods and algorithm to address this issue such as IR sensors, Loop Detectors, RFID and image processing among which image processing shows better result. The expected system should be designed to automatically control the traffic density at a particular junction by using image processing to have a density based dynamic Traffic Signal system.

Keywords: - Traffic Signal System, Image Processing, Traffic Density, Junction, Signal Patterns.

1. INTRODUCTION

Traffic congestion occurs frequently, which affect daily life. Alleviation of traffic congestion not only improves traffic safety and efficiency but also reduces Environmental pollution. Traffic congestion easily arise during large planned events (e.g. sporting games, parades and conferences, etc.). As the problem of urban traffic congestion spreads, there is a pressing need for the introduction of advanced technology and equipment's to improve the state-of-the-art of traffic control. To improve the current traffic management system we have searched on various methods which mainly involve manual control and automatic control. In manual controlling a person or traffic police control traffic by signboard, sign light and whistle whereas in automatic controlling , traffic light changes by calculating the traffic density by some other control method such as sensors, image processing, detectors and RFID. There are problems of manual control system such as man power, exertion and a lot more which can be solved by automatic control system hence we have concentrated and directed our search towards automatic traffic signal control methods and algorithms.

2. AUTOMATIC TRAFFIC CONTROL METHODS

2.1 Magnetic Loop Detectors:

Magnetic loop detectors use magnetic properties to count the number of vehicles on the road. Current traffic management techniques like magnetic loop detectors in which MLD are buried inside the road. It consists of a small inner loop and a relatively large outer loop[1]. The sensor is capable to provide output information such as individual vehicle speed, type, count and length. Thus vehicles that do not conform to lane discipline and flow in a mixed traffic condition can be detected by placing multiples of proposed loops at the junctions in such a way that, the road width must be covered

[2]. The sensor coil can be placed below or on the surface of the road. There are three different inductive loop structures show in the Fig.1. The small loop designated as Loop 1 intended to detect small vehicles like bicycle, motor bike etc. The large one, indicated as Loop 2 detects large vehicles like bus or car. The third loop structure embedding Loop 1 and Loop 2[4]. The small vehicles such as bicycles goes over the large loop cause no considerable change in the loop inductance, this may lead to a miss detection. Whereas the new Loop 3 give a relative change in inductance similar to Loop 2 when a large vehicle pass over it and give a relative change in inductance similar to Loop 1 when small vehicles pass over it.

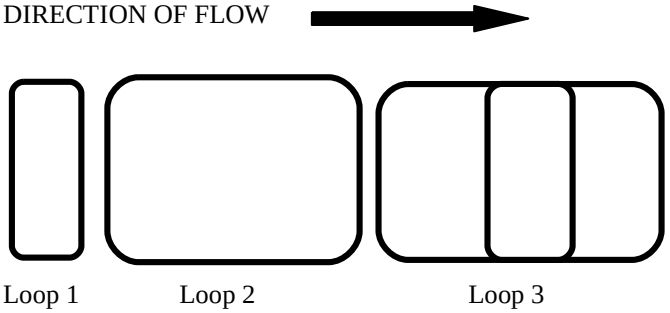

Figure.1: Loop1 small vehicle detector, Loop2 large vehicle detector and Loop 3 new loop detector.

2.2 IR sensors :

IR sensors need to be secured in safe place. Hence this system is expensive to implement. IR sensors are placed in the entire intersecting road at fixed distances from the signal placed in the junction[1]. The time delay in the traffic signal is based on the density of vehicles on the roads. The IR sensors are used to sense the number of vehicles on the road. According to the IR count, micro controller takes appropriate decisions as to which road is to be given the highest priority and the longest time delay for the corresponding traffic lightt[7].

The main blocks of this system consists of:

(1) PIC Microcontroller

(2) Battery

(3) IR sensors

(4) LEDs

During normal time the signal changes automatically on sensing the traffic density at the junction but in case of any emergency vehicle like ambulance, fire brigade etc., requiring priority are built in with RF control to override the set timing by providing instances green signal in the desired direction while blocking the other lanes by red signal for some time. It reduces the possibilities of traffic jams caused by traffic lights to an extent.

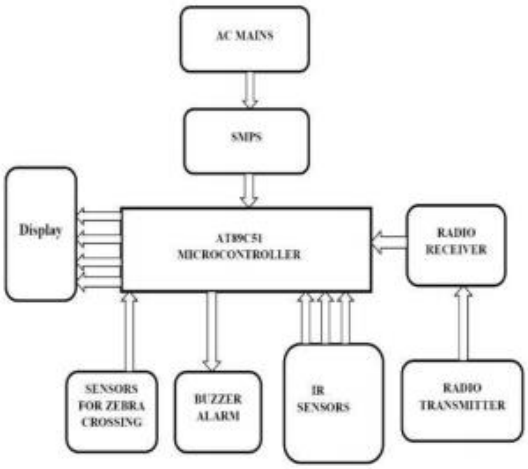

Figure 2. Functional Block Diagram [1]

2.3 Active RFID and GSM technology : System includes active RFID tag, Wireless Coordinator, Wireless Router, GSM modems and a monitoring station software[3]. Data is collected by wireless devices that are mounted along the roadside, from Active RFID tags. Monitoring station collects data through GSM and respond accordingly[3].

(i) check the average speed of vehicles in stretches A, B, C and D as they approach the junction.

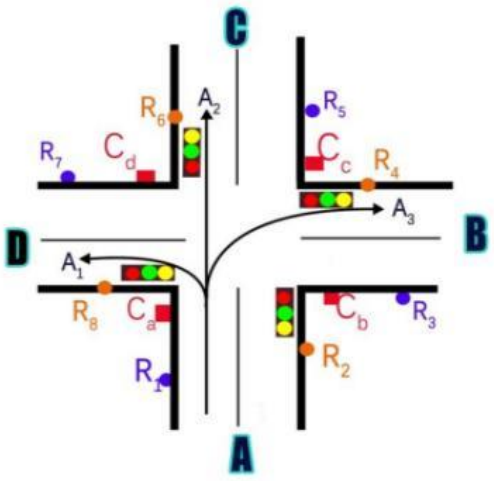

Figure 3. Model junction with RFID devices [4]

(ii) If the average speed of vehicles falls below a threshold at any particular stretch, the system will detect that as congestion and will also measure the intensity of congestion comparing the detected data with the normal traffic speed data already recorded for that stretch. In such a situation, a message is sent to the junction prior to the current junction in that stretch, asking to stop all inflow of traffic in that stretch.

(iii) automatically the system will send another message to the previous junction,notifying to resume flow of vehicles in that stretch.

2.4 Image Processing :

Image Processing is a technique to enhance raw images received from cameras/sensors placed on space probes, aircrafts and satellites or pictures taken in normal day-today life for various applications[1]. An Image is rectangular graphical object. Image processing involves issues related to image representation, compression techniques and various complex operations, which can be carried out on the image data[4]. The operations that come under image processing are image enhancement operations such as sharpening, blurring, brightening, edge enhancement etc. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video; the output of image processing can be either an image or a set of characteristics or parameters related to the image. We propose a system to control traffic light by image processing. The vehicles are detected by the System with the help of images instead of using electronic sensors. A camera will be placed alongside the traffic light. It will capture image sequences. Image processing is a better technique to control the state change of the traffic light. It shows that it can decrease the traffic congestion and avoids the time being wasted by a green light on an empty road. It is also more reliable in estimating vehicle presence because it uses actual traffic images. It visualizes the practicality, so it functions much better than those discussed above.

Paper Title	Methods	Challenges
Smart Traffic Control System with Application of Image Processing Techniques	Roberts Detection Algorithm is used	Noises and scattering of pixels
Real-time Area Based Traffic Density Estimation for Traffic Signal Control System	Magnetic Loop Detectors	High cost and hard implementation
Real time traffic congestion detection and management using Active RFID and GSM technology	RFID and GSM Technology	Complicated and high initial implementation cost
Real time traffic light control using image processing	Canny Edge Detection	Morphological operations

Table 1. Comparative study of methods used in different research papers

3. IMAGE PROCESSING ALGORITHMS

3.1 Edge detection algorithm for image processing :

Three most frequently used edge detection methods are used for comparison. These are (1) Roberts Edge Detection, (2)Sobel Edge Detection, (3) Prewitt edge detection and (4)Canny edge detection. One the other method in edge detections spatial filtering. The details of methods as follows:

3.1.1 The Roberts Detection :

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image[2]. It thus highlights regions of high spatial frequency which often correspond to edges. In its most common usage, the input to the operator is a grayscale image,as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point[5]. Table 1. shows Roberts Mask.

+1	**0**
0	**-1**

Gx

0	**+1**
-1	**0**

Gy

Table 2. Roberts Mask.

3.1.2 The Prewitt Detection:

The prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a rather time consuming calculation to estimate the orientation from the magnitudes in the x and y-directions, the compass edge detection obtains the orientation directly from the kernel with the maximum response. The prewitt operator is limited to8 possible orientations, however experience shows that most

direct orientation estimates are not much more accurate[5]. This gradient based edge detector is estimated in the 3x3neighbourhood for eight directions. All the eight convolution masks are calculated. One convolution mask is then selected,namely that with the largest module.

3.1.3 The Sobel Detection :

Sobel operator is in the form of the filtering operator. It is used to extract the edge. Each point in the image are the two nuclear convolutions. One checks maximum response of the vertical edge, and the other one checks maximum response of the horizontal edge. The maximum value of two convolutions will be referred as output value of the changing point[8]. Sobel operator is easy to achieve in space, has a smoothing effect on the noise, is nearly affected by noise, can provide more accurate edge direction information but it will also detect many false edges with coarse edge width.

-1	**-2**	**-1**
0	**0**	**0**
1	**2**	**1**
-1	**0**	**1**
-2	**0**	**2**
-1	**0**	**1**

Table 3: Sobel Operator

3.1.4 The Canny Detection :

Canny proposed three criteria of the evaluation the pros and cons of performance of edge detection: (1) standard of ratio of signal to noise, that is real edge detection probability is higher and non-edge points sentenced to be lower the probability of edge points, so that the output of ratio of signal to noise is maximum; (2) standard of positioning accuracy, that is there is great possibility that the detected edge points is actually in center of the edge; (3) The unilateral corresponding standard, that is the probability of multiple response in single edge is low, and false edge The response should be the maximum inhibition. Canny operator is based on three criteria. The basic idea uses a Gaussian function to smooth image firstly[5]. Then the maximum value of first derivative also corresponds to the minimum of the first derivative. In other words, both points with dramatic change of gray-scale (strong edge) and points with slight change of gray scale (weak edges) correspond to the second derivative zero-crossing point. Thus these two thresholds are used to detect strong edges and weak edges. The fact that Canny algorithm is not susceptible to noise interference enables its ability to detect true weak edges.

COMPARISON OF EDGE DETECTION

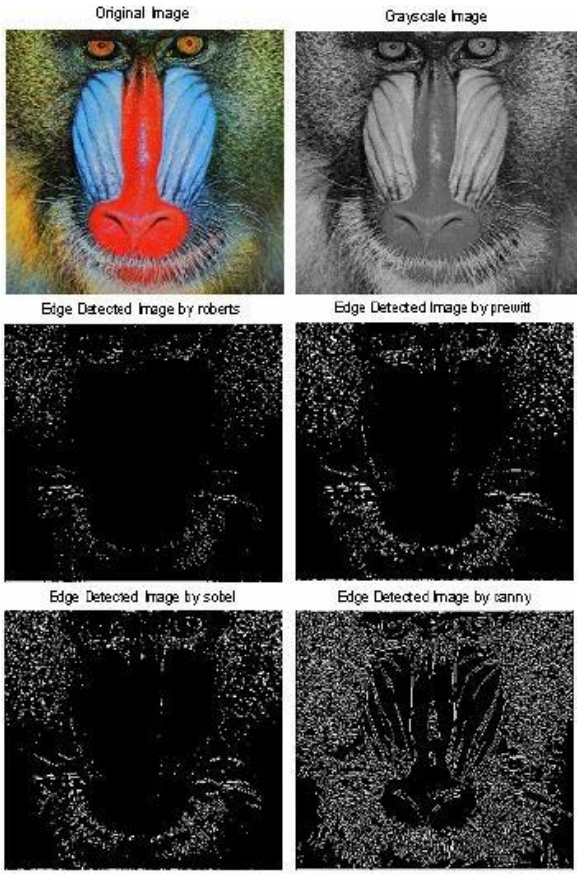

Figure 4. Comparison of images obtained by edge detection algorithms [5]

It can be observed that the output that has been generated by the “Canny detection” has found out the edges of the image more distinctly as compared to the ones that have been found out by Any one of the other edge detection algorithms.

3.2 Filtering algorithms for image processing :

3.2.1 Linear Filters:

Linear filters are used to remove certain type of noise. Here filtering is generally done by blurring the image. These filters blur the edges and destroy the

They have poor performance in removing signal dependent noise. Gaussian and Averaging filters are commonly used linear filters. They are of following types :

1. Gaussian Filter: Gaussian filter is a non-uniform low pass filter[6]. Gaussian filter is used to blur images and remove noise and detail. It does not remove salt & pepper noise effectively

2. Average Filter: The output of average filter is simply the average of pixels contained in the neighborhood of filter mask. It calculates the average of all intensities of the neighborhood of the central pixel and replaces the pixel with that average value[6] . It is mostly used in removing irrelevant details from an image. It has a limitation that it blurs the edges of the image.

3.2.2 Non-Linear Filters:

In recent years, a variety of non-linear filters such as median filter, min filter, max filter have been developed to overcome the shortcoming of linear filter. Non-linear filters exhibit better performance than linear filters.

1. Mean Filter: It is one of the most simplest filter among the existing spatial filters. It uses a filter window which is usually square[2][8]. The filter window replaces the center value in the window with the average mean of all the pixels values in the kernel or window.

2. Median Filter: It is also known as order statistics filter. It is most popular and commonly used non linear filter. It removes noise by smoothing the images. This filter also lowers the intensity variation between one and other pixels of an image[4]. In this filter, the pixel value of image is replaced with the median value The median value is calculated by first arranging all the pixel values in ascending order and then replace the pixel being calculated with the middle pixel value. If the neighboring pixel of image which is to be consider, contains and even no of pixels, then it replaces the pixel with average of two middle pixel values. The median filter gives best result when the impulse noise percentage is less than 0.1 It does not perform well in removing high density salt & pepper noise .

3. Min Filter: Min filter is also known as 0th percentile filter. It replaces the value of pixel by the minimum intensity level of the neighborhood of that pixel[6]. This filter finds darkest points in an image. It removes salt noise from an image containing salt and pepper noise due to its high intensity value.

4. Max Filter: Max filter is also known as 100th percentile filter. It replaces the value of pixel by the maximum intensity level of the neighborhood of that pixel[2][6]. This filter finds brightest points in an image. It removes pepper noise from an image containing salt and pepper noise due to its very low intensity value.

3.3 Adaptive Filters :

These filters works accordingly the statistical characteristics of image inside inside the filter region defined by the mxn rectangular window. They are more complex and gives better performance than existing spatial filters[8]. The most commonly used spatial filter is adaptive median filter which is discussed below :

1. Adaptive Median Filter : It performs well on images containing high density salt & pepper noise. It preserves the details of an image while smoothing non impulse noise[6][1]. It changes its windows size during its operation depending on the certain conditions. It works in two stages. First it calculates the minimum , maximum and median values of sub image window of the corrupted image. In stage one , it checks whether the calculated median itself is a salt or pepper noise or not. If the median is salt or pepper noise, then it increase the size of sub image window and recalculates the minimum, maximum and median values otherwise it proceeds to stage two. In stage two, it checks whether the selected pixel is a salt or pepper noise or not. If it is salt or pepper noise, then it replaces the selected pixel with previously calculated median otherwise the pixel remains unchanged[6].

The comparison results show that Average filter shows better performance in removing Gaussian and Speckle noise while Gaussian filter removes Poisson noise efficiently. The adaptive median filters performed well in removing Salt & Pepper , Uniform, Rayleigh and Erlang noise.

4. PROPOSED SYSTEM

The proposed system adapts the traffic signal timer according to the random traffic density using image processing techniques. This uses cameras to sense the changing traffic patterns around the traffic signal and manipulates the signal timer accordingly by triggering the signals to the timer control system.

(i) Camera Installation: Camera is installed at certain height, which covers the area at certain angle from the horizontal road as [2]shown in figure.

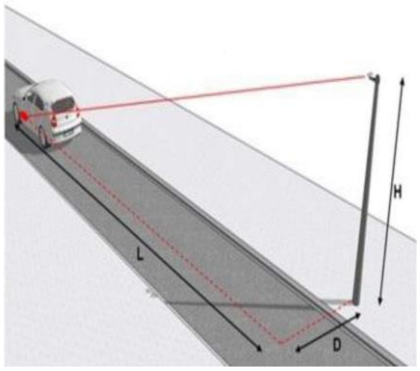

Figure 5: Camera placing [4]

(ii) The objects which is close to camera seems bigger in size and contain more number of pixels in acquired image. Same way objects which are at distant, looks smaller in size and occupies less number of pixel. For this issue camera placement is very important for better vehicle detection and accuracy. Perfect height and angle for camera yield high accuracy for pixel calculation, by ensuring the most area coverage[4].

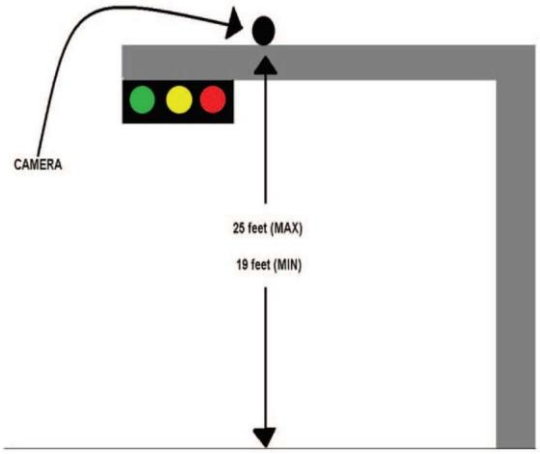

Figure 6: Appropriate height for camera installation [2]

According to expected project. The height must be in a certain range so that the system could detect vehicles and detect as many vehicles as possible in a road. After Taking samples from various heights, we calculated that when the camera's height is in range between 19 feet to 25 it gives us the best result [1]. So, camera's height should not exceed 25 feet otherwise there will be problem to detect vehicles for the system. Any kind of obstacle must not come in front of camera so; it should be placed in such region where clear line of sight is available.

5. CONCLUSION

The study infers that image processing is an efficient and effective method of controlling traffic jam compared to other traditional methods of controlling traffic jam. It works much better and is more consistent compared to systems, which depend on detection of vehicles metal content because it uses actual traffic frames. The use of image processing may help to identify vehicles as they pass and priority can be given to emergency vehicles and help in supervision on a reasonably large scale.

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