International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

Smart Traffic Signal Controller Using Edge Detection Technique

Arul Jothi S[1], Bineeshia J[2]

[1,2]*Department of CSE,PSG College of Technology,Coimbatore, India*

Email: [1]saj.cse@psgtech.ac.in, [2]jb.cse@psgtech.ac.in

Abstract: The explosion in the world population has raised the number of vehicles exponentially during the last decade. Vehicular travel is increasing throughout the world, particularly in large urban areas. The traffic has become a major cause for atrocities in the cities as it may lead to indecorum and road rages. And therefore the need arises for improving traffic control algorithms to overcome increasing demands. This paper provides an approach to deal with traffic congestion by considering density of the traffic. The approach comprehends the traffic congestion pertaining in the urban cities. Detection vehicles is identified through images rather than using electronic sensors. According to traffic conditions, the road traffic light can be controlled. This smart system is intended to control the traffic using electronic sensors and magnetic loop detectors. Forward detection, background subtraction and segmentation are used for calculating the density of vehicles. Furthermore, Round Robin scheduling algorithm with priority scheduling is implemented for varying the light timers at the signal. The system is capable of analyzing the traffic by calculating the number of vehicles using boundary detection in image processing. The system is adaptive to the various loads of vehicles at different times.

Keyword: Background subtraction, Forward detection, Traffic control, Traffic congestion, Segmentation.

1. INTRODUCTION

As the population of the modern cities is increasing day by day the vehicular travel is also increasing day by day which in turn leads to congestion problems. Vehicles often are conflicted with other vehicles on the road and pedestrians because their intended choice of courses of travel intersects into one another, and thus collision occur in the road path. Signs and signals are predominant procedure to control traffic. Some universal signs are the stop signal to stop moving in the path and green sign to move forward in the road path. Nowadays, the traffic signal is a mandatory process to be followed during peak times. The timer set in traffic light depends on fixed manner, which is followed long back. Due to this accidents and congestion occurs between vehicles. This may be due to absence of traffic police. So, even if traffic lights are fixed based on the population of vehicles the timer needs to be adjusted. This is carried out by manual process. Drivers frequently overtake others and obstructions are common [1].

A. Traffic deadlock Controller

Traffic is a situation when more vehicles travel on the road without following proper road rules and fixed traffic light signals. An unbounded traffic will lead to stress in people who are travelling. Nowadays traffic congestion is severe concern to avoid confusions between the travelers. Traffic on roads may consist of all kinds of entities like pedestrians, ridden or herded animals which are least common but result in heavy traffic, vehicles, streetcars and other conveyances, either singly or together, while using the public way which is the trucks and auto for purposes of travel [2].

Researchers all around the world are trying to inculcate various technologies to identify traffic deadlock by using suitable methods. Traffic system with congestion management and reducing the wait time for people travelling will eventually be the expected outcome. A traffic control system is capable of overcoming these issues by constantly gathering information through sensors and dynamically set timer to traffic lights based on the traffic density, mentioned an Intelligent Traffic Light Monitoring System in [3].

B. Scope for proposed system

The paper's objective is to minimize the traffic congestion on the roads of the urban cities using image processing. The system involves continuous sensing of the roads for the number of vehicles crossing a particular signal and the calculation of the density using the method of foreground detection, backward subtraction and segmentation. With the load of the vehicles, the traffic light timer can be adjusted and the congestion can be reduced. Thus the system provides a dynamic way of controlling the traffic light.

2. RELATED WORK

Various researchers focused on designing a smart self-autonomy traffic signal controller using wireless technology. In paper work [4], a Microcontroller device is introduced that has a capability to monitor and control most things around us. The control of traffic lights is well known and is predominant in areas where this type of control system is implemented and is incorporated into the signals, which controls the four sets of traffic lights at the traffic crossing. But, the control of traffic is not flexible, based on many factors like the condition of traffic at the crossing. Rather, the on and off time periods are fixed forth red, green and orange lights. These timing durations are varied as per the day, the day of the week etc. In [5] Vehicle-Actuated Control of isolated intersections was attempted continuously to adjust green times. The simplest type of vehicle-actuated installation has a detector located at a distance ahead of the stop line which senses the road at an intersection approach, and a controller sensitive to signals sent by the detector. Simple traffic-actuated signals suffer from many things and also some of the same weaknesses as those of fixed-timed signals which are practiced in day-to-day life. They will work well if the actual traffic flow is smooth when the unit extension of green signal was selected. Traffic Lights are automatically controlled by timers placed in the system and electrical sensors as discussed in [6]. A traffic light turns ON or OFF depending on the timer. Timer is used in automatic traffic signal light for each phase. Instead an electronic sensor is used to detect vehicles, and indicates a signal. When the road is empty this automatic timer used by sensors will not make any changes in timer value. Authors in [7] came up with the Density Based Signal Management in Traffic System that is used in heavily traffic congested roads and the junction which is based on the time as well as the density. The Road Side Unit (RSU) continuously keeps track of density in all directions and the respective green signal is indicated to the side which has a higher priority on the traffic signal. This is done based on priority pattern also. This technique can clear the traffic and reduces time delay in waiting. Increased green signal timing is allotted when vehicle density on the road side of the traffic is high and less time is allotted for minimum vehicle density of traffic.

The road traffic analysis is characterized by critical parameters flow, speed and density. The Traffic Control Systems which are adaptive receive information from position and speed of vehicle in order to utilize and optimize the traffic signal. They implement various traffic Signal control Algorithms that are discussed in [4]. Moreover, various routing protocols are analyzed. AODB considered as the suitable algorithm for Intelligent Traffic Light. The Author's have referenced a data forecasting model to transmit data between systems. The dynamic traffic control system is studied by the article for predicting path loss and link in the radio based propagation model. The author's suggestion is to use the OBUs system in the Intelligence road Traffic signaling System for references. The author's in [4] have proposed the delay of signal using IR Sensors and microcontroller for controlling the traffic light and density. Generated results from microcontroller of IR are obtained to calculating timer. Priority Based Traffic Lights Controller Using Wireless Sensor Network is introduced in [4].

Foreground detection is an important early task in these fields. On the basis of foreground detection [5], many other applications like object tracking, recognition, and anomaly detection, can be implemented. The basic principle of foreground detection is based on comparing the current frame of a video scene with a background model and detects zones that are significantly different. Although it seems simple, foreground detection in real-world surveillance is often confronted with three challenges.

Moving cast shadows, caused due to the occlusion of sunlight by foreground objects, often exist in traffic scenes. Shadows can be hard under sunny conditions or soft under cloudy conditions. Anyway, they can easily be detected as foreground and interfere with the size and shape information of the segmented objects.

Illumination changes are common in traffic scenes. As the sun moves across the sky, the illumination will change slowly. Sometimes it may change rapidly, e.g., when the sun gets into or gets out of a cloud.

Noise is inevitably introduced during the image capture, compression, and transmission process. If the signal-to-noise ratio is too low, it would be difficult to distinguish foreground objects from the background scene.

In traffic scenes, numerous foreground objects (including vehicles and pedestrians) appear, move, and finally disappear under certain natural and social rules. Their appearance features (including brightness, chromaticity, and texture) differ significantly from those of the background. The probability distributions of these features have different forms and are time-varying. Besides, foreground objects are usually compact in the image space and move smoothly over time. Hence, spatial-temporal context within the video sequence can be exploited.

The extract of multiple heterogeneous image features (i.e., brightness variation, chromaticity variation, and texture variation) from sequence of videos, and to devise a multiple-view strategy of learning to online estimate the conditional probability densities for learning the foreground and background techniques.

Recognizing moving objects from a video sequence is a critical task in video examination, traffic monitoring and analysis. Generally for identifying moving objects background subtraction is used, where each video frame is compared against a reference or background model [6]. Pixels in the current frame that deviate significantly from the background are considered to be moving objects. The generated foreground pixels must accurately correspond to the moving objects of interest. The moving objects are handled in the form of segmentation from stationary background objects. This results in reduced computation time suitable for video surveillance.

A. Objectives for proposed work*:*

Approach in [8] provides the solution to the congestion problem by capturing the image and processing it by canny edge detection. The main disadvantage with canny edge detection is high computation time and being responsible for weak edges. The algorithm discussed in [12] detects the number of vehicles using image processing but is only applicable for Emergency vehicles. Authors in [5, 10] solved the congestion problem by implementing intelligent system, and fixes the traffic signal time to reduce traffic at the intersection. Embedded systems discussed in [11, 13, 14] are considered for controlling the Traffic congestion. The system uses a micro controller for adapting to the traffic environment.

Based on the existing work focus and their incapabilities to deal with traffic effectively, the proposed work objectives are to build up a smart traffic signal controller using dynamic timer control and accurately modify the signal based on density on vehicles in the junction. The remaining section of this paper discusses the implementation of proposed work using various image processing algorithms.

3. PROPOSED WORK

This proposed work tries to build a flexible traffic light controller based on traffic density. The system will detect vehicles through images that are processed to calculate the number of cars, trucks and bikes. A camera is included within the traffic light and some in the street lights depending on the size of the road to be analyzed. It will capture image sequences. Image processing is a stronger tool and a better technique to calculate the number of vehicles and in turn used to control the traffic light. It shows that it can reduce the traffic congestion by a dynamic method to remove the wait time and avoids the time being wasted by a green light on an empty road and also the waiting time of the fewer individuals. With the images, forward detection of the vehicles along with the background subtraction is done. This segregates the type of vehicles and calculates the number of vehicles. After the calculation, it is fed to the simulation where it considers about the different lanes and depending upon the load at different lanes, the timer is adjusted for the signal. Thus the system is adaptive to the environment of the road conditions and can enhance the road transportation.

C. Image Colour Variations

An array, or a matrix, of square pixels (picture elements) which are arranged in rows and columns is an image. Every image is assigned a range from 0 to 255 in a grey scale. Many shades of grey included in grey scale images which most people refer to as black and white images. Usually 256 grayscales are present in a grayscale image. A “true colour” image has 24 bit colour depth = 8 x 8 x 8 bits = 256 x 256 x 256 colours = ~16 million colours. There may be more cycles of grey scales also, for instance 16 bit = 65536 grayscales. A grey scales of 3 can be combined to 281,474,976,710,656 grayscales .Images can be of two types: vector graphics (or line art) and bitmaps (pixel-based or ‘images’). The most common file formats are:

GIF — an 8-bit (256 colour), compressed bit format is used in web. Animated GIF is a sub standard

JPEG—an efficient (i.e. more information per byte) compressed as 24 bit (16 million colours) bitmap format.Mostly used, for web and Internet (bandwidth-limited).

TIFF — the standard 24 bit publication bitmap format.

PS — Postscript, a standard vector format. Includes numerous sub-standards and can be difficult to transport across platforms and operating systems.

PSD — a fabricated Photoshop format which contains all the information in an image

International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

including all the layers. 1 For science communication, the two main colour spaces are RGB and CMYK.

The RGB colour mostly relates to the primary colours Red, Blue, and Green. RGB uses additive colour mixing and is the fundamental colour model which is used in television or any other media that projects colour along with light. It is the constitution colour model used in computers and for web graphics, but it cannot be used for print production.

The colours formed from the primary colours are called secondary colours .The secondary colours are Cyan, yellow and magenta. Red and green combine to make yellow, green and blue to make cyan, and blue and red form magenta. Full intensity combination of red, blue and green provides the white color. The additive model of RGB - Red, Green, and Blue are the primary stimuli for the perception of human colour and are the primary additive colours. Pixel strength can be calculated using the formula, as in:

$$a_i = \frac{I_R(i)E_R(j)+I_C(i)E_C(j)+I_B(i)E_B(j)}{[E_R(j)^2]+[E_C(j)^2]+[E_B(j)^2]} \quad (1)$$

The pixel texture variation is the difference between the foreground and background images. And this can be evaluated using the formula, as in:

$$TV_i = \sqrt{\sum_{\substack{m \in N(i) \\ n \in N(j)}} \left\{ \left(\frac{I_R(m)}{I_R(i)} - \frac{E_R(n)}{E_R(j)} \right)^2 + \left(\frac{I_C(m)}{I_C(i)} - \frac{E_R(n)}{E_R(j)} \right)^2 \right\}} \quad (2)$$

Astronomical images of astronomical objects are usually taken with electronic detectors such as a CCD (Charge Coupled Device). Similar detectors are found in normal digital cameras. Telescope images are nearly always grayscale, but nevertheless contain some colour information. An astronomical image may be taken through a colour filter. Different detectors and telescopes also usually have different sensitivities to different colours (wavelengths)

4. METHODOLOGIES

1) Background subtraction

In background subtraction an image's foreground is extracted for analyzing the scene. Usually regions of an image of interest are objects (humans, cars, text etc.) is present in its foreground. Background subtraction is a widely used approach for detecting moving objects in videos from static cameras. Background subtraction is generally based on a static background hypothesis which is often not applicable in real environments. With indoor scenes, reflections or animated images on screens lead to background changes. In a same way, due to wind, rain or illumination changes brought by weather, static backgrounds methods have difficulties with outdoor scenes. The background model for a pixel can be computed using the formula, as in:

$$xt(m,n) = medianL\,(xt - 0.5L(m,n), \ldots, xt + 0.5L(m,n)) \quad (3)$$

2) Image Segmentation

Image segmentation is the process of dividing a digital image into numerous segments. The aim of segmentation is to make the representation simple into meaningful context to analyze. In particular, image segmentation enables sharing certain characteristics by assigning a label to every pixel in an image.

Image segmentation results in set of segments to collectively cover the entire image. Some characteristic or computed properties like color, intensity, or texture are identified in the region. Based on the characteristics, adjacent regions may differ. When this region is applied to a stack of images, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like marching cubes.

3) Median filter

In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signals, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as "box" or "cross" patterns). Note that if the window has an odd number of entries, then the median is simple to define: it is just the middle value after all the entries in the window are sorted numerically.

4) Cluster Analysis

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). It is a main task of exploratory data mining, and a common technique for statistical data analysis, used in many fields, including machine learning, pattern recognition, image analysis, information retrieval, bioinformatics, data compression, and computer graphics.

Cluster analysis itself is not one specific algorithm, but the general task to be solved. It can be achieved by various algorithms that differ significantly in their notion of what constitutes a cluster and how to efficiently find them. Popular notions of clusters include groups with small distances among the cluster members, dense areas of the data space, intervals or particular statistical distributions. Clustering can therefore be formulated as a multi-objective optimization problem. Cluster analysis as such is not an automatic task, but an iterative process of knowledge discovery or interactive multi-objective optimization that involves trial and failure. It is often necessary to modify data preprocessing and model parameters until the result achieves the desired properties.

5. IMPLEMENTATION

In this section, the densities of vehicles are captured as an image with high quality resolution. The captured image in real time is manipulated to be suitable for proposed implementation. Fig.1 depicts the procedure of the proposed traffic signal controller to schedule time based on the density of vehicles waiting in the signal.

Image Acquisition

The first stage of any image processing operation is the image acquisition stage. 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 by digital photography with a digital camera but other methods are also employed

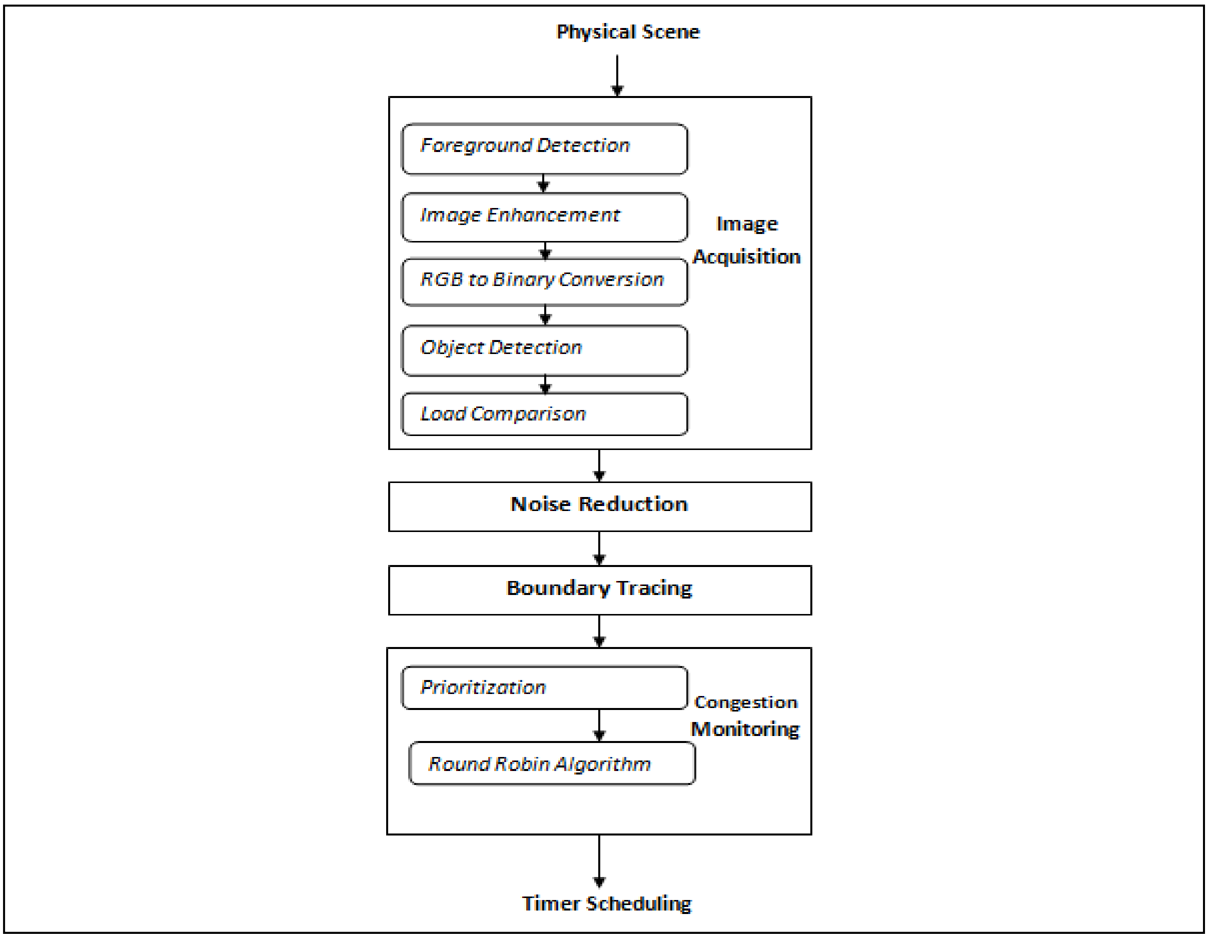


Fig. 1. Structure of smart traffic signal controller.

Foreground detection

Foreground detection is one of the major tasks in the field of Computer Vision whose aim is to detect changes in image sequences. Scenarios where these techniques apply tend to be very diverse. There can be highly variable sequences, such as images with very different lighting, interiors, exteriors, quality, and noise. In addition to processing in real time, systems need to be able to adapt to these changes.

A very good foreground detection system should be able to:

- Build an efficient background (estimate) model.
- Consistent to repetitive movements (leaves, waves, shadows), and long-term changes.

1) Image enhancement

Image enhancement techniques in Image Processing enable you to increase the signal-to-noise ratio and accentuate image features by modifying the colors or intensities of an image. You do the following operations in image enhancement:

- Image deburring
- Device-independent color management
- Image transform
- Image conversion

2) RGB to Binary conversion

Digital image is an image with a single value for each pixel holding only intensity information. The primary colour varies with the saturation, hue and so it is converted to its corresponding Binary data.

3) Object Detection

After the image has been converted, the vehicles are differentiated. The object here corresponds to the vehicles. This tends to provide the number of vehicles crossing the signal juncture at a given time.

4) Load Comparison

The loads of the vehicles are compared at different lanes. This is significant as the timer has to be adjusted depending on the load at different lanes. This comparison can minimize the waiting time of the vehicles at the signal juncture.

The final step is the modification of the timer depending on the comparison.

Noise Reduction

The image is next followed for noise reduction. Digital images are prone to a variety of types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. The noise in the image here is removed using a median filter. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal. For 1D signal, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible (such as "box" or "cross" patterns)

Boundary Tracing

The image is then processed for the connectivity between the components. The connection labeling is necessary for distinguishing the type of vehicles on the road. This is done by “label” which is used to label connected components in the binary image. After labeling is done, the properties of the image regions are extracted. The properties enable to trace the boundary of the regions. This is done by “boundaries” in mat lab. The tracing is followed by filling the boundaries with white pixels so as to remove the holes in it. The holes are black patches within the white boundaries.

The image reaches the final stage in image processing. The number of vehicles is calculated. The vehicles can be of any type and so area calculation is necessary. Area calculation is done by using the boundary properties. The boundaries can provide the count on the number of cars, trucks, buses and other vehicles.

Congestion Monitoring

With the data about the number of vehicles at different lanes, priority is set for different lanes depending upon its density. The priority is set for lanes such that they vary for different time quantum. Setting priority is setting the quantum for each signal. The system uses the procedure of leaving half the load of vehicles from the total number of vehicles in the particular signals. The prioritization is made in units. And this unit depends on many factors like the number of different vehicles involved. Bubble sort is implemented to sort the data in the ascending order. The purpose of sorting the data in ascending order is for prioritization schemes. The signal with the lesser number of cars is given a higher priority and they are to be left first. But the quantum also depends on the prioritized data. The larger the data the quantum gets higher. By this way the congestion problem can be solved. The limit variable is used for the purpose of setting the maximum time before the next schedule takes place. The lower value of timer than the limit variable leads to the situation of the same schedule to be continued and if the value of timer exceeds the limit variable, then the new schedule will be updated and timer value is set to zero. The new schedule will be updated by calling the sort and set priority.

Round Robin is one of the algorithms employed by process and network schedulers in computing. The time slices are assigned to each process in equal proportions and in circular order, handling all processes without priority (also known as cyclic executive).

The system uses Round Robin in such a way that;

1. The signals [s1, s2, s3…..] Are considered as the processes [p1, p2, p3…..].
2. The time quantum in the Round robin algorithm is related to the prioritized value in each signal.
3. Timer is the value of how much time the signals have been green. Here the assumption is each vehicle passes in one second.
4. The timer values are incremented dynamically in each and every signal based on the priority we give to the lanes in the signal.

6. EXPERIMENTAL RESULTS

The intelligent traffic light monitoring system uses various image processing algorithms for its implementation.

A. Image Segregation

Image segregation begins with getting the input images. Two images are fed to the system. The first image is the dynamic image which changes to the traffic environment and the other image is kept as the basic image which is used for comparing with the dynamic image. The image frame in RGB is converted to its HSV colour conversion. HSV is a single value calculated for the single pixel. This value represents the red, green and blue. The background and foreground frames are converted to its corresponding HSV array. After its conversion, XOR of the arrays are taken. This determines where the change has occurred and any pixel change can produce variations in the XOR operation. The XOR operation is followed by its conversion to binary image. Binary image consists of 0's corresponding to no change in the XOR and 1's for the change. And thus a binary image [Array] is obtained. Fig.2 shows the Image segregation which begins with getting the input images. Two images are fed to the system. The first image is the dynamic image which changes to the traffic environment and the other image is kept as the basic image which is used for comparing with the dynamic image.

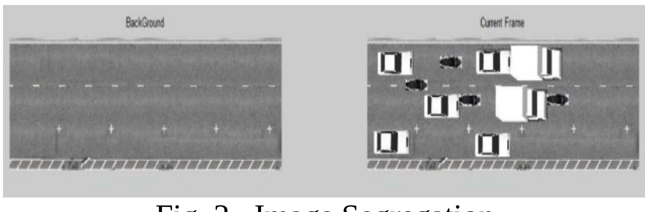
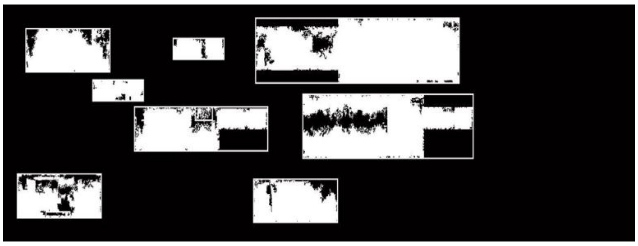


Fig. 2. Image Segregation

Fig.3 shows the result obtained after boundary tracing done using "boundaries" in matlab.

Fig. 3. Boundary Tracing



The tracing is followed by filling the boundaries with white pixels as shown in Fig. 4(a) and (b), so as to remove the holes in it. The holes are black patches within the white boundaries.

Fig. 4(a). Marking white boundaries

Fig. 4(b). Hole filling

B. Vehicle Density Calculation

The image reaches the final stage in image processing. The number of vehicles is calculated. The vehicles can be of any type and so area calculation is necessary. Area calculation is done by using the boundary properties. The boundaries can provide the count on the number of cars, trucks, buses and other vehicles.

```
The count of cars are 5.
The count of bikes are 4.
The count of trucks are 2.
```

Fig. 5. Vehicle Density calculation

The results are estimated in terms of timer delay represented in Table 1. The efficient timer set with the proposed smart traffic signal control system is compared with conventional traffic signal systems that have fixed timer for signal.

Table 1. Estimated delay time for two signals

Signal No.	**Directions**	**Signal Timer (During Peak Time) (in seconds)**		**Delay time (in seconds)**	
		Smart Traffic Signal controller	**Conventional Traffic Signal**	**Smart Traffic Signal controller**	**Conventional Traffic Signal**
1	**North**	230	40	560	790
	East	120	120		
	South	130	130		
	West	40	230		
2	**North**	40	21	700	721
	East	21	40		
	South	170	170		
	West	200	200		

Based on the results obtained, the delay time for the proposed work is comparatively less than conventional techniques in terms of time effectiveness. This infers the simplicity of methods proposed for enabling dynamic traffic signals without affecting time.

7. CONCLUSION

The proposed work infers that image processing is an efficient and effective method of controlling traffic congestion compared to other traditional methods of controlling traffic congestions. It works much better and is more consistent compared to existing systems, which depend on detection of vehicles' metal content because it uses actual traffic frames. The use of multiple sequential cameras will help to increase the analysis of traffic congestion at the local region. The proposed system is very significant in managing the traffic congestion on the roads of the urban cities. As it tries to solve the problem in a dynamic way, it is flexible with the various loads of vehicles on ground. This can enhance the quality of transport across the cities and also mitigates the peoples waiting in the long queue on roads. The system can be a motivation to the government in solving the traffic problem, if it is implemented effectively and efficiently. The proposed work also enhances the quality of the environment at the signal juncture. Overall, the system is effective but still needs an improvement to achieve an improved accuracy. Future enhancements can enable the proposed system to accomplish better results. It includes the usage of advanced technologies to capture images of the road, to obtain accurate information for distinguishing the vehicle's density and to reduce time for processing the image dynamically.

8. REFERENCES

[1] B. Ghazal, K. ElKhatib, K. Chahine and M. Kherfan, "Smart traffic light control system,", Third International Conference on Electrical, Electronics, Computer Engineering and their Applications (EECEA), pp. 140-145, doi: 10.1109/EECEA.2016.7470780, 2016.

[2] Z. Li, C. Li, Y. Zhang and X. Hu, "Intelligent traffic light control system based on real time traffic flows", 14th IEEE Annual Consumer Communications & Networking Conference (CCNC), pp. 624-625, doi: 10.1109/CCNC.2017.7983196, 2017.

[3] R. Sivakumar, G. Vignesh, V. Narayanan, S. Prakash and V. Sivakumar, "Automated traffic light control system and stolen vehicle detection," 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), pp. 1594-1597, doi: 10.1109/RTEICT.2016.7808101, 2016.

[4] Liu Bo ,Zhang Fusheng, “Traffic Signal Control System Based on Wireless Technology”, IEEE Third International Conference on Intelligent System Design and Engineering Applications, China, 13290930,2013.

[5] Subrahmanyam, S.; Panicker, V. Microcontroller Based Self-Regulating Devices in Enclosed Environments. IARS’ International Research Journal, v. 4, n. 1, 2014. DOI: 10.51611/iars.irj.v4i1.2014.35.

[6] Uthara E P, Athira T, Arun A. B, “Density Based Traffic Control System Using Image Processing”, International conference on Emerging Trends and Innovations in Engineering and Technological Research (ICETIETR2k18), Kochi,2018.

[7] Shweta N. Pable, Amit Welekar ,”Implementation on Priority Based Signal Management in Traffic System”, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 5, 2014.

[8] Shruthi K R ,Vinodha. K, “Priority Based Traffic Lights Controller Using Wireless Sensor Networks”, International Journal Of Electronics Signals And Systems (IJESS) ISSN: 2231- 5969, Vol-1 Iss-4, 2012.

[9] Kavya P Walad, Jyothi Shetty, “Traffic Light Control System Using Image Processing”, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801, Vol.2, Special Issue 5, October 2014.

[10] Anil Vishwasrao, Omkar Ramdas Gaikwad, Prof. Kanchan Pujari, Tejas Talathi, "Image Processing Based Traffic Light Control", International Journal of Science, Engineering and Technology Research (IJSETR) Vol 3, Issue 4, 2014.

[11] Pothula, J.; Prasad, C. D.; Veerrraju, M. S. Dynamic Stability and Analysis of SMIB system with FLC Based PSS including Load Damping Parameter Sensitivity. IARS’ International Research Journal, v. 4, n. 2, 2014. DOI: 10.51611/iars.irj.v4i2.2014.37.

[12] K. Vidhya, A. Bazila Banu " Density Based Traffic Signal System" International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Mar. 2013.

[13] Tubaishat, Y. Shang, and H. Shi. "Adaptive traffic light control with wireless sensor networks" Proceedings of IEEE Consumer Communications and Networking Conference,2007, pp. 187-191

[14] Vismay Pandit, Jinesh Doshi, Dhruv Mehta, Ashay Mhatre and Abhilash Janardhan, "Smart Traffic Control System Using Image Processing", International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Vol 3, Issue 1, 2014.

[15] Khalil M. Yousef, Jamal N.Al-Karaki, Ali M. Shatnawi "Intelligent Traffic Light Flow Control System Using Wireless Sensors Networks", Journal of Information Science and Engineering, Sep. 2009.A.

[16] A. Promila Sinhmar, Zakopur " Intelligent Traffic light And Density Control Using IR Sensors And Microcontroller " International Journal of Advanced Technology & Engineering Research, volume 2, Mar. 2013