

Traffic Control Management using Image Processing and Networking

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Abstract: Due to major advancements in technology and rapid economic development, the number of cars on the roads has increased immensely, causing large traffic congestion and accidents, especially during business hours. This has increased the susceptibility to traffic delays but also causes noise and air pollution. This raises health concerns over the toxic fumes produced during combustion. The major contributor to this issue is the conventional time-based traffic control system which doesn't consider real-time traffic scenarios. This calls for the need for a smart traffic management system that collects live traffic information to modify traffic flow, avoiding traffic congestions and accidents while also reducing the amount of idle time for car engines on traffic junctions resulting in lower noise and air pollution. This data includes information about the upcoming traffic that allows for informed traffic control

Keywords- Traffic Management, Image Processing, VANET, Computer Networks, Traffic Congestion, Emergency Response, GMM

1. Introduction

Quick transportation and transit system is one of the basic requirements of the modern metropolitan society. As the urban population increases, so does the number of vehicles on the roads, this growth is not accompanied by infrastructure development leading to traffic congestions. This is the case with countries like India where annual growth in vehicles is around 13% while the annual road extension remains to be only around 4%.

This increases the chances of accidents, greenhouse gas emissions and could also have a catastrophic economic impact.

Traffic lights play a critical role in traffic management. Although most of the traffic lights in India are conventional time-based traffic lights and are designed earlier in such a way that they are made to wait for a static period of time before the signal is changed. The factors of real-time traffic are not considered in such an implementation and time intervals remain static. This could lead to wasted time as one lane could more crowded than others but still must share the same waiting period.

A simple solution to this problem is allocating waiting time based on real time traffic related data which includes vehicle count, traffic density, etc. Roads with greater density are given more time to pass compared to less dense roads.

There are many such solutions to decongest traffic, but no technique is perfect as the real-time scenarios keep on

evolving and the system needs to adapt itself to these changes.

In this project, we tried to provide three self-evolving and resilient strategies to counter traffic congestion. These strategies include an images processing traffic management system using image, an images processing traffic management system using video, and a VANETs (Vehicular Ad-Hoc Networks).

In this project, the image processing is used in two ways using MATLAB, first uses image processing on the image taken at the traffic junction to determine the road density and based on data generated, duration of green light is decided. The second solution uses image processing on video feed to count the number of vehicles.

The third strategy is VANETs, which is simulated through a JAVA Socket program, which provides data exchange between vehicles and traffic control units. In VANETs, vehicles are equipped with an On-Board Unit (OBU) that has embedded sensors, microcontrollers and wireless interfaces enabling communication between vehicles and traffic management system. VANETs allows Traffic management systems to gather traffic related data over the cloud from multiple sources such as vehicles, traffic signals and roadside sensors. This information is then used for traffic management, hazard analysis and infrastructure maintenance and development. VANETs rely on short-range communication such as Wi-Fi, RFID and LTE.



We propose a traffic management system that is an integration of all the three above mentioned systems into a single reliable, effective, and weather independent system.

2. Literature Review

Ying Nie[2] in his study has reported his study on how the number of vehicle production is increasing daily and how traffic is going to increase in the near future. The author has proposed a solution to the current static time signals at junctions. The solution includes the demonstration of image and graphics processing with the use of MATLAB. The traffic at the junctions is collected as images and converted to digital signals to analyze the traffic and then pass the traffic signals based on the intensity.

Prashant Jadhav[3] et al and V Pandit et al[4] emphasize on the absence of no live tracking of the traffic scenario while sending signals. The team has proposed a hardware and software architecture (Kiel for microcontroller programming and MATLAB for image processing). The team have proposed a 5-module system for the current problem of static time delay in traffic signals. The software, MATLAB has been used for practical testing purposes and yielded much better efficiency in traffic control.

Choudekar et al[5] have proposed their approach in Image processing and how efficient this can be in real time. They have used Gradient based edge detection as part of their algorithm to notice changes in the environment captured by the camera. Power law transformation (gamma correction) has been used for the image enhancement process for getting better results when passed through image processing. The above approaches have been implemented and tested in MATLAB 7.8.

A.H. Akoum[6] has emphasized on the point of how the traffic must be analyzed when the vehicle parts images are very small and out of the frame. The author has proposed the idea of video processing instead of Image processing, where the processing done by comparing/subtracting the number of cars in the new frame vs the previous frame. Using the filter technique, the author reached an accuracy of 90%. This method of Video Processing is an extension to Image Processing, because Frames of the Video are passed to the Image Processing.

De Souza et al[1], have emphasized on the idea of how VANETs provide the architecture for Vehicular and Infrastructure Communication. Based on this they have proposed a methodology to traffic management by monitoring the number of vehicles connected to the infrastructure. As an extension to the traffic monitoring on the server/infrastructure, they have also proposed the inclusion of IoT sensors to monitor the background activity like weather condition. As this is an implementation that is IT Based, the authors have highlighted the importance of security.

Mrs. Sangeetha et al[8] developed a prototype that controls traffic flow using image pro-cessing which operates on a Raspberry Pi board, it also uses RF module to detect emergency vehicles. The system is designed to identify and compare the captured images and video with the images stored in the database. The system dynamically changes the signals when an emergency vehicle is detected using the RF Modules. The algorithms used in the system

includes Image Filtering, Thresholding, Measuring Objects, Image Processing, Video Analysis and Counting objects. The image processing includes image filtering, image transformations, colour conversion, histograms, etc. Video analysis includes motion assessment, background subtraction, and object tracking algorithms. Objects are counted by assigning certain indexes to all pixels of an object which is done by converting images into binary form. This signifies the object that the pixel belongs to.

Rahishet et al[9] proposed a system that reduces delays caused due to traffic congestions by applying image processing techniques. This is done by taking images for each lane and pro-cessing them simultaneously and assigning time to each lane depending on the traffic density. Arduino microcontroller runs a MATLAB program to determine traffic density on roads using image processing and control the duration of green signal for each lane. The image processing includes image trimming, image enhancement, thresholding, edge detection and blob analysis for object counting. The system includes Arduino board connected to a DC motor which is used to rotate camera allowing image capture of various lanes and to traffic lights to alter signals based on the program outputs.

3. Methodology

We are presenting 3-unit modules of the system we are going to propose to check out the functionality of each module. The three components are image processing using images from the junctions, image processing using videos before the junction is reached and a network-based system to estimate real-time traffic at the junction using traffic in the server.

We are implementing a 4-phase for Image Analysis System (Figure 1) at the junction level:

Phase 1: Reference Image Pre-Processing

- Initially, CCTVs are used for getting images
- An image of the road is taken in prior and is used as reference image. This reference image undergoes pre-processing which involves
 - Conversion of the RGB image to Gray Image.
 - Image enhancement is performed on the reference image using gamma correction.
- Edge detection is then applied on the reference image to be sent as a parameter to the prewitt edge detection operator.

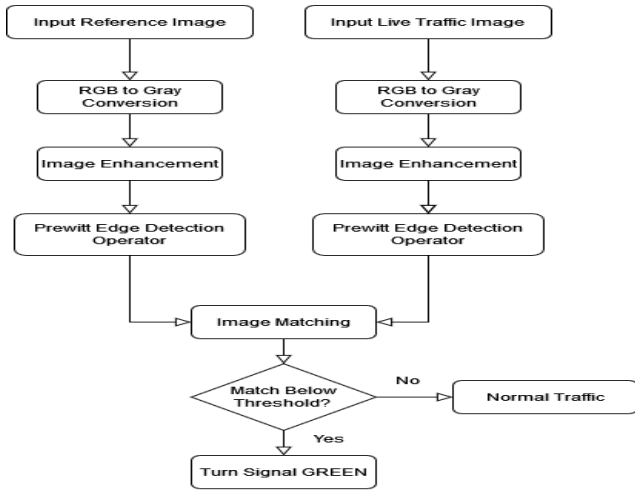


Figure 1: Image Processing using Still Images Overview

Phase 2: Real-Time Image Pre-Processing

- Real Time images of the traffic is captured
- The set of images are passed for processing from RGB format to gray.
- Image enhancement is achieved through gamma correction on the captured images.
- The real-time image undergoes edge-detection using the prewitt edge detection operator.

Phase 3: Image Processing

After Phase 2 has been completed, both the reference and real-time images undergo through an algorithm for finding the similarities between them. On the basis of results obtained, the percentage of the similarity matching is used to control the traffic lights

Phase 4: Signal Response based on the algorithm

Similarity Percentage	Green Light	Red Light
30-60	90	-
60-70	60	-
70-90	30	-
90	-	On

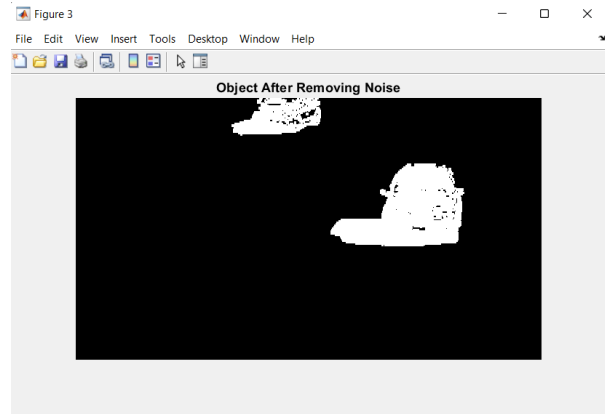
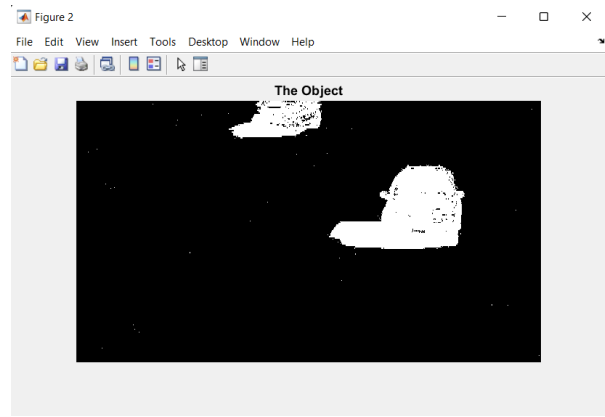
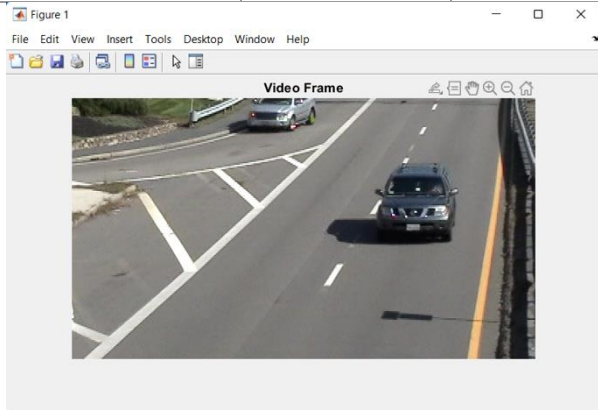


Figure 2. Implementation of Image Enhancement and Image (Blob) Analysis.

The following includes (Figure 3) the steps involved for image processing before a vehicle reaches the junction:

- Video is captured using live CCTV feed.
- The Video is divided into frames of fixed size.
- Foreground Detection is performed on the captured images using Gaussian Mixture Models (GMM)
- Apply image enhancement on the images. Removing noise from the images and running dilate process on the images to smooth the white areas and fill black areas near the perimeter.
- Apply vehicle detection, by disconnecting objects connected through few numbers of pixels so unique objects can be detected separately.
- Use Blob Analysis for Vehicle tracking and counting. (Figure 2)

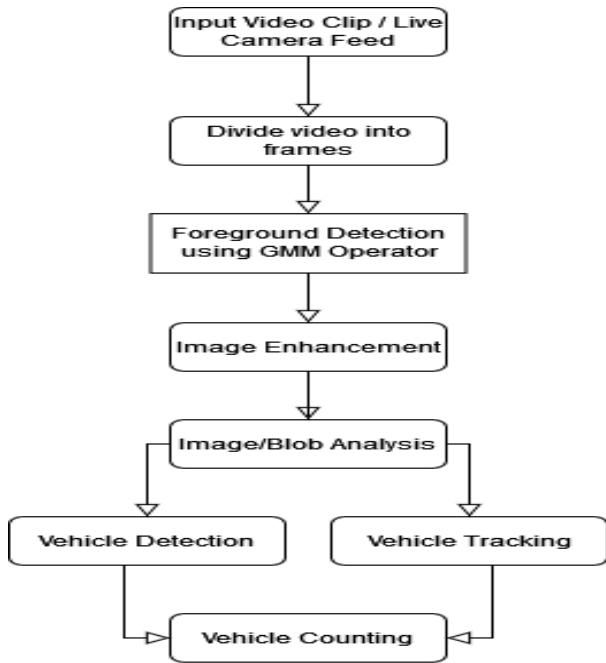


Figure 3. Image Processing using Video Overview

The following is the procedure which is a network-based solution (VANETs) (Figure 4) which is based on incoming server traffic:

- Establishing Connection between Vehicle and Traffic Control Server.
- Data exchange between Vehicle and Server.
- Increasing Vehicle Count.
- Comparing Vehicle Count with specified thresholds. If the count crossed a particular threshold, then Congestion protocol is applied, signal is changed to green for a specific duration.
- Closing connection after vehicle crosses the junction, decrementing vehicle count and re-comparing with the specified thresholds.

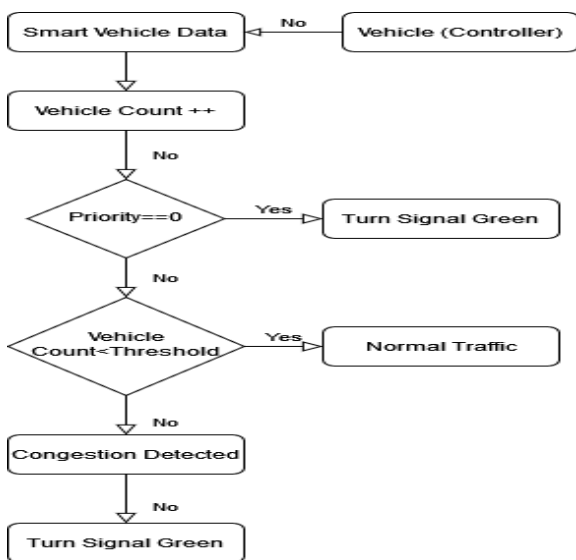


Figure 4. Flow Diagram for a Network Based Solution

4. Results and Discussion

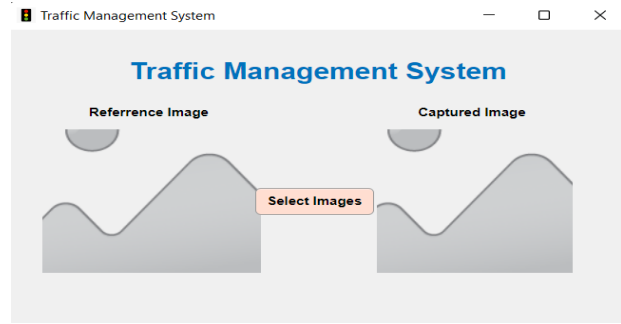


Figure 5(a) Matlab Application Design for Image Processing using Still Image



Figure 5(b) Image Matching Result causing light to turn "RED".

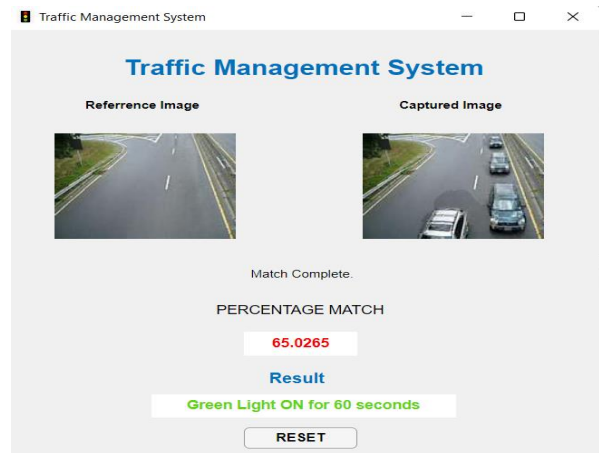


Figure 5(c) Image Matching Result causing the light to turn "GREEN" for 60 seconds.

Figure 5. (a) Matlab Application Design for Image Processing using Still Image.(b) Image Matching Result causing light to turn "RED". (c) Image Matching Result causing the light to turn "GREEN" for 60 seconds.

The solutions presented were successful in determining traffic density (Figure 5) and applying real-time traffic control by allocating the time duration of traffic light to remain "GREEN" or "RED" depending on the real-time traffic scenarios.

The vehicle counting algorithm using image processing on video, is proficient in detecting and tracking vehicles. (Figure 6)

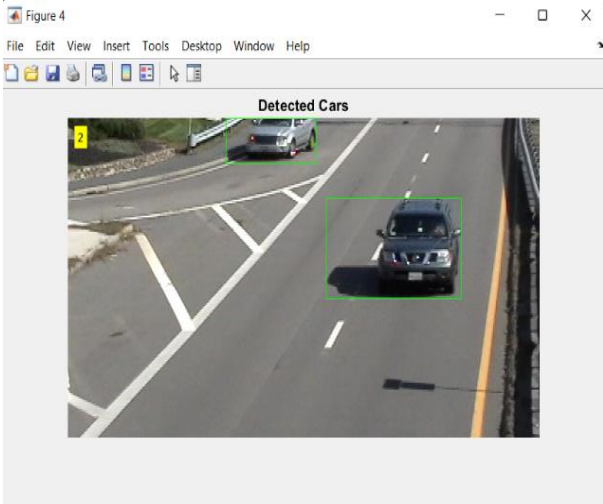


Figure 6. MATLAB Results for Vehicle Counter using Image Processing on video.

The VANET provides a reliable and efficient way to enable communication between vehicles and Traffic Management Systems using IoT applications. It also allows for vehicle identification, emergency alerts (Figure 7) and accident mitigation. It also helps in reducing the response time for emergency services (Figure 9) by utilising prioritisation protocol on altering traffic flow to allow easier access to emergency services. It also notifies non-essential vehicles to give way to emergency service vehicles. It also automatically notifies emergency services if a car faces an accident (Figure 8) and if the air bags of a car are deployed.

```

C:\> Command Prompt - java Client
Microsoft Windows [Version 10.0.22000.593]
(c) Microsoft Corporation. All rights reserved.

C:\Users\karan>cd JavaProg\NC DA

C:\Users\karan\JavaProg\NC DA>javac Client.java

C:\Users\karan\JavaProg\NC DA>java Client
Vin: MH01AE8017
Priority: 3
STMS : Signal Light is RED.
Signal Light GREEN for 40 seconds. Give way for emergency services.
    
```

Figure 7. VANET Communication indicating presence of Emergency Service Vehicles on the lane.

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C:\> Command Prompt - java Client
Microsoft Windows [Version 10.0.22000.593]
(c) Microsoft Corporation. All rights reserved.

C:\Users\karan>cd JavaProg\NC DA

C:\Users\karan\JavaProg\NC DA>javac Client.java

C:\Users\karan\JavaProg\NC DA>java Client
Vin: TN01AS9292
Priority: 3
STMS : Signal Light is GREEN for 5 seconds.
Accident
Emergency Services Alerted
    
```

Figure 8. Traffic Management Server is notified about an Accident.

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C:\> Command Prompt - java Client
Microsoft Windows [Version 10.0.22000.593]
(c) Microsoft Corporation. All rights reserved.

C:\Users\karan>cd JavaProg\NC DA

C:\Users\karan\JavaProg\NC DA>javac Client.java

C:\Users\karan\JavaProg\NC DA>java Client
Vin: DL9CH8863
Priority: 0
STMS : Signal Light is GREEN for 40 seconds.
    
```

Figure 9. Emergency Vehicle identified and Light is turned "GREEN".

VANET also allows for weather and geographically independent Traffic Management. It can be easily implemented by mounting an IoT device on the existing vehicles that uses wireless communications technology like ZigBee, Wi-Fi, RFID or Radio Frequencies.

Drawbacks of the image processing based TMS include dependence on CCTV and requires a lot of computation on large amounts of video files and require a lot of capital investment and require recurring maintenance and replacement since they are not weatherproof. The CCTVs also face difficulty in capturing detailed video in darker environments, decreasing TMS's efficiency in the night. This could be resolved by investing in more expensive CCTV cameras with night vision features.

VANET requires an investment from existing vehicle owners in terms of installing the VANET device, making it difficult to universalise unless the device installation is made mandatory, and the Vehicle manufacturers are directed to house the device in their vehicles before selling them to a customer.

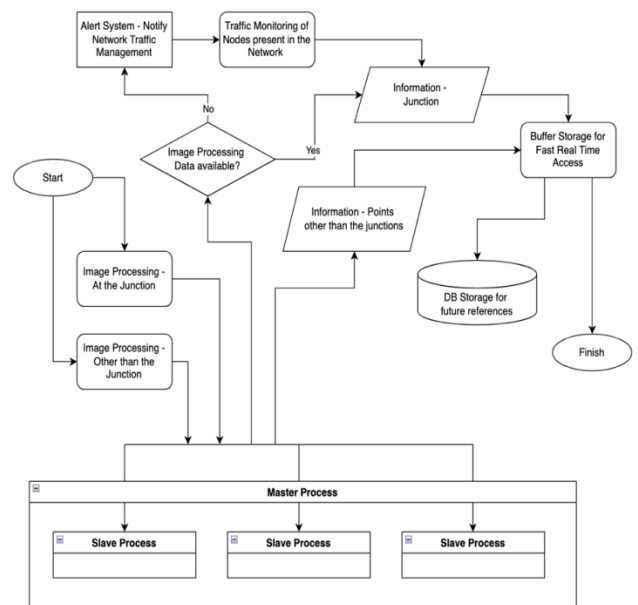


Figure 10. Proposed Model helps in Disaster Recovery and System Continuity

From the above description of unit modules, we are proposing a model (Figure 10) which is resistive from disasters and acts as a secondary and stronger mechanisms for both preventing a disaster like system failure and at the same time maintaining efficiency.

The model processes data based on the image processing and sends the signals after processing is done by the slave processors[10] on the number of cars. This system under failure due to natural or man-made disasters, diverts to the networking based solution.

5. Conclusion

The technological advancements have caused the researchers and engineers to continuously evolve the existing technologies and systems to better keep with current needs. As more and more cities are advancing into smart cities and transforming by implementation of automation in various fields and services, the Traffic Management as Service to has felt the need to evolve by enabling newer and more efficient technologies. In this paper we present three such methods, image processing using still images, vehicle counting using image processing on video and a VANET system connecting vehicles and TMSs using IoT. Smart Traffic management technologies are proven to be more efficient in congestion control than traditional time-based TMSs in terms of reduction in waiting time of vehicles at stop points . With inclusion of modern technologies further services can be catered and integrated over the TMSs like emergency response systems, public transportation, disaster notification, etc.

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