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Smart Traffic Light

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Abstract—With increase in population, there has been a significant rise in the number of vehicles on our roads. This marked increase in vehicles has resulted in most urban areas being gridlocked in traffic jams. In order to reduce this congestion and set up a functional system of traffic management, we have proposed the Smart Traffic Light (STL), which uses image processing and a scheduling algorithm to automatically manage the duration of traffic signals. Another feature of the STL is its management of signals to prioritise emergency vehicles such as ambulances or fire engines by ensuring green signals in their specified routes in order to ensure minimum delay in traffic.

I. INTRODUCTION

Traffic lights came into existence as a preventive measure against accidents at intersections. Modern traffic lights serve this purpose by using 3 lights: the red light indicates that the traffic must stop, the yellow light indicates that the traffic must slow down to a stop and the green light indicates that the traffic may move.

The first electric traffic light was developed by Lester Wire in 1912 and implemented for the first time in 1914 in Cleveland, Ohio. The first system of connected traffic lights was implemented in 1917 in Salt Lake City with 6 intersections controlled simultaneously from a manual switch.

However, as the population increases, so does the number of vehicles that occupy our roads. Therefore, it becomes a necessity to evolve our traffic management system to be as efficient as possible. This is made possible by the giant leaps taken by technology. With tools such as image processing, machine learning, Object recognition and cloud technology, we are able to come up with solutions for real world problems, including traffic management.

The conventional traffic system needs to be upgraded to solve the severe traffic congestion, alleviate transportation troubles, reduce traffic volume and waiting time, minimize overall travel time, optimize cars safety and efficiency, and expand the benefits in health, economic, and environmental sectors.

Efficient traffic management does not just pertain to managing one particular traffic light, but by creating a network of all these individual lights and coordination of the timing and duration of signals based on traffic density, and movement of emergency vehicles such as ambulances, fire engines and police vehicles.

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The objective of the project is to reduce waiting time at traffic signals and traffic jams by predicting and automating the signal durations. Also, we are able to figure out the fastest route for an ambulance to reach its destination, by manipulating the traffic signals. We are also able to synchronize all the traffic signals by connecting them all to the cloud. We also use the cameras to monitor the signals for any rule violations. All the violations are recorded and the rule breakers details are shared to the traffic police.

II. RELATED WORK

This section briefly discusses some of the work done by other authors in the field of traffic management using computer technology.

The paper [1], discusses the use of weighted data and RFID data to detect location of emergency vehicles and decongest lanes so that the vehicles reach faster.

The paper [2], discusses the use of various sensors in order to estimate traffic density and hence allocate the optimal amount of time to be allotted for each signal. At the instant of the signal turning green, the sensors were able to ascertain if there are vehicles present at the signal or not, as well as allocate signal duration based on the number of vehicles present

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The paper [3], discusses the use of LCD screens and infrared sensors in developing a smart traffic signal.

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The paper [4], discusses the synchronization of traffic signals in a straight road using the CTM_UT module, which takes the weighted sum of the delays of the signalized intersections as the parameters.

The paper [5], discusses the use of filter technique in image processing in order to count the number of vehicles in a particular signal. This technique is said to be 90 % accurate

The paper [6], discusses the use of light sensors with strobe detection to detect the siren of an ambulance and manage the traffic to allow it to pass through

The paper [7], discusses the use of RFID to detect of an ambulance at a signal and manipulate the signal to allow the ambulance to pass through.

The paper [8], discusses the use of Bluetooth to detect the presence of an ambulance using Arduino board and HC-05 Bluetooth receiver.

The paper [9],discusses the use webcams to constantly monitor traffic and uses image processing tools in Matlab to perform real time video processing to estimate the traffic density, as well as allocating time for each signal bases on the number of vehicles present at that particular instant.

III. METHODOLOGY

The proposed system is implemented with the objective to reduce the traffic based on density. Four main steps are considered for the system: a) Image capture b) Image Enhancement c) Image processing d) Image classification e) Signal duration. By means of a camera, the traffic light captures the image of the traffic at the time of signal changing color to green. This image is then processed and the traffic density is determined by classifying it into categories (empty, light traffic, medium traffic, heavy traffic, traffic jam).Once classified, the signal duration is determined using a scheduling algorithm. There is also a provision for emergency vehicles, where the location of the vehicle is determined by GPS and the fastest route to the destination is determined. The traffic lights then coordinated such that the vehicles reach the destination with minimal wait time. The below block diagram specifies various modules in the project.

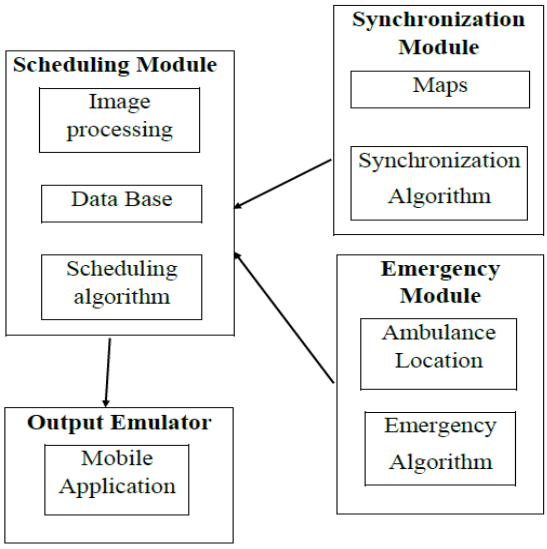

Fig 5.1Block diagram

A. Image Capture

In order to obtain the traffic density, we use a camera that continuously monitors the traffic. At the moment when the signal changes from red to green, the camera takes a photo of the traffic present at the moment. This captured photograph is relayed to the image processing module.

Fig 5.2.Image of vehicles at signal

B. Image Enhancement

Image enhancement is the process of adjusting the pixel values of an image either in the spatial domain or in the frequency domain to improve the visual perception of the captured image. Image enhancement techniques used in the proposed method include noise removal using Wiener filter, Blob analysis and dilation.

C. Image Processing

Once the photo is obtained, we use the image processing tool to count the number of vehicles present. this is done using an object recognition tool to identify each vehicle. The number of vehicles are then counted and is sent to the classification module.

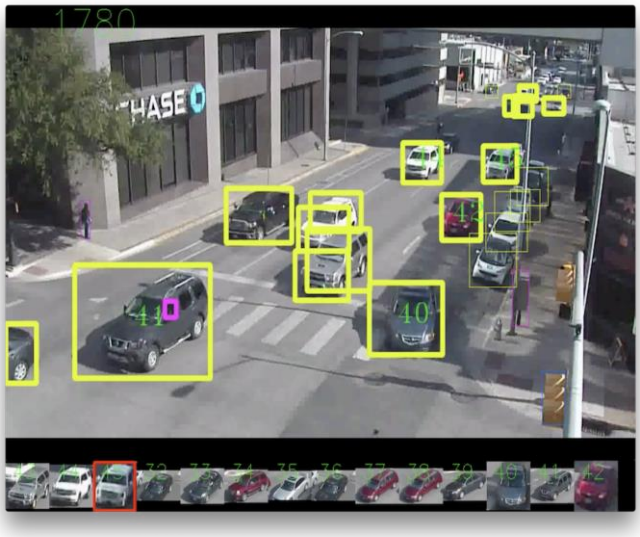

Fig 5.3 Image processing

D. Image Classification

Once the number of vehicles are obtained, it is classified intone of five categories – Empty if there are no vehicles, light traffic if there are less than 10 vehicles, medium traffic if there are 10 – 25 vehicles, heavy traffic if there are 25 – 40 vehicles, traffic jam if there are more than 40 vehicles.

E. Signal Duration

Once the traffic is classified into categories, the signal duration is finalised using a scheduling algorithm. When traffic density is classified as empty, 5 seconds is allocated. When classified as light traffic, 20 seconds is allocated. When classified as medium traffic, 30 seconds is allocated. When classified as heavy traffic, 40 seconds is allocated. When classified as traffic jam, 60 seconds is allocated.

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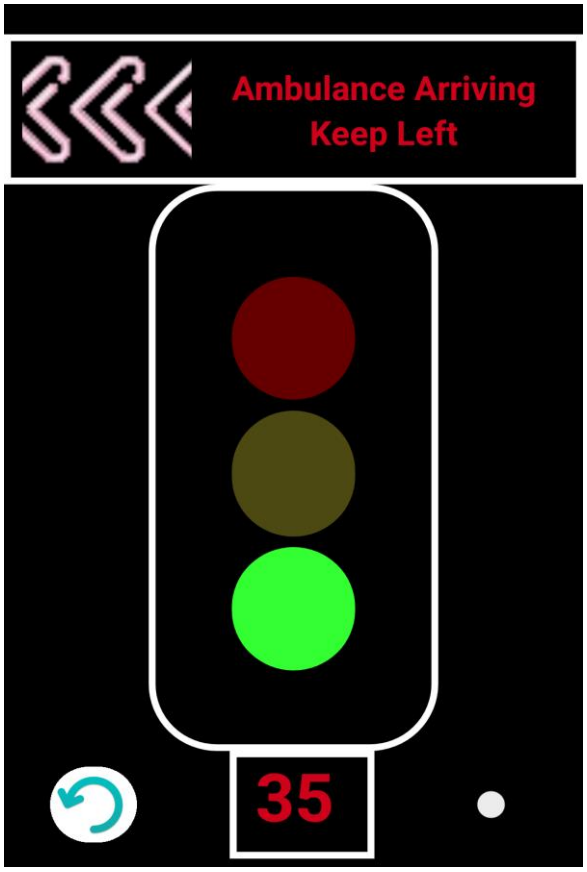

Fig 5.4 Simulation of traffic signal.

F . Synchronization

All the traffic signals are synchronized by connecting them to the cloud. This facilitates better coordination between signals, hence allowing us to regulate the traffic much more easily. In essence, the vehicles waiting at signal 1 would not have to wait as long (ideally need not wait at all) at signal 2. This is done by estimating the traffic at the signal 2 as well as taking into consideration the traffic at signal 1 and the signal duration allotted to it. This greatly reduces waiting time at consecutive signals.

G. Emergency vehicle

When the emergency vehicle begins its journey, we use google maps to identify its location as well as determine the destination from the driver. Once this information is obtained, we map out the fastest route to the destination and send messages to all the traffic signals along the route. The signals keep a track of the progress made by the emergency vehicles and once they come into the vicinity of the signal, the signal turns green and allows the vehicles to go through to make a smooth passage for the emergency vehicle. This is done for all the signals along the route prescribed to the emergency vehicle. However, in case of a traffic jam at any particular signal, the signal is immediately turned green.

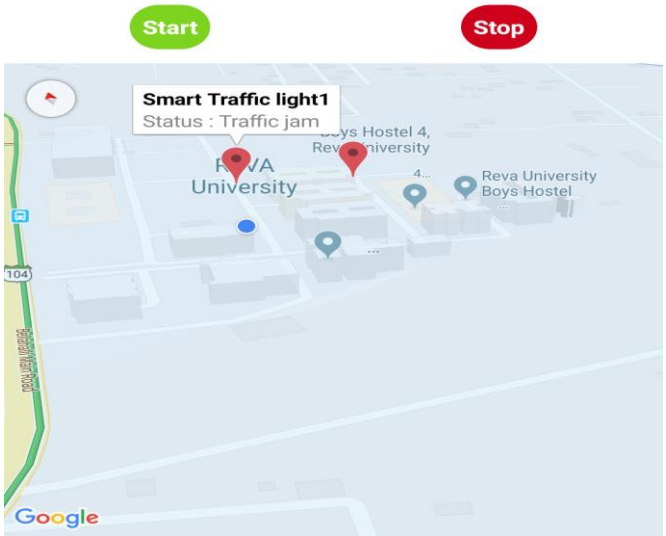

Fig 5.5 UI for Emergency vehicle.

IV. RESULTS AND DISCUSSION

The Smart Traffic Light has several real world applications. It is a cloud based application that allows us to synchronize all the smart traffic lights. It also uses object recognition and image processing technologies to identify and estimate the traffic density. It also uses a scheduling algorithm based on the classification of traffic density to allocate signal duration. The synchronization with cloud and gps capability allows us to decongest lanes and allow emergency vehicles reach their destination quickly.

The result of our project is an application based simulation of Smart Traffic Light and its working while also showcasing the advantage of synchronizing all such traffic lights by ensuring the fastest possible route for emergency vehicles to reach their destination.

The table below compares and contrasts some of the papers that have already been published pertaining to our topic.

Technology Used	**Sensors** in [2],[3] use sensors to estimate the number of vehicles at the traffic signal. **Limitation** 1)sensors unable to detect vehicles blocked by other vehicles 2)expensive to setup and maintain	**Image processing** in this paper. **Solution** 1)The Camera angle ensure all vehicle at the signal are identified 2)Low cost

	RFID in [1],[6] **Bluetooth** in [8] To detect the arrival of ambulance **Limitation** 1)Range of detection is low 2)Decongestion of lanes starts late, hence waiting time increases 3)Installation cost is high	**GPS** in this paper To determine the location of the ambulance. **Solution** 1)Can be detected anywhere 2)Decongestion of lanes starts early based on distance and status of traffic signal 3)No installation cost
Parameters	**Synchronization**	
	1)Distance between signals	1)Distance between signals 2)Status of the signal
	Image Processing	
	1)Number of vehicle	1)Number of vehicles 2)Type of vehicle 3)Size of the vehicle

Table 6.1

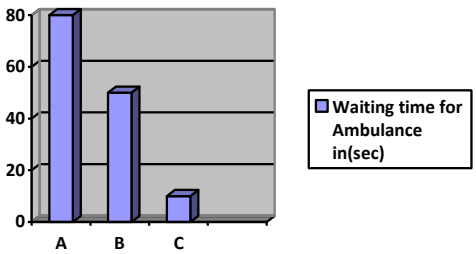

Fig 6.1 Waiting Time

In Fig 6.1 waiting time of A-Rfid[3][6] , B-Bluetooth[8] compared with C- GPS.As seen the waiting time is lower for GPS.

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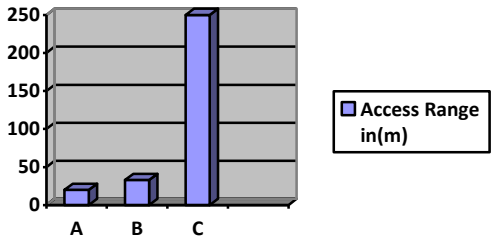

Graph 6.2 Access range

In Fig 6.2 Access range of A-Rfid[1][6] , B-Bluetooth[8] compared with C- GPS.As seen the access range is more for GPS.

V. CONCLUSION AND FUTURE SCOPE

The Smart Traffic Light, if implemented, will not only automate traffic management, but also make it more efficient while also focusing on making emergency service vehicles more easily accessible. The simulated traffic management system allows us to coordinate between multiple intersections that are connected to each other in order to ensure smooth traffic flow. This is possible by connecting each individual traffic light to the cloud. It also facilitates the prioritization of emergency vehicles in major traffic snarls, by finding the fastest route and ensuring the roads remain clear. The future scope of this project would be testing it and the implementing it in every major metropolitan area. There are also some conditions such as extreme weather conditions (fog, snow etc.) which could affect the system. Some of the future enhancements that can be implemented are discussed below

A. *Synchronization with autonomous car* - By synchronizing all the traffic signals as well as connecting them with autonomous cars , we can intimate the duration of the signal to the car which can then decide if the engine needs to be turned off while waiting at the signal. This decision can be taken by taking into account a certain threshold (say 20 seconds) where if the signal duration is greater than the specified threshold the car turns of its engine.

B. *Rule Violation* -Using the cameras attached to the traffic signal, we can also capture images of vehicles breaking traffic rules at signals. Should any vehicle break rules such as jumping a red signal, not wearing helmet etc. , the camera takes a photo of the vehicle, and identifies the number plate. This information is then relayed to the traffic police who are entrusted to take appropriate action

C. *Tracking of vehicles* - Synchronization of the traffic lights yields yet another advantage in that information can be relayed quickly. Suppose a vehicle which is being tracked by the police is spotted at a signal, by estimating the time it takes to each of the closest signals we can identify which signal the vehicle is going to and hence map out a route for the police to follow.

VI. ACKNOWLEDGMENT

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