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Traffic Signal Duration Control by Estimating Vehicle Density

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***Abstract*—** In India traffic congestion is becoming a very serious issue day after day. The heavy traffic jam is a result of large amount of vehicle which is caused by huge population and development in economy. As a part of globalization, time consumption and management means a lot. The fast moving world in which we live today does not want to wait at any cost in middle of the time consuming traffic signals. As a result of this mentality of the people, safety measures are discarded and violated intentionally. Thus a need for density based time saving traffic signal control unit aroused. The density based system would be better than the time based system control as it scans the density of vehicles on road based on Digital image processing. More accurate and easily maintainable system is what we need. This time saving control system can be used in all frequently congested junctions. The proposed system has two sections; the traffic section and the control section. The vehicle density in the junction is estimated by capturing the traffic condition using digital cameras and processed by MATLAB programming. Based on the captured and processed information on Vehicle density the signal durations can be increased or reduced using microcontrollers.

Index Terms- traffic density estimation, traffic control, control section, traffic section, PIC16F87XA, ostus algorithm..

1. INTRODUCTION

The traffic signal system in almost all cities in India is based on the time, that results in wastage of time, more fuel consumption and more congestion on roads. When the vehicle on the road increases the speed of traffic stream decreases which results in some congestions. This makes the whole population in the cities to stand still in the middle of the heavy traffic jam daily. Some steps or measures have to be taken to overcome this situation. This paper is proposing a method to estimate vehicle density using digital image processing and controlling the traffic signal. Traffic congestion near the traffic signal is one of the main problem which we are facing in our day to day life, mainly in metropolitan cities. Traffic congestion are causing challenges for all developed and developing cities. This leads to so many problems such as waiting in front of the signal for hours for the green signal which leads to time wastage. It even creates problem for emergency vehicles like ambulance, fire force etc. Cities are mainly affected by it which results in massive delays, increased fuel wastage and monetary losses.Traffic congestion is a concern largely for four reasons: It is annoying and effects quality of life for everyone who are stuck in it

- It causes many problem and limits future economic expansion.
- Cars stuck in congestion produce more CO2 per mile than the
- free-flowing traffic.
- It adversely affects the people who are in emergency.

When compared with the growth of population, vehicle growth is also increasing rapidly which is influencing traffic system. The normal function of traffic lights should be, to be more controlled and coordinated to ensure that traffic moves as smoothly and safely

as possible. Different control systems are used for this, such as simple clockwork mechanisms, to computerized control and coordination systems that are used to minimize delay for people using the road.

One of the methods used for controlling the traffic signal was the use of timers [1]. It presets the time in the traffic signal for the red light and green light. It works according to the timing and not depending on the traffic density. The main drawback of this method is it does not monitor the traffic density and it does not control the traffic signal timing which causes the vehicles to wait on the junction for hours till the signal becomes green. Manual controlling of traffic signal is one of the oldest technique which requires man power to control the traffic [5]. At different countries, traffic polices are allotted for a particular area or city to control the traffic manually. These traffic polices carry different devices to control the traffic such as sign board, sign light and whistles. The main drawback of this method is it becomes difficult for a traffic police to control large amount of traffic in a four way junction as a result of which congestion increases.

Another technique used for traffic controlling was with the help of sensors [6]. The controller uses the input from detectors, that are sensors that inform the controller that, whether a vehicle or road users are present, to adjust signal timing according to the limits set by the controller programming. It can provide more time to a junction that is experiencing heavy traffic,. These detectors are of three types they are, in-pavement detectors, non-intrusive detectors, and motorized road users detector [6]. These detectors are buried inside the roadways. Inductive detector loops are the detectors which are commonly used. They are sensors which are buried inside the road to detect the presence of traffic waiting at the

signal, and thus it can reduce the time when a green signal is lighted on an empty road. During low traffic density a timer is mostly used as default, and it will have a backup in case of sensor failure. Consequently, small vehicles and bicycles with low metal content may fail to be detected which causes them to wait for long time unless there is a default timer as part of the control system. This is the major drawback of this method.

Another method is coordinated control which has 2 systems and they are synchronized signal system and coordinated signal system [4]. In modern coordinated systems the drivers can travel a long distance without encountering a red light. This coordination can be done easily on one-way streets with constant levels of traffic. One of the drawback of this method is it monitors the speed of the vehicle according to which the green light is encountered once the speed exceeds a particular level the driver will arrive on a red indication and end up stopping, drivers traveling too slow will not arrive at the next signal in time and they cannot utilize the green indication. Some other methods are fixed time control, adaptive control etc. These are some of the oldest and the existing methods used for traffic signal controlling.

The proposed method is designed in such a way, that it solves all these drawbacks and problems which are faced in existing method. And they are solved mostly by estimating the density of vehicles waiting at the junction and accordingly controlling the traffic signal. It can give more time to a junction that is having heavy traffic, or shorten the time at the junction that has few or no traffic waiting for a green light. In urban and crowded cities it's a regular scenario to see huge traffic congestion at the traffic signal which leads to so many problems. The traffic density is estimated using digital image processing and using zigbee wireless transmission system the data is transmitted to the control section, from where the duration of the signal is produced and passed to the traffic section using zigbee transmitter.

The main benefits of the proposed method are:

- It Increases the traffic handling capacity of roads.
- Reduces collision, Reduces the waiting time for both vehicles and pedestrians.
- It encourages traveling within the speed limit to meet green lights.
- It reduces fuel consumption by unnecessary stopping and starting the vehicles, reduces noise and vehicular wear and tear.
- It reduces drivers frustration.

The main advantage is in reducing the duration of green light in the junction were the traffic density is low. In cases, where the junction will be empty and still the green light will be lighted causes vehicles of other junction to wait without any reason, these problems can be solved using this.

2. EXSISTING SYSTEM

With the advancement in wireless communication, so many techniques are developed in which vehicles can form a network for exchanging traffic information among themselves. For this a infrastructure less self maintaining traffic information system is used. In this system as the vehicle travels they collect the traffic data by acting as mobile sensors. For traffic sensing smart phones are used as they are equipped with a variety of sensors such as gyroscope, Accelerometer, GPS etc. These sensors can be used effectively for collecting traffic data. GPS receivers are used mainly for many years. However GPS receiver consumes a lot of power, and hence they shortens the battery life [7]. So as a result of this the existing system uses accelerometers for sensing the traffic information[1].

Traffic information system is very essential for solving a traffic problem effectively. Vehicle speed, vehicle density and travel time which are the Real time traffic information, can help the motorists choose a route more wisely and easily if they know it before. Instead of unnecessarily getting stuck on a congested road, many drivers can choose free route if the information about the traffic condition is known before hand. Almost all the traffic information systems in India are based on some fixed infrastructure, where data's are collected from fixed sensors such as surveillance cameras and Inductive loop detectors. it takes a great effort to install sensors in such kind of systems. In many cases, the road surfaces are digged to implant the sensors underneath it, which requires a large man power and lots of time. Not only that it is even much expensive to install sensors in a large area such as metropolitan cities. Moreover, maintenance of these fixed sensors is also difficult [1]. This system could be made less expensive and effective if the vehicles themselves collect and distribute the traffic information. The main drawback in this type of system is, how to collect and process the data as now the sensors are mobile and distributed. Among these issues, the main things every system designers need to consider are: (i) which are the sensors that must be used. (ii) how to use them properly, to effectively collect the traffic data, and the last and the most important one is (iii) how to convert the data into information which can accurately convey the real traffic condition. The information is gathered by undergoing 3 major steps they are: Data collection, State classification and Regression based speed estimation.

A. Data Collection

To collect the real data sensed by an Accelerometer actual field experiments are conducted. For data collection purpose a simple iOS application is developed and an iPhone5 is used as a mobile device. The following application is designed only for data collection. The main task of this application is to record the status of the essential data and the accelerometer which will later be used for analysis purpose.

The experiment starts by, placing the mobile phone above the dashboard of a vehicle. The mobile phone can be placed any where and in any orientation as the initial state of the accelerometer will be calibrated automatically by the application.

B. State Classification

The data is divided in to blocks once they are collected, each having T seconds. By using this the average speed of the vehicle can be estimated over the period of T. Speed estimation will be mainly based on the various activities of the vehicle. The value chosen for T is 360 seconds. It is important to identify when the vehicle is stationary at a period of T. It is obvious that a vehicle can be always in any of the 2 states: stationary or mobile. These states, that is whether the vehicle is mobile or stationary can be identified by the data sensed by accelerometer. To distinguish between the mobile state and stationary state of a vehicle the following 2 points should be considered: 1) A vehicle will be considered to be in stationary state if the initial value which is obtained from the accelerometer is less than the threshold value. 2) At the same time the vehicle will be considered to be in mobile if the deviation from the initial value is greater than or equal to the threshold value for a duration of at least T seconds

C. Speed Estimation

Once the states are classified, that is vehicle is stationary or not in a period T, the next task is to transform the classified data into average speed. We have to correlate the total time which the vehicle was in motion during the period T to its average speed. If the vehicle can be in motion for a longer period of time, then there are chances that the vehicle can accelerate to a higher speed.

Next, the total time in which the vehicle was mobile is mapped to the average speed. As this is the training phase, we use the speed obtained from the GPS receiver for reference. Once the mapping results are obtained, the average speed can be estimated by using accelerometer data. On the basis of the collected data, the average speed is calculated at every second. The average speed of the vehicle which is denoted by vT, can be obtained from the sampled data's. The total mobile time is taken as 360 seconds, the average speed ranges from 30 to 85km/h. These experiments are performed mainly for sensing the traffic condition in the particular area by the vehicles themselves. With the help of which they can choose wisely a more easy and less congested route. It is able to understand that, If a vehicle is able to be in motion for a longer period of time, then it means that the traffic condition is smooth or the route is less or not congested. This enables the drivers to drive with a great speed. If for the time m= 360 seconds, the vehicles move without any congestion and without any stop. This will effect the accuracy of the estimation process and makes the average speed estimation more difficult. This method as it collects all the information in database will experience so many problems.

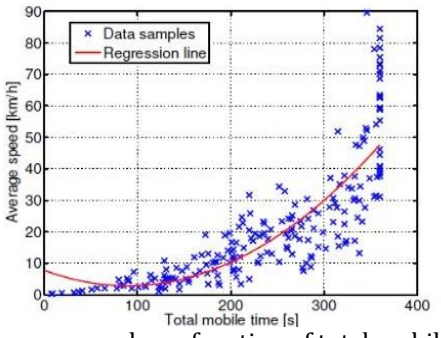

Fig 1. Average speed as a function of total mobile time.

3.PROPOSED SYSTEM

The fast moving world in which we live is facing severe problems due to increasing traffic congestion day after day. The main reason behind this increase in congestion is the population expansion and its need for high volume of vehicles. The traffic jams causes frustration to the drivers and results in road rage, because of which safety measures are discarded and violated intentionally. Thus a density based time saving traffic signal control system is designed. The proposed technique of density based system would be better than a time based system as it scans the density of the vehicles on a road based on digital image processing. With the help of the new system more time can be given to light the green signal at junctions which experience heavy traffic, and can even shorten the time at the junction which have few traffic density. A more accurate and easily maintainable system is our main concern . Our system can be used in all frequently congested road junctions. It has 2 main sections : Control section and the traffic section.

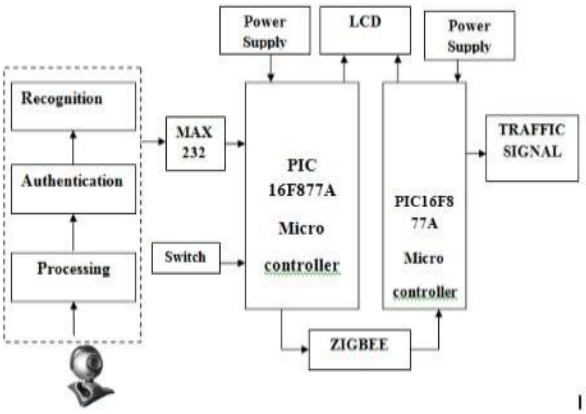

Fig 2. Block diagram of proposed system

There are mainly five units in this system they are:

- Microcontroller Unit.
- Power Supply Unit.

- Display unit.
- Communication Unit.
- Software Unit.

Microcontroller is mainly used for controlling the traffic signal and duration estimation .The condition about the traffic density which is captured by using camera is processed. It is processed through digital image processing and is send to the microcontroller at the control section. In the control section the controller estimates the duration for which each signal is to be lighted on the basis of the received data about the density . The microcontroller at the traffic section is used to control the traffic signal light. Here PIC 16F877A microcontroller is used.

Second, the Power supply unit working can be explained. The supply of 230V AC is converted to 12V DC which is given to the system. For this purpose a step down transformer is used. Supply is converted from AC to DC because the microcontrollers will support only DC supply, which is done by using bridge rectifiers. The rectifier output will have so many ripples, so for filtering out those ripples 2200uf capacitors are used. The filter output is given to the 7805 voltage regulator which will convert the 12V DC again into 5V DC. The output of the regulator will be filtered by using the capacitor. As a result of this we will get a pure 5V DC as power supply unit output. Here microcontroller which we are using is capable of using the supply of 5V DC. Power supply unit is very important for the proper and effective working of our system.

The display unit used here is the LCD (Liquid crystal display). A liquid crystal display (LCD) is a flat panel display, which have flat screens used for displaying graphics and contents virtually. It uses the properties of liquid crystals (LCs), that is the light modulating property. In this proposed method LCD is used to display sensor value, which contain the details about the traffic light signal and the durations.

Zigbee is the communication unit which is used to transmit the sensor values to the monitoring section. Zigbee is a low cost, low power and low latency wireless communication standard. It is IEEE 802.15.4 standard for low cost WPANS. As it is having low latency it reduces the average current. Zigbee operates in the ISM radio bands that is (Industrial, scientific and medical) which is 2.4GHz.Its data rate varies from 20kbit/s to 250kbit/s.

The software unit in the method used are: Proteus and MATLAB. Proteus is a stimulation software where the microcontroller stimulation is performed. The program which is debugged in the controllers are executed in the MpLab. In the MATLAB the digital image processing operation takes place to estimate whether the traffic is heavy or low. Otsu's algorithm is used here.

The main blocks involved in the system are:

Block 1: Camera

Block 2: PIC 16F877A Microcontrollers

Block 3: Max232

Block 4: Zigbee

Block 5: LCD

The camera is used for capturing the images of the vehicles which are waiting at the traffic junction. Afterwards these captured images are processed by using digital image processing.

The Zigbee module which is used acts as both transmitter and receiver[3]. The transmitting and receiving pins of 8051 controllers are connected to the same pins of Zigbee respectively. The signal from the microcontroller is transmitted serially to other controller at the traffic section by using Zigbee module via UART port. The Zigbee is a transceiver that transmits and receives data or information simultaneously. It can transmit data to a wide range. These blocks altogether computes the proposed system.

The main operation or the working of our proposed method is:

The camera is placed on the top of the traffic signal to obtain the clear view of vehicles present at the junction. The traffic level is estimated before entering the traffic section by using MATLAB. The traffic signals are controlled by two methods, automatic and manual method. In automatic mode the camera is used to capture the traffic image and the data is processed by using MATLAB process to identify the vehicle density. These information, that is traffic level is transmitted to the control section through zigbee. The estimation of timing duration and controlling is performed by the microcontrollers. Based on the traffic density, green signal can be lighted for more time on the road which has the more number of vehicles and the congestion on the roads can be reduced. At the same time green signal can be lighted for short period of time, if the density of the vehicles at the junction is less. Thus the traffic signal lights are automatically controlled based on the density of vehicles on corresponding roads.

4.EVALUATION AND RESULT

The proposed scheme is simulated on MATLAB and Proteus. The capturing and processing of traffic image is performed in digital image processing domain, and the stimulation of image processing is done in MATLAB. Firstly, the image path and filename is selected and a particular image is fetched to determine whether the image density is heavy or low. The image is colored which have the primary colors Red, Green and Blue. The algorithm used for this stimulation is

Otsu's algorithm. The RGB color is an additive color in which red, blue, and green light are added together in various ways to produce a broad variety of colors. The main purpose of RGB color model is sensing, representation, and displaying of images in electronic systems, such as computers and television.

The RGB color model is converted to hue which is hue saturation value. Hue is the determination of pure color. Saturation is degree at which the pure color is diluted with the white light. Hue and saturation is together called color carrying information in an image. It separates the intensity component from the color carrying information. In order to determine the pixel value of the image accurately first the image is converted to grayscale image and then to binary image. The graphical representation of image to determine each color intensity is histogram.

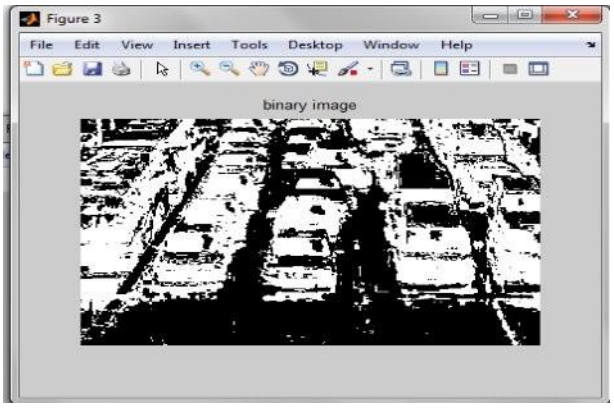

Fig 3. Binary image of traffic density

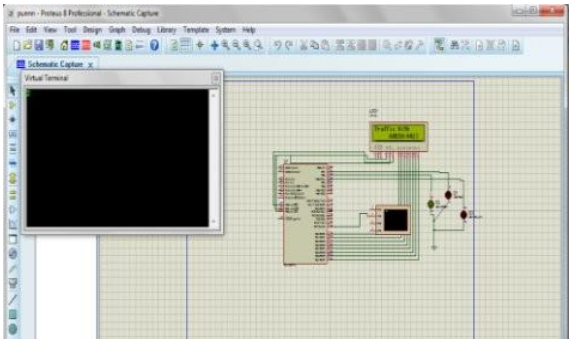

Fig 4. Simulation of control section

The gray threshold computes a global threshold level that can be used to convert an intensity level image in to a binary image. The image is converted to binary mainly in order to find a region of Interest. It is easier to determine the pixel value of an image from binary image then from a colored image .The processed information is transferred to proteus simulation through serial port. If the output is 1 it is considered to be heavy traffic and if it is 0 then the traffic condition is considered low. The proteus program is processed in Mplab and debugged in the microcontroller. The output of this stimulation is the duration of time for which the green and red light must be lighted, and controlling of the traffic signal.

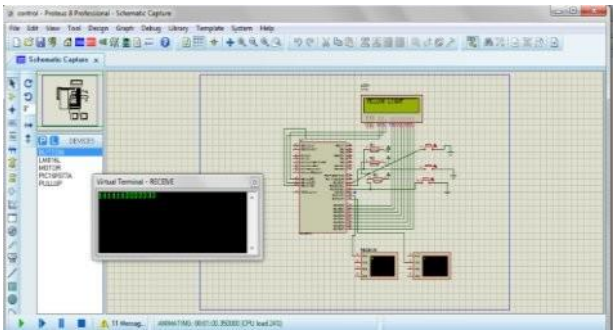

Fig 5. Simulation of traffic section

5.CONCLUSION AND FUTURE SCOPE

In this paper, instead of using the old methods for controlling the traffic signal, a new method is proposed in which the traffic is controlled by estimating the density of vehicles present in the junction. This proposed method helps in reducing the problems related to the heavy traffic congestion at the traffic signal junction which is continously increasing with the passing days. The present world is too busy that it doesnot want to waste there valuable time in the middle of crowded junctions. As a result of this the proposed system is introduced which is a time saving traffic signal control unit, based on density. This technique will be better than the time based system. This paper covers the methodology of implementing the traffic signal control system based on the density of vehicles on road. The main objective of this paper is to estimate the density of vehicles using digital image processing and embedded system. The paper thus gives a method to reduce congestion on road, saves fuel and valuable time.

In the future work the information about the traffic density and the present traffic signal at the junction can be send to the vehicles with the help of GPS and Zigbee trannsreceiver. So that instead of getting stuck unnecessarily on a congested road, drivers can be able to take an alternative less congested route if the information about the road traffic condition is available to them in advance.

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