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Adaptive Traffic Density Management System

A Keerthi Infanta Francy[1*], S Visalachi[2], R Deepa[3]

[1*] Department of Information Technology, Loyola-ICAM College of Engineering and Technology, Chennai, India
[2] Department of Information Technology, Loyola-ICAM College of Engineering and Technology, Chennai, India
[3] Department of Information Technology, Loyola-ICAM College of Engineering and Technology, Chennai, India

[*]*Corresponding Author: francy.keerthi@gmail.com , Tel.: 9962386911*

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***Abstract*—** The traffic signals in many countries are controlled by traffic police manually. Conventional traffic light system is based on fixed time allotment at each side of the junction which cannot be varied as per varying traffic density. This existing system is not intelligent enough to make perfect decisions in varying the signal timings. The proposed system is to develop a smart density based dynamic traffic signal system. This system has ultrasonic sensors placed on dividers to detect the traffic density on each road and changes the signal timing as per the traffic density classification low, medium and high. It also paves way for emergency vehicles by making use of RF transceiver where the emergency vehicle driver sends RF signal and the signal is changed to green for that particular path. The entire system maintains free flow of traffic without manual operations and also optimizes waiting time for the emergency vehicles. Regulating the traffic through this system is inexpensive and it provides better traffic control.

***Keywords*—** Traffic density, Emergency Vehicles, Ultrasonic Sensors, RF Signal, Timer, Traffic congestion

I. INTRODUCTION

The number of vehicles and the need for transportation is continuously growing, and nowadays cities around the world face serious traffic congestion problems: almost every weekday morning and evening during rush hours. These significant increases in the number of vehicles and intensification of traffic proved to be the reason for traffic jams, which affects the functioning in large urban areas and effectively reduces the quality of life in city centres. The spill over effect from congested main roads to secondary roads and side streets as alternative routes may affect neighbourhood amenity and real estate prices.

Traffic congestion is a condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicular queuing. This results in impossibility to forecast the travel time, accurately forces drivers to foresee a longer time to travel "just in case", and less time for productive activities. Traffic jams do not only cause considerable costs due to unproductive time losses; they also augment the probability of accidents and have a negative impact on the environment. The traffic blocked for emergencies may interfere with the passage of emergency vehicles travelling to their destinations, where they are urgently needed.

This extraordinary delay in traffic movement /traffic ambience is largely due to poor traffic management by the responsible authorities which has become more problematic and confusing. Optimizing this traffic delay is a common issue in transportation system. Time is of the essence when ambulances are utilized to save people's lives, but when an ambulance needs to pass through a junction, its speed often must be reduced due to traffic. The idea proposed in [1] is smart road system, where the minimized total trip time is due to minimizing the average waiting time on traffic lights by regulating the signal timing efficiently.

A. Various Methods

In the last few decades, many researchers' attention was focused on developing vehicle detecting systems or the traffic control approach to regulate traffic based on vehicle count [2]. These systems are described below, which are based on traffic science, traffic technology, control theory, typical traffic patterns.

- Traffic Sign Recognition
  The Traffic Sign Recognition (TSR) [3] is used to regulate traffic signs, warn the driver, and command or prohibit certain actions. A fast real-time and robust automatic traffic sign detection and recognition can support and disburden the driver, thus, significantly increase driving safety and comfort. Generally, traffic signs provide the driver various information for safe and efficient navigation. Automatic recognition of traffic signs is, therefore, important for automated intelligent driving vehicle or driver assistance systems. However,

identification of traffic signs with respect to various natural background viewing conditions still remains challenging tasks.

- Sydney Coordinated Adaptive Traffic System
  The Sydney Coordinated Adaptive Traffic System (SCATS) [4] is an intelligent transportation system and an innovative computerized traffic management system. It gathers data on traffic flows in real-time at each intersection and the data is fed via the traffic controller to a central computer. This makes incremental adjustments to traffic signal timings based on minute by minute changes in traffic flow at each intersection. This adaptive traffic control system helps to minimize stops (light traffic), delays (heavy traffic) and travel time by selecting the most appropriate cycle length, splits, and links (or offsets). It determines phase combinations.

- Active traffic management [5] (also known as managed lanes or smart lanes or smart motorways) is method of increasing peak capacity and smoothing traffic flows on busy major highways. Techniques include variable speed limits, hard-shoulder running and ramp-metering controlled by overhead variable message signs.

Developing an advanced traffic control system becomes a crucial task in the process of improving the flow of vehicles through the city. The system needs continuous analysis of traffic intensity in different directions and customizing the operation of traffic lights to the observed needs. Subsequently, the traffic density is being calculated, which enables more efficient and flexible traffic management by regulating the traffic signal timing and service to emergency services.

The rest of this paper is organized as follows. Section II describes about the existing methodologies with its advantages and disadvantages. Section III is the proposed system Adaptive Traffic Density Management System. Section IV is the results and discussion. Section V concludes the paper with the future work.

II. EXISTING METHODOLOGIES

The Infra-red (IR) detectors are used to detect the traffic density and various other parameters such as count, presence and speed of the vehicles [6]. These sensor detected values are controlled by the microprocessor which in turn automates the signal timings based on the traffic density. These values can be stored in the cloud and a graphical view of the traffic density can be sent to the users for better route optimization. The sound sensor can be used to detect the presence of emergency vehicle such as ambulance and automate the signal timing. IR sensor can detect only up to 10-500m in range. Sunlight can disrupt the IR signal and IR energy can be absorbed by fog, rain and snow. The installation and maintenance cost is high. The sound sensors can detect only from 10-120dB. Video analysis using camera sensor network can be used to capture images at regular intervals of time to monitor the traffic flow [7]. The clarity of the images is very poor. This methodology works only when there is good light and weather condition.

Inductive loop detection is another method where a car passes changes the inductance of the loop and the change in energy level is used to determine the number and speed of the vehicles [8]. The major disadvantages of this method are poor reliability, improper connections inside roads, poor pavement leads to frequent digging of road which makes this method inefficient. The Radio-frequency identification (RFID) can be attached at each vehicle to detect the presence of vehicle. It is especially used to reduce the traffic in toll gates. But installing RFID tags at each vehicle is not efficient, cost is also high. Sending traffic information to drivers is one of the solutions to find the optimal route but when there is only one possible route to reach the destination traffic still continues [9]. The best way to measure the traffic density is by using ultrasonic sensors on roads (especially in dividers) [10].It is cheaper and more accurate.

III. ADAPTIVE TRAFFIC DENSITY MANAGEMENT SYSTEM

Traffic congestion has caused various censorious problems in highly populated cities all over the world. There are various methods proposed already as discussed in the section II which has both advantages and disadvantages. The proposed system, Adaptive Traffic Management System is much more practical and applicable in real time. Fig. 1 shows the architecture of Adaptive Traffic Density Management System. The main components are ultrasonic sensors and buzzers.

The ultrasonic sensors are placed in the dividers approximately 150 meters apart. Fig. 2 shows the first sensor placed from the traffic signal at a distance of 50meters. It measures the distance between the object (vehicle) and the divider and then analyzes the traffic density based on the sensor values detected. The traffic density is been classified as high, medium and low. From the traffic signal, the low traffic is below 50 meters (till the first sensor), the medium traffic is 120 meters (between the first and second sensor), and the high-traffic is above 120 meters (till second sensor). The timer in the signal changes accordingly based on the classification of traffic density.

Figure 1. Architecture of Adaptive Traffic Density Management System

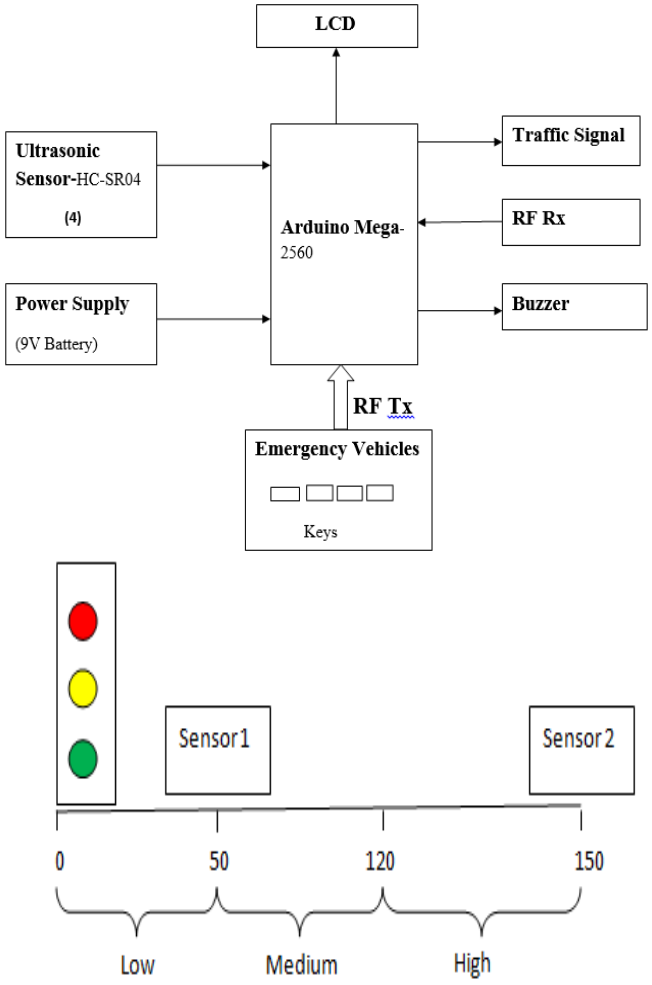

Figure 2. Placement of ultrasonic sensors

In case if emergency vehicle arrives the emergency vehicle driver can choose the path with the keys given to him and that particular path will be cleared for the vehicle to pass through. A buzzer is placed in the traffic signal to alert other drivers when the emergency vehicle arrives to avoid traffic congestion.

A. Ultrasonic sensors

Ultrasonic Sensor is a device that can measure the distance of an object by interpreting the echoes from radio or sound waves (calculates time interval between sending the signal (TRIGGER) and receiving the signal (ECHO) to determine distance [11]. It is beneficial to use because of the following advantages:

- Measure distance and are easy to use and reliable.
- Resistance to climatic changes (unaffected by atmospheric dust, rain and other minute particles)
- High sensing distance capability compare to inductive/capacitive proximity sensors
- Can detect complex shaped objects
- Lifetime approximately 3years
- Waves can travel up to 40,000 Hz

B. Buzzer

Buzzer is an electrical device that is used to make a buzzing sound to attract someone's attention or to alert people [12]. In case of emergency vehicles, the road has to be cleared immediately for the vehicle to move without any delay. Hence, the buzzer is used to indicate or notify other vehicle drivers about the particular path clearance through which the emergency vehicle has to pass through.

IV. Results And Discussion

In the existing system, the signal timing is predefined and it cannot be changed dynamically with the traffic density [13]. The timing is same even when there is no traffic or heavy traffic. Thus, there is wastage on green light timing when there is less traffic. During high traffic congestion, green light timing is not reduced completely in certain cases where the vehicle just moves a little forward and has to wait again in traffic.

In the proposed adaptive traffic density management system, the ultrasonic sensor detects the traffic density and classifies it as high, moderate and low. The signal timing is been changed accordingly to reduce the traffic congestion. Fig. 3 shows the sensor values for the classification of traffic density. Fig. 4 shows the sensor values for the analysis of traffic density measurement.

In fig. 4 with sensor reading, the density range and the classification low, medium and high is also considered. According to the density range, the signal timing is regulated. Hence, dynamic approach is needed to reduce the traffic congestion efficiently. When the density is sensed as low traffic from 0-50m (as shown in fig.4) the timer is regulated to 30 seconds for the green signal, if there is medium traffic 60 seconds is allocated for the green signal and for high traffic 90 seconds is allocated for the green signal. Hence, there is no wastage of green signal timing and congestion is reduced when there is high traffic density.

Sensor Readings	Density
55	M
110	M
155	H
24	L
88	M
147.32	H
65	M
132	H
120	H
56	M
56	M
36	L
37	L

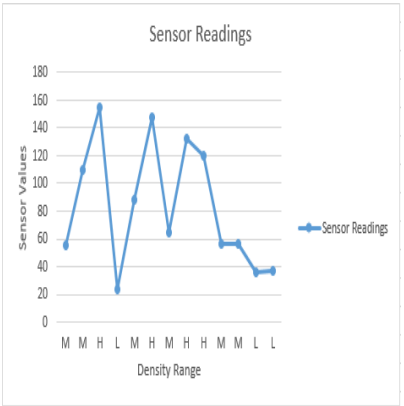

Figure 3. Traffic density classification

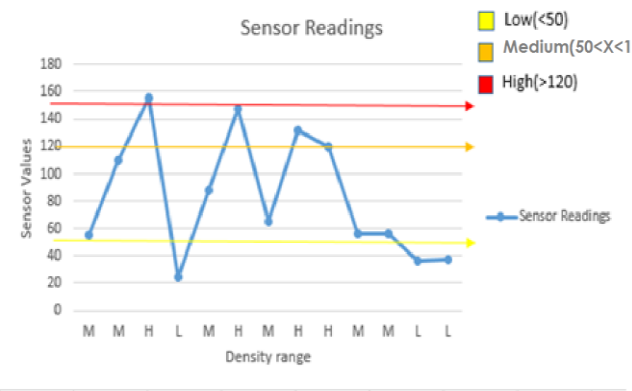

Figure 4. Analysis of traffic density measurement

V. CONCLUSION AND FUTURE WORK

The existing traffic control system had a drawback of time being wasted on green light on the empty road as the signal timings were based only on predefined time intervals. This drawback is overcome by adaptive traffic density management system, which measures the traffic density using ultrasonic sensors and regulates the signal timing accordingly. This system also paves the way for the emergency vehicles by clearing its path with the dynamic traffic light control management system. Thus, this system reduces the wastage of green signal timing and congestion when there is high traffic density. Future work includes continuous monitoring of sensor values in a web server and sending traffic information to the drivers for better route optimization.

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Authors Profile

Keerthi Infanta Francy is pursuing her final year B.Tech information technology in Loyola-ICAM College of Engineering and Technology. Her area of interests include IOT and mobile app development. Her research interests are Cryptgraphy and Network Security and Cyber Forensics.

Visalachi S is pursuing her final year B.Tech information technology in Loyola-ICAM College of Engineering Technology. Her area of interests include Web designing and andoid app development. Her research interest include IOT and data mining.She has pubished her research paper in the national conference in the IOT domain.

Dr R Deepa is an Associate Professor in the Department of Information Technology, Loyola-ICAM College of Engineering and Technology, Chennai. She has received her B.Tech in Information Technology from the University of Madras, Chennai, India in 2004, M.E. in Computer Science and Engineering from the Anna University, Chennai, India in 2006 and PhD in Information and Communication Engineering from College of Engineering Guindy, Anna University, Chennai in 2014. Her current research interests include internet of things, mobile ad hoc networks, distributed systems, web services and semantic web. She is a recognized supervisor of Anna University to guide Ph.D and M.S (by research) in the area of Computer Science and Engineering and Information Technology. She has published various research papers in the National/International Conferences and Journals. She is the member of ISTE and Computer Society of India. She has 6 years of teaching experience and 4 years of Research Experience.

