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Density based traffic control system

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Abstract: With ever increasing number of vehicles, traffic congestion has become a major problem faced in most of the metropolitan cities across the world and therefore traffic automated system with decision making capabilities must be implemented. The objective of the project is to build a traffic control system where the signal changes automatically by sensing the traffic density at any junction. The vehicle congestion at the junction, is regulated with the help of infrared sensors which interface with an Arduino mega controller. In order to obtain an accurate density, each lane is incorporated with two IR sensors. This in turn regulates the traffic consistently and in an automated manner, thereby improving the effectiveness of the system.

Keywords: Traffic congestion, Vehicle detection, Infrared sensors, Arduino-controlled.

I. INTRODUCTION

Research shows that, people in metropolitan cities like Bangalore lose 243 hours annually in traffic. The time exhausted on traffic is more and therefore, regulation of traffic is dominant part of everyday life which need to be enhanced. As an individual spends so much of his/her valuable time delayed in traffic, traffic regulation is an important factor that must be improved.

In a typical manual traffic control system, traffic is regulated using manpower and there is no orderly flow of traffic. In case of cram-full congestion, control of traffic is challenging and time consuming. To overcome the challenges faced in manual traffic control, we need to implement an improvised system. This paper proposes a system that helps in regulating traffic in an effective manner with the use IR sensors and Arduino. The IR sensors are placed in each lane which detects the vehicle movement and send the information to Arduino. Arduino processes the information received from the sensors and sends signal to the LEDs placed in that lane accordingly.

This leads to an effective sequencing of traffic and does so in an automated/consistent manner. This allows for better regulation of traffic, especially during times when there is high density on all lanes.

II. PROBLEM DEFNITION

Monitoring millions of vehicles in real-time traffic every second is time consuming and is a challenging task. The traditional traffic control system cannot handle the dynamics and complexities involved with traffic densities today. The traditional system is not closed loop and without effective feedback, it lacks in terms of efficiency.

In the year 2020, an average of 657 road accidents have been recorded in Bangalore. Accidents are one of the major problems that are faced in most of the metropolitan cities. This occurs as a result of people's lack of patience, which causes them to disregard traffic signals and speed. A well acknowledged traffic control system is the solution to this problem. Also spending one’s precious time on a fixed timer-based traffic signal when there is no traffic in the lane or spending time on the high-density traffic lane when the low-density traffic lane signal is green is of insignificant. In order to overcome this chaos, we can shift to automatic traffic signals. One such system can be developed using sensors.

III. LITERATURE SURVEY

The manual traffic control system uses manpower, for the evaluation and regulation of traffic. It is the simplest method implemented, yet a stressful and tiring task for the person in control. Siddamma et al. proposed a system that uses various sign boards and signals for traffic management. [1] This method is extremely efficient in order to maintain a safe traffic regulation, specifically in areas hosting special events or concerts. If a particular lane has high density, the police controls and regulates the vehicles in that lane accordingly. Sometimes, the police come across an emergency vehicle in a lane, then the priority is given to that lane. But, if there are similar circumstances in multiple lanes, then there are chances of losing control over traffic management. Also, in case of extreme traffic congestion, it might get challenging for the police officer to regulate the traffic efficiently and in a timely manner.

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Mishra et al. proposed a traffic signalling system that employs NE-555 timer in discrete cross-roads. A pedestrian crossing signal is additionally implemented. [2] This makes the system a dynamic controller, which is very beneficial. A fixed duration of intervals is given to red, yellow and green signal and pedestrian crossing signal. The duration of the pulse is decided using a decade counter, which fires after every N pulses. However, the pedestrians are supposed to wait until the traffic is cleared.

The ATmega8 microcontroller is the heart of the system proposed by Kumar et al. The system is implemented with four IR sensors connected to the microcontroller, which are placed on four respective lanes. Once the IR sensor outputs are received, the system is programmed accordingly to manage traffic, by assigning signals to the respective lanes. [3] The key advantage of the microcontroller is that it can be easily interfaced with additional RAM, ROM and I/O ports. Nonetheless, it seems to have a downside due to its complex structure and restricted number of executions.

Sensors are installed at a predetermined distance from the crossroads to detect the speed and sound waves of the siren at a predefined level.[4] Sensors transmit data wirelessly with the traffic control systems at the two junctions based on speed. The two intersections' WSN traffic control systems seem to be able to reduce traffic flow by communicating with each other and assigning the appropriate time for red and green lights so that emergency vehicles can pass swiftly. It may be counterproductive in the event of a breakdown, as it is difficult to correct a fault in a complicated system.

Raspberry Pi and MATLAB are being used to create this traffic control prototype system. Raspberry Pi is the controller of the entire system, which provides a timing-based traffic control. [5] Image processing is used to measure the density on the lanes by converting the image captured (source image) into an output image (contour image) i.e., to count the number of vehicles on the lane, thereby determining the density. The system is beneficial as it gives an accurate density of vehicles. But the interpreted programming language is slow and is not free of cost like an OpenCV, hence it is not applicable to real time applications.

IV. METHODOLOGY

The objective of the prototype system is to control and regulate traffic congestion based on the vehicle density. Arduino Mega 2560 is the controller of the system. The Infrared sensors are employed to detect the vehicle density on the lanes. LEDs are used to emulate the signals on each lane namely Red, Yellow, Green. Considering cross-roads with four lanes, a pair of IR sensors and a set of 3 LEDs are incorporated on each lane which are thereby interfaced with Arduino Mega.

IR sensors function as the input to the Arduino, and the LEDs are the output of the Arduino, thereby managing the traffic well. Once the pair of IR sensor detects vehicles on the respective lanes, the receiver of the IR sensor receives data, processes it, and transmits the data to the Arduino controller through its transmitter. The Arduino Mega is programmed and dumped with the codes, as per the requirements and functionality of the traffic control system. The Arduino Mega, thus controls the LED output and clears the traffic at the junction, lane-wise based on the concentration of the vehicles on each lane. The lane with high vehicle density, is prioritized, and will be freed first, by giving green signal to that lane, while all the other lanes remain at halt i.e., the lanes are given a red signal.

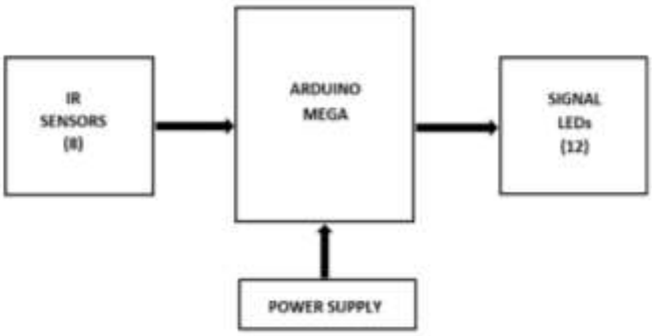

Fig 1: Block diagram for the overall system developed

We come across a few scenarios that are reviewed and controlled according to specifications. When there are no vehicles on any of the lanes, then the green signal toggles between all the four lanes at an equal interval, until any of the lanes encounter vehicles. In case of high density on one of the lanes, then that lane is first cleared by giving a green signal, keeping all the other lanes at standstill i.e., red signal. If two or three lanes have a high vehicle density, then the green

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signal iterates between the two or three respective lanes, leaving the lanes with no density at halt, and freeing the traffic in this high density effectively until the traffic is cleared on all the lanes. If high density is detected on all the four lanes, then green signal iterates between all the four lanes until the traffic congestion in all the lanes are cleared effectively. The processing of all the cases and instances are done in an orderly (1-2-3-4) and iterative manner.

V. COMPONENTS

The components used for this study are given below:

1. Infrared Sensors - The IR sensor consists of transmitter and receiver and emits infrared light. When an obstacle comes in line with the infrared light, the IR transmitter sends out radiation, out of which some radiation reaches the obstacle and some of it reflects from the obstacle to the IR receiver. The sensor's output is determined by the intensity of the IR receiver's signal.

2. Arduino Mega 2560 - It's an open-source microcontroller based on the ATmega2560. It has 54 digital I/O pins, 16 analogue pins, 4 hardware serial UART ports, and a 16MHz crystal oscillator. The USB cable can be used to configure the controller. The Arduino IDE application can be used to dump codes onto the board.

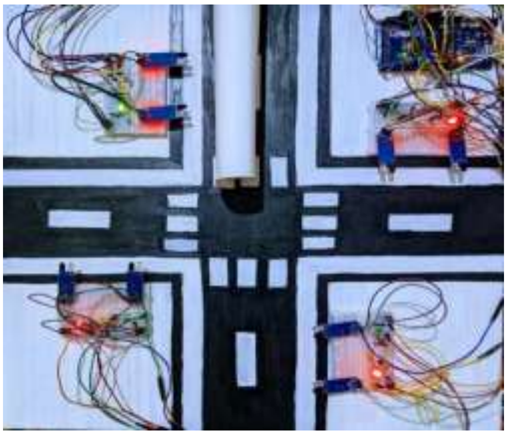

Fig 2: Depiction of the density-based traffic control system

VI. FLOWCHART

The flowchart depicts the traffic control system's functionality in detail. The signals are regulated in accordance with the inputs of the IR sensors.
When both IR sensors on a lane detect high density, the lane receives a green signal, and the traffic in that lane is cleared. If the IR sensors on their respective lanes do not detect any traffic, the controller moves to the next lane and checks the IR sensor inputs, repeating the process.
The controller monitors vehicle density in each lane and updates the signals accordingly. The system repeats the same steps in a loop.

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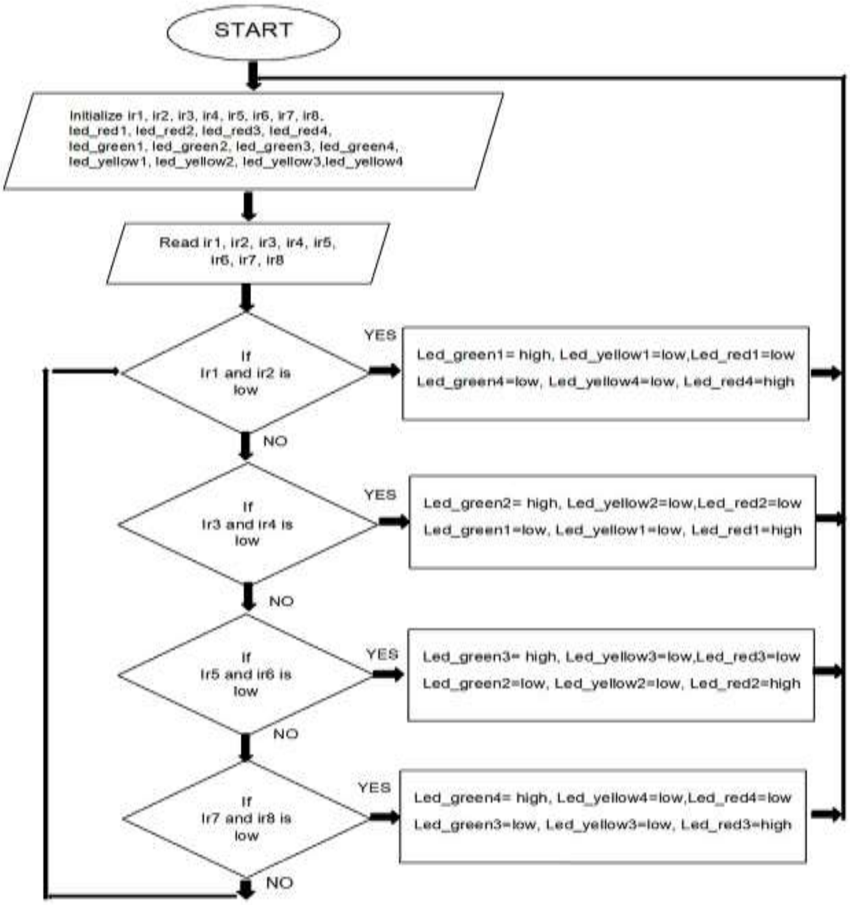

Fig 3: Flow chart explaining the working of the prototype

VII. ADVANTAGES AND DISADVANTAGES

Advantages

- Efficient regulation and management of traffic. Each lane is given the priority based on the vehicle density. So, the lane with the higher density will be cleared faster, thereby avoiding traffic congestion.
- One time implementation hence it is cost efficient.
- System works endlessly without manual control. The controller takes the charge of analysing the inputs from the IR sensors and regulates the signals.
- The system checks each lane for the vehicle density, in a loop, hence regulating traffic in a timely manner.

Disadvantages

- The range of IR sensors is very less therefore confined to small area. Exact number of vehicles on the lane cannot be calculated.

VIII. CONCLUSION

The system is implemented, to automate and emulate traffic, by prioritizing the lanes with high density. Clearing the traffic based on the vehicle density, shortens the wait time in the lanes with high density. The controller of the system prioritizes the lanes based on the data received from the IR sensors, thereby managing traffic efficiently. By being able to prioritise the traffic signal based on the vehicles in each lane, the proposed system succeeds to improve the efficiency of the traffic signal.

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IX. FUTURE WORK

The proposed system can be improvised by using MATLAB software and image processing techniques. Using these techniques, the density of each lane that is number of vehicles in each lane can be calculated and prioritised accordingly. Therefore, accuracy can be improved.

By using voice recognition module, emergency vehicle sound will be picked up and signal can be changed automatically in case of an emergency.

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