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A NOVEL METHOD FOR IOT BASED SMART TRAFFIC SYSTEM

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Abstract

According to India's 2019 Urbanization Report, one-third of the country's population lives in cities. This has increased the demand for cities to provide unique services that leverage technological breakthroughs to alleviate and control traffic congestion. The primary objectives of smart traffic systems are to eliminate time delays and waiting times for vehicles to pass due to the hard-coded nature of the current traffic system. According to digital India, smart cities cannot be intelligent without traffic management systems; hence, monitoring, managing, simulating, optimising, and operating traffic in urban areas is necessary to accommodate density-based traffic rather than time-based traffic. The paper proposes a novel algorithm for intelligent traffic systems based on values from an Internet of Things (IoT)-IR sensor. This proposed program gathers data from multiple infrared sensors and automatically sets the timing mechanism for traffic systems based on the length of traffic. For this system, several sensors and considerations in sensor selection are examined from a managerial approach. The user may select and install two or three infrared sensors in this system, depending on the amount of traffic in the lane. The density of traffic on the roadways will be determined using infrared sensors mounted on each lane. These sensors will provide data to the Arduino, which will analyse it using a unique algorithm. Rather than the static approach used by the existing system, it dynamically adjusts the timing for each direction based on traffic density. The background programme analyses traffic on previously scheduled routes and plans the next cycle time in real time to minimise vehicle wait times during each cycle of the time mechanism.

Keywords: IoT, Smart Traffic Management, Smart City, Traffic Congestion, Arduino, IR Sensors

1. INTRODUCTION

In urban areas, as the population grows, so does the number of automobiles on the road. Even Nevertheless, in many major cities, traffic is still managed manually by a centrally controlled traffic system, as a human must be there to ensure that cars pass without causing too much commotion and that they follow correct order and traffic rules. The key issues in India, according to the report "Smart Transportation - Transforming Indian Cities," are insufficient and inefficient public transportation infrastructure, transportation emissions and air quality, and improperly integrated Intelligent Transportation Systems (ITS). It has also been observed that during peak hours, drivers on popular roads are forced to wait for long periods of time when delayed at a signal, as cars continue to line up on the road. According to a Hindustan Times report, traffic congestion in Mumbai causes drivers to spend 53 percent extra time on the road [1]. For these conditions, a proper traffic management system is required, which will ensure that traffic is correctly handled without the need for human intervention. The transportation system is one of several interconnected subsystems that make up a city. It is the foundation of the global economy [2]. It is also a vital component of the smart city [3]. As the world population grows, so does the number of automobiles on the road, increasing the frequency of traffic jams [4] [5]. In certain cases, cell phone snatching at traffic signals has been observed in metropolitan areas [6]. It also has a detrimental effect on the ecosystem [7] and on industrial efficiency [8]. The paper offers a unique method for intelligent traffic systems based on IoT-IR sensor readings. This suggested programme collects data from various infrared sensors and automatically sets traffic system timing based on traffic length. The proposed approach to smart traffic management can be helpful in eliminating manual participation and improving traffic efficiency.

2. LITERATURE REVIEW

Many researchers have sought to overcome the difficulties associated with vehicle detection and tracking. S. Indu et al. [9] and H. H. Kenchannavar et al. [10] presented systems that use motion detection techniques to identify automobiles as moving blobs and follow them for several consecutive frames. The optical flow algorithm, framework differencing, and background subtraction are employed to detect vehicles during the day. While these systems are highly accurate at detecting and tracking automobiles during the day, they fail at night due to inadequate illumination. Rajiv Kumar Nath et al. [11] used template matching to detect night vehicles. However, the method is not very useful because it requires building a large library of templates and estimating correlation is a difficult task. Pazoki A. R et al. [12], and Wei Zhang et al. [13] presented algorithms for night vehicle detection based on headlight pairing and tracking.

The city of Pittsburgh, Pennsylvania, Artificial Intelligence (AI) based new smart traffic management system called Surtrac. In 2016, employing radar sensors and cameras integrated into Pittsburgh's traffic lights, this system cut travel time by 25% and congestion by 40% at 50 junctions [1]. In addition, AI uses the big data collected by these sensors to identify the most problematic traffic conditions and optimize circulation in real-time urban ways [1].

The prominent feature of Surtrac is its decentralized approach, intelligent traffic signals of interaction directly, in real-time, to monitor incoming vehicle flows [1]; this motivated the proposed system.

Binbin Zhou et al. suggested an adaptive traffic signal control system. In comparison to a fixed-time control algorithm and an actuated control algorithm [14], this method dynamically adjusts the sequence and length of traffic lights in response to real-time traffic monitoring, increasing throughput and decreasing the average waiting time of the vehicle. The concept is demonstrated on the iSensNet transportation testbed, which relays real-time traffic data via a wireless sensor network.

Using the platform of a new type of wireless electronic licence plate system, Zhichao Wang et al. proposed focusing on optimization algorithms of signal timing of urban junctions combined with vehicle location [8]. The new strategy effectively lowered the total queue time and increased the intersection's traffic capacity. A. Prakash et al. presented an architecture to allow mobile networks to move seamlessly across heterogeneous networks. They investigated a vehicular situation in which a vehicle's mobility is supported by various internet service providers (ISPs) and advocated employing multiple mobile router-based handover systems in automobiles [15]. Two fuzzy-based systems (FPRS1 and FPRS2) are employed to improve the dependability of the suggested technique in Yi Liu et altest-bed .'s employing IoT and P2P technologies. The internet of things (IoT) is a sort of internet application that allows items to actively interact with other network members, allowing them to be active participants with other network members, which is a valuable asset in Smart Traffic systems.

3. PRESENT TRAFFIC SIGNALLING SYSTEM

Following numerous enhancements to today's digital hegemony [16] traffic control in India is a severe challenge. In many parts of India, manual traffic control systems are still in operation. To ensure that those who operate motor vehicles are familiar with the road laws and the activities involved, the driver licensing authority must demand a comparable and equivalent education programme [17]. When traffic lights are activated in different directions with a set time delay, a specific cycle switches from one signal to the next, resulting in undesirable and excessive congestion on one lane. The other highways, on the other hand, are still empty [18]. The technology we presented measures traffic density on specific pathways and controls signal timing. Two infrared transceivers count obstructions and provide an estimate of traffic density on a particular lane, which is sent to a control unit, which makes the appropriate judgments [11].

Most of the researchers discussed the Smart traffic system features like classification of vehicles, Speed and traffic direction measurement, Traffic simulation software, Traffic lights controllers, License plate recognition, counting of vehicles, Traffic control software priority green light, etc. So to make commercial applications of all these features requires different technologies like sensors, AI, and cloud-based technologies. Various researchers used different approaches like real-time video images from the cameras to control traffic [19], priority vehicle detection using deep learning techniques [20], IoT technologies for traffic management [21], and different techniques of fuzzy logic controllers for traffic management. Generally, non-intrusive sensors are used to monitor road traffic. These sensors are classified into three types: embedded magnetometers, pneumatic tube sensors, and inductive loops. They can be mounted in three different ways: on a pole, on a bridge, or on the roadside at ground level [22]. From the managerial point of view, to select the sensors, factors to be considered are- quality, quantity, accuracy, and trustworthiness, cost factor, low maintenance, climate conditions. Researchers used different types of Non-intrusive sensors like Video cameras, Infrared, Ultrasonic, Acoustic array sensors, Radar sensors, Road surface condition sensors and RFID to detect traffic density. This system takes into account the applications of infrared sensors, such as speed measurement, vehicle length, volume, and lane occupancy; and, in accordance with our system requirements and expert opinion, IR sensors are employed.

After reviewing all the techniques mentioned above, the research aims at designing a decentralized low Traffic control system using IOT IR sensors and algorithms to prioritize green light based on traffic density.

4. PROPOSED SYSTEM

People have been using the old traditional way of manually monitoring, which is hectic and also not very much efficient, and too time-consuming. This system is here to overcome the old situation and develop a new trend to give a better managing system, only by using the density-based traffic system with sensors where we can track the number of cars. The sensors will notify about the density, and accordingly, proper actions will be taken. Traditional manual monitoring methods take a lot of time and resources. Also, the accuracy and time management of these systems is not up to the mark.

The system operates on the principle of adjusting the delay of traffic signals based on the amount of time that traffic is backed up through an assigned section of road. Eight sensors are installed on four sides of a four-way to analyse the length of traffic jams caused by vehicles on the path. Infrared sensors are being used in place of traffic control systems in order to create a density-based traffic light system. These sensors are spaced apart by a predetermined distance. If only one sensor appears to be activated, this is normal; but, if both sensors appear to be activated, this signal will prioritize. Numerous factors will be evaluated for turning signal green or red.

4.1 Data from sensors

There are two sensors on each lane, which will help determine the lane's density level. Here we have set 3 conditions based on sensor inputs. The table 1 represents the conditions for the sensors in three different classes Low, Medium, and High.

Table 1: Traffic Density States by IR Sensors - 2 IR sensors

Condition/ sensors	Sensor-S1	Sensor-S2	Status of the Signal
Condition 1	0	0	Low
Condition 2	1	0	Normal
Condition 3	1	1	High

(*similarly three IR sensors in each lane with 4 conditions like 000-low, 100-normal, 110 –medium and 111-high)

1.2 Traffic actions based on the signal density level

If all signals are in a low-density state, all signals work in the normal period where there are four signals which can be labeled as A, B, C, D, and density can be varying as High and Low. If signal A shows HIGH density, then signal A gets priority, and it will turn to Green, and other signals will be Red. If more than one signal has a high density, both signals will get priority and work serially. For example, considering signal A and signal B having high density, then first Signal A will open, and in particular period A gets red, and Signal B will open. Similarly, if signals A, B, and C have high density, then A will open first, then B and C.

The table 2 represents the different situations and actions in those situations.

Table 2: Traffic actions based on the Signal by considering two IR sensors on each way

Cases	Signal Density				Actions
	A	*B*	*C*	*D*	
Case 1	L	L	L	L	The normal flow of the signal.
Case 2	H	L	L	L	A will have priority.
Case 3	L	H	L	L	B will have priority.
Case 4	H	H	L	L	A and B will have priority.
Case 5	L	L	H	L	C will have priority.
Case 6	H	L	H	L	A and C will have priority.
Case 7	L	H	H	L	B and C will have priority.
Case 8	H	H	H	L	A, B, and C will have priority.
Case 9	L	L	L	H	D will have priority.
Case 10	H	L	L	H	A and D will have priority.
Case 11	L	H	L	H	B and D will have priority.
Case 12	H	H	L	H	A B and D will have priority.
Case 13	L	L	H	H	C and D will have priority.
Case 14	H	L	H	H	A, C, and D will have priority.
Case 15	L	H	H	H	B, C, and D will have priority.
Case 16	H	H	H	H	The normal flow of the signal.

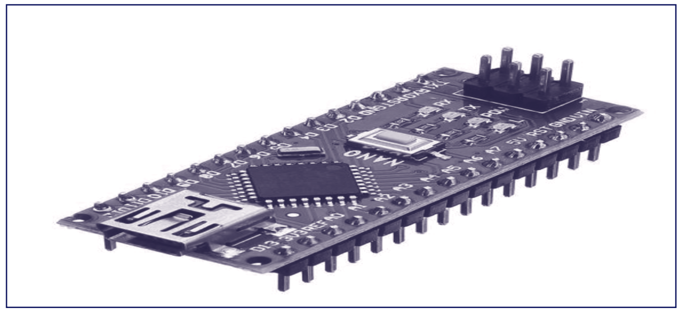
***(For two IR sensors, Here, H = High and L = Low, For three IR sensors H=High, M-medium, L=low, this table is not shown here due to page limit)**

4.3 System Hardware and Working

Measuring the way Density:

- For this IR sensors will be used.
- Initially, the sensors will be placed in the middle of the way.
- Each lane will have two sensors.
- The second sensor will be placed at a fixed distance where if a vehicle is detected at that distance, the lane will be considered to be densely packed.
- The sensors will send the output of density to the Arduino Nano shown in fig 1 as input.

Fig 1. Arduino Nano



4.4 LED and IR Sensors:

IR Sensor Circuit Diagram is shown in fig 2.

- It will be used to collect input from IR sensors shown in fig 3 and then provide the LED's appropriate output according to the instructions given in the code.
- Three LEDs of color Red, Yellow, and Green will be lit according to the instructions given by Arduino.
- This will also help to reduce the manual controlling of traffic.
- The sensors will be placed in the middle of the lanes. So each lane will have two sensors.
- The sensors will detect the amount of traffic on the lane; accordingly, it will send output to Arduino as high or low.
- High means the way is pretty full, while low implies the road is not full.

The basic workflow of the system is as shown in fig 4.

Fig 2. IR Sensor Circuit Diagram

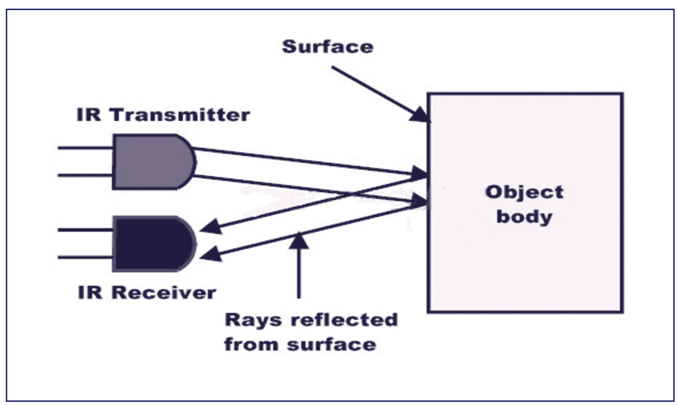


Fig 3. IR Sensor

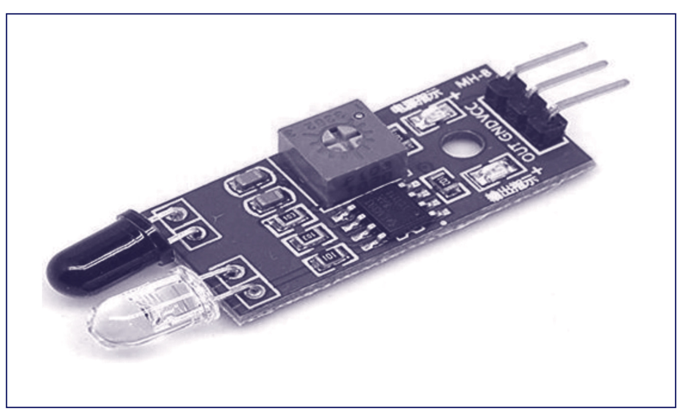
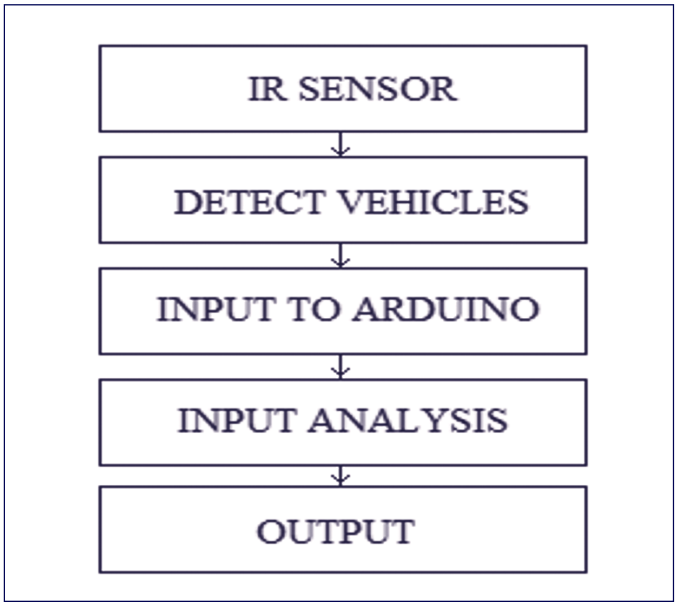


Fig 4. The basic workflow of the system



1.4.0.1 IR Sensor and Vehicle Detection: IR sensors are used to extract data from real-time environments by detecting the obstacles, which, in our case, are cars.

1.4.0.2 Input to Arduino: IR sensors send the data to the Arduino, which then analyzes it.

1.4.0.3 Input Analysis: According to the input received, the Arduino board will decide the action to be taken to prioritize the four signals i.e., A, B, C, and D, using an algorithm.

1.4.0.4 Output phase: Depending upon the signals' densities, either one of the signals (A, B, C or D) or two, or three or all the four of them will have priority. If the densities of all four signals are either high or low, the signal will continue to flow normally.

Algorithm:

This algorithm is implemented in embedded C

Input - Input from IR sensors, K-no of IR sensors in each way, Last_cycle_case, current_cycle_case initial time parameter(60 sec) , time (range- 60sec, 120sec, 150 sec depending on current case and last case.),

Output- Open the particular road green signal for a specific time and complete the cycle.

1) Initialize the System

Set initial parameters:

```
    set lastcycle=case1;
    time=60sec;
2) Read_Sensor-values()
3) Determine_Priority_Case()//OUTPUT CURRENTCASE
4) IF CURRENTCASE =CASE1 AND LASTCYCLE=CASE1 Then
    //NORMALCASE
    Openroad_A(time);
    Openroad_B(time);
    Openroad_C(time);
    Openroad_D(time);
    GO TO STEP 2
ENDIF
IF CURRENTCASE =CASE2 AND LASTCYCLE=CASE1Then
    //CASE2 WITH TIME 120SEC
    TIME= 120SSEC;
    Openroad_A(time);
    TIME=60SEC;
    Openroad_B(time);
    Openroad_C(time);
    Openroad_D(time);
    GO TO STEP 2
ELSEIF CURRENTCASE =CASE2 AND LASTCYCLE=CASE2 Then
    TIME= 150SSEC;
    Openroad_A(time);
    TIME=60SEC;
    Openroad_B(time);
    Openroad_C(time);
    Openroad_D(time);
    GO TO STEP 2
ENDIF
IF CURRENTCASE =CASE3 AND LASTCYCLE=CASE1Then
    //CASE2 WITH TIME 120SEC
    TIME= 120SSEC;
    Openroad_A(time);
    TIME=60SEC;
    Openroad_B(time);
    Openroad_C(time);
    Openroad_D(time);
    LASTCYCLE=CASE2
    GO TO STEP 2
ELSEIF CURRENTCASE =CASE3 AND LASTCYCLE=CASE3 Then
    TIME= 150SSEC;
    Openroad_A(time);
    TIME=60SEC;
    Openroad_B(time);
    Openroad_C(time);
    Openroad_D(time);
    GO TO STEP 2
ENDIF
```

The same approach is used to set the remaining r cases. Then default case is set as a normal case. The open road module will open the green signal of that particular lane for the defined time period and delay is introduced to complete the cycle.

5. IMPLEMENTATION DETAILS AND RESULTS

The suggested system operates on the principle of adjusting the delay of traffic signals based on the length of traffic jam-related traffic that passes through a designated segment of route. Eight sensors are installed on four sides of a four-way road to study the density and duration of traffic jams that pass through the region covered by the sensors. In this example, infrared sensors are used to design a density-based traffic signal system. Those sensors are placed at some particular distance between two sensors. If just one sensor appears to be activated, it can be considered normal. If both sensors appear to be activated, this signal will take precedence. This system is designed for one lane system. Further, more IR signals are needed for the multilane system and placed intelligently to detect and design the system. Fig 5 shows the implementation of system prototype used for testing the proposed system and fig 6 shows the working of proposed IoT based smart traffic system.

Fig 5. Implementation of system prototype

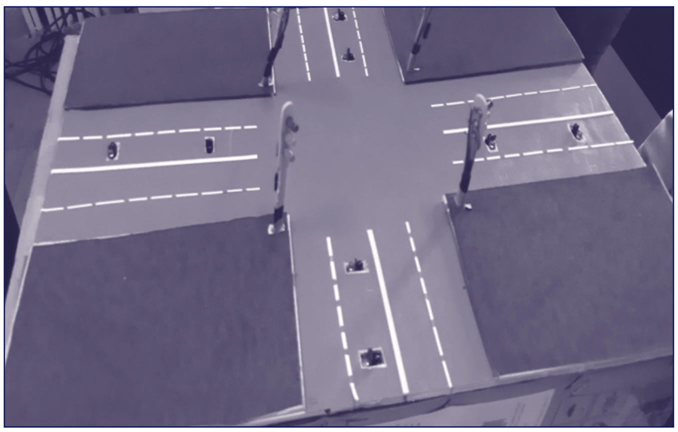
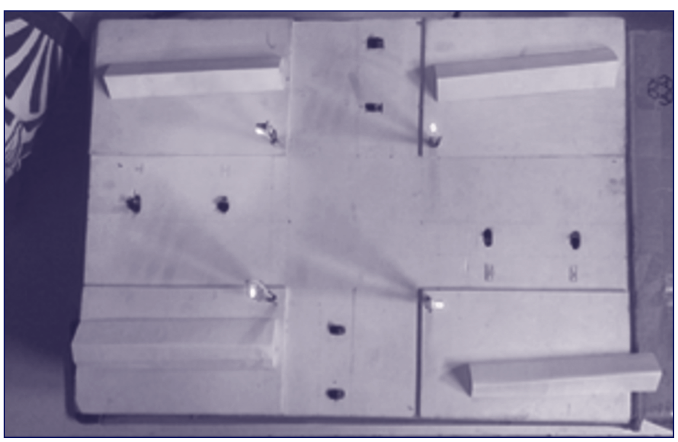


Fig 6. Working of IOT based smart traffic system



6. CONCLUSION, LIMITATIONS AND FUTURE SCOPE

This paper examined several aspects of future smart traffic systems, which will aid managers in commercialising them. The system has been conceived, built, and tested. The technology created aims to eliminate undesirable delays induced by traffic lights. Congestion caused by more vehicles on the road lanes during peak hours (morning and late evening) is alleviated by counting vehicles, identifying traffic length along each route, and prioritising lanes with more vehicles. The system employed Arduino UNO adaptive traffic light controllers. worked well and is reasonably priced (IR sensors, Arduino kit, pole, and sensor box). Due to the pandemic, the experiments were conducted at home and in the college lab. However, it may be easily implemented on roads to produce comparable results. The system proposed offers benefits such as delay saving, fuel-saving, less emission of CO2, user satisfaction, and overall productivity improvements.

Besides the hardware cost (IR sensors and kit), managers should consider construction, maintenance, and IR sensor life span when implementing this project. This system uses IR sensors, which can sometimes absorb regular light, resulting in incorrect system results and working only for short distances. But IR sensors may be placed precisely to determine traffic density.

In the future, by employing sound or infrared sensors, Arduino could detect an ambulance approaching traffic lights. It can be given top priority regardless of lane traffic. So it can save drug-dependent people's lives.

Future research should focus on mass-producing the device that can be used on all roadways to reduce traffic congestion. Also, the traffic check station may have wireless transmitters that warn crossings of approaching vehicles. The sensor network can connect to GPS and short-wave radio. With a feed-forward system, the signalling system will be smoother and less congested.

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