

IR Based Traffic Density Detection & Signal Adjustment

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Abstract: *In the present day world, with growing technologies and adverse development in the metropolitan cities, traffic administration has become one of the most important fields to be dealt with. The main role of a traffic administration is to constantly improve the traffic control system and effectively regulate the same. With the number of vehicle users constantly increasing, the facility provided by the current system is limited and inefficient with respect to the energy and time consumed. A survey shows that an average person spends about four to six months of his/her entire life just waiting for the green light to be turned ON at a signal. It is also been identified that this inadequate facility and irrational distribution of signal control is leading to such traffic issues. These inefficient traffic control system is also contributing to various traffic violation wherein the people don't possess the patience to wait for that interval of the signal which does not have much vehicle density than the other existing densities. Avoiding conditions of extreme traffic jams is highly important in the current situation. Hence in this proposed system of traffic control, we focus on the traffic density rather than just giving control to the signals on a fixed time basis. This proposed in based on vehicle detection by IR sensors, analysisation and computation of the scenarios by the Arduino UNO and the same gives the control depending on the control time in the code to the LED's . On a whole, this system senses the presence of the vehicle in that given lane and suitably gives control to the signals.*

Keywords: Traffic Density Detection, Signal Management, Microcontroller, IR Signal, Automation

I. INTRODUCTION

Traffic administration has the goal to constantly improve traffic system and regulation. As the number of vehicle users constantly increases and resources provided by current infrastructures are limited, intelligent control of traffic will become a point of focus in the future. Avoiding traffic jams is beneficial to both environment and economy. In our research we focus and optimization of traffic light controller in a city using IR sensor and developed using Arduino. An intelligent transportation system (ITS) estimates the traffic parameters and optimizes traffic signal to reduce vehicle delays and stop. Fixed control on traffic is basically not control according to the density, but in a manner of programming which is already fixed in the system. This paper proposes an intelligent system using Arduino for implementing it in the city. Urbanization and the rapid increase in the number of vehicles have led to significant traffic congestion in cities worldwide. Traditional traffic management systems, which rely on fixed signal timings and manual adjustments, often fail to adapt to real-time traffic conditions, resulting in inefficient traffic flow, increased travel times, fuel wastage, and elevated pollution levels. To address these challenges, the integration of Internet of Things (IoT) technology into traffic management offers a promising solution. This project focuses on developing a Vehicle DensityBased Smart Traffic Management System utilizing IoT. The objective is to create a dynamic and adaptive traffic control system that responds to real-time vehicle density data, thereby optimizing traffic flow and reducing congestion.



Traffic congestion is a severe problem in most of the cities across the world and it has become a nightmare for the citizens. It is caused by delay in signal, inappropriate timing of traffic signalling etc. The delay of traffic light is hard coded and it does not depend on traffic. Therefore, for optimising traffic control, there is an increasing demand in systematic quick automatic system. This paper is designed to develop a density based dynamic traffic signal control. The signal timing changes automatically on sensing the traffic density at the junction. The microcontroller used in this project is ARDUINO. The system contains IR sensors (transmitter and receiver) which will be mounted on the either side of the road on poles. It gets activated and receives the signal as the vehicles passes close by it.

Aim & Objective:

The aim of this project is to design and develop an IR-based smart traffic control system using Arduino UNO that can efficiently manage traffic signals based on real-time vehicle density. The system uses IR sensors to detect the presence of vehicles in different lanes and automatically controls the traffic lights accordingly, giving priority to lanes with higher traffic. This helps in reducing unnecessary waiting time and improving overall traffic flow. The Arduino UNO acts as the central controller, processing sensor data and adjusting signal timings dynamically. Additionally, a 16x2 LCD display is used to show the current lane status and signal information. The main objectives of this project are to automate traffic signal operation, optimize signal timing, reduce congestion, enhance road efficiency, and provide a low-cost, reliable, and scalable solution for modern traffic management systems.

II. LITERATURE SURVEY

Smart traffic management systems (STMS) are an essential part of modern urban infrastructure, providing solutions for traffic congestion, accident reduction, and improved efficiency in transportation. A vehicle density-based smart traffic management system utilizes sensors to detect the volume of vehicles on the road and adjust traffic signals dynamically. This survey explores existing studies

1. **Smart Traffic Control Systems:** Smart traffic management systems are developed to reduce traffic congestion, particularly in metropolitan areas. A common strategy is the use of sensors to detect realtime traffic conditions and dynamically adjust the signaling system based on vehicle flow. Studies have shown that traditional traffic light systems often fail to adapt to fluctuating traffic densities, leading to unnecessary delays. Implementing sensor-based systems can mitigate these inefficiencies.
2. **Ultrasonic Sensors in Traffic Systems:** Ultrasonic sensors are widely used for detecting objects by emitting sound waves at high frequencies and measuring the time taken for the echo to return after bouncing off the object. In traffic management systems, ultrasonic sensors can be placed on traffic signals or roadside poles to detect the presence and density of vehicles.
3. **Arduino Mega as a Microcontroller:** The Arduino Mega is a popular choice for controlling traffic management systems because of its multiple input/output pins, computational power, and ease of programming. It supports integration with multiple sensors and modules, making it ideal for developing complex traffic management systems.
4. **Challenges in Implementation:** While ultrasonic sensors and Arduino-based systems are practical and low-cost, several challenges need to be addressed: **Environmental Conditions:** Ultrasonic sensors are susceptible to environmental interference, such as heavy rain or fog, which can affect accuracy. **Accuracy:** showed reduced accuracy in detecting vehicles in foggy or rainy conditions. **Scalability:** For larger, multi-lane roads, a single Arduino Mega controller may not be enough to handle multiple sensors efficiently. **Systems need**
5. **Future Research Directions** **Integration of Multiple Sensor Types:** Combining ultrasonic sensors with other types of sensors (e.g., infrared, cameras) to improve accuracy in various environmental conditions. **Advanced Algorithms:** Development of more sophisticated algorithms that can predict traffic patterns and not just react to real-time data. **Wireless Sensor Networks:** Utilizing wireless that focus on using ultrasonic sensors and Arduino Mega for vehicle detection and traffic management. **Deshmukh et al. (2021)** found that ultrasonic sensors, though efficient in normal weather conditions, communication to create more scalable traffic management system.



III. EXISTING SYSTEM

Traffic management is an essential part of urban planning, aimed at improving traffic flow, reducing congestion, and ensuring road safety. Traditional traffic management systems have evolved over time with the incorporation of technology, yet many cities still rely on conventional traffic control methods. Below is an overview of the existing systems, categorized by technological advancement and functionality.

1. **Traditional Traffic Management:** Traditional traffic management systems are largely static and follow predetermined schedules, often based on historical traffic patterns or fixed time cycles for traffic lights. **Fixed-Time Traffic Signals:** This system uses traffic lights that operate on a fixed schedule, irrespective of the real-time traffic situation. These signals are pre-programmed based on average traffic conditions during different times of the day (e.g., peak hours vs. non-peak hours).

2. **Manual Traffic Control Operation:** Traffic management is manually controlled by police officers or traffic wardens at busy intersections or during special events.

3. **Preset Traffic Patterns Operation:** Traffic management is based on predefined patterns derived from historical traffic data. Traffic signals and road signage are set according to these patterns, which reflect the expected peak and non-peak hours.

4. **Traffic Signs and Road Markings Operation:** Traffic management relies heavily on road signs (stop signs, yield signs, speed limits) and road markings (lane demarcations, pedestrian crossings) to regulate traffic flow.

Challenges of Traditional Traffic Management Inflexibility: Traditional systems lack the ability to adapt to real-time changes in traffic, which leads to inefficiencies, especially during peak hours, accidents, or special events. **Congestion and Delays:** With fixed signals and preset patterns, congestion often occurs because the system cannot adjust dynamically to the actual volume of traffic on the roads. **Environmental Impact:** Fixed-time traffic lights result in vehicles idling for longer periods, leading to increased fuel consumption and emissions. Traditional traffic management systems rely on fixed schedules, road signage, and manual interventions. While these systems are cost-effective and have been useful for decades, they fall short in addressing the challenges posed by modern traffic conditions, such as increasing urbanization, unpredictable traffic patterns, and environmental concerns. The shift toward more intelligent, dynamic systems is essential for improving efficiency, reducing congestion, and enhancing safety.

IV. SYSTEM ARCHITECTURE

An RFID tag (of frequency 125khz) is attached to every product in the mall and the reader (EM-18) is attached to the trolley. At the time of purchase, the tag attached to the product is scanned by the reader. Each tag has a unique EPC. Based on the EPC received by the Arduino, the information of the product is displayed on the LCD along with the updated cost.

This information is also sent to central PC with the help of HC-12 transmitter at the trolley and HC-12 receiver at the PC. If the customer wants to remove the added product, the product should be scanned again. Then the cost of the corresponding product will be deducted from the bill. The push button is provided at the trolley to indicate the end of the shopping. On pressing of push button, the final bill is displayed on the LCD and the payment through precharged card can be done. Recharged cards are unique RFID tags provided for each customer. These cards contain the information such as the customer identification number and the balance available in the card. By scanning precharged cards, payment is done at the trolley itself. Finally, LCD shows the balance available in their card. This whole information is available on the serial monitor of central PC.



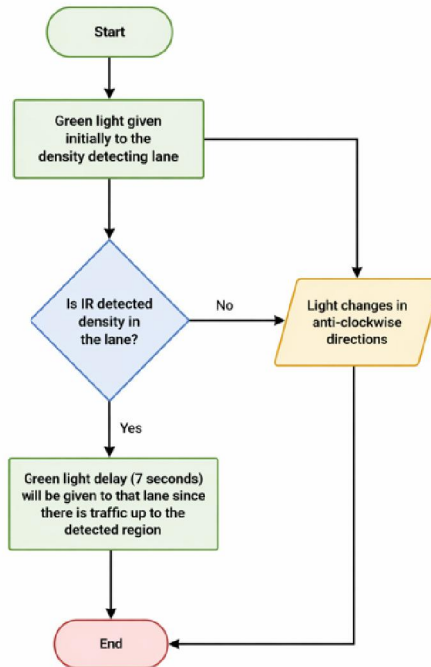


Fig. 1. Flow Chart of Working

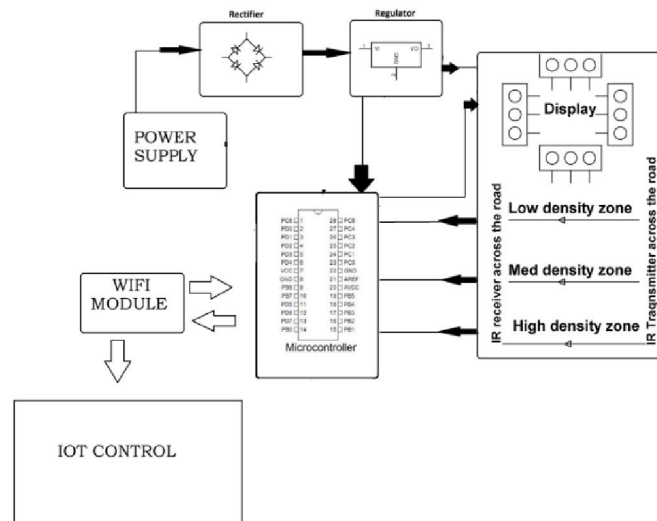


Fig. 2. Block Diagram

A. Arduino Uno:

The Uno R3 is an ATmega328P microcontroller-based development board. This is widely popular in Embedded electronics because of the available resources and easy to use by everybody features. With 14 digital input/output pins where 6 can be configured and used as PWM outputs, 6 as analog inputs is a great addition for I/O related operations. Powered with a 16 MHz ceramic resonator, an USB connection, a power jack, an ICSP header, and a reset button. It



includes a LED that can be useful in multiple applications or to test the board functionality. A voltage regulator, better to say an LDO, is available inside this development board to make this Arduino compatible for a wide range of input voltages. The application is very easy, just upload the code, and run.
Development board

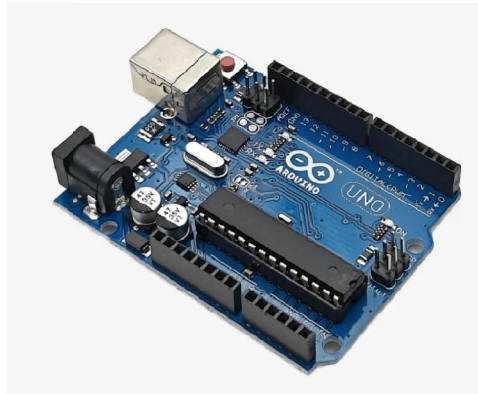


Fig. 3. Arduino Uno

B. IR Sensor:

An IR (Infrared) sensor is an electronic device which can be used to sense certain parameters of its surroundings by either emitting or detecting radiations. It can also measure heat of an object and detect motion. It uses the infrared light to sense objects in front of them and map or guess their distance. This system consists of 8 IR sensors as a detector of 4 junctions. IR transmitter looks like an LED. This IR transmitter always emits IR rays from it. The operating voltage of this IR transmitter is 2 to 3v. These IR (infra-red) rays are invisible to the human eye. But we can see these IR radiations through camera. IR transmitter transmits IR rays that are received by IR receiver. Generally, IR receiver has high resistance in the order of mega ohms but when it is receiving IR rays the resistance is very low. The operating voltage of IR receiver also 2 to 3V. We have to place these IR pair in such a way that when we place an obstacle in front of this IR pair, IR receiver should be able to receive the IR rays. When power is supplied, the transmitted IR rays hit the object and reflect back to the IR receiver.



Fig. 4. IR Sensor

C. LED Traffic Signal:

The LED Traffic Light Module is a compact and easy-to-use component designed for educational, hobby, and DIY electronic projects. Operating on a 5V DC supply, it replicates a real-world traffic signal system with red, yellow, and green LEDs arranged in a vertical format. Its simple common cathode design allows effortless wiring and control, making it perfect for beginners experimenting with microcontrollers like Arduino, Raspberry Pi, and other development boards. Ideal for traffic light simulations, robotic signaling, and learning applications, this module offers a hands-on experience in understanding LED sequencing and timing control.





Fig. 5. LED Traffic Signal

D. LCD Display:

The 16x2 LCD Display with IIC/I2C interface featuring a green backlight and black characters is an efficient and user-friendly display module for embedded systems. It is widely used in electronics projects due to its compatibility with I2C communication, which minimizes the number of GPIO pins required for interfacing.

This display is ideal for various applications like robotics, IoT devices, home automation systems, and educational projects. Its green backlight ensures excellent readability, while the adjustable contrast allows users to fine-tune the display for optimal performance in different environments

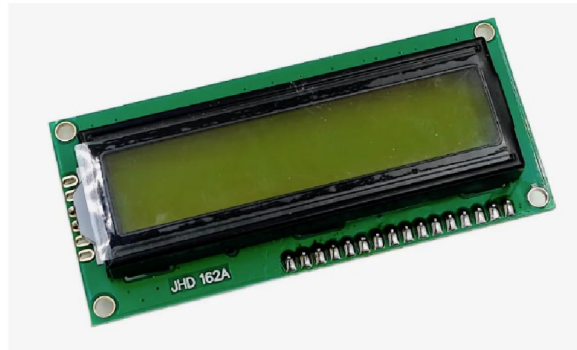


Fig.6. 16x2 LCD Display

V. CONCLUSION

The proposed traffic control system is the very basic step towards achieving automation in the field of traffic control system. With various advancements taking place in today's world, people are in search for automated systems which not only saves their time but also a lot of energy in different forms. The saving of fuel (petrol, diesel, natural gas), reduction in time of the operation of automobile engines, reduction in the emission of the harmful gases in the atmosphere. Thus this system helps in reducing the number of accidents that take place just because of this improper traffic control system and paving way to a better traffic control system. The proposed system aims to save the number of man-hours wasted at the signals and hence making effective utilization of time. Further a lot of work and progress can be made on these lines by giving priority to emergency tag vehicles. Also, a lot of work can be done on the usage of solar energy of the operation of such systems which can also make them highly energy efficient. It is also possible to make use of gas sensors to control the timing of the timers in the traffic nodes. Using GPRS map as an additional step for progress in this area, the best route can be figured out for emergency as well as police vehicle.



VI. FUTURE SCOPE

- Density-based traffic sensing technologies have enhanced traffic management, but they can be improved. These systems can be more adaptable and accurate using AI and ML. AI systems can forecast peak traffic patterns and improve signal timings to prevent congestion by studying past traffic data AI-powered anomaly detection may also inform authorities of uncommon traffic situations like accidents or road closures. This rapid reaction capacity reduces traffic flow disruptions via quick actions.
- IoT integration allows real-time vehicle-traffic management system communication, expanding system capabilities. Vehicles might get alerts on signal changes or congestion ahead, allowing drivers to adapt routes or speeds. Solar panels might power these systems, reducing costs and environmental effect.
- Vehicle-to-everything (V2X) connectivity, which connects automobiles, infrastructure, and pedestrians, is another prospective improvement. This might enable automated traffic control systems, decreasing human interference and improving efficiency.

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