IoT Based Traffic Light Management System

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***Abstract*- Systems for controlling traffic lights are widely used to keep an eye on and regulate how vehicles travel through intersections of several roadways. Their goal is to guarantee that vehicles are travelling through the transit corridors with ease. However, considering the numerous parameters involved, managing the effective flow of vehicles at junctions is a challenging task. Variable flows approaching the intersections cannot be appropriately handled by the conventional and traditional systems. Additionally, the way that traffic is currently organised does not account for how a lane's line of vehicles changes over time or for emergency vehicles passing through. Traffic bottlenecks and congestion result from this. We propose an Arduino microcontroller-based system that uses sensors to assess traffic density and dynamically generates timed windows with different time levels. In addition, software is developed to address the issue of emergency vehicles getting stuck on congested intersection lanes.**

Keywords- Traffic congestion, Intersection management, Variable flows, Arduino microcontroller, Sensor technology, Traffic density measurement, Traffic flow optimization, Dynamic timing slots, Emergency vehicle prioritization

I. INTRODUCTION

Sophisticated traffic control systems, such as traffic light management systems, use relevant algorithms and real-time traffic data to regulate traffic flow. The system's goals include reducing traffic congestion and increasing general traffic flow.

Regardless of the volume of traffic, traditional traffic light management systems run on a regular schedule with predetermined intervals between signal changes. On the other hand, IoT-based traffic light control systems utilize sensors to monitor traffic flow density and modify the timing of traffic lights in real-time according to the actual traffic circumstances.

Real-time traffic data collection and analysis is done via a control system. Based on the data, the control system can alter the traffic signal timing.

An IoT-based traffic light management system has advantages such as fewer traffic jams, faster travel times, increased traffic safety, and lower greenhouse gas emissions. Also, the technology enables traffic officials to more effectively control traffic during rush hours and emergencies.

Ultimately, in order to improve the efficiency and security of urban transport networks, a smart traffic light management system needs to be a part of the infrastructure of a smart city.

II. LITERATURE SURVEY

In an effort to alleviate the growing traffic congestion in cities, S. Javaid, et al [1] suggest a smart traffic control system. The system controls traffic on both local and centralised servers by leveraging the ideas of IoT and AI. To gather information on traffic density, sensors, security cameras, and RFIDs placed on the side of the road are used. Subsequently, the system modifies signal timings to control traffic flow according to the number of vehicles on the road. Additionally, it provides real-time traffic data and statistics to authorities for better decision-making and future road planning. The proposed system is designed to be decentralized, ensuring its effectiveness even in the event of server crashes.

The goal of the work [2] by A. Sharif et al. is to create an affordable Smart Traffic System (STS) for smart cities. The Internet of Things (IoT) technology is used by the system to rapidly collect traffic data and transmit it for analysis. After that, real-time streaming data is evaluated with Big Data analytics to determine traffic density and use predictive analytics to offer solutions.

To solve the problem of traffic congestion, S. S. R and L. Rajendran suggest a model [3] of a camera-based traffic monitoring and processing system. In addition to having provisions for emergency vehicles, the system seeks to shorten cycle times. It adjusts traffic signal timing in response to current traffic demand by using adaptive traffic control system and image processing techniques. makes specific accommodations for emergency vehicles in order to maintain efficient traffic flow. High-resolution cameras and image processing techniques are used in the process to identify changing traffic patterns, after which signals are sent to the timer control system to adjust the traffic signal timer.

Enhancing the capacity to observe and manage the traffic system is the primary goal of L. J. Baptist Andrews, et al [4]. This entails creating a wireless based emergency vehicle clearing system and linking the suggested method with the regional control centre. The secondary goal is to improve air quality through air recycling and lessen pollution by decreasing traffic congestion. Density-based traffic controller, wireless based emergency vehicle clearing, IoT-enabled traffic gateway, and air pollution avoidance and air purification system are the four operating modes of the proposed system.

Using IoT-enabled technology, V. Bali et al. suggests a way to make "Green Corridors" for emergency vehicles so they can avoid traffic and save time [5]. When emergency vehicles approach, the planned Smart Traffic Management System makes better use of optical sensing, RFIDs, and radar systems to direct traffic. The technology directs oncoming vehicles to change lanes and creates a "Green Corridor" for the emergency vehicle by displaying arrival messages on LCD panels. Emergency response vehicles arrive at their locations promptly because the STMS eliminates delay time. To further increase the usefulness of the system, the author also offers future improvements such incorporating cloud computing, an Android application, and map approaches.

III. The Proposed System

The proposed system looks to solve the problem of traffic congestion in India, which is a major issue due to the inefficient traffic management system. The system is poorly designed for traffic flow, resulting in long waiting times for drivers and reduced effectiveness. An IoT-based traffic light management system can solve these problems by analysing real-time traffic data to adjust signals and timing dynamically. It is designed to optimize the timing and sequencing of traffic lights to reduce waiting times for drivers. By optimizing the timing of traffic lights based on real-time data, the system can reduce congestion and delay at intersections. The system uses data such as traffic queue length to adjust traffic light timing and sequencing dynamically. This allows the system to adapt to changing traffic conditions. The system will prioritize different types of emergency vehicles to prevent them from getting stuck in traffic and improve the safety of people.

Design Specifications:

1. **NodeMCU**: Based on the ESP8266 microcontroller, NodeMCU is a development board featuring 11 digital I/O pins, 3.3V operation, and an 80 MHz clock speed. It has attributes such as support for the Arduino IDE and 4 MB of flash memory and Wi-Fi.

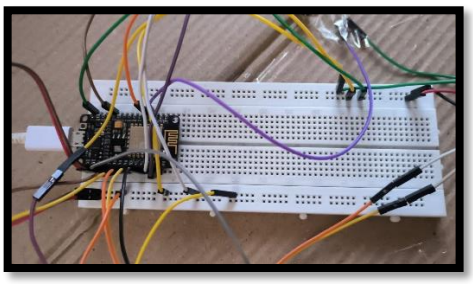

Fig 1. Breadboard, NodeMCU, Jumper wires

2. **Ultrasonic sensor:** A device for measuring distance is the HC-SR04 Ultrasonic Sensor. Its precision is 3 mm, and its range is 2 to 400 cm. It has an easy-to-use interface with trigger and echo pins, and it runs at 5V DC.

Fig 2. HC-SR04 Ultrasonic sensor

3. **OLED display:** An OLED display with 128x64 pixels is a small and energy-efficient panel. It offers strong contrast and brilliant colors with 128 columns and 64 rows of pixels.

Fig 3. OLED Display

4. **Traffic signal LEDs:** LEDs are used as status indicators for device states and communication feedback, providing visual cues to users and aiding in fault diagnosis.
5. **Arduino IoT Cloud:** A platform that integrates development and management for IoT applications [6]. It makes it easier to connect Arduino devices to the internet, allowing for remote control and monitoring. It provides functions like real-time monitoring and automation, data logging, and dashboard generation.

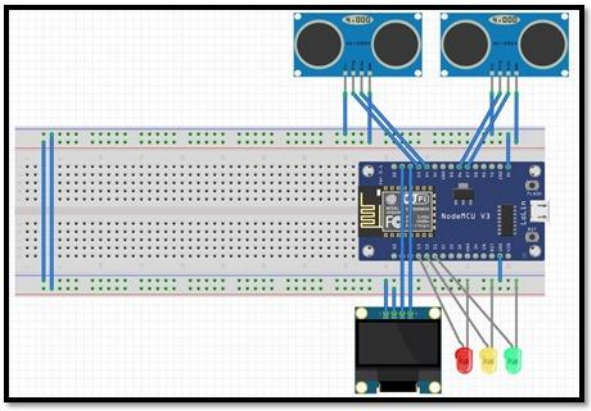

Fig.4 Design Specification

IV. Technical Methodology

The ultrasonic sensor HC-SR04, collects real-time data and sends it to NodeMCU, which determines the flow of traffic. Traffic light timings are adjusted by the controller accordingly. The NodeMCU instructs the traffic light to extend the timer of the green signal for any lane with heavy traffic. The possibility shifts to another lane with more traffic and more vehicles, if any other lane has comparatively little traffic flow, then the traffic signal doesn't turn green for that lane.

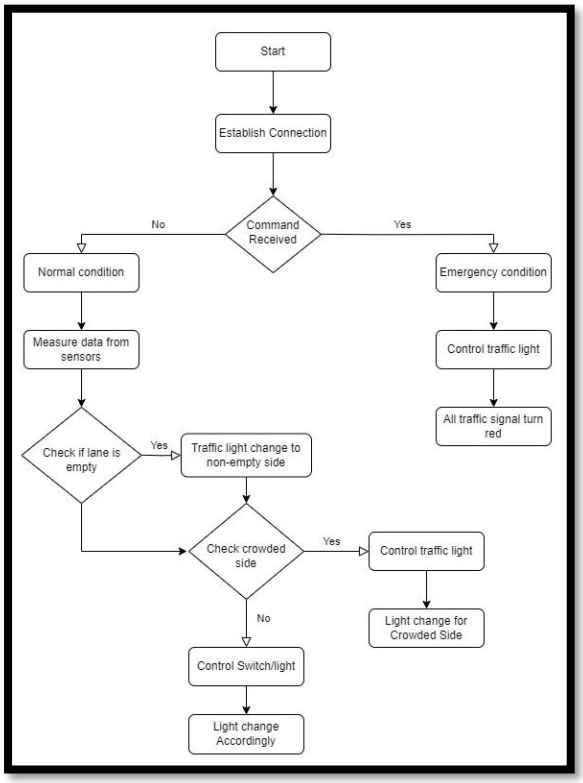

Fig 5. Flowchart for IoT-based Traffic management system

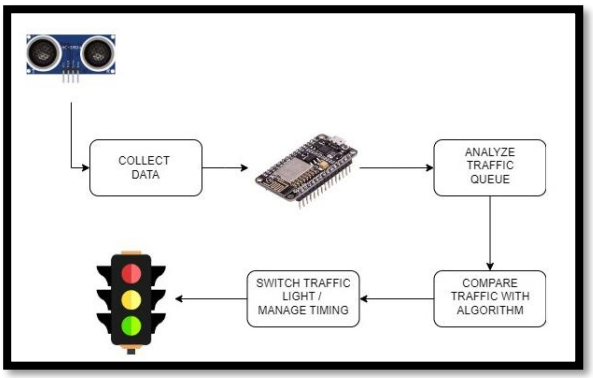

Fig 6. Illustration of algorithm

The created application interface can be used in the case of emergency vehicles such as ambulances and fire brigades. In order to allow the emergency vehicle to cross the intersection swiftly, the user presses the button on the application. Then, the application sends a signal to the controller instructing it to set all the other traffic signals to turn red for some time. After the completion of time, everything gets back to normal and the traffic signals work according to traffic.

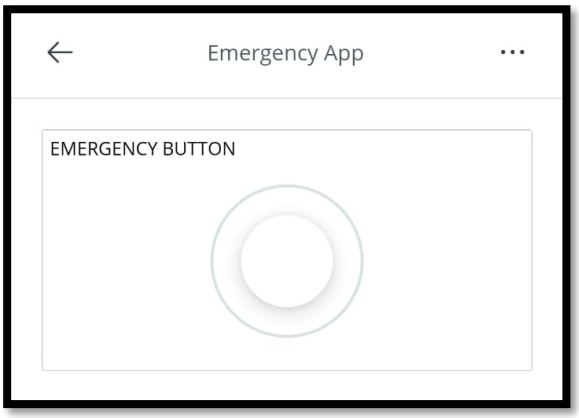

Fig 7. Application with the emergency button

V. Future Scope

IoT-based traffic light management systems have a bright future ahead of them, with many opportunities for growth and development. Here are some potential future scopes:

i. Integration with connected vehicles: The system can be integrated with connected and advanced communication technology-enabled automobiles to enable more effective traffic management as more vehicles become connected and equipped with these features. Real-time traffic light information is available to vehicles, enabling them to adjust their speed and anticipate signal changes. This helps to ease congestion and improve traffic flow.

ii. Adaptive algorithms: The traffic light management system's adaptive capabilities may be improved by developments in artificial intelligence and machine learning methods. The system can learn and forecast traffic patterns by examining past and current data.

This enables more precise signal timing and proactive traffic flow management.

iii. Expansion to smart city initiatives: Systems for managing traffic lights intelligently can be incorporated into larger smart city projects. To build a complete urban mobility ecosystem, they might be connected to smart parking systems, public transportation networks, and emergency services. Better coordination between various urban mobility factors may be made possible by this integration, leading to more effective transport systems.

iv. Utilization of advanced sensors: In order to acquire more precise and detailed traffic data, modern sensors or computer vision systems may be used in traffic management in the future. As a result, traffic signal timings may be more precisely controlled and optimized. These sensors can offer real-time information regarding traffic volume, vehicle kinds, and pedestrian movements.

v. Implementation of predictive analytics: The traffic light management system can forecast traffic situations based on previous and current data by using predictive analytics. This skill can assist with traffic management and general efficiency by assisting authorities in predicting and reducing traffic congestion before it happens.

VI. Conclusion

To sum up, the traffic light management system that is based on the Internet of Things has demonstrated potential in improving traffic flow, decreasing traffic, and improving safety. Comparing the traffic light management system to traditional traffic signal systems, there are numerous benefits. To optimize traffic flow, lessen congestion, boost safety, and increase overall transportation efficiency, it makes use of cutting-edge technology real time data analysis. The technology improves coordination between several intersections, dynamically modifies signal timings, and efficiently adapts to shifting traffic situations. By implementing a smart traffic light management system, cities can reap significant benefits in terms of traffic control and overall urban mobility. Based on real-time traffic data, the technology optimizes traffic signal timings, resulting in shorter commuter delays and trip times. Additionally, by enhancing fuel efficiency and reducing traffic, it contributes to lower emissions and a greener environment. The traffic light management systems will continue to advance and change in the years to come, helping to build more sustainable and effective urban transportation networks.

VII. References

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