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SMART TRAFFIC LIGHT SIGNALING STRATEGY AND EMERGENCY VEHICLE PRIORITY USING EMBEDDED SYSTEMS

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1.ABSTRACT

In order to address traffic congestion in contemporary cities, this project proposes a "Smart Traffic Light Signalling Strategy and Emergency Vehicle Priority Using Embedded Systems". In order to minimize delays, optimize traffic flow, and increase public safety, the system makes use of real-time traffic monitoring, dynamic signal adjustment, and emergency vehicle prioritizing. Through real-time adaptation, this technology provides a viable, scalable, and sustainable way to enhance urban transportation. The suggested system monitors traffic density and identifies emergency vehicles by integrating embedded technologies such as sound, infrared, and ultrasonic sensors. After processing the sensor data, the microcontroller of the system modifies the traffic lights to prioritize the most crowded lanes and provide emergency vehicles with immediate access. The system can react

flexibly to shifting traffic conditions thanks to its real-time traffic monitoring capability, which lowers the possibility of congestion and minimizes delays. Critical services, including fire engines and ambulances, can react swiftly and effectively in emergency circumstances thanks to the emergency vehicle prioritizing function. Because of its scalable and modular design, the system may be readily integrated with current traffic infrastructure and customized. Utilizing easily accessible and reasonably priced parts, like the Arduino UNO microcontroller, guarantees hat the system is economical and usable by communities of all sizes.

2.INTRODUCTION

Vehicle densities in cities around the world have significantly increased as a result of urbanization and fast population expansion. Critical issues brought on by the exponential increase in traffic include extended traffic jams, emergency service delays, elevated pollution, and the waste of time and fuel. Due to their inability to adjust to the dynamic and unpredictable nature of real-time traffic, traditional traffic management systems—which are based on fixed signal cycles—are frequently inadequate in addressing these problems. To address this inefficiency and improve urban traffic management, intelligent and flexible traffic control systems must be developed. This project suggests a Smart Traffic Light Signalling Strategy Using Embedded Systems to address these issues. It is intended to prioritize emergency vehicles and optimize traffic flow in a methodical and effective manner.

The incapacity of traditional traffic systems to adjust to current traffic circumstances is one of their main disadvantages. Regardless of vehicle density, fixed signal cycles allot the same amount of time to each lane. Because of this, lanes with heavy traffic suffer from protracted delays, whereas lanes with moderate traffic squander time on green signals. In addition to making traffic worse, this inefficiency raises automobile emissions, which further deteriorates the environment. Additionally, these systems are ill-equipped to give emergency vehicles priority, which might result in delays that could endanger lives in dire circumstances. Thus, there is a growing need for a traffic management system that is dynamic, real-time, and adaptive.

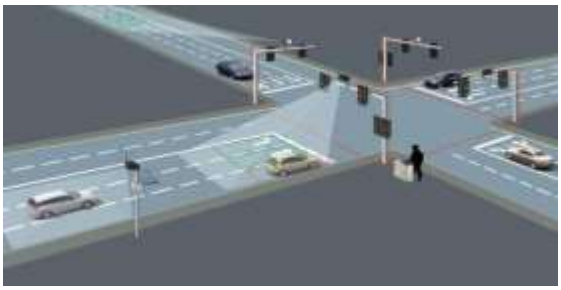
3. LITERATURE SURVEY

Prakash, N., Udayakumar, N., & Kumareshan, N. (2020). "Intelligent Traffic Signalling Method Employing Embedded Systems." International Conference on Computer Informatics and Communication (ICCCI) 2020. This paper introduces a novel approach to address traffic congestion and excessive signal time using infrared sensor technology. The proposed system serves as a more efficient alternative to manually operated traffic signals. Traffic density is assessed by an object detection sensor positioned along the signal path, adjusting signal timing automatically based on this density. The system's simplicity makes it an effective solution, particularly in reducing delays, such as when allowing an ambulance to pass. In such cases, the system will not only turn the traffic light green but also activate the specific path signal, providing a more immediate

response. Shanmayi Manasi, P., Nishitha, N., Pratyusha, V., & Ramesh, T.K. (2020). "Smart Traffic Light Signaling Strategy." International Conference on Communication and Signal Processing, July 28–30, 2020, India. This project proposes a Smart Traffic Light Signaling Strategy utilizing embedded systems to alleviate urban traffic congestion. The system employs real-time sensor inputs for dynamic signal control, optimizing traffic flow while giving priority to emergency vehicles. Controlled by an Arduino UNO microcontroller, the system operates autonomously, offering a cost-effective, adaptable solution to modern traffic management challenges.

4. EXISTING SYSTEM

Fixed-time signal cycles, in which each lane is given a set amount of time for green, yellow, and red lights, are the mainstay of the current traffic management systems. These technologies cause delays and inefficiency because they don't take into account the traffic circumstances in real time. For example, the set timing stays the same when one lane is heavily congested while the others are comparatively clear, which results in severe congestion in the impacted lane. Furthermore, there is no system in place to provide priority to emergency vehicles, such fire trucks or ambulances, which frequently lose crucial reaction time while waiting for their turn in the signal cycle. Traffic police occasionally utilize manual intervention to modify signal timings during crises or busy hours, however this method is time-consuming, prone to human error, and not always effective.



3.1 DISADVANTAGES:

- **Fixed Timings:** Signals follow predetermined cycles, which wastes time in less congested lanes and slows in busy ones.
- **No Emergency Priority**: There are significant delays since emergency vehicles are not given priority.
- More Pollution: Long periods of idle at signals result in higher emissions and fuel consumption.
- **Manual Dependency:** Decreases productivity by requiring human intervention during emergencies or busy times.
- **Lack of Technology:** Is unable to

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interface with contemporary smart city technology or adjust to real-time situations.

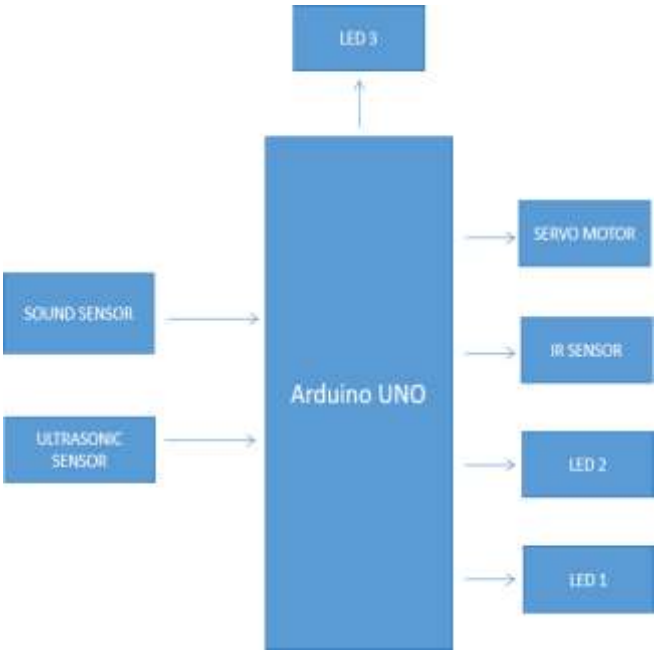
5.PROPOSED SYSTEM

The proposed system introduces a Smart Traffic Light Signaling Strategy Using Embedded Systemsthat dynamically manages traffic based on real-time conditions. It uses ultrasonic and infrared (IR)sensors to monitor traffic density in each lane and adjust signal timings accordingly. If a lane experiences heavy traffic, the system prioritizes it by turning the red light off, allowing vehicles tomove. For lanes with lighter traffic, a timer ensures fair allocation of movement time to prevent gridlocks. Additionally, a sound sensor detects the sirens of emergency vehicles, enabling the system to override the current signal cycle and give immediate green light priority to the corresponding lane, ensuring quick clearance. Controlled by an Arduino UNO microcontroller, thesystem processes real-time data autonomously, reducing the need for human intervention. This adaptive and automated approach improves traffic flow, reduces congestion, and ensures faster passage for emergency vehicles, offering a practical and scalable solution for urban traffic management.

4.1 ADVANTAGES:

- **Optimized Traffic Flow:** By modifying signal timings in response to traffic density, real-time data processing helps to ease congestion and guarantee smoother intersection flow.
- **Shorter Waiting Times:** Dynamic signal control reduces needless waits for cars and pedestrians, increasing productivity.
- **Priority Handling:** By giving emergency vehicles, public transportation, and pedestrians priority, these technologies can improve efficiency and safety.
- **Flexibility and Scalability:** Because embedded systems are modular, adding new capabilities like IOT connectivity or Al-based traffic prediction is simple.

6 . BLOCK DIAGRAM



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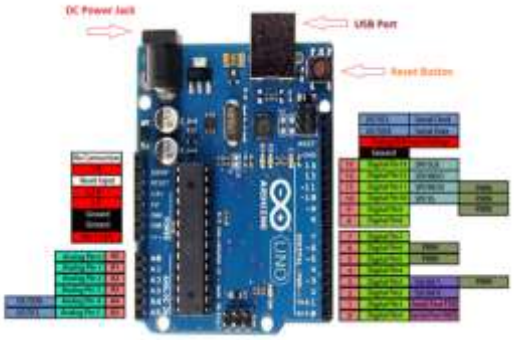
7. HARDWARE DESCRIPTION

Arduino UNO



The Arduino Uno is an open-source microcontroller board developed by Arduino.cc, featuring the Microchip ATmega328P microprocessor.The board operates with a voltage range of 7 to 20 volts and can be powered either via a 9-volt external battery or through the USB connection. It shares similarities with the Leonardo and Arduino Nano models. To control the microcontroller, users write instructions using the Arduino programming language (based on Wiring) and the Arduino Software (IDE), which is built on Processing.

ULTRASONIC SENSOR

By employing ultrasonic waves, ultrasonic sensors are able to measure distance. An ultrasonic wave is sent out by the sensor head, which then receives the wave's reflection back from the target. Ultrasonic sensors use the time interval between emission and reception to calculate the target's distance. An optical sensor has a transmitter and receiver, whereas an ultrasonic sensor uses a single ultrasonic element for both emission and reception. In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately.This sensor enables miniaturization of the sensor head.

IR SENSOR

An infrared sensor is an electronic device used to detect specific environmental elements by emitting and detecting infrared radiation. These sensors are capable of both detecting motion and measuring the temperature of objects. Known as passive infrared sensors, they detect infrared radiation without emitting it themselves. All objects emit some form of heat radiation in the infrared spectrum,

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which, although invisible to the human eye, can be detected by an infrared sensor. The sensor typically consists of an IR LED (Light Emitting Diode) as the emitter and an IR photodiode, which is sensitive to the same wavelength of infrared light as the LED, serving as the detector. When infrared light hits the photodiode, it causes changes in resistance and output voltage, which correspond to the intensity of the IR light received.

SERVO MOTOR

A servo motor is a type of rotary actuator or motor that allows precise control over acceleration, speed, and angular position. Unlike standard motors, it incorporates additional features that enable this level of precision. To achieve this, a servo motor combines a standard motor with a position-feedback sensor, which ensures accurate control of its movements.

SOUND SENSOR

One kind of module used to detect sound is the sound sensor. This module is typically used to measure sound intensity. This module's primary applications are security, monitoring, and switches. For convenience, this sensor's accuracy can be adjusted.

A microphone is used by this sensor to supply input to an amplifier, peak detector, and buffer. A microcontroller receives an o/p voltage signal from this sensor when it detects a sound. It then carries out the necessary processing. This sensor is capable of detecting noise levels at frequencies of 3 kHz and 6 kHz, which correspond to the range where the human ear is most sensitive, measured in decibels (dB). To measure sound levels, a decibel meter app, available for Android smartphones, can be utilized.

LED

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An LED (Light Emitting Diode) is a p-n junction diode that emits light when forward biased. It consists of a specially doped semiconductor material. The manufacturing process of LEDs is relatively simple as it involves depositing three layers of semiconductor material onto a substrate. These layers are arranged in sequence: the P-type region at the top, the active region in the middle, and the N-type region at the bottom. The structure showcases these three semiconductor zones, with holes present in the P-type region, electrons in the N-type region, and both holes and electrons in the active region, where the light emission occurs.

8. SOFTWARE DISCRAPTION

ARDUINO IDE

ArduinoSoftware(IDE)

Draws are programs created with the Arduino Programming Interface (IDE). These sketches were created in the text editor and saved with the file extension. No. In addition to cutting and copying, the editor offers features for text replacement and search. The message area displays errors and provides input during trading and saving. All of the information, including comprehensive error warnings, is output to the console via the Arduino Software (IDE). The planned board and sequential port are shown in the window's lower right corner. Using the toolbar buttons, you can upload programs, create, open, and verify programs, and open the serial monitor.

9.APPLICATION

Optimized Traffic Flow: Dynamically adjusts traffic light cycles based on real-time traffic data collected through sensors (e.g., inductive loops, cameras, or infrared sensors) to reduce congestion and improve

overall traffic flow. Uses adaptive signal control to manage intersections more efficiently, reducing delays and travel time for vehicles.

Congestion Control: Monitors traffic conditions and adjusts light timings in real-time to alleviate congestion at critical junctions, especially during rush hours or special events. Reduces the likelihood of traffic jams by adjusting green light durations and allowing for smoother transitions between traffic lanes.

Reduction in Idle Time: Minimizes the time vehicles spend idling at traffic lights, which can lower fuel consumption and emissions, contributing to environmental sustainability.

10.CONCLUSION

A workable, effective, and scalable answer to today's urban traffic problems is the Smart Traffic Light Signaling Strategy Using Embedded Systems. The system dynamically modifies signal timings to alleviate congestion and guarantee smooth vehicle flow by integrating real-time traffic sensing utilizing ultrasonic and infrared sensors. Faster response times during emergencies are made possible by the crucial layer of safety and efficiency added by the incorporation of a sound sensor to prioritize emergency vehicles. This technology minimizes delays and improves overall traffic management by adjusting to changing traffic circumstances, in contrast to conventional fixed-time systems. It is a promising step toward intelligent transportation systems and smart city development because of its modular architecture, cost, and potential for integration with cutting-edge technologies like vehicle-to-infrastructure (V2I) communication. This method prioritizes emergency vehicles while addressing traffic offer a significant improvement in Urban mobility, safety and sustainability.

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