# Smart Traffic Congestion Control Strategy Using Embedded Systems

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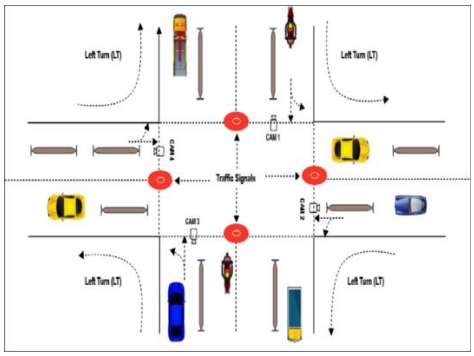
## ABSTRACT

*Traffic congestion has become a major challenge in urban areas due to the rapid increase in vehicle population and limited road infrastructure. Conventional traffic control systems operate on fixed time signals and fail to respond to real-time traffic conditions. This paper presents a smart traffic congestion control strategy using embedded systems to improve traffic flow efficiency. The proposed system is developed using an Arduino UNO as the central controller. Ultrasonic sensors are employed to measure vehicle density on each lane, while IR sensors detect vehicle presence at junctions. Sound sensors are used to identify emergency vehicle sirens, enabling priority-based signal control. Based on sensor inputs, the Arduino dynamically adjusts signal timings to reduce congestion. Servo motors are used to control physical barriers or signal indicators, ensuring smooth traffic movement. LED indicators represent traffic signal status for each lane. The system operates in real time and adapts to changing traffic conditions. This approach minimizes waiting time, fuel consumption, and environmental pollution. Experimental observations demonstrate improved traffic flow compared to conventional systems. The proposed solution is cost-effective, scalable, and suitable for smart city applications. This work highlights the potential of embedded systems in developing intelligent transportation solutions.*

## INTRODUCTION

Traffic congestion is a growing concern in modern cities, causing delays, fuel wastage, and increased air pollution. Traditional traffic management systems rely on predefined signal timings that do not account for real-time traffic variations. As a result, heavily congested lanes often experience unnecessary delays. Advances in embedded systems and sensor

technology enable the development of intelligent traffic control mechanisms. Smart traffic systems aim to monitor traffic conditions dynamically and make real-time decisions. Embedded platforms such as Arduino provide a low-cost and flexible solution for implementing such systems. Sensors like ultrasonic and IR sensors can effectively detect vehicle presence and density. Sound sensors further enhance the system by identifying emergency vehicles and granting them priority passage. Actuators such as servo motors help in physical signal or gate control. LED indicators visually represent traffic signals for drivers.




The integration of these components creates an adaptive traffic control framework. This system improves road utilization efficiency and reduces congestion. It also supports emergency response services by reducing their travel time. The proposed strategy aligns with the objectives of smart cities and intelligent transportation systems. Overall, this approach offers an efficient and sustainable solution to urban traffic management problems. 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.

## LITERATURE SURVEY

In 2020, Prakash, N. Udayakumar, and Kumareshan, N. Intelligent Traffic Signalling Method Employing Embedded Systems International Conference on Computer Informatics and Communication (ICCCI) 2020.To address the critical problems of traffic congestion and traffic signal time consumption, a novel approach utilizing infrared sensor technology is suggested. It may be the most effective replacement for a manually operated traffic signal. Traffic density is measured by the object detection sensor placed at the traffic

signal path. Depending on the density it offers the automatic signal timing correspondingly. The current system remains simpler as a result. Passing an ambulance right away is uncomfortable due to lengthy lines at traffic signals. The specific path signal will turn blue in addition to the green light.

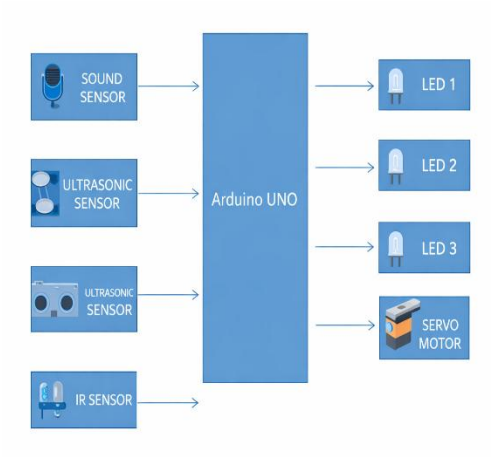
## EXISTING SYSTEM

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.

## PROPOSED SYSTEM

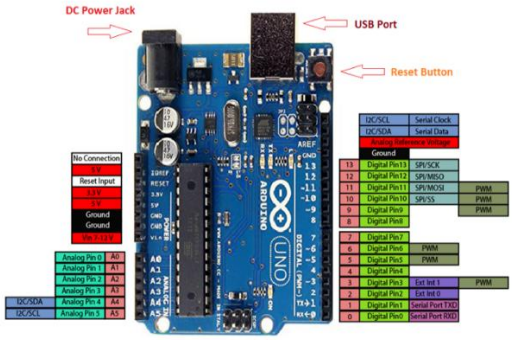
The proposed system introduces a Smart Traffic Light Signaling Strategy Using Embedded Systemsthat dynamically manages traffic based on real-time conditions. It uses ultrasonic and infrared (IR)sensors to monitor traffic density in each lane and adjust signal timings accordingly. If a lane experiences 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.

## BLOCK DIAGRAM




## 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, 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.

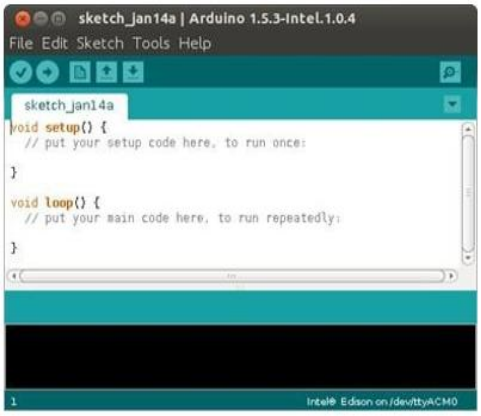
## LED

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.

## 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.

## CONCLUSION

The smart traffic congestion control system using embedded technology provides an effective alternative to traditional traffic signal systems. By utilizing real-time sensor data, the system dynamically manages traffic flow. The Arduino UNO successfully integrates multiple sensors and actuators for intelligent decision-making. Emergency vehicle detection enhances road safety and response time. The proposed system reduces traffic congestion and waiting time at junctions. It also contributes to lower fuel consumption and reduced emissions. The system is cost-effective and easy to implement. It can be deployed in urban and semi-urban areas. Overall, the proposed

strategy improves traffic efficiency. This work demonstrates the practical application of embedded systems in smart transportation.

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