Smart Traffic Signal System using AI, ML, IOT with zero signal for Emergency Vehicle

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ABSTRACT

In the bustling urban landscapes, the surge in population and automobile usage has transformed traffic congestion into a critical issue. The impact extends beyond mere delays and frayed nerves for drivers; it significantly amplifies fuel consumption and worsens air pollution, painting a grim picture of our current transportation systems. In our pursuit of a solution, we've developed a cutting-edge approach that harnesses the power of Artificial Intelligence (AI), Machine Intelligence (MI), and the Internet of Things (IoT). Recognizing a crucial flaw in the existing setup—emergency vehicles struggling to manpower through congested roadways—we propose a system that promises to be a game-changer. picture this: an emergency vehicle weaving through traffic, unimpeded and without the need for flashing red lights until it's close to its destination. Our proposed system relies on a combination of AI, MI, and IoT to bring about this transformation. It's not just about reducing delays; it's about saving lives and minimizing property loss.

To make this vision a reality, we've streamlined the solution into four main devices: CCTV Cameras, Arduino UNO, GPS NEO 6M, and SIM 900A. These elements work in harmony to create a model of a camera-based traffic monitoring and processing system. The uniqueness of our approach lies in its ability to identify emergency vehicles and dynamically adjust traffic signals to facilitate their swift passage.

Keywords – Vehicles, Traffic Signals, Emergency Vehicle, Ambulance, GPS, roadways, congestion, automobile

1. INTRODUCTION

In heavily populated metropolitan regions with poor infrastructure, traffic congestion is a common problem. It results from elements like rapid population growth and shoddy public transportation, which fuel an increase in autos. Adaptive traffic control systems are typically required because fixed-time traffic signal systems sometimes struggle to handle dynamic traffic circumstances.
Adaptive traffic control systems adapt to real traffic patterns and optimize by taking into account the number of vehicles in each la ne. Based on the data collected, the system can decide what should be done first: reduce waiting time or reduce the number of acci dents and pollution. It uses camera-based technology to provide solutions for traffic congestion as well as intelligent transportation systems including infraction detection, giving emergency vehicles priority, and civic management.
The main contributions can be summarized as follows:

1. Emergency vehicles can get to their destination faster due to these newly created signalling systems.
2. There will be assurances for the safety of other moving cars.
3. Idling cars release more carbon dioxide into the atmosphere than moving cars. The system will reduce pollution in the ar ea where it is installed.
4. It will also prevent cars from creating noise pollution when the emergency vehicle pulls up.
5. GSM infrastructure, which is frequently utilized in intelligent home systems, can be applied to intelligent transportation systems as well and will support these applications. Furthermore, intelligent traffic systems and intelligent traffic light applications will benefit from the application of the techniques and materials employed in the created signalling system.

2. LITERATURE REVIEW

Reference [2] suggests option using video processing. Before being delivered to the servers, where a C++-based algorithm is utilized to generate the results, the video from the live feed is processed. The concepts of dynamic coding and hard coding are compared; the dynamic algorithm demonstrated a 35% improvement.

Reference [4] proposes a fuzzy logic-controlled highway signal that is adjustable to right now circumstances of traffic has been offered. For the main and secondary driveways, this system uses two fuzzy controllers with three inputs and one output. VISSIM and MATLAB were used to conduct a simulation, which improved traffic conditions at low traffic densities.

In Reference [6], image processing ways have been paired with a support vector machine algorithm. Images in tiny frames are taken from live video. Not only can this device detect traffic density, but it can also detect red light violations.

The reference [8] examines a number of traffic light management system strategies. This study notes that all approaches share the same architecture: choose input data, parse it, extract traffic parameters from it, calculate density, and update parameters.

Reference [15] proposes a radio frequency model of an emergency traffic signal. The project's prototype operates on a 434 MHz frequency and modifies the traffic signal sequence to alter if and when emergency vehicles pass a junction. It then immediately returns to normal before the emergency mode is activated.

Reference [16] described a method requiring a real-time feed from the junction cameras to compute the distance between the car and the hospital. By timing the sequence and duration of the green light based on the observed distance, it employs an improved algorithm to reduce travel time.

Reference [17] proposed a model that offers a particular comprehensive approach to our intended situation. IOT is used in this project to enable the real-time collection and processing of medical data via smart sensors that can be incorporated into wearable devices. Kapileswar Nellore et. Al.

3. Methodology

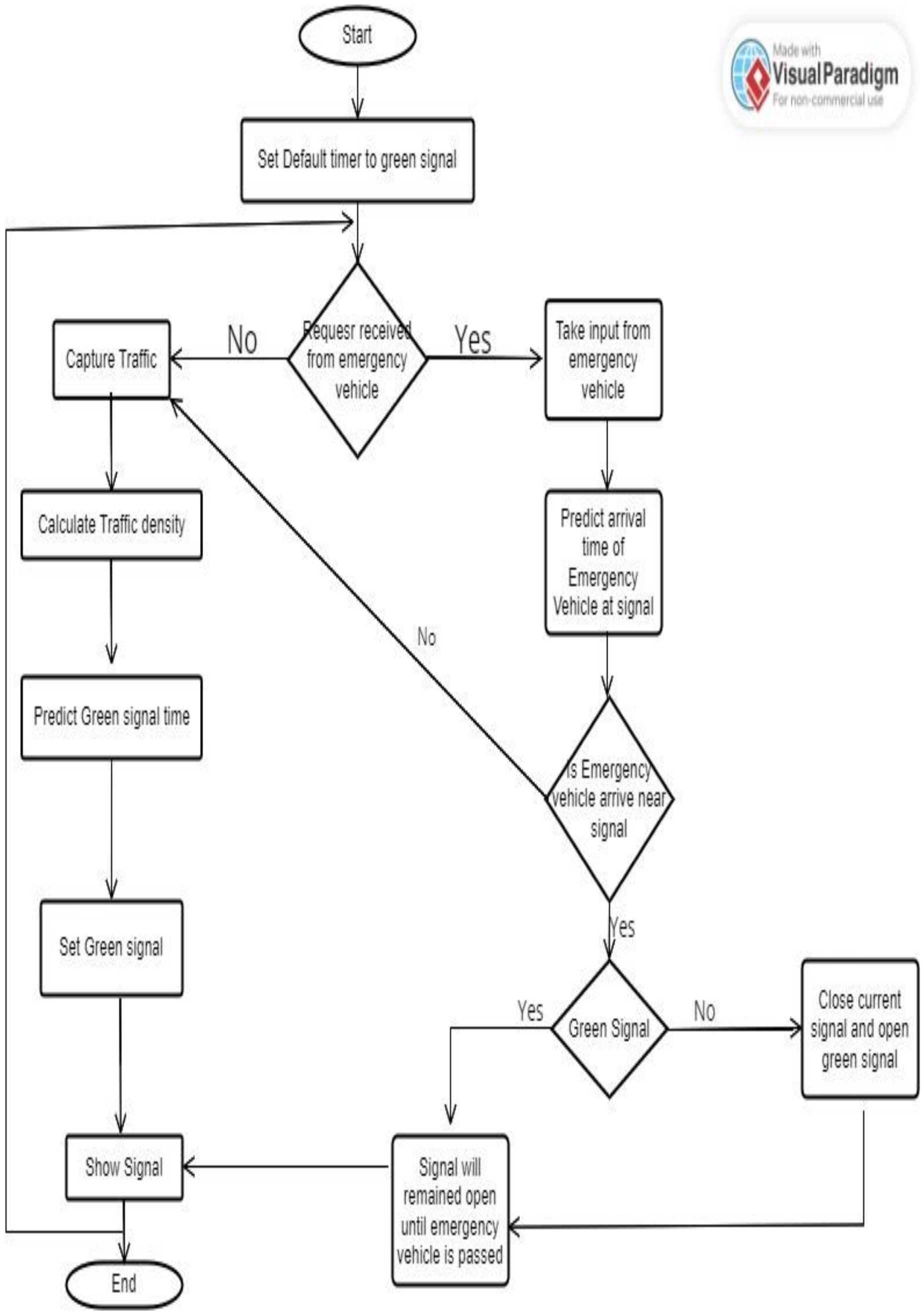

Figure 1: Flowchart representing the working algorithm of adaptive traffic management system and prioritizing emergency vehicle.

3.1.1 Capturing Traffic:

The CCTV cameras captures the real time traffic videos. Once the video stream is captured, the frames can be processed for traffic management purposes.

Figure 2: Utilizing OpenCV for image processing

3.1.2 Vehicle Detection:

Open CV can process video frames in real-time capture by CCTV cameras, making it suitable for applications that require fast object detection. By using computer vision techniques to detect vehicles in the video frames.

Figure 3: Data extraction (vehicle count) using OpenCV

When we get the count of vehicles we are going to calculate the density of vehicles by using following formula.

$$Traffic\ Density = \frac{Total\ number\ of\ vehicles\ detected}{Total\ size\ of\ image}$$

3.1.3 ML Algorithm:

After density calculation, the green signal timing is predicted by using the ml algorithm.

Density(%)	Time(seconds)
0 - 15	20
15 - 30	30
30 - 45	60
45 - 60	80
60 - 75	100
75 - 100	120

Figure 4: Green signal time

3.1.4 Signal Switching Module:

The Signal Switching Module serves as a critical component in our traffic management system, employing an intelligent algorithm to optimize signal timings based on real-time traffic density information from the vehicle detecting module.

Unlike traditional systems that prioritize the direction with the highest density first, our approach involves a cyclic switching mechanism. Instead of prompting drivers to alter their behavior or causing confusion, the signals transition in a predetermined order. This mimics the familiar sequence of red, green, and yellow signals, maintaining continuity with the existing system.

The Signal Switching Algorithm utilizes the traffic density data to dynamically adjust the green signal timer for the current direction and update the red signal timers for other directions. By doing so, it ensures an efficient and synchronized flow of traffic. The cyclic switching process is designed to balance the demands of various directions, preventing bottlenecks and optimizing the overall traffic flow.

Importantly, this approach considers the existing signal sequence, ensuring that the signals follow the traditional red, green, yellow sequence. This familiarity is key to preventing confusion among drivers and maintaining the smooth operation of the traffic signal system. The inclusion of yellow signals further enhances safety, providing a transitional phase between green and red to alert drivers to impending changes.

In essence, the Signal Switching Module not only adapts to real-time traffic conditions but also does so seamlessly, minimizing disruptions and promoting a harmonious flow of vehicles through the intersection. It represents a step forward in traffic management, leveraging technology to enhance efficiency without necessitating significant changes in driver behavior or causing unnecessary confusion on the road.

3.2 Database

For a traffic management system that involves real-time data processing, needs a database that can handle concurrent access, store various types of data (e.g., traffic density, GPS coordinates, emergency vehicle information), and support quick retrieval and updates.

MySQL: MySQL is a popular open-source relational database that is well-suited for this project. It offers excellent performance, scalability, and reliability, making it suitable for handling real-time traffic data.

Database Connectivity: Develop APIs or services to allow the Arduino Uno and mobile application to interact with the database. These interfaces enable the retrieval of real-time data and the submission of control commands (e.g., updating traffic light timings, querying emergency vehicle status).

3.3Emergency Vehicle Priority:

The scope of this project is in cities with huge traffic, which will make it difficult for an emergency vehicles. The project consists of four main hardware components:

3.3.1 GPS Module NEO 6M
3.3.2 Arduino UNO
3.3.3 GSM SIM 900A Modem
3.3.4 CCTV Cameras
3.3.5 Four-Channel 5 V Relay Board

3.3.1 GPS Module NEO 6M

The traffic control room receives the ambulance's real-time location through GPS Module NEO 6M. So that the ambulance may pass, the traffic control room can make the necessary clearances.

3.3.2 Arduino UNO

The code for sending the ambulance's real-time location is stored in Arduino UNO. It uses SIM 900A to relay the location, which it receives from the GPS Neo 6M, to the traffic control center and hospitals.

3.3.3 GSM SIM 900A Modem

A text message with the emergency vehicle's current location is sent to the traffic control room using the GSM-enabled SIM 900A.

3.3.4 CCTV Cameras

At traffic lights, CCTV cameras are set up to record the flow of traffic.

3.3.5 Four-Channel 5 V Relay Board

The relay board allows you to control the traffic lights (red, yellow, green) at intersections. Each relay on the board can be connected to a specific light (e.g., one relay for red, one for yellow, one for green).

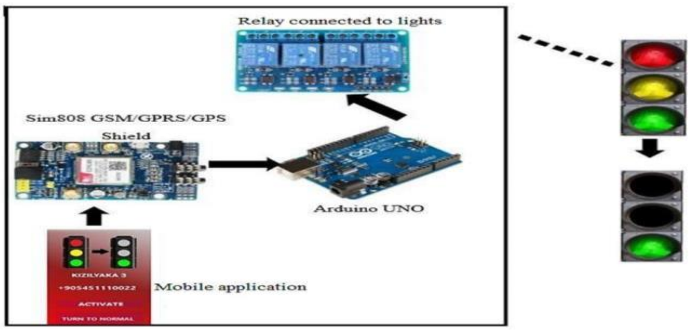

Figure 5: Overview of Proposed system

3.4 Mobile Application:

1. To initiate the use of the emergency automobile, the user must first log onto the mobile app, ensuring secure access to the system.
2. Once the user specifies the target location and the app determines the driver's current position, a route is automatically generated to guide the driver effectively.
3. Upon completion of the route mapping, the system utilizes latitude and longitude data to precisely identify the locations of traffic signal lights along the designated path.
4. To navigate through the route, the driver selects the first signal light encountered. By pressing the "Activate" button on the control screen, the designated traffic light turns green as the vehicle approaches. This action triggers the transmission of an ON message to the system associated with the car's route light.
5. The Sim808 GSM/GPRS/GPS module facilitates the transmission of this message to the Arduino upon receipt.
6. The Arduino, acting as the brain of the system, decodes the received signals. It then takes control of the relay connected to the traffic lights, ensuring that the designated light turns green to facilitate the vehicle's passage. Subsequently, after the vehicle passes the intersection, the driver uses the mobile application to send a "return to normal" message. This message triggers the system to reset the traffic light timing, restoring regular traffic flow.

4. CONCLUSION

1.The proposed system sets the green signal time adaptively according to the real time traffic density.
2.This system will give passage to emergency vehicles without approaching any red signal till their final destination by using GPS tracking.
3.Thus by using adaptive traffic control system we can reduce congestion and waiting time, which will reduce fuel consumption and air pollution.
4.So this system will prevent the excessive traffic jams which leads to smooth traffic flow and also saves many lives by giving passage to emergency vehicles.

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