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Smart Ambulance System: An IoT-Based Framework for Real-Time Traffic Prioritization and Emergency Routing

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Abstract

Traffic congestion has become a major issue in modern cities due to the rapid increase in the number of vehicles. One of the most critical problems caused by traffic congestion is the delay faced by emergency vehicles such as ambulances. These delays can lead to loss of lives due to late medical assistance. Therefore, there is a need for an intelligent system that can provide priority to ambulances on roads.

The proposed Smart Ambulance System uses Internet of Things (IoT) technology to provide real-time traffic clearance for ambulances. The system identifies the ambulance using wireless communication and automatically controls traffic signals to provide a clear path. Additionally, patient information can be transmitted to nearby hospitals in advance, enabling them to prepare for emergency treatment.

This system integrates Arduino-based hardware, IoT modules, and mobile applications to create an efficient and reliable traffic management solution. The implementation of this system can significantly reduce response time, improve emergency services, and contribute to the development of smart cities.

Keywords

IoT, Smart Ambulance, Traffic Management, Emergency Routing, Arduino, Zigbee, Real-time Monitoring

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1. Introduction

In today's world, traffic congestion is one of the biggest challenges faced by urban areas. With the increasing population and number of vehicles, managing traffic efficiently has become difficult. Emergency vehicles such as ambulances require immediate attention and fast movement, but they often get stuck in traffic signals and congestion.
Time plays a crucial role in saving human lives. Even a delay of a few minutes can result in serious consequences for patients. Therefore, it is essential to design a system that gives priority to ambulances and ensures smooth movement through traffic.
The Smart Ambulance System is developed to address this issue by using IoT technology.

2. Literature Review

Many researchers have worked on traffic management and emergency vehicle prioritization using different technologies. Traditional systems mainly rely on fixed-time traffic signals or manual control, which are not efficient in handling real-time traffic conditions. Some systems use sensors placed on roads to detect vehicle density, but they increases implementation cost and require continuous maintenance.Wireless communication technologies such as Zigbee and RF modules have been used in earlier systems to enable communication between vehicles and traffic signals. However, these systems have limitations such as short communication range and lack of scalability.In recent years, IoT-based systems have gained popularity due to their ability to collect real-time data and provide intelligent control. Technologies like Arduino, NodeMCU, and mobile applications are widely used for developing smart traffic solutions. Some systems also integrate GPS tracking and cloud platforms to improve monitoring and control.

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1. Proposed System

The proposed Smart Ambulance System aims to provide an efficient and intelligent solution for managing traffic during emergencies. The system focuses on reducing delays faced by ambulances by providing priority at traffic signals.The system continuously monitors the movement of ambulances using IoT-based communication. When an ambulance is detected near a traffic signal, a signal is sent to the control unit. The traffic light is automatically turned green, while other directions are set to red, ensuring a clear path for the ambulance.A mobile application (such as Blynk) is used by the ambulance driver to activate the system. The system can also transmit patient data to hospitals, enabling better preparation before the ambulance arrives. This approach improves response time, reduces traffic congestion, and ensures efficient emergency handling

3.1 System Architecture

The system consists of the following major components:

1. Ambulance Unit

The ambulance is equipped with an IoT module and a mobile application. The driver can activate the system using the application, which sends a signal to the traffic control system indicating the presence of an emergency vehicle.

2. Traffic Control Unit

This unit consists of an Arduino microcontroller connected to traffic lights and relays. It receives signals from the ambulance and controls the traffic lights accordingly. When an ambulance is detected, the corresponding signal turns green to allow free movement.

3. Communication Module (IoT/Wi-Fi Module)

The communication module enables data transmission between the ambulance and traffic signals. It uses wireless communication to send real-time information, ensuring quick and reliable operation.

4. Control and Processing Unit

The Arduino Mega acts as the central processing unit of the system. It processes incoming signals and controls the output devices such as traffic lights and buzzers. It ensures that the system operates efficiently and in real time.

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Fig : Block diagram of proposed system

4. Implementation (Hardware + IoT)

4.1 Hardware Implementation

ESP32 Microcontroller The Arduino Mega acts as the central processing unit of the system. It receives signals from the IoT module and controls the traffic lights accordingly. It processes input data and sends commands to output devices like relays, LEDs, and buzzers. Its multiple input/output pins make it suitable for handling complex traffic control operations.

Traffic Light System (LED Setup) The traffic light system consists of red, yellow, and green LEDs that represent real-time traffic signals. These lights are controlled by the Arduino. When an ambulance is detected, the green signal is activated for the required path, while other signals remain red to ensure a clear**.**

Relay Module The relay module is used to switch traffic lights automatically based on the signal received from the Arduino. It acts as an interface between low-power control signals and high-power traffic light circuits.

Power Supply Unit The power supply provides the required voltage to all components in the system. It converts AC power into regulated DC power for safe and stable operation of the circuit.

4.2 IoT-Based Control System

In this system, IoT technology is used to enable communication between the ambulance and traffic signals. A mobile application (such as Blynk) is used by the ambulance driver to send signal when approaching a junction.

The transmitted signal is received by the Wi-Fi module and processed by the Arduino. Based on this input, the system automatically changes the traffic signal to green for the ambulance path. Other signals are turned red to avoid interference.

The system operates in real time, ensuring quick response and minimal delay. It can also be extended to send alerts to hospitals or control rooms for better emergency management. This approach improves efficiency and ensures faster movement of emergency vehicles.

Table1: Traffic Density and Signal Timing Analysis

Year	Avg Traffic Density (Jun)	Avg Traffic Density (Jul)	Avg Traffic Density (Aug)	Avg Traffic Density (Sept)	Avg Signal Delay (sec)
2021	120 vehicles/min	135 vehicles/min	150 vehicles/min	140 vehicles/min	95 sec

2022	130 vehicles/min	145 vehicles/min	160 vehicles/min	150 vehicles/min	88 sec
2023	140 vehicles/min	155 vehicles/min	170 vehicles/min	160 vehicles/min	80 sec
2024	150 vehicles/min	165 vehicles/min	180 vehicles/min	170 vehicles/min	72 sec

Fig : NodeMCU , LoRa Module , DHT11 , Rain Sensor , Speaker

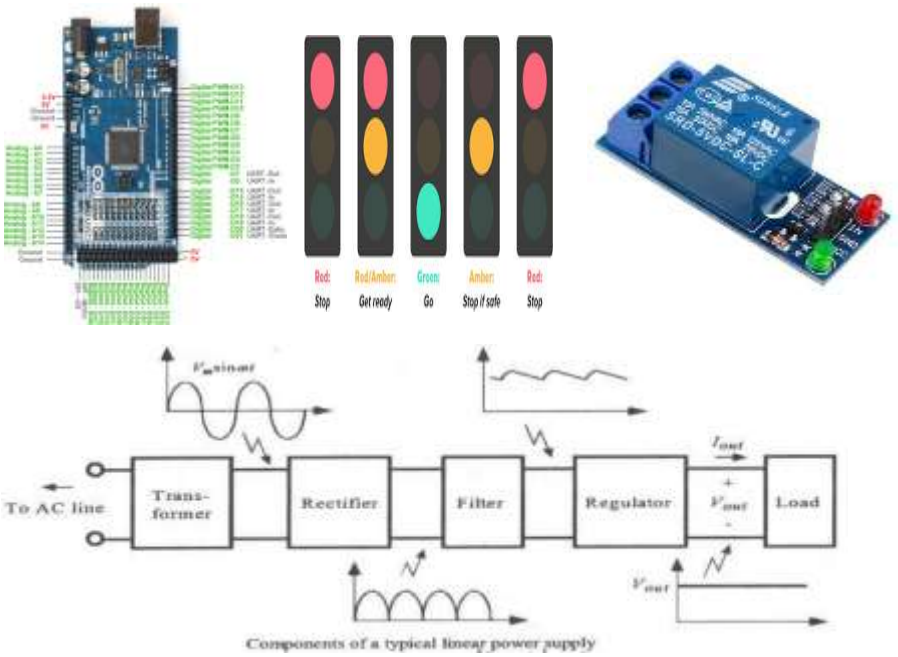

Fig : NodeMCU , Traffic signal setup , Realay Module , power supply unit

4.3 Alert Transmission via IoT / Mobile Application

The proposed system uses IoT technology and a mobile application (such as Blynk) to enable real-time communication between the ambulance and traffic control system. When theambulance driver activates the system through the mobile app, a signal is sent via the Wi-Fi module (ESP8266/NodeMCU) to the traffic controller.The Arduino processes this signal and automatically changes the traffic lights to green along the ambulance route. At the same time, alerts such as buzzer sounds and visual indicators are activated to notify nearby vehicles and pedestrians.This system ensures quick response and efficient traffic clearance, reducing delays during emergencies.

5 . Result

The developed Smart Ambulance System effectively improves emergency response time by reducing delays caused by traffic congestion. The automatic control of traffic signals ensures a

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clear path for ambulances, allowing them to reach hospitals faster.The use of IoT communication provides reliable and real-time operation of the system. Alerts such as buzzer signals help in clearing traffic quickly and safely. Compared to traditional systems, the proposed system offers better efficiency, reduced waiting time, and improved coordination between ambulance and traffic signals.

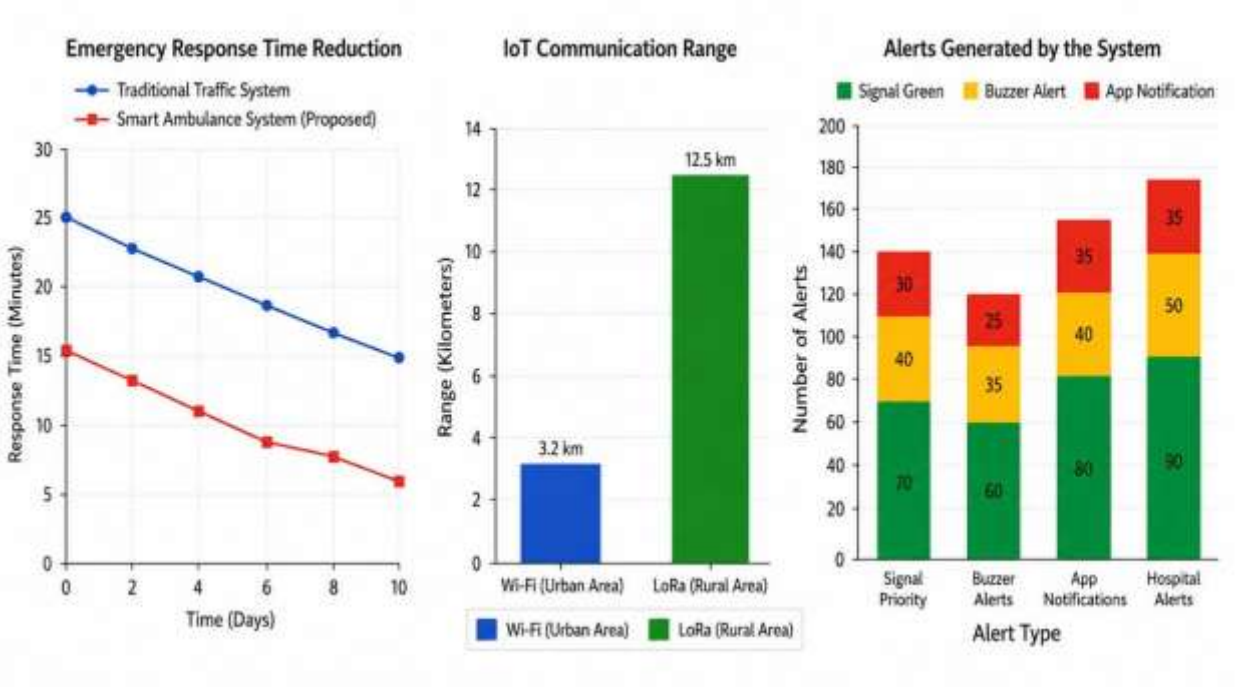

Fig : Performance Analysis of the Proposed Smart Ambulance System

6. Conclusion

This paper presents a Smart Ambulance System that uses IoT technology to improve emergency response by providing real-time traffic clearance. The system enables communication between ambulances and traffic signals, allowing automatic control of signals to ensure a clear path for emergency vehicles.

The use of IoT-based communication and real-time monitoring makes the system efficient and reliable in urban traffic conditions. The integration of automated signal control and alert mechanisms helps reduce delays and improves the chances of saving lives during emergencies.

In the future, the system can be enhanced by integrating GPS tracking, AI-based traffic prediction, and cloud-based monitoring to further improve efficiency and scalability.

Authors Contribution

Dr. Shaik Bajidvali supervised the overall project work and provided technical guidance for system design and implementation. G. Fahami Jameela and B. Vivek Kumar Reddy contributed to system design, coding, and preparation of the project report. J. Mythri and K. Ramya worked on hardware implementation including Arduino, traffic light setup, and IoT communication modules. A. Obulesu contributed to system integration, testing, and result analysis. All team members participated in documentation and approved the final report.

Conflicts Of Interest

The authors declare no conflicts of interest regarding the publication of this project.

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