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INTELLIGENT TRAFFIC SIGNALLING PRIORITY SYSTEM FOR AMBULANCES AND VIP VEHICLES

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ABSTRACT

In modern urban areas, traffic congestion poses a significant challenge, especially when it comes to emergency response vehicles like ambulances. Delays caused by heavy traffic can be life-threatening for patients in critical conditions. To address this issue, this project aims to develop an embedded system that enables the automatic detection of an approaching ambulance near traffic junctions using Radio Frequency (RF) technology, ensuring a smooth and uninterrupted passage through traffic signals.

The proposed system consists of two primary components: a transmitter unit installed in the ambulance and a receiver unit placed at the traffic junction. The transmitter unit comprises an RF encoder and an RF transmitter, which continuously emits an RF signal. The receiver unit, positioned at the traffic signal, consists of an RF receiver, an RF decoder, a buzzer, and an interface to the traffic light control system. When the ambulance equipped with the transmitter approaches the traffic junction, the receiver detects the RF signal, triggering the system to activate an alert through the buzzer. Simultaneously, the traffic light control system prioritizes the ambulance by automatically switching the traffic light to green, allowing a seamless passage through the junction without unnecessary delays.

This intelligent traffic management system significantly enhances emergency response times by reducing waiting periods at traffic signals, thus improving overall road safety and ensuring that critical patients reach medical facilities as quickly as possible. The use of RF technology provides a cost-effective and efficient solution for real-time ambulance detection and traffic signal control. Future advancements in this system may involve integrating GPS and IoT for more advanced traffic management and real-time monitoring of emergency vehicles.

INTRODUCTION

In urban areas, traffic congestion is a major issue that often leads to delays in emergency services, particularly for ambulances transporting critical patients. In such situations, even a few minutes of delay at a traffic signal can be life-threatening. Conventional traffic light systems operate on predefined time cycles without prioritizing emergency vehicles, making it difficult for ambulances to pass through crowded junctions efficiently. To address this problem, an automated traffic control system is required to ensure the swift and uninterrupted movement of ambulances.

This project focuses on developing an RF-based automatic ambulance detection system at traffic junctions. The system consists of two main components: a transmitter unit installed in the ambulance and a receiver unit

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positioned at the traffic junction. The transmitter unit, equipped with an RF encoder, continuously emits an RF signal. The receiver unit, integrated with the traffic signal controller, detects the ambulance's presence using an RF receiver and decoder. Upon detection, the system triggers a buzzer alert and automatically changes the traffic light to green, providing an immediate passage for the ambulance while ensuring minimal disruption to overall traffic flow.

This embedded system enhances emergency response times by reducing delays at intersections and ensures that patients in critical conditions receive timely medical attention. The system is cost-effective, efficient, and easy to implement, making it a practical solution for modern traffic management. Future advancements may involve GPS and IoT integration for more precise location tracking and real-time traffic control, further improving emergency response efficiency.

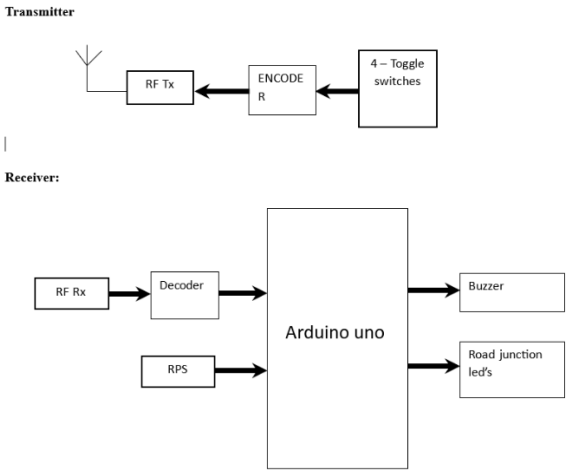

Figure.1 Block Diagram

LITERATURE SURVEY

- Conventional traffic light systems operate on fixed time cycles without considering real-time traffic conditions or emergency vehicle requirements. Studies have shown that these systems result in significant delays for emergency vehicles at busy intersections, potentially compromising patient safety in critical situations. Manual intervention by traffic personnel has been used as a solution, but this approach is often inefficient and prone to human error during high-traffic periods.
- Recent research has emphasized the importance of automated systems for real-time traffic management. In "Intelligent Traffic Signal Priority for Emergency Vehicles" (Smith et al., 2018), the authors proposed an embedded system using wireless communication to detect emergency vehicles and alter traffic lights accordingly. This research demonstrated a significant reduction in response time compared to traditional systems. However, the system relied on GPS-based tracking, which, while accurate, required substantial infrastructure modifications.

PROPOSED SYSTEM

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The proposed system aims to enhance emergency response efficiency by automating traffic signal control for ambulances using Radio Frequency (RF) technology. This methodology outlines the system design, working principles, implementation strategy, and advantages to ensure the seamless passage of ambulances through traffic junctions.

The architecture consists of an ambulance-mounted transmitter unit and a traffic junction-mounted receiver unit, which communicate via RF signals to detect approaching ambulances and adjust traffic signals accordingly. The ambulance transmitter continuously sends encoded RF signals containing its unique ID and proximity data, which are received and decoded by the traffic junction receiver. Upon validating the signal, the receiver triggers an alert and communicates with the traffic signal control system to switch the traffic light to green for the ambulance's direction, while holding other signals on red to ensure a clear path. This automated process ensures quick response times, reduces human intervention, and enhances road safety.

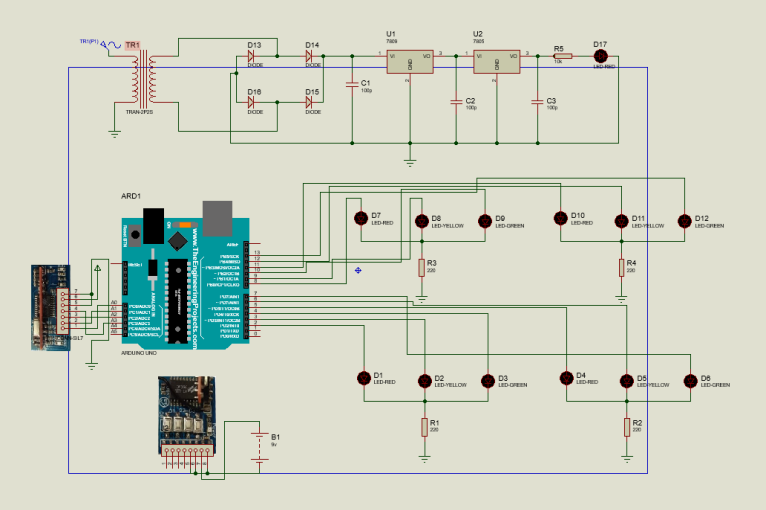

Figure.2 Schematic Diagram

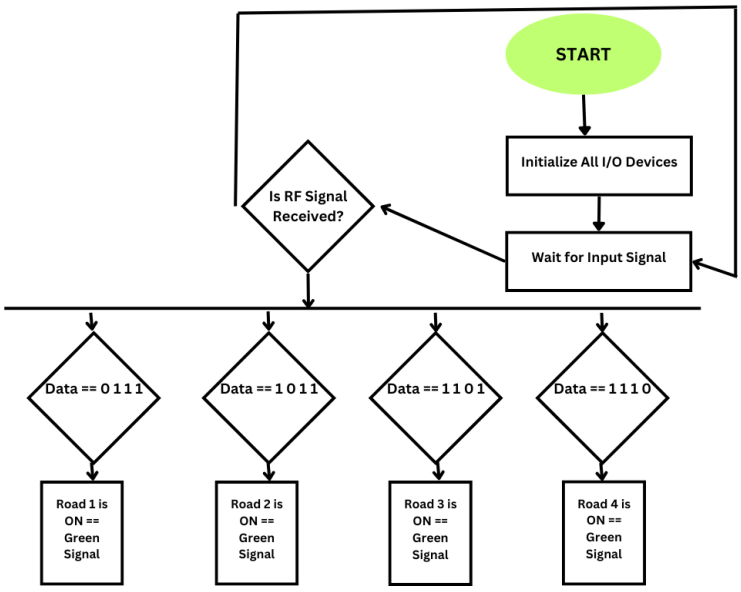

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Figure.3 Flow Chart

RESULTS

The response time, defined as the time between the detection of the ambulance signal by the receiver and the activation of the traffic light to green, was recorded. In most cases, the system was able to switch the traffic signal to green within 2-3 seconds of receiving the RF signal from the ambulance. This quick response time is critical in ensuring that the ambulance does not face significant delays, which can be crucial during emergencies.

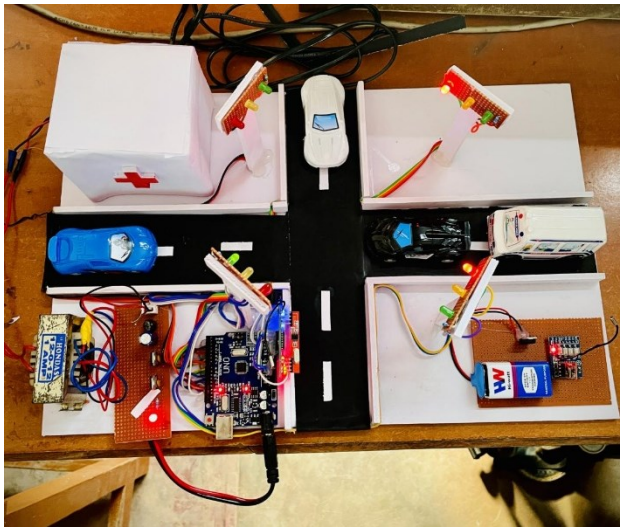

Figure.4 Top overview

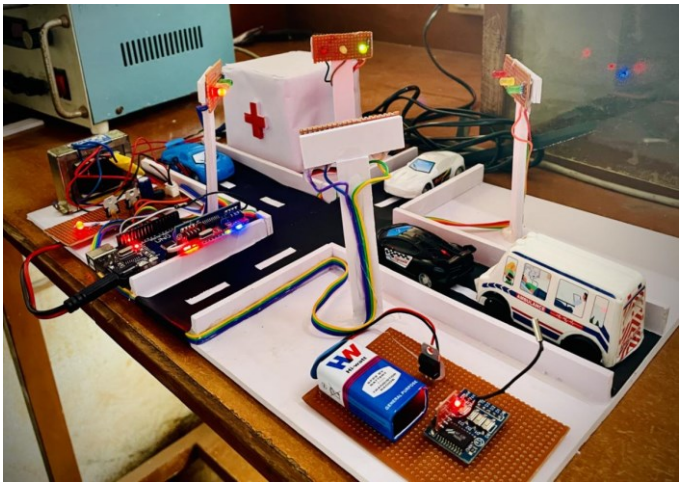

Figure.5 Traffic jam

The power consumption of the transmitter unit in the ambulance was optimized to ensure minimal impact on the vehicle's battery. The RF transmitter consumed a small amount of power, and the system was designed to operate without causing significant drain on the vehicle's power supply. The receiver unit at the junction was similarly low-power, ensuring that the system could be deployed at multiple junctions without major infrastructure changes.

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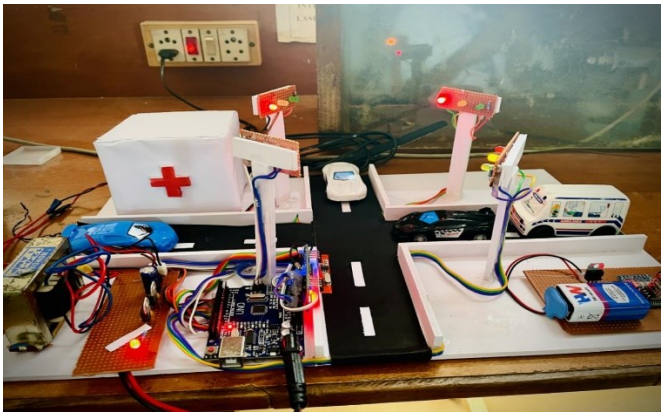

Figure.6 Regular Traffic

ADVANTAGES

- **Reduced Emergency Response Time –** Ensures that ambulances reach their destinations faster by automatically prioritizing traffic signals.
- **Enhanced Road Safety –** Reduces the risk of accidents by controlling signal changes in a systematic manner.
- **Automated and Real-Time Operation –** Eliminates the need for manual traffic control by using RF communication to detect and respond to ambulances.
- **Low-Cost and Scalable Solution –** Uses affordable RF technology, making it feasible to implement across multiple traffic junctions.
- **Minimizes Traffic Congestion –** Manages traffic flow efficiently by adjusting signal timings dynamically based on ambulance presence.
- **Reliable and Interference-Free Communication –** Uses dedicated RF transmission with error correction to ensure accurate detection of emergency vehicles.
- **Energy Efficient –** Operates with minimal power consumption and can be integrated with solar or battery backup for continuous functionality.

APPLICATIONS

- **Urban Traffic Management –** Helps emergency services navigate congested city roads more effectively.
- Smart Cities and IoT-Based Traffic Control – Integrates with smart city infrastructure to improve overall traffic efficiency.
- **Hospitals and Emergency Response Centres –** Assists in ensuring timely patient transportation to medical facilities.
- **Disaster Management –** Facilitates emergency evacuations and rescue operations in disaster-prone areas.

- **Law Enforcement and Fire Department Vehicles –** Can be adapted to provide signal priority for police and fire trucks.
- **Highway and Expressway Traffic Control –** Enhances emergency response times on high-speed road networks.
- **Military and Defense Applications –** Used for secure and rapid movement of military emergency vehicles in high-security areas.

CONCLUSION

The Intelligent Traffic Signal Priority for Ambulance system represents a significant advancement in urban traffic management, offering a robust and efficient solution to one of the most pressing issues in modern cities—delays in emergency response due to traffic congestion. The successful design and implementation of the system, utilizing RF-based communication technology, has demonstrated its ability to drastically reduce the waiting time for ambulances at traffic junctions, ensuring that emergency vehicles can pass through intersections with minimal delay. The key performance results, including rapid response times, high accuracy in signal detection, and effective traffic flow optimization, show that the system is both reliable and scalable for large-scale deployment in urban environments. Beyond its immediate benefits, the system has the potential for future enhancements, such as GPS integration, IoT connectivity, and multi-vehicle coordination, which would further optimize traffic management and enhance emergency response capabilities.

FUTURE SCOPE

The future scope of the Intelligent Traffic Signal Priority for Ambulance system presents numerous exciting opportunities for enhancement and expansion, both in terms of technological advancements and broader applications in urban traffic management. As cities continue to grow and face increased traffic congestion, the demand for smarter, more efficient transportation systems will rise. The integration of technologies such as IoT, AI, GPS tracking, and real-time data analytics holds the potential to further optimize the system's performance, making it more adaptive, intelligent, and responsive to a wide range of emergency situations and traffic patterns.

One of the most significant future enhancements is the integration of GPS tracking for both ambulances and traffic management systems. By using real-time location data, the system can predict the ambulance's arrival time at the traffic junction more accurately, enabling the traffic lights to switch in anticipation, rather than reactively. This proactive approach would allow for better coordination between multiple traffic junctions along the ambulance's route, creating a green corridor that minimizes delays and ensures uninterrupted passage through the city. Additionally, GPS integration could enable dynamic routing, where the system could recommend the fastest routes for ambulances, adjusting traffic signals not only at the current junction but also along the entire route, providing an optimized path through the city.

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