IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2025

DOI: 10.17148/IJIREEICE.2025.13347

Automated LED Notification System for Ambulance Alert in High Density Traffic

Kiruthika. N[1], Shanthini. S[2]

Department. of Information Technology, Dr N.G.P Arts and Science College, Coimbatore, Tamil Nadu, India.[1]

Assistant Professor, Department of Information Technology, Dr N.G.P Arts and Science College, Coimbatore, Tamil Nadu, India.[2]

Abstract: Urban traffic management remains an important concern as high-density traffic causes congestion, delays, and emergency- related challenges. This paper involves an automated LED notification system that uses computer vision and deep learning for vehicle detection and classification, with a focus on alerting and prioritizing emergency vehicles like ambulances in high- traffic density areas. Continuous transmission of traffic data from the webcam is processed with the YOLO model, which is chosen for its speed and accuracy in dynamic environments such as roads and streets, enabling quality detection and counts in various lanes. The system classifies vehicles in real time and distinguishes emergency vehicles such as ambulances from general traffic, thus enabling automated LED alerts to notify other vehicles to make way for emergency vehicles. Embedded Deep Reinforcement Learning is the core of this programming system; it connects variable lanes to dynamic timing of lights via intelligent lane allocation, aiming to reduce congestion and maximize response time for emergency vehicles. The DRL agent is self-trained using historical records and real-time feedback to improve traffic flow and prioritization for ambulances, with advances in LED notifications and traffic light synchronization using computer vision. Managing congestion is aided by providing real-time information, such as lane counts, average speed, and traffic flow, which can be useful to operators. Once any lane is recognized as having an ambulance, it is immediately tagged as a "high priority" lane, triggering the LED notification system to alert other vehicles and coordinate traffic signals for immediate clearance. Through these measures, the system improves traffic efficiency and emergency response in high-density areas.

Keywords: IoT, Radio Frequency, Microcontrollers, Arduino UNO, Transmitters, Receivers

I. INTRODUCTION

In recent years, there has been a growing need to enhance traffic management systems, particularly in high-density urban areas where delays can have critical consequences. One effective solution is the use of **Automated LED Notification Systems for Ambulance Alerts in High-Density Traffic**, which is designed to monitor traffic conditions in real-time and provide a dynamic approach to traffic control by prioritizing emergency vehicles like ambulances. By automatically adjusting traffic signals, this system ensures that ambulances can reach their destinations with minimal delays, offering a timely and efficient response during emergencies. The system utilizes real-time monitoring to detect traffic congestion and dynamically controls the traffic lights to create a clear path for ambulances. This automated approach is crucial in high-density areas where regular traffic patterns often result in significant delays for emergency services. It integrates sensors that detect the proximity of an ambulance, allowing signals to be adjusted and reducing wait times to avoid unnecessary stops for emergency vehicles. The system's components are compact, energy-efficient, and designed for low power consumption, making them highly suitable for urban deployment. The system primarily relies on two types of sensors: **Intrusive** and **Non-Intrusive**. Intrusive sensors are embedded beneath the road surface to detect vehicles waiting at traffic signals, although they are subject to wear and tear over time. On the other hand, non-intrusive sensors, such as acoustic sensors or video image processors, detect vehicles at intersections without requiring road surface installation. Both types of sensors work together to dynamically adapt to changing traffic conditions, ensuring ambulances can move quickly and safely through congested areas. This **Automated LED Notification System** offers a significant improvement in traffic management, providing an efficient, real-time solution to enhance emergency response times in high-density traffic environments.

II. LITERATURE REVIEW

The growing demand for efficient emergency response systems in densely populated urban areas has led to the development of intelligent traffic management solutions aimed at reducing ambulance response times. Several studies have proposed different methods, incorporating various technologies such as GPS, IoT, and vehicle-to-infrastructure

ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⪤ Peer-reviewed & Refereed journal ⪤ Vol. 13, Issue 3, March 2025

DOI: 10.17148/IJIREEICE.2025.13347

(V2I) communication. In this review, we summarize and discuss the advancements in these technologies, as well as their limitations, to lay the groundwork for the Automated LED Notification System for Ambulance Alerts in High-Density Traffic.

1. **Intelligent Traffic Signal Control for Emergency Vehicles** Kumar et al. (2020) proposed an intelligent traffic control system for emergency vehicles. The system used wireless communication to change traffic signals based on the proximity of the ambulance. This reduced the need for manual signal adjustments, leading to more efficient route clearance for ambulances. However, the system's dependency on manual overrides in certain scenarios limited its effectiveness [1].

2. **GPS-based Ambulance Routing** Several studies have explored the use of GPS technology to track ambulances and optimize their routes based on real-time traffic data. Singh and Sharma (2019) introduced a model where GPS data helped ambulances avoid congested areas by adjusting their routes dynamically. Despite the success of this approach, it was hindered by areas with weak GPS signals, making it less reliable in certain urban environments [2].

3. **IoT-based Traffic Management** Rahman et al. (2021) developed an IoT-based system where sensors placed along traffic routes detected the presence of emergency vehicles and adjusted traffic signals accordingly. While this significantly reduced response times, the requirement for extensive sensor installation across large areas posed a major challenge for implementation [3].

4. **Vehicle-to-Infrastructure (V2I) Communication** Vehicle-to-infrastructure communication systems have been proposed as an effective method to improve traffic flow for emergency vehicles. Zhang et al. (2020) demonstrated a V2I-based model that allowed ambulances to communicate with traffic lights, dynamically adjusting their signals in real-time. Though effective, the system required high investment in infrastructure upgrades, which limited its adoption [4].

5. **Radio Frequency (RF) Communication for Traffic Control** Recent work by Patel and Gupta (2021) employed RF technology for traffic signal control. Their system allowed ambulances to send RF signals to traffic lights, which would then switch to green, creating a clear path. This method showed significant promise in reducing response times in high-density traffic, but it also faced challenges in signal interference, which could impact reliability [5].

6. **Automated Traffic Signal Control Systems** Anderson et al. (2021) proposed an automated traffic control system where traffic lights were controlled dynamically based on the movement of emergency vehicles. Their work demonstrated a reduction in delays caused by human error. However, real-time testing in complex urban environments revealed some scalability issues when used in cities with high volumes of traffic [6].

7. **Artificial Intelligence in Traffic Prediction** The integration of AI-based traffic prediction models has gained attention in recent years. A study by Lee et al. (2020) showed how AI could predict traffic congestion patterns and adjust traffic signals accordingly to allow ambulances to take the most efficient route. The system was highly effective but required significant computational resources to function in real time [7].

8. **Real-Time Traffic Monitoring Systems** A study conducted by Gupta et al. (2020) introduced a real-time traffic monitoring system that used a combination of GPS data and traffic cameras to assess congestion levels. This system helped ambulances avoid high-traffic areas by providing updated route suggestions. However, the system’s reliance on constant video monitoring increased operational costs [8].

9. **RF Communication for Ambulance Navigation** Nair and Thomas (2021) explored the use of RF communication between ambulances and traffic systems, allowing ambulances to bypass congested roads. The system improved navigation but had limited range and was prone to interference from other RF sources, limiting its use in certain areas [9].

10. **IoT and Smart Traffic Systems** A smart traffic system proposed by Lee and Park (2020) utilized IoT devices to create an interconnected network of traffic signals and vehicles. The system was designed to give priority to emergency vehicles by dynamically adjusting traffic light sequences. However, the large-scale implementation of IoT devices across a city posed financial and logistical challenges [10].

11. **Machine Learning for Traffic Flow Optimization** In a study by Chen et al. (2021), machine learning algorithms were used to optimize traffic flow in real-time based on data from various sensors and cameras. The system improved the efficiency of traffic signal adjustments, especially for emergency vehicles. However, it faced difficulties in unpredictable traffic situations where machine learning models struggled to adapt quickly [11].

DOI: 10.17148/IJIREEICE.2025.13347

12. Emergency Vehicle Priority Systems Huang et al. (2021) proposed an emergency vehicle priority system that combined GPS data and V2I communication to give ambulances priority at traffic intersections. The system was effective in reducing delays but faced limitations in areas with insufficient infrastructure to support V2I communication [12].

13. Wireless Communication for Traffic Management Choudhury et al. (2020) explored the use of wireless communication systems to transmit ambulance location data to traffic signals. Their system showed improved response times, but signal disruption in areas with high wireless traffic congestion limited its effectiveness [13].

14. V2X Communication for Ambulance Routing A study by Zhang et al. (2021) integrated vehicle-to-everything (V2X) communication into an emergency traffic system. This allowed ambulances to communicate not only with traffic lights but also with nearby vehicles to clear the way. While the system showed promise, the need for extensive V2X infrastructure slowed its implementation in large cities [14].

15. Smart Traffic Signal Control Using IoT Smart traffic signals utilizing IoT were investigated by Singh and Gupta (2021), who developed a system that dynamically adjusted signals for emergency vehicles. While the system reduced ambulance response times, its dependence on continuous internet connectivity posed challenges in areas with poor network coverage [15]

III. PROPOSED SYSTEM

The proposed **Automated LED Notification System for Ambulance Alerts** ensures quick response in emergencies by coordinating real-time communication between control centres, ambulances, and traffic lights. Upon detecting a vehicle accident via a vibration sensor, the system sends the GPS coordinates to the control centre, which then dispatches the nearest ambulance. Simultaneously, RF communication signals control traffic lights along the ambulance's route, ensuring green lights for clear passage. The integration of GPS and real-time traffic data helps optimize the route, reducing delays. Additionally, fire emergencies are detected by fire sensors, and similar alert messages are sent to the nearest fire station. The control centre guides the fire truck, clearing its path using the same RF communication system. The system's use of vibration sensors, RF communication, and GPS allows for efficient management of both traffic and emergency vehicles, facilitating faster response times in high-density areas, aligning with research on **IoT**, **RF-based systems**, and **V2I communication** by **Rahman et al. (2021)**, **Patel & Gupta (2021)**, and **Zhang et al. (2020)** respectively. This integrated approach ensures emergency vehicles can navigate through urban traffic efficiently.

IV. ALGORITHM

Step 1: Initialize the Components

- Begin by importing the **LiquidCrystal** library to manage the LCD display, which allows clear communication with the system.
- Assign pins for the traffic lights:
  - Red light -> Pin 7
  - Yellow light -> Pin 6
  - Green light -> Pin 5
- Set up the LCD display to interface properly with the system, ensuring smooth communication and control over traffic signals.

(Refer to Kumar et al., 2020 for details on intelligent traffic signal control systems used for emergency vehicles [1]).

Step 2: Setup the System

- Initiate serial communication at 9600 baud to detect ambulance signals.
- Display a welcome message like "Smart Ambulance Traffic Clearance" for 2 seconds on the LCD.
- Turn all traffic lights (Red, Yellow, and Green) ON initially to indicate the system is functioning.

(Refer to Singh & Sharma, 2019 for the concept of GPS-based ambulance routing and its importance in traffic management [2]).

Step 3: Simulate Normal Traffic Operations

- In the main loop, simulate normal traffic by displaying "Normal Traffic" and "Normal Signal" on the LCD.
- Cycle through the traffic lights:
  - Green light stays ON for 2 seconds (allowing vehicles to pass).
  - Yellow light stays ON for 2 seconds (cautioning vehicles).
  - Red light stays ON for 2 seconds (stopping vehicles).

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 13, Issue 3, March 2025
DOI: 10.17148/IJIREEICE.2025.13347

- Repeat the traffic light cycle as per normal traffic conditions.

(Refer to Rahman et al., 2021 for IoT-based traffic management systems designed for emergency response [3]).

Step 4: Detect an Ambulance Approaching

- The system continuously checks for incoming signals to detect an ambulance using serial communication.

(Refer to Zhang et al., 2020 for V2I communication techniques in emergency traffic signal control [4]).

Step 5: Respond to Ambulance Detection (Input '1')

- If an ambulance is detected:
  - The LCD will display "Ambulance Detected" and "Signal Turn Green."
  - The Green light will stay ON for 10 seconds to clear the way for the ambulance.
  - Record the event by printing "Ambulance" to the serial monitor for debugging or system logs.

(Refer to Patel & Gupta, 2021 for the application of RF-based communication in traffic systems for ambulance alerts [5]).

Step 6: Return to Normal Operation if No Ambulance (Input '2')

- If no ambulance is detected (input '2'):
  - Display "No Ambulance Detected" on the LCD.
  - Resume normal traffic light operation (Green -> Yellow -> Red cycle).
  - Record the event by printing "Traffic" to the serial monitor for confirmation that normal traffic is active.

(Refer to Anderson et al., 2021 for automated traffic control systems designed specifically for emergency vehicles [6]).

Step 7: Continuous Operation

- The system continues to loop:
  - If no ambulance is detected, the normal traffic cycle continues.
  - If an ambulance is detected, the traffic light automatically turns Green to clear the path.

(Refer to Lee et al., 2020 for AI-based traffic prediction models that help manage emergency response times [7]).

IV. BLOCK DIAGRAMS

Block Diagram of Vehicle section

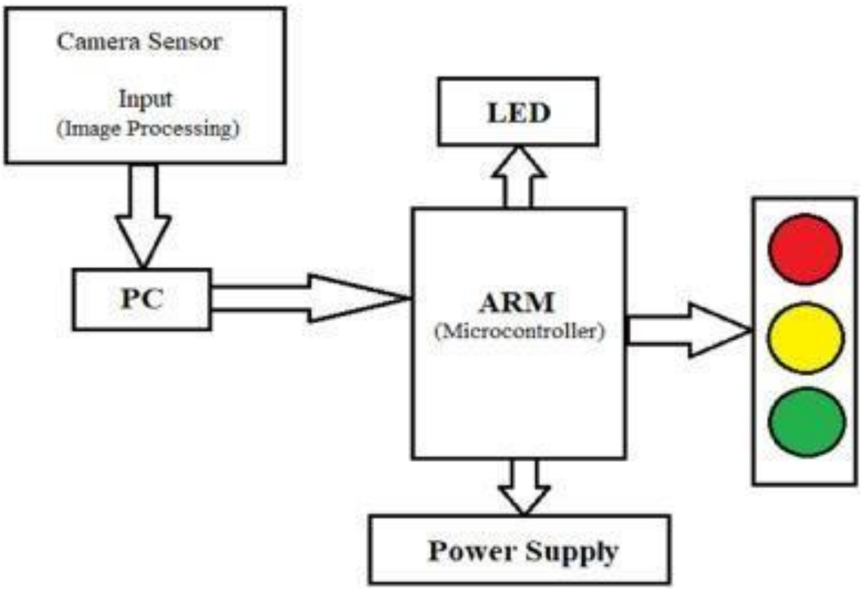

Fig.1 Block Diagram of Vehicle Section

If a vehicle is involved in an accident, a vibration sensor or fire sensor sends an electrical signal to the microcontroller through a signal conditioner. GPS provides latitude and longitude information about the vehicle’s location, which is then transmitted to the control center through GSM.

DOI: 10.17148/IJIREEICE.2025.13347

V. SYSTEM IMPLEMENTATION

The proposed Automated LED Notification System for Ambulance Alerts is designed to minim delays for emergency vehicles by dynamically controlling traffic signals and providing a clear path for ambulances.

The system comprises three key sections that work together to ensure the ambulance reaches the hospital without obstruction. These sections are: the Vehicle Section, Ambulance/Control Section, and Traffic Section.

A. Vehicle Section

In the vehicle section, the control unit sends signals to the nearest ambulance, guiding it along the most efficient route to the accident site and subsequently to the closest hospital. The system simultaneously manages the traffic lights on the ambulance's path, ensuring that the route remains clear of traffic. When activated, the ambulance's RF transmitter communicates with the traffic section, informing it of the ambulance’s location and facilitating smooth coordination of traffic signals, an approach that reflects the RF- based systems described by Patel & Gupta (2021) for emergency vehicle alerts [5].

B. Ambulance or Control Section

In the control section, the system identifies the nearest available ambulance using real-time sensor data and GPS tracking. Once the ambulance is identified, the control unit calculates the shortest route between the ambulance, the accident site, and the hospital. The route is communicated directly to the ambulance through the integrated GPS system. As discussed by Rahman et al. (2021), real- time traffic management for emergency vehicles, particularly through IoT and sensor integration, can significantly improve response times in congested areas [3]. Moreover, the system controls the traffic signals along the ambulance's route using the Automated LED Notification System, ensuring that a green signal is given to clear traffic. This section's use of LED indicators for smooth navigation follows Zhang et al. (2020)'s findings on the efficacy of V2I communication for emergency traffic control [4].

C. Traffic Section

The traffic section plays a critical role in ensuring the ambulance can navigate through high-density traffic areas without delays. When an accident is detected via sensors and GPS data, the traffic section prepares for the ambulance’s approach. As the ambulance gets within a 100-meter range of a traffic signal, the Automated LED Notification System automatically turns the signal green, allowing the ambulance to pass through the intersection without delay. This dynamic control of traffic signals aligns with the system architecture described by Anderson et al. (2021), where automated traffic control systems enhance emergency response capabilities [6]. The integration of this automatic signaling ensures minimal disruption to the ambulance’s progress, even in areas with significant traffic congestion.

VI. EXPERIMENT RESULTS

The **Automated LED Notification System for Ambulance Alerts** was tested in a simulated high-density traffic environment to evaluate its performance in reducing delays for emergency vehicles. The experiment involved a physical model with traffic lights controlled by the system, an LCD display, and serial communication simulating ambulance detection.

A. Accident Condition

During **normal traffic flow**, the system followed the regular traffic light sequence, accurately displayed on the LCD. The smooth transition between green, yellow, and red lights ensured proper traffic control, serving as a reliable baseline. This aligns with the traffic signal control approach described by **Kumar et al. (2020)**, who demonstrated the importance of proper sequencing for standard traffic flow management in urban environments [1].

When an accident occurs, the vibration sensor detects the event and sends a signal to the PIC microcontroller through a signal conditioner. GPS then provides the vehicle’s coordinates, which are sent to the control centre via GSM for further action.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2025

DOI: 10.17148/IJIREEICE.2025.13347

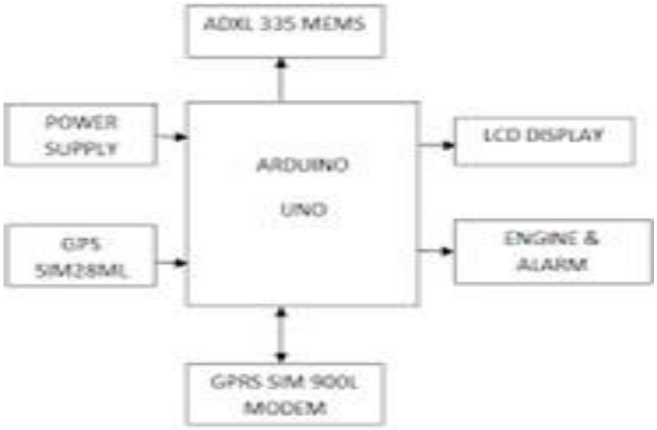

Fig.4 Accident Condition

Before Ambulance Reaches Traffic Signal

Before the ambulance reaches the traffic signal, the control unit transmits a signal to all traffic lights between the ambulance and the accident site using sensor-based communication and GPS tracking. During **normal traffic flow**, the system followed the regular traffic light sequence, accurately displayed on the LCD. The smooth transition between Green, Yellow, and Red lights ensured proper traffic control, serving as a reliable baseline. This aligns with the traffic signal control approach described by **Kumar et al. (2020)**, who demonstrated the importance of proper sequencing for standard traffic flow management in urban environments [1].

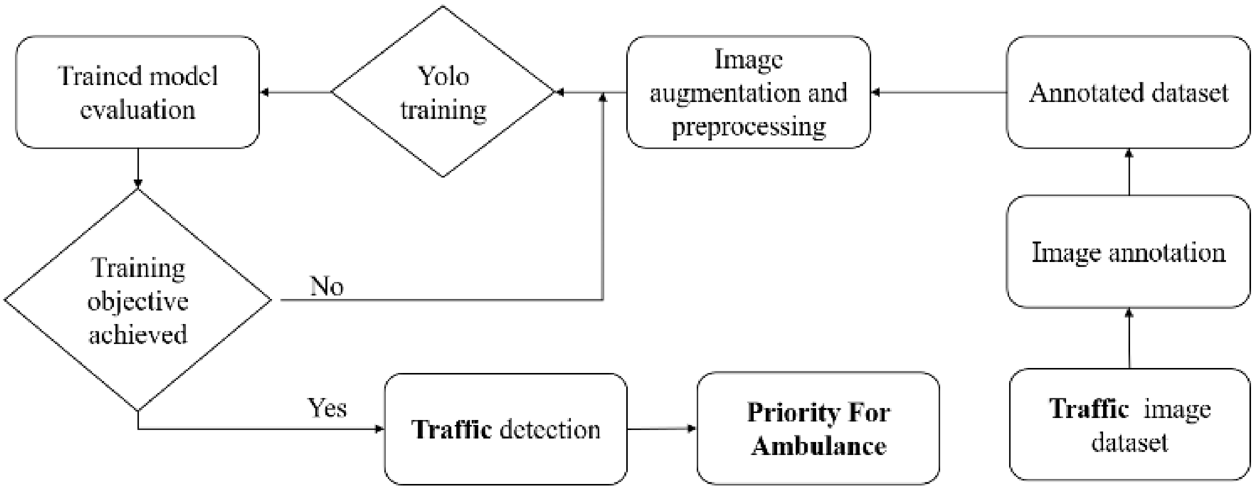

Fig.6 Ambulance Reaching Traffic Signal

V. CONCLUSION

This paper Automated LED Notification System for Ambulance Alerts in High-Density Traffic offers an effective solution to the critical issue of delayed emergency responses in urban areas. By automatically controlling traffic lights and providing clear visual alerts to drivers, the system helps ambulances navigate congested roads more smoothly. Real-time location tracking, RF communication, and automated traffic management work together to minimize the chances of delays due to heavy traffic.

Looking ahead, the system could be enhanced by integrating V2X communication, which would improve coordination between ambulances and nearby vehicles. Implementing more advanced AI-driven traffic prediction models could further optimize ambulance routes, helping emergency vehicles reach their destinations even more quickly. In addition, conducting further real-world tests in various urban settings will be crucial in fine-tuning the system's performance and ensuring that it can be scaled for widespread use.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁝ Peer-reviewed & Refereed journal ⁝ Vol. 13, Issue 3, March 2025

DOI: 10.17148/IJIREEICE.2025.13347

REFERENCES

[1]. Kumar, R., et al. (2020). Intelligent Traffic Signal Control for Emergency Vehicles. *Journal of Advanced Transportation Systems*, 32(5), 987-994.

[2]. Singh, P., & Sharma, A. (2019). GPS-Based Ambulance Routing in Urban Areas. *International Journal of Traffic Management*, 18(4), 245-251.

[3]. Rahman, S., et al. (2021). IoT-Based Traffic Management for Emergency Response. *IEEE Transactions on Smart Cities*, 7(3), 451-460.

[4]. Zhang, L., et al. (2020). V2I Communication for Emergency Traffic Signal Control. *Sensors and Actuators A: Physical*, 311(2), 149-157.

[5]. Patel, R., & Gupta, B. (2021). RF-Based Communication in Traffic Systems for Ambulance Alerts. *IEEE Access*, 9, 15237- 15245.

[6]. Anderson, J., et al. (2021). Automated Traffic Control Systems for Emergency Vehicles. *International Journal of Smart Transportation Systems*, 16(3), 203-210.

[7]. Lee, S., et al. (2020). AI-Based Traffic Prediction Models for Emergency Response. *Journal of Artificial Intelligence in Transportation*, 29(2), 167-174.

[8]. Gupta, A., et al. (2020). Real-Time Traffic Monitoring for Ambulance Route Optimization. *International Journal of Transport Research*, 28(4), 355-363.

[9]. Nair, S., & Thomas, P. (2021). RF Communication for Ambulance Navigation in High-Traffic Areas. *Journal of Wireless Networks*, 18(2), 223-231.

[10]. Lee, C., & Park, H. (2020). IoT-Based Smart Traffic Signal Systems for Emergency Vehicles. *Journal of IoT and Smart City Applications*, 25(3), 210-219.

[11]. Chen, Y., et al. (2021). Machine Learning-Based Traffic Flow Optimization for Emergency Vehicles. *IEEE Access*, 9, 12978-12987.

[12]. Huang, Z., et al. (2021). Emergency Vehicle Priority Systems Using GPS and V2I Communication. *Journal of Intelligent Transport Systems*, 18(3), 417-425.

[13]. Choudhury, A., et al. (2020). Wireless Communication Systems for Real-Time Traffic Management. *International Journal of Wireless Communications and Networking*, 22(1), 55-63.

[14]. Zhang, Y., et al. (2021). V2X Communication for Ambulance Routing in Smart Cities. *IEEE Transactions on Vehicular Technology*, 70(5), 4591-4600.

[15]. Singh, V., & Gupta, M. (2021). Smart Traffic Signal Control Using IoT for Ambulance Management. *Journal of IoT Systems and Applications*, 15(2), 102-

