

Smart Traffic Management System with Emergency Vehicle Priority and Air Quality Tracking

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Abstract— This paper presents a smart traffic management system designed to optimize vehicle movement at road intersections and minimize congestion. The proposed system utilizes Arduino Mega and Arduino Nano microcontrollers to manage a four-way junction based on real-time traffic conditions. Infrared (IR) sensors are deployed on each lane to measure vehicle density, allowing dynamic adjustment of signal timings instead of fixed delays. To enhance emergency response, a LoRaWAN module is incorporated to detect signals from emergency vehicles and automatically prioritize their route by switching the traffic signal to green. Additionally, an MQ-7 gas sensor is used to monitor carbon monoxide levels produced by vehicular emissions, with live data displayed on an LCD screen. RGB LEDs are used to represent traffic signals, and the system is demonstrated using a prototype model with toy vehicles. This approach offers a cost-effective and scalable solution for intelligent traffic control, improving road safety, reducing waiting time, and contributing to environmental monitoring.

Keywords- LoraWan Technology, Traffic management, Embedded System.

1. INTRODUCTION

Smart transportation systems combine modern sensing technologies, communication networks, and intelligent control methods to efficiently regulate traffic movement. These systems aim to reduce congestion, improve travel time, and enhance road safety. The Internet of Things (IoT) plays a crucial role by enabling interconnected devices such as sensors and controllers to exchange data and automate decision-making across domains including transportation, healthcare, and energy management. With the rapid growth of connected devices, large-scale integration of IoT has become a key component in developing intelligent infrastructure.

Wireless sensor networks are widely used to gather real-time environmental and traffic-related data. Recent advancements in imaging systems have also contributed significantly to vehicle detection, as modern cameras have become more affordable, compact, and capable of delivering high-resolution outputs. In addition, improvements in hardware technologies, including multicore and parallel processing, have enabled real-time implementation of traffic monitoring and detection algorithms. As a result, vehicle detection using vision-based techniques and IoT integration has become an active area of research in intelligent transportation systems.

The proposed Smart Traffic Management System using Arduino focuses on adaptive signal control at road intersections. It utilizes IR sensors to detect vehicle density on each lane and adjusts signal timings dynamically based on real-time conditions. To address emergency situations, a LoRaWAN-based communication module is incorporated to

identify approaching emergency vehicles and provide them with priority by overriding standard traffic signals. Additionally, an MQ-7 gas sensor is used to monitor carbon monoxide levels caused by vehicular emissions, with live data displayed on an LCD screen. By integrating traffic monitoring, emergency handling, and pollution detection, the system offers a practical, low-cost, and scalable solution for efficient and safer traffic management.

2. LITERATURE REVIEW

Several researchers have contributed to the development of intelligent traffic management systems using different approaches. S. Indu and H. H. Kenchannavar introduced a vehicle detection method based on motion analysis, where moving vehicles are identified as objects and tracked across multiple frames. Techniques such as optical flow, frame differencing, and background subtraction are commonly applied for vehicle detection, especially during daytime conditions [1].

Hao Dong, Xingguo Xiong, and Xuan Zhang implemented a traffic signal control system on an FPGA platform, combining both automatic timer-based operation and manual control. The system was first simulated using VHDL and later validated through hardware implementation [2].

N. Dinesh Kumar and co-authors developed a traffic light control model using LabVIEW, where signals operate based on predefined time intervals. Compared to conventional

microcontroller-based systems, the LabVIEW approach provides greater flexibility for design modifications and debugging due to its graphical programming environment [3].

Ashwini Y and colleagues proposed a vehicle-mounted system that utilizes GPS technology to detect and report accidents. Their design emphasizes simplicity, cost-effectiveness, and low power consumption [4].

T. Saidani and co-researchers discussed the benefits of using Xilinx System Generator for implementing computer vision algorithms. This approach simplifies development compared to traditional hardware description languages such as VHDL or Verilog [5].

B. Dilip and team presented a cost-effective FPGA-based traffic light controller incorporating pedestrian signalling features. The system operates on a fixed timing cycle and utilizes tools like Chip Scope Pro and Virtual Input/Output for implementation [6].

Binbin Zhou and collaborators proposed an adaptive traffic signal control technique that adjusts signal duration and sequence according to real-time traffic conditions. By using wireless sensor networks for data transmission, their approach improves traffic flow efficiency and reduces vehicle waiting time compared to fixed-time methods [7].

Rongrong Tian and Xu Zhang utilized traffic simulation tools such as TRANSYT and VISSIM to develop and evaluate optimized signal timing plans. Their findings indicate that adaptive signal control significantly reduces traffic delays when compared to traditional fixed-time strategies [8].

Jianhua Guo and co-authors introduced an optimization model for large-scale traffic signal timing based on user equilibrium conditions. Using a genetic algorithm and simulation tools like PARAMICS, they demonstrated improvements in travel time and traffic flow efficiency across urban networks [9].

Gustav Nilsson and Giacomo Como explored dynamic feedback-based traffic signal control strategies using proportional allocation principles. Their work established system stability through mathematical modelling and the use of Lyapunov functions, ensuring reliable performance under varying traffic conditions [10].

3. METHODOLOGY

The proposed smart traffic management system is designed to improve urban traffic flow by using an intelligent and automated approach based on real-time conditions. The system is built around Arduino microcontrollers and integrates multiple technologies such as IR sensors, LoRaWAN communication, and gas sensing to ensure efficient traffic control at a four-way junction. Each lane of the intersection is equipped with IR sensors that continuously detect the presence and number of vehicles. This data is sent to the microcontroller, which analyses

the traffic density on each lane and dynamically adjusts the signal timings. Lanes with higher vehicle density are given longer green signals, while less congested lanes receive shorter durations, thereby reducing waiting time and minimizing traffic congestion.

In addition to density-based control, the system incorporates an emergency vehicle prioritization feature using LoRaWAN communication technology. An emergency vehicle is fitted with a LoRa transmitter that sends a wireless alert signal as it approaches the junction. This signal is received by a LoRa module connected to the traffic control unit. Upon detection, the system immediately overrides the normal traffic sequence and turns the signal green for the specific lane through which the emergency vehicle is approaching, while all other lanes are set to red. This ensures a clear and uninterrupted path for emergency services such as ambulances and fire trucks, significantly improving response times.

Furthermore, the system includes an air pollution monitoring module using an MQ-7 gas sensor, which measures the concentration of carbon monoxide produced by vehicle emissions at the intersection. The sensor continuously collects environmental data, which is processed by the microcontroller and displayed on an LCD screen for real-time monitoring. This feature not only helps in traffic management but also contributes to environmental awareness by tracking pollution levels in congested areas. Overall, the proposed system offers a cost-effective, scalable, and efficient solution for modern traffic management, combining automation, real-time decision-making, and smart communication technologies to enhance both road safety and environmental monitoring.

3.1. BLOCK DIAGRAM

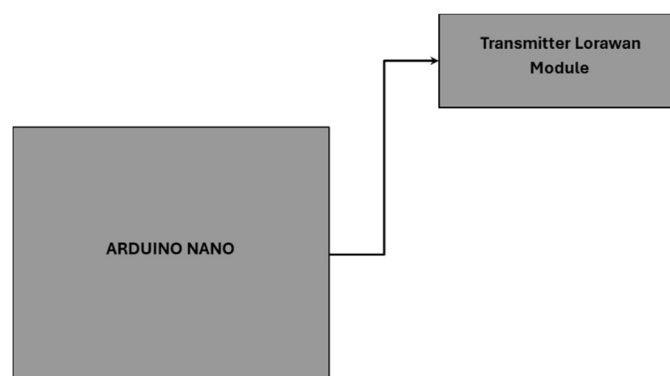


Fig.1. TRANSMITTER SYSTEM

The block diagram in Fig. 1 represents the transmission system of the proposed model. In this setup, the Arduino Nano acts as the main microcontroller, controlling the overall operation of the transmission unit. It processes the input signal generated during an emergency situation and prepares the data to be transmitted. The Arduino Nano is connected to a LoRaWAN transmitter

module, which is responsible for wireless communication. When an emergency vehicle is activated, the Arduino sends a signal to the LoRa module. This module then transmits the signal wirelessly over a long distance to the receiver unit placed at the traffic junction. The use of LoRaWAN technology ensures reliable and low-power communication, making it suitable for real-time applications. This transmission system plays an important role in sending emergency alerts quickly, allowing the traffic control system to respond immediately and provide a clear path for emergency vehicles.

data, emergency signals, and environmental monitoring to ensure efficient, safe, and intelligent traffic control.

3.2. FLOW CHART

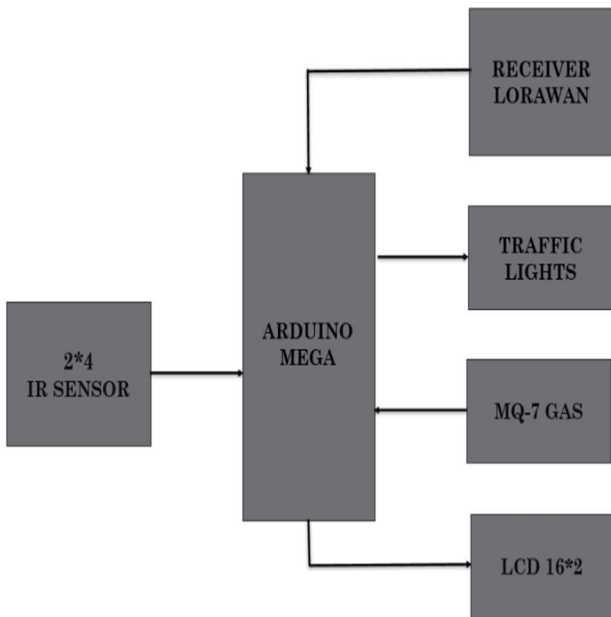
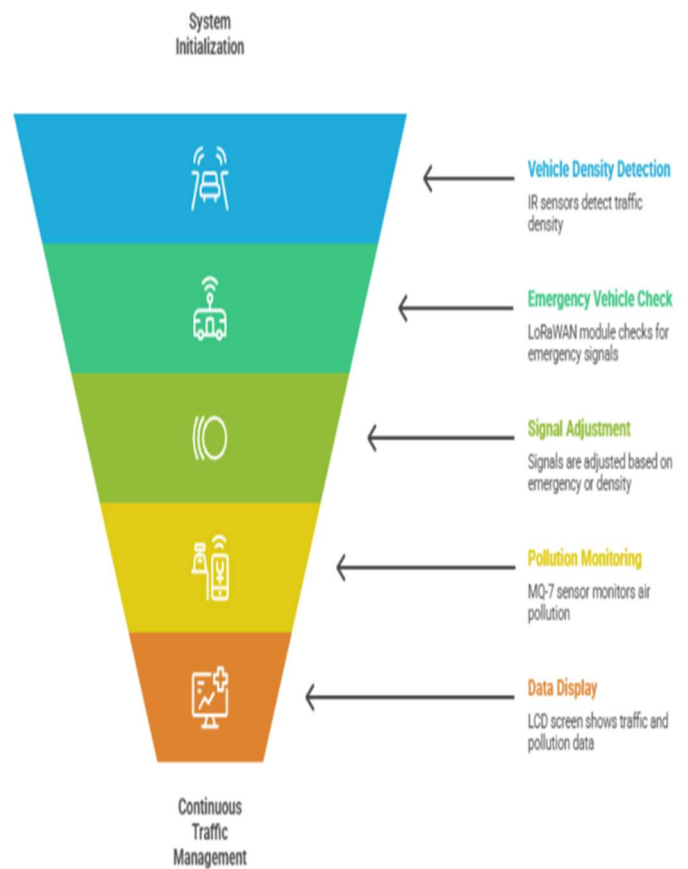


Fig.2.RECEIVER SYSTEM

The block diagram in Fig. 2 represents the receiver system of the proposed smart traffic management model. In this system, the Arduino Mega acts as the central microcontroller, responsible for controlling and coordinating all the connected components. It receives inputs from multiple devices, processes the data, and accordingly controls the traffic signals and display units. On the input side, the system includes a LoRaWAN receiver module, which receives wireless signals sent from the transmitter unit (emergency vehicle). Along with this, eight IR sensors (2×4 configuration) are installed on the lanes to detect vehicle presence and measure traffic density at the intersection. These sensors continuously send data to the Arduino Mega for analysis. Based on the received data, the Arduino controls the traffic lights, adjusting signal timings dynamically according to traffic density or giving priority during emergency situations. The system also includes an MQ-7 gas sensor to monitor air pollution levels caused by vehicle emissions. The measured values are processed and displayed on a 16×2 LCD display for real-time monitoring. Overall, this receiver system plays a crucial role in decision-making by combining traffic density



The flowchart represents the working process of the smart traffic management system. It begins with system initialization, where all components such as sensors and communication modules are activated. The system then detects vehicle density using IR sensors to analyse traffic conditions at each lane. Simultaneously, the LoRaWAN module checks for any emergency vehicle signals. Based on the detected traffic density or emergency condition, the system adjusts the traffic signals dynamically. The MQ-7 gas sensor continuously monitors air pollution levels at the junction. Finally, all relevant data, including traffic status and pollution levels, are displayed on the LCD screen. This process runs continuously to ensure efficient and real-time traffic management.

3.3. EXPERIMENTAL RESULT



Figure 3.3(a) Image of Project

Figure 3.3(a) shows the complete prototype of the smart traffic management system. It includes Arduino boards, IR sensors, traffic signal LEDs, LoRa modules, and the LCD display. Toy vehicles are used to simulate real-time traffic conditions at a four-way junction, demonstrating the overall working of the system.

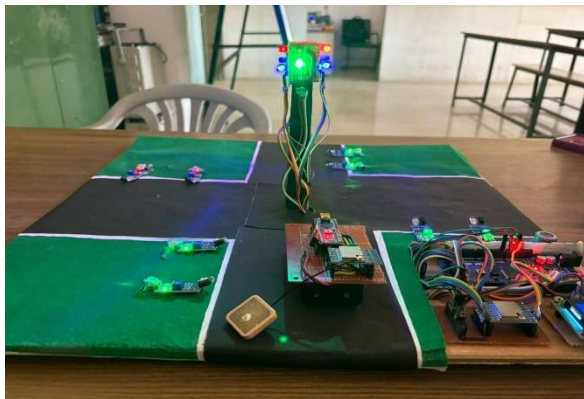


Figure 3.3(b) Emergency Vehicle Detection

Figure 3.3(b) demonstrates the emergency vehicle detection feature using LoRaWAN communication. When an emergency signal is transmitted, the system detects it and immediately gives



priority by turning the respective lane signal to green while stopping other lanes, ensuring a clear path.



Figure 3.3(c) Receiver system

Figure 3.3(c) shows the receiver module setup, where the Arduino Mega processes inputs from the LoRa receiver and IR sensors. It controls the traffic lights and displays relevant information, showing how the system manages traffic dynamically at the junction.

Figure 3.3(d) Density Detected using IR Sensor

Figure 3.3(d) illustrates how IR sensors detect vehicle presence and density on each lane. Based on the number of vehicles detected, the system adjusts the traffic signal timing, giving more time to congested lanes and reducing waiting time.

4. CONCLUSION

There is an exigent need for an efficient traffic management system in our country, as India meets with 384 road accidents every day. We must decrease traffic jams and congestion as a result of population growth in order to decrease road accidents. In this implementation, we have Arduino Nano and LoraWan module Technology. It is developed with the integration of all hardware components utilising an Arduino Nano, Arduino Mega and LORAWAN MODULE technology. Additionally, the inclusion of MQ-7 gas sensors allows continuous monitoring of air pollution levels, with live data displayed on an LCD for awareness and analysis. The system effectively reduced the delay at traffic junctions and we also reduced the delay time for emergency vehicles. Overall, the paper proves that intelligent traffic systems can be implemented using simple embedded technologies to enhance road efficiency, emergency response, and environmental monitoring, and it can be further expanded for real-world smart city applications.

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REFERENCES

- [1] Indu, S., Gupta, M., & Bhattacharyya, A., —Vehicle tracking and speed estimation using optical flow methodl, *International Journal on Engineering Science and Technology*, vol.3, no.1, pp.429-434, 2020
- [2] Hao Dong, Xingguo Xiong, Xuan Zhang, —Design and Implementation of a Real Time Traffic Light Control System Based on FPGA, *Proceeding of the 1st Conference on ASEE*, April 3-5, 2020, USA.
- [3] N. Dinesh Kumar, G. Bharagava Sai and K. Shiva Kumar, —Traffic Control System using LABVIEW, *Global Journal of Advanced Engineering Technologies*, vol.2, pp. 47-49, 2021.
- [4] Ashwini Y. Dakhole and Mrunalini P. Moon, —Design of Intelligent Traffic Control System Based on ARML, *International Journal of Advanced Research in Computer Science and Management Studies*, vol.1, pp.76-80, 2020.
- [5] Saidani, T., Dia, D., Elhamzi, W., Atri, M., & Tourki, R, —Hardware simulation for video processing using xilinx system generatorl, *In Proceedings of the World Congress on Engineering*, vol.1, pp.3-7, July 2021
- [6] Dilip, B., Alekhya, Y., & Bharathi, P. D., —FPGA Implementation of an Advanced Traffic Light Controller using Verilog HDLl, *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, vol.1, no.7, pp-1, 2021.
- [7] Zhou, B., Cao, J., Zeng, X., & Wu, H., —Adaptive traffic light control in wireless sensor network-based intelligent transportation systeml, *In Vehicular Technology Conference Fall (VTC 2020-Fall)*, 72nd, pp.1-5, September 2020.
- [8] Rongrong Tian , Xu Zhang, “Design and Evaluation of an Adaptive Traffic Signal Control System – A Case Study in Hefei”, *China 2020 ,International Symposium of Transport Simulation (ISTS’ 16 Conference)*, June 23~25, 2020
- [9] Jianhua Guo, Ye Kong, Zongzhi Li, Wei Huang, Jinde Cao, Yun Wei, “A model and genetic algorithm for area-wide intersection signal optimization under user equilibrium traffic”, *International Association for Mathematics and Computers in Simulation (IMACS)*, 0378-4754 (2021).
- [10] Gustav Nilsson _ Giacomo Como, “On Generalized Proportional Allocation Policies for Traffic Signal Control”, *International Federation of Automatic Control*, 50-1 (2020) 9643–9648.