IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 2, September 2025
Impact Factor: 7.67

A Review on Intelligent Traffic Flow Optimization with Automatic Movable Road Barriers

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Abstract: *Traffic congestion and inefficient road space utilization are major challenges in modern urban transportation systems. The "Automatic Movable Road Divider" project aims to provide a dynamic and intelligent solution to these problems by designing a road divider system that can be automatically repositioned based on real-time traffic conditions. This system employs sensors, microcontrollers (e.g., Arduino), and motorized mechanisms to detect traffic density in multiple lanes and adjust the position of the divider accordingly. During peak hours, the divider shifts to allocate more lanes to the congested direction, thereby optimizing traffic flow and reducing delays. The system can be controlled automatically through an embedded program or manually via remote control, ensuring flexibility and safety The design integrates infrared or ultrasonic sensors to monitor vehicle count and lane occupancy in real-time. A central microcontroller processes the sensor data and controls a series of motors or actuators that move the divider units along embedded tracks or wheels. Safety features such as emergency stop mechanisms, LED indicators, and obstacle detection ensure reliable and secure operation. The system is powered by either a mains supply or solar energy, promoting sustainability. This adaptable infrastructure can be especially beneficial in cities with varying traffic patterns throughout the day, such as near schools, business districts, or event venues. The project has the potential to replace traditional static dividers in metropolitan areas, offering a cost-effective, adaptive, and technologically advanced approach to traffic management.*

Keywords: Automatic Road Divider, Movable Barrier System, Traffic Management, Smart Traffic Control, Lane Optimization, Real-time Traffic Monitoring.

I. INTRODUCTION

Urbanization and the rapid increase in vehicle population have led to significant traffic congestion in cities worldwide. Conventional road infrastructure often lacks the adaptability to handle fluctuating traffic volumes during different times of the day. One common issue is the unequal lane usage during peak hours where one side of the road may experience heavy traffic while the other side remains underutilized. This imbalance causes delays, fuel wastage, and increased pollution levels. Traditional road dividers are static and do not offer any flexibility in lane management. As traffic patterns vary throughout the day, there is a pressing need for a system that can dynamically allocate lanes to suit real-time conditions.

A movable road divider system provides an innovative approach to solve this problem. It offers the ability to adapt lane distribution based on actual traffic demand, optimizing road usage and minimizing congestion. The Automatic Movable Road Divider is a smart system designed to automatically adjust the position of a road barrier depending on traffic flow. It uses a combination of sensors (such as ultrasonic or IR sensors) to detect vehicle density, a microcontroller (like Arduino or Raspberry Pi) to process the data, and motorized mechanisms to move the divider units. The dividers are mounted on tracks or wheels and can shift laterally to expand or reduce the number of lanes in a specific direction.

This system offers several advantages, including improved traffic flow, reduced fuel consumption, and enhanced road safety. It can be especially useful in areas where traffic patterns vary significantly throughout the day, such as near schools, commercial zones, or highways leading into city centres. The system also supports remote and automated

DOI: 10.48175/IJARSCT-29039

control, making it suitable for integration into modern intelligent transportation systems (ITS) and smart city infrastructure. The primary objective of this project is to design and prototype a fully functional automatic movable road divider that can operate in real-time based on live traffic data. The system aims to be cost effective, reliable, and scalable for different types of roads and environments.

By implementing this project, we hope to demonstrate how automation and smart technology can be used to address real world traffic management challenges in a sustainable and efficient manner. Additionally, the system can reduce traffic-related stress for drivers by ensuring smoother journeys during rush hours. It promotes environmental sustainability by lowering carbon emissions through reduced idling time. The flexibility of this system makes it adaptable for both urban and semi-urban road networks. Moreover, it can be integrated with IoT platforms for remote monitoring and predictive traffic management.

The project also opens opportunities for future advancements like AI-based traffic prediction and autonomous vehicle compatibility. In developing countries, where rapid urban growth outpaces infrastructure upgrades, this system can provide a practical and affordable solution. Its modular design ensures easy maintenance and scalability according to traffic demands. Ultimately, the Automatic Movable Road Divider is not just a traffic management tool but also a step toward building smarter, safer, and greener cities.

II. LITERATURE SURVEY

Several studies have explored the automation of road dividers and traffic management systems using embedded technology and automation principles.

Dalmia et al. [1] (2018) implemented an IoT-based movable road divider, demonstrating how real-time monitoring and control can effectively manage lane allocation. Sri et al. [2] (2017) designed and implemented a smart movable road divider system using IoT, with emphasis on reducing congestion through automated traffic lane adjustment.

Pavithra et al. [3] (2021) proposed a smart moving road divider for densely populated traffic zones, focusing on low-cost embedded automation and effective traffic regulation.

Djahel [4] (2015) studied approaches to reduce emergency service response time in smart cities through adaptive and fuzzy techniques, concepts relevant to traffic clearance and prioritization.

Weil et al. [5] (1998) provided one of the earliest studies on traffic incident detection sensors and algorithms, which established a basis for sensor-driven automation in intelligent traffic systems. Ravish et al.

[6] (2019) contributed to the software implementation of an automatic movable road barrier, showcasing the feasibility of replacing manual systems with automation to improve traffic management.

Srikanth et al. [7] (2019) further enhanced this field by designing a smart movable road divider with ambulance clearance using IoT, underlining the importance of embedded electronics and automation for emergency response.

A more detailed version of Ravish et al.'s work [8] (2019) presented the complete software implementation of an automatic movable road barrier, including technical specifications and conference validation, thereby strengthening the feasibility of automated traffic solutions.

Agrawal and Maheshwari [9] (2021) extended this work by integrating IoT cloud-based control to manage movable road dividers and ensure ambulance path clearance.

III. PROPOSED METHODOLOGY

Power Supply to System:

The system is powered using a battery or an external power source, supplying energy to all components like Arduino, motors, and sensors. A regulated power supply is used to ensure stable voltage levels and prevent damage to sensitive electronics. In some cases, a voltage regulator or DC-DC converter is incorporated to provide the required operating voltage for different modules. Rechargeable batteries can be used for portable applications, while an external adapter ensures continuous power during long operations. Proper power management is implemented to distribute energy efficiently, prevent overloading, and enhance the overall reliability and performance of the system.

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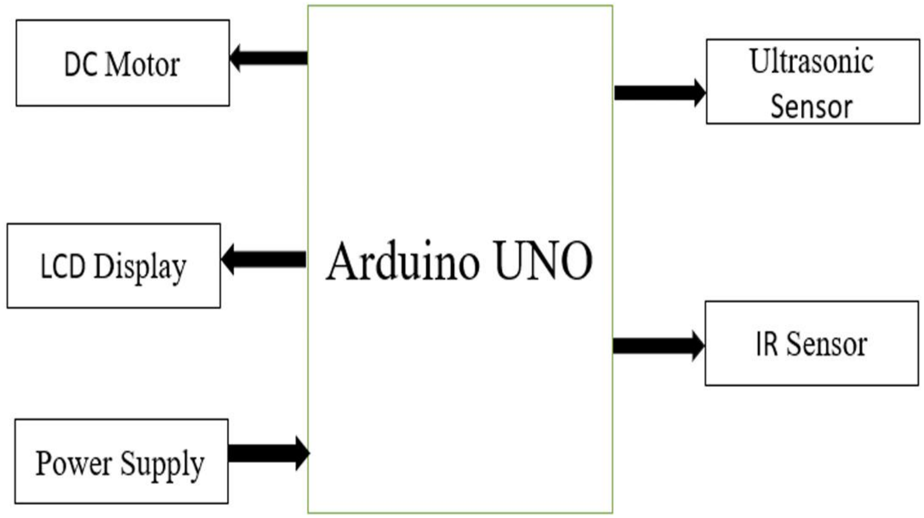

Fig 1: Block diagram of Automatic Movable Road Divider

Ultrasonic Sensor Detection:
Ultrasonic sensors continuously monitor traffic density on both sides of the road by measuring the distance to vehicles in each lane. These sensors emit high-frequency sound waves and calculate the time taken for the echo to return, thereby determining the proximity of vehicles accurately. The collected data helps in analyzing traffic conditions in real time, which can be used for dynamic signal control or intelligent traffic management.
Their high precision and reliability make them suitable for detecting vehicles even in low-light or adverse weather conditions, ensuring smooth and efficient traffic flow. Additionally, ultrasonic sensors are cost-effective, easy to install, and require minimal maintenance, making them ideal for large-scale deployment. They are highly resistant to dust and dirt accumulation, which ensures consistent performance in outdoor environments. By providing accurate vehicle count and distance measurements, these sensors enable better decision-making for automated systems such as movable road dividers. Furthermore, their integration with microcontrollers or IoT platforms allows seamless data transfer for remote monitoring and centralized traffic control.

Input Processing by Arduino UNO:
The Arduino UNO reads the sensor data and compares traffic levels on each side to determine which direction has higher traffic flow. It processes the inputs from the ultrasonic sensors in real time and uses predefined logic to make decisions for controlling the traffic signals. Based on the analyzed data, the Arduino prioritizes lanes with higher traffic density to reduce congestion and waiting time. Additionally, the Arduino can handle multiple inputs simultaneously, ensuring smooth coordination between sensors and signal control mechanisms. Its fast processing capability and ease of programming make it an efficient choice for real-time traffic management applications.

Decision-Making Logic:
Based on the comparison, the Arduino decides whether to shift the road divider to increase the number of lanes on the congested side. The decision-making process is driven by predefined algorithms that analyze real-time traffic data and select the optimal lane configuration. If one side shows higher traffic density, the Arduino activates the motor mechanism to adjust the divider accordingly, ensuring better traffic flow. Safety checks and limit switches are also integrated to prevent incorrect movements and ensure smooth operation. This intelligent logic helps in reducing congestion, improving road efficiency, and providing a dynamic traffic management solution

Motor Activation:

If lane adjustment is needed, the Arduino sends a signal to a DC motor or motor driver to move the divider blocks in the required direction along a guided track. The motor driver acts as an interface between the Arduino and the motor, providing sufficient current and voltage for smooth operation. Limit switches or position sensors are often integrated to ensure accurate positioning and prevent the divider from exceeding its boundaries.

The motor movement is controlled gradually to maintain stability and safety on the road. Additionally, an emergency stop mechanism can be included to halt the motor instantly in case of any obstruction or malfunction, ensuring reliable and secure lane adjustments.

Divider Movement:

The motor drives the divider (usually with wheels or a mechanical linkage) to shift lanes either left or right depending on traffic needs. The movement is guided along a fixed track or rail to ensure precise alignment and stability. Sensors such as limit switches or infrared detectors are used to monitor the exact position of the divider and prevent misalignment. The smooth and controlled movement of the divider ensures safety for vehicles on the road while dynamically optimizing lane allocation. This automated adjustment helps manage heavy traffic efficiently and reduces congestion during peak hours.

The system generally uses DC gear motors or stepper motors because of their high torque and precise motion control. These motors are chosen based on the divider's weight and load-bearing capacity. A motor driver circuit interfaces with the microcontroller to control speed and direction. Pulse Width Modulation (PWM) is used to regulate motor speed gradually, avoiding sudden movements that could create unsafe conditions for nearby vehicles.

The divider is mounted on heavy-duty wheels or roller-based rails that allow smooth lateral movement even on uneven road surfaces. For additional stability, anti-slip wheels and shock-absorbing mechanisms are used to minimize vibrations during operation. To further enhance safety, ultrasonic or IR obstacle detection sensors are integrated to detect approaching vehicles during movement and stop the divider immediately if necessary.

The microcontroller processes real-time traffic data from sensors and decides when and how much the divider should shift. It coordinates motor speed, direction, and braking to ensure precise positioning. A feedback system using rotary encoders or position sensors continuously monitors the divider's movement and provides accurate position data to prevent errors or overshooting.

Additionally, the system includes a manual override feature, allowing traffic operators to control the divider when required, such as during road maintenance, emergencies, or sudden traffic diversions. The divider is built using weather-resistant materials to withstand heat, rain, and dust, ensuring durability and long-term reliability.

Stop Condition:

Limit switches or timing logic stop the motor once the divider reaches the desired position, preventing over-shifting. These limit switches act as safety mechanisms, ensuring that the divider does not move beyond its defined boundaries. In some cases, position sensors or encoders are also used for precise detection and accurate stopping. Additionally, the Arduino can implement timing-based logic to halt the motor after a calculated duration if sensor data is unavailable or malfunctioning. This controlled stopping mechanism protects the mechanical components from damage, enhances system reliability, and ensures smooth and safe divider operation.

Continuous Monitoring:

The system continuously monitors traffic and adjusts the divider whenever there's a significant change in traffic density. Ultrasonic sensors constantly send real-time data to the Arduino, allowing it to analyze traffic flow dynamically. If congestion levels rise on one side, the system promptly reconfigures the lane distribution to balance the traffic load. This continuous monitoring ensures optimal road utilization and reduces waiting times for vehicles. Additionally, the system can be integrated with IoT or SCADA platforms to provide live traffic updates, remote monitoring, and data logging for better traffic management and future planning. Change in traffic density.

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IR Sensor:
An Infrared (IR) sensor is an essential component in dynamic traffic management systems, used to detect the presence and movement of vehicles. It works by emitting infrared light and sensing its reflection from nearby objects, making it highly effective for short-range detection. In this system, IR sensors are strategically placed near lanes to monitor vehicle presence and measure traffic density by counting the number of vehicles passing through a particular section. The data collected from these sensors is processed by the Arduino UNO to determine whether a lane is occupied or free, enabling accurate traffic analysis. When used alongside ultrasonic sensors, IR sensors enhance the overall accuracy and reliability of traffic monitoring. They are low-power, cost-effective, and capable of working efficiently even in low-light conditions, ensuring consistent performance during both day and night. By providing real-time vehicle detection, IR sensors support the Arduino's decision-making process for adjusting lane dividers, thereby improving road utilization and reducing congestion effectively.

LCD Display:
An LCD display is used to visually present real-time information about the system's operation, including traffic density, lane adjustments, divider positions, and overall system status. It serves as a user-friendly interface between the system and the operator, ensuring better monitoring and control. Typically, a 16x2 or 20x4 character LCD module is used, connected to the Arduino or microcontroller via parallel or I2C communication, with I2C preferred for its simpler wiring and reduced pin usage. The display shows clear messages like "Shifting Divider Left," "Shifting Divider Right," "High Traffic on Right Lane," "Normal Traffic Flow," or "Emergency Stop Activated," helping operators and drivers understand the current status of the system. It also aids in troubleshooting by providing alerts in case of sensor failures, motor issues, or divider misalignment.
To enhance visibility, the LCD is equipped with a backlight and adjustable contrast, making it readable in low-light as well as bright daylight conditions. Additionally, it can display real-time quantitative data such as vehicle counts, divider position in centimetres, and motor speed, allowing operators to monitor the system precisely and make timely decisions. By providing instant feedback and operational details, the LCD acts as an essential human-machine interface (HMI), improving situational awareness, coordination, and the overall efficiency of the automatic movable road divider system.

IV. CONCLUSION

The automatic movable road divider is an innovative solution designed to manage urban traffic more efficiently. By using sensor-based automation, it can shift road dividers according to real-time traffic flow, ensuring better lane distribution during peak hours. This not only reduces traffic congestion but also enhances safety by minimizing the need for manual labor and sudden lane changes. Its ability to adapt to varying traffic conditions makes it highly effective in improving road usage and reducing travel time. In addition, this system is particularly useful in areas like highways, bridges, tunnels, and smart city projects where space and flexibility are limited. It can also be integrated with emergency systems to provide quick response routes when needed. Overall, the automatic movable road divider is a reliable and intelligent traffic management solution that contributes significantly to modern transportation infrastructure.

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IJARSCT

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ISSN: 2581-9429
Volume 5, Issue 2, September 2025
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