

SMART TRAFFIC MANAGEMENT: A REVIEW

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ABSTRACT

Traffic congestion has become one of the biggest challenges in rapidly growing urban areas, especially in India, where the number of vehicles is increasing much faster than the development of roads and transport infrastructure. Outdated traffic signal systems, weak enforcement of traffic rules, signal failures, and inefficient traffic management make the problem even worse, resulting in long delays, wasted fuel, increased pollution, economic losses, and significant stress for commuters. Ambulances, police cars, and fire trucks are vehicles used in emergencies to help people who are hurt, enforce the law, and put out fires. Traditional traffic lights usually operate on fixed timers and do not respond to real-time traffic flow, causing situations where a road with very little traffic still gets long green time while a busy lane receives too little, leading to heavy congestion. They gather real-time information about traffic levels, vehicle speed, accidents, and road conditions. Using this data, the system can automatically adjust traffic lights, control intersections, and help traffic move more smoothly across the city.

KEYWORDS

Smart Traffic Management (STM), real-time data, IoT devices, sensors, cameras, artificial intelligence (AI), RFID technology.

INTRODUCTION

A Smart Traffic Management System is a technology that helps traffic move more smoothly and safely. It uses real-time information from cameras, sensors, and other devices to see what's happening on the roads. Instead of using traffic lights that switch on a set schedule, the system can change them depending on what's really happening on the road—like how many cars are waiting or if an ambulance needs to pass. This helps reduce traffic jams, save time, cut pollution, and make driving safer.

Traffic jams happen when there are too many vehicles on the road, causing cars to move slowly, wait in long lines, and take longer to reach their destination. This is a big problem in India's big cities because the roads often can't handle all the traffic. Cars on major highways like Mumbai–Chennai and Delhi–Chennai often move very slowly, averaging less than 20 km/h. The Smart Traffic Management System is designed to make traffic flow smoother by using sensors, communication technology, and automated algorithms. Instead of using the same red and green light timings all the time, this system adjusts the signals based on how many vehicles are actually at the intersection. If there are a lot of cars, the green light stays on longer. If there are only a few cars, the red light might stay on longer for other lanes. To make traffic move more smoothly in big cities, it is important to decide the green signal time in a smarter and more accurate way. For this, a special method is

used where vehicles are separated into different types, and a modern technology called YOLO (You Only Look Once) is used to detect them.

It is therefore recognized that dynamic traffic management is essential. In most countries, traffic is still controlled using fixed-time signals, while in large cities of some developed nations, traffic is managed through partially automated systems.

We are facing a growing challenge as traffic continues to increase in cities around the world. With a rising global population, people rely heavily on vehicles for everyday travel. This increasing dependence is largely driven by the ongoing urbanization of rural areas. To address these traffic problems, researchers are exploring smart traffic management systems as a modern solution for improving traffic regulation.

OBJECTIVES

1. **Traffic Flow Optimization:** Finding better ways to keep cars moving smoothly and reduce traffic jams in cities.
2. **Real-time Monitoring:** Continuously keeping an eye on traffic and collecting up-to-date information to understand what's happening on the roads.
3. **Reduce Commuting Time:** Help people get to their destinations faster and with less stress.
4. **Environmental Benefits:** Cut down on pollution and fuel use by easing traffic jams.

COMPONENTS OF SMART TRAFFIC MANAGEMENT

DATA COLLECTION AND SENSING

- **Sensors:** Different types of sensors—like cameras, radar, magnetic sensors, and RFID tags—gather real-time information about how many vehicles are on the road, how fast they're moving, and how crowded the roads are.
- **Cameras:** Video systems and traffic cameras watch the roads, spot accidents or unusual situations, and collect useful information for analysis.
- **Drones:** Drones can fly over areas that are hard to reach and capture traffic data from above, making it easier to monitor large or complex locations.

CONTROL AND RESPONSE SYSTEMS

- **Adaptive Traffic Signals:** Traffic lights change their timing based on what's actually happening on the road, instead of following a fixed schedule.
- **Vehicle Connectivity (V2X):** Cars can share information with each other and with road systems, helping traffic move more smoothly and safely.
- **Integrated Public Transportation:** Bus and train schedules are coordinated with traffic systems to cut down delays and keep everything running more efficiently.

LITERATURE SURVEY

1. Vehicles can have RFID tags that store their information. When a vehicle passes a traffic signal, the RFID system counts it. Based on how many vehicles pass each second, the signal can adjust its red and green timing automatically. If the traffic flow becomes too low or reaches a set limit, the controller makes the signal turn red. This helps manage traffic dynamically and detect congestion.

2. Smart traffic management refers to the use of advanced technologies and data analytics to improve the efficiency and effectiveness of traffic systems. This modern approach leverages tools such as sensors, cameras, and artificial intelligence (AI) to monitor and control traffic flow, reduce congestion, and enhance roadway safety.

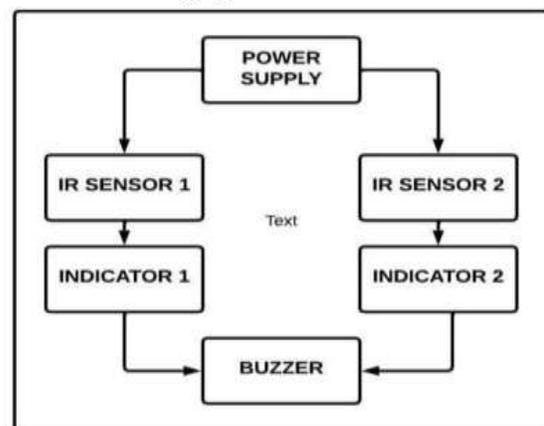


Fig 1. At Turning

3. Artificial Intelligence (AI) refers to intelligent behavior demonstrated by machines. A computer uses its own logic and algorithms to predict solutions to problems. AI can perform tasks as effectively as the human brain by learning from its surroundings and

taking actions that normally require human intelligence.

This paper reviews how artificial intelligence can play an important role in future traffic management systems. Urban traffic congestion is a major problem faced by developed countries today. It affects people’s daily lives and is often made worse by inefficient human-based traffic management.

4. Recent studies (2021–2024) show that AI is becoming essential in intelligent traffic management. Goenawan (2024) presents a smart traffic system that uses YOLOv5 for vehicle detection and an RNN-LSTM model to predict traffic for the next 12 hours, allowing traffic-light cycles to be adjusted automatically. Ben Youssef et al. (2021) review how deep learning and machine learning improve multi-vehicle recognition and tracking, highlighting the potential of AI-based tracking systems for better traffic control.

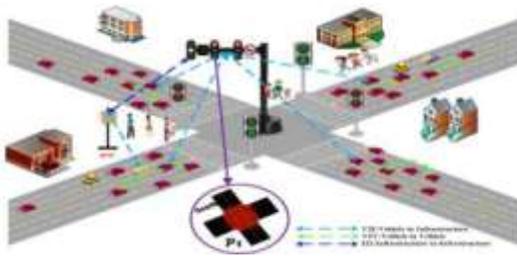


Fig .2 Traffic Signal Control

5. Smart traffic management systems that use vehicle detection have become a major focus of interest.

6. The LED Traffic Light Signal Module is used to create a mini traffic light model. It is small, bright, and easy to use. The module can be connected to a PWM pin on the Arduino to control the brightness of the lights. It is very useful in DIY projects, especially for traffic management system models. This sensor is commonly used in obstacle-avoiding robots, proximity detection systems, and electronics projects. It only measures infrared radiation, so it works as a passive sensor. A sound sensor module is used to detect sound levels in the environment. It contains a microphone that senses audio signals. It can also detect noise frequencies between 3kHz to 6kHz. This sensor is widely used in security systems, home automation, switches, and monitoring systems to trigger actions when sound is detected.

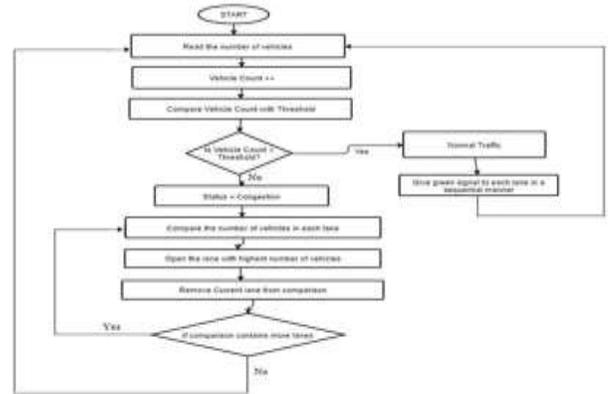


Fig 3 . Implementation details of modules

7. The exiting traffic system is generally controlled by the traffic police. The main drawback of this system controlled by the traffic police is that the system is not smart enough to deal with the traffic congestion. The traffic police official can either block a road for more amount of time or let the vehicles on another road pass by i.e. the decision making may not be smart enough and it entirely depends on the official’s decision. Moreover, even if traffic lights are used the time interval for which the vehicles will be showed green or red signal is fixed.

Therefore, it may not be able to solve the problem of traffic congestion. In India, it has been seen that even after the presence of traffic lights, traffic police officials are on duty, which means that in this system more manpower is required and it is not economical in nature. In the paper presented by Mohammed Sarrab, Supriya Pulparambil, proposes an IOT based system model to collect, process, and store real-time traffic data. The objective is to provide real-time traffic updates on traffic congestion and unusual traffic incidents through roadside message units.

8. The Internet of Things (IOT), also called the Internet of Everything (IoE), includes all smart devices that connect to the internet and share information. These devices have built-in sensors and small processors that help them collect data from their surroundings and send it to other devices. They can also talk to each other directly, which is known as machine-to-machine (M2M) communication. Humans can control these devices when needed—such as setting them up, giving instructions, or checking their data—but most of the time, they work on their own without much human help. IOT has grown rapidly because electronic parts have become smaller and

cheaper, and internet connectivity is available almost everywhere. These smart devices create a large amount of data. This data helps improve how devices work, but it also raises concerns about privacy and security. Even with these concerns, IOT technology provides real-time information like never before. It allows people to monitor their homes from anywhere for safety and helps businesses work more efficiently by reducing waste, preventing unexpected breakdowns, and improving productivity.

9. Every day, traffic congestion has become a major problem. Since automated systems are not widely available in India, we need to use IOT-based technology to monitor and control traffic signals more efficiently. On many roads, the number of vehicles is very high, so we must assign priority levels based on how heavy the traffic is.

10. This study talks about using live camera footage to check traffic. The video is processed and then sent to a server where a C++ program analyzes it. They tested two types of methods—fixed (hard-coded) rules and flexible (dynamic) rules. The flexible method worked better and improved the results by 35%. This paper explains how Model Predictive Control (MPC) can be used to manage traffic on highways. It focuses on controlling the speed of vehicles and deciding which lane they should use.

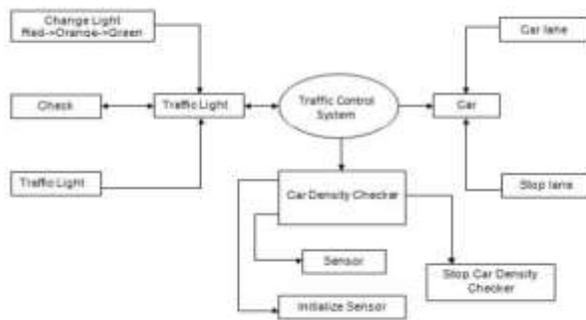


Fig 4. Overall Diagram of Traffic

11. Cities are growing very fast. As per a UN report, the number of people living in cities increases by almost 1.84% every year. Today, more than half (56%) of the world’s population lives in cities, and this number will keep rising. By 2050, most people in developing countries (64%) and developed countries (86%) will be living in urban areas. Because of this population growth, the number of vehicles on the road—especially in India—has also gone up. This leads to heavy traffic, long waiting times, and more

pollution. Traditional traffic lights cannot handle this level of congestion anymore.

12. Cities today are growing fast, and with more people come more vehicles—and more traffic problems. Because of this, many studies show that old-style traffic systems are not enough anymore. That’s where Intelligent Traffic Management Systems (ITMS) come in. Research explains that ITMS use smart technologies like AI, IoT devices, and big data to understand what’s happening on the roads in real time. For example, AI can learn traffic patterns and help control signal timings better so vehicles don’t get stuck at red lights for too long. IoT sensors placed on roads and vehicles keep sending live information about traffic flow, accidents, and road conditions. This helps traffic systems respond quickly to any situation. Studies also show that when all this data is analyzed properly, it helps reduce traffic jams, avoid accidents, and even cut down pollution because vehicles spend less time idling. However, researchers also mention some challenges. ITMS technology can be expensive to set up, and because huge amounts of data are involved, security and privacy need to be handled carefully. It also requires trained people to operate and maintain the system.

METHODOLOGY

The method we propose is affordable and can be expanded to different places, making it practical for real-world use. The system can send alerts to traffic officials so they can take action when needed, such as giving fines or using the information to improve traffic flow and safety.

A transportation system is considered efficient when it meets its goals without wasting resources. This means traffic movement should be improved in a way that matches the system’s purpose and budget. Good traffic management is an essential part of any smart city. Today, traffic congestion is a big problem, especially in large cities. Old traffic systems are no longer able to handle because more and more vehicles are on the roads, this paper proposes a smart traffic management system to help handle the traffic better that uses IOT and a decentralized design to make traffic movement smoother. It also uses intelligent algorithms to handle different traffic situations more accurately.

Video analysis works by using a smart camera that has built-in sensors and a small computer. This camera constantly watches the traffic and processes the video to understand what’s happening on the road.

The RFID controller consists of an RFID interrogator, It is used to communicate with RFID tags. The controller receives the information that the reader collects. A communication interface then helps the controller send commands and share data with other parts of the system. AI models can be developed to analyze both historical and real-time traffic data. By combining and processing this information, the models can identify trends and patterns in traffic flow. This helps in understanding how traffic behaves and in predicting future traffic conditions.

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