INTELLI TRAFFIC MANAGEMENT SYSTEM

Amarnath C
Computer Science Engineering
Amal Jyothi College of Engineering
Kottayam, India
amarnathc2026@cs.ajce.in

Adarsh P Kurian
Computer Science Engineering
Amal Jyothi College of Engineering
Kottayam, India
adarshpkurian2026@cs.ajce.in

Fabeela Ali Rawther
Computer Science Engineering
Amal Jyothi College of Engineering
Kottayam, India
fabeelaalirawther@amaljyothi.ac.in

Adarsh K Sundaresan
Computer Science Engineering
Amal Jyothi College of Engineering
Kottayam, India
adarshksundaresan2026@cs.ajce.in

Adarsh Suresh
Computer Science Engineering
Amal Jyothi College of Engineering
Kottayam, India
adarshsuresh2026@cs.ajce.in

ABSTRACT: Urbanization and rapid population growth have significantly increased traffic congestion, pollution, and fuel consumption our metropolitan areas. Traditional traffic management systems are rigid which rely only on fixed signal timings, fail to adapt to real-time traffic conditions. This leading to inefficient traffic flow and prolonged delays. The advancement of Internet of Things (IoT) and Machine Learning (ML) provides a promising solution to these challenges.

This paper presents a Intelli Traffic Management System (ITMS) that utilizes IoT sensors, AI-driven traffic analysis, and real-time data processing to optimize signal timings dynamically. The system employs YOLO v11 for vehicle detection, LSTM neural networks for congestion prediction, and a Priority Round Robin Algorithm for adaptive traffic signal control. These components work together to analyse live traffic conditions, adjust signal durations accordingly, and ensuring seamless urban mobility.

The web-based integration allows instantaneous updates, enabling traffic the users to monitor congestion. Traffic administrators manually control intersections, and improve emergency response times. Additionally, by reducing idle time at junctions, the system contributes to fuel conservation, lower carbon emissions, and enhanced road efficiency. Through data-driven urban planning and intelligent decision-making, STMS represents a crucial step toward sustainable and eco-friendly smart cities.

Keywords:
Smart Traffic, IoT, Machine Learning, Urban Mobility, Sustainable Transportation, Adaptive Signal Control

I. INDRODUCTION

Urban traffic congestion results in increased travel times, increased fuel combustion that results more air pollution. Conventional traffic systems are not able to respond to real-time traffic conditions. The purpose of this project is to create an intelligent traffic management system that controls traffic signals based on real time traffic conditions so that traffic flow is

smoother throughout the city. This paper describes a Intelli Traffic Management System, an autonomous system that uses IoT, Machine Learning (ML) to provide real-time adaptive traffic control. The system keeps track of real time traffic conditions under observation with the help of IoT sensors and cameras to minimize the waiting period. It has manual override functionality for emergency actions. Made to be scalable and interoperable, this system can easily adapt to future urban infrastructure, providing smooth multi-intersection management.

II.LITERATURE SURVEY

Literature Survey: Enhancing Intelli Traffic Management Systems.

1. Existing Traffic Management Systems:

Traditional traffic management systems often rely on fixed signal timings and manual monitoring, leading to inefficiencies such as congestion and delays. While some systems incorporate basic sensors to adjust signals based on traffic flow, they generally lack real-time adaptability and predictive capabilities. This limitation underscores the need for more intelligent solutions in urban traffic management [1][7].

2. Recent Research on AI & IoT in Traffic Control:

A. Adaptive Traffic Control Systems (ATCS):

Recent studies highlight the transformative potential of integrating Artificial Intelligence (AI), the Internet of Things (IoT), and predictive analytics into Adaptive Traffic Control Systems (ATCS). These integrations enable real-time data processing and dynamic signal adjustments, leading to more efficient traffic management. However, challenges such as data privacy, system interoperability, and ethical concerns must be addressed to fully realize these benefits [2].

B. Faster R-CNN for Vehicle Detection:

Advanced deep learning methods, such as the Faster Region-Convolutional Neural Network (Faster R-CNN), have been employed for vehicle segmentation in traffic surveillance. These approaches effectively address challenges like occlusions and varying traffic densities, enhancing the accuracy of vehicle detection and overall traffic monitoring [3].

C. Real-World Applications:

Several cities have implemented AI-driven traffic management systems to improve urban mobility:

- Pittsburgh's Rapid Flow Project: Utilizes AI to optimize traffic light timings, resulting in reduced travel times and emissions [5].
- Singapore's Land Transport Authority: Employs AI to predict congestion and provide real-time updates, enhancing overall traffic flow [6].

These implementations demonstrate the practical benefits of integrating AI into traffic management [4].

3.Challenges in Existing Solutions

Despite advancements, several challenges persist:

A. Absence of a Website View of Traffic Congestion: Most existing systems lack a centralized web interface where users and officials can view real-time traffic conditions, limiting public accessibility to traffic updates.

B. Lack of a User-Friendly Traffic Congestion View: Commuters and stakeholders lack a dedicated user interface to access real-time congestion levels, making route planning inefficient.

C. Junction-Specific Traffic Insights Are Missing: Existing systems do not provide comprehensive junction-level traffic details, making it difficult for drivers and city officials to analyse localized congestion patterns.

4. How Our Approach Solves These Issues

Our proposed Intelligent Traffic Management System addresses these challenges through:

A. Providing a Website View of Traffic Congestion: A centralized web-based dashboard that visualizes real-time traffic conditions, accessible to the public and authorities.

B. Developing a User-Friendly Traffic Congestion View: A mobile and web platform that provides live congestion updates, helping users plan their routes efficiently.

C. By Using Machine Learning-based congestion prediction by LSTM (Long Short-Term Memory Network)[9] it can deliver more accurate real time traffic signals.

D. Implementing Junction-Level Traffic Insights: Real-time junction-specific data visualization to help drivers, emergency services, and city planners make informed decisions.

Urban traffic congestion is one of the biggest challenges faced by modern cities, leading to wasted time, increased fuel consumption, and higher emissions. Our Intelligent Traffic Management System is designed to tackle this issue using IoT sensors, ML based-driven traffic predictions, and real-time data analysis.

The entire backend infrastructure is built using GoLang, a high-performance programming language that allows efficient handling of real-time traffic data.

III. PROJECT STRUCTURE

Urban traffic congestion is one of the biggest challenges faced by modern cities, leading to wasted time, increased fuel consumption, and higher emissions. Our Intelligent Traffic Management System is designed to tackle this issue using IoT sensors, ML based-driven traffic predictions, and real-time data analysis. By dynamically adjusting traffic signals and providing a centralized monitoring dashboard, this system ensures smoother traffic flow, reduced congestion, and improved road safety.

A. FRONTEND

Frontend of the Intelli Traffic Management System is developed in HTML, CSS, and JavaScript to provide an interactive and user-friendly interface. Some of the major functionalities of the frontend are:

1. Interactive Dashboard – It presents the real-time traffic congestion rate, emergency vehicle and signal control condition.
2. Role-Based Access Control – Two different logins for traffic administrators and regular users.
3. Google Maps API Integration – Offers live traffic visualization.
4. Graphical Traffic Junction Simulation – Utilizes JavaScript Canvas for an animated real-time traffic flow and signal change simulation.

Graphical Traffic Simulation Using JavaScript Canvas

The JavaScript Canvas API is used to dynamically simulate traffic junctions. The graphical model depicts:

1. Cars entering the junction and waiting at signals.
2. Traffic lights adapting dynamically according to real-time data.

This is because this methodology permits traffic administrators to see in real-time what the congestion is doing, run tests of varying traffic conditions, and adjust system parameters.

((Refer the figure1 below.)

B. BACKEND

The backend serves as the core computational engine of the system, responsible for:

1. Real-time traffic signal adjustments using the Priority Round Robin Algorithm.
2. Vehicle detection and analysis using YOLO v11 and IoT cameras.
3. Machine Learning-based congestion prediction using LSTM (Long Short-Term Memory Network).
4. Data synchronization between the frontend and backend using Web Sockets.

I. Centralized Backend Development in GoLang

The entire backend infrastructure is built using GoLang, a high-performance programming language that allows efficient handling of real-time traffic data.

Why GoLang?

1. Concurrency Handling – Efficiently processes real-time data streams.
2. Lightweight & Fast – Provides low-latency execution for signal adjustments.

3. Scalable & Secure – Allows handling of multiple junctions in a large city.

The Priority Round Robin Algorithm is implemented in GoLang to dynamically control signal durations. It prioritizes lanes based on vehicle density detected at each junction.

II. Integration of Python for AI-Powered Traffic Analysis

While GoLang is used for the core backend processing, Python is used for real-time traffic data analysis and machine learning predictions.

1. Vehicle Detection & Traffic Monitoring
   - IoT-enabled cameras capture real-time images at junctions.
   - YOLO v11 (a deep learning object detection model) processes the images to count vehicles in each direction.
   - Data is transmitted to the backend for further analysis.

2. Traffic Prediction Using LSTM
   - The system feeds historical traffic data into an LSTM neural network.
   - LSTM predicts traffic patterns, helping to determine signal duration adjustments.
   - The predicted data is passed to the Priority Round Robin Algorithm, which dynamically controls the signals based on congestion levels.

3. How Python & GoLang Work Together?
   - Python processes real-time traffic images and predicts congestion patterns.
   - The processed data is transferred to the GoLang backend, which adjusts traffic signals dynamically.
   - The final decision is sent to the frontend, updating the dashboard and traffic simulation.

C.DATABASE

For efficient storage and retrieval of real-time traffic data, we chose MongoDB a NoSQL database for optimized handling of unstructured and dynamic data. we choose MongoDB because it can handle high-velocity real-time data effectively. Main functions are:

1.Real-Time Traffic Data
   - Stores live traffic statistics from IoT sensors and cameras.
   - Includes vehicle counts, speed estimates, and congestion data.

2. Historical Data for Machine Learning
   - Stores past congestion trends, used for LSTM training.
   - Helps predict peak-hour congestion and seasonal traffic patterns.

3. Emergency Vehicle Logs
   - Keeps records of ambulances, fire trucks, and law enforcement vehicles detected by the system.
   - Ensures priority clearance for emergency situations.

4. User Authentication & Access Control
   - Implements role-based access management.
   - Ensures secure storage of admin and user credentials.

IV WORKFLOW

At its core, the system continuously monitors traffic conditions, analyses patterns, and makes intelligent decisions to optimize signal timings. Traffic administrators also have the flexibility to intervene manually when needed.

In the webpage of IMTS there have been a login page that will securely authenticate the users and give different interfaces for normal users and traffic administrators. From there the users get real time traffic conditions of different traffic junctions. It includes Google map interface that helps to users to access different junctions by just clicking on the map.

The traffic administrators' interface has enabled with provision to manually control the traffic system when emergency happens.

A. MODULES

1. **Real-Time Traffic Monitoring**: IoT-powered sensors and cameras gather live traffic data.

Using YOLO v11[8], the vehicle count is collected and analysed from all the directions and plotted. This data will be dynamically displayed on the dashboard of the system's webpage to depict real-time traffic conditions.

This data of a day is given as a input to the LSTM(Long Short Term Memory Network) [9]where it will process the data and train the system predicts the patterns in the traffic junction and feed this data into the Round Robin Priority algorithm(a modified algorithm specially for this).Using the algorithm, the timer in each direction will set a waiting period based on real time traffic condition in that junction and previous trends in such situations.

2. **Smart Traffic Signal Control**: Signal durations are adjusted dynamically based on real-time traffic density. Coordinated signal timing ensures vehicles move efficiently, reducing unnecessary waiting at traffic junctions

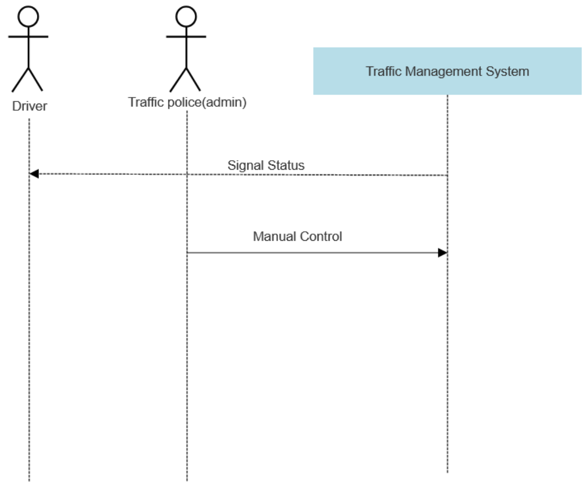
3. Centralized Control & Manual Override: A live dashboard provides traffic authorities with real-time insights.

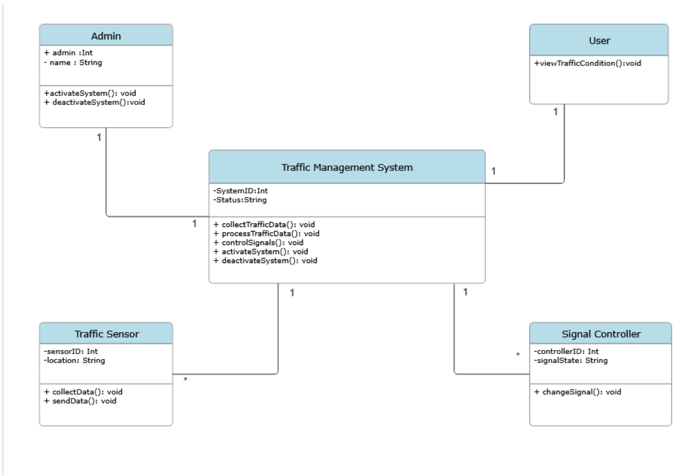
Officials can manually adjust signals during special events, accidents, or road maintenance to ensure smooth movement.

Technology Behind the System

- *IoT Sensors & Cameras – To continuously monitor and collect traffic images.*
- YOLO V11 is used to collect and analyse vehicle count from cameras.
- Machine Learning (TensorFlow/LSTM) – To predict congestion and optimize signal control.
- Cloud Computing – For fast, centralized data processing and dashboard visualization.

This system brings cities one step closer to efficient, data-driven traffic management, ultimately improving the daily commute and making urban roads safer for everyone.
(Refer to the sequence, activity, and class diagrams for a detailed system workflow and architecture.)





B. Benefits of the System

1.Traffic Flow Optimization – Through real time analysis and also predicting using previous history data as input for our algorithm we can dynamically changes the traffic signals of a junction so it reduces congestion delays by up to 30%.

2. Fuel & Emission Reduction – By reducing congestion delays it can minimize idling, leading to 20% lower CO_2 emissions and reduce air pollution.

3. Smart Route Navigation – Helps drivers choose the least congested paths by observing current traffic conditions over the junctions using the user interface.

C. Limitations

While the system offers significant advantages, some limitations exist:

- Internet Dependency – Requires a stable internet connection for real-time processing and transmission of data accurately.
- Scalability Concerns – Adding multiple intersections increases computational load so it will need more powerful system/cloud required for it.

D. Abbreviations and Acronyms

- **ITMS** – Intelli Traffic Management System.
- **IoT** – Internet of Things.
- **ML** – Machine Learning.
- **LSTM** – Long Short-Term Memory Network.
- **YOLO** – You Only Look Once (Object Detection Model).
- **JWT** – JSON Web Token (for authentication).
- **RBAC** – Role-Based Access Control.

E. Results

A few screenshots of our project which has been completed has been included:

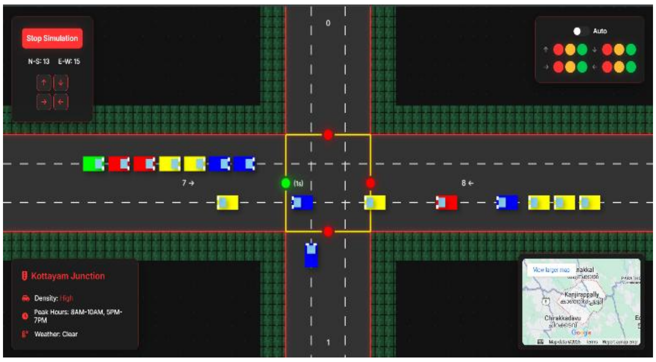


figure1. Graphical simulation of a traffic junction.

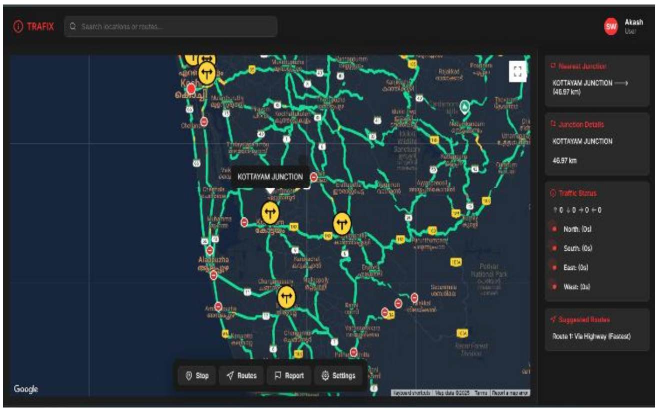


Figure 2.user interface

V. CONCLUSION

In this paper a Intelli traffic management system overcomes the limitations of conventional static traffic systems by integrating real-time data analysis and ML-based forecasting. Our system automatically adapts traffic signals to real-time congestion information and traffic history, allowing smooth traffic movement and minimized waiting times. Traffic Administrators are able to monitor real-time conditions and manually operate intersections when the need arises. This solution enhances urban mobility substantially, minimizes congestion, and maximizes overall transportation efficiency

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