Traffic Congestion System Using Big Data And IOT

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***Abstract*—The project is designed to develop a density based dynamic traffic signal system. The signal timing changes automatically on sensing the traffic density at the junction. Traffic congestion is a severe problem in many major cities across the world and it has become a nightmare for the commuters in these cities. Conventional traffic light system is based on fixed time concept allotted to each side of the junction which cannot be varied as per varying traffic density. Junction timings allotted are fixed. Sometimes higher traffic density at one side of the junction demands longer green time as compared to standard allotted time. The object detection in the traffic signal is processed and converted into simulator then its threshold is calculated based on which the contour has been drawn in order to calculate the number of vehicles present in the area. After calculating the number of vehicles, we will come to know in which side the density is high based on which signals will be allotted for a particular side.**

***Index Terms*—Internet of Things (IoT), Big Data Analytics, Intelligent Traffic Management, Smart Cities Predictive Analytics, Machine Learning, Real-Time Data Processing, Urban Mobility, Traffic Congestion.**

I. INTRODUCTION

We can integrate our system with an application for analyzing the official traffic news web sites, so as to capture traffic condition notifications in real-time. Thus, our system will be able to signal traffic-related events in the worst case at the same time of the notifications on the web sites. Further, we are investigating the integration of our system into a more complex traffic detection infrastructure. This infrastructure may include both advanced physical sensors and social sensors such as streams of social media. In particular, social sensors may provide a low-cost wide coverage of the road network, especially in those areas (e.g., urban and suburban) where traditional traffic sensors are missing. Imaging to pattern and object recognition for different purposes. One such application is object detection of mobile targets in a particular environment. Vehicle detection on roads is an example of such object detection which is used for traffic analysis, monitor and control. Vehicle detection on roads is an example of such object detection which is used for traffic analysis, monitor and control. Hence, an initial step for traffic controlling is vehicle detection and classification using traffic measuring techniques. Image processing-based techniques are one of the most widely used techniques which achieve this objective.

Many algorithms have been proposed connected with vehicle detection and classification. In, image segmentation and edge detection methods are employed. Background extraction and estimation techniques are used to isolate the vehicles of interest. Similarly, vehicle detection can be achieved with the help of vehicle shadows. This approach becomes difficult if shadows of other objects like overhead bridges overlap with the shadows of Classification of vehicles based on their sizes or shapes play an importation role in traffic management and flow control [5].

Irrespective of the algorithm or technique being employed, camera positioning and the quality of camera play an important and critical role in vehicle detection. High altitude aerial camera is an example of camera positioning which is often used due to its wide area coverage.

II. LITERATURE SURVEY

Sr. No.	Project Title	Authors	Year
1.	An IoT Application in a Smart Traffic Management System.	Zanella, A., et al.	2025
2.	Hybrid deep learning-based traffic congestion control IOT.	Khan M. A., Al-Sultan S.	2025
3.	Machine Learning for Predicting Traffic and Determining Road Capacity.	Alex Lewis, Rina Azoulay, Esther David	2024
4.	Proposal of a Machine Learning Approach for Traffic Flow Prediction.	GarcAa-Laencina, P. J., et al.	2024
5.	Big Data Analytics for Smart Cities: Optimizing Urban Traffic Management Using Real-Time Data Processing.	Mohammad Miftah, Dewi Immaniar Desrianti, Nanda Septiani, Ahmad Yadi Fauzi, Cole Williams.	2021
6.	Self-learning adaptive traffic signal control for real-time safety optimization.	Yao, H., et al.	2020
7.	Intelligent Traffic Management with Internet of Things (IoT) and Big Data.	Chaubey, P. K., et al.	2019
8.	Big Data Analytics for Smart Cities: Optimizing Urban Traffic Management Using Real-Time Data Processing.	Mohammad Miftah, Dewi Immaniar Desrianti, Nanda Septiani, Ahmad Yadi Fauzi, Cole Williams	2025
9.	An IoT Application in a Smart Traffic Management System.	Zanella, A., et al.	2025

III. METHODOLOGY

1. System Requirements & Ingestion Setup

- The foundation of the methodology relies on establishing the logistical and technical framework required to process live environments.
- Data Source: The system takes live inputs from a distributed network of road CCTV surveillance cameras positioned at traffic intersections.
- Computing Environment: The software architecture is developed using Python within the Spyder IDE, utilizing an underlying Dbsqlite database to handle local configurations. The system is optimized to run efficiently on standard hardware (Intel i3 processor, 4GB RAM).
- Security & Access Boundary: To prevent unauthorized or illegal use, the deployment requires explicit administrator registration, alongside strict login and logout modules for authenticated users.

2. Image Processing & Video Analysis Pipeline

Once the live video feed is captured from the intersection, the core automated processing engine takes over:

[CCTV Video Input] → [Frame Extraction]
↓
[Density Count] ← [Object Detection]

- Step 1: Frame Extraction: Real-time video input cannot be calculated as a single continuous block, so the system breaks the raw live video stream into a series of sequential image frames.
- Step 2: Pre-Processing: Individual frames are isolated and pre-processed to standardize the image data (such as formatting or noise reduction), optimizing the matrices for higher computing efficiency, less memory space, and faster response times.
- Step 3: Object Detection (Vehicle Isolation): Using machine learning and computer vision techniques, the system evaluates the visual features of the frames. It applies classification features to isolate mobile targets (vehicles) from static backgrounds and ambient infrastructure.
- Step 4: Density Counting: The system analyzes the isolated objects on a per-lane basis to dynamically tally the Vehicle Count for each intersection lane.

3. Dynamic Decision-Making & Signal Control Logic

After the real-time vehicle counts are calculated, the mathematical and operational control logic determines the intersection's behavior:

- Mathematical Modeling: The system treats the intersection environment as a formal system function, S = {I, P, O}.
- Input (I): The live, lane-wise vehicle counting metrics.
- Procedure (P): The internal system prioritization logic that weighs the current inputs to determine traffic urgency.
- Output (O): The automated generation of the predicted signal release states.

- Priority Allocation:

The system aggregates the vehicle counts across all four lanes at the intersection. It ranks the lanes by immediate density to eliminate manual traffic handling or rigid fixed timers.

- Hardware Modulation (Signal Release):

Based on the lane priority weights, the system automatically triggers a command to adjust signal states. The highly congested lane is dynamically allocated a green light window to clear traffic, while the remaining lanes are set to Red.

4. System Testing & Quality Assurance

To verify that the implementation works reliably under variable conditions before final deployment, the methodology incorporates a multi-tiered testing plan:

- GUI & Registration Testing:

Validates user-facing components, checking that input validation loops correctly flag empty required fields, mismatched passwords, invalid formatting in email fields, or incorrect phone digit counts.

- System Component Verification:

System-level test cases systematically track data flow reliability—ranging from file handling, attribute identification, and weight analysis performance to query execution accuracy.

- Loop Perpetuation:

Once verified, the entire pipeline operates as a continuous, closed-loop system, dynamically repeating the analysis to adapt to changing, unpredictable urban traffic conditions.

IV. PROBLEM STATEMENT

Traffic congestion has become a major issue in urban areas due to the rapid increase in the number of vehicles and limited road infrastructure. The existing traffic management systems mostly rely on fixed-time signal control, which does not adapt to real-time traffic conditions.

As a result
- Increased waiting time at traffic signals
- Uneven distribution of vehicles across lanes
- Traffic jams due to poor coordination between signals

These problems mainly arise due to lack of automation, poor coordination, and absence of real-time decision-making systems.

V. OBJECTIVE

The main objective of this project is to design and develop a real-time traffic detection and management system using machine learning and image processing techniques.
- To analyze traffic density in real-time using video input.
- To dynamically adjust signal timing based on vehicle count.
- To eliminate manual intervention in traffic signal control.
- To enable automatic decision-making based on lane-wise traffic.
- To reduce congestion and waiting time at intersections.

VI. SYSTEM REQUIREMENTS

Database Requirements Road CCTV surveillance
Software Requirements (Platform Choice)
- Operating system: Windows 7 onwards
- Coding Language: Python
- IDE: Spyder
- Database: Dbsqlite

Hardware Requirements
- System: Intel I3 Processor.
- Hard Disk: 40 GB.
- Monitor: 15 VGA
- Ram: 4GB

SYSTEM MODEL

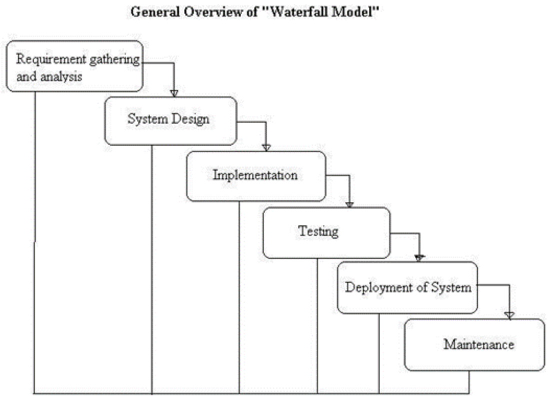

Figure 1: System Model

ALGORITHM WORKFLOW

Step 1: Ingestion & Frame Extraction

The system captures real-time video feeds from road CCTV surveillance networks positioned at an intersection.

The raw traffic video stream is broken down sequentially into individual images (frames) for analysis.

Step 2: Pre-Processing

Extracted frames undergo noise reduction and conversion (such as grayscale or resizing) to optimize execution speed on standard processing environments.

Step 3: Object Detection (Vehicle Isolation)

Computer vision models evaluate the frame to identify and classify targets (e.g., separating vehicles from background elements or stationary infrastructure).

Step 4: Vehicle Counting

The system aggregates the identified vehicles on a per-lane basis to compute a live Vehicle Count (I).

Step 5: Dynamic State Allocation

The system compares the calculated vehicle density across all lanes at the intersection.

The lane with the highest accumulation of vehicles is assigned maximum priority.

Step 6: Signal Release Action

The system automatically triggers a command instructing the traffic hardware to switch the high-density lane to Green, while retaining or switching lesser-congested lanes to Red.

Step 7: Loop Perpetuation

The loop continuously restarts, ensuring the timings dynamically self-optimize to match fluctuating, chaotic urban traffic patterns in real-time.

VII. SYSTEM ARCHITECTURE

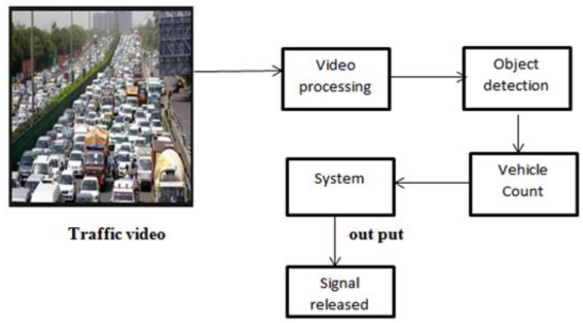

Figure 2: System Architecture

1. Traffic Video

Traffic video is the input source of the system. CCTV cameras are installed at road intersections to continuously capture live traffic footage. These cameras monitor vehicle movement, traffic density, and road conditions in real time. The captured video contains information about cars, buses, trucks, and motorcycles. This live video stream is sent to the processing unit for further analysis and decision-making.

2. Video Processing

In the video processing stage, the captured traffic video is converted into multiple image frames. The system removes noise, improves image quality, and adjusts brightness and contrast to make vehicle detection more accurate. Various image processing techniques are applied to prepare the video for analysis. This step ensures that the system receives clear and usable data. Proper video processing improves the overall performance of the traffic management system.

3. Object Detection

Object detection identifies and locates vehicles present in the processed video frames. Machine learning and deep learning algorithms such as YOLO are used to detect cars, buses, trucks, and motorcycles. The system draws bounding boxes around detected vehicles and classifies them into different categories.

This process helps in understanding the current traffic situation. Accurate object detection is essential for reliable vehicle counting and traffic analysis.

4. Vehicle Count
After detecting vehicles, the system counts the number of vehicles in each lane or road segment. The vehicle count helps determine traffic density and congestion levels at an intersection. A higher vehicle count indicates heavier traffic and a greater need for signal priority. The counting process is performed continuously to provide real-time traffic information. This data becomes the basis for intelligent traffic signal control.

5. System (Decision-Making Unit)
The decision-making unit acts as the brain of the entire system. It receives vehicle count and traffic density information from all lanes and compares the traffic load. Based on predefined rules or machine learning algorithms, it decides which lane requires more green signal time. The system aims to minimize waiting time and improve traffic flow. This intelligent decision-making helps reduce congestion and optimize road utilization.

6. Output
The output stage generates the final traffic control decision based on the analysis performed by the system. It provides information such as vehicle count, traffic density, congestion level, and recommended signal timing. The output is displayed on a monitoring dashboard and sent to the traffic signal controller. Traffic authorities can also monitor the system through this output. This stage ensures that traffic management decisions are implemented effectively.

7. Signal Released
In the final stage, the traffic signal controller receives commands from the system and adjusts signal timings automatically. Lanes with higher traffic density are given longer green signal durations, while less congested lanes receive shorter durations. This dynamic signal control reduces unnecessary waiting and improves traffic movement. The process is repeated continuously as traffic conditions change. As a result, the system provides efficient and intelligent traffic management in real time.

VIII. RESULT

Figure 3: Output 1

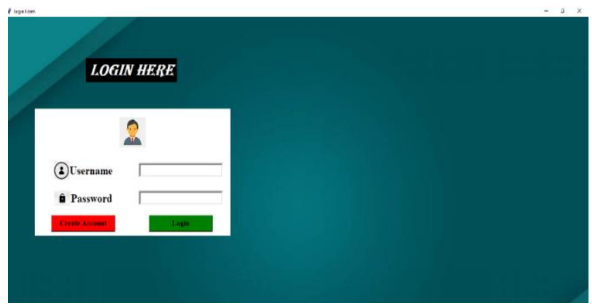

Figure 4: Output 2

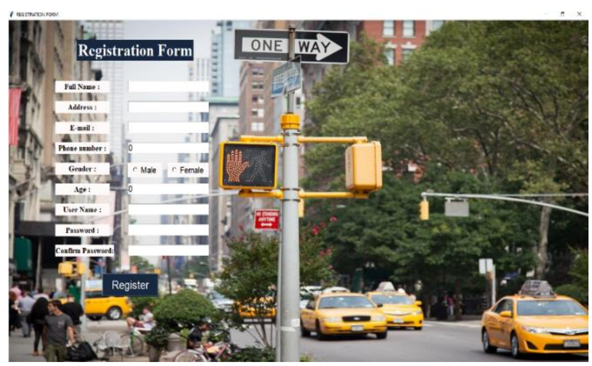

Figure 5: Output 3

Figure 6: Output 4

Figure 7: Output 5

IX. CONCLUSION

The real-time traffic management system demonstrates the effectiveness of machine learning and computer vision techniques in analyzing and controlling traffic flow. By utilizing image processing and vehicle detection methods, the system dynamically adjusts traffic signal timings based on real-time traffic density. This automated approach reduces the dependency on manual traffic control, minimizes waiting time at intersections, and improves overall traffic efficiency. The system provides a scalable and intelligent solution for modern urban traffic problems, contributing to reduced congestion, better fuel efficiency, and enhanced commuter experience. Overall, the project supports data-driven traffic management and lays the foundation for smart city transportation systems.

REFERENCES

[1] J. Nagalapuram, "A Framework for Smart City Traffic Management Utilizing BDA and IoT," Engineering, Technology & Applied Science Research, vol. 14, no. 6, pp. 18989–18993, 2024.

[2] Y. Ma et al., "Machine Learning Based Adaptive Traffic Prediction and Control for Intelligent Transportation Systems," Scientific Reports, 2025.

[3] M. Ponnusamy, A. Senthil Kumar, and M. Balamurugan, "Traffic Monitoring in Smart Cities Using Internet of Things and Robotic Technology," J. Inst. Eng. (India), Ser. B, 2023.

[4] J. Zhang, F. Wang, K. Wang, W. Lin, and X. Xu, "A Hybrid Deep Learning-Based Traffic Congestion Control in IoT-Based Smart City," Alexandria Engineering Journal, 2024.

[5] M. A. Ahad et al., "Traffic Management: Implementing AI to Optimize Traffic Flow and Reduce Congestion," SSRN Electronic Journal, 2024.

[6] M. Al-Absi et al., "ASTM: Autonomous Smart Traffic Management System Using Artificial Intelligence," 2024.

[7] C. Cicek et al., "A Comparative Analysis of Machine Learning Models for Traffic Accident Severity Prediction," 2025.

[8] R. Kaur and S. Singh, "A Comprehensive Review of Object Detection with Deep Learning," Digital Signal Processing, vol. 132, Jan. 2023.

[9] "How IoT and Big Data Are Driving Smart Traffic Management and Smart Cities," Int. J. Eng. Res. Technol. (IJERT), vol. 11, no. 7, 2022.

[10] "IoT Based Smart Traffic Management System," Int. J. Eng. Res. Technol. (IJERT), 2021.

[11] V. Mandal and Y. Adu-Gyamfi, "Object Detection and Tracking Algorithms for Vehicle Counting: A Comparative Analysis," J. Big Data Analytics in Transportation, vol. 2, no. 3, pp. 251–261, Dec. 2020.

[12] Y. Chen et al., "Bibliometric Methods in Traffic Flow Prediction Based on Artificial Intelligence," Expert Systems with Applications, vol. 228, Oct. 2023.

[13] A. Sharif, F. Li, M. Khalil, and T. Kumar, "Internet of Things: A Smart Traffic Management System for Smart Cities Using Big Data Analytics," in Proc. IEEE 14th Annu. Consumer Communications and Networking Conf. (CCNC), 2017.

[14] C. Cicek et al., "A Comparative Analysis of Machine Learning Models for Traffic Accident Severity Prediction with a Focus on Explainability," 2025.