AI POWERED TRAFFIC SIGNALLING SYSTEM

First A.Mr.Holge Arjun Ganesh, Second B. Mr. Bendkule Vikas Bhimaji, and Third C. Mr.Teltumbade Ayush Raju Forth D.Mr. Sayyad Juber Ejaj
Projects guide -Prof Habib Adnan Abdulla
S.N.D. College of Engineering & Research Center
College in Babhulgaon Kh., Maharashtra

***Abstract*—Traffic management is one of the biggest challenges in today's cities. Traditional traffic lights work on fixed timers and do not consider the actual number of vehicles on the road. This often results in long waiting times, fuel wastage, and increased air pollution. To solve this problem, we propose an AI Powered Traffic Signaling System that can control signals based on real-time traffic conditions .In this project, cameras are installed at traffic junctions to capture live video. Using Artificial Intelligence (AI) and Computer Vision techniques, the system can detect and count the number of vehicles in each lane. Based on the traffic density, the system automatically decides how much green signal time should be given to each road. This makes the traffic flow smoother and reduces unnecessary delays. The system uses Raspberry Pi or Jetson Nano as a controller, along with AI models like YOLO (You Only Look Once) for vehicle detection. A dashboard is also provided to monitor live traffic and allow manual control when needed. The system is designed to be safe, efficient, and adaptive. The expected results of this project are reduced waiting time for vehicles, better traffic flow at busy junctions, lower fuel consumption, and less pollution. This system can also be integrated with Smart City projects in the future and can be extended to give priority to emergency vehicles like ambulances and fire trucks.**

Index Terms—Artificial Intelligence (AI), Traffic Management, Smart Traffic Signal, Vehicle Detection, Computer Vision, YOLO, Raspberry Pi, Jetson Nano, Machine Learning, Real-Time Monitoring, Adaptive Signal Control, Smart City.

I. INTRODUCTION

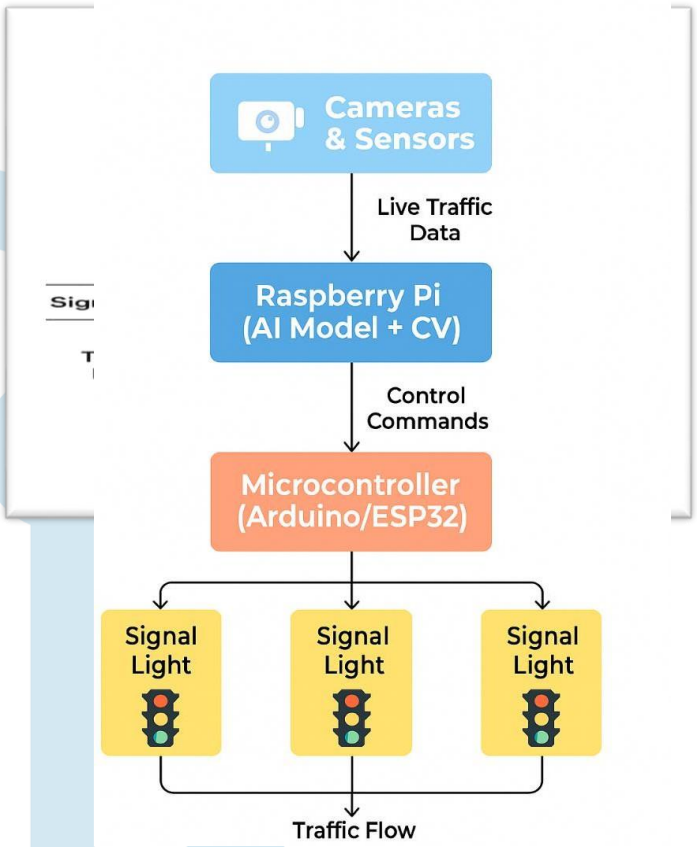
Traffic jams are a big problem in cities. Normal traffic signals work with fixed timers and do not check how many vehicles are actually waiting. Because of this, vehicles waste time, fuel, and cause more pollution. This project will make a smart traffic signal that uses Artificial Intelligence (AI). The system will look at traffic using cameras and AI models, and then decide how much time to give to each signal. This will help reduce waiting time and improve traffic flow. Traffic is one of the most common problems in almost every city of the world, especially in developing countries like India. Every day, thousands of vehicles move through roads, junctions, and signals. As the number of vehicles increases, traffic management becomes more difficult. The current traffic light system that is used in most places works on fixed time intervals. For example, one signal may stay green for 60 seconds, then red for 60 seconds, and so on, regardless of how many vehicles are actually waiting at the junction. This type of system is simple, but it has many disadvantages. Sometimes, vehicles are forced to wait at a red light even when there is no traffic on the other side. In other cases, heavy traffic keeps waiting longer because the green time is too short. This causes problems such as traffic jams, time loss, fuel wastage, and pollution. To solve these problems, we need a traffic management system that is smart, automatic, and adaptive. This is where Artificial Intelligence (AI) can play a major role. AI has the ability to process live data, learn from patterns, and make decisions in real time. By using AI, we can create a traffic light system that changes the signal timing based on the actual traffic condition. This means if one road has heavy traffic, it will get more green signal time, while an empty road will get less. In this way, the system will be fair, efficient, and useful for reducing traffic problems. In the proposed project, a camera is installed at the traffic signal junction. This camera continuously records the live traffic. The video is then processed using computer vision and AI algorithms. These algorithms are trained to detect vehicles such as cars, bikes, buses, and trucks. Once the vehicles are detected, the system counts how many are waiting in each lane.

II. LITERATURE SURVEY

Year	Title	Author	Methodology	Contribution	Limitation
2025	Optimizing Urban Intersection Management in Mixed Traffic Using Deep Reinforcement Learning and Genetic Algorithms	Jiajun Shen et al.	DRL + Genetic Algorithm for adaptive lane configuration in mixed traffic.	↑ Avg. speed **17.6%**, ↓ waiting time **33.3%** when CAV > 60%.	Simulation only; requires CAV infrastructure.
2022	Traffic Signal Control System Using Deep Reinforcement Learning With Emphasis on Reinforcing Successful Experiences	Naoki Kodama et al.	Multi-agent DRL with Dual Targeting Algorithm (DTA).	↓ Waiting time **33%** vs. standard DQN; stable convergence in SUMO.	High memory/ CPU cost; only simulation, no real deployment.
2023	Real-Time Adaptive Traffic Signal Control with CAVs	Google Research	AI-driven adaptive control using Connected & Automated Vehicle (CAV) data in SUMO.	Reduced vehicle stops and emissions; improved adaptive traffic flow.	Only tested in SUMO, not real-world deployment.
2025	Artificial Intelligence in Intelligent Traffic Signal Control	Xuanning Zhang	Deep Q-Network (DQN) with real- time traffic data; tested in simulation + Beijing.	↑ Traffic flow **7%**, ↓ travel time **25%**, ↓ congestion **26.7%**, ↓ accidents **40%**.	Computationally expensive, integration challenges.

III. EXITING SYSTEM

IV. PROPOSED SYSTEM



V. BENEFITS

I. **Real-Time Adaptability** – Signal timings adjust dynamically based on actual traffic density
II. **Reduced Traffic Congestion** – Helps in clearing heavy traffic lanes faster.
III. **Emergency Vehicle Priority** – Automatically gives way to ambulances, fire trucks, and police vehicles
IV. **Fuel & Time Saving** – Less waiting reduces fuel consumption and travel time.
V. **Pollution Reduction** – Decreased idling vehicles result in lower carbon emissions.
VI. **Data Collection** – System stores traffic data for future planning, analysis, and optimization.

VI. SOFTWARE REQUIREMEN

FUNCTIONAL REQUIREMENT:

I. The system shall capture real-time traffic data using cameras and sensors.
II. The system shall detect and count vehicles using AI/Computer Vision algorithms.
III. The system shall classify vehicles (car, bus, bike, truck, emergency vehicle).

IV. The system shall calculate traffic density for each lane.
V. The system shall dynamically adjust traffic signal timings based on traffic density.
VI. The system shall provide priority to emergency vehicles by immediately turning signals green.
VII. The system shall send control commands to the microcontroller for operating traffic lights.
VIII. The system shall store traffic data for logging and future analysis.
IX. The system shall provide a real-time dashboard for monitoring and control.
X. The system shall switch to a **fixed-timer mode** in case of system/AI failure.

NON-FUNCTIONAL REQUIREMENT:

I. **Performance** – The system shall update signal decisions within 2 seconds of traffic data input.
II. **Accuracy** – The AI detection system shall achieve at least 85–90% accuracy in identifying vehicles.
III. **Reliability** – The system shall work continuously with minimal downtime (24/7 operation).
IV. **Scalability** – The system shall be extendable from a single junction to multiple city-wide deployments.
V. **Security** – Traffic data shall be protected from unauthorized access using encryption.
VI. **Maintainability** – The system software shall support easy updates, debugging, and AI model improvements.
VII. **Usability** – The dashboard shall be user-friendly, simple, and responsive for operators.
VIII. **Portability** – The system shall run on Raspberry Pi and be adaptable to other microcontrollers.
IX. **Efficiency** – The system shall consume minimal CPU, memory, and power while processing data.
X. **Availability** – The system shall maintain at least 99% uptime under normal operating condition

VII. HARDWARE REQUIREMENT

Component	Specification
Processing Unit	Raspberry Pi 4 (Quad-core, 4 GB RAM, 32 GB SD card)
Camera Module	HD Camera (720p/1080p, 30 FPS), 7 segment display 2 digit
Microcontroller	Raspberry / ESP32
Traffic Lights	Standard LED Signal (Red, Yellow, Green)
Connectivity	Wi-Fi / 3G / 4G / Ethernet
Power Supply	220V AC with UPS / Battery Backup
Monitoring Device	Android Smartphone / PC
Smartphone Specs	Min. 2 GB RAM, 100 MB Storage, 5-inch Display, Android 6.0+

VIII. SOFTWARE REQUIREMENT

I. Front-End Requirements

- **Platform**: Web Application
- **Language**: HTML, CSS, JavaScript
- **Framework**: React.js / Angular / Vue.js
- **UI Libraries**: Bootstrap / Tailwind CSS for clean design
- **IDE**: VS Code / PyCharm/jupyter

II. Back-End Requirements

- **Language**: Python
- **Framework**: Flask / Django (for REST APIs & backend logic)
- **Database:** MySQL / PostgreSQL/NoSQL:/MongoDB
- **Authentication**: JWT (JSON Web Tokens) / OAuth2
- **APIs**: Optional – Govt. Traffic APIs, Google Maps API, or custom APIs for real-time vehicle data

III. AI/ML Requirements

- **Programming Language**: Python
- Libraries:
  - **TensorFlow / PyTorch** – for AI model development
  - **OpenCV** – for vehicle detection using cameras
  - **NumPy, Pandas** – for data handling
  - **Scikit-learn** – for ML algorithms

Environment: Jupyter Notebook / Google Colab (for model training and testing

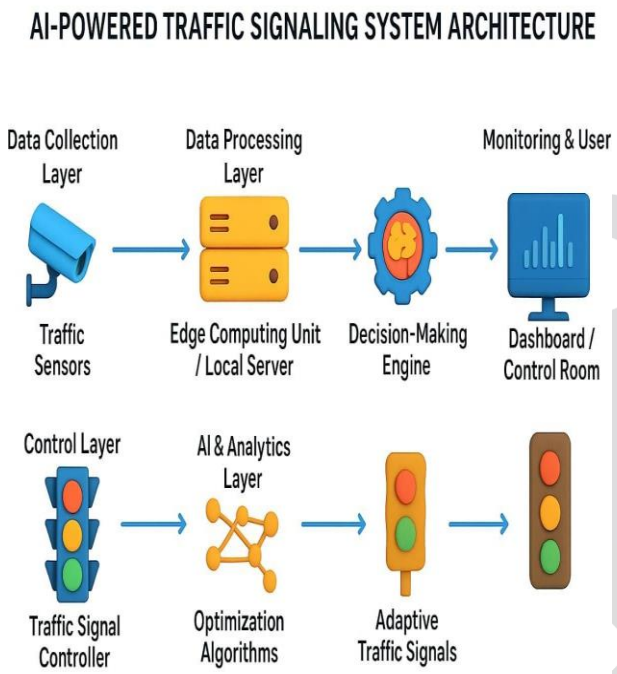
IV. Tools & Libraries

- **Docker** – for containerization (optional)
- **GitHub / GitLab** – for version control
- **Postman** – for API testing
- **Matplotlib / Seaborn** – for data visualization and analysis

V. Operating System Support

- **Server Deployment**: Ubuntu Linux (preferred) / Windows Server
- **User Access**: Any modern browser (Chrome, Firefox, Edge, Safari)

IX .SYSTEM ARCHITECTURE



CONCLUSION

AI-Powered Traffic Signalling project demonstrates the practical application of artificial intelligence in managing urban traffic efficiently. By using real-time data from sensors and cameras, the system intelligently adjusts signal timings based on current traffic conditions, reducing congestion, minimizing waiting time, and improving fuel efficiency. The AI algorithms, such as reinforcement learning, enable dynamic decision-making that adapts to changing traffic patterns, prioritizes emergency vehicles, and ensures pedestrian safety. This project highlights the potential of AI to transform conventional traffic systems into **smart and responsive infrastructure**. Despite challenges like high initial cost and dependence on sensor accuracy, the system offers significant benefits in road safety, time savings, and environmental impact. The dashboard and analytics features further provide valuable insights for city traffic planning. Overall, this project serves as a **foundation for future enhancements** in smart city initiatives, including predictive traffic management and integration with autonomous vehicles, paving the way toward sustainable and efficient urban mobility

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