# TRAFFIC MANAGENT SYSTEM WITH AI & IOT

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**Keywords:**

Artificial Intelligence (AI), Internet of Things (IoT), YOLOv5, Smart Traffic Management, Computer Vision

**Introduction:**

Cities all over the world are dealing with extreme traffic congestion, delays, and road safety hazards as a result of fast urbanisation and an increase in the number of vehicles on the road. Conventional traffic signal systems use static timers, which frequently results in ineffective signal cycles, higher fuel usage, and irritated commuters. Urban traffic problems are also made worse by manual road incident monitoring and delayed emergency vehicle clearance.

Intelligent and flexible traffic control systems are quickly becoming vital parts of contemporary city infrastructure to handle these urgent problems. the combination of Internet of Things (IoT), computer vision, and artificial intelligence (AI) technologies.

This project suggests a thorough Traffic Management System with three essential modules:

1. Dynamic Traffic Light Adjustment: This feature uses OpenCV and YOLOv5 to automatically modify signal timings based on the traffic density in real time.
2. Incident Detection and Traveler Notification: This system uses 3D-CNN and Optical Flow to identify accidents or irregularities and uses LED panels to alert commuters.
3. Emergency Vehicle Detection and Signal Control: This feature prioritises the movement of emergency vehicles by superseding routine signal functions.

**Objectives:**

This project's main goal is to use computer vision, deep learning, and the Internet of Things to create and deploy an intelligent traffic management system. The system's objectives are to identify accidents or other unusual events at intersections, dynamically modify traffic signal timings depending on real-time vehicle density, and promptly notify commuters. Additionally, it overrides conventional signal sequences to guarantee emergency vehicles priority clearance. The project's main goal is to develop a real-time, scalable, and affordable operating model that can be incorporated into smart city infrastructures to improve urban safety and mobility.

**Methodology:**

1. Understand the Requirements

- Hardware: Cameras (HD, low-light), LED panels, sensors (motion/vehicle counting).
- Software: Traffic analysis algorithms, LED control systems.
- Connectivity: Reliable network for communication.
- Power Supply: Backup for continuous operation.

2. Install Cameras and Sensors

- Camera Types: HD cameras with low-light capability.
- Placement: Strategic junction placement.
- Additional Sensors: Motion/vehicle-counting sensors for accuracy.

3. Set Up Data Processing System

- Central Server/Edge Devices: Use AI for congestion detection.
- Machine Learning: Train models using traffic data.

4. Connect Cameras to Control System

- Network Setup: Ensure real-time data transmission between cameras and server.

5. Program LED Display Panels

- Panel Installation: Place panels at a distance.
- Alert System: Send real-time alerts to LED panels.

6. Integrate Decision-Making System

- Congestion Data: Identify alternative routes and display alerts automatically.

7. Testing

- Simulations: Test traffic scenarios and system responsiveness under different conditions.

8. Deployment

- Pilot: Roll out in one or two junctions, monitor and gather feedback.

9. Maintenance and Scaling

- Maintenance: Regular checks and updates.
- Expansion: Scale to more areas after successful testing.

Technology Stack:

- Cameras: CCTV or smart cameras with AI.
- Software: Python, OpenCV for AI and image processing.
- Cloud: AWS/Google Cloud for data hosting.

Microcontrollers: Arduino/Raspberry Pi for LED panels.

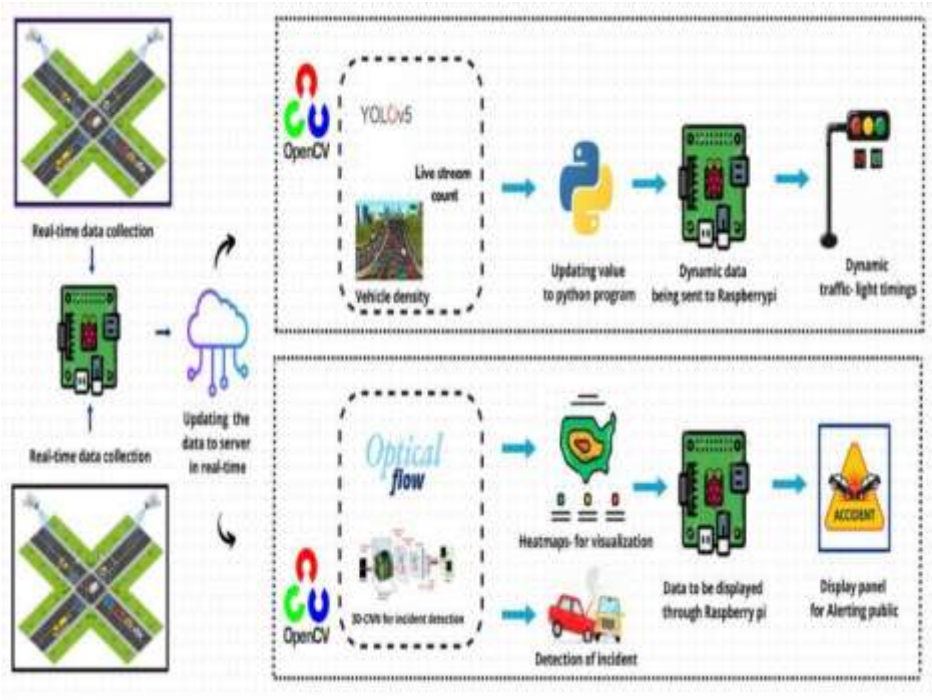


Figure 1: Smart Traffic Management System Architecture.

## Result and Conclusion:

## Module 1:Project Image

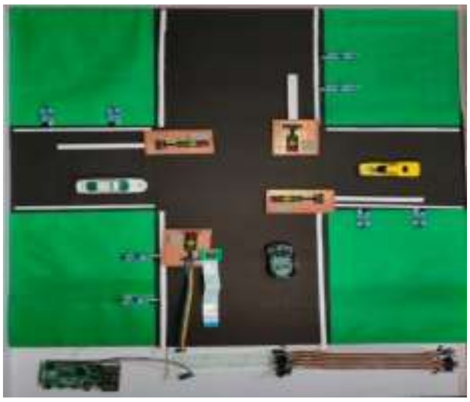

Fig 2. Image showing the bird view of physical model (& Module 1).

1. Bird's Eye View of the Physical Model (Module 1 as well)

    - The physical model's top-down view shows intersections, roadways, traffic signals, and sensors in Fig. 2.
    - It captures and processes real-time traffic data using Raspberry Pi, cameras, IoT sensors, and LED panels.
    - This scaled-down urban traffic simulation allows AI-driven optimization testing before real-world implementation.
    - The model's traffic lights automatically adjust based on vehicle density, resembling intelligent traffic management.

- The AI and IoT-based traffic control prototype in Fig. 3 proves smart urban mobility solutions are possible.

## Module 2: Detection of emergency Vehicle.

Fig 3. Image showing Emergency vehicle detection.

2. Emergency Vehicle Detection (Module 2):
    - The AI-powered emergency vehicle recognition system that guarantees preferential clearance for fire trucks and ambulances is shown in Fig. 3.
    - The technology recognizes emergency vehicles and extracts their geolocation from live video streams using YOLOv5 object detection.
    - The device instantly gives emergency lanes a green light upon detection, overriding the regular traffic signals.
    - A camera, Raspberry Pi, and a Python-based processing unit make up the real-time vehicle recognition setup shown in Fig. 3.
    - The system enhances overall road safety and shortens emergency response times by putting this mechanism into place.

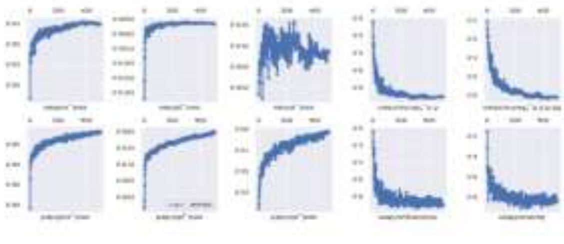

Fig 4. Image showing training process of accident detection model.

3. Training Data for Accident Detection (Module 2)
    - The training dataset for accident detection, which includes labeled accident and non-accident scenarios, is shown in Fig. 3.

- This dataset is used to train a 3D-CNN deep learning model that can identify unexpected movement patterns, crashes, and abrupt vehicle stops.
- The dataset ensures accurate and varied training by including both synthetic and real-world accident footage.
- The training procedure, represented in Fig. 4, boosts the model's capacity to minimize false positives and improve detection speed.
- After training, this model is installed on cloud servers and Raspberry Pis, allowing for real-time accident monitoring at city crossings.

**Module 3: Detection of Accident.**


**F**ig 5. Here we have detected an accident

### 4. Accident Detection (Module 3)

- An AI-based accident detection system that highlights the impacted area in real-time is shown in Fig. 5.
- To identify abrupt braking and unusual vehicle movement, the system uses 3D-CNN models and optical flow algorithms.
- When an accident is detected, the technology automatically notifies traffic authorities.
- Authorities can locate the incident by using the visual marking of the observed accident area in the video feed in Fig 5.
- By improving emergency response times, this quick detection and alerting system lessens accident-related traffic congestion.


Fig 6. Expected display in real scenario

5. **Real-Life Display (Module 3)**

- The LED display system that gives commuters real-time traffic and accident updates is shown in Fig. 6.
- The system helps drivers make educated decisions by displaying real-time traffic data, alternate routes, and emergency notifications.
- A Raspberry Pi processes data from AI-based analytics and Internet of Things sensors before sending it to the display board.
- Real-time notifications reduce delays and increase the effectiveness of traffic management overall thanks to the implementation shown in Fig 6.
- This dynamic display system is essential to emergency rerouting plans and adaptive traffic flow modifications.

**Conclusion:**

To improve urban traffic control, the proposed AI-Based Traffic Management System combines deep learning, computer vision, and the Internet of Things. The system ensures effective traffic flow by dynamically adjusting traffic lights depending on real-time vehicle density using YOLOv5 and OpenCV. Furthermore, automatic incident detection is made possible by 3D-CNN and Optical Flow, enabling authorities and travellers to react quickly to mishaps.

This system's low cost and excellent efficiency, achieved through the use of Raspberry Pi 4 and cloud-based computing, make it a feasible option for smart cities. The traveler alert system, traffic optimisation, and real-time data processing greatly increase road safety by reducing congestion and speeding up emergency response times. Future research can concentrate on extending the system to multi-lane crossings and highways, integrating vehicle-to-infrastructure (V2I) communication, and utilising predictive analytics for traffic forecasts. The initiative opens the door to safer, more intelligent, and more effective urban mobility by showcasing the possibilities of AI and IoT in intelligent traffic management.

**Project Outcome & Industry Relevance:**

he Traffic Management System is a good example of how AI, computer vision, and IoT may be used together to address practical urban problems. By prioritising emergency vehicles, detecting events in real time, and dynamically optimising traffic flow, the project greatly reduces congestion and enhances road safety. From an industry standpoint, this technology is highly relevant to smart city initiatives, municipal corporations, and urban planning agencies. It is highly adaptable and inexpensive to add into current infrastructure. While the real-time traveler alert system improves commuter experience and traffic transparency, the event detection module helps emergency response services by reducing delays. This research can serve as a basis for future advancements in data-driven urban mobility management and autonomous traffic control, and it is in line with current developments in intelligent transport systems (ITS).

**Working Model vs. Simulation/Study:**

Using a Raspberry Pi 4, cameras, LED traffic lights, and display panels, an actual working model of a small-scale traffic intersection arrangement was created for this project. The model exhibits dynamic signal control, incident alert systems, real-time video recording, and vehicle detection using YOLOv5. The accuracy of vehicle detection, traffic density analysis, and anomaly identification utilising 3D-CNN and Optical Flow methods was verified by software simulations and controlled experiments in addition to the physical prototype. Prior to being deployed on the operational hardware, these simulations assisted in optimising algorithm thresholds and decision logic. The functioning model and simulations together offer a comprehensive proof of concept, guaranteeing the hardware integration and AI-driven decision-making systems' scalability and functionality for practical uses.

**Project outcomes and Learnings:**

The Traffic Management System is a good example of how AI, computer vision, and IoT may be used together to address practical urban problems. By prioritising emergency vehicles, detecting events in real time, and dynamically optimising traffic flow, the project greatly reduces congestion and enhances road safety. Through the use of OpenCV, Raspberry Pi, and YOLOv5, it provides an intelligent, scalable, and affordable system that can be implemented throughout smart cities.

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**Future Scope:**

The Traffic Management System's significant scalability and improvement potential enable its integration into more comprehensive and intelligent urban infrastructure. In the future, the system can be enhanced using Machine Learning (ML) algorithms that adapt to road construction, special events, or seasonal traffic patterns to produce even more precise traffic forecasts. Incorporating 5G networks can also enhance real-time communication between traffic signals, automobiles, and control centres, ensuring lightning-fast data transfer and better coordination.

Vehicle-to-infrastructure (V2I) technology may allow cars and traffic systems to communicate directly, improving routing efficiency and facilitating seamless intersection transitions. In order to significantly simplify traffic management and offer sophisticated issue detection via real-time vehicle-to-vehicle communication, future iterations of the system may possibly integrate autonomous cars.

Additionally, the system can be extended to track weather and air quality, providing more thorough information for safety precautions and urban planning. Cloud computing integration may also enable data analytics on a larger scale, assisting smart city projects and optimising traffic in cities throughout the world.