INTELLIGENT REAL-TIME TRAFFIC MANAGEMENT SYSTEM

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Keywords:

Real-Time Traffic Management System, You Only Look Once (YOLO), Machine Learning (ML), Internet of Things (IoT), YOLOv8

Introduction:

As the number of vehicles rises, cities confront increasing challenges with traffic management, which result in significant delays, increased pollution, and decreased living standards. Conventional traffic lights with set timings are sometimes insufficient, particularly in emergencies and during rush hours. To increase flow efficiency and traffic management, this project suggests implementing Machine Learning (ML) in a smart traffic signal control system.

The system provides real-time vehicle counts by using the custom-trained YOLOv8 model and dynamically modifies the signal timings based on traffic volumes by using real-time data to precisely recognize different vehicle types under diverse situations. As a consequence, there is less congestion during times of low traffic and optimal flow at times of high traffic. This results in less congestion during times of low traffic and optimal flow at times of high traffic. This helps in better traffic flow and reduces fuel consumption and emissions. Additionally, with the help of IoT, signals at multiple junctions can be coordinated to give a better flow of traffic. IoT also helps in creating a common log of the traffic density at each junction at constant time intervals which helps in further training an AI model that can predict future traffic patterns.

Objectives:

The objective of a smart traffic control system is to optimise traffic flow, reduce congestion, improve safety, and enhance the overall efficiency of the transportation infrastructure. Specifically, the aims include:

Traffic Flow Optimization: Predicting Traffic conditions and adjusting signal timings in real-time to optimise the flow of vehicles through intersections, reducing waiting time and improving the overall efficiency of the road network during peak hours for heavy traffic flow junctions and for emergency vehicles like Ambulances, Traffic Police, Fire Engines, etc.

Congestion Reduction: By intelligently managing traffic signals and routing, this helps in dispersing traffic more evenly across the network, thus minimising congestion hotspots.

Safety Improvements: The AI-ML model can analyse traffic patterns and identify potentially dangerous conditions before accidents occur. By adjusting traffic signals or alerting drivers to dangers, the system can significantly reduce the likelihood of collisions.

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Environmental Benefits: Efficient traffic management leads to reduced vehicle idling and smoother flows, which in turn lowers fuel consumption and decreases vehicle emissions, contributing to a healthier environment.

Emergency Response Optimization: Smart traffic control systems can prioritise emergency vehicles by providing them with green lights, ensuring they reach their destinations as quickly as possible, which can be crucial in life-threatening situations.

Adaptive Traffic Signals: Unlike traditional traffic lights that operate on present timing, Smart Traffic systems can adapt signal timings based on actual traffic conditions, including variations due to time of day, weather conditions, accidents, or special events.

Data-Driven Decisions: By continuously analysing traffic data, AI-ML algorithms can help city planners and traffic engineers make informed decisions about where to invest in infrastructure improvements.

Enhanced User Experience: For motorists and pedestrians, smart traffic systems aim to provide a smoother and more predictable travel experience, with reduced travel times and less uncertainty.

Integration with Other Modes of Transportation: Smart traffic control systems can be integrated with public transportation and non-motorized traffic (like bicycles and pedestrian paths), optimising the entire urban mobility landscape, not just vehicular traffic.

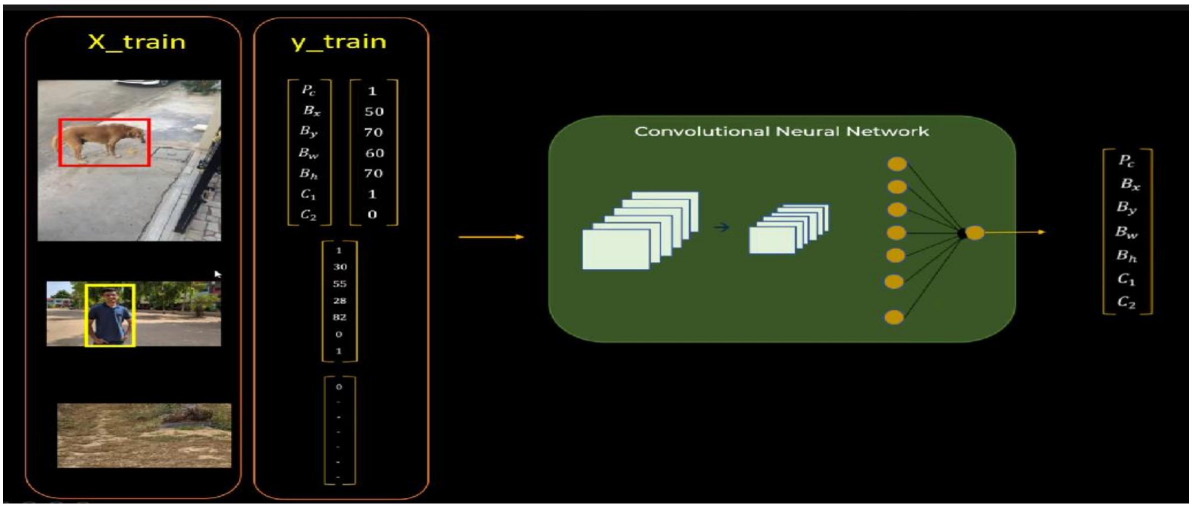
Scalability and Flexibility: AI algorithms can be scaled and adapted as cities grow and traffic patterns evolve, ensuring that the traffic control system remains effective over time.

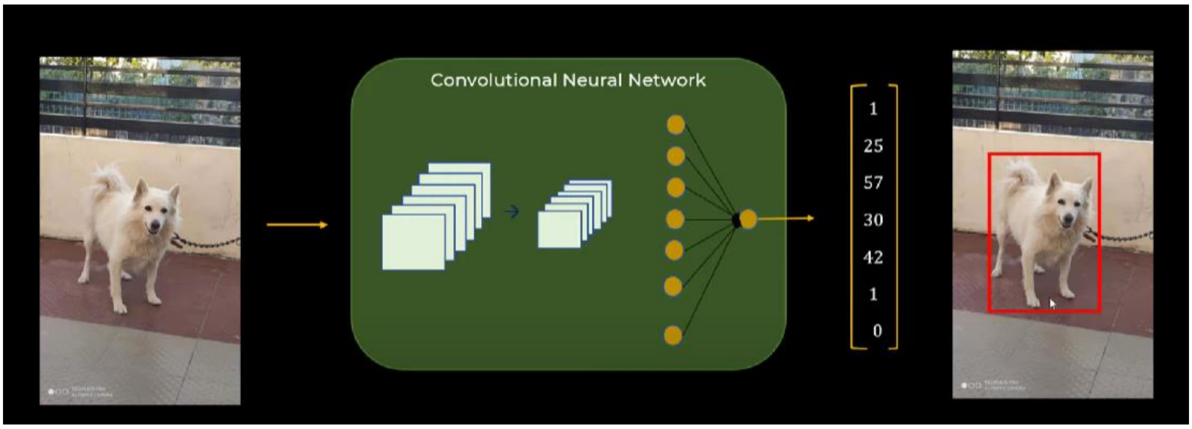
Methodology:

1. **Data Collection:** Gather the dataset to train the YOLOv8 model. This involves taking images and videos of real traffic on the roads with different kinds of vehicles. The dataset is then split into Train, Validate, and Test.

2. **Annotation:** This involves drawing bounding boxes around each vehicle to train the ML model.

3. **YOLOv8 Model:** YOLO stands for You Only Look Once. It is used for Object Detection which involves identifying and localising objects within an image or a video frame.





4. **Training the ML Model:** Train the YOLOv8 model on the annotated dataset using Google Colab. Around 14000 images are used for training and 3000 images for validation. Additionally, the hyperparameters which include learning rate, batch size, and number of epochs are tuned to optimise model accuracy and reduce losses.

```
      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
 1108/10000        13G     0.5547     0.5684      1.083        192        640: 100% 143/143 [06:21<00:00,  2.67s/it]
                 Class     Images  Instances      Box(P          R       mAP50  mAP50-95): 100% 15/15 [00:39<00:00,  2.62s/it]
                   all       2836       3798      0.839       0.83       0.871      0.721

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
 1109/10000        13G     0.5634     0.5783      1.086        155        640: 100% 143/143 [06:05<00:00,  2.56s/it]
                 Class     Images  Instances      Box(P          R       mAP50  mAP50-95): 100% 15/15 [00:42<00:00,  2.85s/it]
                   all       2836       3798      0.845      0.816       0.871      0.721

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
 1110/10000        13G     0.5664     0.5776       1.09        141        640: 100% 143/143 [06:02<00:00,  2.54s/it]
                 Class     Images  Instances      Box(P          R       mAP50  mAP50-95): 100% 15/15 [00:43<00:00,  2.92s/it]
                   all       2836       3798      0.845      0.817       0.871      0.722

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
 1111/10000        13G     0.5691     0.5832      1.095        288        640:  50% 71/143 [03:05<02:32,  2.12s/it]
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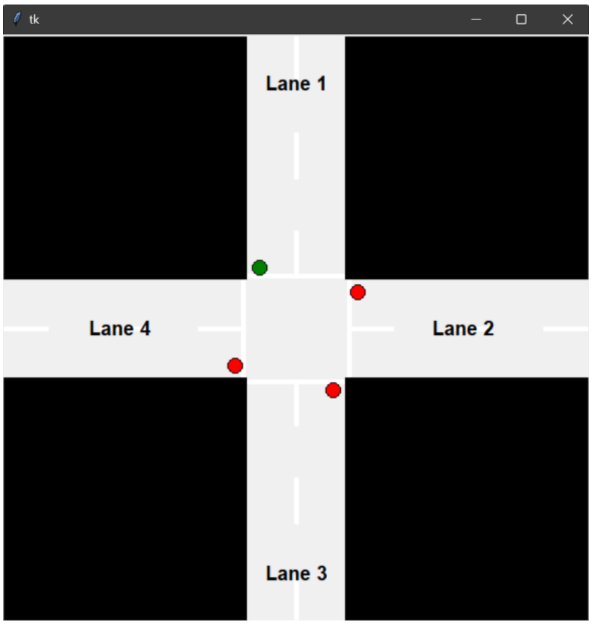
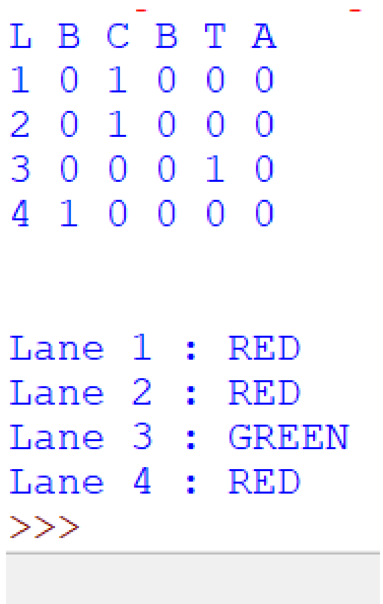
5. **Traffic Signal Control Algorithm Development:** Develop an algorithm to count vehicles detected by the YOLOv8 model in each lane at a traffic junction and adjust the signal duration based on the type of vehicle and number of vehicles.





6. **IoT:** Connecting IoT to the algorithm will coordinate signals at other nearby junctions and also create a log Excel sheet of the traffic at constant intervals.

	A	B	C	D	E	F	G	H
1	Junction1				Junction2			
2	Signal1	Signal2	Signal3	Signal4	Signal1	Signal2	Signal3	Signal4
3	8	2	3	5	8	1	2	7
4	3	15	1	19	11	7	16	8
5	8	7	19	12	15	7	9	8
6	12	12	7	3	2	4	19	15
7	10	6	7	0	4	7	6	4

7. **Testing:** Integrate the vehicle detection and signal control algorithms with the traffic signal control systems for real-time data exchange and control. Perform real-world testing on a small scale, monitoring performance and making necessary adjustments.

8. **Deployment and Monitoring:** Deploy the system across multiple intersections after successful testing and validation. Continuously monitor performance, collect feedback, and update the AI models with new data to enhance accuracy and adapt to changing traffic patterns.

Conclusion:

The Dataset used for training consists of 14,251 train images and 2,836 validation images. The model is being trained using the YOLOv8 which is currently trained till the 1111 epoch. The dataset consists of eight different types of vehicles which include Ambulance, Auto, Bike, Bus, Car, Police, Truck and Fire Engine.

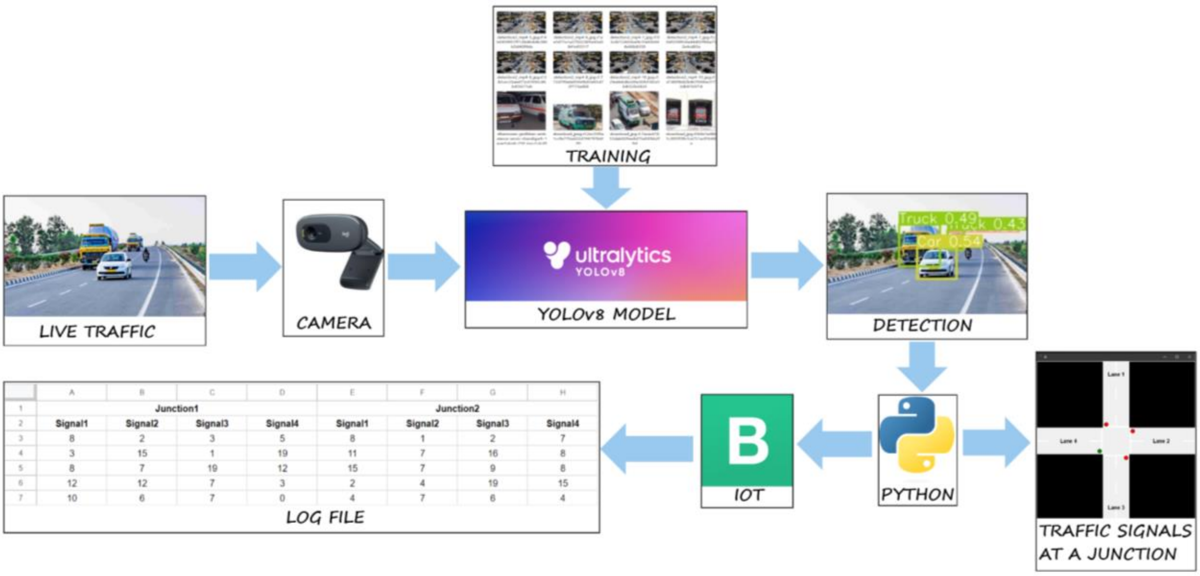
Detection Output

With this project, there will be effective and smooth movement of traffic at critical junctions for all emergency vehicles like Ambulances, Fire Engines and Police vehicles which results in saving many lives.

There will be effective management of traffic flow which helps in the smooth and efficient movement of vehicles depending on the density of the vehicles at critical junctions. This saves a lot of travel time.

With the help of IoT, the traffic signals are synchronised at nearby junctions, which saves a lot of time, and fuel thus resulting in smooth movement of traffic. Additionally, the density of traffic at specified time intervals is monitored and stored in an Excel sheet, which can help in the prediction of future traffic patterns.

Flowchart of the Model



Scope for future work:

Pedestrian Detection: It is possible to expand the functionality of the system to include pedestrian detection.

Expanded Vehicle Detection: More types of vehicles can be included in the system's present repertoire for vehicle detection.

Audio Data Integration: Including sound detection can help the system identify emergency vehicles based on their sirens or horns, which will increase accuracy and reaction time.

Cloud-Based Traffic Management System: A cloud platform may be used to store traffic data from a network of intersections. This makes it easier to analyse and coordinate activities centrally, which allows for network-wide traffic flow management that is optimum.