SmartRaahi

AI-Based Helmet Detection and Traffic Risk Prediction

problem statement

Unpredictability
High risk of road accidents due to unpredictable traffic and road conditions.

Congestion
Traffic jams at major junctions cause delays and inefficiency.

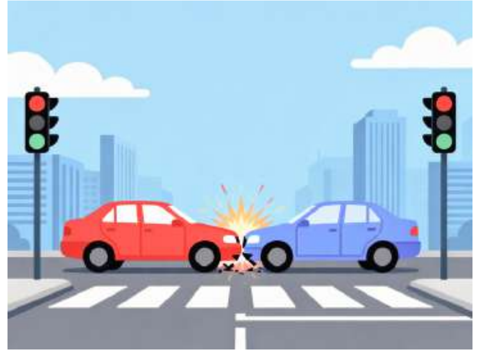
Road Violations
Non-helmet riding and red-line crossing lead to unsafe traffic conditions.

Lack of Real-Time Monitoring
Insufficient real-time traffic insights for proactive management.

Solution Aim:
By combining predictive analytics, real-time monitoring, and automated enforcement, the system aims to improve traffic flow, enhance road safety, and support proactive decision-making for urban transportation management.

objectives

- Predict the likelihood of road accidents using historical traffic, weather, and road condition data.
- Forecast traffic levels at multiple junctions to optimize traffic flow and reduce congestion.
- Predict vehicle maintenance requirements to ensure timely servicing and reduce breakdowns.
- Detect riders without helmets in images and videos, and automatically capture their number plates for enforcement and monitoring.
- Detect bikers crossing predefined red lines or virtual boundaries to identify lane violations and restricted-zone breaches.
- Provide a unified platform integrating predictive analytics, real-time monitoring, and automated enforcement for smarter traffic management.

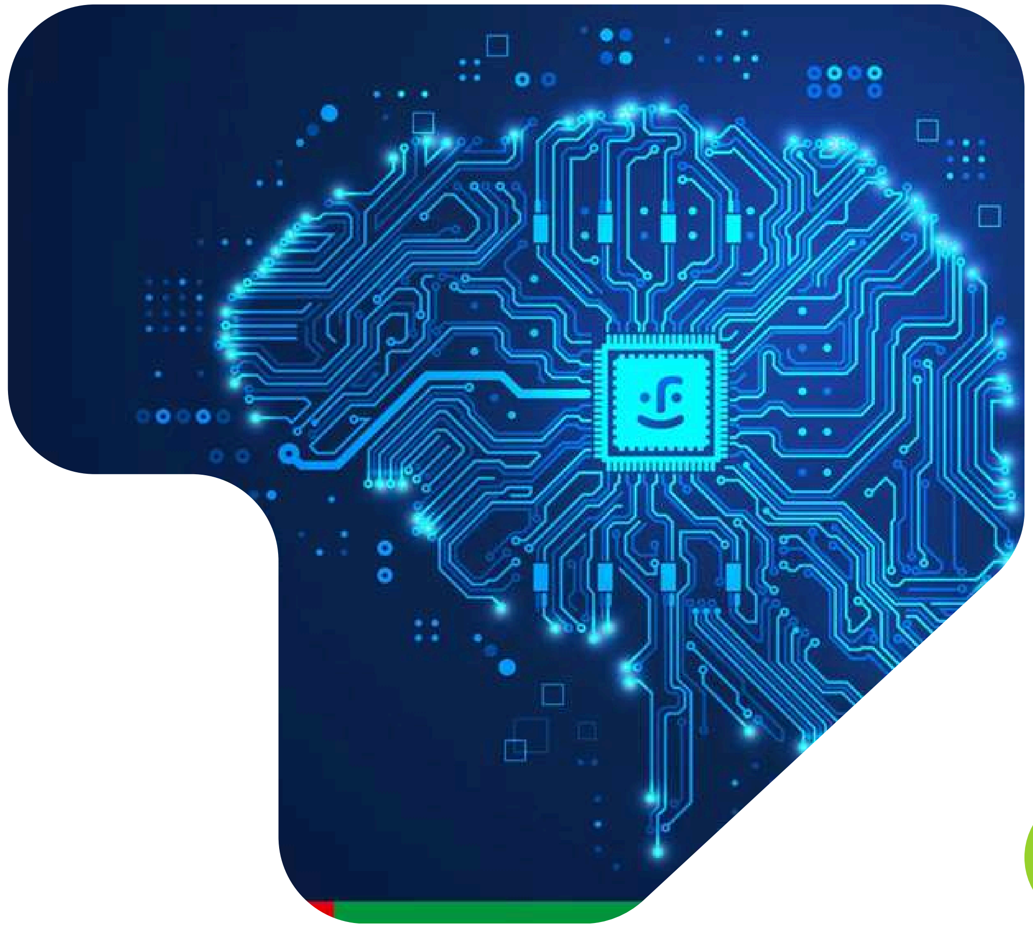


Road Traffic Accidents Dataset

Smart Traffic Management Dataset

Vehicle Maintenance Dataset

Dataset sources



Implementation

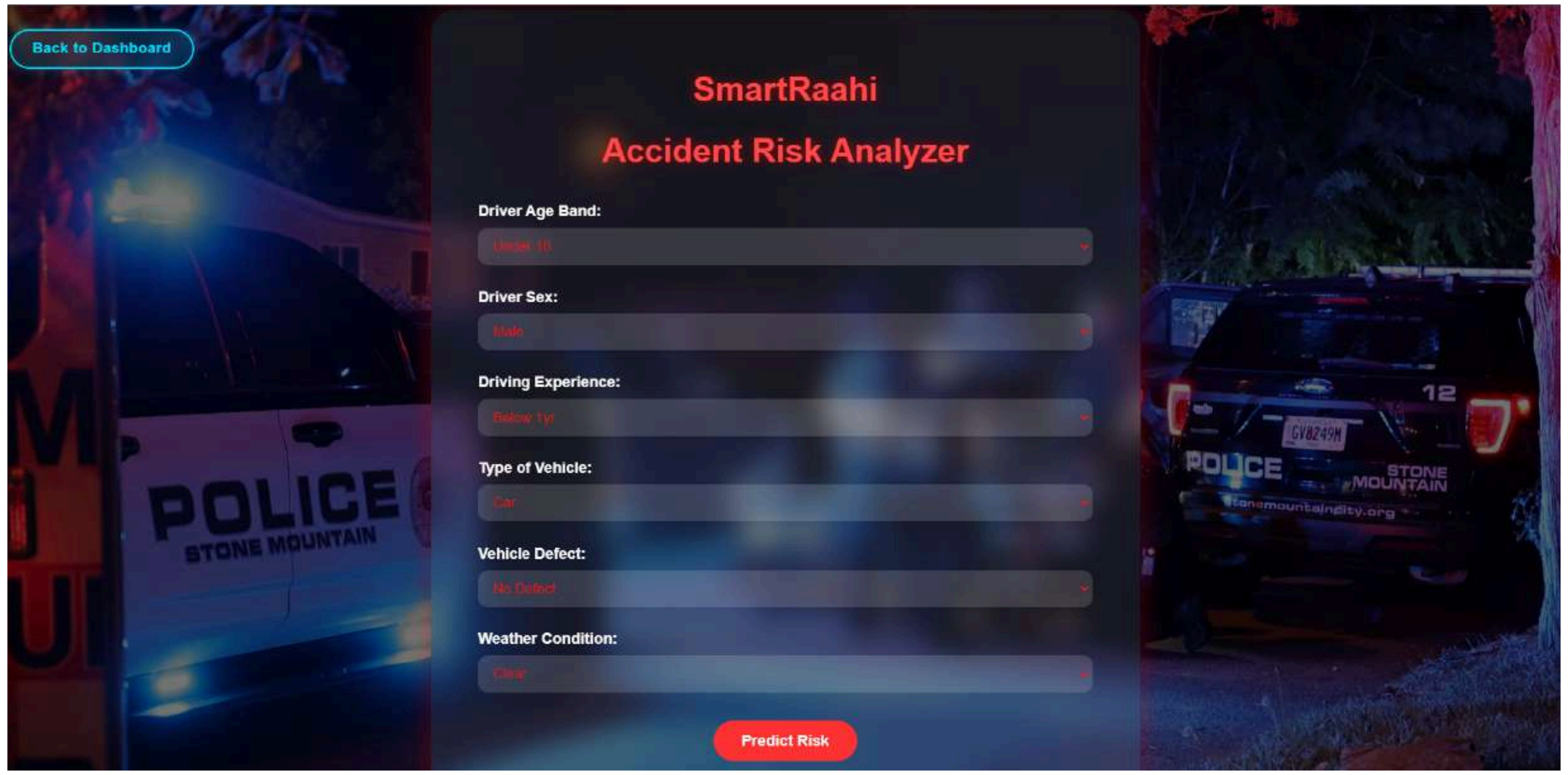
1. Accident Prediction

Goal: Predict the likelihood of road accidents based on historical data.

Technique: Random Forest Regression

Details:

- Explored multiple ML methods like linear regression and gradient boosting.
- Random Forest gave the best performance, minimized errors, and high R^2 value.
- Trained on historical traffic, weather, and road conditions.
- Outputs probability scores for accident risk to aid proactive traffic management.



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Accident Risk Analyzer

Driver Age Band: Under 18

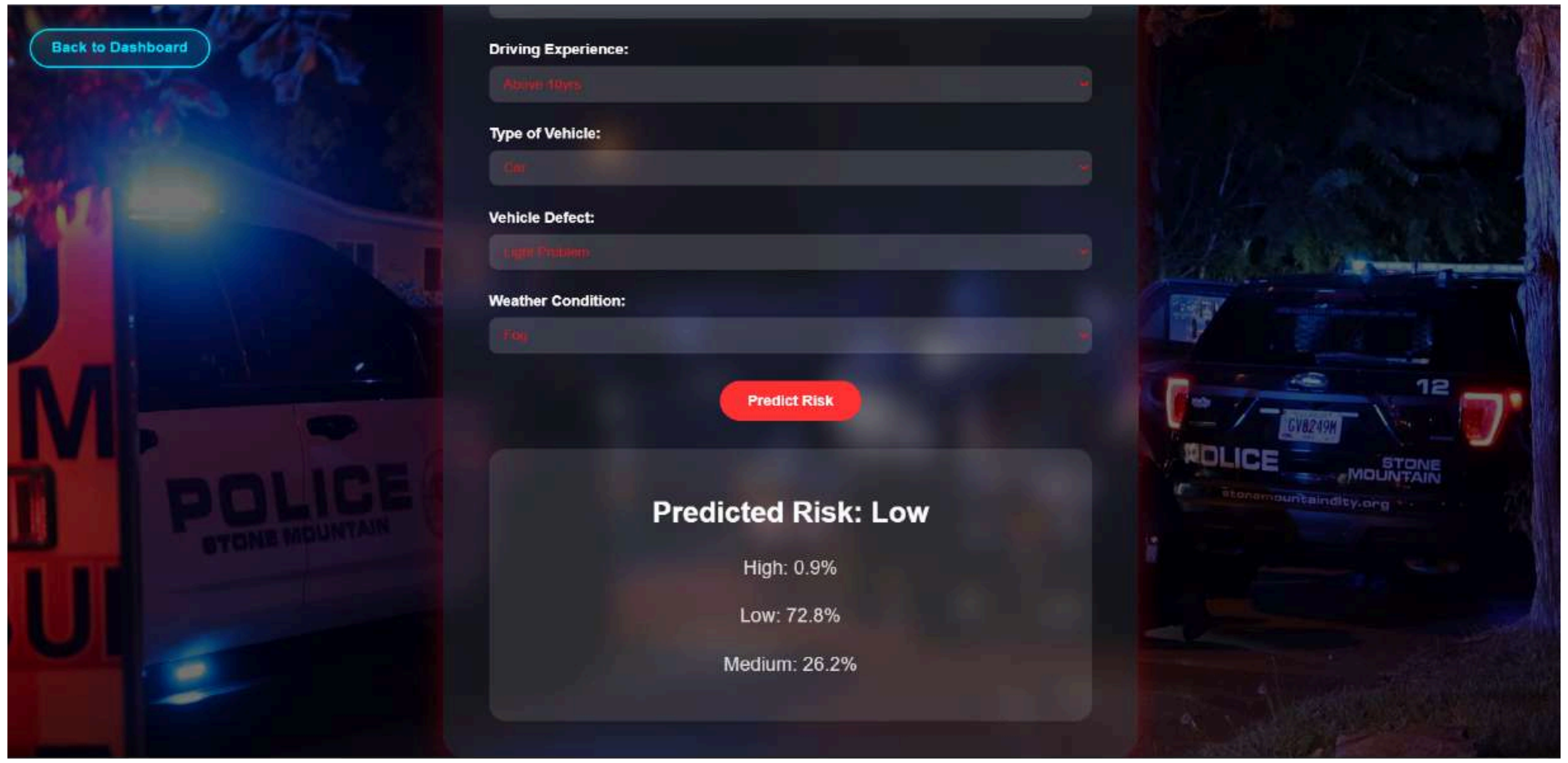
Driver Sex: Male

Driving Experience: Below 1yr

Type of Vehicle: Car

Vehicle Defect: No Defect

Weather Condition: Clear



Driving Experience: Above 10yrs

Type of Vehicle: Car

Vehicle Defect: Light Problem

Weather Condition: Fog

Predicted Risk: Low

High: 0.9%

Low: 72.8%

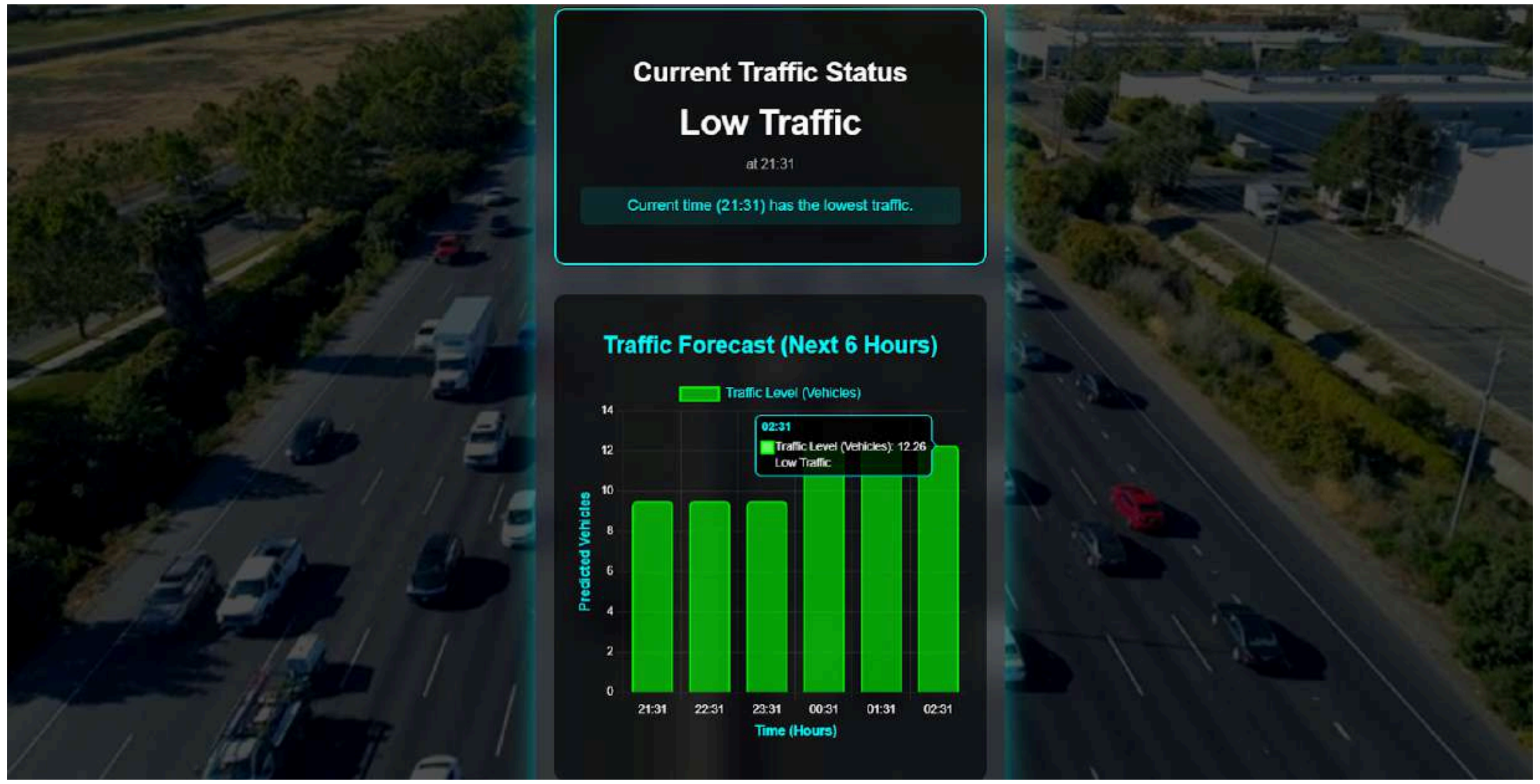
Medium: 26.2%

Implementation

2. Traffic Prediction on 4 Junctions

Goal: Forecast vehicle counts and traffic levels at multiple junctions.
Technique: Random Forest Regression
Details:

- Evaluated linear regression and support vector regression.
- Random Forest provided superior accuracy and lower mean squared error.
- Uses historical data: timestamps, junction numbers, and vehicle counts.
- Predicts traffic levels for next few hours and provides real-time status for better signal control.



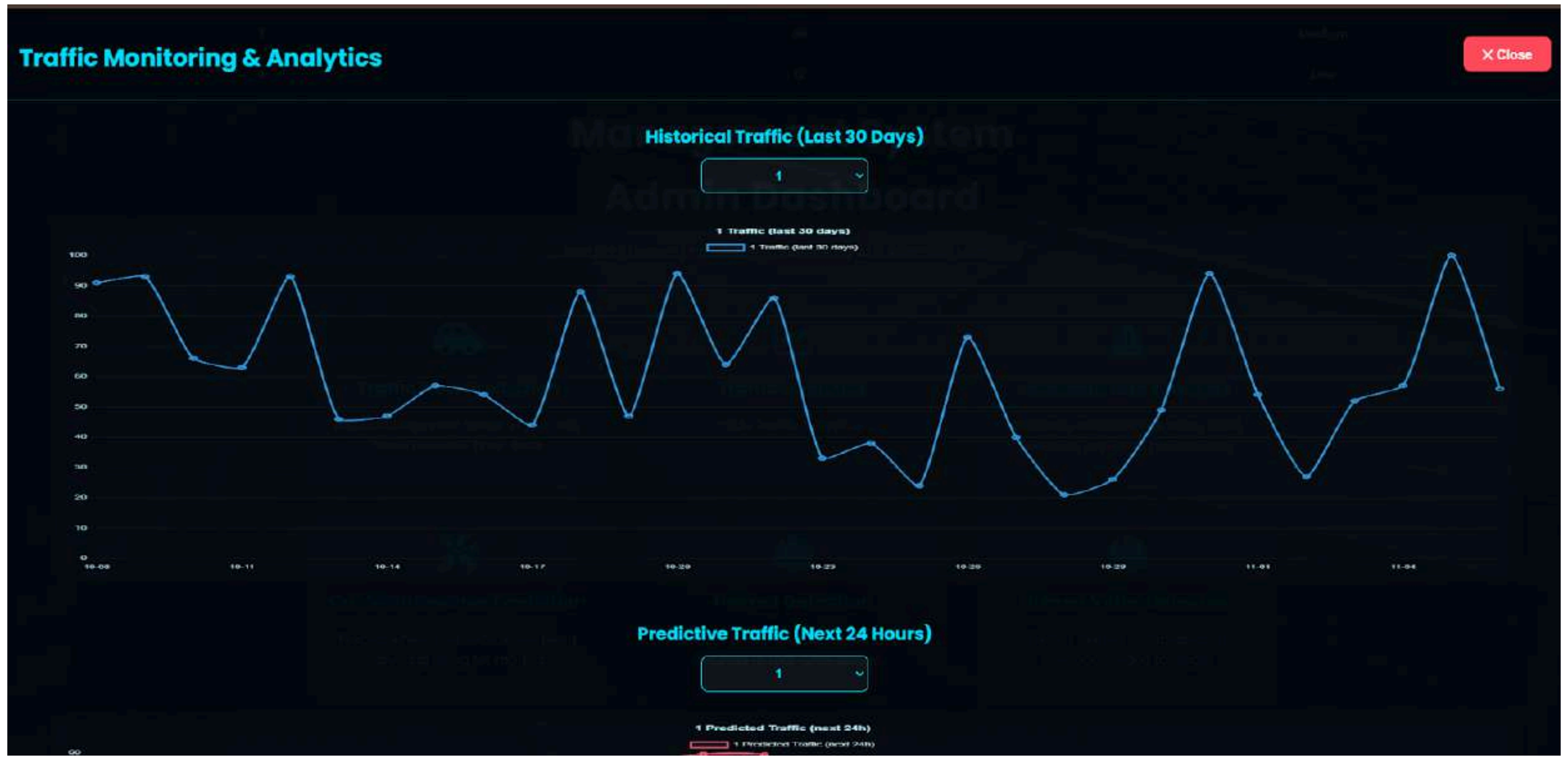
Current Traffic Status

Low Traffic

at 21:31

Current time (21:31) has the lowest traffic.

Traffic Forecast (Next 6 Hours)



Traffic Monitoring & Analytics

Historical Traffic (Last 30 Days)

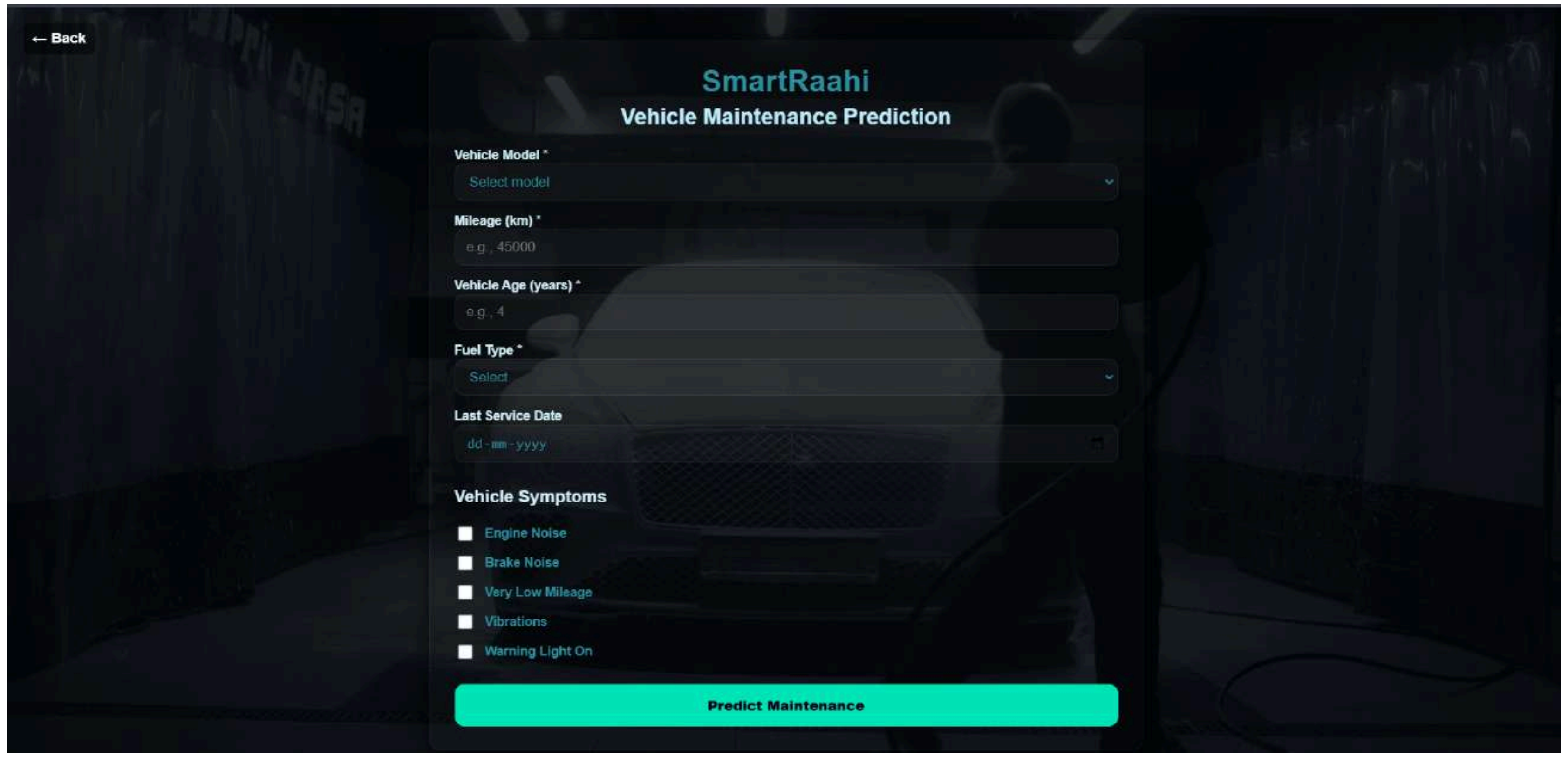
Predictive Traffic (Next 24 Hours)

Implementation

3. Car Maintenance Prediction

Goal: Predict whether a vehicle requires maintenance or servicing.
Technique: Random Forest Classification
Details:

- Tested logistic regression, k-nearest neighbors, and decision trees.
- Random Forest achieved highest accuracy and balanced precision/recall.
- Trained on mileage, age, and past maintenance records.
- Outputs probability or score indicating maintenance need, helping plan timely servicing.



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Vehicle Maintenance Prediction

Vehicle Model *
Select model

Mileage (km) *
e.g., 45000

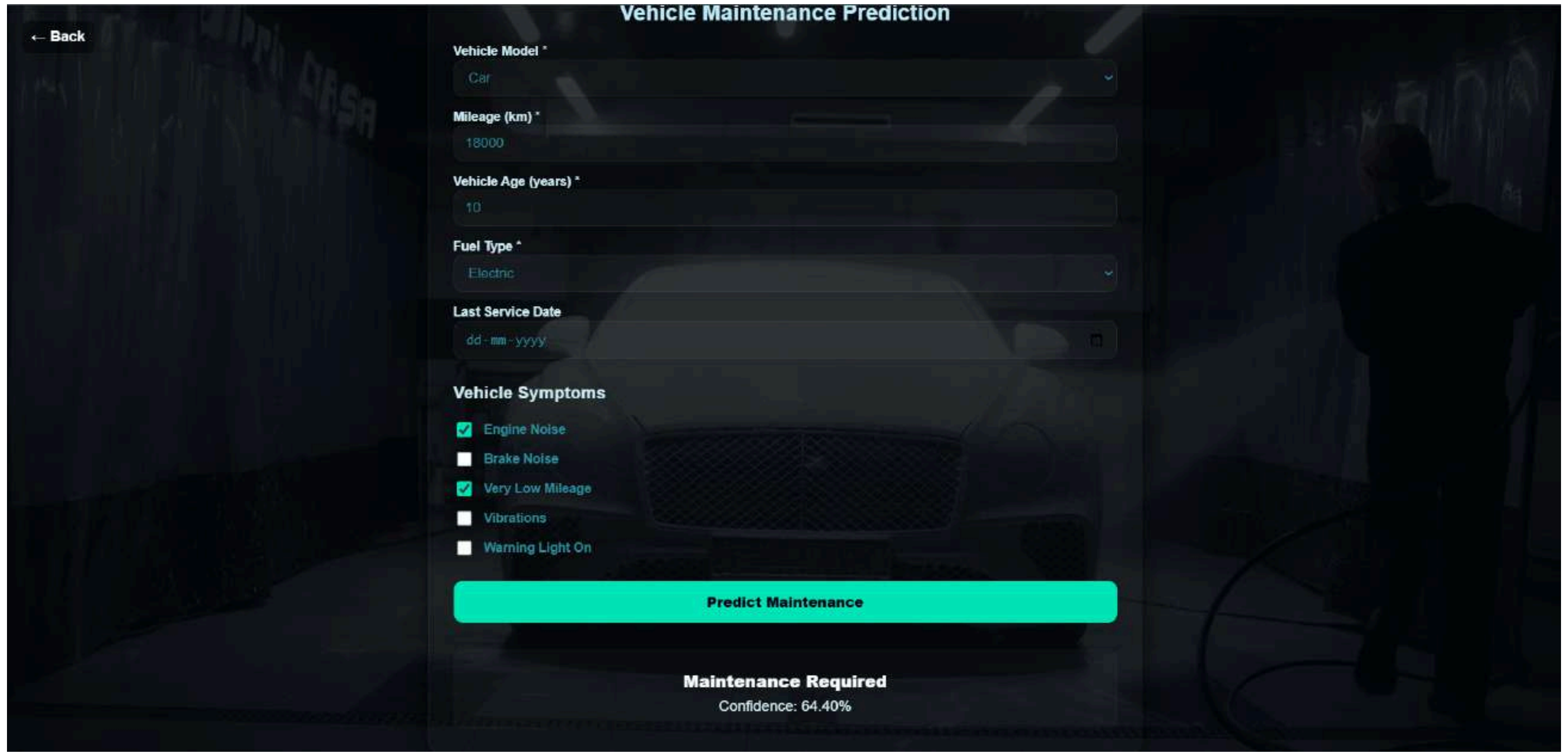
Vehicle Age (years) *
e.g., 4

Fuel Type *
Select

Last Service Date
dd - mm - yyyy

Vehicle Symptoms

□ Engine Noise
□ Brake Noise
□ Very Low Mileage
□ Vibrations
□ Warning Light On



Vehicle Maintenance Prediction

Vehicle Model *
Car

Mileage (km) *
18000

Vehicle Age (years) *
10

Fuel Type *
Electric

Last Service Date
dd - mm - yyyy

Vehicle Symptoms

☑ Engine Noise
□ Brake Noise
☑ Very Low Mileage
□ Vibrations
□ Warning Light On

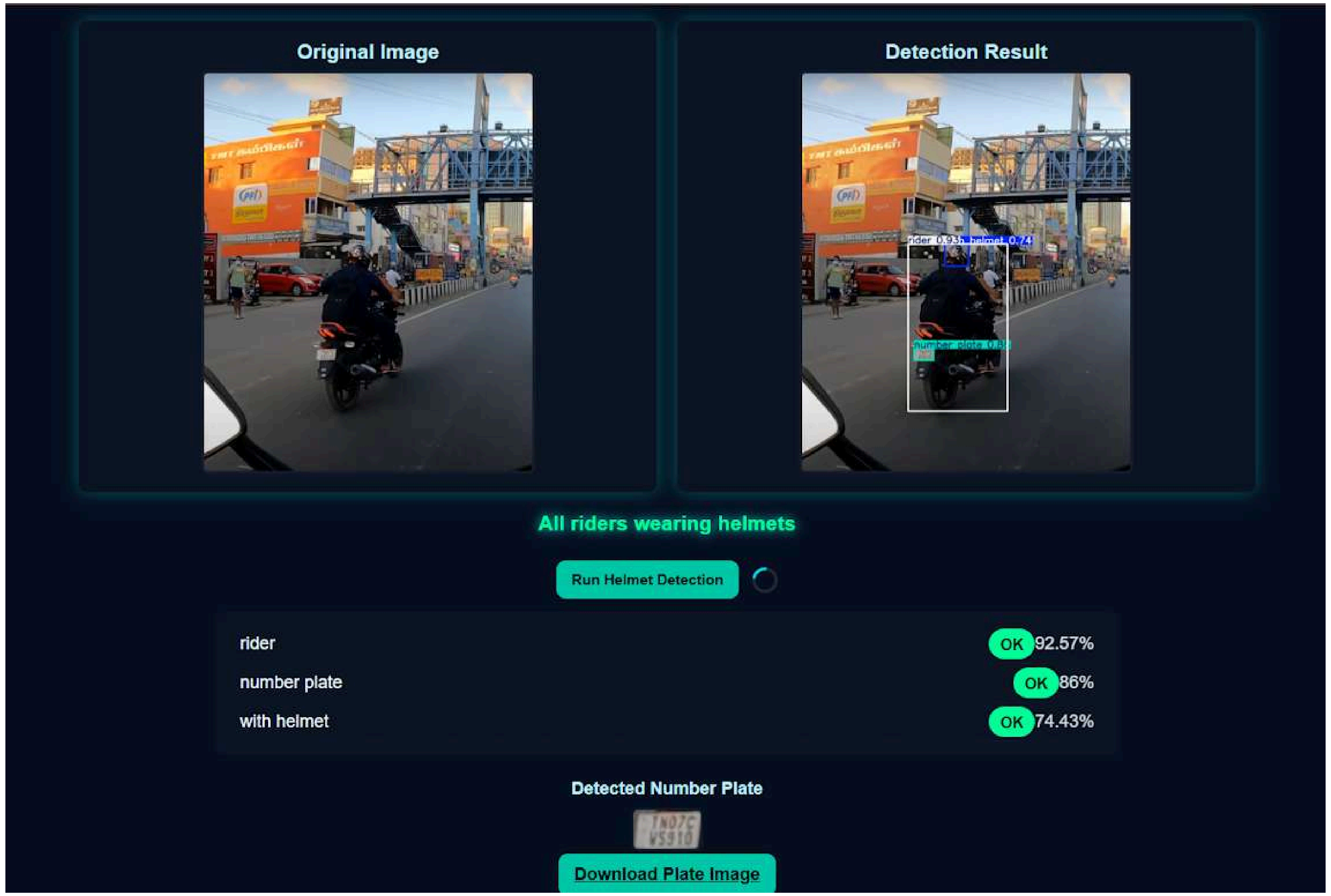
Maintenance Required
Confidence: 64.40%

Implementation

4. Helmet & Number Plate Detection (Image-Based)

Goal: Detect riders without helmets in images and capture number plates.
Technique: YOLOv8 Object Detection
Details:

- Data Annotation: Raw traffic images annotated in RoboFlow for riders, helmets, and number plates.
- Dataset Prep: Split into train, validation, and test sets in YOLO format.
- Model Training: Trained YOLOv8 for 50 epochs; optimized for speed and accuracy.
- Prediction & Output: Detects riders without helmets; crops violators’ plates automatically and stores only the cropped part.



All riders wearing helmets

rider OK 92.57%
number plate OK 86%
with helmet OK 74.43%

Detected Number Plate

Implementation

5. Helmet & Number Plate Detection (Video-Based)

Goal: Detect helmet violations in real-time from traffic videos.
Technique: YOLOv8 + Video Frame Processing
Details:

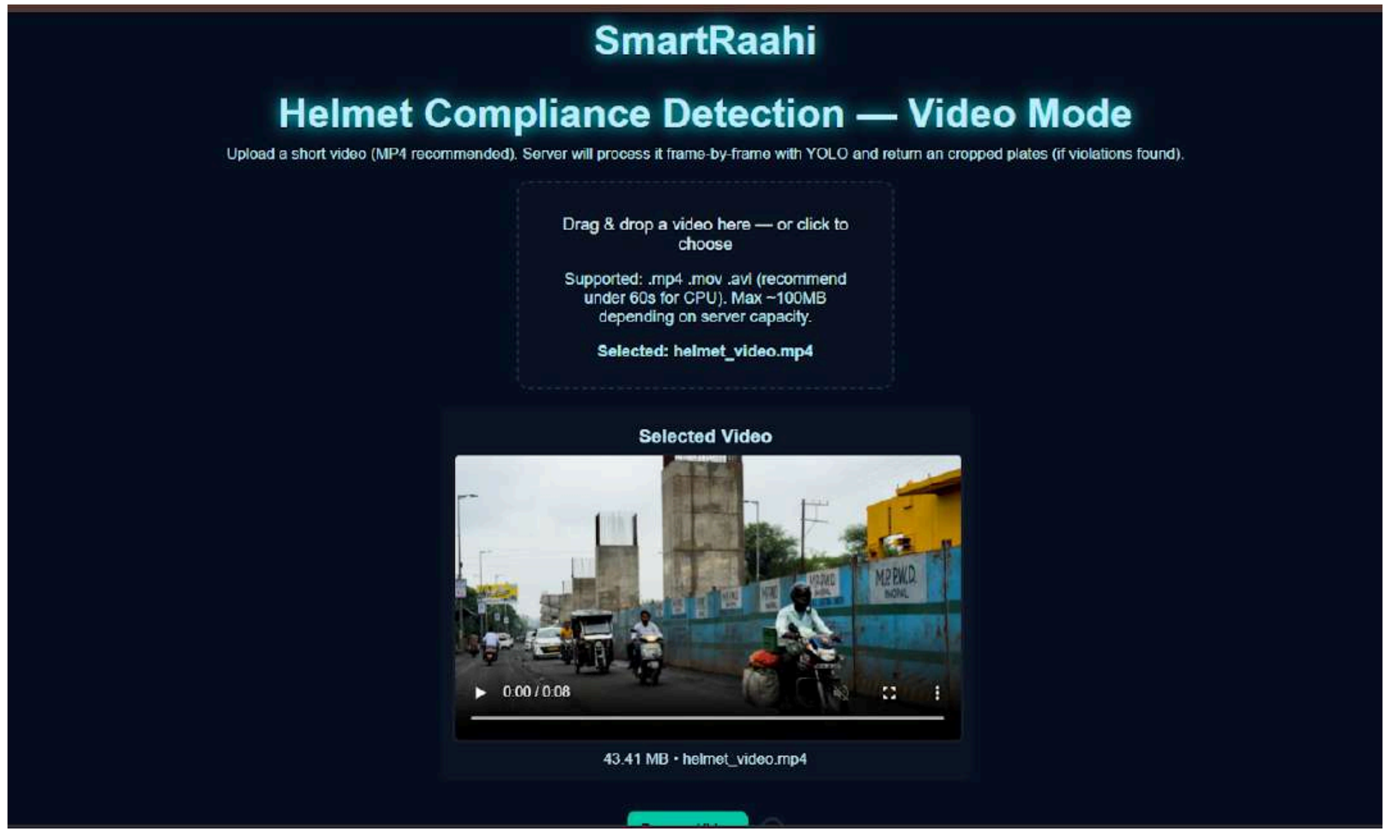
Frame Processing: Video frames processed sequentially with YOLOv8.

Detection: Detects riders without helmets and their number plates.

Plate Cropping: Crops plates and stores only the cropped part.

Annotated Video: Reassembles frames with bounding boxes for visualization.

Why YOLOv8: Accurate real-time detection of multiple objects; bounding boxes for complex traffic scenes; faster than traditional CNN classifiers.



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Helmet Compliance Detection — Video Mode

Upload a short video (MP4 recommended). Server will process it frame-by-frame with YOLO and return an cropped plates (if violations found).

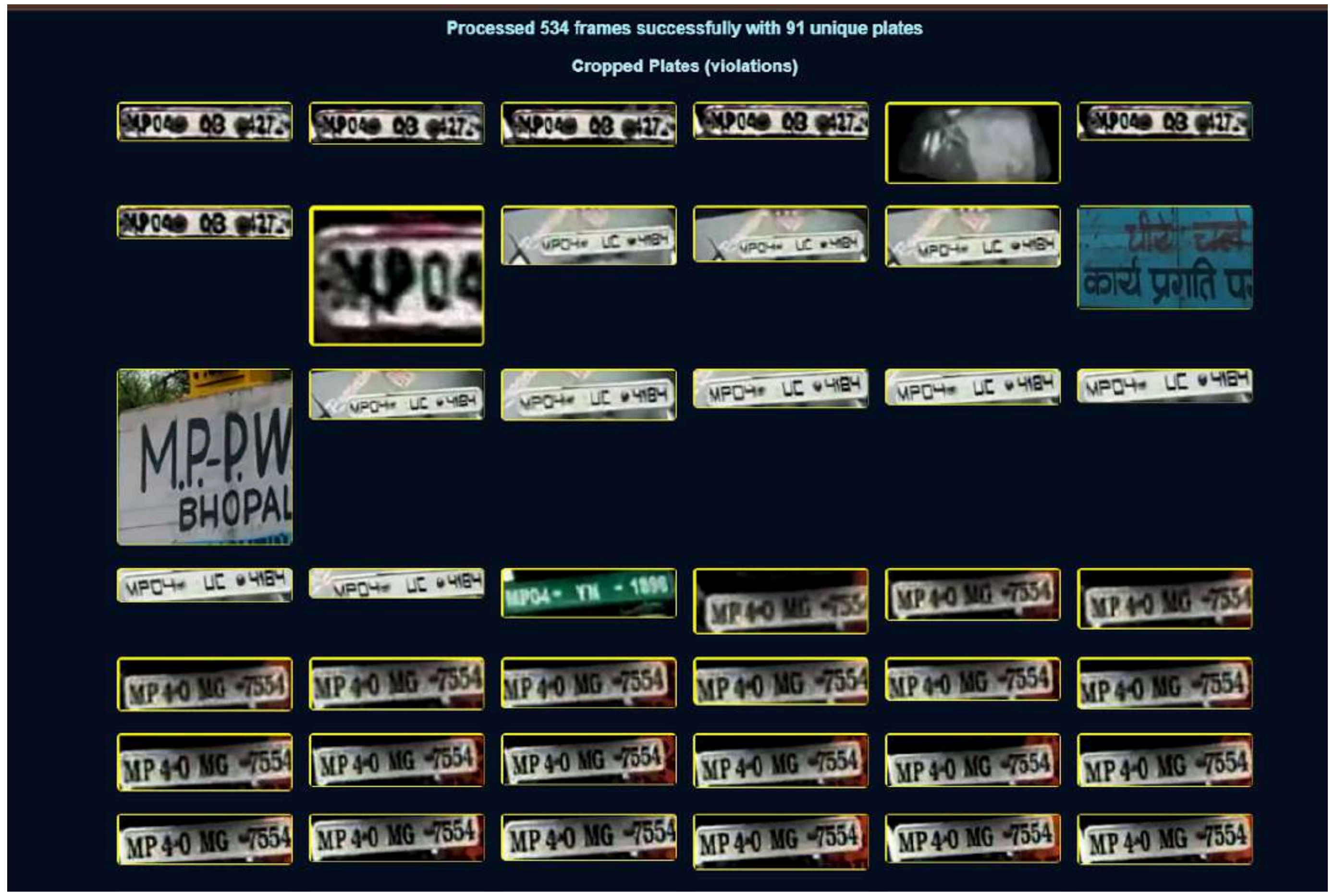
Drag & drop a video here — or click to choose

Supported: .mp4 .mov .avi (recommend under 60s for CPU). Max ~100MB depending on server capacity.

Selected: helmet_video.mp4

Selected Video

43.41 MB • helmet_video.mp4



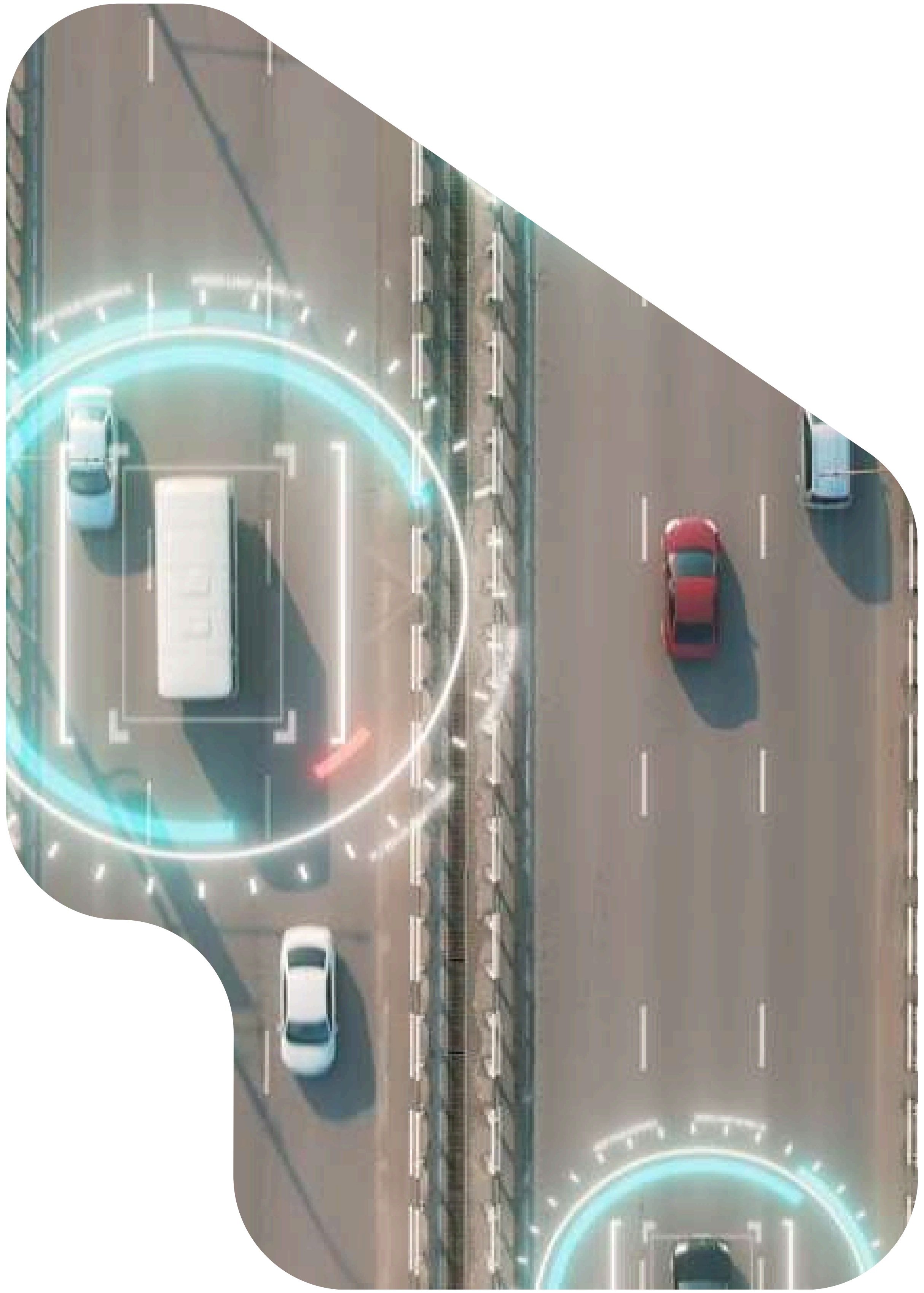
Processed 534 frames successfully with 91 unique plates

Cropped Plates (violations)

Implementation

6. Random Forest Model Saving & Loading

- Goal: Enable the trained models to be reused in the frontend/backend system.
- Technique: Python pickle
- Details: All Random Forest models were saved as .pkl files after training. These files can be loaded for predictions in real-time without retraining, facilitating seamless integration with the application's frontend.

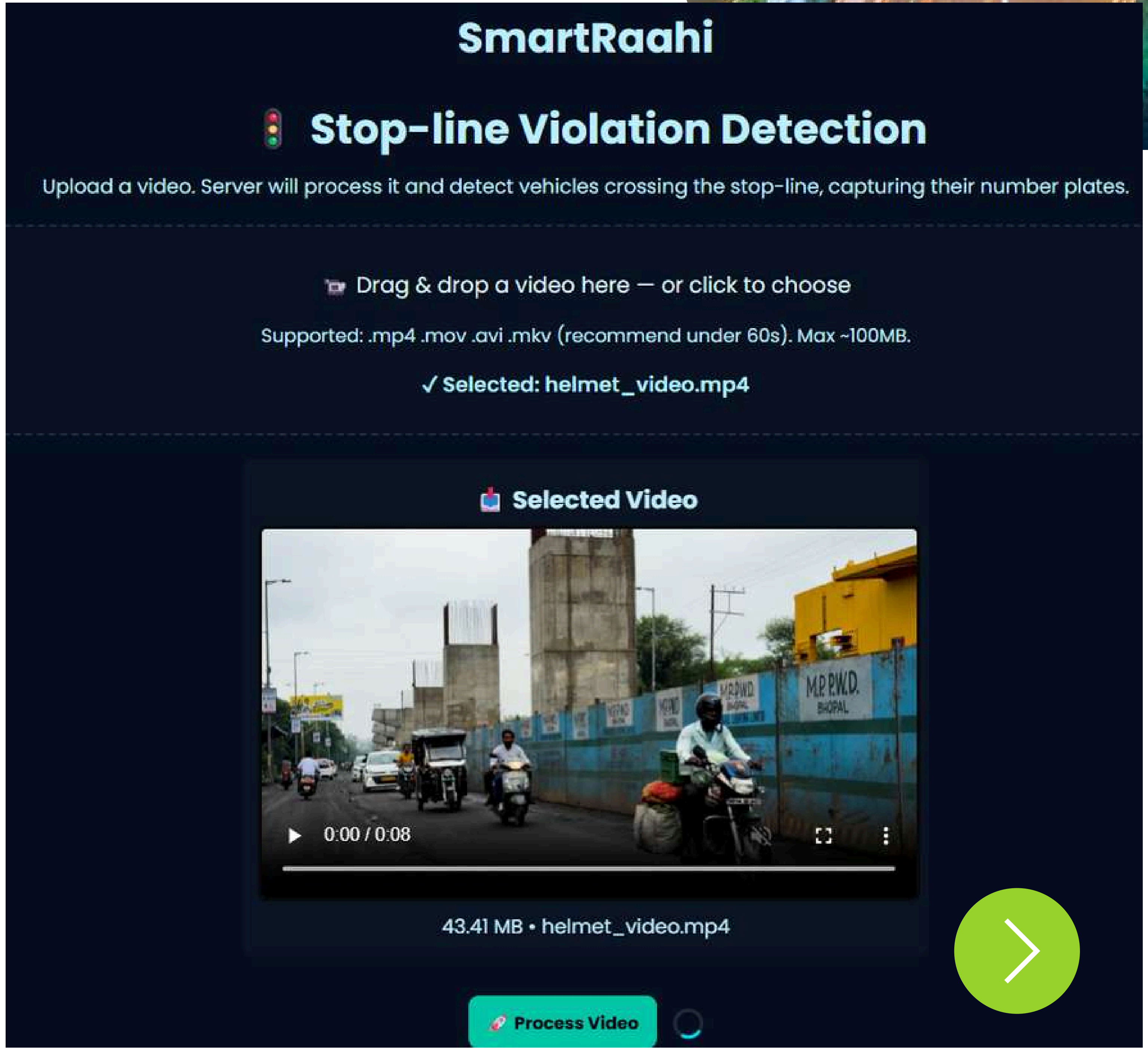


Implementation

7. Stop-Line Violation Detection

Goal : Detect vehicles crossing the stop-line when the traffic signal is red and capture their number plates.
Technique : YOLOv8 Object Detection + Object Tracking
Details:

- Virtual Stop-Line: A virtual boundary is drawn in the video feed at the traffic signal.
- Violation Detection: If the signal is red, any vehicle crossing the line is flagged as a violation.
- Object Tracking: Tracks vehicle movement to detect crossing accurately.
- Number Plate Capture: Crops the number plate region for violating vehicles.
- Metadata Storage: Saves cropped number plate images and stores metadata including timestamp, frame number, and violation type.



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🚦 Stop-line Violation Detection

Upload a video. Server will process it and detect vehicles crossing the stop-line, capturing their number plates.

📹 Drag & drop a video here — or click to choose

Supported: .mp4 .mov .avi .mkv (recommend under 60s). Max ~100MB.

✓ Selected: helmet_video.mp4

Selected Video

43.41 MB • helmet_video.mp4

future scope

- **Enhanced Rule Enforcement**: Detect seat belt violations, over-speeding etc.
- **Automated Number Plate Recognition**: Integrate OCR to directly map violations to vehicle records.
- **Adaptive Traffic Control**: Use AI/Reinforcement Learning to optimize signal timings in real-time.
- **Advanced YOLO Architectures**: Use F-YOLOv8, GhostConv, and attention-enhanced models to improve small-object detection and low-light performance.
- **City-Wide Implementation**: Deploy across multiple junctions for centralized traffic monitoring.
- **Smart City Integration**: Connect with emergency response, public transport, and IoT vehicle sensors.
- **Real-Time Alerts**: Notify authorities and drivers to prevent accidents and reduce congestion.

conclusion

- SmartRaahi integrates computer vision and ML for intelligent traffic management.
- YOLOv8 reliably detects riders, helmet usage, and number plates in real time.
- Random Forest accurately predicts traffic flow, maintenance needs, and accident risk.
- Modules work together to enable proactive road-safety monitoring.
- Lightweight AI models create a practical and scalable smart-transport solution.
- Overall, the system demonstrates a practical and scalable approach to supporting smarter traffic monitoring, proactive decision-making, and safer urban transportation management.

references

[1] F. Pedregosa, G. Varoquaux, A. Gramfort, et al., "Scikit-learn: Machine Learning in Python," Journal of Machine Learning Research, vol. 12, pp. 2825–2830, 2011.

[2] "Machine Learning," Kluwer Academic Publishers, vol. 45, pp. 5–32, 2001.

[3] C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

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[5] A. G. Howard, et al., "MobileNets: Efficient Convolutional Neural Networks for Mobile Vision Applications," arXiv preprint arXiv:1704.04861, 2017.

[6] Roboflow, "Annotation and Dataset Management for Computer Vision," 2023.

thank you