Team Synergy: Solution Proposal for AI/ML Hackathon on Road Safety

Swati Mishra, Ayushman Bhowmik, Sayak Hatui, Abhijeet Kumar, 3^{rd} year.

Aakriti Roy, Aniruddha Mukherjee, 2^{nd} year.

School of Computer Engineering, Kalinga Institute of Industrial Technology

1 Introduction

Road safety is a critical concern globally, with road accidents causing significant human and economic losses. In total, 168,491 people were killed and 443,366 injured in 461,312 road crashes last year, in India alone. While traditional methods such as traffic signs, speed limits and road safety authority play a role in mitigating risks, the integration of technology, particularly machine learning, can be leveraged as a powerful tool to avoid human error and address road safety issues comprehensively.

The objective of this project is to optimize traffic flow by using computer vision, machine learning, and deep learning techniques. The system described analyzes video footage from traffic cameras and cameras installed in the vehicle to provide real-time suggestions to both user and the road safety authority for improving road safety. This proactive approach empowers users to avoid accidents by making informed decisions based on real-time information.

2 Current Issues with Road Safety

The problem statements deals with the issue of traffic flow optimization for road safety. Some existing problems in the current road safety infrastructure are:

- Unsafe roads containing Potholes
- Traffic Congestion and overcrowding
- Poor traffic management
- Limited Pedestrian Infrastructure
- Poor lighting and visibility
- Over-speeding vehicles
- Inadequate emergency response system
- Poor vehicle safety standards

3 Proposed Solution

The solution proposed is a system consisting of machine learning, deep learning and computer vision algorithms which is trained on multitudes of data, takes input from both cameras installed on user's vehicle and CCTV installed by authorities, and provides valuable insights, fostering efficient and secure daily operations for individuals, government entities, and organizations. These features, combined with real-time analysis, contribute to a comprehensive and dynamic system for addressing everyday needs.

The codebase for the proposed solution can be found here: https://github.com/swatimishra02/Road-Safety-management

4 Methodology

For most of the image processing and video computational tasks, the adopted methodology in the project has been the YOLOV8 model. It is a state-of-the-art image segmentation and object detection model. There are other object detection models available such as GroundingDINO, YOLOv5, Detectron2 etc; but YOLOv8 was chosen for this project for the following reasons:

- YOLOv8(medium) has a 50.2 mAP score at 1.83 milliseconds on the COCO dataset and A100 TensorRT.
- Anchor free architecture
- Mosiac Data augmentation-stitching multiple images and videos, from different CCTV cameras and vehicles.
- Modified loss function.

5 Features

The following problems were addressed using Machine Learning models.

1. Counting Number of People in a Frame
2. Pothole Detection
3. Traffic Light Detection
4. Vehicle Speed Calculation
5. Vehicle Lane Detector
6. Lane-Wise Vehicle Tracking

5.1 Counting Number of People in a Frame

5.1.1 Libraries

Ultralytics YOLO, openCV and cvzone

5.1.2 Dataset

COCO Dataset

5.1.3 Functionality

- Counts the number of people in a frame in real time
- Identifies entities described in the COCO dataset such as Humans, Cars, bikes, pedestrian, zebra-crossing, traffic light etc;
- Creates a bounding box around every person in frame
- Gives us the speed of every person and vehicle.

https://github.com/swatimishra02/Road-Safety-management/blob/main/people-counter.py

Figure 1: Output: People tracked

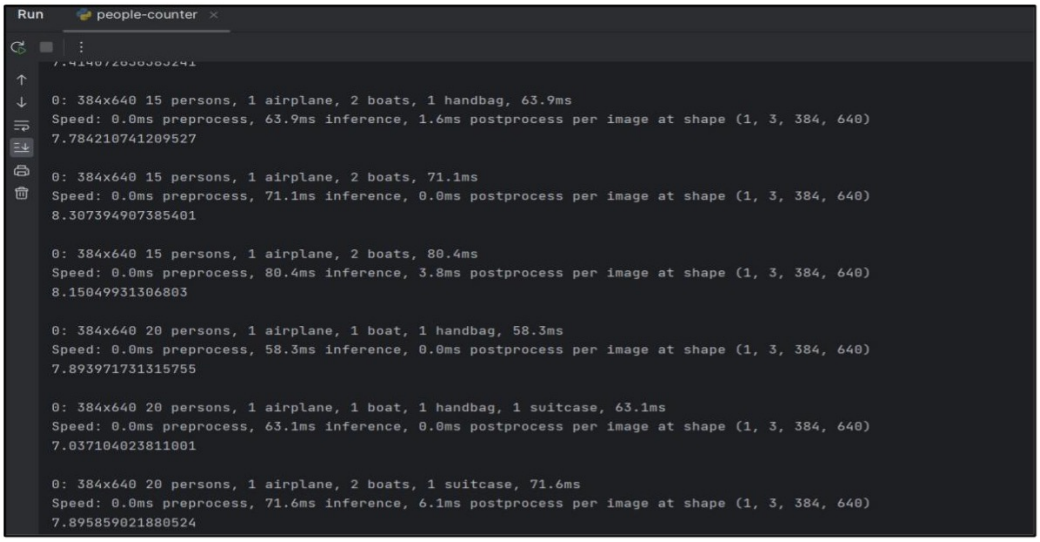

Figure 2: Output: Log of tacking

5.2 Pothole Detection

5.2.1 TechStack

Ultralytics YOLO, PyTorch, Hydra

5.2.2 Dataset

COCO Dataset

5.2.3 Functionality

- Detects Potholes on the road in real time
- This information is used to classify safe roads with unsafe roads, and the speed of the incoming vehicles around such danger zones can be monitored by the authorities for better safety.

5.2.4 Code

https://github.com/swatimishra02/Road-Safety-management/tree/37aa3c825e9776a9e63a441b5046130426715aea/1_Pothole-Detection

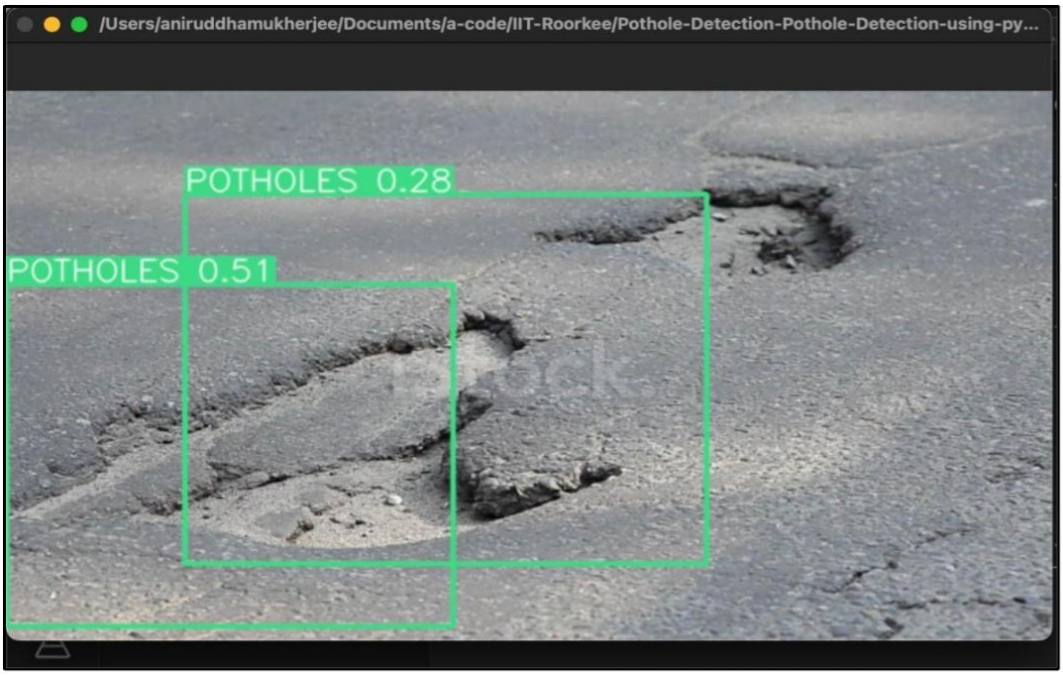

Figure 3: Output: Pothole detected.

Figure 4: Output: Pothole detected.

5.3 Traffic Light Detection

5.3.1 TechStack

PyTorch, Transfer learning, RCNN

5.3.2 Dataset

Lisa Traffic light dataset

5.3.3 Functionality

- Detects traffic lights and the signal shown(red/yellow/green) displayed by it.
- This information is used to automatically flag the movement of vehicles during red/yellow light, have information about the speed of vehicles/people during green light.
- The collective information can also be used to implement algorithms (ex. The Fuzzy logic algorithm) for better vehicular flow at traffic-light intersections by optimizing a dynamic allocation of times.

5.3.4 Code

https://github.com/swatimishra02/Road-Safety-management/tree/37aa3c825e9776a9e63a441b5046130426715aea/4_Traffic-Light-Detection

Figure 5: Output: Green Traffic Signal is Detected

5.4 Vehicle Speed Calculation

5.4.1 TechStacks

OpenCV, DLib, YoloV8, DeepSORT Tracking

5.4.2 Functionality

- Calculates speed of all the vehicles running in a particular area
- Automatically flags vehicles over-speeding

5.4.3 Code

https://github.com/swatimishra02/Road-Safety-management/tree/37aa3c825e9776a9e63a441b5046130426715aea/3_Vehicle-Speed-Check-Estimator

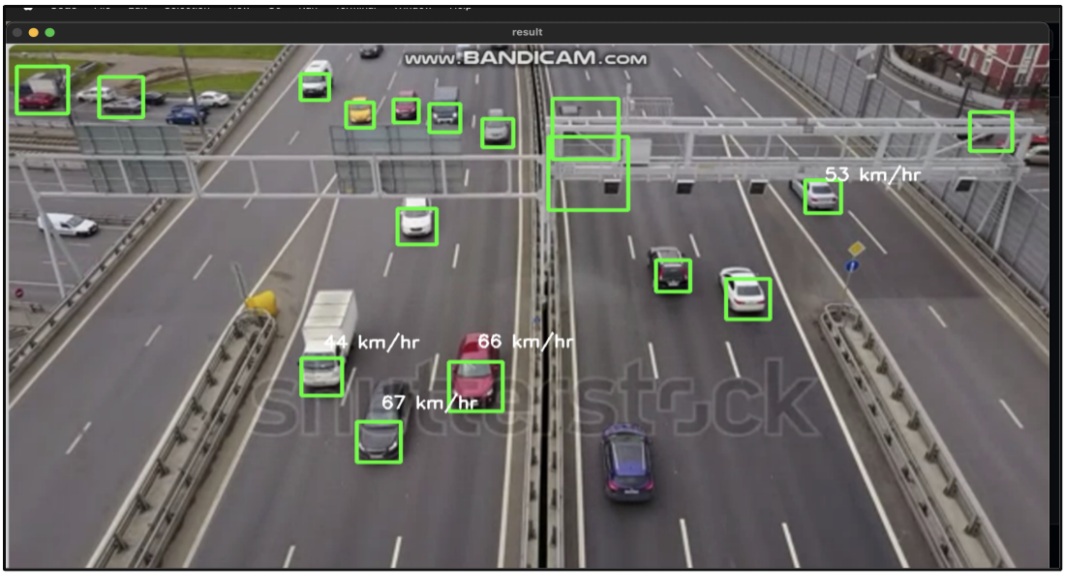

Figure 6: Output: Speed is detected

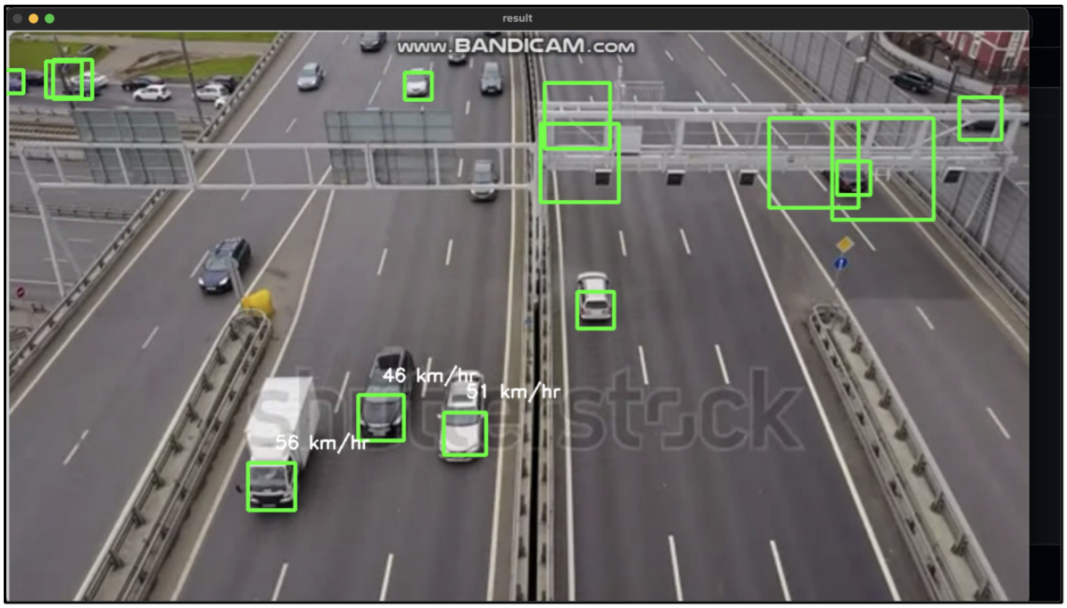

Figure 7: Output: Speed is detected

5.5 Vehicle Lane Detector

5.5.1 TechStacks

YoloV8

5.5.2 Functionality

- Accurate lane detection allows the system to track the vehicle's position within the lane, ensuring it stays within the designated driving area.
- The system can provide real-time warnings to the driver if it detects signs of unintentional lane departure, reducing the risk of collisions due to drifting into adjacent lanes.
- Curvature estimation provides information on possible upcoming turns.
- The pipeline includes distortion correction, color thresholding, and gradient analysis, which collectively improve visibility in various lighting and weather conditions, such as low light, shadows, or adverse weather.

5.5.3 Code

https://github.com/swatimishra02/Road-Safety-management/tree/37aa3c825e9776a9e63a441b5046130426715aea/5_LaneDetection

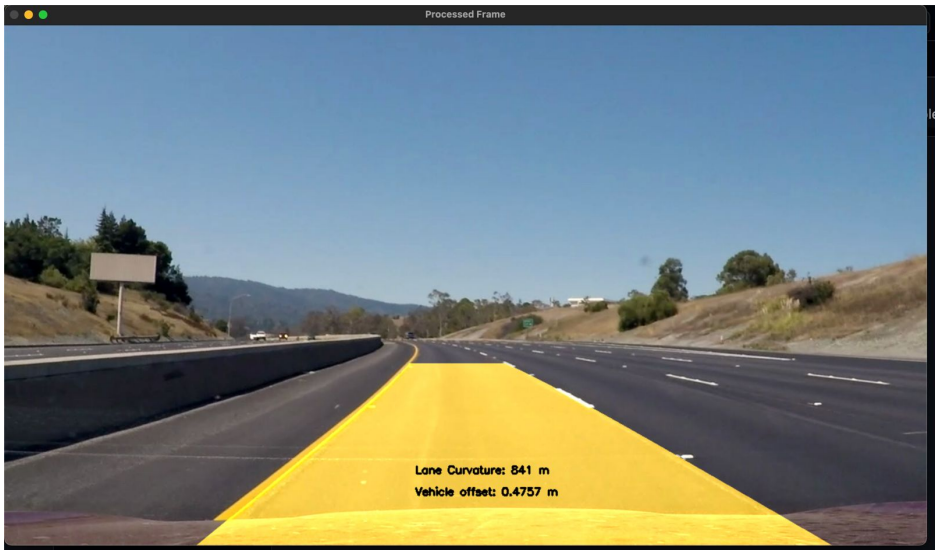

Figure 8: Lane Detection being performed

5.6 Lane-Wise Vehicle Tracking

5.6.1 TechStack

YoloV8, DeepSORT

5.6.2 Functionality

- This model's main utility is is for one-way roads and highways. If a vehicle enters on a one-way road from the opposite direction, it will be immediately flagged and alarmed.
- Keeps count of number of vehicles travelling on the lane, which helps us keep track of the crowd on highways, possible incoming crowd on further roads, and avoid overcrowding.
- Also detects the type of vehicle entering(truck/car/bus etc) for separated lanes of different vehicles.

5.6.3 Code

https://github.com/swatimishra02/Road-Safety-management/tree/a99c794a7426d1f95133cbd37d0a604ec224ca0d/5_LaneDetection

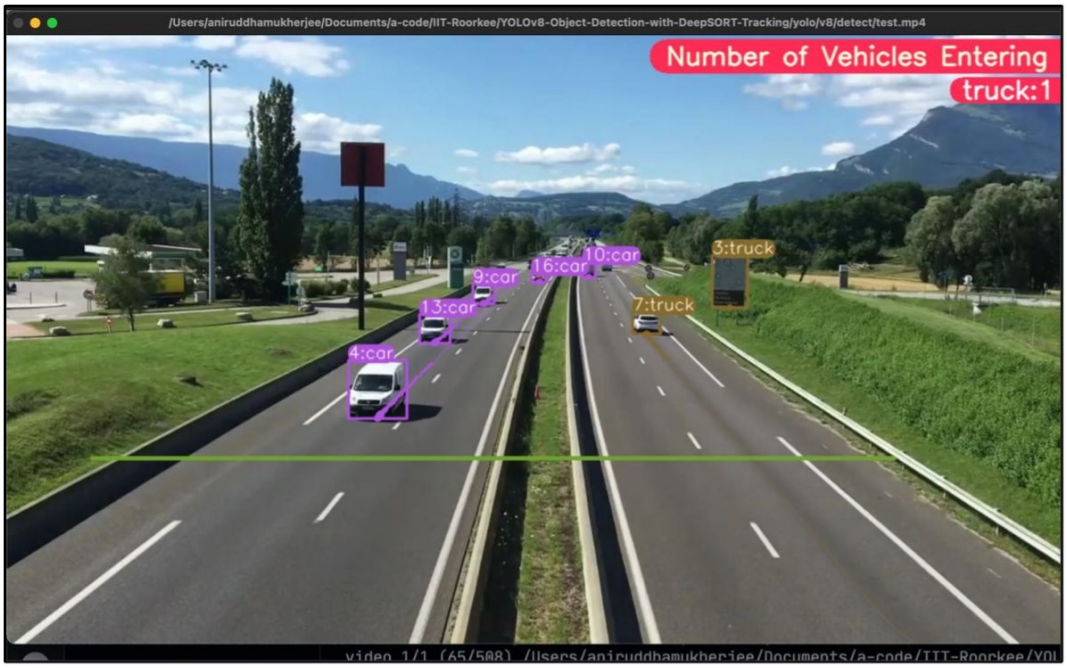

Figure 9: Output: In-Out Count Maintained

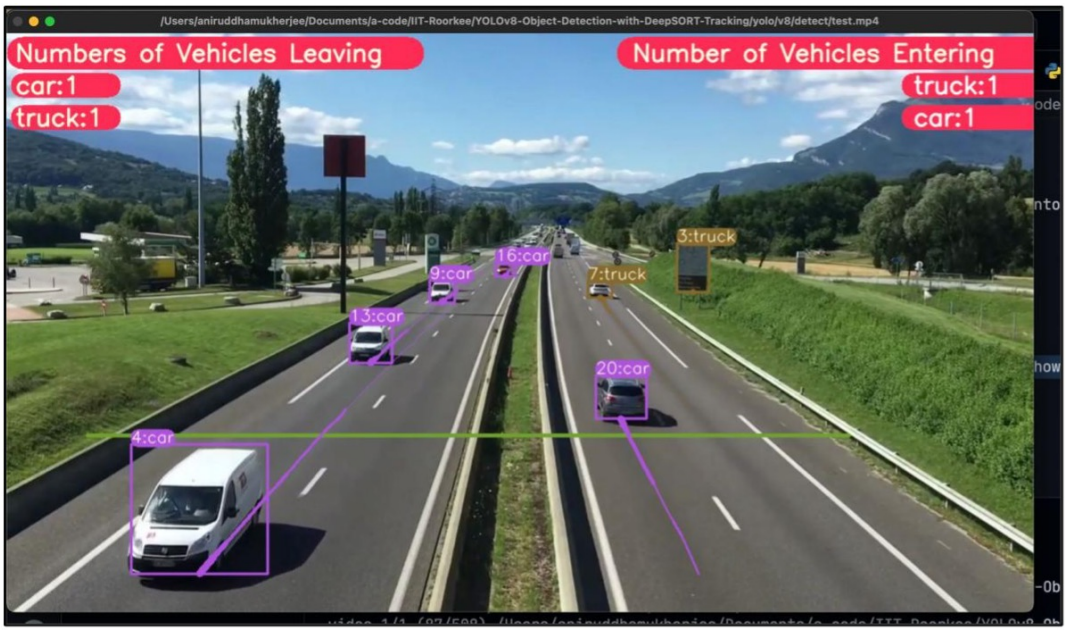

Figure 10: Output: In-Out Count Updated

6 Integrating The Model with Existing Systems

In India, currently several laws, rules and regulations are in place to manage road safety. Even then, India ranks the highest in road accidents and deaths. Our proposed solution automates most of the manual tracking of preventive

measure of road safety, while making predictions to prevent mishaps even before they occur.

The systems proposed are integrated in 2 perspectives:

- Camera installed in vehicles
- CCTV cameras on roads

With the input from these two systems, the task of monitoring vehicles and humans for law enforcement gets completely automated, and the actions can be taken much faster in case of mishaps.

But in most of the rural places in India, there is no proper road infrastructure and no ways of monitoring movement on roads. For such areas, these systems can be integrated with IoT sensors (such as ultrasonic sensors) and connected to the vehicle, which gives live feedback to the user itself.

The collected data can also be used by the authorities to develop better road safety infrastructure.

7 References

1. https://www.analyticsvidhya.com/blog/2023/01/machine-learning-solution-predicting-road-accident-severity/
2. https://github.com/roboflow/notebooks/blob/main/notebooks/how-to-track-and-count-vehicles-with-yolov8.ipynb
3. Traffic Analysis with YOLOv8 and ByteTrack - Vehicle Detection and Tracking: https://public.roboflow.com/object-detection/pothole
4. https://roboflow.com/models/object-detection
5. https://pyimagesearch.com/2019/12/02/opencv-vehicle-detection-tracking-and-speed-estimation/
6. https://github.com/topics/traffic-sign-recognition
7. https://github.com/dineshresearch/Novel-Deep-Learning-Model-for-Traffic-Sign-Detection-Using-Capsule-Networks
8. https://www.kaggle.com/code/soumya044/lane-line-detection
9. https://www.youtube.com/watch?v=iRTuCYx6quQ
10. https://www.analyticsvidhya.com/blog/2021/11/complete-guide-to-people-counting-and-tracking-end-to-end-deep-learning-project/