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Department of AIML

Helmet and Number Plate Detection with YOLOv8

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Introduction

Road traffic accidents are sudden, unplanned events that significantly impact human life, particularly in low- and middle-income countries, which account for **85% of global fatalities** and **90% of disability-adjusted life years lost** due to such injuries. Among these, two-wheeler accidents stand out as a major concern, with head injuries being the most frequent and severe. Studies have shown that riders not wearing helmets are at a significantly higher risk of fatal head injuries, increasing the **likelihood of death by nearly 40% and severe injuries by 70%**. This underscores the critical importance of helmet usage in preventing life-threatening injuries.

To address this issue, the current study aims to develop an advanced detection system integrating **YOLOv8 and TensorFlow** for enhanced helmet detection and number plate recognition. Utilizing YOLOv8, the system focuses on identifying helmets on individuals with high precision and recall across diverse scenarios. Meanwhile, **TensorFlow's Optical Character Recognition (OCR)** capabilities are leveraged for accurate number plate recognition, ensuring reliable alphanumeric interpretation. Furthermore, the study evaluates the system's real-time processing capabilities to make it suitable for practical applications in safety enforcement and traffic monitoring. By achieving these objectives, the study aspires to contribute to improved road safety measures and stricter compliance with helmet laws.

Link for reference: https://timesofindia.indiatimes.com/city/bengaluru/75-of-two-wheeler-accident-victims-in-bengaluru-in-2022-had-helmets-on/articleshow/101093014.cms

Objective

1. Develop an advanced detection system integrating **YOLOv8 for helmet detection** and TensorFlow for number plate recognition.
2. Enhance helmet detection by **maximizing detection accuracy** across various helmet types and scenarios while **maintaining high recall and precision**.
3. Improve number plate recognition using **Optical Character Recognition (OCR)** for **accurate identification of alphanumeric characters** in diverse conditions.
4. Validate the **system's real-time processing capability** to ensure its effectiveness for practical applications in safety enforcement and traffic monitoring.

Literature Survey

Sl No	Author and Paper title	Details of Publication	Summary of the Paper
1.	**A Profile of Two Wheeler Road Traffic Accidents and Head Injuries in Bangalore** Dipti Prajapati, Samishtarani Sabat,Sanika Bhilare,Rashmi Visheand Prof. Suman Bhujbal.	Researchgate, January 2014, Medico-Legal Update 14(1):139 DOI:10.5958/j.0974-1283.14.1.034	Head is the most common site to be injured in road traffic accidents. Factors and events contributing to accident may arise from man, machine and environment, may occur either before, during or after accident. Hence the present study was conducted to know the patterns of accident and head injuries involving riders and pillion riders of two wheelers. This study was conducted from 1st April 2009 to 30th Sept 2010 at Victoria Hospital Mortuary, Bangalore. A total of 245 cases of deaths due to two wheeler accidents were reported for the autopsy. Riders constituted (76.33%) and pillion riders (23.67%). Most victims were male (87.75%), 20 to 39 years constitutes 70.20% of victims, most of the accidents have occurred during 6PM - 12midnight, Helmets used by the victims (64.17%), skull fractures (67.75%) were observed in the two wheeler accidental death. Subdural hemorrhage was the commonest intracranial hemorrhage and rib injuries were commonly associated with head injuries.
2.	**Pattern of two wheeler road traffic accidents in rural setting: a retrospective study** Vipin Gupta, Anil Kumar, Prashant Gupta and Somendra Pal Singh	Researchgate January 2016, International Surgery Journal, DOI:10.18203/2349-2902.isj20160952	Motor cyclists are about 25 times more risk than passenger car occupants to die because of road traffic accidents. OBJECTIVEs of the study were, to study pattern of two wheeler road traffic accidents in rural setting. Methods: The present research is a retrospective analysis of all the two-wheeler accidents victim admitted in emergency, during the period ranging from September 2015 to February 2016. Results: Among the total 2,544 patient of RTA admitted within the study period; 1,257 patients (i.e.49.41%) were due to two-wheeler accidents. Next is pedestrian (n=516, 20.2%), light motor vehicle (n=464, 18.23%), and heavy motor vehicle accidents contribute (n=307, 12.06%). Conclusions: lack of road driving sense and lack of knowledge of traffic rules. Regarding the type of vehicles involved in these accidents, the maximum number of accidents was due to two wheeler vehicles (scooter/motorcycle). Keywords: Two wheeler RTA, Stray animals, Rural RTA.
3.	**Fatal road traffic accident in motorcyclists not wearing helmets** Harnam Singh and Akash Deep Aggarwal	Researchgate, January 2011,Journal of Punjab Academy of Forensic Medicine and Toxicology 11(1):9-11	04 Cases of road accident deaths in motorcyclists were studied over a period of one year. Out of which 99 (95.2%) cases were males and 5 cases (4.8%) were females. Motorcyclists were the third commonest type of road users killed in traffic accidents accounting for 23.1% of all accident deaths. Majority of accidents occurred between 6-8 PM (16.3%) followed by 12-2 PM (14.4%). None of the victim was wearing helmet at the time of accident. The commonest age group involved was 21-30 years (48.9%). None of the victim was above age 60 years.

Literature Survey

Sl No	Author and Paper title	Details of Publication	Summary of the Paper
4.	**Deep Learning-Based Automatic Helmet Recognition for Two-Wheeled Road Safety** Maros Jakubec, Eva Lieskovska, Alexander Brezani, Jana Tothova	Published by Researchgate, January 2014 Medico-Legal Update 14(1):139 DOI:10.5958/j.0974-1283.14.1.034	The present study was conducted to know the patterns of accident and head injuries involving riders and pillion riders of two wheelers. This study was conducted from 1st April 2009 to 30th Sept 2010 at Victoria Hospital Mortuary, Bangalore. A total of 245 cases of deaths due to two wheeler accidents were reported for the autopsy. Riders constituted (76.33%) and pillion riders (23.67%). Most victims were male (87.75%), 20 to 39 years constitutes 70.20% of victims, most of the accidents have occurred during 6PM - 12midnight, Helmets used by the victims (64.17%), skull fractures (67.75%) were observed in the two wheeler accidental death. Subdural hemorrhage was the commonest intracranial hemorrhage and rib injuries were commonly associated with head injuries.
5.	**Deep Learning based smart traffic light system using Image Processing with YOLO v7** Mr Avinash Rangari and Mrs. Ashwini Chouthmol	1. S. A. Meshram and R. S. Lande, "Traffic surveillance by using image processing," 2018 International Conference on Research in Intelligent and Computing in Engineering (RICE), 2018, pp. 1-3, doi: 10.1109/RICE.2018.	Roadblocks increase mileage, increase transport costs, and pollute the air in addition to adding to the driver's stress and further delays. Therefore, we designed a smart traffic light management system employing the recently launched YOLO V7. The new version V7 of the YOLO algorithm outperforms all previous object detection models in both speed and accuracy. As it is the fastest and most accurate real-time object detection model hence it is the best algorithm to deploy in traffic controlling system. YOLO V7 is +120% faster than other previous models and shows the best speed to accuracy balance.
6.	**Traffic Surveillance Using Computer Vision and Deep Learning Methods** Harpreet Singh Bedi, Praveen Kumar Malik, Rajesh Singh, Ramendra Singh and Nitasha Bisht	IOP Conference Series: Earth and Environmental Science, Volume 1285, 1st International Conference on Sustainable Energy Sources, Technologies and Systems 2023 03/08/2023 - 05/08/2023 Phagwara, India	Traffic Surveillance using Computer Vision and Deep Learning, we propose a smart vision-based system which accurately provides live traffic statistics like the speed of the traffic and the count of Vehicles passed on a road in between a time interval. The system takes a video feed as an input, which could be live footage provided by a CCTV camera at a traffic junction, and on querying starting and ending timestamps, it outputs the count of the vehicles and speed of the traffic in between the queried timestamps. We divide this problem into two major sub-problems, firstly detecting a vehicle, followed by tracking the detected vehicle. Although there exist many algorithms for detecting objects as well as for tracking objects, one of the major problems is integrating both. As ambiguities like detecting an already detected vehicle, many occur while tracking the vehicles. In our work, we emphasize handling such ambiguities using Deep Learning and we also provide a comparative performance analysis of our system with the already existing ones.

Literature Survey

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7.	**YOLOV5 Based A Real Time Automatic Number Plate And Helmet Recognition System** S Maheswaran; N Indhumathi; S Deepan Kumar; G Murugesan; Prakash Duraisamy; S Nandita.	Wadare, Kiran & Sharma, Mr & Patil, Mrs.Sheetal & Bewoor, Mrs. Mrunal & Pawar, Avinash & Kadam, Amol & Patil, Suhas. (2023). Vehicle Number Plate Detection using YoloV8 and EasyOCR.14th ICCCNT IEEE Conference July 6-8, 2023 IIT - Delhi,Delhi.	This research aims to advance the field of automated vehicle identification through the development and evaluation of a sophisticated number plate detection system utilizing YOLOv8 and EasyOCR. The main goal is to use YOLOv8's strong object detection skills to precisely locate and identify car license plates in a variety of difficult-to-reach environments. Through the integration of EasyOCR, the study aims to improve the system's high precision and reliability in reading and interpreting alphanumeric characters from the identified number plates. The system's performance in real-world settings will be closely examined in this research, with an emphasis on how well it works with various plate designs, lighting setups, and environmental variables. The goal of this thorough assessment is to show how the system may significantly advance traffic management and automated vehicle identification technologies, which will ultimately improve automated monitoring and enforcement systems.
8.	**Helmet Detection and Number Plate Recognition** Tushar Kale, Alisha Dhavale, Aniket Randhavan, Mrs. V. S Inamdar	IJRASET,IJRASET52559,2023-05-19,2321-9653.	Developing countries have always relied on motorcycles as their primary mode of transportation, but unfortunately, the number of motorcycle accidents has been on the rise in recent years. One of the leading causes of fatalities in these accidents is the lack of helmet usage by motorcyclists. To ensure that motorcyclists wear helmets, traditional methods include manual monitoring by traffic police at intersections or the use of CCTV footage to identify those not wearing a helmet. However, these methods require significant human effort and intervention.
9.	**Enhanced Precision in Motorcycle Helmet Detection: YOLOv5 and Darknet Approach** Dr Ranjan Sarmah,Pranjit Lahon,Tazliqutddin Ahmed	Researchgate,July 2024,DOI:10.21203/rs.3.rs-4577583/v1, LicenseCC BY 4.0	In India, helmets symbolize safety and civic responsibility, bearing cultural significance. However, a 22% increase in accidents and a 17.5% rise in fatalities in 2022-23 underscore the critical importance of helmet compliance beyond legal mandates. Non-compliance not only elevates the risk of injuries and fatalities but also entails legal consequences. Notably, 47,000 Indians died in 2021 due to not wearing helmets, emphasizing the pivotal role of helmet usage in road safety. This research focuses on improving motorcycle helmet detection to ensure compliance and reduce the risk of fatal head injuries for riders, extending its impact beyond geographical limits.

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10.	**Vehicle Number Plate Detection using YoloV8 and EasyOCR** Mrs.Sheetal S. Patil,Dr. Suhas H. Pati,Dr. Avinash M.Pawar,Dr. Mrunal S.Bewoor,Dr. Amol K.Kadam,Dr.Uday C. Patkar,Mr. Kiran Wadare and Mr. Siddhant Sharma	The Institue of Engineering and technology (IET), **29 June 2021,** **https://doi.org/10.1049/ipr2.12295**	In traffic accidents, motorcycle accidents are the main cause of casualties, especially in developing countries. The main cause of fatal injuries in motorcycle accidents is that motorcycle riders or passengers do not wear helmets. In this paper, an automatic helmet detection of motorcyclists method based on deep learning is presented. The method consists of two steps. The first step uses the improved YOLOv5 detector to detect motorcycles (including motorcyclists) from video surveillance. The second step takes the motorcycles detected in the previous step as input and continues to use the improved YOLOv5 detector to detect whether the motorcyclists wear helmets. The improvement of the YOLOv5 detector includes the fusion of triplet attention and the use of soft-NMS instead of NMS.
11.	**AUTOMATIC NUMBER PLATE RECOGNITION SYSTEM** Anushka Dalvi ,Jasmine Fernandes, Christeen Toms ,Benzil Saju,Ujala Patil	International Journal of Creative Research Thoughts, 2024 IJCRT | Volume 12, Issue 4 April 2024 | ISSN: 2320-2882	Automatic Number Plate Recognition (ANPR) is a technology that detects number plates from images and uses optical character recognition to read them. Its primary aim is to accurately identify vehicle number plates aiding in vehicle tracking and traffic data collection while minimizing the need for direct driver interaction. It has various applications, including law enforcement, toll collection, parking management, and traffic monitoring. This technical report outlines the development, implementation, and evaluation of an ANPR system.
12.	**Edge-AI-Based Real-Time Automated License Plate Recognition System** Cheng-Jian Lin, Chen-Chia Chuang and Hsueh-Yi Lin	MDPI, Appl. Sci. 2022, 12(3), 1445; https://doi.org/10.3390/app12031445	The rapid development of urban intelligence has turned intelligent transport system (ITS) development into a primary goal of traffic management. Automated license plate recognition (ALPR) for moving vehicles is a core aspect of ITS. Most ALPR systems send images back to a server for license plate recognition. To reduce delays and bandwidth use during image transmission, this study proposes an edge-AI-based real-time ALPR (ER-ALPR) system, in which an AGX XAVIER embedded system is embedded on the edge of a camera to achieve real-time image input to an AGX edge device and to enable real-time automatic license plate character recognition.
13.	**License plate recognition system in unconstrained scenes via a new image correction scheme and improved CRNN** Zhan Rao, Dezhi Yang, Ning Chen, Jian Liu	Elseiver,Expert Systems with Applications Volume 243, 1 June 2024, 122878 ,https://doi.org/10.24433/CO.0006948.v1	The performance of current license plate recognition systems is significantly affected by large-angle deflection in unconstrained scenes. For addressing this issue, this paper develops a license plate recognition system via a new image correction scheme and an improved CRNN (Convolutional Recurrent Neural Network). In which, the yolov5l is firstly introduced for license plate detection, and it is trained by transfer learning in order to address insufficient data.

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14.	**YOLO-LHD: an enhanced lightweight approach for helmet wearing detection in industrial environments** Lianhua Hu,Jiaqi Ren	ORIGINAL RESEARCH article Front. Built Environ., 10 November 2023 Sec. Structural Sensing, Control and Asset Management Volume 9 - 2023 | https://doi.org/10.3389/fbuil.2023.1288445	Establishing a lightweight yet high-precision object detection algorithm is paramount for accurately assessing workers' helmet-wearing status in intricate industrial settings. Helmet detection is inherently challenging due to factors like the diminutive target size, intricate backgrounds, and the need to strike a balance between model compactness and detection accuracy. In this paper, we propose YOLO-LHD (You Only Look Once-Lightweight Helmet Detection), an efficient framework built upon the YOLOv8 object detection model. The proposed approach enhances the model's ability to detect small targets in complex scenes by incorporating the Coordinate attention mechanism and Focal loss function, which introduce high-resolution features and large-scale detection heads.
15.	**Camera-mounted Helmet detection with Yolo v8 on custom dataset** Adithya Krishna R,Sandeep P,Sonu P.	ACM Digital Library, DOI: https://doi.org/10.1145/3675888.3676032 IC3 2024: 2024 Sixteenth International Conference on Contemporary Computing (IC3-2024), Noida, India, August 2024	The model for naturally recognizing bikes and riders in rush hour gridlocks for distinguishing images between civilians riding wearing helmets and those who are not wearing helmets. Further, the model scans to detect if the rider who is wearing a helmet, is using a camera that is attached to the helmet which is an offence as it tampers with the original structure of the helmet. This is an offense and we are automating the detection of these offenses. The model is trained with a custom-labeled dataset to identify helmets and omits the result. An annotating bounding box is used to mark the detected objects and make an accurate prediction. The classified image is printed as the final result.
16.	**Research on the Application of Helmet Detection Based on YOLOv4** Yongze Ji1, Yu Cao1, Xu Cheng, Qiong Zhang	Scietific Research, August 2022, DOI: 10.4236/jcc.2022.108009	Helmets are one of the important measures to ensure the safety of construction workers. Because the harm caused by not wearing safety helmets as required is great, the wearing of safety helmets has also attracted more and more people's attention. At present, the main method of helmet detection is the YOLO series of algorithms. They often only focus on detection accuracy, ignoring the actual situation during deployment, that is, a balance between accuracy and speed is required. Therefore, this paper proposes a helmet detection application based on YOLOv4 algorithm, and combined with the MobileNet network, it has achieved good results in terms of detection accuracy and speed. Through transfer learning and tuning parameters, the mAP and FPS values detected in this paper on the public safety helmet datasets are 94.47% and 27.36%, which exceed the research work of some similar papers. This paper also combines YOLOv4 and MobileNetv3 networks to propose a mobileNet-based YOLOv4 helmet detection application. Its mAP and FPS values are 91.47% and 42.58%, respectively, which meet the accuracy and real-time requirements of current hardware deployment.

Literature Survey

Sl No	Author and Paper title	Details of Publication	Summary of the Paper
17.	**Advancing Road Safety: Helmet Detection with Artificial Intelligence** PrithvirajSingh Solanki	Researchgate,October 2024 DOI:10.70127/irjedt.vol.06.issue11.251	- The objective of the smart helmet is to provide a means and apparatus for detecting and reporting accidents. Sensors, and cloud computing infrastructures are utilised for building the system. The accident detection system communicates the accelerometer values to the processor which continuously monitors for erratic variations. When an accident occurs, the related details are sent to the emergency contacts by utilizing a cloud based service. The vehicle location is obtained by making use ofthe global positioning system
18.	**Konnect: An Internet of Things(IoT) based smart helmet for accident detection and notification** Sreenithy Chandran; Sneha Chandrasekar; N Edna Elizabeth	IEEE,2016 IEEE Annual India Conference (INDICON), DOI: 10.1109/INDICON.2016.7839052	The objective of the smart helmet is to provide a means and apparatus for detecting and reporting accidents. Sensors, Wi-Fi enabled processor, and cloud computing infrastructures are utilised for building the system. The accident detection system communicates the accelerometer values to the processor which continuously monitors for erratic variations. When an accident occurs, the related details are sent to the emergency contacts by utilizing a cloud based service. The vehicle location is obtained by making use of the global positioning system. The system promises a reliable and quick delivery of information relating to the accident in real time and is appropriately named Konnect. Thus, by making use of the ubiquitous connectivity which is a salient feature for the smart cities, a smart helmet for accident detection is built.
19.	**DETECTION AND CLASSIFICATION OF VEHICLES BY USING TRAFFIC VIDEO BASED ON YOLOV8** Ali Osman Gökcan and Resul Çöteli	Research gate, Conference: UMTEB - XIV International Scientific Research Congress - September 14-15, 2023,At: Naples, Italy,Volume: 530-538 PP	In this study, an adaptive traffic signalization method based on YOLOv8 (You Only Look Once), which is one of the CNN (convolutional neural network) architectures, is proposed instead of the fixed-duration traditional systems used in traffic signalization. The proposed method is based on computer vision with deep learning. Real traffic images from 10 different intersections were used for the training of the deep neural network. The image labeling process was done according to 7 classes created as car, bike, suv, van, bus, truck and person. The number of vehicles waiting at the red light was obtained by using the coordinate information of the bounding boxes belonging to the vehicles in the software prepared in Python programming language. The green light duration was calculated with the help of the vehicle numbers obtained from the classification and the scores assigned to the vehicle class. In this way, the green light duration is not fixed, but varies depending on the number of vehicles waiting at the intersection branches. The object detection and classification performance of the proposed method was obtained as 91%. It is predicted that with the proposed method, the waiting time at the red light, fuel consumption at the waiting moment, air pollution, stress level of drivers, accidents and many traffic problems will decrease.

Literature Survey

Sl No	Author and Paper title	Details of Publication	Summary of the Paper
20.	**Helmet Detection and Number Plate Recognition Using YOLOv8 and Tensorflow Algorithm in Machine Learning** Dipti Prajapati, Samishtarani Sabat,Sanika Bhilare,Rashmi Visheand Prof. Suman Bhujbal.	Dipti Prajapati, Samishtarani Sabat, Sanika Bhilare, Rashmi Vishe, Prof. Suman Bhujbal, Helmet Detection and Number Plate Recognition Using YOLOv8 and Tensorflow Algorithm in Machine Learning , International Journal of Innovative Research in Computer Science & Technology (IJIRCST) , Vol-12, Issue 2., March 2024, ISSN 2347 - 5552	The primary objective of this research paper is to develop and assess an advanced detection system utilizing YOLOv8 and TensorFlow for accurate helmet detection and number plate recognition.Through the use of the YOLOv8 model, the study seeks to maximize detection errors over a range of helmet kinds and situations while maintaining high recall and precision in the identification of helmets on persons. Meanwhile, the study concentrates on using TensorFlow to improve car number plate recognition, incorporating OCR to accurately read and understand alphanumeric letters in a variety of scenarios. In order to make the system appropriate for real-world uses in safety enforcement and traffic monitoring, the study also attempts to verify the system's real-time processing capability.

Summary of Literature Survey

The summary of research explores the development of a robust, real-time traffic monitoring system focused on detecting helmets on motorcyclists and recognizing vehicle number plates using advanced computer vision and deep learning techniques. Leveraging the **YOLOv8 framework, known for its high precision and real-time processing capabilities**, the system is designed to address traffic safety and law enforcement challenges effectively.

Key Objectives and Features:

1. **Helmet Detection**:The system ensures high precision in identifying the presence or absence of helmets on motorcyclists, crucial for **promoting safety compliance**. Using fine-tuned YOLOv8 models, the detection is reliable across diverse conditions, including different helmet types, lighting variations, and occlusions.
2. **License Plate Recognition**:Incorporating OCR techniques, the system achieves **consistent recognition of number plates**, regardless of the **angle or lighting conditions**. This includes accurate alphanumeric character extraction for actionable insights.
3. **Real-Time Processing**:Designed for **continuous traffic monitoring**, the system processes live video feeds to deliver **timely detections** of violations. Its minimal latency ensures swift identification and reporting of traffic offenses, aiding **real-time law enforcement**.
4. **Actionable Output Generation**:The system generates **detailed outputs**, including violation alerts and annotated images, enabling authorities to strengthen traffic law enforcement. The generated data supports a range of legal and administrative actions, such as issuing fines or investigating accidents.
5. **Scalability and Adaptability**:Designed with **scalability** in mind, the solution is applicable across diverse environments, from **urban intersections to rural highways**. Its adaptability to varying road and traffic conditions enhances its usability for global traffic management systems.
6. **Optimization for Efficiency**:The framework emphasizes **low computational overhead**, ensuring that the system operates with **minimal latency** while maintaining high accuracy.

Requirement Analysis – Hardware Specification

1. Computing Device

- Option 1: Personal Computer/Workstation
  - Processor: Intel Core i5/i7 or AMD Ryzen 5/7 (or higher)
  - GPU: NVIDIA GTX 1660 Ti, RTX 3060, or better (for training/inference acceleration)
  - RAM: Minimum 16 GB (32 GB preferred for smoother operations)
  - Storage: SSD with at least 256 GB for the operating system and tools; an additional 1 TB HDD/SSD for datasets.
- Option 2: Laptop
  - High-performance laptops with dedicated GPUs (e.g., NVIDIA RTX 30 series).
- Option 3: Edge Devices (for deployment)
  - NVIDIA Jetson Nano, Xavier NX, or Orin for edge-based deployment.

2. Camera

- Resolution: Minimum 1080p; higher resolutions (e.g., 4K) can enhance detection accuracy.
- Frame Rate: 30 FPS or higher for real-time detection.
- Connectivity: USB, IP, or CSI interface depending on deployment.

3. Power Supply

- Stable power source with backup (e.g., UPS) for uninterrupted processing.

4. Networking

- Reliable internet connectivity for software updates, data uploads, or cloud processing.

5. Optional Peripherals

- Microphone (for voice-enabled features if needed).
- Edge computing devices (e.g., Raspberry Pi 4 for lightweight deployment alongside an accelerator like Google Coral or Intel Movidius).

Requirement Analysis – Software Specification

1. Operating System

- Windows 10/11 (64-bit) or Linux (Ubuntu 20.04 LTS or later) for development and training.
- Linux-based OS recommended for deployment on edge devices.

2. Programming Environment

- Python Version: 3.8 or later.

3. Deep Learning Frameworks

- PyTorch 2.0 or later (YOLOv8 is PyTorch-based).
- TensorFlow (optional for preprocessing or supporting features).

4. Object Detection Framework

- YOLOv8 from the [Ultralytics GitHub repository](https://github.com/ultralytics/ultralytics).

5. Additional Python Libraries

- Machine Learning: OpenCV, NumPy, Matplotlib, Pandas, Scikit-learn.
- Image Processing: PIL (Pillow), Albumentations.
- Visualization: Seaborn, Plotly.
- Deployment: Flask/FastAPI (for creating APIs), Streamlit (for creating dashboards).

6. Development Tools

- Code Editor: Visual Studio Code, PyCharm, or Jupyter Notebook.
- Version Control: Git and GitHub/Bitbucket/GitLab for collaboration.

7. Dataset Management

- Annotation Tools: Roboflow, LabelImg, or CVAT for labeling the dataset.
- Dataset Sources: Custom datasets (manually collected or augmented) or open datasets.

System architecture

1. Input Layer

- Source:
  - Live video feed from a camera (CCTV, IP camera, or USB webcam).
  - Pre-recorded video or images from local or cloud storage.
- Preprocessing:
  - Resizing and normalization of input frames.
  - Frame extraction (if video input).

2. Detection Layer

- Object Detection Model:
  - YOLOv8 model trained for:
    - Detecting helmets on riders.
    - Detecting and recognizing vehicle number plates.
- Key Components:
  - Model Inference: Runs the YOLOv8 model on input frames.
  - Hardware Acceleration: Uses GPU/TPU for faster inference.
- Outputs:
  - Bounding boxes with object labels (e.g., "Helmet", "No Helmet", "Number Plate")
  - Confidence scores for each detection.

System architecture

3. Post-Processing Layer

- Filtering:
  - Removes detections below a confidence threshold.
- Annotation:
  - Draws bounding boxes and labels on frames for visualization.
- OCR (for Number Plate):
  - Optical Character Recognition (OCR) extracts text from detected number plates.
  - Tools: Tesseract OCR or Deep Learning-based OCR (e.g., EasyOCR).

4. Decision Layer

- Helmet Detection Logic:
  - Identifies riders without helmets.
  - Flags violations for further action.
- Number Plate Recognition:
  - Cross-verifies number plates with a database (e.g., registered vehicles, blacklist).
- Violation Reporting:
  - Logs violations with rider images, timestamps, and extracted number plate text.

System architecture

5. Output Layer

- User Interface (UI):
  - Displays processed frames in real-time with annotated detections.
  - Tools: OpenCV (for local display), Streamlit or Flask (for web-based UI).
- Alerts and Actions:
  - Sends violation alerts (e.g., SMS, email).
  - Stores violation data in a database.
- Reports:
  - Generates periodic reports for authorities (e.g., logs of helmet violations, number plates).

6. Storage Layer

- Database:
  - Stores logs of violations, including:
    - Images of violations.
    - Number plate details.
    - Timestamps and metadata.
  - Options: MySQL, PostgreSQL, or MongoDB.
- Data Backup:
  - Cloud storage for long-term archival.

System architecture

7. Deployment Layer

- Local Deployment:
  - Real-time processing on edge devices like NVIDIA Jetson Nano or a GPU-enabled workstation.
- Cloud Deployment:
  - Process video streams via cloud servers for scalability.
  - Use platforms like AWS or Google Cloud for hosting the YOLOv8 model and database.
- Hybrid Deployment:
  - Process inference on the edge device and offload storage or complex tasks (e.g., OCR) to the cloud.

Methodology

1. Problem Definition

- Objective:
  - Detect whether riders are wearing helmets.
  - Detect and recognize vehicle number plates.
- Scope:
  - Real-time monitoring or offline processing of video streams.
  - Generation of actionable insights for traffic law enforcement.

2. Data Collection and Preparation

- Dataset Collection:
  - Helmet Detection:
  - Images/videos of motorbike riders with and without helmets.
  - Number Plate Detection:
    - Images/videos of vehicles with clearly visible number plates.
    - Diverse conditions (day/night, varying weather, different camera angles).
- Data Sources:
  - Open datasets (e.g., Roboflow, Kaggle).
  - Custom datasets captured from cameras or public footage.

Methodology

- Data Annotation:
  - Label bounding boxes for:
    - Riders wearing helmets.
    - Riders without helmets.
    - Number plates.
  - Tools: LabelImg, Roboflow, or CVAT.
- Data Augmentation:
  - Apply transformations to increase dataset diversity:
    - Rotation, scaling, flipping, brightness/contrast adjustments, and noise addition.

3. Model Development

- YOLOv8 Model Training:
  - Pre-trained Weights:
    - Use pre-trained YOLOv8 weights for faster training (transfer learning).
  - Custom Training:
    - Train on annotated dataset for helmet and number plate detection.
  - Hyperparameter Tuning:
    - Batch size, learning rate, confidence threshold, and IoU threshold.

Methodology

- Evaluation Metrics:
  - Precision, Recall, mAP (mean Average Precision), and F1 score.
- Iteration:
  - Optimize model by fine-tuning hyperparameters and retraining.

4. Post-Processing

- Helmet Detection:
  - Use detected bounding boxes to classify:
    - "Helmet" vs. "No Helmet".
- Number Plate Recognition:
  - Apply OCR (e.g., Tesseract or EasyOCR) on detected number plate regions.
    - Preprocess the plate region for OCR accuracy (grayscale, thresholding).

5. System Integration

- Pipeline Development:
  - Integrate YOLOv8 model into a pipeline:
    - Input: Camera feed or stored video.
    - Processing: Detection and classification.
    - Output: Annotated frames and violation data.

Methodology

- Database Integration:
  - Store detected violations and number plates in a database for later analysis.
- Alert System:
  - Notify relevant authorities in real-time via:
    - SMS, email, or system dashboard.

6. Deployment

- Deployment Environment:
  - Local: On a GPU-enabled system or edge device (e.g., NVIDIA Jetson Nano).
  - Cloud: For scalability and accessibility.
  - Hybrid: Local inference with cloud-based storage and advanced processing.
- Optimization:
  - Quantize the YOLOv8 model for edge devices (using TensorRT or ONNX).

7. Testing and Validation

- Real-world Scenarios:
  - Evaluate performance in varying lighting, angles, and traffic conditions.

Methodology

- Metrics:
  - Analyze detection speed, accuracy, and false positive/negative rates.
- User Feedback:
  - Gather feedback from traffic enforcers or system users for improvements.

8. Maintenance and Upgrades

- Regular Updates:
  - Update the model with new data to handle edge cases and improve accuracy.
- Scalability:
  - Enhance system to handle higher traffic volumes or integrate additional features (e.g., speed detection, vehicle classification).

Module 8A: Data collection and preprocessing

Input -

- The input data needs to be collected in real-time and should consist of videos and images of riders in traffic junctions in varying light conditions, weather conditions and traffic density levels.
- Some example data sources could be traffic surveillance systems, publicly available datasets and custom captured data or videos.

Process -

- Data annotation is widely important and can be performed by using tools like RoboFlow which wide range of annotation formats.
- It needs to be ensured that the data should have even balance of all the annotation classes i.e. 'Helmet', 'No Helmet', 'Rider' and 'Number Plate'.
- There should be an exclusion of blurred and noisy images. An alternative could also be to process that image under denoising and deblurring by applying certain image processing techniques.
- Image resizing is also important so that the YOLO model does not face any issues with input dimensions.

Output -

- Provides us with a preprocessed dataset with annotations and image resized with normalized pixel values according to YOLO compatibility.

Module 8B : Implementation of ANN/DL algorithm

Input -

- Resized images with annotated bounding boxes for helmets and number plates in YOLO format
- The model architecture is YOLO v8 having hyperparameters such as learning rate, batch size and number of epochs.
- There is a requirement for GPU enabled system for training and frameworks involve PyTorch or TensorFlow.

Process -

- In this process for object detection we need to use YOLOv8 for which we can train a model on this preprocessed dataset and load the trained weights in COCO format to leverage transfer learning.

- **Model architecture overview -**

1. In the backbone layer, extracts features from input images which uses CSPDarknet.
2. In the neck layer, aggregates feature maps of different resolutions to detect objects at varying scales.
3. In the head layer, which outputs bounding boxes, class probabilities and confidence scores.

Module 8B : Implementation of ANN/DL algorithm

Process -

- **Implementation of architecture-**

1. It is important to use frameworks like PyTorch and TensorFlow and libraries like Ultralytics which is useful for YOLO.
2. We need to define certain loss functions i.e bounding box loss and classification loss.
3. In the training loop also it is very important to monitor the metrics such as mAP and precision in every epoch training.

Output-

- One of the outputs is definitely the trained YOLOv8 DL model for detection of helmets and number plates.
- Performance metrics such as mAP, precision and recall after every epoch training.
- Annotated images/video demonstrating the model’s performance in real-world traffic scenarios.

Module 8C : Testing and Validation

Input -

- The trained model whose final weights of the trained YOLO v8 model for loading of the model.
- A dataset separate from the training dataset which contains annotated images and videos with proper preprocessing and normalization applied.

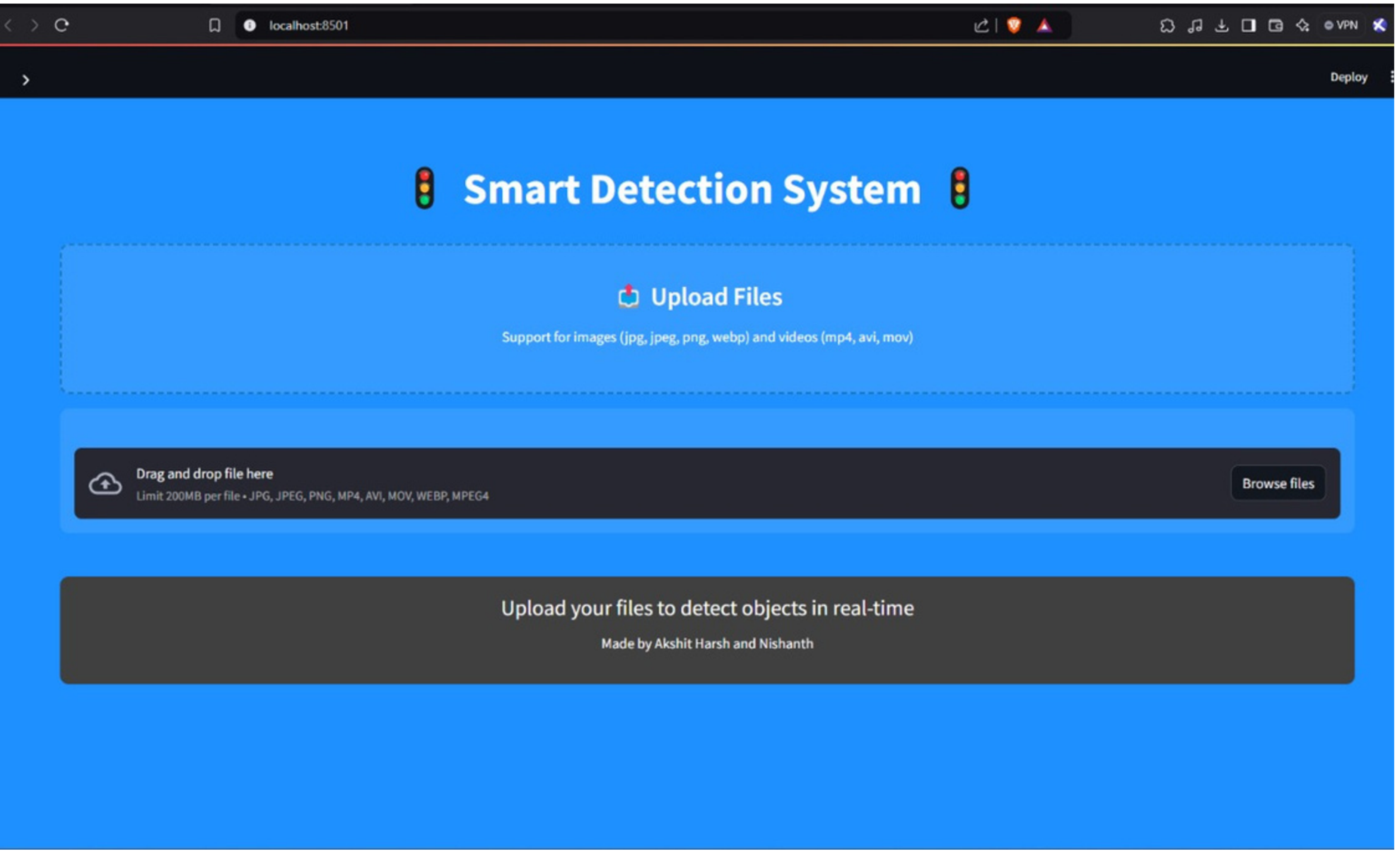
Process -

- Loading the model and using the data loader to iterate over the validation and testing dataset.
- Computing of the precision, recall and F1 score for 'Helmet' and 'No helmet'.
- Make use of confusion matrices to visualize results.
- Calculation of Intersection over Union(IoU) for bounding box accuracy.
- Compare predicted outputs with ground truth to identify patterns in errors.

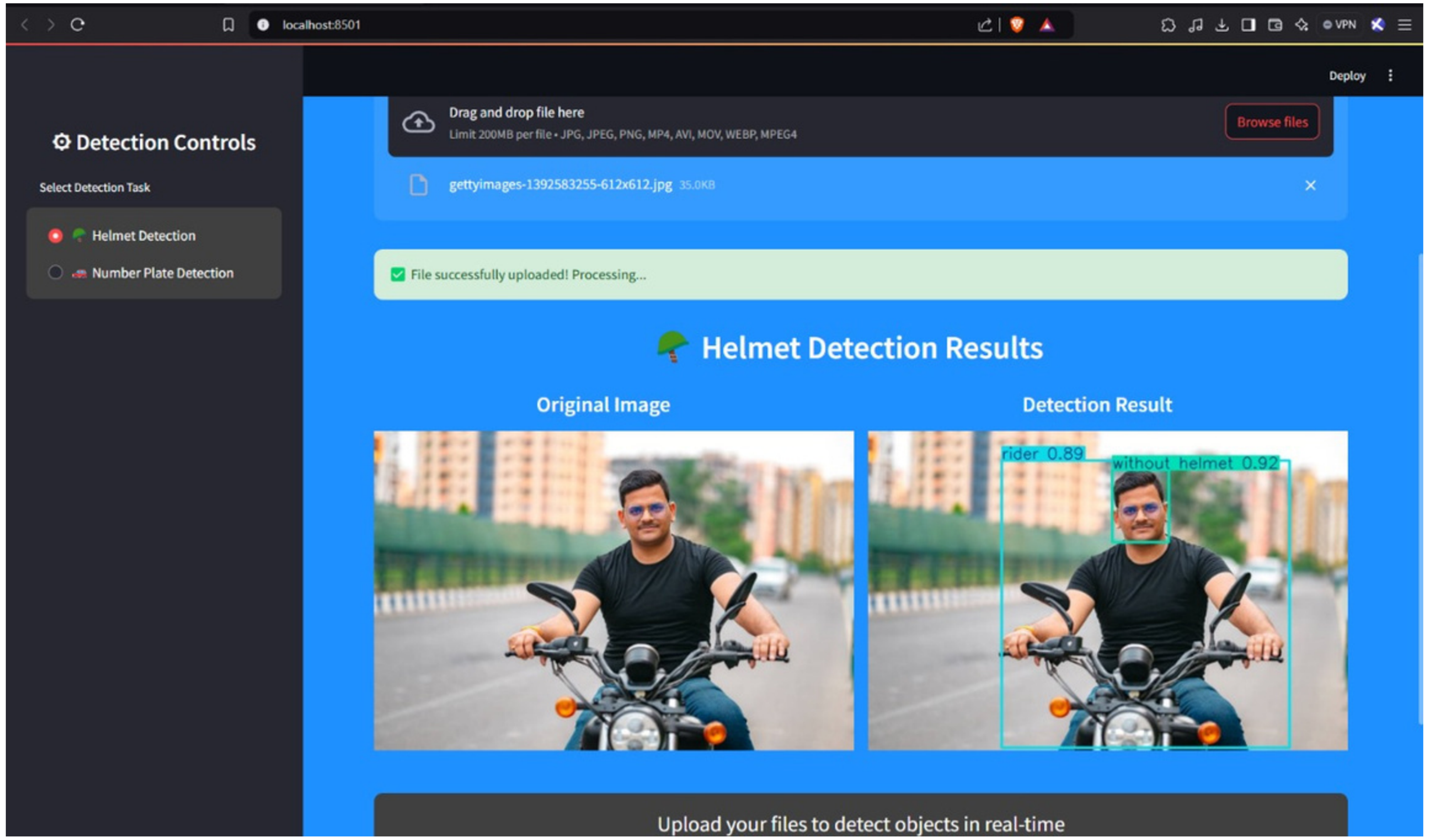
Output -

- Highlighting of validation and test results in terms of mAP, precision, recall and F1 score.
- Images with predicted bounding boxes and class labels showing correct decisions and highlighting errors.

Results:

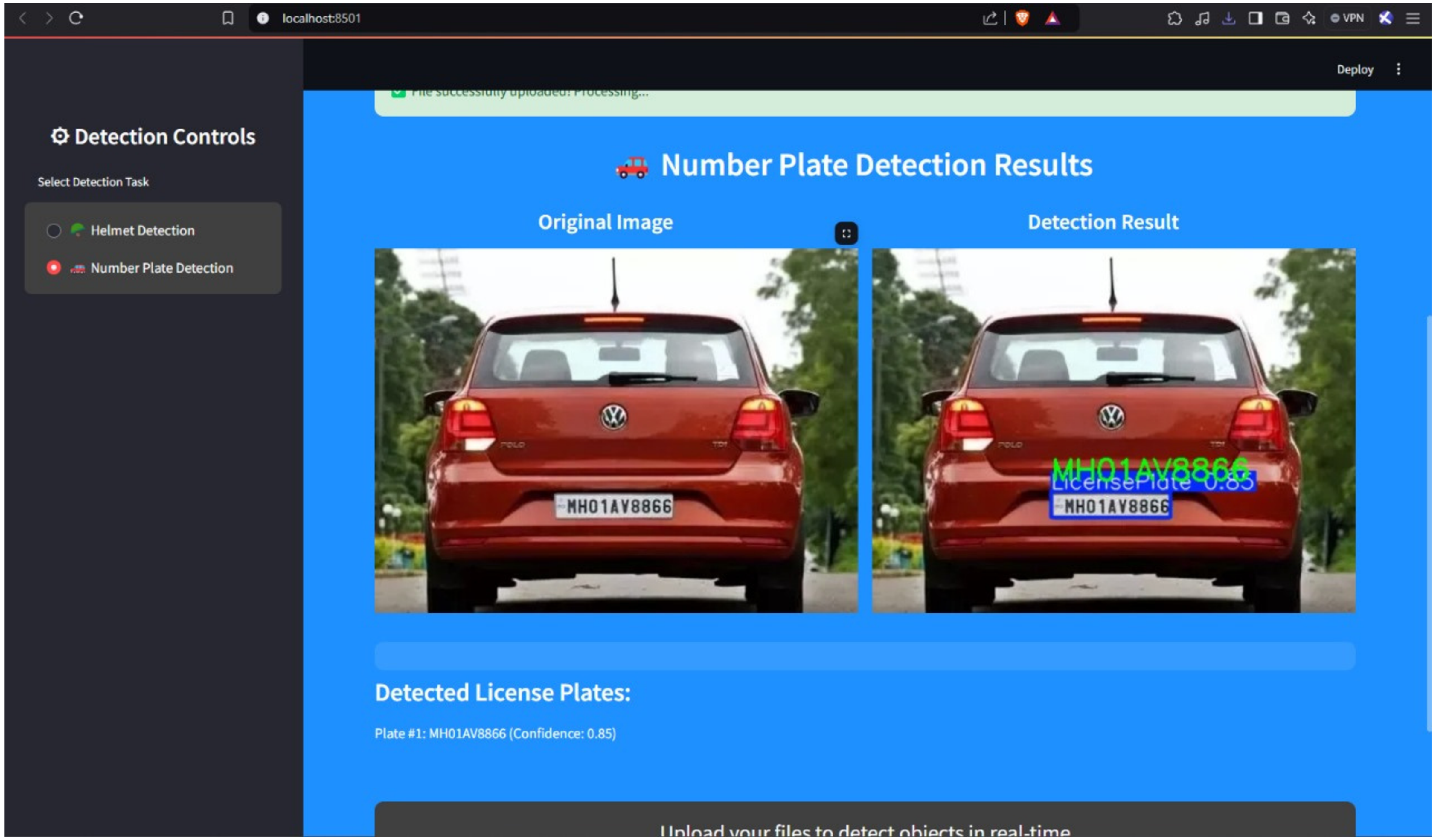


Home page



Helmet Detection Output

Results:



Number Plate Detection Output

Conclusion:

- **Effective Safety Enforcement:** The system ensures real-time detection of helmet violations and accurate number plate recognition for improved traffic law enforcement.
- **High Accuracy & Recall:** YOLOv8 enhances helmet detection across diverse scenarios, while OCR ensures reliable number plate recognition.
- **Robust Pipeline:** Seamless integration of detection models, database storage, and alert mechanisms for automated violation tracking.
- **Scalable & Deployable:** Adaptable for local (edge devices) or cloud-based deployments, ensuring accessibility and efficiency.
- **Continuous Improvement:** Regular updates and model retraining enhance performance, addressing real-world challenges and increasing accuracy over time.

Future works:

- **Edge Device Integration for RV College:** Deploy the system on edge devices (e.g., NVIDIA Jetson Nano) using a dataset collected from RV College to enable real-time helmet and number plate detection within the campus, ensuring efficient and localized processing.

- **Accuracy Enhancement & Advanced Alert System:** Improve detection accuracy through better model training, enhanced OCR techniques, and refined data preprocessing. Integrate an automated alert system to notify authorities instantly via SMS, email, or dashboard notifications for prompt action.

THANK YOU