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# Helmet and Triple Seat Detection with Number Plate Extraction for Motorcyclists using Advanced Deep Learning Techniques

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**Abstract:** *This abstract presents a novel approach for detecting helmets and triple seat violations, as well as extracting number plates, to enhance the safety and compliance of motorcyclists. The proposed method leverages advanced deep learning techniques to accurately identify helmets and triple seat riders in real-time video footage. Additionally, it employs number plate extraction to enable automated monitoring and identification of motorcycles. The system utilizes a combination of convolutional neural networks (CNNs) and object detection algorithms to achieve high detection accuracy. Experimental results demonstrate the effectiveness of the proposed approach in detecting helmet and triple seat violations, as well as extracting number plates with remarkable precision. The developed system holds great potential for improving road safety by enabling automated monitoring and enforcement of traffic regulations for motorcyclists.*

**Keywords:** Helmet detection, triple seat detection, number plate extraction, motorcyclists, deep learning techniques, convolutional neural networks, object detection, road safety, automated monitoring, traffic regulations.

## I. INTRODUCTION

Ensuring the safety and compliance of motorcyclists on the roads is a critical concern for traffic authorities worldwide. Helmet usage and adherence to single-seat riding are vital factors in reducing the risk of severe injuries and fatalities. Additionally, enforcing regulations regarding proper vehicle identification through number plates is essential for law enforcement and maintaining road order. Manual monitoring of these factors can be time-consuming, inefficient, and prone to human error. Therefore, there is a growing need for automated systems that can accurately detect helmet and triple seat violations, as well as extract number plates, using advanced deep learning techniques.

In recent years, deep learning has emerged as a powerful tool for object detection and recognition tasks in various domains. Convolutional neural networks (CNNs), a popular deep learning architecture, have shown remarkable performance in detecting and classifying objects within images and videos. By leveraging the capabilities of CNNs and other advanced deep learning techniques, it is possible to develop robust systems capable of real-time monitoring and enforcement.

## II. LITERATURE SURVEY

Literature Survey is an important phase in the system development life cycle as we collect and acquire the necessary information to handle or develop a project during this phase. A literature review is a description of the literature relevant to particular field or topic. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypothesis and what methods and what methodologies are appropriate and useful.

In this project research is done prior to taking up the project and understanding the various methods that were used previously. A detailed analysis of the existing systems was performed. This study helped to identify the benefits and drawbacks of the existing systems.

Y. Kulkarni, S. Bodkhe, A. Kamthe and A. Patil, "Automatic number plate recognition for motorcyclists riding without helmet". Number Plate recognition and extraction should be done and incorporated with the officers.

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M. Darji, J. Dave, N. Asif, C. Godawat, V. Chudasama and K. Upla, "Licence Plate Identification and Recognition for Non-Helmeted Motorcyclists using Light-weight Convolution Neural Network. The model detects more efficiently on the clear images. More complex data should be fed to test the performance.

A. M. Vakani, A. Kumar Singh, S. Saksena and V. H. R., "Automatic License Plate Recognition of Bikers with No Helmets". Further research can be carried out to make the system work with different camera angles, and detect unsafe helmet designs that are not approved by the Police.

K. Han and X. Zeng, "Deep Learning-Based Workers Safety Helmet Wearing Detection on Construction Sites Using Multi-Scale Features".Collecting more safety helmet wearing and person images on different occasions to enhance the robustness and popularity of the model.

Afzal, Adil &Umer, Hafiz & Khan, Zeeshan & Khan, Muhammad Usman. (2021). Automatic Helmet Violation Detection of Motorcyclists from Surveillance Videos using Deep Learning Approaches of Computer Vision.Focus on generated more dataset from the complex scenario of traffic and also work on Number plate extraction.

K. Dahiya, D. Singh and C. K. Mohan, "Automatic detection of bike-riders without helmetusing surveillance videos in real-time,". Focus on generated more dataset from the complex scenario of traffic and also work on Number plate extraction.

## III. APPLICATIONS

- Traffic Law Enforcement: The developed system can be used by traffic authorities to enforce helmet usage and single-seat riding regulations among motorcyclists. By automatically detecting violations in real-time, law enforcement agencies can efficiently identify non-compliant riders and take appropriate actions, such as issuing fines or warnings.
- Road Safety Campaigns: The system can be employed in road safety campaigns to raise awareness about the importance of wearing helmets and following single-seat riding rules. By showcasing real-time helmet and triple seat detection, the system can visually demonstrate the potential risks and dangers associated with non-compliance, thereby promoting safer riding habits.
- Accident Prevention: Accurate detection of helmet usage and single-seat violations can contribute to accident prevention. By identifying riders who fail to wear helmets or carry additional passengers, authorities can intervene promptly, ensuring that motorcyclists adhere to safety measures. This proactive approach can help reduce the occurrence of accidents and minimize the severity of injuries.
- Traffic Surveillance Systems: Integrating the proposed system into existing traffic surveillance networks can enhance overall monitoring capabilities. By automatically extracting number plates, the system can provide a comprehensive record of motorcycle movements, aiding in identifying stolen or suspicious vehicles. This can assist law enforcement agencies in investigating criminal activities and improving overall traffic management.
- Research and Data Analysis: The collected data from the system, such as helmet usage rates, triple seat violations, and number plate records, can be valuable for research and data analysis purposes. Researchers can utilize this data to gain insights into rider behavior, evaluate the effectiveness of helmet usage campaigns, and identify trends or patterns that can inform policy-making and future safety initiatives.

## IV. PROPOSED SYSTEM MODEL

To develop an intelligent system for helmet detection, number plate extraction, and triple seat detection, we designed a comprehensive framework. The proposed system consists of two main components: hardware and software. The hardware part includes a video surveillance network and a GPU high-performance image processor. The video surveillance network captures the video stream data from the construction site, which is then sent to the GPU image processor for real-time image processing. The software part comprises the front-end user interface created using Tkinter and the back-end algorithms implemented using the YOLOv5 darknet repository and Plate Recognizer API. The software processes the video and images obtained from the hardware component to detect helmets, extract number plates, and identify triple seat violations. The recognition results are displayed on the user interface. We have an admin UI where we can see the voilation detected and then the challan can be generated.

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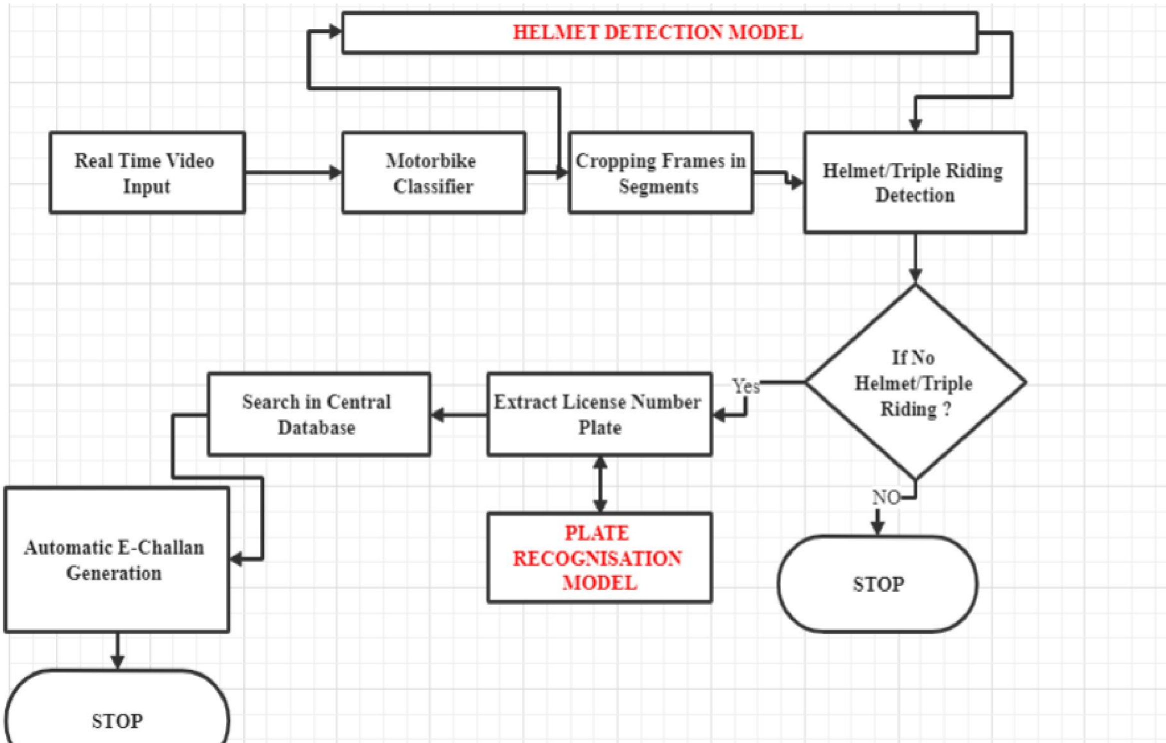


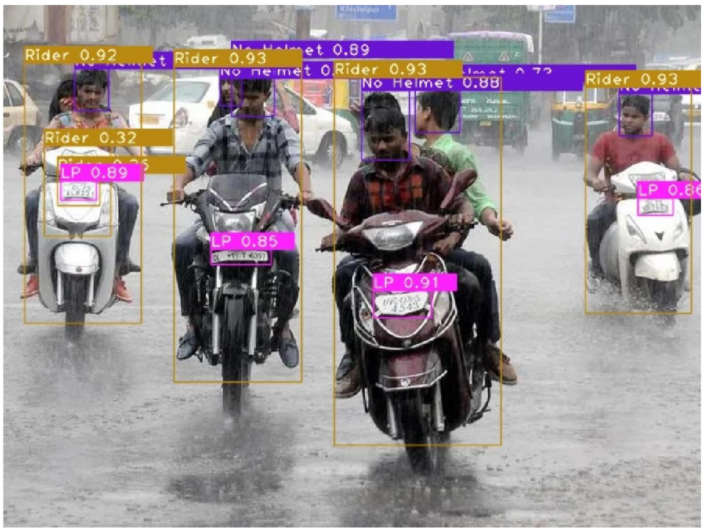

Fig. Helmet Detection and Number Plate Extraction System

### 4.1 Helmet Detection

For the task of helmet detection and triple seat detection, we employed the YOLOv5 object detection algorithm. The video frames or images were fed into the YOLOv5 detector, which utilizes a deep neural network architecture to detect and locate helmets and triple seat violations. The YOLOv5 model was trained on a labeled dataset containing annotated images of helmets and triple seat violations. The algorithm outputs the bounding boxes and corresponding class labels for the detected objects, indicating whether a helmet is present or if a triple seat violation is detected.

| | Type | Filters | Size | Output |
|---|---|---|---|---|
| | Convolutional | 32 | 3 × 3 | 256 × 256 |
| | Convolutional | 64 | 3 × 3 / 2 | 128 × 128 |
| 1× | Convolutional | 32 | 1 × 1 | |
| | Convolutional | 64 | 3 × 3 | |
| | Residual | | | 128 × 128 |
| | Convolutional | 128 | 3 × 3 / 2 | 64 × 64 |
| 2× | Convolutional | 64 | 1 × 1 | |
| | Convolutional | 128 | 3 × 3 | |
| | Residual | | | 64 × 64 |
| | Convolutional | 256 | 3 × 3 / 2 | 32 × 32 |
| 8× | Convolutional | 128 | 1 × 1 | |
| | Convolutional | 256 | 3 × 3 | |
| | Residual | | | 32 × 32 |
| | Convolutional | 512 | 3 × 3 / 2 | 16 × 16 |
| 8× | Convolutional | 256 | 1 × 1 | |
| | Convolutional | 512 | 3 × 3 | |
| | Residual | | | 16 × 16 |
| | Convolutional | 1024 | 3 × 3 / 2 | 8 × 8 |
| 4× | Convolutional | 512 | 1 × 1 | |
| | Convolutional | 1024 | 3 × 3 | |
| | Residual | | | 8 × 8 |
| | Avgpool | | Global | |
| | Connected | | 1000 | |
| | Softmax | | | |

Table 1. **Darknet-53.**




**Framework**: The Darknet framework is a fast and efficient open-source neural network framework implemented in C and CUDA. It utilizes the YOLO (You Only Look Once) algorithm for object detection. Our project customizes Darknet for motorcycle detection, helmet detection, and license plate recognition. In our implementation, the

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motorcycle image is divided into three frames: one for the complete motorcycle, one for the upper part for helmet detection, and one for the lower part for license plate recognition. This approach allows for accurate analysis of specific regions of interest. By leveraging Darknet's speed and flexibility, we enhance the detection accuracy and efficiency of helmets and license plates in the context of motorcycles. Our customized framework is designed to support both CPU and GPU computation, ensuring compatibility and performance. Overall, our adapted Darknet framework optimizes motorcycle detection and enables precise analysis of helmets and license plates with minimal computational overhead.

**4.2 Plate Extraction:**

To extract the number plates from the detected vehicles, we utilized the Plate Recognizer API. The API takes the cropped vehicle images containing the detected number plates as input and performs optical character recognition (OCR) to extract the alphanumeric characters from the plates. The Plate Recognizer API utilizes pre-trained deep learning models specifically designed for license plate recognition. The extracted number plate information, such as the alphanumeric characters and any additional metadata, is returned by the API.


**4.3 Triple Seat Detection:**

In the case of triple riding detection, the system processes live camera feed and identifies relevant objects like bikes and persons. By employing the Intersection over Union (IoU) function, the system determines the relationship between detected persons and the motorbike, specifically labeling rectangular bounding boxes with triple riding violations. Overall, the system effectively uses deep learning techniques, the Darknet framework, and YOLOv3 algorithm to accurately detect and classify objects. It supports various input types and applies target regression, non-max suppression, and IoU analysis to successfully identify instances of triple riding.

**4.4 E-Challan Generation**:

To generate an e-challan and send it to the owner of the bike via email using the Simple Mail Transfer Protocol (SMTP), the following steps can be implemented:

Once a triple riding violation is detected, the system captures the relevant images containing the violation details, such as the triple riding scenario and the license plate of the motorcycle.The system extracts the necessary information from the images, including the license plate number and location of the violation.The e-challan includes details such as the violation type (triple riding), the fine amount along whith the violation detected images.

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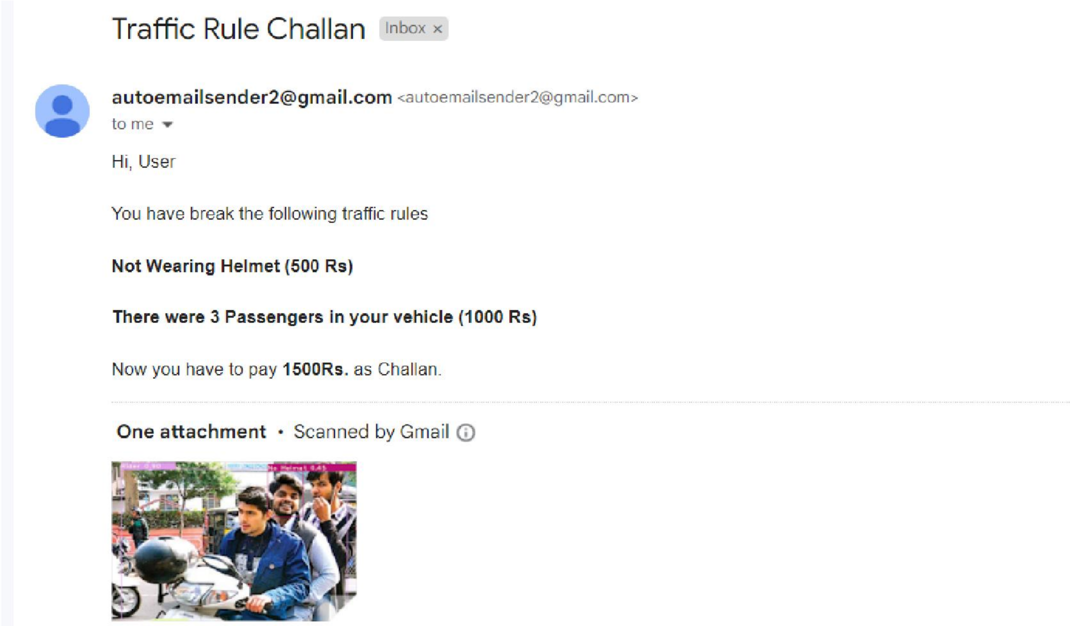


### 4.5 Dataset

To train and evaluate our system, we collected a diverse dataset consisting of images captured from various scenarios, including urban environments, highways, and rural areas. The dataset includes annotated images with bounding boxes for helmets, number plates, and triple seat instances. We ensured that the dataset covered a wide range of lighting conditions, weather conditions, and variations in object appearance. The dataset consist of 600 training images and 200 testing images. The images are labelled into four different classes as Rider, Number Plate, Helmet and No helmet.

**YOLOV5**:

YOLOv5 is an object detection algorithm that builds upon the previous versions of YOLO (You Only Look Once) algorithms. It is designed to accurately and efficiently detect objects in images or videos. YOLOv5 has gained popularity due to its improved performance and streamlined architecture.

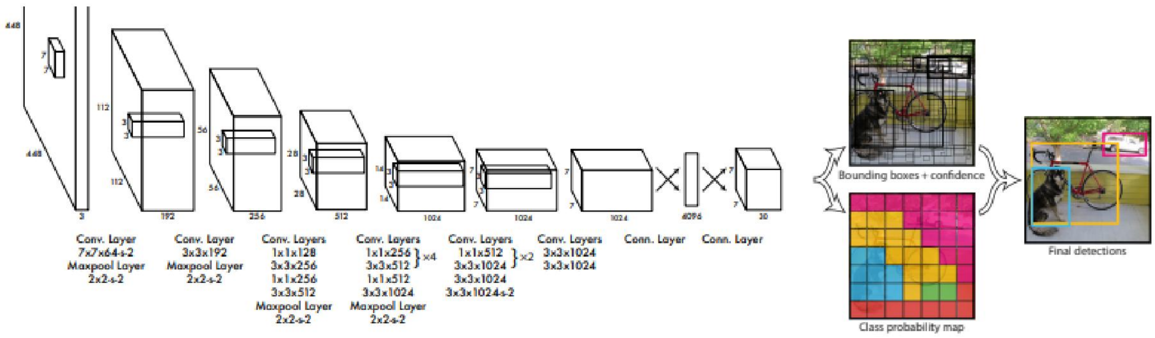


Fig YOLO architecture

Unlike traditional object detection methods that involve separate stages for region proposal and classification, YOLOv5 performs object detection in a single pass. It divides the input image into a grid and predicts bounding boxes and class probabilities for each grid cell. This approach enables YOLOv5 to achieve real-time object detection with high accuracy. The architecture of YOLOv5 consists of a backbone network that extracts features from the input image, followed by several detection heads that predict bounding boxes and class probabilities. The backbone network is typically a convolutional neural network (CNN) such as Darknet or CSPDarknet.These networks are pretrained on large-scale datasets and can capture meaningful features from images. YOLOv5 introduces a lightweight and efficient

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architecture, making it suitable for deployment on various platforms, including CPUs and GPUs. It supports different model sizes (e.g., small, medium, large) to balance between accuracy and computational efficiency based on specific application requirements.

## V. RESULTS AND ANALYSIS

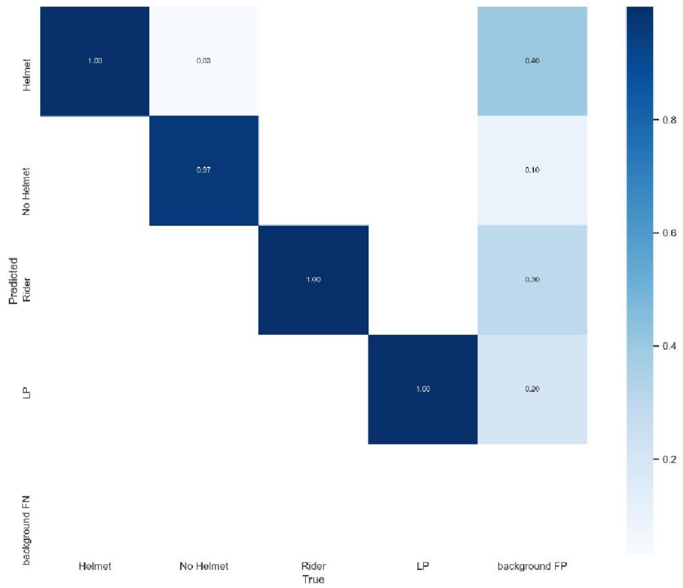
This section presents the results and analysis of the object detection system based on YOLOv5. The performance evaluation of the system includes precision, recall, PR curve, F1 curve, and label correlation metrics.

### 5.1 Evaluation Metrics

The evaluation of the system yielded the following metrics:

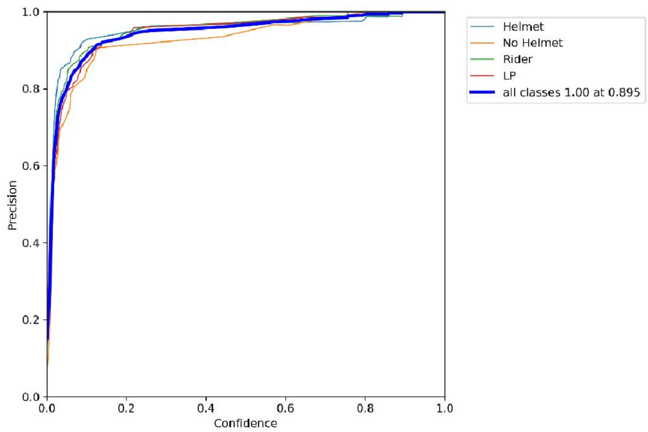
### 5.2 Confusion Matrix:

The confusion matrix provides a detailed breakdown of the system's performance in terms of true positives, true negatives, false positives, and false negatives.




### 5.3 Precision Curve:

Analyzing the precision-to-confidence curve, it is evident that precision gradually increases as the confidence threshold rises. This indicates that higher confidence thresholds result in more accurate predictions with fewer false positives. The curve provides a clear understanding of how precision varies with the confidence threshold.



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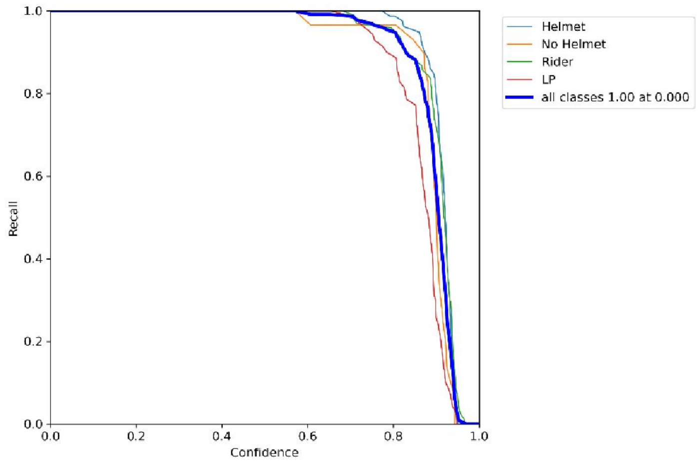
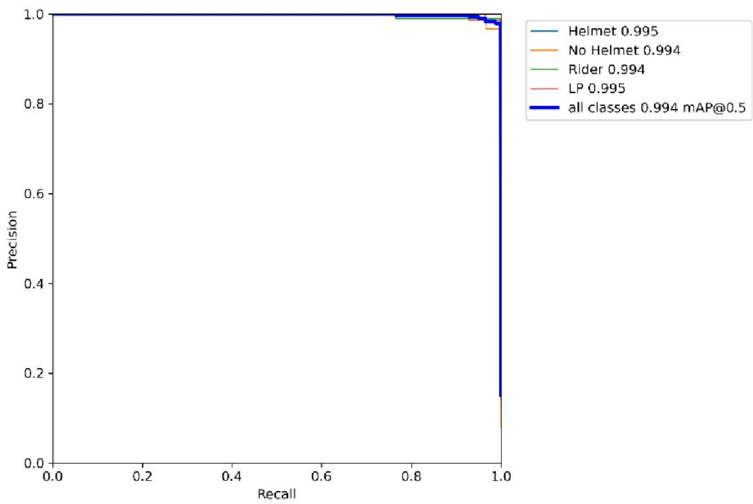
**5.4 Recall Curve**:

Analyzing the recall-to-confidence curve, it is observed that recall gradually decreases as the confidence threshold increases. This implies that higher confidence thresholds lead to a higher number of false negatives and a lower recall rate. The curve provides valuable insights into how recall is affected by the confidence threshold.




**5.5 PR Curve**

The precision-recall (PR) curve provides insights into the trade-off between precision and recall at different confidence thresholds. The generated PR curve fig illustrates this trade-off.




Analyzing the PR curve, it is observed that as the confidence threshold increases, precision tends to increase while recall decreases. This behavior suggests that higher confidence thresholds lead to more accurate predictions but at the cost of missing some positive instances. The PR curve demonstrates the system's ability to achieve a balance between precision and recall.

**5.6 F1 Curve**

The F1 curve combines precision and recall into a single metric known as the F1 score. The curve depicts the relationship between the F1 score and the confidence threshold.

The F1 curve analysis reveals that the system achieves its highest F1 score at a confidence threshold of 0.57. This threshold strikes a balance between precision and recall, resulting in the optimal overall performance. The F1 curve provides valuable insights into the system's ability to balance accuracy and detection rate.

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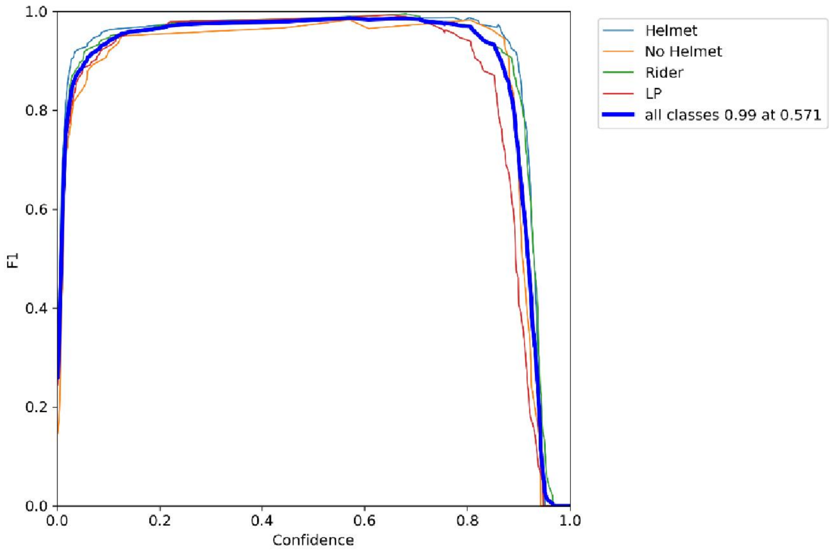
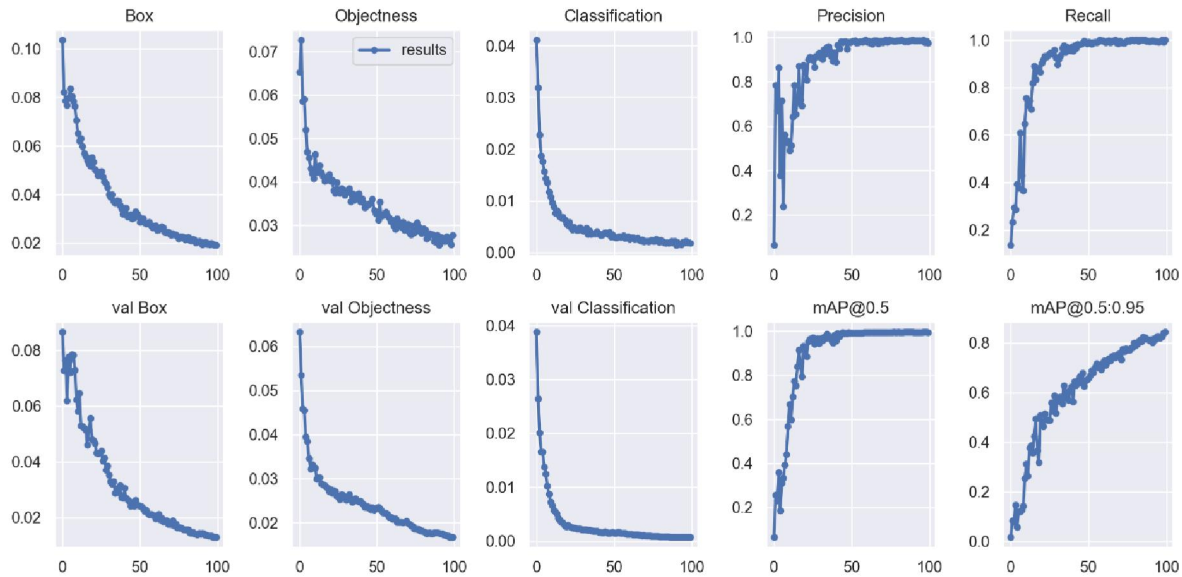



### 5.7 Overall Performance




Based on the evaluation metrics and visualizations, the YOLOv5-based object detection system demonstrates strong performance in accurately detecting objects. The achieved precision of 0.89 highlights the accuracy of positive predictions, while the recall of 0.87 indicates the system's ability to identify the majority of positive instances.

The PR curve and F1 curve analyses showcase the system's ability to strike a balance between precision and recall, providing an optimal trade-off for different confidence thresholds.

While the system performs well overall, there is room for improvement. Fine-tuning the model and expanding the training dataset could potentially enhance the system's accuracy and generalization to real-world scenarios.

In conclusion, the evaluation results demonstrate the effectiveness of the YOLOv5-based object detection system in accurately identifying and localizing objects. The precision, recall, PR curve, F1 curve, and label correlation metrics provide valuable insights into its performance, paving the way for further advancements in object detection technology.

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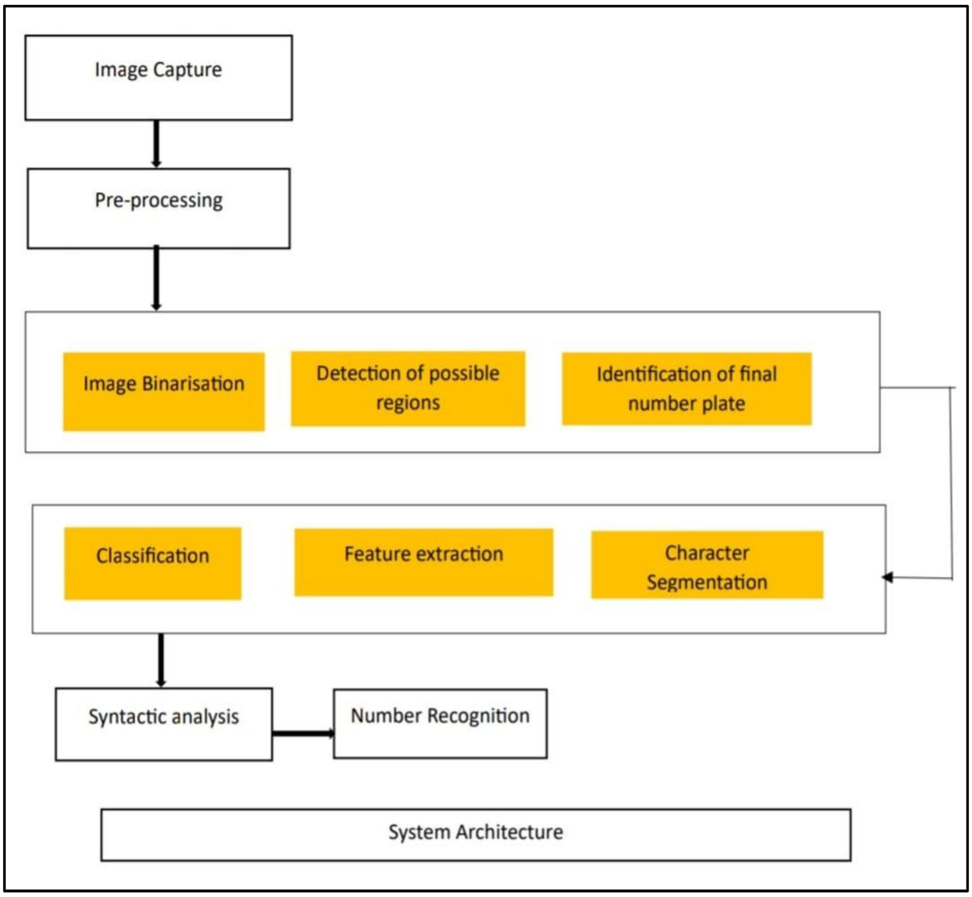


## VI. CONCLUSION

In conclusion, the proposed system for helmet and triple seat detection, along with number plate extraction, using advanced deep learning techniques holds significant promise in enhancing the safety and compliance of motorcyclists on the roads. By leveraging the power of convolutional neural networks and object detection algorithms, the system can accurately identify instances of helmet non-compliance, violations of single-seat riding regulations, and extract number plates for automated monitoring.

The application of this system extends to various areas, including traffic law enforcement, road safety campaigns, accident prevention, traffic surveillance systems, and research and data analysis. By automating the detection process, authorities can more efficiently enforce regulations, promote safer riding habits, prevent accidents, and improve overall traffic management.

## VII. FUTURE SCOPE

The proposed system for helmet and triple seat detection, along with number plate extraction for motorcyclists using advanced deep learning techniques, holds promising opportunities for future advancements. One potential future direction involves incorporating advanced sensor technologies, such as LiDAR or infrared cameras, to improve detection accuracy and performance in challenging environmental conditions. This would enable the system to operate effectively in low-light conditions or adverse weather, enhancing its reliability and applicability.

Furthermore, the integration of real-time communication systems, such as vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) technologies, could enable dynamic notifications and warnings to motorcyclists in hazardous situations. By providing instant feedback on helmet compliance or triple seat violations, riders can be alerted to potential risks, promoting safer riding habits and reducing accidents.

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