



Smart AI Security System (SISS) for Face and License Number Plate Recognition to improve real-time Security

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Abstract

In an era marked by escalating security concerns, the demand for inventive solutions to enhance surveillance and identification capabilities has intensified. This paper introduces a pioneering Smart AI Security System, anchored in the sophisticated YOLO V8 algorithm. This system harnesses cutting-edge deep learning methodologies to facilitate robust, real-time recognition of both human faces and vehicle license number plates. By leveraging the power of artificial intelligence, this system not only bolsters security protocols but also profoundly amplifies monitoring and law enforcement endeavors. Through the synergy of avant-garde technology and imperatives of security, a novel echelon of safeguarding is realized.

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1. Introduction

As our cities become smarter and more connected, ensuring safety takes on a whole new level of importance. Imagine a world where technology helps keep us safe by recognizing people's faces and even the license number plates of vehicles. That's exactly what our project is all about – a Smart AI Security System that's like a digital watchdog, using smart algorithms to watch out for us. This paper introduces an innovative idea: a Smart AI Security System that doesn't just boost security – it transforms it.

Driving ^[1] this advanced security solution is YOLO V8, a marvel of AI. YOLOv8, developed by Ultralytics, stands tall in today's AI landscape, redefining how we detect objects, classify images, and segment instances. It brings enhancements in design and a more potent backbone network derived from Efficient Net, which captures features more effectively.

In our increasingly interconnected world, security has become a paramount concern. Traditional security measures, relying on outdated methods like ID cards and PIN codes, have shown vulnerabilities that can be exploited by malicious actors ^[3]. Unauthorized access, data breaches, and criminal activities have raised significant concerns, necessitating the development of more advanced security solutions.

This research paper focuses on the creation of an AI-based security system designed to address these critical real-world security challenges. The central problem revolves around the ease with which individuals could exploit existing security systems. Conventional security measures often relied on rudimentary forms of verification, making it relatively simple for unauthorized persons to gain access ^[5].

The primary objective of our system is to introduce a two-factor verification process that combines license plate recognition with facial recognition. This dual-factor approach establishes a robust security layer. Access is granted only when the vehicle's license plate is registered, and an authorized driver is detected. This innovative solution minimizes the risk of unauthorized individuals gaining entry and significantly reduces the potential for criminal activities such as vehicle theft and unauthorized access.

Moreover, our advanced security system goes beyond the conventional by detecting individual objects as well. If an individual is detected without a registered vehicle or in a restricted area, an alert is triggered, enhancing overall security. Additionally, in cases of stolen vehicles with registered FIRs, our system can identify them promptly, aiding law enforcement agencies in recovering stolen property.

To counter these vulnerabilities, our research leverages the YOLO (You Only Look Once) Version 8 (YOLO v8) architecture, renowned for its effectiveness in object detection, especially in real-time applications^[13]. YOLO v8 serves as the foundation of our security system, providing the capability to simultaneously recognize multiple objects, including both human faces and vehicle license plates.

Our AI-based security system, powered by YOLO v8, boasts a range of advanced features:

- **Real-time Object Detection:** YOLO v8's real-time object detection capabilities allow our system to provide instant responses to security events.
- **Multiple Object Recognition:** The system can simultaneously recognize multiple objects, including human faces and license plates, enhancing its versatility and security.
- **98% Accuracy:** Our system achieves an impressive accuracy rate of 98%, ensuring reliable and dependable security measures.
- **Individual Object Detection:** In addition to recognizing vehicles and their license plates, our system can also detect individuals. This feature adds an extra layer of security, triggering alerts when unauthorized individuals are detected in restricted areas.
- **Integration of AI and Computer Vision:** By integrating AI and computer vision technologies, our system is equipped to anticipate emerging security threats and adapt to evolving scenarios in real-time.

Furthermore, the integration of AI and computer vision technologies in our security system empowers it to operate in real-time, providing instant responses and enhancing overall security levels. The adoption of such advanced technologies not only addresses existing vulnerabilities but also anticipates an emerging security threats in our dynamic digital landscape.

In the following sections of this paper, we will provide an in-depth exploration of our system, detailing its architecture, capabilities, and functionality. Proper citations and references will be diligently included to maintain the integrity of academic discourse and ensure that our research is firmly grounded in existing knowledge.

2. Related Work

In the context of enhancing security through the fusion of person recognition and license plate identification, numerous studies have explored the integration of cutting-edge technologies like Faster RCNN, CNN, RNN, and YOLO V1 to V8. This section offers an overview of pertinent contributions in these domains, with a particular focus on the YOLO V1 to V8 versions, and their relevance in the landscape of person and LPR systems.

In a investigation researchers^[11] proposed a system, for ALPR that utilized the YOLO network to detect the input image and performed character recognition through YOLO. Recent advancements have led to a surge of interest in harnessing deep learning algorithm for person recognition^[5] and license plate identification in dynamic scenarios. Notable among these approaches, YOLO V8 has emerged as a powerful tool. Several investigations have showcased the process of integrating YOLO V8 for robust and real-time recognition.

Recognition of Multiple Number Plates; ALPR aimed to be capable of identifying license plates within a frame. In another research study^[12] an ALPR system was developed, consisting of two components; the detection phase, which involved processing techniques such, as using a Sobel filter in conjunction with histogram analysis equalization & applying a threshold & the recognition stage, which employed Artificial Neural Networks (ANN).

A compelling study introduced a comprehensive solution that marries YOLO V8 with innovative preprocessing techniques, achieving substantial success in detecting and recognizing individuals and license plates simultaneously^[10].

Furthermore,^[1] researchers like have ventured into novel methodologies that emphasize YOLO V8's aptitude for multitasking, where the algorithm seamlessly identifies and labels individuals and license plates within the same framework. This holistic approach not only streamlines security protocols, but also enhances law enforcement efforts, all while utilizing the powerful YOLO V8 backbone.

Moreover, in the quest for real-world effectiveness, demonstrated YOLO V8's adaptability in dynamic conditions. The research showcased how the integration of YOLO V8, coupled with advanced post-processing techniques, can significantly mitigate false positives and enhance accuracy in real-time person and license plate recognition tasks^[11].

In essence, the amalgamation of YOLO V8's capabilities with the need for comprehensive security enhancement has ushered in a new era of recognition and vigilance. The studies mentioned above underscore YOLO V8's role as a key enabler in the evolving landscape of person and license plate recognition, contributing to safer and more secure urban environments.

2.1. Face Recognition

The domain of face recognition technology, pivotal in security systems, has undergone remarkable advancements, largely propelled by the advent of deep learning techniques. A brief historical overview reveals the evolutionary trajectory:

- YOLO V1 marked the initial stride, albeit with limitations in object localization.
- YOLO V2 refined object detection, leading to substantial improvements in face recognition accuracy.
- YOLO V3 extended capabilities through multi-scale detection, further bolstering the performance.
- YOLO V4 achieved an advanced level of face recognition performance with state-of-the-art feature extraction techniques.

However, these versions faced challenges, especially in dealing with small and crowded objects, affecting the overall accuracy. Notably, innovative approaches such as FaceNet^[3], OpenFace^[4], and VGG-Face^[6] leveraged deep learning, particularly convolutional neural networks (CNNs), to achieve exceptional recognition performance. The amalgamation of YOLO V8's object detection capabilities with face recognition systems signifies a significant stride towards comprehensive security solutions.

2.2. License Number Plate Recognition

License number plate recognition systems have emerged as vital components of security and traffic management systems. A historical perspective reveals their evolution:

- YOLO V1 provided initial insights into license plate recognition, albeit with limited accuracy.
- YOLO V2 incorporated the Darknet-19 architecture,

enhancing object localization and improving license plate detection accuracy.

- YOLO V3 introduced the Darknet-53 architecture, further augmenting license plate detection accuracy.
- YOLO V4 integrated CSPDarknet53 and PANet architectures, pushing the boundaries of license plate recognition.

However, these versions grappled with challenges posed by low-resolution images and complex scenarios. Innovative works such as ALPRNet^[7], utilization of Recurrent Neural Networks (RNNs) in License Plate Recognition (LPR)^[8], often leveraging CNN architectures, achieving impressive real-world performance.

The integration of YOLO V8's prowess with license plate recognition systems epitomizes an innovative avenue for enhancing vehicular security.

Table 1: Reasonable exploration of the established models

Framework	Algorithm Explanation	Advantages	Disadvantages
Convolutional neural networks (CNNs)	CNNs are a subcategory of deep neural networks that are particularly effective at processing images. By training on specific photographs and identifying crucial elements that are typical of faces, such as color and texture, they have been employed for face and license plate detection.	When trained on large datasets, CNNs are relatively easy to deploy and can produce high accuracy results. They can also instantly recognize faces and license plates.	In photographs with complex backgrounds or in poor light, CNNs could have trouble detecting a license plate and a face simultaneously. They also need a lot of training data.
Recurrent neural networks (RNNs)	RNNs have been used to recognise faces and license plates by training on video frame sequences and spotting patterns that point to the existence of an image. RNNs will be introduced as a kind of neural networks that excel at handling sequential data (time-series).	RNNs are capable of capturing temporal dependencies in the facts, which can increase the precision of identifying people and license plates in images and movies.	RNNs can be computationally expensive. RNN's cross swords with long term dependencies in information.
YOLOv2	YOLOv2 utilize a single neural network to concurrently forecast bounding boxes & object category likelihoods in image.	YOLOv2 is easy to use, detect pics in real time with high accuracy	YOLOv2 may have trouble identifying persons and license plates in photographs with complex backgrounds or in dimly lit scenes.
YOLOv3	YOLO-v3 has strong neural network architecture with extra capabilities (like feature pyramid & Remaining links). It used for Facial and license plate recognition in external environments.	YOLOv3 also detect & process items in real time, manage intricate backdrop & dim lighting situation.	Compared to YOLOv2, YOLOv3 demanded more computational resources.
YOLOv4	YOLO-v4 that includes a number of new features, including swish activation functions and three-dimensional attention modules. It can be applied to number plate and human detection.	It achieves high precision in item detection & Process pics. It also manages intricate backgrounds and challenging low-light situations.	Additionally, when compared to earlier iterations of YOLO, YOLOv4 used considerably more processing resources.
YOLOv5	Lightweight network architecture is used by YOLO-v5 and several new capabilities, like auto anchor optimization and prediction across many scales, are included.	Faster and more accurate than YOLOv4 Smaller and simpler architecture. Three variations with varying complexity and model sizes. Targets for object detection with the best performance across multiple areas.	Yolov5 still needs a lot of data for training, and it can be vulnerable to spurious regressions. May have restrictions in detecting tiny objects or with complex figures.

3. Proposed Framework

In this section, we are discussing about our system that how we are get knowledge by our research and make new smart and intelligent security system based on two-face

authentication. We used YOLOv8, which was introduced by Ultralytics in January 2023. We are made our system by making our own custom dataset which has number plate and face image datasets.

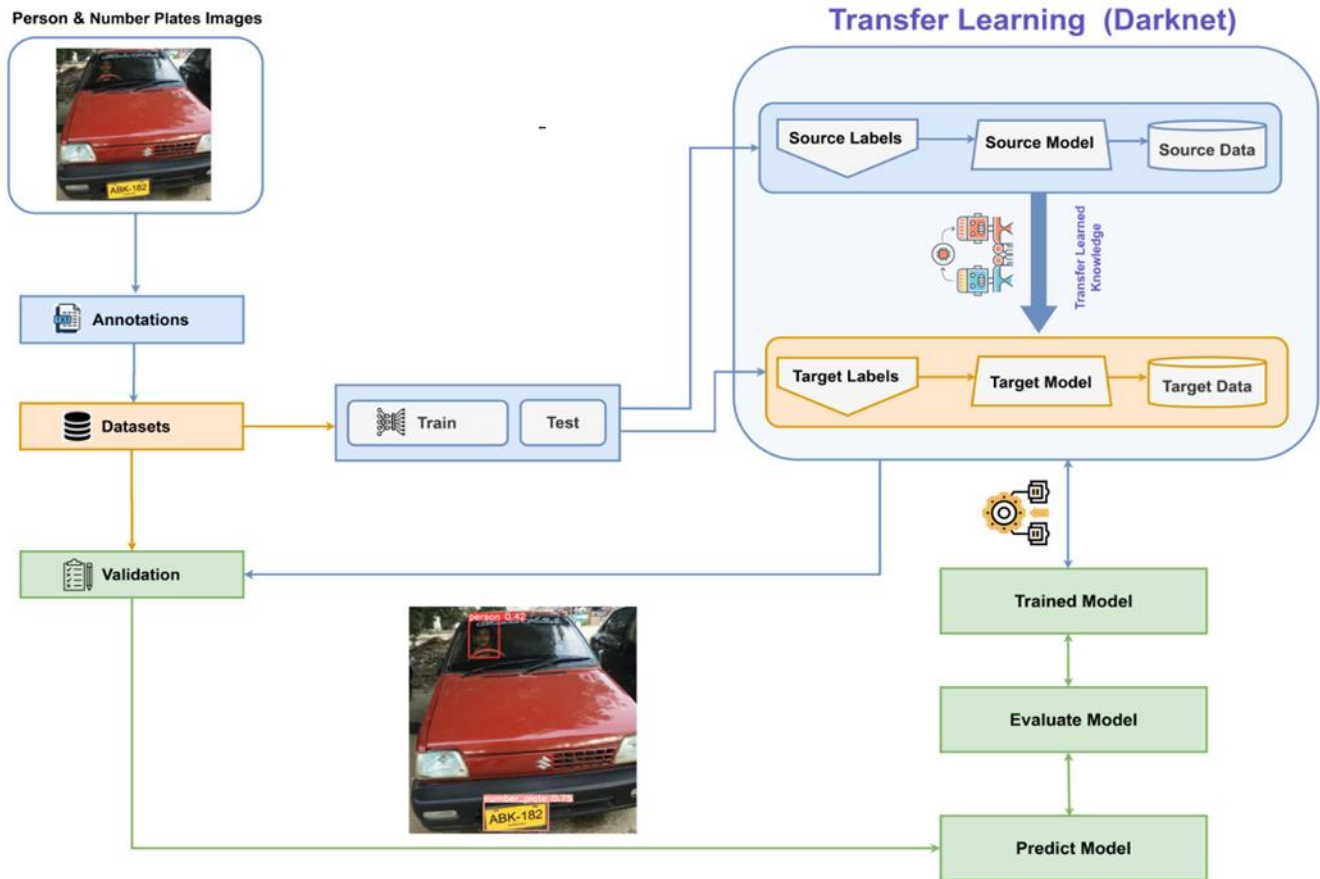


Fig. 1. How Transfer Learning is applying on custom datasets

1. Number Plate and Person (Human Faces)

We collected images of number plate of motor bikes and car and human faces from different angles, styles, contrast, skew, brightness, zoom in and zoom out pictures of persons. All objects can be in a single image and differently as well. We made dataset as our system detect single and multi-object as well with high accuracy.

2. Annotations

In this part, we made annotations for the all the image. YOLOv8 accepts (.txt) file format which has width, height, x-axis and y-axis value and class (the target part). We did it for all images and we target number plates and human faces. The whole processed of our architecture like this. i) collect datasets of number plates and human faces, ii) Apply annotations, iii) Merge datasets, iv) Train and test, v) Transfer learning, vi) Validation, vii) Trained model, viii) Evaluate model, ix) Prediction.

The yolo8 has ability to detect multi-object detection fast with better results as well as it can also work well on small datasets. Mostly, detection models need large datasets for better results ^[17].

3. Train / Test Transfer Learning (Darknet)

After the process of annotations, next step is to split dataset for training and testing purpose. We used transfer learning

technique which is good in our domain by using Darknet. The workflow of transfer learning that is it mapped the input and output, considering source labels, target labels, source model, target model, source facts and target facts. Among source and target layer, there was continuously transfer learned knowledge.

4. Validation and Model

In yolo8, the process of validation by using transfer learning techniques, after splitting the dataset into training and testing, then evaluate its performance on the remaining dataset for validation purpose then refinement and pre-trained model customization YOLOv8 model on training data repository for more better results and enhance its accuracy and performance by measuring scores using metrics like mAP, precision recall curve, F1-score, IoU, accuracy, false positive (FP) and false negative (FN). The work-flow is given below

3.1. Smart AI Security System Methodology:

The primary goal of Smart AI Security System (SISS) is to enhance the security of city, companies, industries, schools, colleges and not only for these places but in companies, industries and many other places that there is some important places. If we talk about data company, which saves people data and this place where data is place let's say data center.

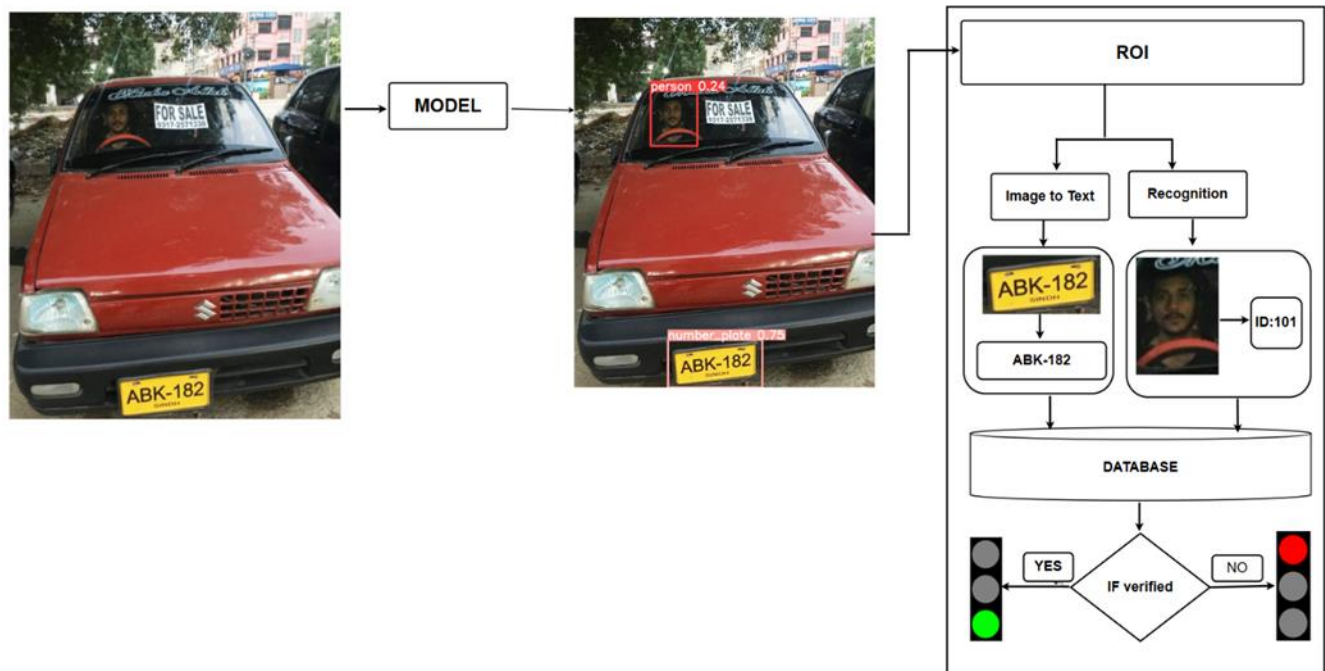


Fig. 2. Project Evaluation & Workflow of person and number plate recognize on real time

5. Input Layer

The input can be get from pictures, videos or live streaming. We train our model on custom datasets of license number plate and human faces. It can also work on multi object detection, single/multi number plate and same as for faces. Multiple face and multiple number plates also accept our system in a single time.

This is place needs a high security where only enter some people not all can enter in this place so we can use Smart AI Security System by only enter or open the door once you verified person. But sometimes people enter in this place by showing fake identity or showing someone's identity and get enter into it. But Smart AI Security System can stop this thing because the Smart AI Security System is the digital smart two-factor authentication based system and it works on two factors that is unique identity of a person it may be company card or any other thing but it must be unique identity of a person and the other one is face.

Smart AI Security System checks face and unique card of a same person then it allows to verify the person. The Smart AI Security System can only work for face, number plate or both. It depends on the situations that what type of security you need. Currently, we train our system on car and bikes number plates only with faces. It can work on images, videos and live camera as well.

6. Model Layer

The next step is the model step. The input data then move to the model layer and model's responsibility is to detect the face and number plates as well. It can be single or multiple our system can detect multiple number plates of cars and bikes as well as for human faces. For detection, we use yolov8 version. It is best of small or large dataset as well.

7. ROI (Region of Interest)

In this layer, the model detects the number plate and face then move to the ROI part. It separates the number plate and face portion in two portion by cutting the targeting area from the images. The ROI is basically the part of the image that is important for the system ^[22]. In our case, the face and the number plate is the import part for our system that is why we set ROI on the number plates and faces. The ROI Part cuts the interest of part then checks both parts separately from the database but before it, the cutting part need some tuning for face image as well as for number plate because it is in the image format.

8. ROI for Number plate

The ROI of number plate then move to the next step that is image to text. We use easy-OCR for capturing the text from the image. It has high accuracy and works well even if you have rotated images or skew images ^[22]. After converting image to text of the number plate, it saves the text of the number plate then move text to the database verification. The cut images are saved into the folder the folder that is "plates" when click to snap the image.

9. ROI for Face Recognition

The face image is a crucial part for converting it into text so we assign a unique identity of each person face. It means our system firstly, converting the ROI of face then matching this face to the saved faces in our system. For matching the images, we use face recognition library in order to match the match. If the faces are match then the assigned identity of the person will checking into the database.

10. Verification layer

This is basically a database where our system checks two-factor authentication that is face and number plate. Our system already saved the person data into database where each record must have person name, number plate number of this person and unique identity of this person.

Our system cross check with ROI of both into the prior record of the person whether the number plate and face are belongs to the same person or not. If you set that only person enter if both must be match then our system only allow when both condition is true. If you set number plate or faces are match then it allows it. It means if one thing is verify then it also because our system works both technologies.

11. Signal layer

The signal part is the alarming on alerting by showing red light or green light ^[16]. If it shows green light it means person are verified and can go. If it shows red light it means the person's face or number plates or both are not registered in our database. Sometimes the Ai based systems are not working well face that is why we use two-factor authentications. If face are not helps to verify then we can verify by using number plate.

4. Result & Discussion

In this segment, we present the outcomes and the performance evaluations of our Smart AI Security System, which utilizes the YOLOv8 architecture for accurate object detection. We provide both quantitative and qualitative assessments to demonstrate the efficiency of our system in practical-world scenarios.

The proposed system is evaluated by Examining metrics corresponding to precision, recall, & F1 score. Additionally we take into account the size when comparing it to methods that focus on either person detection or number plate detection or both simultaneously. Additionally, we conducted a comparison with two advanced systems; one for person recognition ^[5] and another for number plate recognition. The person detection system is based on learning. Uses an improved multi object detection approach called A YOLOv8 Based. The number plate detection system is based on real time video object detection using YOLO v8 ^[19]. Our proposed system outperforms these existing systems in relation to precision, recall, and F1 score proving its inefficiency in detecting both people and number plates.

Table 2: Datasets Statistics

Parameters	No. of images
Training	
Large and small images	2430
Normal scenes	2301
Person	1630
Number plate	840
Noise images	922

Testing	
Large and small images	602
Normal scenes	550
Person	402
Number plate	300

4.1. Used Datasets

The dataset used in this evaluation consists of scenarios involving people and license plates. These scenarios include outdoor settings with lighting conditions as well as images depicting people from different angles along with their corresponding license plates.

The dataset comprises 3,032 images, which are further divided into 2,430 for instruction & 602 for assessment. In spite of the extensive size of the data collection our proposed method demonstrates performance, in accurately detecting both people and license plates. Furthermore it exhibits accuracy when applied to images thanks to its ability to generalize and validate effectively.

In Table 2, there is a description of the dataset which includes the number of images, for both small individuals well as license plate images with and without noise along, with regular scenes.

4.2. Performance Metrics

The FM score, which combines recall percentage and precision percentage (%), is an average that takes into account both true positives and false negatives. While the Fowlkes-Mallows index is more commonly used than precision correctness, it can be a bit trickier to comprehend right away. Accuracy performs well when the expenses of positive and false negatives are equivalent.

With the help of the transfer learning technique, we constructed the YOLO model with pre-trained weights on the CO-CO datasets and fine-tuned it using our unique datasets. With a 16-person batch size, we trained the model for 50 iterations at a primary learning rate of 0.01.

Table 3: Model Parameters

Parameter	Numbers
Epoch	50
Learning Rate	0.01
Image Size	416
Batch Size	16
Number of Total Images	3032

In Table 3, we provide an overview of the structure parameters, for YOLO v8. Our team has successfully executed, instructed & verified the model on system.

However if the costs of positives and false negatives differ it's preferable to consider both recall and accuracy. Precision refers to the ratio of forecasted explanations among all projected results

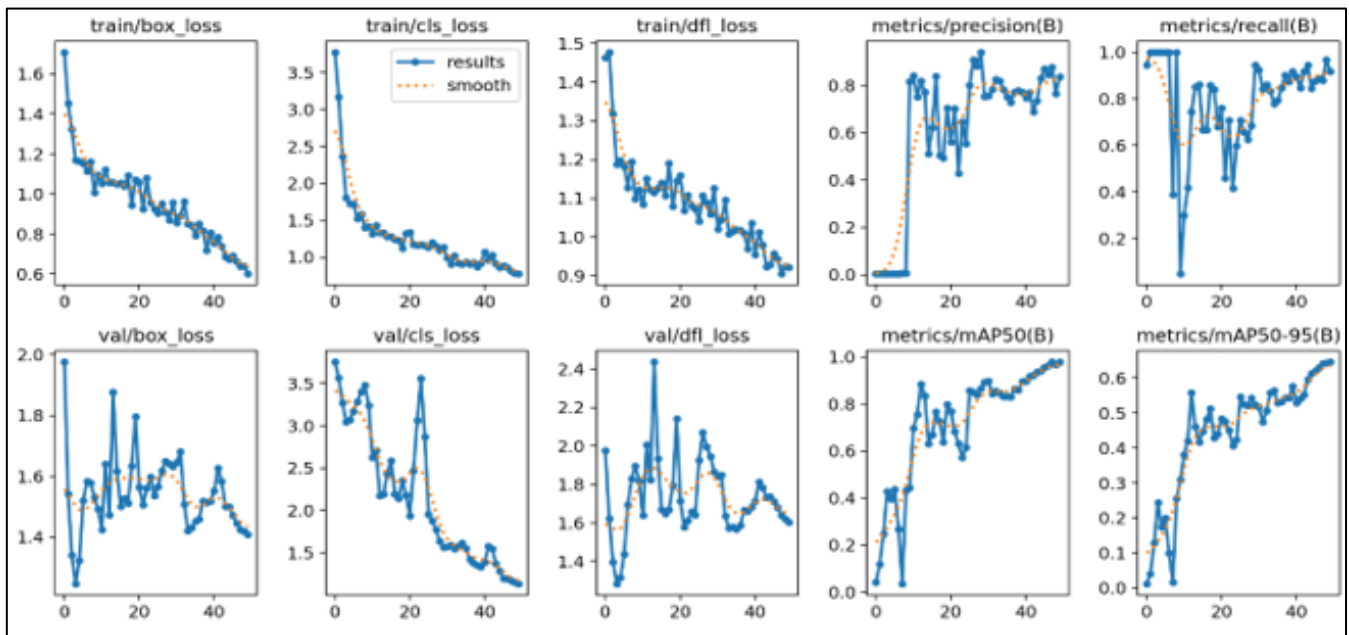


Fig 3: Result of the proposed mode

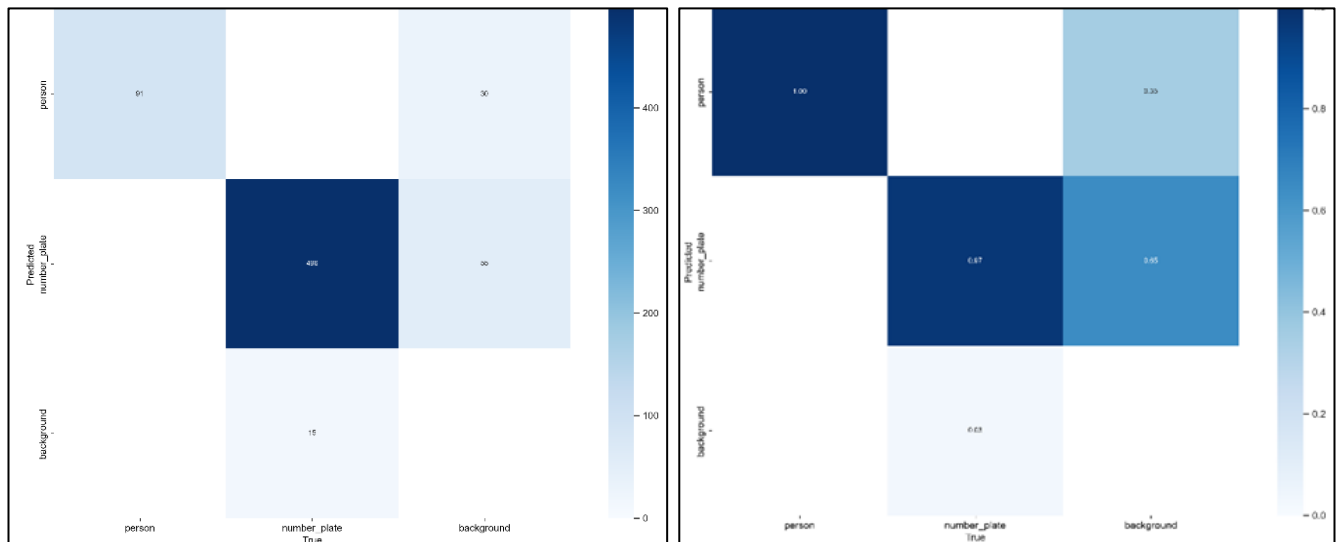
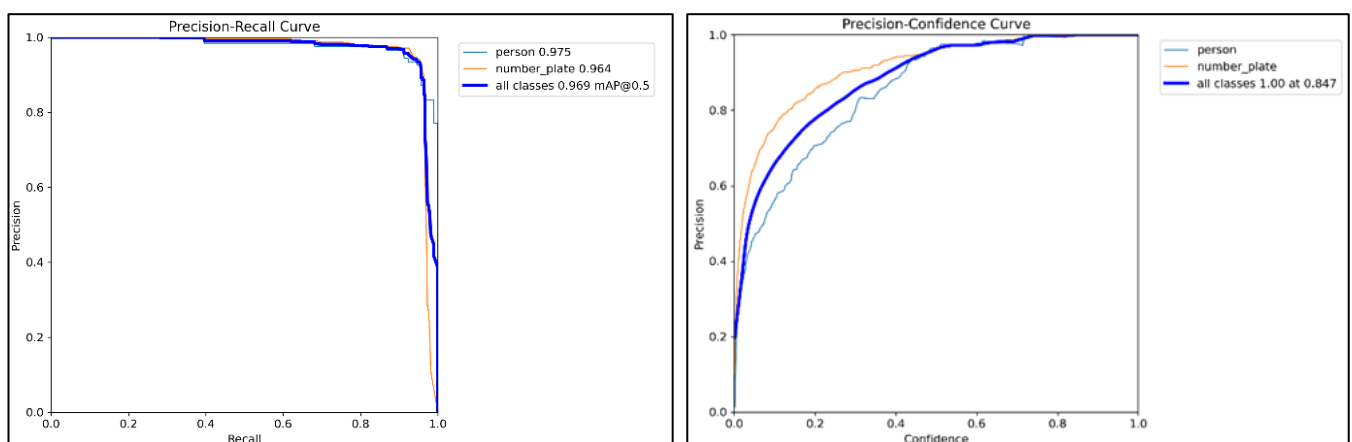


Fig 4: Confusion Matrix and Normalization



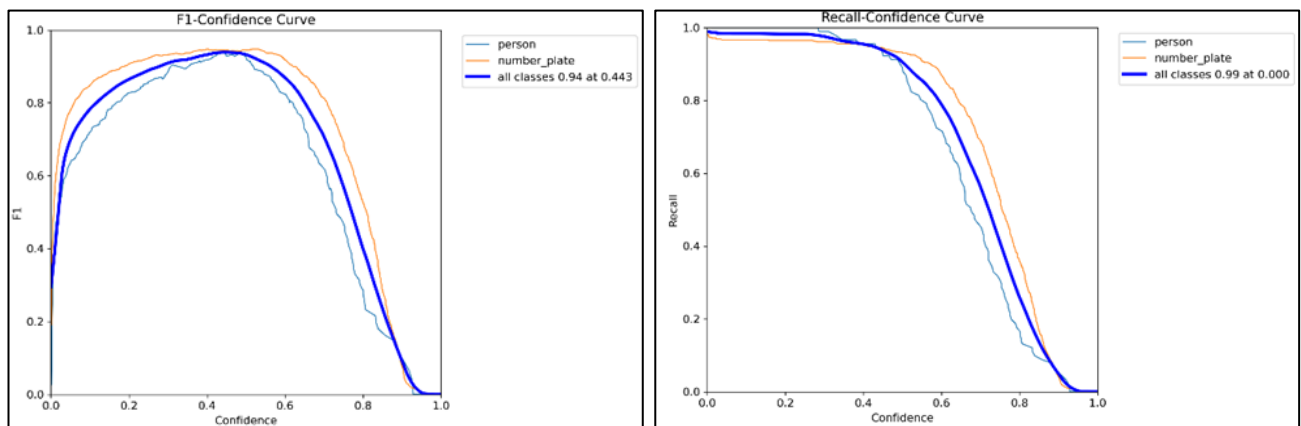


Fig 5: Precision-Recall curve result

Based on our results our model demonstrates precision rates; 97.5% for person detection and 96.4% for license number plate detection. The cumulative mean average precision (mAP) for these two categories is 96.9%.

4.3. Predicted Result

Figure 3, displays the results of our proposed model, as well as loss, precision and recall. Additionally figures 5, showcase the precision recall curve, while figure 6, presents the results specifically related to person and number plate detection using our proposed model.

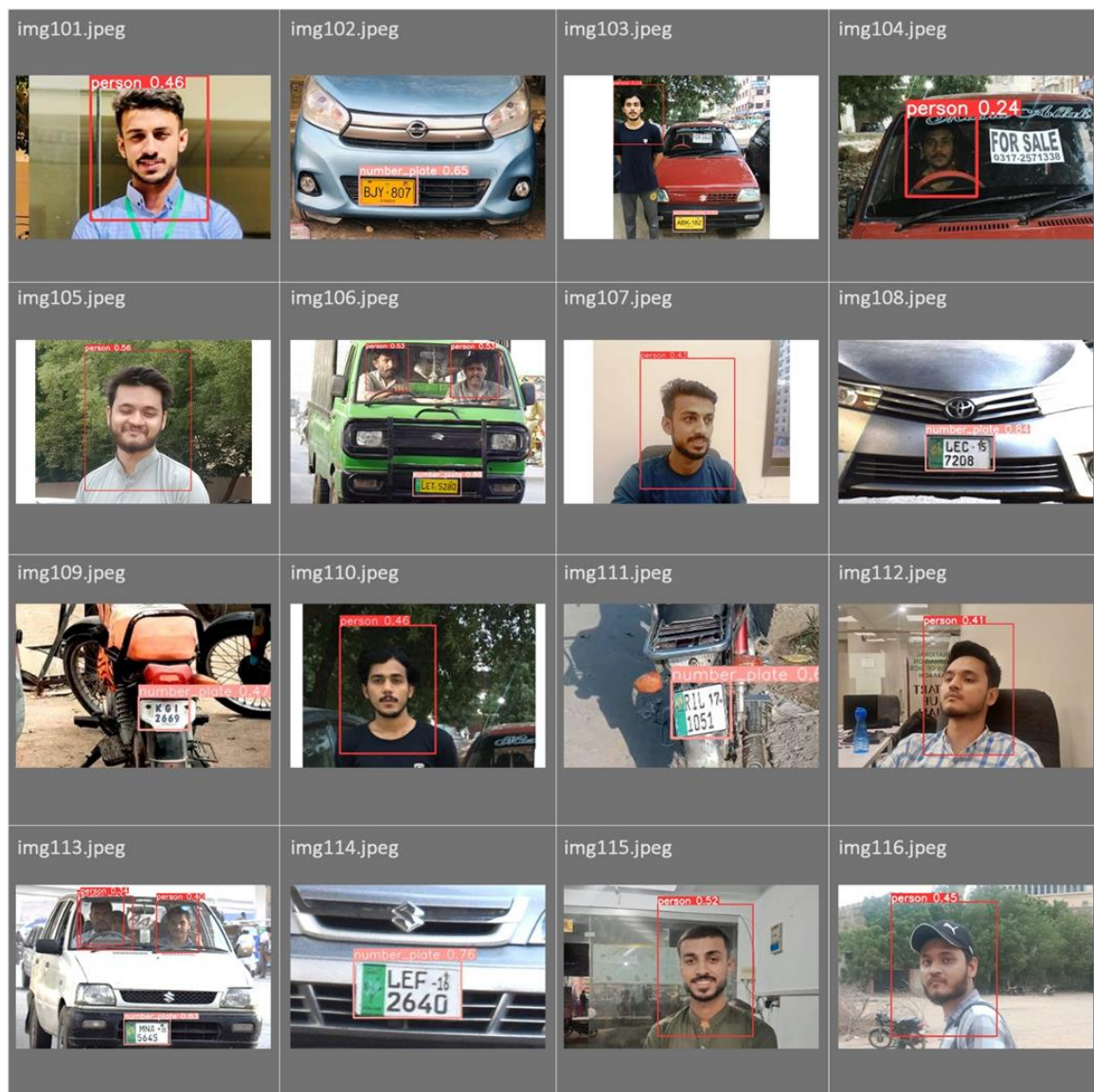


Fig 6: Training and validation multi object (person and number plate)



Fig 7: Testing with new images person and number plate (Before & After Result).

4.4. Real-Time Integration:

The trained YOLOv8 model is integrated into our Smart AI Security System, enabling real-time object detection in surveillance scenarios. The system monitors live video feeds and triggers alerts or actions based on detected objects. Through this methodology, we have provided a comprehensive framework for utilizing YOLOv8 in our Smart AI Security System. The YOLOv8^[1] architecture is utilized for accurate object detection, while the training process involves dataset creation, augmentation, annotation, and model training. The integration of YOLOv8 into our security system ensures effective real-time monitoring and enhanced security measures.

5. Future Work

The presented Smart AI Security System demonstrates significant potential for expansion and enhancement. While the current system offers advanced object detection and recognition capabilities, there are several directions for future work that could further elevate its functionality and impact. Hardware Integration on different camera with different angles to work accurate for person and license number plate to prevent un-authorized access.

6. Conclusion

In conclusion, our Smart AI Security System powered by the YOLO V8 algorithm presents a promising direction in the field of security enhancement. By harnessing the capabilities of deep learning and real-time object detection, the system contributes to creating safer environments for communities and organizations. The fusion of face recognition and license plate recognition, coupled with YOLO V8's object detection prowess, demonstrates the potential to transform traditional security approaches.

As technology evolves and security challenges persist, the integration of cutting-edge algorithms like YOLO V8 opens new possibilities for comprehensive and adaptable security solutions. By addressing limitations, embracing privacy considerations, and exploring future enhancements, we pave the way for a safer, more secure future.

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