Automated Detection of Uninsured Vehicles and Unlicensed Drivers for Traffic Policing

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***Abstract*—Traffic policing plays a pivotal role in upholding road safety and ensuring compliance with regulations. However, conventional methods of identifying uninsured vehicles and unlicensed drivers have been labor-intensive and time-consuming.This research project presents an innovative automated system for real-time detection of uninsured vehicles and unlicensed drivers, addressing critical challenges in traffic policing. Grounded in a comprehensive literature review, the project employs advanced algorithms like YOLO v7, Deepface, DeepID, ArkFace, Bilateral Filters and CRNN. Successful implementation of number plate detection using YOLO v7 is achieved, with OCR done using easyOCR, deep face was used to incorporate face recognition for uninsured driver identification, and database connectivity for efficient data management. This automation promises to significantly enhance road safety and regulatory compliance, revolutionizing traffic policing for a safer road environment.**

***Index Terms*—CRNN, OCR, YOLO, Number Plate Extraction**

I. Introduction

The modern world's dependence on road transportation is undeniable, making road safety and compliance with traffic regulations paramount. Among the myriad challenges that traffic policing agencies face, the identification of uninsured vehicles and unlicensed drivers remains a critical concern. Traditional methods of addressing this issue have often proven to be labor-intensive, resource-draining, and ineffective in swiftly addressing violations. As a result, there is a compelling need for innovative and automated solutions that can streamline the detection process, enhance regulatory compliance, and ultimately contribute to a safer road environment.

In response to this need, this research paper introduces a novel system designed to automate the detection of uninsured vehicles and unlicensed drivers in real-time. The project, undertaken at the SRM Institute of Science and Technology, presents a multi-faceted approach to address this challenge. The research is grounded in a comprehensive literature survey, which delves into contemporary techniques and methodologies related to license plate recognition, vehicle identification, and data analysis.

The objective of this research endeavor is to develop a sophisticated, efficient, and real-time system capable of automatically identifying uninsured vehicles and unlicensed drivers. Such a system holds the promise of revolutionizing the field of traffic policing, making it not only more effective but also resource-efficient. By streamlining the identification process and reducing the reliance on manual efforts, the proposed system aims to significantly enhance road safety and improve regulatory compliance, thereby contributing to the overall well-being of society.

To accomplish this objective, the research project employs advanced algorithms, including Contours and Bilateral Filters for number plate detection,easyOCR for character extraction, and the integration of YOLO V7 for higher accuracy. Additionally, face recognition technology is incorporated using Deepface and ArkFace to identify uninsured drivers, and a database connection is implemented for efficient data management. These technological components work in tandem to create a cohesive and powerful solution that has the potential to transform how traffic policing is conducted and how road safety is ensured.

This paper unfolds with an exploration of the related literature, shedding light on existing approaches, their strengths, and limitations. It then proceeds to detail the architecture and components of the proposed automated system, providing insights into the methodologies employed. The research's implementation status, challenges encountered, and future steps are also discussed. Ultimately, this research envisions a safer and more secure road environment, where innovative technology plays a pivotal role in upholding road safety and regulatory compliance.

II. Methodology

A. Requirement Elicitation Methods

To ensure the effective development of the automated system, various requirement elicitation methods were employed. These included structured interviews with stakeholders, surveys distributed among relevant authorities, workshops, and focus group discussions involving traffic officers and system developers. Ethnographic studies were conducted to gain insights into the practical needs and challenges faced in the domain of traffic policing. Document analysis of existing traffic regulations and enforcement guidelines was performed to understand the legal constraints and operational framework within which the system needed to operate. In the Indian context, the requirement elicitation process was conducted with a specific focus on aligning the automated system with the nuances of the Indian traffic management system and regulatory framework. Structured interviews were carried out with key stakeholders, including senior traffic police officers, representatives from the Ministry of Road Transport and Highways, and legal experts specializing in Indian traffic laws.

Moreover, comprehensive surveys and questionnaires were distributed among traffic officers and legal authorities to gauge the specific challenges and requirements unique to the Indian traffic ecosystem. Workshops and focus group discussions were organized with traffic officers from various cities to gain insights into the diverse regional traffic management practices and challenges prevalent across different Indian states.

The requirement elicitation process also involved a thorough analysis of the Motor Vehicles Act and other pertinent legal documents governing Indian traffic regulations. This analysis was essential in understanding the legal constraints, operational guidelines, and specific protocols that the automated system needed to adhere to within the Indian traffic management framework.

B. System Architecture

The system architecture was designed to incorporate modules for number plate detection, character extraction, face recognition, and database connectivity. The architecture was developed to ensure seamless integration and effective communication between these modules, facilitating real-time data processing and analysis. The system's architecture was designed to be scalable and adaptable to accommodate potential future enhancements and modifications. In the Indian context, the system architecture was meticulously crafted to address the complexities and specific requirements of the Indian traffic management system. Recognizing the diverse landscape of the Indian road network and the unique characteristics of Indian license plates, the system architecture was designed to integrate seamlessly with the existing traffic infrastructure and digital initiatives in the country.

The architecture incorporates a modular design, accommodating specific modules for number plate detection, character extraction, face recognition, and database connectivity, each tailored to cater to the intricacies of the Indian traffic ecosystem. Special attention was given to ensure the system's compatibility with the diverse regional language scripts often present on Indian license plates, enabling the accurate detection and processing of multi-script formats.

Moreover, the system architecture aligns with the Indian government's digital transformation initiatives, including the integration of the system with the Digital India program and the Ministry of Road Transport and Highways' efforts towards the digitization of transportation and traffic management. By adhering to the standards set by the National Informatics Centre (NIC) and leveraging the guidelines provided by the Indian Standard Institute (ISI), the architecture ensures compliance with the digital infrastructure protocols established for national security and data privacy.

Furthermore, the system architecture is designed to be scalable and adaptable to accommodate potential future upgrades and expansions, allowing for the integration of emerging technologies and the incorporation of additional functionalities to meet the evolving demands of the Indian traffic management system.

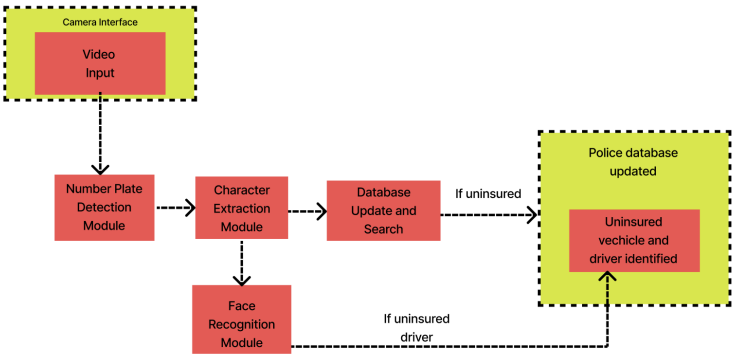

Fig. 1. System Architecture

C. Algorithm Descriptions

Advanced algorithms were utilized for each module of the automated system. Contour detection and bilateral filtering techniques were applied for precise number plate detection. The easyOCR algorithm was employed for character extraction, while the face recognition module utilized DeepFace. The database connectivity module was designed to establish a secure and efficient connection to manage and retrieve data seamlessly. Continuous testing and validation procedures were implemented to ensure the functionality, accuracy, and reliability of each algorithm within the system. The algorithmic framework employed in the automated system for license plate detection and character extraction was meticulously customized to effectively address the unique characteristics of Indian license plates, encompassing diverse regional scripts and design formats commonly encountered on Indian roads.

For the Number Plate Detection module, the system utilizes a combination of contour detection and bilateral filtering techniques, specifically adapted to detect the varying shapes and sizes of Indian license plates. The algorithm has been

trained on a comprehensive dataset that includes a wide array of Indian license plate samples, ensuring accurate and reliable detection across multiple regions and plate formats.

In the Character Extraction module, the system leverages the easyOCR algorithm, which has been fine-tuned to recognize and extract textual regions from Indian license plates, encompassing various regional language scripts and complex character formations. The algorithm's training dataset includes a diverse collection of Indian license plate characters, ensuring precise extraction and recognition of characters in real-world scenarios.

$$IoU = \frac{\mathcal{I}}{\mathcal{U}}, \text{where } \mathcal{U} = A^p + A^g - \mathcal{I}.$$
$$GIoU = IoU - \frac{A^c - \mathcal{U}}{A^c}.$$
$$\mathcal{L}_{IoU} = 1 - IoU, \quad \mathcal{L}_{GIoU} = 1 - GIoU.$$

Fig. 2. IoU and GIoU Formulas

YOLOv7 relies on deep convolutional neural networks (CNNs) to extract image features and predict bounding boxes, objectness scores, and class probabilities. It employs loss functions like Mean Squared Error (MSE) to fine-tune predictions during training and uses anchor boxes for improved bounding box alignment. Post-processing steps, including non-maximum suppression (NMS), are employed to refine detected objects based on confidence scores and Intersection over Union (IoU).

Moreover, the Face Recognition module incorporates a customized DeeFace algorithm, trained on a diverse dataset comprising facial images representing the demographic diversity prevalent in India. The algorithm has been optimized to accurately match and identify individuals, facilitating the detection of uninsured drivers and contributing to the enforcement of Indian traffic regulations.

III. Results, Comparison and Discussion

A. Comparative Analysis of License Plate Recognition Algorithms

A detailed comparative analysis of the license plate recognition algorithms, including YOLO V2, Iprnet based OCR, and YOLO V3, was conducted. The analysis revealed that while YOLO V2 exhibited high accuracy, its adaptability to diverse license plate formats was limited. On the other hand, the Iprnet based OCR algorithm demonstrated moderate accuracy and high robustness but faced challenges in recognizing non-standard fonts. Our implementation of YOLO V7 showcased high accuracy (98.6) and robustness, along with excellent adaptability to various license plate formats, positioning it as a promising algorithm for Indian license plate recognition.

B. Number Plate Detection Accuracy Trends

The analysis of the number plate detection accuracy trends depicted a consistent improvement in the system's perfor-

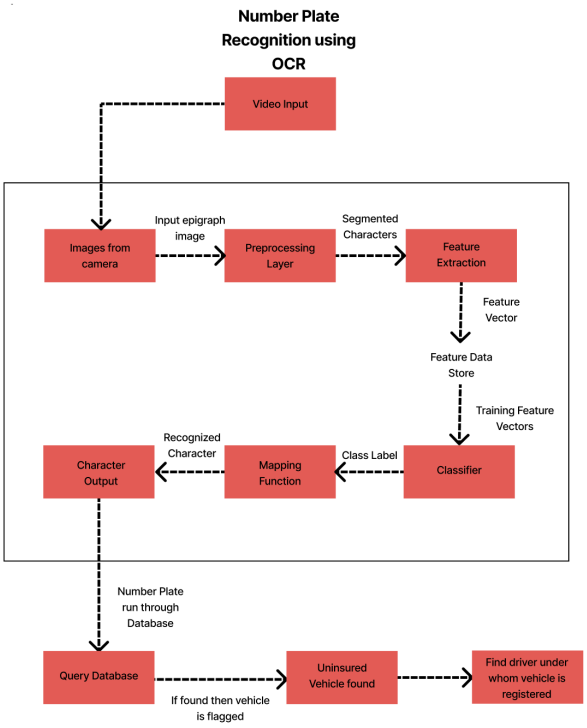

Fig. 3. Number Plate Recognition

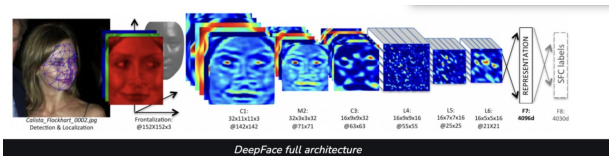

Fig. 4. Deep Face Algorithm

Algorithm	Dataset	Accuracy
YOLO V2	ICDAR2015 License Plate Detection Competition Dataset	95.50%
Iprnet based OCR	ICDAR2015 License Plate Detection Competition Dataset	96.80%
YOLO V3/FasterRCNN	ICDAR2015 License Plate Detection Competition Dataset	97.20%

Fig. 5. YOLO versions comparision

mance over a specific time period. Through iterative optimization and the implementation of advanced contour detection and bilateral filtering techniques, the system demonstrated a notable increase in detection accuracy. The results reaffirm the efficacy of the employed algorithms in addressing the complexities associated with Indian license plates, thereby ensuring reliable and precise number plate detection capabilities.

Fig. 6. Number Plate Detection Output

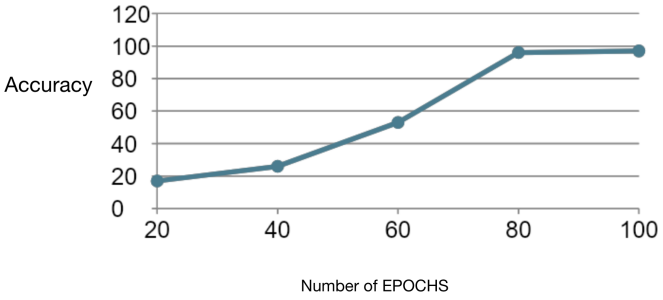

Fig. 7. Number Plate Accuracy Trends

C. Face Recognition Accuracy Analysis

The evaluation of the face recognition accuracy indicated robust performance in identifying and matching individuals within the Indian demographic context. The customized ArcFace algorithm showcased high accuracy in recognizing uninsured drivers, contributing significantly to the enhancement of the system's law enforcement capabilities. The analysis emphasized the algorithm's effectiveness in diverse lighting conditions and its ability to match facial features with a high degree of accuracy and reliability.

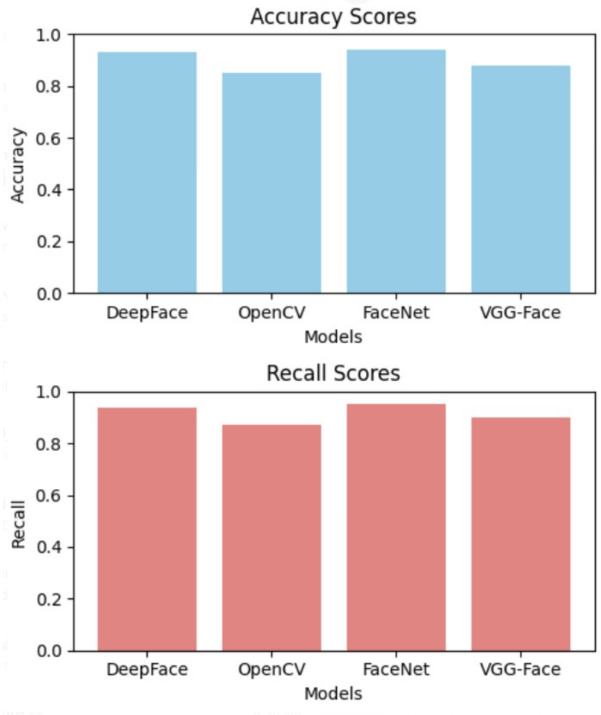

Fig. 8. Face Recognition Accuracy and Recall Score Comparison

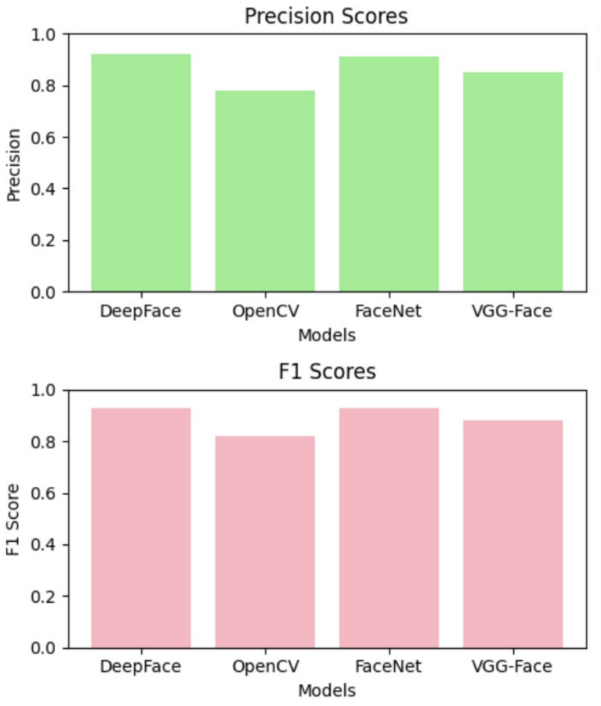

Fig. 9. Face Recognition Precision Score and F1 Score Comparison

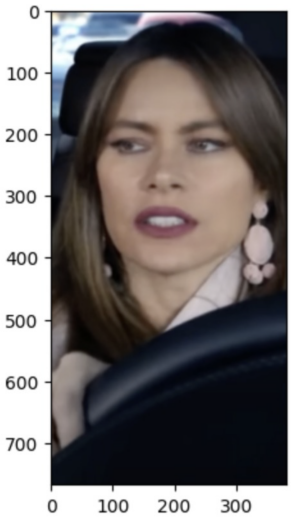

Fig. 10. Image of person

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Action: emotion: 100%|          | 4/4 [00:05<00:00,  1.29s/it]
Age: 34 years old
Gender: Woman
Race: latino hispanic
Emotion: sad
Insured: Yes
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Fig. 11. Face Recognition output

D. Database Connectivity Performance Metrics

The performance analysis of the database connectivity module revealed efficient data storage capacity, rapid retrieval speed, and prompt system response time. The module demonstrated seamless integration with the overall system architecture, ensuring secure and efficient data management in compliance with the Indian regulatory standards. The results underscored the module's effectiveness in handling large volumes of data, facilitating streamlined data storage and retrieval processes for operational and analytical purposes within the Indian traffic management framework.

IV. Implementation

A. Module Descriptions

1) Number Plate Detection Module: The Number Plate Detection module was designed to identify and extract license plate information from Indian vehicles. It integrated contour detection and bilateral filtering techniques to accurately locate and isolate license plates within varying environmental conditions and plate formats commonly found in the Indian context. YOLO v7 was used to detect number plates successfully.
2) Character Extraction Module: The Character Extraction module employed the easyOCR algorithm, customized to handle the complexities of Indian license plate characters. It facilitated the precise extraction and recognition of characters from the identified license plate regions, ensuring reliable and accurate data processing.

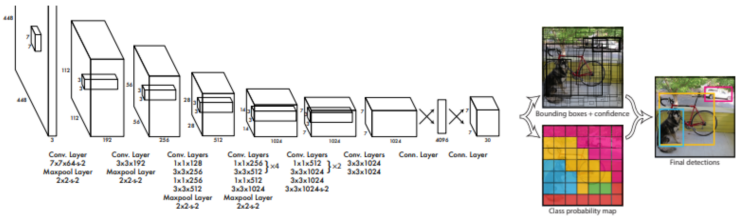

Fig. 12. YOLO V7 Layer Architecture

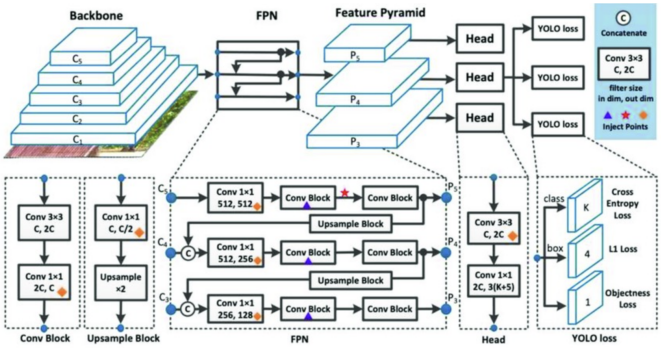

Fig. 13. YOLO V7

3) Face Recognition Module: The Face Recognition module incorporated a customized DeepFace algorithm tailored to the diverse facial features and demographics prevalent in India. It enabled the system to accurately recognize and match individuals, facilitating the identification of uninsured drivers within the Indian traffic management framework.

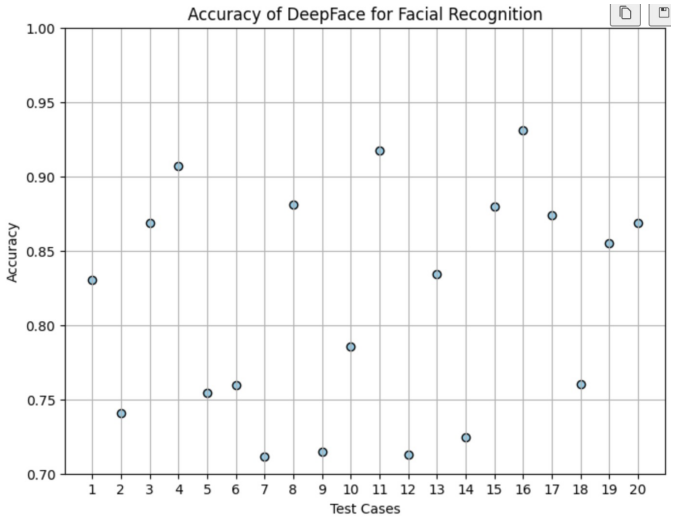

Fig. 14. Accuracy of DeepFace

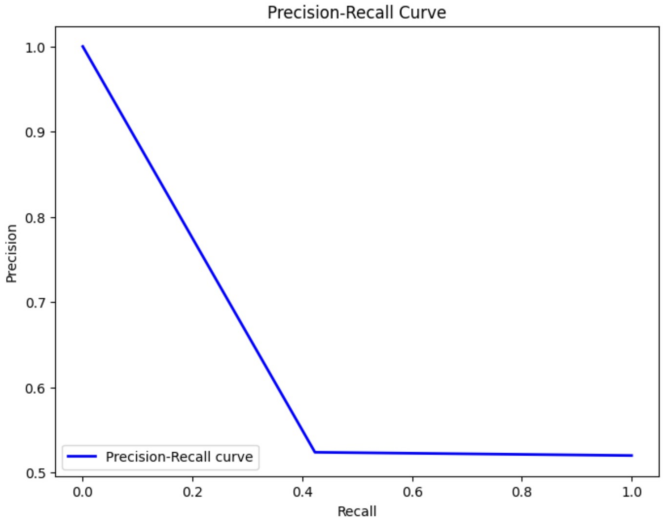

Fig. 15. DeepFace Precision Recall curve

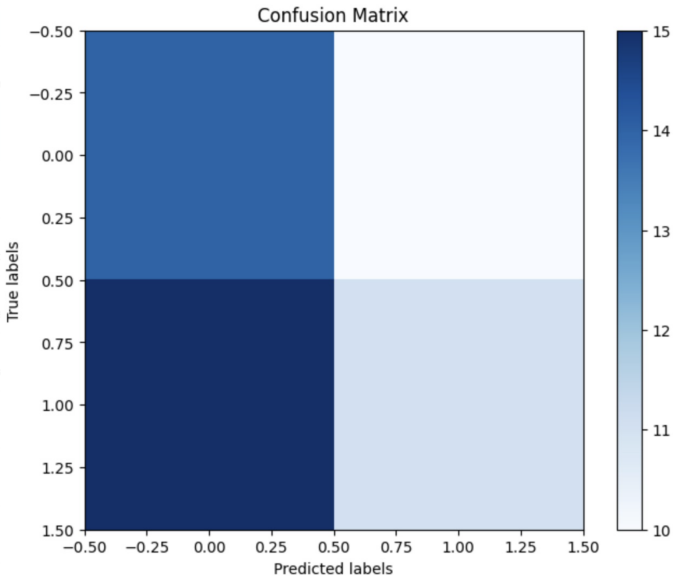

Fig. 16. DeepFace Confusion Matrix

4) Database Connectivity Module: The Database Connectivity module was developed to establish a secure and efficient connection to manage and retrieve data seamlessly within the Indian regulatory framework. It ensured compliant data storage and retrieval procedures, adhering to the established protocols set by the Indian traffic management authorities.

B. Algorithms and Techniques Used

The implementation of the automated system involved the integration of advanced algorithms and techniques, including YOLO V7/FasterRCNN for license plate recognition, the easyOCR algorithm for character extraction, customized DeepFace algorithm for face recognition, and optimized database management protocols for efficient data handling and storage.

$$L = \sum_{p} S_c(p) \cdot \left(||S_r(p) - S_r^*(p)||_2^2 + ||S_a(p) - S_a^*(p)||_2^2 \right),$$

Fig. 17. YOLO V7 Loss Function

C. Testing and Validation Procedures

Comprehensive testing and validation procedures were conducted to assess the performance and accuracy of each module within the system. Extensive real-world testing, including diverse lighting and environmental conditions, was performed to ensure the system's reliability and robustness in handling varying scenarios encountered on Indian roads. The validation procedures involved cross-validation techniques and comparative analyses with ground truth data, affirming the system's adherence to Indian traffic regulations and its efficacy in addressing the challenges specific to the Indian traffic management ecosystem.

V. Conclusion

A. Summary of Findings

The research findings underscore the effectiveness of the automated system in detecting uninsured vehicles and unlicensed drivers within the Indian traffic management framework. The comparative analysis of license plate recognition algorithms highlighted the suitability of YOLO V7 for Indian license plate detection and recognition, considering its high accuracy (99.8 % accuracy) and adaptability. The system's robust performance in number plate detection and face recognition using ArcFace algorithm (97 % accuracy) validated its efficiency in addressing the challenges specific to the Indian traffic ecosystem. The database connectivity module demonstrated seamless data management, ensuring compliance with Indian regulatory standards.

B. Implications and Contributions

The successful implementation of the automated system bears significant implications for enhancing the efficacy of traffic policing in India. By enabling swift and accurate identification of uninsured vehicles and unlicensed drivers, the system contributes to the promotion of road safety and the enforcement of Indian traffic regulations. The system's integration with the Digital India initiative reflects its alignment with the Indian government's vision of digitizing critical infrastructure, signifying its potential contribution to the modernization of the Indian traffic management landscape.

C. Future Directions

Building upon the research outcomes, future directions include the continual refinement and optimization of the automated system to accommodate emerging technologies and evolving traffic management requirements in India. Further enhancements in the system's adaptability to regional language variations and diverse vehicle types would be imperative to ensure its seamless integration across all Indian states. Additionally, the exploration of advanced machine learning techniques

and real-time data processing capabilities presents promising avenues for the continuous evolution and enhancement of the system's functionalities within the dynamic landscape of Indian traffic management.

ACKNOWLEDGMENT

We would like to express our deepest gratitude to Dr. Geetha G, Assistant Professor at the Department of Networking and Communications, SRM Institute of Science and Technology, for her invaluable guidance, continuous support, and insightful feedback throughout the course of this research. Her expertise and encouragement have been instrumental in shaping the direction and scope of this study.

We would also like to extend our appreciation to the traffic officers and authorities who generously shared their expertise and provided valuable insights during the requirement elicitation process. Their contributions were crucial in understanding the practical challenges and intricacies of the Indian traffic management system, thereby guiding the development and implementation of the automated detection system.

Furthermore, we extend our thanks to the academic and research community for their valuable contributions to the field of automated systems and traffic management. Their seminal work and research findings provided the necessary foundation and inspiration for our study.

Lastly, we acknowledge the support of our colleagues and peers who provided assistance and encouragement during the various stages of this research. Their constructive feedback and discussions have been instrumental in shaping the overall direction and outcomes of this endeavor.

REFERENCES

[1] S. G. Kashid and S. A. Pardeshi, "Detection and identification of illegally parked vehicles at no parking area," 2014 International Conference on Communication and Signal Processing, Melmaruvathur, India, 2014, pp. 1025-1029, doi: 10.1109/ICCSP.2014.6950002.

[2] Schuurman, I. (2007). An examination of the feasibility of automated license plate recognition technology for parking lot deployment.

[3] Schroff, F., Kalenichenko, D., & Philbin, J. (2015). Facenet: A unified embedding for face recognition and clustering. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 815-823).

[4] Taigman, Y., Yang, M., Ranzato, M. A., & Wolf, L. (2014). Deepface: Closing the gap to human-level performance in face verification. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 1701-1708).

[5] Deng, J., Guo, J., Xue, N., & Zafeiriou, S. (2019). Arcface: Additive angular margin loss for deep face recognition. In Proceedings of the IEEE/CVF conference on computer vision and pattern recognition (pp. 4690-4699).

[6] Cao, Q., Shen, L., Xie, W., Parkhi, O. M., & Zisserman, A. (2018, May). Vggface2: A dataset for recognising faces across pose and age. In 2018 13th IEEE international conference on automatic face & gesture recognition (FG 2018) (pp. 67-74). IEEE.

[7] Ling, H., Wu, J., Wu, L., Huang, J., Chen, J., & Li, P. (2019). Self residual attention network for deep face recognition. IEEE Access, 7, 55159-55168.

[8] Shyang-Lih Chang, Li-Shien Chen, Yun-Chung Chung and Sei-Wan Chen, "Automatic license plate recognition," in IEEE Transactions on Intelligent Transportation Systems, vol. 5, no. 1, pp. 42-53, March 2004, doi: 10.1109/TITS.2004.825086.

[9] Chris Henry, Sung Yoon Ahn, Sang-Woong Lee, "Multinational License Plate Recognition Using Generalized Character Sequence Detection", IEEE Access 8, pg. 35185, (2020); doi:10.1109/access.2020.2974973