IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
 Journal UGC CARE Listed (Group-I) Volume 11, Issue 02 2022

Critical Challenges In Indian License Plate Recognition: Issues In Pre-Processing, Segmentation, And Recognition

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ABSTRACT:

Automatic license plate recognition (ALPR) is required to make India smarter, improve law enforcement and make toll easier to collect tolls. Changes in the environment, fonts, oclusation and plates make things very difficult. This study examines many important issues related to early processing, division and understanding of Indian vehicle plate identity. The main targets are to find mistakes in the system and to improve algorithm. The recognition method works very well, using Convenable Neural Network (CNN), photo improvement, fuzzy thresholding and deep automatic separation. The experimental results demonstrate that more challenging conditions enhance accuracy, hence reducing segmentation mistakes and augmenting OCR performance. The discussions focus on traffic automation, security surveillance, and smart city initiatives. Future research should primarily focus on scalable solutions for real-time edge computing.

Keywords: License Plate Recognition, Image Pre-processing, Segmentation, OCR, Deep Learning.

INTRODUCTION:

Automatic vehicle license plate recognition (ALPR) is an important part of smart transport network, safety measures and toll collections as it can intensify and accurately identify vehicles without any help of individual drivers. A typical system involves pre-processing the image, breaking it up, and recognizing the characters. ALPR is crucial, but the difficulty is that license plates in India don't have standards, have varying typefaces, colors, and orientations, and are affected by bad lighting, motion blur, dust, and occlusion [2]. Strong algorithms for complex backgrounds and plate patterns are needed for these issues. Recent advances in deep learning and computer vision, particularly CNNs and object identification frameworks like Faster R-CNN, have improved detection accuracy in demanding situations [3][4]. Traditional methods still make segmentation and recognition mistakes due to noise and partial occlusion [5]. Thus, hybrid solutions that combine advanced picture enhancing algorithms with machine learning models to increase real-time performance are needed. These issues must be addressed to improve traffic surveillance, security, and smart city projects in India.

LITERATURE REVIEW:

Recently, India's Automatic License Plate Recognition (ALPR) systems have been investigated to improve their precision and dependability. Due to its different fonts, plate types, and harsh climate, India presents many challenges. Sharma et al. [6] used Deep Learning and SVM to identify characters. The hybrid methodology inspired this method. Hybrid research yields more accurate outcomes than traditional methods. Ganta and Svsrk's image-processing technique identified and recognized Indian license plates [7]. Due to noise and poor light, the approach

performed poorly in real-world conditions despite performing well in controlled situations. To overcome these constraints, Jawale et al. [8] linked the Internet of Things (IoT) to CNN-based recognition for real-time applications. Scalability and remote monitoring were enabled by this implementation. Tarasa [9] examined their impact on the accuracy of character recognition using strategies and optical characters enhancing various paintings. This experiment demonstrated the importance of adaptive thresholding and noise reduction. Mir et al. [10] This analysis was conducted to evaluate the efficacy of these algorithms. Even though there have been major reforms, it is still difficult to know, staining of movement, and controlling plate discrepancies. Therefore, we need to quickly develop new systems that include older processing of images methods with new ones using nerve network.

Research Gap:

Sharma et al. [4] Use deep learning and SVM to make Indian license plate recognition better. Ganta and SVSRK [7] set up image processing to find the plate, but the noise made things difficult. Jewel et al. [[] Combining IOT and CNN models for real-time recognition made scalability better. Tavares [9] examined pre-processing options and recommended adaptive thresholding for OCR accuracy. Mir et al. [10] highlighted YOLO(You Only Look Once) and Faster R-CNN deep learning models for comprehensive ALPR. Despite these advances, occlusions, uneven plates, and low-light situations remain tough.

METHODOLOGY:

This study involved uses image processing and deep learning to solve Indian License Plate Recognition problems experimentally.

The framework that has been suggested consists of three basic stages:

- Pre-processing,
- Segmentation, and
- Recognition.

During the pre-processing step, acquired vehicle images are subjected to adaptive histogram equalization, Gaussian filter-based noise reduction, and contrast enhancement to optimize visibility across diverse lighting situations.

Segmentation using adaptive thresholding, edge detection, and morphology isolates the license plate region even in complex backdrops. Next, contour-based analysis breaks characters up into parts. Recognition uses a CNN that has been trained on 50,000 labeled images of Indian license plates from highways, city streets, and toll booths. The dataset is 70% training, 15% validation, and 15% testing. Data augmentation methods including rotation, scaling, and blurring improve model generalization. Performance is assessed by accuracy, precision, recall, and F1-score. To verify improvements, OCR-based and standard SVM techniques are compared. Scalable and quick implementation in intelligent transportation systems is the goal.

RESULTS AND DISCUSSIONS:

This research used a set of 50,000 photographs shot in different settings, such as low light, motion blur, and obstructions, to test the planned Indian License Plate Recognition system. We compared the performance to that of traditional OCR and SVM-based models. The main things

that were looked at were detection accuracy, character segmentation accuracy, and total recognition accuracy. The experimental results demonstrate that the hybrid approach, which combines adaptive pre-processing with CNN-based recognition, significantly outperformed baseline methods. Table 1 shows a comparison of the methods, showing improvements in the rates of segmentation and recognition. Figure 1 shows examples of the system's output in difficult settings, such as photos taken at night and plates that are out of shape.

Table 1: Performance Comparison of ALPR Methods

Method	**Detection Accuracy**	**Segmentation Accuracy**	**Recognition Accuracy**
Traditional OCR	82.5%	78.0%	76.2%
SVM-based Approach	88.0%	84.5%	82.0%
Proposed CNN Model	96.5%	93.8%	94.2%

Figure 1: Output of Proposed ALPR Model on Challenging Scenarios

These findings show that the suggested model is robust in real-world settings, ensuring excellent accuracy for intelligent transportation applications. The CNN-based ALPR model outperforms OCR and SVM methods due to its ability to handle different lighting conditions, warped plates, and motion blur. According to Jawale et al. [8], CNN architectures work well in real-time recognition systems with IoT for scalability. While their research focused on IoT-enabled monitoring, our study enhances accuracy through advanced pre-processing and resilient segmentation, ensuring reliable performance in difficult Indian traffic conditions. Tavares [9] found that adaptive thresholding and noise reduction significantly improve OCR accuracy, proving that pre-processing improves recognition rates. Our proposed framework combines similar advances, enabling performance gains. For comprehensive ALPR solutions, Mir et al. [10] studied deep learning and advanced object detection algorithms like YOLO and Faster R-CNN. Since CNN-based segmentation and recognition outperformed older methods, our findings support their findings. The suggested model solves long-standing difficulties including non-standardized plates and environmental variability while scaling up for inclusion into smart traffic control systems across India.

CONCLUSION:

Indian license plate identification faces several significant problems, including as non-standardized formats, low-light conditions, and motion distortions. The suggested CNN-based ALPR design is quite good at getting around these problems. The system was able to be more accurate than normal optical character recognition and support vector machine models by using adaptive pre-processing, robust segmentation, and deep learning-based recognition. The results show that combining image enhancement with CNN topologies is a good way to provide reliable performance in real-world situations. This study enhances intelligent transportation systems by providing a scalable and efficient solution for traffic monitoring and law enforcement. In the future, we should focus on real-time edge deployment and improving datasets to make them more flexible.

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