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Automatic Number Plate Recognition Using Pre-Trained CNNs

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Abstract : Automatic number plate recognition (ANPR) is a picture processing technology which uses a number (license) plate to spot the vehicle. The main objective is to efficiently design an automatic vehicle identification system by using the vehicle's number plate. The system is implemented in traffic rules and regulation, Parking Management etc. It can be also used in on the entrance for security control of a highly restricted area like military zones or areas around top government offices e.g. Military Base, Parliament, Supreme Court etc. Thedeveloped system initially detects the vehicle then captures the vehicle image. Vehicle numberplate region is captured using the image segmentation in a picture. CNN is used to improve theplate detection The resulting data is then can be used to compare with the records on a databaseso as to come up with the specific information like the vehicle owner, place of registration, address, etc. The system is implemented using Python and CNN as an image processing library,and its performance is tested on real images. It is observed from the experiment that the developed system conveniently recognizes and detects the vehicle's number plate on real images.

IndexTerms- **CNN, ANPR, Image Segmentation**

1. INTRODUCTION

In today's world, efficient vehicle identification and monitoring are critical for various applications, ranging from traffic management to security enforcement. Automatic Number Plate Recognition (ANPR) systems have emerged as a pivotal technology in this context, leveraging image processing to accurately identify vehicles by their license plates. ANPR systems are widely used for enforcing traffic rules, managing parking lots, and controlling access to restricted areas such as military zones and government offices.The primary objectiveof ANPR technology is to create a reliable system that can automatically detect, capture, and recognize vehicle number plates in real-time. This involves several key steps: vehicle detection, image capture, number plate localization, character segmentation, and character recognition. By integrating advanced techniques such as Convolutional Neural Networks (CNN), ANPR systems have significantly improved in terms of accuracy and speed [1].

Implementing an ANPR system involves sophisticated image processing algorithms and robustdatabase management. The system must efficiently handle various challenges, such as differentlighting conditions, varying plate designs, and obstructions. Once the number plate is recognized, the system can cross-reference the data with a database to obtain detailed information about the vehicle, including the owner's identity, registration details, and address[2].

This paper presents the development and implementation of an ANPR system using Python and CNNs for enhanced image processing. The system's performance is evaluated using real- world images, demonstrating its capability to accurately recognize and detect vehicle number plates in various conditions [3].

2. LITERATURE SURVEY

In this section, we provide an overview of recent research related to Automatic License Plate Recognition (ALPR) systems. A common technique for vehicle character recognition is template matching. In one study, researchers developed an ALPR system using feature extraction based on template matching, where they applied grayscale conversion, dilation, normalization, and the Sobel operator for vertical edge detection. Image segmentation was achieved through binarization, and Optical Character Recognition (OCR) was performed using template matching with cross-correlation. Another study utilized a similar method, employingtemplate matching and the bounding box technique for OCR-based car number plate recognition. Additionally, one study proposed an ALPR system using machine learning for effective vehicle tracking, with license plate data extraction via the bounding box method andcharacter recognition through template matching [4].

Recognizing Indian license plates presents unique challenges, prompting several studies to focus on this area. One study designed an ALPR system for an Indian university campus, featuring three main modules: Faster R-CNN for training, pre-processing involving Top-hat and Black-hat transforms along with Gaussian smoothing, and Tesseract OCR for character recognition. Another research effort used the YOLO network for detecting input images, withcharacter recognition also performed by YOLO[6].

Several critical features must be considered for an efficient ALPR system, including the abilityto recognize different types of license plates. For instance, one study developed an ALPR system capable of recognizing multiple license plates within a single frame. This system

included a detection phase using a Sobel filter with histogram equalization and thresholding, followed by a recognition phase using an Artificial Neural Network (ANN).

Another important feature is recognizing plates captured from various angles. Researchers proposed an optimized learning model for this purpose, employing Tiny-YOLOv2 for one- stage object detection, which increased the number of grids and anchor boxes for accurate character recognition. Recognizing multi-line license plates is also crucial. One research teamdeveloped an ANN-based system for single and double-line license plates that bypasses the character segmentation step, using a Bidirectional Long Short-Term Memory (LSTM) model to predict character sequences [8].

Additionally, the ability to handle multi-style license plates with varying font styles is essential. A study proposed a Multi-Style License Plate Recognition (MSLPR) system utilizing a 2-layerFeedforward Back-Propagation ANN for character recognition [9].

ALPR is a vital component of Intelligent Transportation Systems (ITS). One team explored thefuture scope of ITS services and proposed a novel architecture, identifying several challengesin the field. Another team developed an ALPR system using a modified Ant Colony Optimization (ACO) algorithm for edge detection, character segmentation through ConnectedComponent Analysis (CCA) and Kohonen neural network, and character recognition using inductive learning and Support Vector Machines (SVM). In a different study, researchers implemented an OCR system based on a Field Programmable Gate Array (FPGA), featuring a feed-forward neural network for efficient OCR implementation, achieving a 98.2% accuracy rate. Similarly, another ALPR system utilized YOLO's seven layers for single-class detection,employing a sliding window for character detection and recognition, effective even on dark and blurry images [11].

A study focused on deep learning techniques for intelligent transportation systems demonstrated significant reductions in data transmission delays and improved system accuracy,highlighting the potential of deep learning in enhancing ALPR system performance.

3. PROPOSED METHOD:

In the realm of Automatic License Plate Recognition (ALPR) systems, the integration of advanced deep learning architectures has significantly improved the accuracy and efficiency ofcharacter recognition and feature extraction. Our model leverages the strengths of two state- of-the-art neural network architectures: MobileNetV2 and ResNet50, to develop a robust and reliable ALPR system[13]. Figure 1. shows MobileNetv2 Architecture.

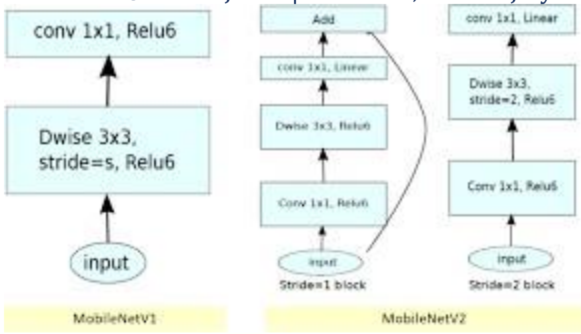

Figure 1. MobileNetv2 Architecture

MobileNetV2, renowned for its lightweight and efficient design, is employed for character training. This architecture is particularly advantageous in ALPR systems due to its ability to deliver high performance while maintaining a low computational footprint. MobileNetV2 achieves this through the use of depthwise separable convolutions, which reduce the number of parameters and computational cost, making it ideal for real-time applications where speed and resource efficiency are crucial[12]. Figure 2 shows ResNet50 Architecture.

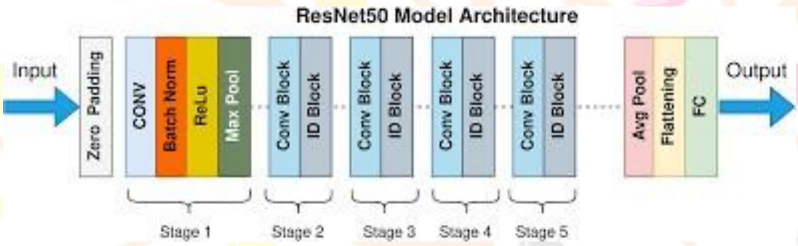

Figure 2 shows ResNet50 Architecture

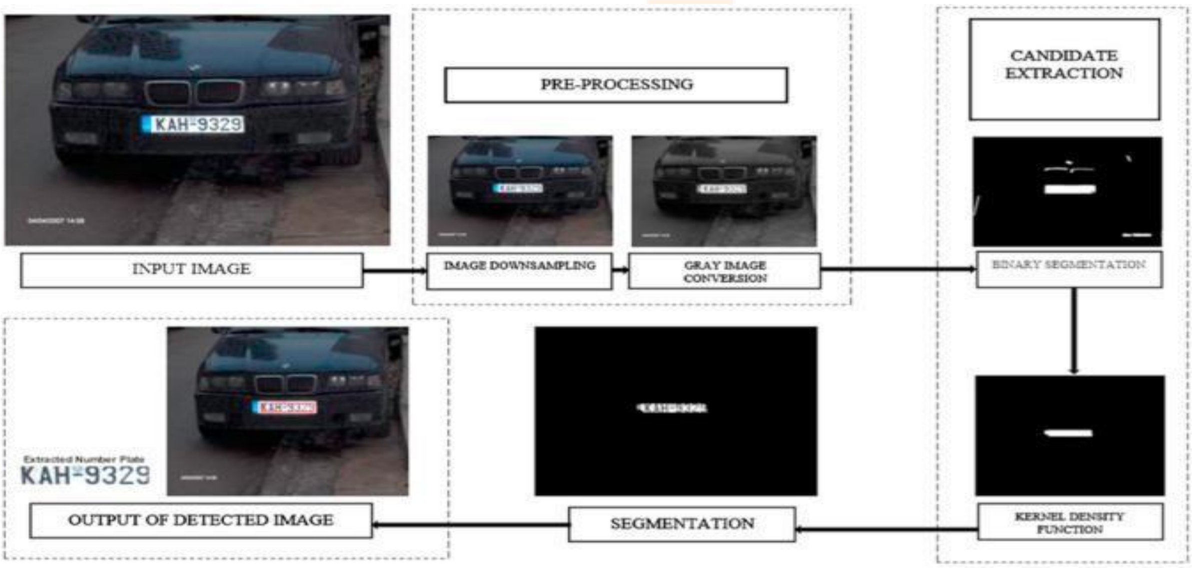

Figure.3: The Proposed Model of ATPR

On the other hand, ResNet50 is utilized for feature extraction from the license plates. ResNet50, a deep residual network, excels in capturing intricate features and patterns within images due to its deep architecture and the use of residual connections, which mitigate the vanishing gradient problem. This makes ResNet50 exceptionally effective in extracting detailed features from complex and variable license plate images, enhancing the system's ability to accurately detect and recognize license plates under diverse conditions.

By combining MobileNetV2 and ResNet50, our model benefits from the complementary strengths of both architectures. MobileNetV2's efficient character training ensures swift and accurate recognition of individual characters, while ResNet50's powerful feature extraction capabilities enable precise identification and differentiation of license plates. This dual- architecture approach not only enhances the overall performance of the ALPR system but also ensures its scalability and adaptability to various real-world scenarios, including different lighting conditions, angles, and plate designs. Figure.1 shows architecture of the proposed model.

In this proposed system, the character training for the characters from A to Z, 0 to 9 is done by pre-trained Mobilenetv2. Figure.2 shows the feature extraction from the characters.

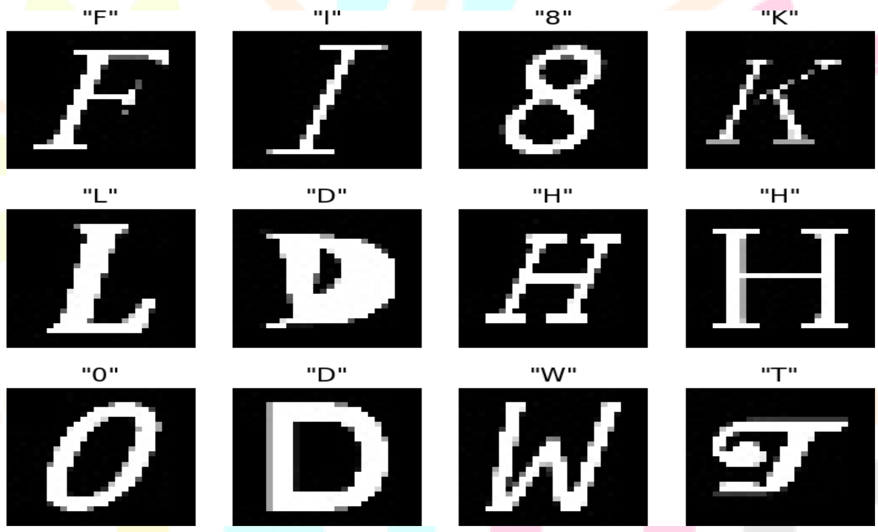

Figure.4 Feature extraction from the character dataset

Resnet-50 is used to segment number plate from the vehicle. Figure 5 shows the number platesegmentation using Resnet-50.

Figure.5 Image of Number plate of a vehicle.

Figure 6. Extracted License plate from the vehicle image.

Recognition of character is done from the Segmented image shown in figure.6. The Figure 7shows how the character are recognised from the segmented image.

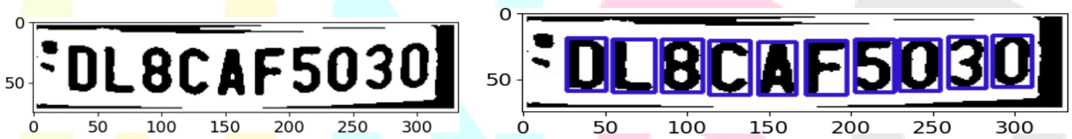

Figure 7. shows characters recognised from the number plate.

4. RESULTS AND DISCUSSION

The performances of the proposed algorithm has been evaluated with devised training sets of various sample size. The classification accuracies with different training samplesare depicted in Figure 6. Two graphs illustrating the F1 score and precision metrics over several epochs for both training and validation datasets.

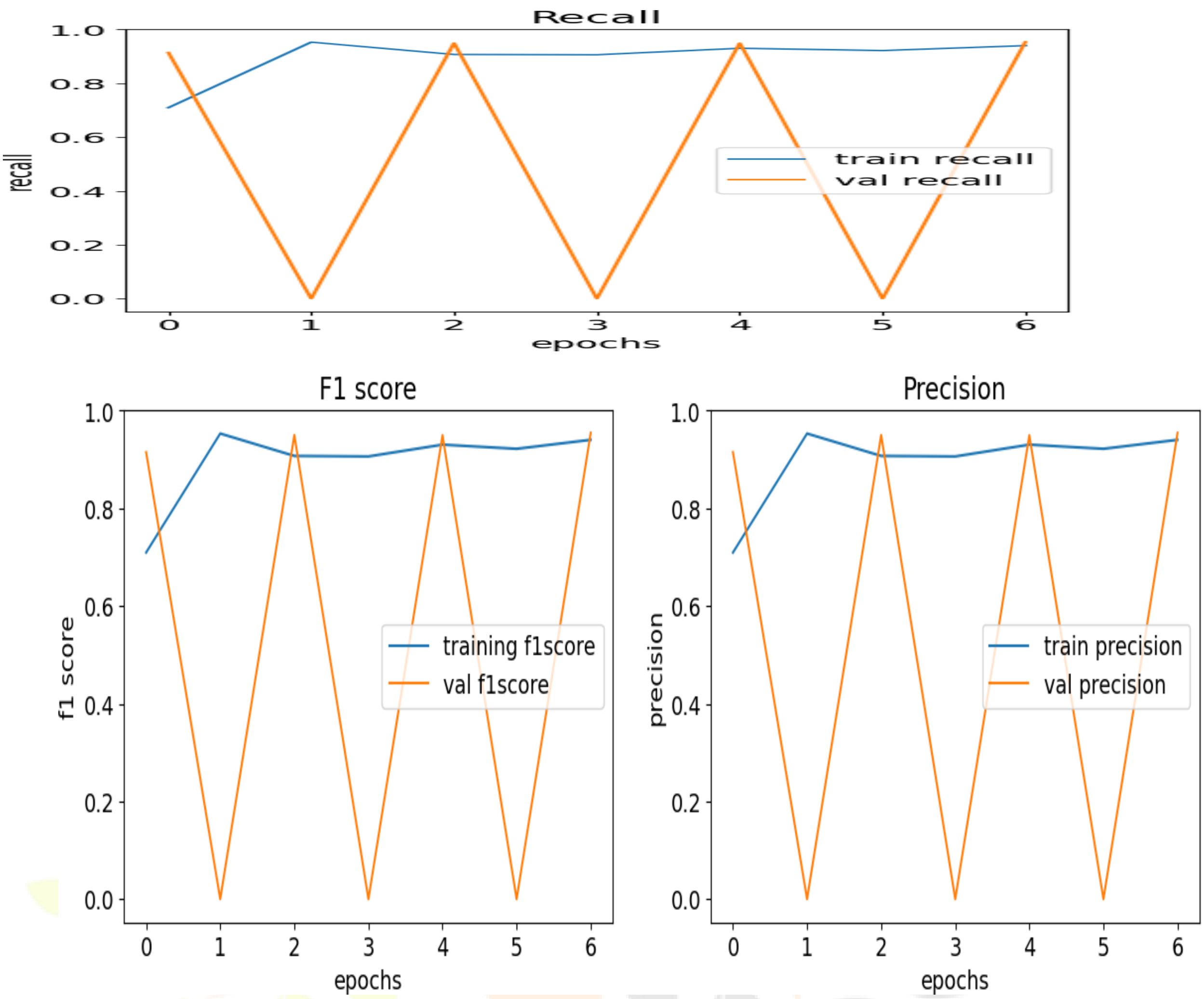

Figure 8 illustrates the performance of the model

5. Conclusion:

In this paper, we have undertaken an effort to recognize the state or province of a vehicle basedon its number plate using self-generated features within a pre-trained Convolutional Neural Network (CNN). The initial results obtained from this study are highly encouraging, even though the training was conducted with a relatively small dataset. The findings of ourinvestigation demonstrate the potential and promising future of employing CNNs for such automated applications.

In conclusion, our proposed model exhibits strong performance in recognizing the state or province from vehicle number plates. The model's ability to deliver accurate results with limited training data underscores its potential effectiveness. However, addressing the challenges of real-time application remains essential to fully leverage the benefits of CNNs in practical, real-world environments. Our ongoing and future work will focus on enhancing themodel's robustness and efficiency to ensure it meets the demands of real-time implementation.

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