Comparison Study About Vehicle Detection and Plate Number Recognition

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A R T I C L E   I N F O

A B S T R A C T

Vehicle detection is crucial to the management of Intelligent Transportation Systems of urban traffic. Optical character recognition is many systems use, like the automatic number plate recognition system (NPR). Using various techniques and methodologies, such as convolution or deep neural networks, morphological operations, optical character recognition, and edge detection, such a system has been widely utilized to identify car license plates. Numerous applications algorithms of vehicle identification become possible after the development of many helpful techniques in computer vision and the availability number of related images as a dataset. In this paper, the various plate numbers of the specific vehicle will be and reviewed. Vehicle detection systems suffer from a variety of difficulties and constraints such as the all the surrounding state of clarity for the license plate, non-standard formats of the plate, complex situations, camera quality and clarity, the position and distance of the camera, the distortion in the image, contrast issues, reflections and the state day and night images As a result, numerous methods for comprehending and assessing the idea behind the vehicle number plate recognition systems have been presented with simply explaining the importance and drawbacks of each system.

1. Introduction

Recognition of vehicle plate numbers (VPNs) is used in a variety of traffic management, observation, and surveillance systems. Most Stages as the primary learning areas for VPN content [1].
An ANPR system typically divided into main four stages:
  1- Images as a dataset collection.
  2- license plate detection.
  3- digits segmentation.
  4- digits recognition.

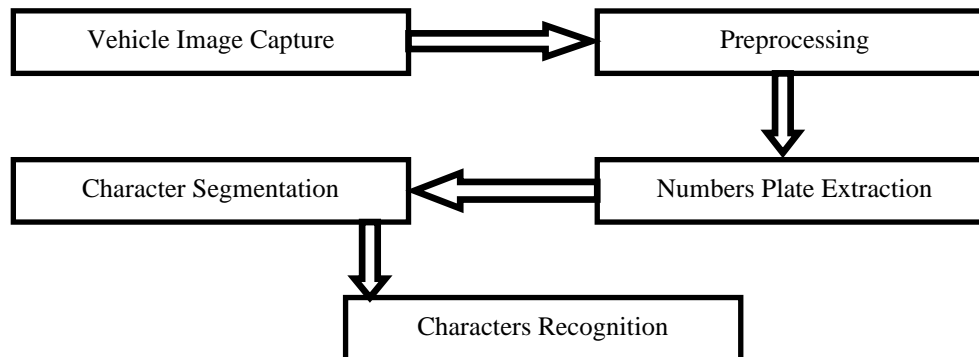∗Corresponding author

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As illustrated in Figure 1 Image collecting is Automatic License Plate Recognition (ALPR) first stage. Photographs can typically be taken out of videos, collection of images by cameras. The second stage involves finding and extracting the license plate from an image. Typically, this stage comes after the object detection step. For plate detection, edge detection is usually applied. Numerous techniques have been suggested to handle the plate detection problem in addition to edge detection. [16]

Following the plate detection, the segmentation step is carried out to divide the region into sections for identifying letters and numbers. The third part is to read the vehicle plate using Optical Character Recognition (OCR) technique to obtain each character and recognize it using a database that has been recorded for every alphanumeric character. Each segment is divided into digits and letters in this step. [20]

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┌────────────────────────┐        ┌────────────────────────┐
│  Vehicle Image Capture │ ═════► │      Preprocessing     │
└────────────────────────┘        └────────────────────────┘
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┌────────────────────────┐        ┌────────────────────────┐
│  Character Segmentation│ ◄═════ │ Numbers Plate Extraction│
└────────────────────────┘        └────────────────────────┘
           ║
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┌────────────────────────┐
│  Characters Recognition│
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Fig.1 An ANPR System Block Schematic[16].

The vehicle plate detection and the object recognition stages are the two main stages that recent research has essentially divided the ALPR phase into. These methods separate the time-consuming and computationally complex detection and recognition phases. Another difficult task in object recognition is character. [2]

Network for Object Detection and Training Convolution Neural Networks (CNN)-based models and its derivate models, such as Region Based Convolution Neural (RCNN) [23], are widely employed in computer vision tasks such object identification, classification, tracking, and segmentation for car detection on the camera or video.[17]
Mask RCNN extends the quicker identifying each instance of the object of interest in a pixel-level image and achieving instance segmentation using region suggestions.

License plates are labeled and cropped from their original images for license plate recognition. The method of classification and recognition for their own letters and numbers is then applied. The empty lines between characters are disclosed to split the license plate characters and produce split filter elements when the concept of this step applies to characters from the license plate filter that are recognized and then matched with characters, a CNN classifier is trained to recognize the characters on license plates to categorize these hashed filters.[5]

## 2. CNN Based Recognition Process

plate recognition (LPR) technique, which focuses on license plate (LP) localization, segmentation, and character recognition, has drawn the attention of many scholars. Numerous research using the applications of morphology, relaxation labeling, and linked components have successfully segmented [18]. Additionally, a maximum number of character analysis techniques have been used in its including classification, fuzzy C-means, K-Nearest Neighbor (KNN), Artificial Neural Networks (ANN), Markov chain model and support vector machines (SVM) classifier.[6]
Part of the methods only consider the segmentation of individual characters line and two types of digits analyses were produced, namely, English digits and numbers. Despite these approaches arese approaches being capable of computing the region of inserting an LP divided and understand, these approaches are capable of computing the region.[19]
A well-known deep learning (DL) model called CNN is utilized to identify characters in segmented LPs. Figure 2 illustrates the Fully Connected Transformation, Aggregation fully connected (FC) layers that make up a CNN. These layers are used to add or remove blocks from a CNN model or to build a model with a variety of block sizes.[13]
Each pixel is not connected to an additional layer with weights and biases because of differences across NN to NN in this regard. causes the entire picture to be divided into smaller components [22]. The pooling layer is used to cut down on the amount of parameters and spatial dimension in the image, which lowers the processing cost. The input is held

in a preset function. Here, the (FC) layer is given the attenuated output of the pooling layer as an input. Each neuron from the previous layer is linked to the current layer in a typical NN.[15]

Input segmented image   convolution and pooling layers   fully connected layers
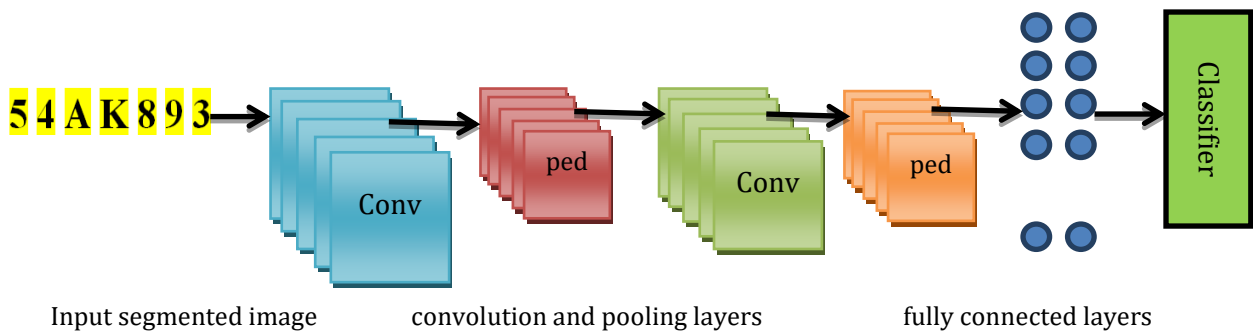
Fig. 2 Architecture of CNN for Character Recognition.

Along with various CNN architecture models, several activation functions are employed [21]. There are several nonlinear activation functions, including Swish, Rectified Linear Unit (ReLU)), and non-linear function of the activation facilitates training process acceleration. It is discovered that the ReLU function outperforms others.[14]

A different technique for recognition desired character may be called an optical character recognition (OCR), Which compares each character to the whole alphanumeric database. In order to match each individual character, the correlation approach. Once the number has been located, it is then saved in a variable in string format. The character is then checked against the database to authorize the car. According to the comparison's outcome, the resultant signals are presented. As illustrated in figure 3 templates will be available for all characters, including A-Z and 0-9**.**
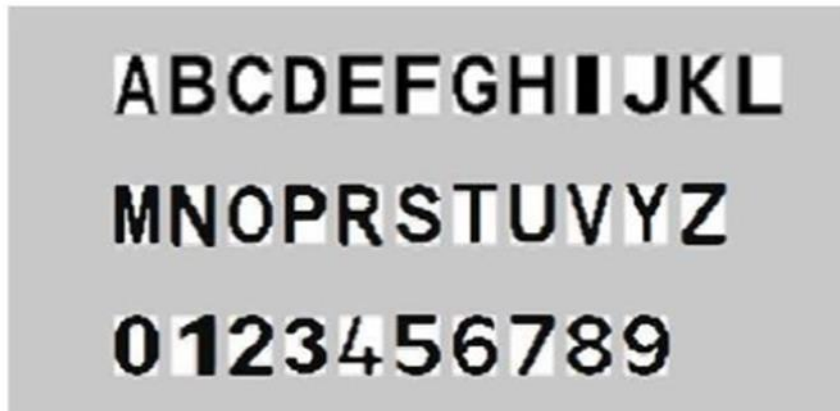
Fig .3 Database of Templates.

The picture is initially turned into a binary, or black and white, image which is one of the main stages in the OCR process. Cropping and separating the lines from the picture rows would be the next [15]. There same procedure is done on each row's columns to separate each character. After that, the template files are loaded. The templates file is a file that contains the pictures of each letter and number, and it is this file that all characters will be compared against in order to identify each character.[20]

3. Methods

S Silva and C Jung. [7], proposed the Automatic License Plate Recognition (ALPR) system for its importance in many intelligent transmission and monitoring systems appliations.
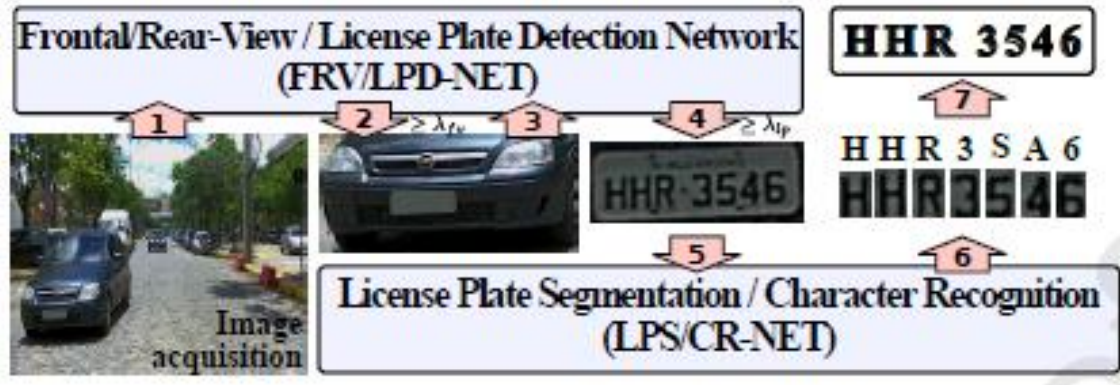
Fig .4 Automatic License Plate Recognition (ALPR) system.

A comprehensive Automated plate recognition method depend on a specific convolutional neural network (CNN) which is used as illustrated in Figure 4. This method uses two passes on the same CNN to identify the vehicle and license plate area, followed by a second CNN for character recognition. Datasets of Brazilian and European license plates, the method tested the Open-ALPR (European) and SSIG (Brazilian) datasets' average LPD precisions were 90:94% and 96:09%, respectively, It outperformed both a commercial system and competing academic methods in terms of accuracy rates.

Salah Al- Ghayalin. [8], proposed developing a system car Plate Recognition Automatically that runsout effectively for all kinds of LPs which is a difficult and challenging task because many countries design different models for LPs. Convolutional neural networks (CNNs) with two stages are employed, desired CNNs are built on the open source (YOLO) verison3 framework. The block diagram for the proposed system or models for the purpose of LPs detection and digits recognition, there are two training stages. The models for detecting LPs and recognition digits in the desired LPs are employed in the second testing phase to find and identify the position of the LP in a video. Since the recognition of LP stage is carried out at every frame, many false recognitions will be made for the specific plate. The correct recognitions are kept and the incorrect recognitions are eliminated using the similarity and frequency of expected LPs. The proposed method is outlined in three primary steps for ease of understanding:
1- plate detection.
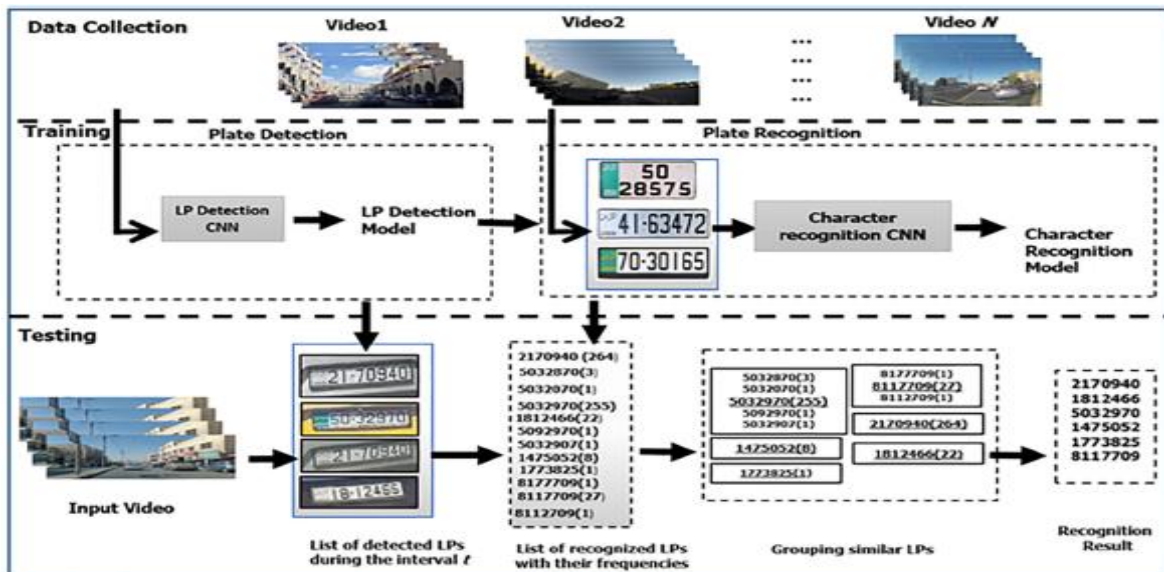2- Digit recognition.
3- Plate number recognition.

Fig .5 Main Steps of the Suggested JALPR Approach.

According to experimental findings, commercial systems' recognition accuracy is less than 81% whereas that of Jordanian license plates in real YouTube videos is 87%.

Naaman Omar et.al. [9], proposed Automatic license plate (ALP) detection and recognition because it is essential for both parking management and traffic surveillance systems, as well as for preserving the efficiency of contemporary urban life, to develop a successful vehicle detection and identification system in northern Iraq, a sequential deep learning strategy is suggested. The plate number, the city region, and the state region are the three regions that make up a car registration plate in northern are defined by the deep semantic hash network. After that, a deep decoder network design is used to implement the hash. The chosen license plate regions are fed into two different Convolutional Neural Network (CNN) models to recognize Arabic numerals and identify cities. While the previously proven CNN model was enhanced for city recognition, the CNN model for Arabic numeral recognition was constructed and trained from scratch, as illustrated in Figure 6.
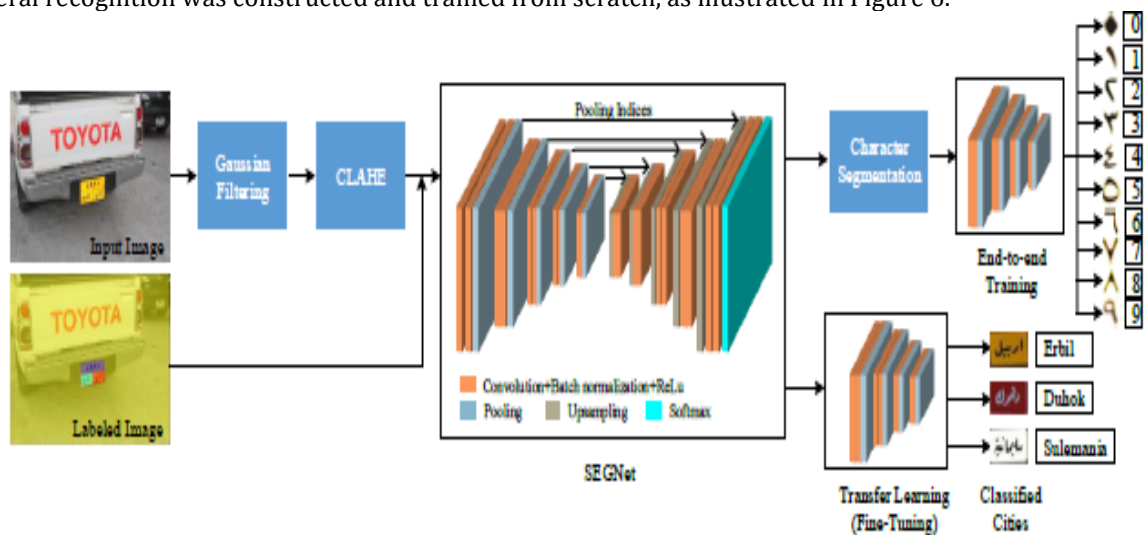
Fig .6 License Plates Detecting and Identifying Method.

The results demonstrated that the suggested strategy is successful detects and identifies license plates. The computed F-measure scores were 91.01 %, 92.10 %, and 94.43 %, respectively, for recall and accuracy. Additionally, it was discovered that Arabic number classification accuracy was 99.37 % and city appellation classification accuracy was 92.26 %, respectively.

J M S V Ravi Kumar et.al. [10], presented One type of (STDM) smart transportation / detection number plate recognition (NPR) model by using digitally acquired photos, the specific application strongly enables the model for recognizing and automatically reading the license plate of a specific car. This effort extracts the vehicle's number plate from the image using mathematical morphological techniques (erosion, stretching).

This is based on several activities, including picture optimization, grey-scale conversion, and edge detection of binary filters to detect and translating a particular car license plate. Then, using a template match with the OCR on the letters, the hashing technique is used to find the text on the number plate. After finishing the aforementioned actions, this method can quickly and precisely identify the license plate number from a vehicle image as illustrated in Figure 7.

Fig .7 Test Vehicle Image Model.

Testing the program in Python language and trains the program by using specific training samples and defined the model by using libraries of the Python program as the results in the output as shown above. Then, a desired file is used to identify a wanted for test image that was excluded from the training dataset. For improved detection visibility, the license plate region has a red border.

Fig .8 Graphical User Interface.

In the graphic above Figure 8, a.NET GUI software calls a Python language and displays the expected results in a usable manner.

Karrar A. Kadhim et.al**.** [11], proposed a system for motor license plate understanding and recognition using images of desired vehicle and analysis was provided. It requires precise license plate position identification, then the characters from the plate number are extracted, Although the symbols were extracted using a histogram-based method, utilizing morphological algorithms that adjusted and corrected the license plate's various viewing angles, plate edge detection was performed. After that, the extracted characters and the templates were compared. and according to the outcomes, the accuracy analysis for each stage in the suggested method is displayed in Table 1. The highest levels of accuracy (100%) were shown in Processes 1 and 3, demonstrating the effectiveness of the algorithms utilized in both steps. However the algorithms utilized in the other steps, , have a few flaws. For example, the algorithm's highest accuracy for segmentation process of the character was 0.95% percent accuracy, While the approach for localizing license plates has a higher precision of 95.2%. The algorithm used in the characters matching stage was the least accurate (88.3 %)., 80 % was found to be the system's overall accuracy.

Table 1. Results for the examined automatic license plate recognition system.

Detection	Quantity	Seccess	Error	Accuracy %
Adjustment of the distance between the observer and the vehicle	85	85	0	100
The location of license plate	85	81	4	95.2
Adjustment angle for license	81	81	0	100
Character segmentation	81	77	4	95
Character matching	77	68	9	88.3
Total	85	68	17	80

This method effectively detected license plate and established a strong basis for more complex license plate recognition systems.

Ibtisam Soleimani and others. [5], Due to the difficulty in identifying license plates, which requires expensive and time-consuming calculations, Suggested the usage of a 2D wavelet transform to retrieve the input image's vertical edges, as illustrated in Figure 9.
Finding potential license plate areas, the desired density of the image edges in the vertical direction is calculated initially, next, the proposed system used specific CNN classifier to confirm these potential regions, after that by exploiting the space between the characters, the characters are split. These candidates are then classified according to various CNN classification guidelines, and the tests conducted on cars with Moroccan license plates, showed great accuracy showed great accuracy.

Fig .9 Sub-bands of 2D-WD.

The accuracy for detecting LPs is up to 98.4% and the calculated accuracy for recognition is up to 98.9% as listed results in Table 2. In specific cases the results reach 99.43% for localization and 98.9% for recognition.

Table 2. accuracies of LPs detection and digits recognition.

Video Sequences	Detection Accuracy %	Recognition Accuracy %
1	98.4	98.9
2	96.23	98.5
3	97.4	97.9

Hendry and Rung- Ching Chena. [2], suggested (YOLO)-darknet deep learning algorithm for Taiwanese car license plates can be recognized using automatic license plate recognition (ALPR), As shown in the Figure 10. Use the dataset of (AOLP) that comprised six digits LPs to discover a single class using YOLO's 7 convolutional layers. The technique for detecting car license plates involves sliding windows. Each slide window is detected by a unique framework after detecting each license plate digit. The system has a detection accuracy of 98.22 % and a recognition accuracy of 78% for digits of LPs. The method performs only one detection and recognition

stage for every tested image, which takes between 800 milliseconds and one second. The system is also evaluated in various challenging environments, including those with a rainy background, complete darkness, and varying levels of image saturation.
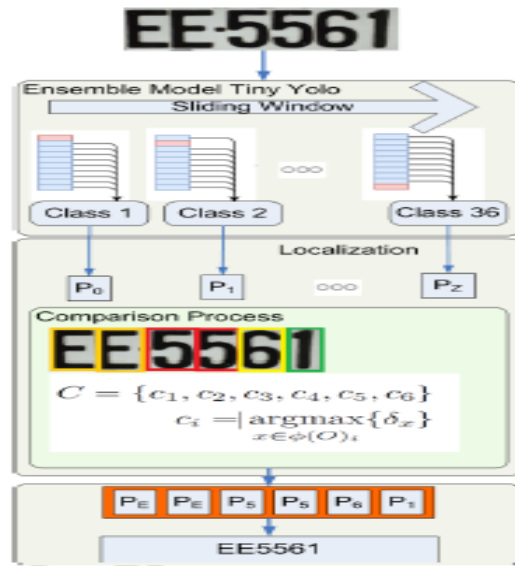

Fig .10 Architecture of the proposed system.

IRINA V. P. et.al. [6], suggested a car plate recognition procedure for solving difficult states due to differences in colors, viewpoints, formats, specific shapes, and unsteady lighting states during the acquisition process of images, the OKM-CNN model, which is described in this study, as demonstrated in Figure 11.
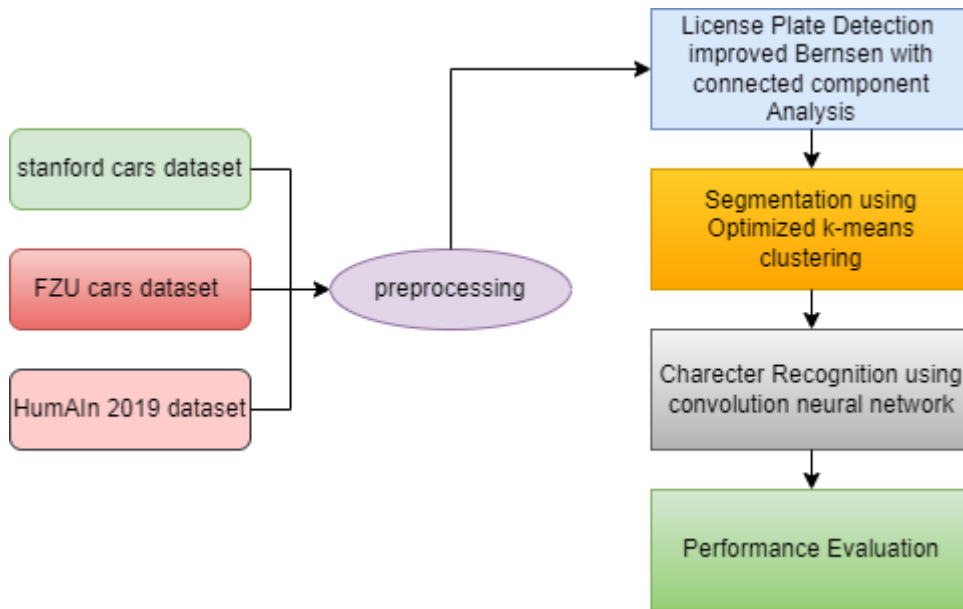

Fig .11 Suggested OKM-CNN method's general structure.

 a powerful learning of the proposed model that uses clustering-based segmentation, Convolutional Neural Network (CNN) for recognition and specific optimal K-means method (OKM). that uses the detection stage of LPs, segmentation by OKM method, and CNN model for LP recognition. A thorough experimental investigation was carried out using the (HumAIn 2019) Challenge datasets. The successful simulation outcome substantially increased the OKM-CNN model's performance compared to the other approaches.

Table 3. Results of overall accuracy (%) of OKM-CNN

| Model	Overall Accuracy
ZF	0.942
VGG16	0.971
VGG_CNN_M_1024	0.967
ResNet101	0.943
ResNet50	0.976
OKM_CNN	0.981

The complete accuracy analysis supplied by the applied dataset and the OKM-CNN method is summarized in Table 3. By offering a higher accuracy of 0.981, it is clear that the provided system attained the best performance for recognition. Both the VGG16 and ResNet 50 models simultaneously produced more accurate finding, with accuracies of 97.1% and 97.6%. The ZF and ResNet 101 models only obtained minimal accuracy with values of (0.942 / 0.943), respectively, whereas the (VGG CNN M 1024) model significantly increased accuracy to 0.967. The proposed OKM-CNN model achieved more accurate recognition on every used image than the older methods.

S. A. Shinde, in [3] strong system to avoid the speed of the vehicle, one method for obtaining the vehicle number from a moving vehicle is the Automatic Number Plate Recognition (ANPR) system, an image processing technique called automatic number plate recognition (ANPR) uses a car's number to identify it. creating special and effective method for in-picture image segmentation-based extraction of a car's LP region. Character recognition is done using optical character recognition technology. The resulting information is then utilized to compare with database records to determine specific information, such as the car's owner, registration location, address, etc. as demonstrated in Figure 12.
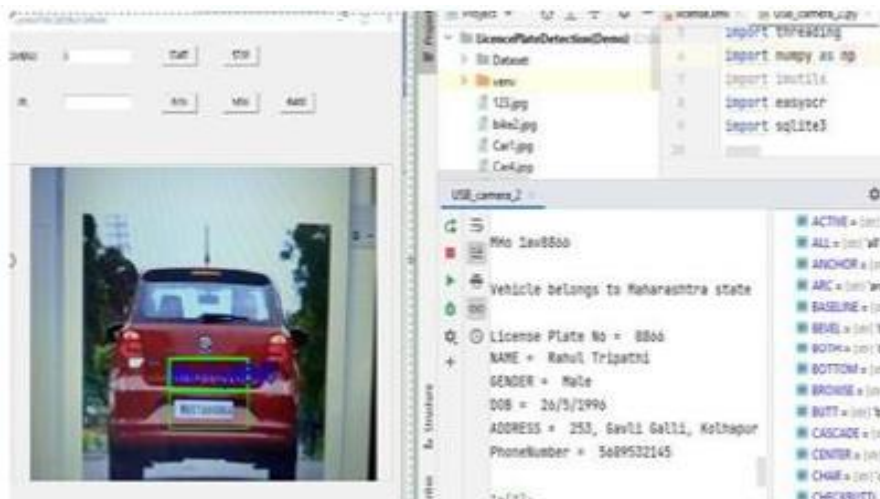
Fig .12 Final Output of ANPR in search.

R. K. Varma. in [12] suggested a new image processing method for identification and recognition that can be non-standard number plates, noisy, cross-angled and dimly lit for some countries with not unique number plate. This work pre-processes the images using some useful transformations like morphological and Gaussian smoothing and thresholding, among other image processing methods, as demonstrated in Figure 13.
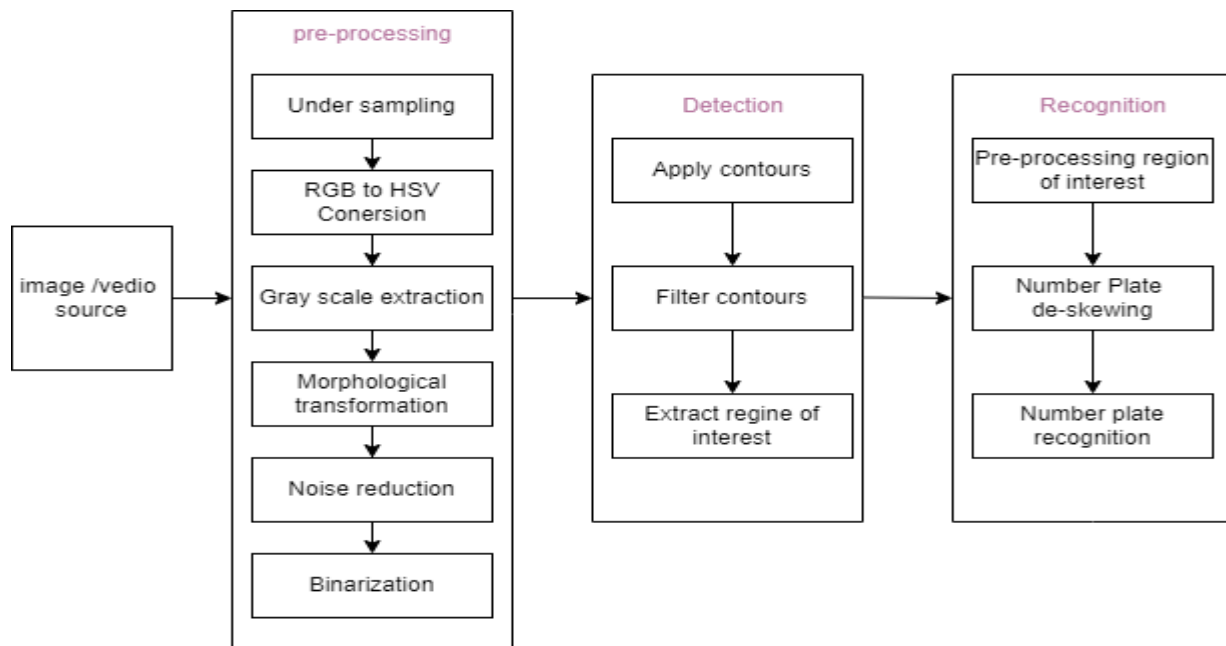
Fig .13 The proposed number plate recognition system.

Following that, outlines are applied per the boundaries for number plate segmentation, and features are filtered depending on the dimensions of the specific character and localization. The KNN technique is then applied for digits for identification filtering the region of interest and the removing of the aberration. The suggested approaches demonstrated distortion, for character identification, the K-nearest neighbor technique is employed. The suggested methods produced encouraging outcomes as shown in Table 4.

Table 4. System Accuracy[12].

Work	Component	Number of samples	Accuracy
This Work	Number plate Detection	101(images)	98.02%
This Work	Character Recognition	768(characters)	96.22%
[24]	Number plate Detection	250	85%
[24]	Character Recognition	214	80%
[12]	Number plate Detection	95	97.89%
[12]	Character Recognition	-	96.84%

Different font characters may be recognized. However, it is important that when measuring the weight of the different lines, a proper balance must be achieved. The model may become too much and produce poor generalization and biased prediction if it contains too many lines. Fewer lines will result in a misfit of the model, resulting in an inaccurate prediction. Moreover, because there is a dearth of data, complex methods like gradient boosting tend to over-ingest data, which results in inaccurate predictions. So, K-Neighbors and other, simpler models seem to work just fine.

4. Conclusion

Many systems are used to identify vehicles based on their license plate numbers, some of which are summarized in this study. Various image processing methods are used in the development of a vehicle number plate recognition system, even while the processing stages in various research, from collecting and preprocessing plate pictures for character and number recognition, are largely the same, they have produced results with varying degrees of accuracy. Several number plate recognition techniques available, some of which rely on image processing, some of which employ character recognition, and others of which organize number plates using machine learning and deep learning techniques. This essay provided an overview of license plate data. Deep learning algorithms, such neural networks, have proven to be the most popular and effective option for recognition since they require less time and produce high recognition accuracy rates. According to this review, image processing techniques produced acceptable results even if

they required additional processing techniques, while machine learning models produced superior outcomes. This model can easily be rebuilt by adding, removing, and rearranging the available convolutional and pooling layers.

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