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Image Enhancement and Automated Number Plate Recognition

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ABSTRACT

Automatic Number Plate Recognition (ANPR) and Vehicle Number plate detection (VNPD) systems. ANPR, is a technology that enables automatic detection, recognition, and identification of vehicle license plates, while VNPD is a subset of ANPR that focuses specifically on detecting and recognizing license plates. Several researchers have explored different approaches to ANPR and VNPD systems, as evidenced by the various papers listed. For instance, presented an e security system for vehicles number tracking at a parking lot, proposed a method of monitoring traffic signals, and violations using ANPR and GSM. In order to proceed, the conventional Grab Cut algorithm must first interactively give a candidate frame. for the target detection job to be done. To automate the identification of the licence plate by the Grab Cut algorithm, we update the candidate frame by incorporating the aspect ratio of the licence plate as the foreground extraction feature. Then, to fully implement picture noise reduction, we combined the Bernsen algorithm with the Wiener filter, which is extensively used in the fields of digital signal processing in order to increase the detection precision of conventional target identification techniques. Overall, the papers listed in the question demonstrate the wide-ranging applications of ANPR and VNPD technologies, from parking lot security to traffic signal control to driver assistance systems. These technologies have the potential to improve safety, efficiency, and security on the road, and researchers continue to explore new approaches to their development and implementation.

Keywords: Detection of Number Plate, Convolutional Neural Network-(CNN), Object detection, character identification, Machine Learning-(ML).

INTRODUCTION

Automatic Number Plate Recognition-(ANPR) is a technology that enables automatic detection, recognition, and identification of vehicles license plate**[4]**. ANPR systems are equipped with specialized cameras and software that can capture high-quality images of license plates, even in challenging lighting or weather conditions. These images are then processed using advanced algorithms that can extract the relevant information from the plate, such as the vehicle's registration number and country of origin.

With India's population growing exponentially, the number of unlicensed cars has increased at an exponential rate, which has only exacerbated the nation's long-standing traffic problem. As a result, there were more general crimes and traffic delays. Thus, it is essential to enforce the adoption of a system for delivering sanctions quickly. It takes a lot of effort and money to restrict access to business facilities to just authorized vehicles. In order to efficiently extract information from a licence plate's image once it has been

captured, we need a trustworthy and efficient method. Automatic number plate identification is a method for extracting the characters of licence plates numbers from photographs**[7]**. ANPR technology is constantly evolving, with new advancements being made in areas such as image processing, machine learning, and artificial intelligence. As a result, ANPR systems are becoming more accurate, reliable, and efficient, and their applications are becoming more widespread. In this context, ANPR is a key technology for improving safety, security, and efficiency on the road, and it is likely to be continue to play an essential role in the transportation and law enforcement for years to come. Intelligent transportation is already being advanced by the use of ANPR technology. Systems are taking the place of interpersonal communication. The roadsides camera are no more the only security measures in places. It has changed period of time to become a mobile, Several ANPR devices were initially utilized in cars, but more recently, as smart phone technology advanced, they also became portable. Because to its less expensive provisioning, ANPR is usually used by the toll and the parking sectors. The ANPR system, in contrast to Ultra High Frequency Radio Frequency Identification (UHFRFID) systems, recognize the registration number plate without the need for an additional transponder.

LITERATURE REVIEW

Several studies have concentrated on conventional computer vision methods for licence plate identification among the extant assessments of the ALPR context. Moreover, none of

Aspects including single-stage licence plate identification methods, ANPR's datasets, the licenses plates recognition methods in challenging environment settings have all been thoroughly researched by them. Consequently, the primarily contributing to this study has concentrated on the performance of cutting-edge ALPR's models under adverse environmental changes and other difficult circumstances **[7]**.

By supplying an understanding of the current techniques, approaches, and models, we anticipate that the people of this study will include both beginner and expert individuals who are interested in constructing ALPR's systems **[7]**. The survey is particularly intended at academics and programmers in the fields of deep learning and computer vision. Our survey does not, however, focus primarily on imparting a deeper technical understanding of the various image processing (IM) and also the machine learning (ML) techniques. Instead, focus on the possibility of offering and using current image processing (IM), computer vision (CV), and deep learning (DL) approaches for the ALPR's task **[7]**. We are particularly interested in the following contributions. We examine the benefits and drawbacks of strategies and approaches in both an individualised and comprehensive manner, enabling the designers of the ALPR system to make choices. Based on quality, processing value, and robustness to changing environmental circumstances, we report the performance of various choices. We also assess each choice's effect on the accuracy and computing costs for the system as a whole. By examining publicly accessible ALPR datasets, together with their present problems and available fixes, we offer numerous specifications for an ALPR benchmark.

Sr no	Title	Authors	Year	Algorithm Used	Description
1	License Plate Localization in Complex Environments Based on Improved GrabCut Algorithm	HENGLIANG SHI1 AND DONGNAN ZHAO2	2022	Grab Cut, Wiener filter	The improved GrabCut algorithm used the aspect ratio of the license plate as the foreground extraction feature and introduced the Wiener filter and Bernsen algorithm to reduce image noise and improve detection precision. The algorithm achieved 99.34% accuracy for license plate localization and a detection speed of 0.29s/frame, surpassing traditional GrabCut and other license plate localization algorithms. The algorithm was tested on the CCPD dataset, which includes vehicle images from diverse natural scenes, including low-resolution images.
2	Indian Vehicle Number Plate Detection and Recognition using Deep Learning	Lalitha Madanbhavi1,Geeta R. Bharamagoudar2,Nikita Parakh3, Nikhil Pujari4 Praveen Kakhandaki, Meena S.M6	2022	Deep Learning, RCNN, CNN	They created a deep-learning based method using convolutional neural networks for number plate detection and recognition. Our approach achieved high accuracy rates of 98.46% for RCNN and 95.98% for CNN models. The methodology provides a solution to the identified gap in image processing techniques.
3	Automatic Number Plate Recognition:A Detailed Survey of Relevant Algorithms	Lubna 1 , Naveed Mufti 2, and Syed Afaq Ali Shah	2021		Technologies and services towards smart-vehicles and Intelligent-Transportation-Systems (ITS), continues to revolutionize many aspects of human life. This paper presents a detailed survey of current techniques and advancements in Automatic-Number-Plate-Recognition (ANPR) systems.with a comprehensive performance comparison of various real-time tested and simulated algorithms,including those involving computer vision
4	Vehicle number plate detection using Python and Open CV	AS Mohammed Shariff, Raghav Bhatia, Raghwendra Kuma and Sarthak Jhas.	2021	Open cv, Tesseract, Canny Edge detection.	In this paper, an efficient and an amazingly Simple method is used to recognize the number plate. In the proposed method, Open CV library along with python language is used for image processing using py tesseract. The input image is taken and converted into grayscale image and the processed image is filtered through bilateral filter to remove unwantedcharacters. In this paper.
5	Intelligent System for Vehicles Number Plate Detection and Recognition Using Convolutional Neural Networks	Nur- A-Alam, Mominul Ahsan 2, Md. Abdul Based and Julfikar Haider.	2021	neural networks; deep learning; bounding box method	The intelligent sys- tem can play a vital role in traffic control through the number plate detection of the vehicles. In this research work, a system is developed for detecting and recognizing of vehicle number plates using a convolutional neural network (CNN), a deep learning technique. This system comprises of two parts: number plate detection and number plate recognition. In the detection part, a vehicle's image is captured through a digital
6	Automated License Plate Recognition: A Survey on Methods and Techniques.	JITHMI SHASHIRANGANA, HESHAN PADMASIR, DULANI MEEDENIYA	2020	EDGE-BASED METHODS, COLOUR-BASED METHODS, EXTURE-BASED METHODS	The operational specifications of these systems are diverse due to the differences in the intended application. For instance, they may need to run on handheld devices or cloud servers, or operate in low light and adverse weather conditions. In order to meet these requirements, a variety of techniques have been developed for license plate recognition. Even though there has been a notable improvement in the current ALPR methods, there is a requirement to be filled in **recommendation algorithm is evaluated by the TOPN list experiment.**

MATERIALS & METHODS

PROPOSED SYSTEM:

Using the Sobel technique, edges may be detected by computing the gradient of image intensity at each pixel of the picture. It detects the direction and velocity at which the transition from bright to dark is most quickly. Edge detection with the Sobel filtering technique is accomplished using the following terms: In Open-CV,

cv2.Sobel[image, cv2.CV8U,1,0, kernel_size=3] is utilised to accomplish edge detection with kernel_size of 3**[2]**.
Apply Counters: The process used to create contours known as contour tracing and it is also known as Border-Following. The lines of Same intensity pointing and running along the boundaries is known as a contour. Finding contour in Open-CV**[2]** is as same as, to finding a light-colored object against a dark background, So the Inversion operations must be used during the Adaptive Gaussian Threshold Stage(AGTS). Recognition of text on licence plates using optical character recognition (OCR) is possible with Python Tesseract**[2]**. In other words it will determine and interpret any text that is enclosed in the images. We have used this tool finally to obtain the text present in the filtered, de-skewed contour.

1. METHODOLOGY

Before proceeding with the character recognition process, it is necessary to pre-process the region of interest. There may be instances where two or more contours, such as in the case of the number "zero," completely enclose one another. If the internal contour is detected at the time of contouring process, it could be mistaken as a separate character, resulting in the identification of two different characters during the recognition process. To avoid this, we resize the image as needed during the pre-processing stage. Deskewing a licence plate: Skew is the amount of rotation required to bring a picture back into alignment with its horizontal and vertical axes. Degrees are used to quantify skew. De-skewing, It is the method of removing a skew by rotating a picture in the alternate direction by the identical amount as its skew. This causes the text edition to flow across the leaf rather than at a point of view, creating an picture that is aligned both inclined and upright. In our project, ratio and rotation is used to complete this phase ().

2. System Architecture:

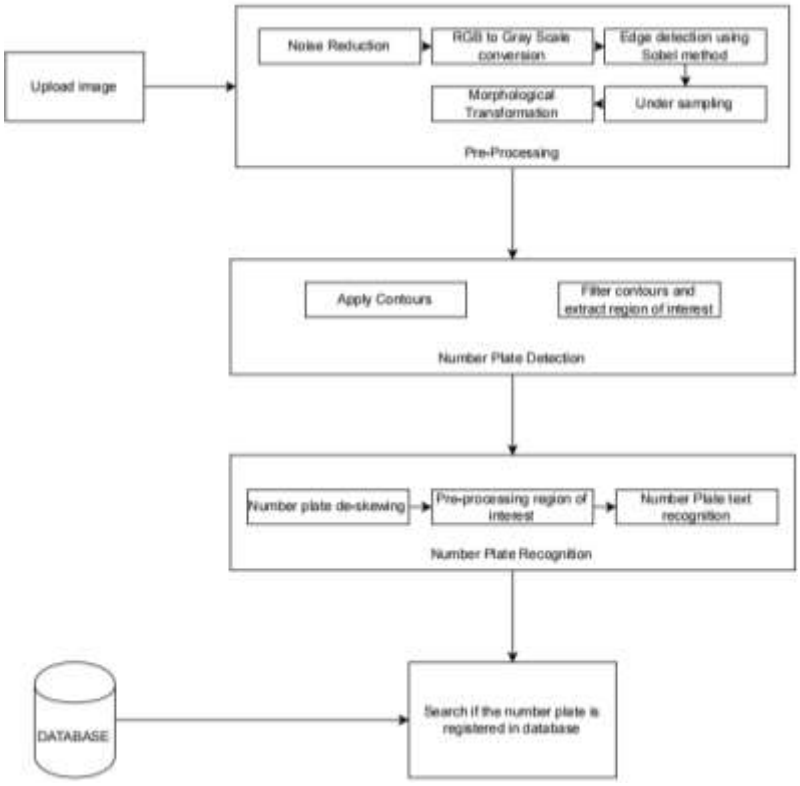

Fig 1 [System Architecture]

1. Algorithm:

- **Convolutional Neural Network (CNN):**

Convolutional Neural networks(CNN) are highly effective in recognizing and processing images. They consist of various internal layers including convolutional pooling layers and the Fully connected layers. The convolutional layers play a critical role in a CNN by using filters to extract features such as edges textures, and the shapes from the input of the image**[37]**. After that outcome of the convolutional layers, is passed through the pooling layers to down sample the features, and maps and retain the most important information During, reducing the Spatial Dimension. Finally many more, fully connected layers are applied to the outcome of the pooling layers to make predictions or classification of the image**[4]**. In summary CNN's have achieved exceptional performance in image recognition tasks and are widely used in computer vision applications.

- **YOLOv3:**

To begin with, the YOLOv3 algorithm partitions an image into a grid and each cell in the grid predicts the presence of a fixed number of boundary boxes, or anchor boxes, around objects that fit within predetermined categories. Each boundary box is responsible for detecting only one object and has an associated confidence score that indicates the accuracy of the prediction**[8]**. Prior to creating the boundary boxes the dimensions of the ground truth boxes from the original datasets are clustered to identify the most common sizes and shapes. This process helps to optimize the accuracy of the boundary box predictions.

- **OCR (optical character recognition):**

OCR which stands for Optical Character Recognitions(ocr)**[1]**, is a method that utilizes digital images of physical documents, such as scanned paper documents to recognize and identify printed or handwritten text characters. The primary functionality of OCR’s is to read the text(character) of a documents and convert it into a code that is been processed for data analysis. At times OCR is also known as text recognition.

2. Mathematical Model

Input: The algorithm's input is an image with the dimensions (416x416x3), where 416 denotes the picture's height and width and 3 denotes its RGB colour channels.

Gaussian filtering:

Gaussian filtering is an image processing technique that involves convolving an image with a Gaussian function to withdraw high frequency noise and also retain low frequency details. The Gaussian function is defined by a bell-shaped curve with a peak at (0,0) and rapidly decays with distance from the peak. The mathematical model for Gaussian filtering involves the Gaussian function with the standard deviation σ which is used to generate the Gaussian kernel. The image is then convolved with the kernel using a convolution operation to obtain a blurred version of the original image with the degree of blurring determined by the value of σ and the kernel size used.

The mathematical model for Gaussian filtering is as follows:

G(p, q) = (1 / (2πσ^2)) * e^-(p^2 + q^2) / (2σ^2)

where G(p,q) is the Gaussian function at position (p,q) σ, It is the Standard Deviation of the Gaussian function and e is a Euler's number. The Gaussian function is defined as a bell-shaped curve with a peak at (0,0) and decays rapidly as the distance from the peak increases**[4],[9]**.

Sobel method:

The Sobel method is an image processing technique used for edge detection. It involves convolving an image with a Sobel operator to highlight regions of the image with high spatial gradient values which correspond to edges of the image**[7]**. The mathematical model for the Sobel-operator is as follows:

Gp = [-1 0 1; -2 0 2; -1 0 1] **Gq = [-1 -2 -1; 0 0 0; 1 2 1]**

where Gp and Gq are the horizontal and vertical Sobel operators respectively.

The Sobel method is an image processing technique used for detecting edges in an image. It involves using two mathematical operators, Gp and Gq. Which are convolved with the images to compute the flat and vertical gradients respectively. The order of magnitude of the gradient is then calculated by taking the square root of the sum of the squared gradient values. This magnitude image is then thresholded to identify edges in the original image. The Sobel method is commonly used in computer vision applications such as image segmentation and object detection.

- Convolutional layers: Many Convolutional layers with various filter types and densities are applied to the input image. These layers lower the image's spatial dimensions and extract its characteristics. Let's consider the monochrome images as z, represented as an MN matrix's with entry as the xij entry for i=1,..…,m and j=1,…..,n. A convolution kernel "#"is taken as an ll matrix and is convolved with the image to produce another image matrix y**[35]**. The convolution operation at index i and the j covers a box. In the input text x around (i,j) using kernel H, and performs the vectorized inner product of H and the covers the area. Convolutional neural networks use multiple such convolutions, as shown in this illustrative animation. The index functions a(i,u) and b(j,v) can be modified in certain variants, and i and j that are out of range are treated as 0.

$$y_{ij} = \sum_{u=1}^{\ell} \sum_{s=1}^{\ell} H_{us} x_{a(i,u),b(j,s)},$$

- Max-pooling layers: To further minimize the output's spatial dimensions, The Max pooling layer is added after each convolutional layer. As a result, the network receptive field is widened and becomes more effective**[4]**.
- Yolov3 employs residual blocks, which are intended to make it simpler for the network to understand intricate characteristics. The network can learn the residual characteristics by using the skip connection and two Convolutional layers that make up each residual block. Given an input image I, the YOLOv3 model first applies a series of convolutional layers to extract features. These features are then passed to a neck architecture, such as the SPP or PANet, which combines the features at different scales to generate a set of feature maps. These feature maps are then processed by a set of detection heads, each responsible for predicting the bounding boxes and class probabilities for objects in a particular range of sizes**[8]**.

Let F denote the set of feature maps generated by the neck architecture, and let H denote the set of detection heads. Each detection head h ∈ H produces a set of anchor boxes with different aspect ratios and scales, denoted by Ah. For each anchor box a ∈ Ah, the detection head outputs four coordinates bx, by, bw, bh representing the center coordinates and width and height of the box, as well as a vector of class probabilities p = (p1, p2, ..., pC) where C is the number of object classes.The predicted bounding box coordinates bx, by, bw, bh are obtained by applying a set of learned transformations to the feature maps F. Specifically, let T(F) denote the set of predicted bounding box coordinates for a given detection head h. Then, **T(F) = σ(B(F) ⊗ W)** where **B(F)** is a set of learned convolutional filters that generate a set of bounding box proposals, W is a set of learned weights that transform these proposals into final bounding box coordinates, and σ is the sigmoid function. Similarly, the predicted class probabilities p are obtained by applying a set of learned transformations to the feature maps F. Let

P(F) denote the set of predicted class probabilities for a given detection head h. Then, **P(F) = σ(C(F) ⊗ W')** where **C(F)** is a set of learned convolutional filters that generate a set of class probability proposals, W' is a set of learned weights that transform these proposals into final class probabilities, and σ is the sigmoid function.

Finally, the YOLOv3 model combines the predictions from all detection heads to obtain the final set of bounding boxes and class probabilities. Specifically, for each anchor box a, the model selects the detection head h that generates the highest score, and uses the predicted bounding box coordinates and class probabilities from that detection head for that anchor box. The model then applies non-maximum suppression to remove overlapping bounding boxes and outputs the final set of predictions.

- Layers for detection: The outputs of the convolutional layers is sent through a number of the layers for detection, which identify the size, class, and location of the objects in the picture**[35],[37]**. Three detection layers, each of which is responsible for recognising objects at various scales, are used by Yolov3.

Non-max suppression: Following the detection layers, the most reliable detections are chosen by removing duplicates using a non-max suppression method. This approach suppresses overlapping detections after using a threshold to exclude low-confidence detections to generate the final output.

CONCLUSION

The Automated Number Plate Recognition (ANPR) literature focuses on identification, extraction, and recognition of licenses plates, with techniques like De-blurring, De-noising, and the geometric transformations to improve the accuracy. LPR is useful for access control, traffic monitoring, ticketing, and security in smart cities, which require efficient and streamlined algorithms. An open challenge is in countries where not all vehicles have standardized license plates. As more cameras are deployed, there will be a greater need for re-identification of cars to map their trajectories. Automatic Number Plate Recognition (ANPR) technology has significantly impacted the transportation and security industry by facilitating the fast and precise identification of vehicles. ANPR systems have numerous applications, including access controlling, the traffic monitoring, and the automatic violation ticketing and also the toll booth ticketing, and surveillance. With the advancements in image processing techniques, ANPR algorithms have become more robust and efficient, allowing them to handle challenging situations such as low-resolution images, motion blur, and complex backgrounds. Despite these advancements, some countries' lack of standardization in license plate formats poses a challenge for ANPR. Overall, ANPR technology is a valuable tool that can enhance transportation system safety and efficiency while enabling effective law enforcement.

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