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Enhanced Machine Learning Vehicle Plate Number Recognition System

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Abstract:
The Automatic Vehicle Number Plate Recognition System (AVNPRS) is a system that reads vehicle registration number plates from photographs using optical character recognition (OCR), which produces vehicle location data. Police departments all across the world employ (AVNPRS) to enforce the law, including determining whether a vehicle is registered or licensed. In this research work, we address the problem of car license plate detection. We developed a model for the Automatic Detection of Vehicle Number Pate Recognition. An Optical Character Recognition system which works with Convolutional Neural Network was employed. The system achieves approximately 95% accuracy license plate detection and recognition for majority of the classes of the dataset tested. The system is also tested with different condition complexities, such as rainy background, darkness and dimness, and different hues and saturation of images. It can be concluded from this work that the AVNPRS system herein develop is efficient in the recognition of vehicle plate Numbers, hence, and adaptable solution for the tolling of vehicles.

Keywords: Optical Character, Convolutional Neural Network, Plate Numbers Recognition, Machine Learning, Character Recognition and Segmentation, Digital Image Processing

INTRODUCTION

Machine learning, neural networks and artificial intelligence are ideas which have detonated in fame the beyond couple of years. It permits the natural investigation tremendous measures of information and pursue choices in light of its patters. Automatic Vehicle Number Plate Recognition System has become part of our lives and promises to stay in future, integrable with proposed transportation technologies. Automatic Vehicle Number Plate Recognition System (AVNPRS) is a framework that employs optical character recognition (OCR) on images to read vehicle registration number plates to generate vehicle location data. It can be used to store the images captured by the cameras as well as the text from the vehicle number plate, with some configured to store a photograph of the driver. (AVNPRS) is used by police forces around the world for law enforcement purposes, including checking if a vehicle is registered or licensed. The systems commonly use infrared lighting to allow the camera to take the picture at any time of day or night. This technology must take into account plate variations from place to place [1].

In Nigeria, different Vehicle License Plate (VLP) numbering system have evolved over time.

The immediate past VLP used in Nigeria has white background with the alphanumeric printed in blue, red or green color. When the alphanumeric is written in red, it indicates that the vehicle is a commercial vehicle; when it is written in blue, it indicates that the vehicle is privately owned; and

when it is written in green, it indicates that the vehicle is owned by the government. The individualized VLP numbering system is used by many ministries and parastatals owned by the government [2].

One area of strong fascination is the recognizable proof of vehicle number plate of which is the focal point of this work. Such distinguishing proof can be done on either a fixed or moving vehicle relying upon the degree of refinement of the created calculation and camera property chose. The number plate frequently distinguished is utilized to question a data set to get important data or to complete an activity, for example, conceding admittance to a limited climate. Such data set might contain a scope of data from pre-put away history of vehicle utilization, area, proprietor data, traffic offenses, tickets and so forth. Such subtleties are many times involved by the police for reconnaissance to alleviate crimes and to find vehicles in cutting edge nations of the world.

Significance of the Study

The development of technology is a fundamental aspect of modern civilization. Every sector is working tirelessly to make the most of recent technological advances in order to automate some of the labor-intensive activities they would typically carry out. In order to make vehicle number recognition less time-consuming and more effective in a fast-paced environment, it is also urgently necessary to implement automation solutions.

This particular study is restricted to solely offering methods for automatic vehicle plate number recognition. It works hard to develop a model that will analyze in-vehicle license plates in real-time.

Specific Objectives of this Study

This research work aims to build a model for automatically capturing and processing the images in Vehicle Plate Number. It covers the fundamental elements of AVNPRS Systems by investigating their presentation rundown, upsides and downsides likewise.

This study proposes thus:

1. An intelligent algorithm to recognize Vehicle Plate Numbers.
2. AVNPRS image processing base techniques for Number Plates
3. A platform for easy accessing of Vehicle Number Plates

THE CONCEPT OF AUTOMATIC VEHICLE NUMBER PLATE RECOGNITION SYSTEM (AVNPRS)

An automatic mass surveillance method known as the Automatic Vehicle Number Plate Recognition System (AVNPRS) uses a variety of Digital Image Processing (DIP) techniques and optical character recognition (OCR) on images to study and comprehend vehicle registration plates. An AVNPRS camera is used to capture an image of a vehicle number plate (VNP) in a typical AVNPRS system [3]. The AVNPRS camera is triggered by either electronic hardware equipped with sensors like infrared (IR) sensors or motion detection software associated with the AVNPRS camera to initiate this capture of the VNP. Although exiting CCTV cameras can be utilized, specialized AV [4]. NPRS cameras frequently yield superior result. After the VNP has been captured, the image is processed using digital image processing (DIP) software to locate the number plate's position in the captured image and extract the letters and characters so that optical character recognition (OCR) software can identify them [5].

After that, the extracted data is saved and compared to a database to see if there is a match. The AVNPRS system can, for instance, open a barrier at a highway toll, immediately notify the police about a stolen vehicle, unregister a vehicle of interest (VOI), or even carry out a specified function for which it has been designed. The identification of vehicle number plates, which is the focus of this work, is a topic of intense interest. Depending on the chosen camera property and the level of sophistication of the developed algorithm, this type of identification can be carried out on either a stationary or moving vehicle. A lot of the time, the number plate is used to query a database for relevant information or to do something like grant access to a restricted environment. This kind of database might contain a variety of data, including information about the owner, location, traffic violations, tickets, and pre-stored vehicle usage histories [6].

To enable the system, recognize captured alphanumeric characters, a mat template with images of A-Z and 0-9 was added to a mat file. The image that contained these alphanumeric characters was then read and turned into a greyscale image. It was then further transformed into its binary equivalent and stored in its data set for comparison with the VPN image's extracted alphanumeric characters. A procedure similar to that used to extract the binary from the vehicle's image was used to extract the VNP's alphanumeric character. The final outcome was determined to be the most extreme coordinated. The researchers were able to demonstrate that the developed system can recognize the vehicle (VNP) from a user-stored database using image processing techniques using this approach. They asserted that the system was compatible with a wide range of conditions and different kinds of number plates. It is essential to point out that, despite the fact that their research was successful in recognizing all 26 alphabets and numbers 0 to 9, neither the nature of the algorithm that was used to create the image classifier was used for the OCR nor the confidence distribution that was obtained for the characters were highlighted in order for them to demonstrate or quantify the accuracy of the AVNPRS system that was developed. Without this, there is no real way to assess how accurate the research was. Also, their work didn't say how many test cases the AVNPRS system was tested on [7].

AVNPRS framework [8] externally capture the vehicle photos and record the metadata in its primary store, the information acquired can be used for a few other smart transportation applications. While storing a complete data set of traffic development, this may possibly include vehicle acknowledgment through date and time stepping as well as specific location. The different vehicle frameworks and their examination can be shown using the figure below.

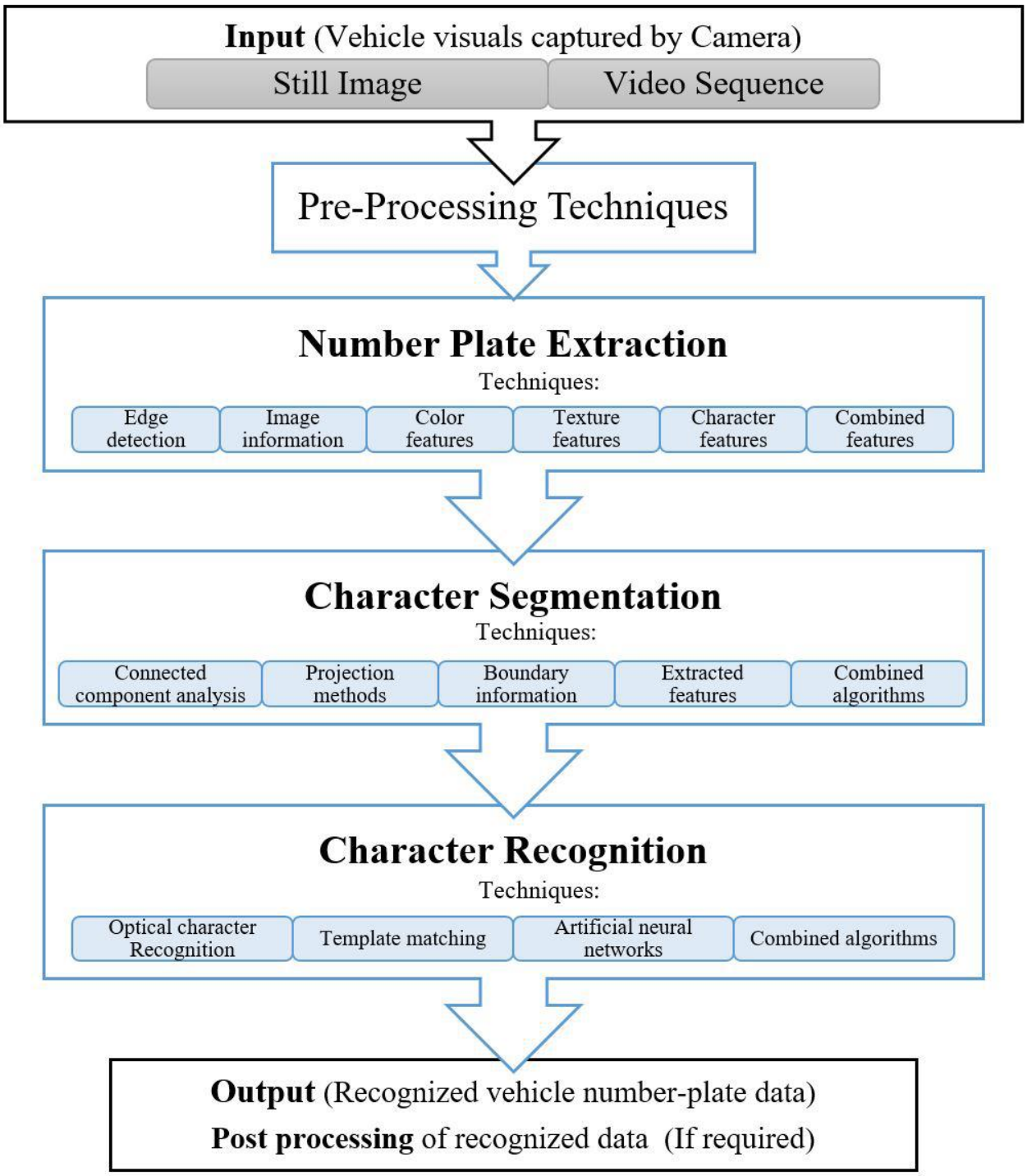

Figure 1. AVNPRS framework: General processes of number plate recognition system [8].

Image Acquisition Stage: A colored image of a vehicle is taken with a digital camera during the image acquisition stage. For the purposes of processing, images were taken both during daylight and at night. The captured images are then sent to the pre-processing stage, where they are converted from RGB to NTSC standard grayscale images. The grayscale image is then processed by a median filter, which replaces the pixel valve with the median equivalent and calculates the pixel's median value. The sharpness of the grayscale image is maintained while noise is removed from it by this nonlinear filter.

Plate Extraction Stage: The plate localization process is carried out on the image during the plate extraction stage to identify pixels that do not belong to the region of the image that contains the license plate. It locates both horizontal and vertical segments of the number plate by employing the horizontal and vertical localization phase. The Sobel mask edge detection for vertical and horizontal line filtration is the operator that brought about this.

Character Segmentation Stage: The character segmentation stage identifies the isolated characters and divides the extracted license plate into individual character images, allowing for clear identification of each number plate character. Character region enhancement, noise removal, and projection analysis were the components of this procedure.

Character Recognition Stage: This stage involved recognizing previously extracted characters from the license plate. An Artificial Neural Network (ANN) was used. They used two distinct ANNs, each with a similar architecture but distinct input numbers, to improve recognition efficiency for alphanumerical characters with similar appearances, such as "0" as "O," "2" as "Z," and "8" as "B." Their research paper yields promising results, with an extraction accuracy of 97%, character segmentation accuracy of 96%, and character recognition accuracy of 98% for the 200 plate numbers tested. Another study on ALPR for traffic violation detection identified ten steps for license plate identification. In the initial stage, they took a color image of the vehicle from either the front or the back using a digital camera. They turned the colored image into a grayscale one at the second stage [9]. This was finished by isolating the 24-cycle esteem hued picture to the RGB (red, green, blue) parts, so the subsequent picture is a 8-digit dark worth. The next step is to encourage dilation, which brightens the gray scale image and prevents the erosion of small dark spots on the image that may contain important information due to the image's rapid intensity change. At the third stage, they used the Matlap "imerode" function to apply erosion to shrink the image regions. Morphological processing was used in the fourth stage to preserve the structural properties and enable edge detection. Matlap function "imsubtract" and the Sobel filter were used to accomplish this. Convolution was used to sharpen and brighten the image during the fifth stage. At the sixth stage, character isolation and the removal of foreground pixels from binary images were achieved through a thinning process. The use of a rectangular bounding box to connect regions that contain all of the pixels that are present in them is the final step in stage seven after the processing of thinning has been completed. The eighth stage dealt with character segmentation, which required taking characters from the license plate and passing them through an OCR module. Utilizing optical character recognition (OCR) to process the characters and obtain a text character was the ninth and final stage of their work. This involved translating the text into character codes after scanning it character by character.

The effectiveness of AVNPRS framework depends on the viability of every individual stage. A parameter used to quantify the whole process is the performance-rate or success-rate, which is the ratio of the number of number-plates successfully recognized to the total number of input images taken. The performance rate involves all the three stages of recognition process, number plate extraction, segmentation and character recognition. The AVNPRS system collects the primary form of the information from AVNPRS software including the images and its associated metadata. It provides the transport system with automation and security features. Its integration in Intelligent Tutoring System makes it possible to automate the system by providing services in toll collections, traffic analysis, improving law enforcement's and building a comprehensive database of traffic movements. Integrating AVNPRS with Information Communication Technology (ICT) tools is another useful feature of the technology. The information from AVNPRS

frameworks can be very much used for demonstrating and execution of different parts of transport systems, for example, to display Passenger Mobility Systems [10], traffic flow analysis and road network control strategies using Network Fundamental Diagram (NFD) models [11] in vehicle routing choice model to decide on Route and Path Choices of Freight Vehicles and travel demand patterns through Floating Car Data (FCD)

Related Works

[12] took into account scenarios like different lighting, blurry or skewed images, noisy images, standard numerical plates, and plates that are only partially worn out. Morphological transformations, gaussian limping, and gaussian thresholds are just a few of the image processing techniques used in these works during the pre-processing phase [13]. The system used a smart infrared sensor to find moving objects, a camera to take a picture, and text was taken from the picture and saved on a Web page. This work established a VRPN system that is extremely cost-effective. The primary component selected for main system work is the Raspberry Pi. Python programming and Open CV have been utilized for character segmentation and recognition.

[14] on Review on Automatic vehicle licence plate focuses on recent research on proposed algorithms' technicality, accuracy, and license plate format for platform identification systems in various nations with distinct environments and license plate formats.

[15] opined that the identification of a vehicle's number plate in traffic control is the subject of this article. AVNPRS is very helpful and reliable for effective traffic monitoring. A device that uses a powerful picture processing technology is able to quickly identify automobiles from various angles and output ownership information. The AVNPRS systems are very important to the development of the smart transport network.

The rapid growth of automobiles, motorcycles, and other vehicles has made automatic identification of numerical plates a well-known idea today. Technologies for vehicle identification and image processing are incorporated into this Automatic Vehicle Number Plate Recognition System. This report frames the various techniques, advantages and burdens of acknowledgment and permits everybody the best to pick an easy to use, successful and un-influenced approach. This system shouldn't be affected by speed, light, text size, or styles.

[17] This paper introduces the vehicle's license plate-based automatic recognition system. Image processing algorithms are used by the system to identify the car from the user's computer database. The method works well for a lot of different situations and different numerical plates. The system is updated and run in Matlab, and real photos show that it works. In the current work, countervailed number plate work was done. This procedure is separated from images and has trouble with turmoil. In order to improve body detection, the proposed work proposes a novel approach that uses conventional neural network classifiers to de-noise and reorganize better characters.

In recent years, one of the most significant challenges in Smart Transport Systems has been the Vehicle License Platform Recognition (VLPR) framework. The examination of the obstacles and variations of license plates (LPs), such as different lighting and hazardous environments, has recently emerged as a significant and complicated research topic. An in-depth investigation of existing VLPR approaches was conducted, and throughout this document, an analytical review based on the characteristics and methodologies utilized was carried out. Additionally, an

analytical comparison of benefits, drawbacks, and outcomes has been provided for each categorized attribute [18].

The proposed work shows the automated identification number plate system employing the number plate for the vehicle. The method has been tested on actual images and has been implemented in Matlab. A number plate recognition system is one kind of intelligent transportation system [19]. To recover a vehicle numbers plate, the format matching method is likewise utilized. When it comes to identifying threats to safety, the automatic identification number plate system is crucial. Division of character for the partition of each person here. The primary objective of this research project is to investigate the License Plate Recognition Framework's picture segmentation and recognition issues in depth and discover alternative solutions [20] There are three main phases identified in these applications. To begin, a larger scene image's license plate area must be located and extracted. Second, a license plate region must be utilized in order to remove the alphanumeric characters from the plate from the background. Thirdly, make them available for an OCR system to recognize. An acquisition system's image (such as a video or still camera) must clearly contain the license plate in order to successfully read it and identify a vehicle.

[21] The model matching was performed using numerical plates obtained from static pictures and 80.8 percent average accuracy was achieved. This accuracy may be significantly improved by using two neural network layers and appropriately setting the camera to capture the best frame. The suggested system's implementation can be expanded to include multiple car plates in a single frame by employing multileveled evolutionary algorithms.

[23] Traffic monitoring is essential for building a better city. To punish motorcycle riders who do not wear caskets, motorcycle and helmet detection and number plate recognition can be used. Machine learning and image processing technology have developed as a result of the rapid expansion of online tools and integrated models that can be used in a wide range of contexts.

In today's frantic traffic system, an essential system is the automated license detection system [23]. Automatically monitoring traffic laws and other enforcement activities is helpful. In India, rash driving in vehicles that break a number of traffic laws is common. The particulars of the car present a significant challenge for traffic police officers. To work with and immediately screen the traffic guidelines on vehicles, the mechanized permit discovery framework was in this manner concocted and executed throughout the long term. The various approaches to automatic license detection are discussed in detail in this article.

This paper introduces the vehicle's license plate-based automatic recognition system. Image processing algorithms are used by the system to identify the car from the user's computer database [24]. The method works well for a lot of different situations and different numerical plates. The system is updated, performed, and real photos are tested using Python and Java. In the current work, countervailed number plate work was done. This procedure is separated from images and has trouble with turmoil. In order to improve body detection, the proposed work proposes a novel approach that uses conventional neural network classifiers to de-noise and reorganize better characters.

ENHANCED MACHINE LEARNING VEHICLE PLATE NUMBER RECOGNITION SYSTEM

A set of sample images are collected and used to test the system. The results of the test can be classified into two categories. Plate region detection and extraction result and the OCR result. Static snapshots of cars were captured for testing purpose. Standing cars with few regional plates have been included. At first, the aim was to include all the regional car plates but it was difficult to obtain all of the regional plates. This is because most of the samples in Nigeria are not regional plates. However, few regional samples were found. In addition, some samples were also obtained from the internet.

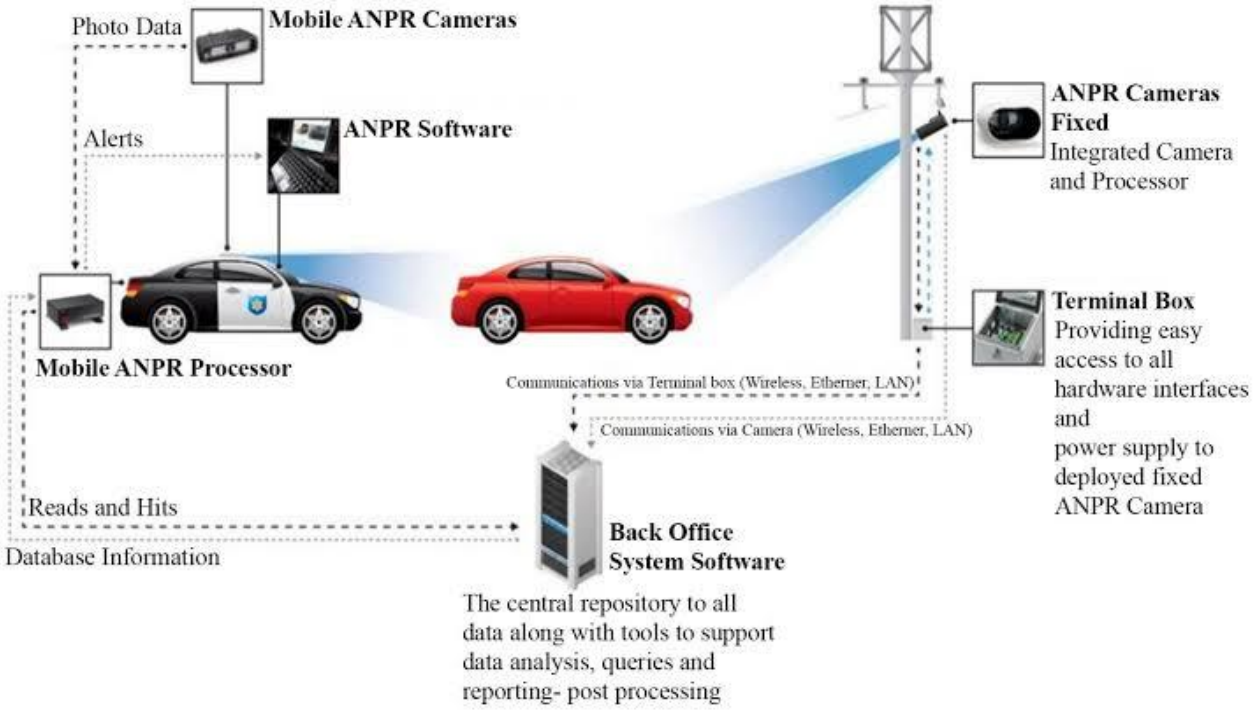

Figure 2: Conceptual Imagining

The main causes for the extraction failure are the contrast or brightness of the image and distance from camera. Images with low contrast have high chance to fail. This is due to the fact that the binary image will have more noise (in this case, much coloring or unnecessary filters). Also, as the distance increases, the plate region will be small. This problem can be minimized by setting the distance value between the camera and the vehicle.

Optical Character Recognition (OCR)System

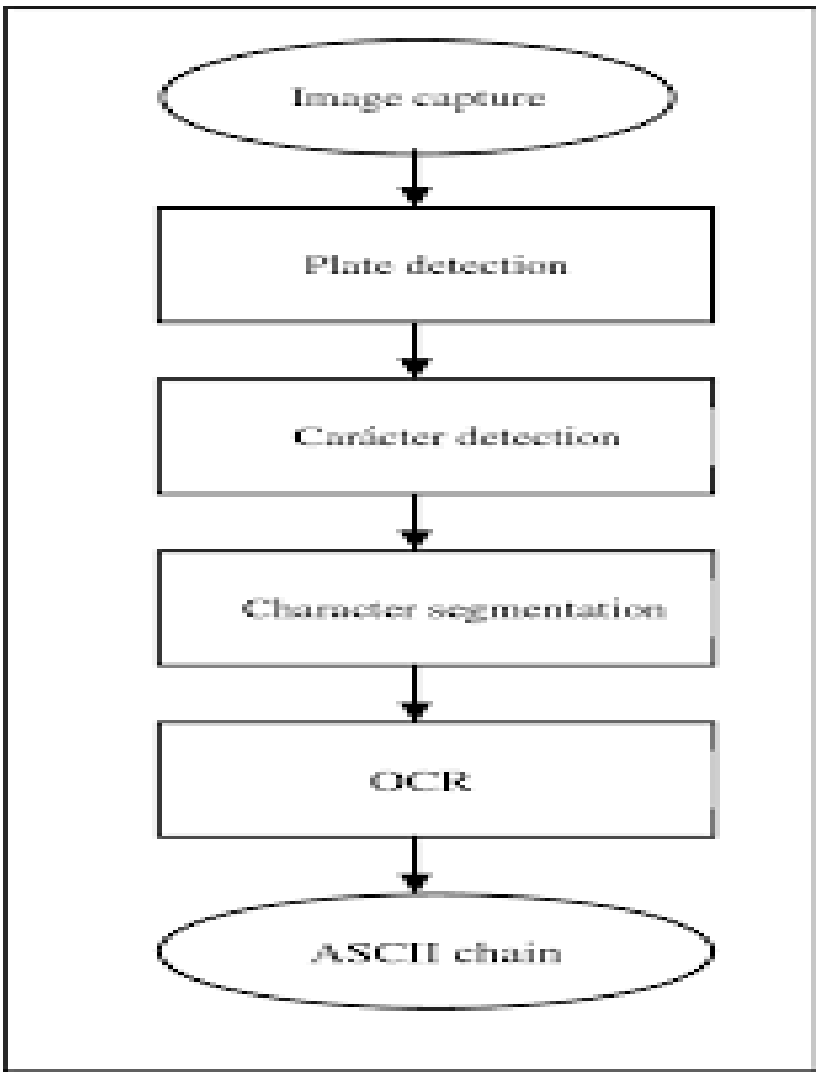

Figure 3: OCR Modeled Process

The accuracy of the OCR is directly influenced by the plate extraction system. This means that if the plate region fails to extract, the output of the OCR will be incorrect sample. The sample plates, which are used for plate extraction purpose, are also used for checking the OCR recognition rate. The input for the OCR is the plate image which contains characters (numbers, and English alphabets).

The plate extraction stage performs the process of plate localization on the image to identify pixels that does not belong to the region of the image having the license plate. It uses horizontal and vertical localization phase to locate both horizontal and vertical segments of the number plate. The operator used to bring about this is the Sobel mask edge detection for vertical and horizontal line filtration. Next is the character segmentation stage, this stage recognizes the isolated characters and dividing the extracted license plate into individual character images, the character in each number plate can be identified clearly. This process was divided into character region enhancement, noise removal and projection analysis.

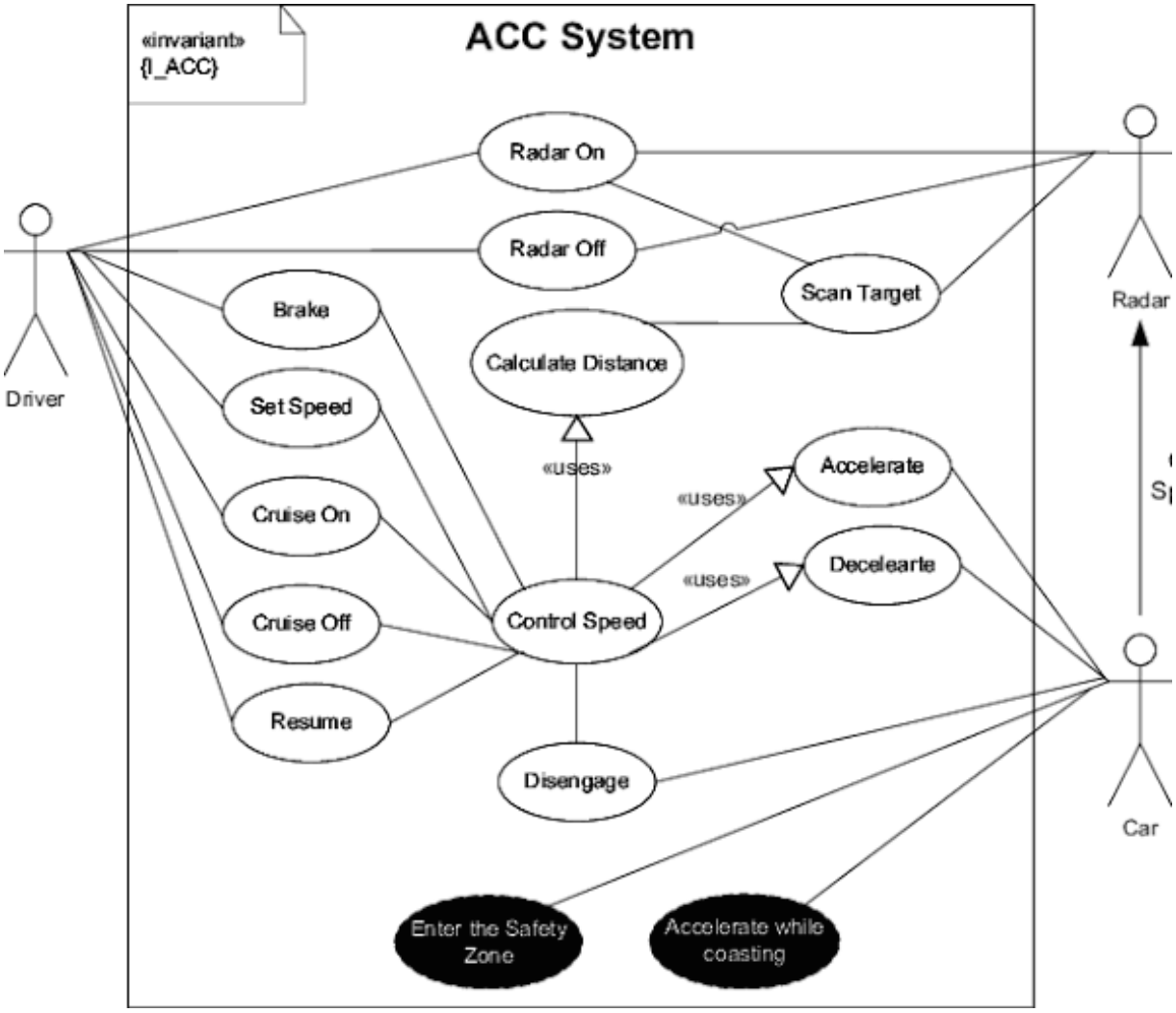

Figure 4: Evaluation Procedural System

The failure encountered in testing the CPR system can be viewed as two categories; Failure in the plate region detection and extraction and failure of OCR system. The failure of the plate region detection and extraction is resulted due to several factors such as image quality, angle between the camera and the car, and distance between the camera and the car. The image quality directly affects the accuracy of the system. The result gives good response for high quality images. The angle between the camera and the car also influences the extraction algorithm. This is due to the variation in angle introduces variation in the illumination level and light reflection that may reduce the image quality. As a result, the extraction rate may degrade. In addition, the distance between the plate and the camera can have less influence because it can be adjusted using some techniques. But for this research, the distance used for taking the snapshots is almost constant. The second failure category is the OCR failure. This can be further classified into three aspects, failure of the plate extractor, failure in the character segmentation process and failure in classification process. The first cause results in total failure of the OCR. Since the failure in the plate extract will transmit unwanted input to the OCR, the final output will be incorrect output. The segmentation failure is the failure caused due to the failure of the segmentation algorithm. This failure again can be analyzed as two views, error in segmenting unwanted symbols as character and error in segmenting unwanted details in the image. The first segmentation error is caused when connected components are assumed as a single region. This error can be minimized by setting a rule for object to be segmented as a character or not. The second error is caused when

unwanted details are segmented along with the characters. For example, the position of the bolts used to attach the plate on the car highly influences the segmentation result. Failure in classification occurs when the classifier wrongly classifies/recognizes a character. Error of classifying the segmented character to the correct character class also affects the OCR performance.

AVNRS RESULT AND DISCUSSION

Automatic License Number Plate Recognition Systems are available in all shapes and sizes:

1. ANPR executed in measured lighting situations with predictable number plate types can utilize basic techniques for image processing.
2. More advanced ANPR systems use dedicated object detectors, like HOG + Linear SVM, SSDs, YOLO, and Faster R-CNN to localize license number plates in images.
3. State-of-the-art ANPR software uses Recurrent Neural Networks (RNNs) and Long Short-Term Memory networks (LSTMs) in order to aid in better OCRing of the text from the number plates themselves.
4. Even more advanced ANPR systems utilize specialized neural network architectures in order to preprocess and clean images before they are OCRed, thereby developing the accuracy of ANPR.

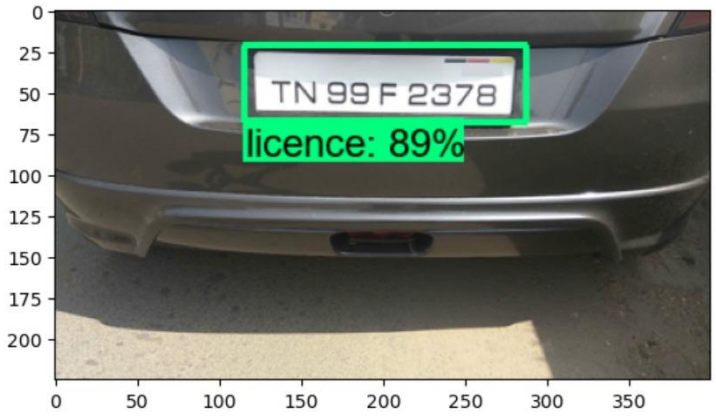

Figure 3: The Image recognition

The fact that makes Automatic License Number Plate Recognition more complicated may require operating in real-time.

For instance, let us consider an ANPR system that is mounted on a toll road. It has to be able to detect the number plate of each vehicle passing by, OCR the characters on the plate, and then store this data in a database so the vehicle's owner can be billed for the toll.

Few compounding factors make ANPR extremely challenging, involving finding a set of data we can utilize in order to train a custom model for ANPR. Large, robust datasets of ANPR that are utilized to train state-of-the-art models are tightly guarded and hardly (if ever) released publicly:

1. These datasets consist of sensitive identifying details associated with the vehicle, driver, and location.

2. The datasets of ANPR are tedious to curate, needing an unbelievable time investment and staff hours to interpret.
3. The contracts of ANPR with local and federal governments tend to be extremely reasonable. It is often not the trained model that is valuable; however, instead of the dataset that a specified company has curated.
4. For the same cause, we will observe ANPR industries acquired not for their ANPR system but for the data itself.

CONCLUSION

In this paper, we presented an automatic license plate recognition system a reasonable deal of accuracy. In general, from the above results, it can be stated that the recognition rate of the CPR system is directly influenced by the quality of the input image and character recognition system. Most of the errors in the CPR are due to plate region extraction process and the errors that occur in the OCR system are the character segmentation error. From this result, it can be analyzed that the CPR accuracy is directly influenced by the plate region extraction and detection module and character segmentation and extraction module. Obtaining the CPR accuracy of 95% for majority of the data set shows that the model does a good work in the recognition and detection of vehicle Number plates.

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