AUTOMATED LICENSE PLATE DETECTION AND RECOGNITION

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APPROVAL

This Project titled "**Automated License Plate Detection and Recognition**", submitted by Md. Habibur Rahman, ID No: 183-15-2274 and Md. Rakibul Islam, ID No: 183-15-2264 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on September 12, 2022.

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ABSTRACT

Automated license plate recognition is important in many contexts like security and law enforcement, monitoring vehicles, automated parking control, etc. To enable these automated services, we are reviewing and combining several established methods in this paper. There were three steps involved in reading car license plates: plate detection, plate extraction, and character recognition. Each stage has many sub-steps. For every sub-step, we have reviewed many methods, and chosen the one that proved to be the best solution after thorough testing and observation. The main objective of this research is to gain high accuracy using as less CPU Time as possible, keeping into consideration the facts like- lighting conditions, vehicle motion, noisy plates, and segmented words in the input image. Our primary target of this thesis is to extract a clean image of license plates of private or community vehicles. Although we target our system to be able to detect standard license plates, we also tested our methods on non-standard plates.

Keywords: Digital Image Processing, Automated License Plate Recognition (ALPR), Automated Number Plate Recognition (ANPR), Number Plate Detection.

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CHAPTER 1
Introduction

The discipline of image processing and computer vision is notable for its work on license plate recognition. An ANPR system must be developed in order to automate tasks like parking management, traffic control, and security maintenance. Only a small amount of study has been done on this subject, high accuracy and runtime are promised, however a tested system has not yet been used in real-world situations.

System components include Plate localization, Plate Extraction, Character Segmentation, and Character Recognition are part of automated license plate recognition (ALPR) systems. Any kind of image can be used as an input for plate localization, which, if accessible, outputs the region information of the license plate. The license plate localized by the prior submodule is intended to be extracted and cleansed during plate extraction. Character segmentation divides each character into its own picture from the blank plate. Finally, using the input image of a character, the Character Recognition module identifies the character.

1.1 Objectives

Our goal is to figure out how to use the Automated License Plate Recognition technology for license plates because it is not only offering excellent accuracy but also works effectively and everywhere. In this thesis, character segmentation is the final stage of image processing. Making it simple for any existing OpenCV system to detect the character.

1.2 Motivation

Our major motivation is to create a full and properly useable system for license plate detection because there isn't one still in place. This method will aid in the establishment of traffic order and offer a solid framework for the effective use of the law. The parking lot industries are also another opportunity again for system's commercialization.

1.3 Research Question

As like as research question for this thesis are:

1. How can we develop and test a number of systems?
2. How to maintain vast dataset for license plate images?
3. How can the dataset be fully sorted by classifying it into multiple types?
4. How should input image be prepared for character segmentation using the OpenCV system?

1.4 Challenges

During this investigation, there are several problems to take into account.

1. Assessing past systems and finding their inadequacies
2. Finding a method to put multiple systems into action and test them.
3. creating a sizable dataset of photos of license plates.
4. Classifying the dataset by figuring out its various types and classes

1.5 Report Organization

In this full thesis, we divided into different chapter. First, we discuss in some background study on introduction chapter 1 also make some sub section like objective, motivation, research question, and challenges. In next section chapter 2 see some background study in Standard license plate, Plate fonts, and Structure of the plate. Thirdly, we see existing research papers in this fields and review in chapter 3. Chapter 4 discuss about methodology organization for chapter 5 in Results and Discussions and then discuss our future work.

CHAPTER 2

Background Study

2.1 Standard License Plate

There are many distinct kinds vehicles include private cars, auto-rickshaws, pick-up trucks, delivery vans, mobile medical clinics, microbuses, articulated trucks, and more. In reality, the format and uniformity of the license plate were not chosen. However, the government has recently required digital license plates for all cars.

Table 1: Consideration in our transportation class.

Serial No.	Identifier	Begin Number	End Number	Types
i	KHA	49	97	Delivery truck van
ii	MA	13	97	Pickup van
iii	THA	13	97	Ambulance Mobile-dispensary
iv	DHA	13	99	Cargo-truck
v	MA	17	95	Heavy-truck
vi	KA	15	95	Motor-Car
vii	NA	13	97	President’s office car
viii	GHA	13	97	Pym’s office (Any vehicle)
ix	HA	63	90	Articulated-truck
x	TA	13	60	Micro-bus
xi	GA	13	97	Taxi-Cab

2.2 Plate Fonts

Although the digital license plate offers verified languages, not all car owners in other nations strictly abide by these laws. However, there have been no universal fonts in the present dataset. For this thesis work, the typefaces may differ yet still be well understandable.

Fig. 1: Input image

2.3 Structure of Plate

Typically, there is just one line of text on the digital license plate (see Figure 1). In the provided example, the top line is written in English.

CHAPTER 3

Literature Review

The first task was to find the problem domain to work on. The next task was to make literature reviews for our work plan and also for ensuring that we are not doing something again or worse. We’ve found a few papers related to ALPR for English languages. Finally, we did select 24 papers to read and review for our thesis work. We’ve written 7 review papers that seemed close to our topic. From those papers and reviews, we’ve managed to find and understand our particular domain of work which will be described in the later parts.

3.1 Affiliated Works

The subsequent chapters of the chapter will go through some of the earlier research on license plate recognition. The five main processes that make up the complete procedure are preprocessing, feature analysis, region analysis, character segmentation, and recognition. In this chapter, these steps will be briefly discussed.

3.2 Preprocessing

In order to achieve better performance in the following sections, preprocessing techniques are used. After image capture, one of the most important duties is this. It makes sure that accurate data is entered into the crucial parts of the system that detects and recognizes license plates. The most typical method involves two phases. For the next processes, the picture is transformed to a grayscale image format [15]. The image is then cleaned up of any further noise using a variety of techniques depending on the situation. The Median filter and the Gaussian filter are the most frequently used methods for removing noise from input images [16, 17]. Many researchers [6] also employ the contrast enhancement method in this pre-processing stage.

3.3 Feature Analysis

After an image has been correctly preprocessed, feature analysis must be performed to identify the license plate. The most popular method for feature analysis is to check the edges for any rectangle-shaped areas. Some researchers utilize horizontal lines to locate the plate border, while others hunt for vertical lines. Edge detection is frequently carried out using Sobel edge detection [4] and [3]. As for certain exceptions, some studies seek for high-contrast regions rather than using edge detection [22]. According to this procedure, the plate frequently has an area that is more contrast than other areas of the image.

3.4 Region Analysis

Several areas of the image may be contenders for the license plate component when the feature analysis is completed. Filtering is required to reduce the quantity of possibilities by evaluating and eliminating them in order to solve this challenge. Examination of the characteristics of the candidate region's bounding rectangle is a fairly common approach for completing the project. For candidate screening, we may, for instance, consider factors such as aspect ratio, size breadth, height, and position. One common trick is to calculate the features of rectangles to determine the likely region for a license plate [5]. Additionally, to identify the real plate region, Anorgasmia and Ahmadabad [6] [7] [3] examined various geometrical aspects of the candidate locations. Following this with further technique additions, Garcon, Cheever, and Castro [8] argued that the license plate region is the one that can be separated into sub-sections of well specified size. Similar to Hung and Hsieh [9], other researchers have employed the geometrical features approach to filter the potential locations while taking into account the characters on the license plate. A somewhat different technique for finding by using high-density edges then horizontal projection, Chen, Chen, Huang, and Wang [10] proposed the license plate region.

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3.5 Character Segmentation

Sometimes, segmenting characters before delivering them to the recognition system is necessary for character recognition. Different researchers used different techniques for this part of the work. The common technique of segmenting the character using histograms was invented by Songkok [22]. The approach involved adding up or summing the vertical and horizontal projections. For character segmentation, the connected-component labeling approach used by Yoon et al. [5] and Mangled [10] might be used. identification of the linked characters, which are shown in black on a white background. Then add a bounding box to the character blobs. Liaqat [17] used two methods to achieve this technique: the contour finding algorithm was used to discover related edges after the Canny algorithm had detected the edges. There are alternative techniques for labeling and segmentation. Much of the knowledge acquired in this stage was used in the subsequent recognition process. All of this data can be incorporated into a character recognition method. Sai et al. [11] conducted additional testing at this point to make sure the chosen characters were those of the real license plate and not another component of the image. In order to pass this test, the character density had to be within a certain range, the width had to be less than the height, and the character rectangles had to have the same width and height.

3.6 Character Detection

A technique for character recognition can take all of this information into account. [4] Sai et al attempted a second assessment of this stage to make sure that the chosen characters indeed form the license plate and not some other component of the image. Sometimes, segmenting characters before delivering them to the recognition system is necessary for character recognition. For this aspect of the investigation, different researchers employed different methodologies. The simplest ways of dividing the letter using histograms was invented by Songkok [2]. The approach involved adding up or summing the vertical and horizontal projections.

3.7 Character Recognition

There are only a few techniques to finish the character recognition phase of license plate recognition. There are two phases to the most common approach. First, a programming engine or package recognition engine is given the characters from the previous stage. One excellent option for a character recognition engine is Open source Tesseract OCR. If it is properly taught, it can produce text from the provided picture of characters. The second strategy is to use customized recognition techniques. Features are calculated for each character. The OCR algorithm initially extracts characteristics for character recognition before comparing them to previously established patterns [19]. Following the same methodology, Alginate [12] attempted to extract 88 characteristics for each character, compared those features to features that had already been retrieved. Single and Yixian [16] extracted characters using a histogram, and template matching was used to identify them. Ghosh, Sharma, Islam, Biswas, and Akhter [13] employed neural network approaches for character recognition later, when they were well-known. Utilizing the training feature dataset that was previously provided, the module is first trained before being used to recognize characters.

3.8 Comparisons

Three factors of license plate detection, character recognition, and overall accuracy can be used to describe the accuracy of a license plate recognition system. Table 2 provides a summary of the methodology and issues of some earlier research projects.

- Comparisons paper of table:

Table 2: Comparison Paper

Author and year	Detection (%)	Recognition (%)	Overall (%)
Kong et al. (2005) [3]	96.1		
Juntanasub and Sureerattanan (2005) [19]	92		
Waterhouse (2006) [15]	96	83 and 93	
Huang, Chen, Chang, and Sadness (2009) [9]	96.7	97.1	93.9
Alginahi (2011) [12]	98.3	98.63	94.9
Maglad (2012) [10]	95	91	
Joarder, Mahmud, Tasnuva, Kawser, Bulbul (2012) [1]	92.1	84.16	75.51

3.9 Paper Summary

Review of previous works shows that the edge detection approach can be used effectively to find the license plate region. Geometrical feature analysis is an appropriate approach for this. Some researchers used their own recognition system, others used OCR engines like tesseract. Some parts of all these researches can be used further in this work, others are of no use for future work.

CHAPTER 4

Methodology

This chapter describes our process to detect license plate given an input image, and separation of the individual numbers and character sequence from detected license plate. The input image may come from variety of sources. We have put on a validation method to detect if there is actually a license plate in the input image.

4.1 Implementation

We used Python 3.x to implement our solution, relying on the Anaconda repository's OpenCV-3 and NumPy components. The OpenCV package offers a wide range of image processing tools and methods, which came in extremely handy for our application. The most popular tool for handling 2D arrays is NumPy, which we also used to create a Multilayer Perceptron model for character recognition.
We utilized a different implementation for testing and analysis. In this implementation, we broke down complex tasks into a series of steps. These levels operate as separate modules. For instance, the Gaussian filter stage will only apply the filter to a subset of the input images before placing the output in a different folder so that it can be used as an input for next stages. During our investigation, this testing strategy proven to be quite helpful and time-saving.

4.2 Overview

Our procedure is divided into numerous steps. There are various stages in each level. Figure 2 displays a summary of all stags in our procedure. The process will be described in more details in the following sections.

- Flow chart an overview of the plate detection procedure is given in below:

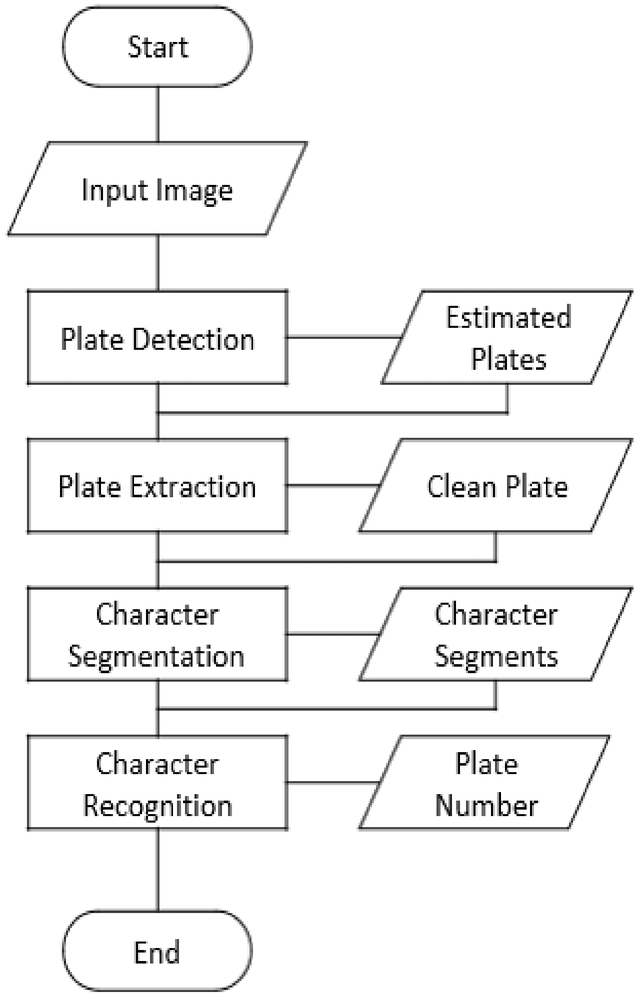

Fig. 2: The plate detection procedure overview.

4.3 Input Image

The image utilized as the input is a 24-bit color image with red, green, and blue channels. Image compression, though, might cause information to be lost. We choose to use the 640 x 480 resolution after considering reviews.

4.4 Plate Detection

To create a picture appropriate for feature analysis for following stages, on the input image, the Plate Detection step runs a number of operations. In our situation, it also outputs potential plate locations and shrinks the search area.

4.5 Plate Extraction

In the plate extraction process, each area that resembles a plate from the previous step is examined, extracted, rotated correctly, and in order to get ready for the following module. The step of character segmentation is when the characters are separated from the background. This allows the OCR to recognize the characters. An OCR system is used for character recognition to identify specific characters and text pictures.

4.6 Plate Localization

This stage contains a sequence of steps that enhance the plate like regions of an image and output an image that can be used directly for the next stage - plate detection. Most of the steps here are implemented following [1] [6] [2] and. We may drastically cut processing time by reducing the size of an image. However, picture reduction might lead to information loss. Based on reviews, we chose to use the size 640480. In the first stage, we resize the supplied image to fit this dimension. Figure 3 shows a sample image. We applied a low threshold value to the gradient image. In this case, we used an adaptive threshold technique called Otsu's Binarization using an offset value of 85, which we obtained empirically. During our inquiry, this testing technique worked well and helped us save a ton of time. The input image may originate from number of sources. We have put on a validation method to detect if there is actually a license plate in the input image.

4.7 Character Segmentation

Character segmentation is the phase when the characters are separated from the plate. The OCR can recognize the characters as a result of this.

Fig. 3: A sample gray-scale image

The gradient picture was then given a low threshold value. In this case, we applied Otsu's Binarization, an adaptive threshold approach, with an offset value of 85 that we got empirically. However, picture reducing might lead to information loss. From evaluations, we chose to utilize the dimension: 640×480. In the first stage, we resize the supplied image to fit this dimension. A example image is shown in Figure 3.

4.8 Image Enhancement

To improve the contrast of the image surrounding the plate-like sections, we employed the Gaussian image. The entire image is split into 8 × 8 panes, each measuring 60 × 80 pixels in size, to improve calculation efficiency. We used bilinear interpolation to get the weight and mean intensity for each window. Additionally, we may significantly reduce processing time by using the Numbly library for matrix operations. The final image may be seen in Figure 4. The area around the license plate is now much whiter.

Fig. 4: Enhanced Image

4.9 Matched Filter

The next step is to highlight areas of the improved image that resemble a license plate in order to find the plate. In order to emphasize the intensity constancy throughout the horizontal direction and within the plate-like areas, a variety of Gaussian functions were used. We determined these characteristics through observation and experimentation. The major lobe's deviation in the x direction is represented by the symbol. At locations that resembled plates, this filtering process offers a strong reaction. The outcome is measured against a cutoff point that is around 80% of the maximum intensity. This procedure is known as smoothing, and the smoothing cutoff value called the threshold.

4.9.1 Plate and Regions Extraction

In this stage, the primary regions recovered are the area around the license plate. Actual license plates could be detected by this Nevertheless, it offers a fairly accurate estimate of the license plate's placement. In order to begin, we used a mixture model to calculate each contour in the image. The boundaries of each contour were then confirmed. If the bounding rectangle's measurements are accurate, we extract the area and region data image. Figure 5 displays the previous staged removed plates.

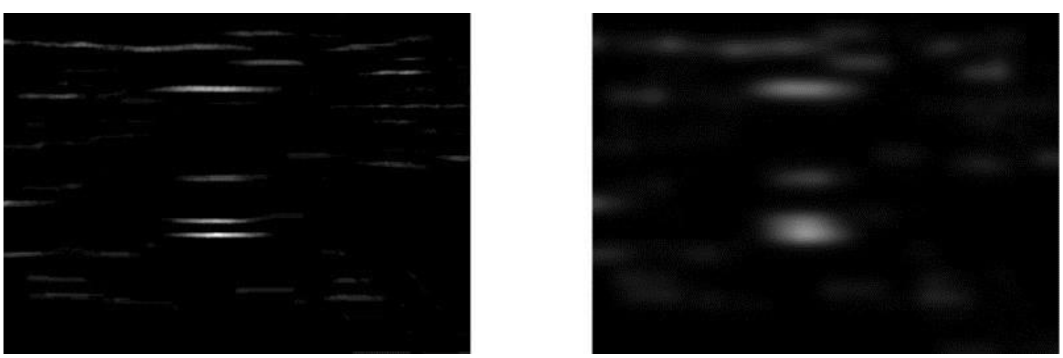

Fig. 5: After applying the mixture model and gaussian blur

4.9.2 Plate Extraction

This section explains how to extract the license plate using the pre-processing stage's results. In this module, we merged some of the methods from [1] and [14].

Figure. 6: First estimation

4.9.3 Edge Analysis

To the projected license plate numbers, we looked for edges after applying a threshold value (Figure 7). One well-known edge detection method is called Canny Edge Detection. There is a direct use for OpenCV. For the localized estimate's edges detection, we used the default OpenCV function.

Fig. 7: Edges

4.9.4 Contour Analysis

The most of the time, Canny edge detection works flawlessly and offers plainly visible outlines around plate boundaries [14]. We receive a set of contours after sending the clever image to OpenCV's function. Before choosing a contour as a potential plate, many parameters for each of these contours are examined in compliance with [14].

4.9.5 Width and Height

To be recognized by the OCR, the width and height of the detected contour must be greater than a certain margin. For the predicted plate, we defined the minimum dimensions to be 30 pixels in width and 75 pixels in height.

4.9.6 Extraction and Area Ratio

The next thing we do is determine if the contour's area exceeds 10% of the overall picture. Keep in mind that we obtained this image by locating the plate-like sections during the pre-processing phase. Here, the plate picture is taken from the original image using a potential plate region that we learned about in the previous stage. As we did in the previous step, Additionally, the image is rotated to conform to the rotation angle. An OpenCV rotation matrix of scale 1 is created to rotate this object. Reducing the size of an image allows us to significantly decrease processing time. However, image reduction may lead to information loss. We choose to utilize the dimension after reading reviews. Here, the plate picture is extracted from the input image using the region data we obtained in the previous phase.

- The extracted plate after rotation and scaling is given in below:

Fig. 8: The extracted plate after rotation and scaling

4.9.7 Converting to Binary Image

For convenience, the picture from the previous stage must be converted to binary. There are two types of license plates: white text on black plates for private vehicles and black writing on white plates for public transportation. On be precise, we initially applied two filters one time and the other to the image to make it black and white. Then, the proportion of non-zero pixels in each image was contrasted. The binary picture that has the smaller ratio is more likely chosen as the predicted binary image. With the groups experience, different sorts of license plates are converted to binary pictures.

4.9.8 Character Segmentation

The goal of this stage is to separate all characters into different images to send them to OCR for recognition. We used horizontal and vertical projections in this step [4]. Horizontal projection is done by taking the mean of all columns across the rows of the image. Figure 9 shows a graph of mean values across the rows. To calculate this mean we followed the formula from Algorithm 1. We set the cutoff line to be ≥ 1. and separated the entire plate into two segments. A technique for character segmentation can take all of this information into account. To make sure that the chosen characters, and not some other element of the image, form the real license plate, Sai et al. tested additional judgment of this stage. For this test, the character density had to be within a certain range, the width had to be less than the height, and the width had to be about equal to the height.

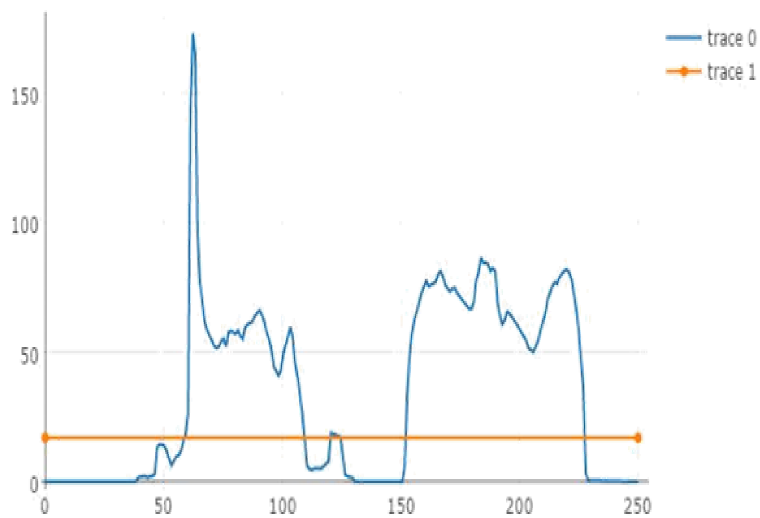

Fig. 9: Horizontal projection plot

4.9.9 Character Recognition

The last and most significant component of the automated system is character recognition. Despite not creating a system for recognition, we looked into several avenues and created a straightforward feature extraction that would be useful in our future work. Although we didn't actually achieve it, we shared the concept and the aim of building a multilayer feed-forward neural network for character recognition. The top 27 characteristics that will help us identify a character have been extracted. We retrieved the same number of features for each segmented character and sent them into the neural network's categorization input. The amount of computations was successfully decreased by our choice of features, increasing the system's effectiveness. Here, we'll give a basic explanation of how we extract attributes. The picture is initially converted into a normalized binary image, which only contains two values: 1 for on-character pixels and 0 for background pixels.

Fig. 10: Character Recognition

From the detected image we extracted the license plate and then declare for the character recognition which is given in above. We took the identical number plate feature and added it to the convolutional neural network's classifier's input.

4.9.10 Character Recognition with CNN Model

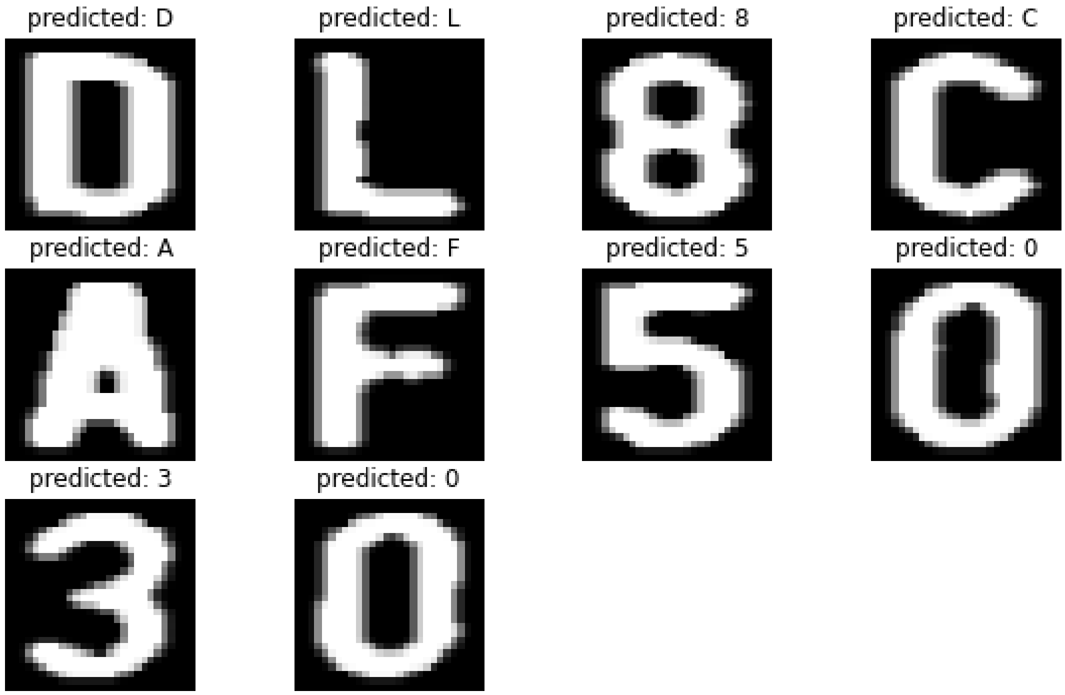

Fig.11: Character Recognition with CNN model

We have used CNN model to perform character recognition. For our research we have used CNN algorithms. The Convolutional Neural Network works by getting an image, designating based on the different objects of the image, and then distinguishing them from each other. CNN requires very little pre-process data as compared to other deep learning models. One of the main capabilities of Convolutional Neural Network is that applies primitive methods for training and classifiers, which makes it enough to learn characteristics of the target object. There are three types of layer like convolutional, pooling and a fully connected layer. Convolutional Neural Network naturally distinguisher the significant elements with no human communication. To this end CNN would be an optimal answer for picture order issues and it is likewise computationally effective.

CHAPTER 5

Results and Discussions

In this section we offer the accuracy, classification report, and confusion matrix of this system in several types of models that we utilized for my study, as well as a commentary of the results. In addition, we will test our model using performance matrix in this chapter. Using multiple classification methods such as CNN and VGG-19, as well as performance measures, we can determine which one is best for our models. The confusion measures also indicate precision, recall and f1 score.

To access the performance of our suggested model VGG-19 we used performance metrics. The confusion matrix, accuracy score, precision score, recall score and f1 score were all completed. And also compared each other algorithm for knowing best accuracy.

5.1 Loss Curves

- Training and validation loss curves for VGG19:

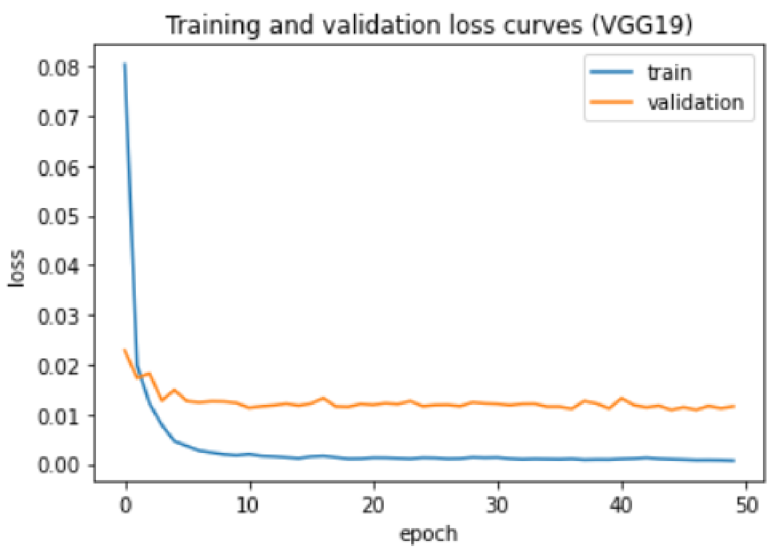

Fig. 12: Training Loss

Model loss indicate by the blue color line and Approach by the orange color line in the upper figure. Here, as the approach moves forward, model loss is gaining downward.

5.2 Accuracy Curves

- Training and validation accuracy curves for VGG19:

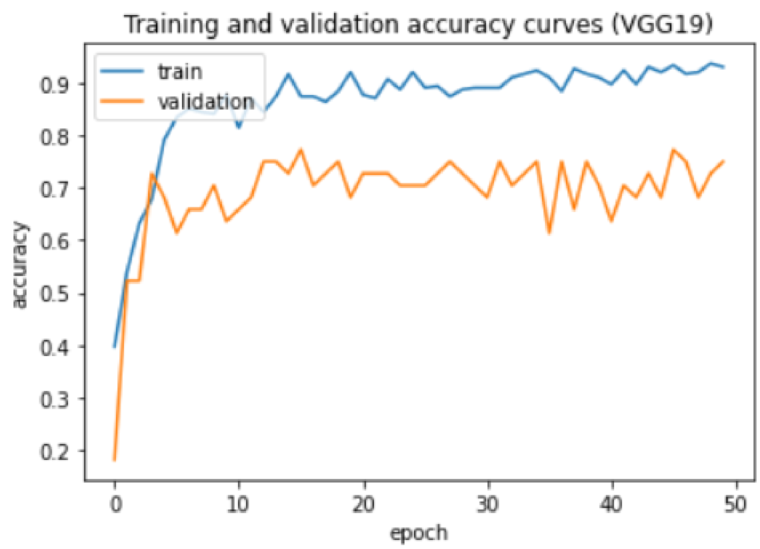

Fig. 13: Training Accuracy

Model accuracy is indicated by the blue color and Approach by the orange color line in the upper finger. Here, as the approach moves forward model accuracy is gaining upward.

5.3 Experiment Results and Discussion

We are evaluated on car license plate database. This dataset contains images with bounding box annotations of the car license plates within the image.

Using the line interpretation technique, the license plate is tracked, and a key frame is chosen. The extracted license plate is produced once the selected frame has through the extraction procedure. Fragmenting the retrieved license plate allows the characters to be identified via template matching. We employ a deep learning algorithm named VGG19. The suggested work's success rate is roughly identical to that of the recent methods. The accuracy of the proposed approach is observed to be 86.20%, and the model testing loss is 0.41%.

CHAPTER 6

Conclusions and Future work

Our objective was to implement a highly accurate and effective system. Our ability to achieve a high score in plate localization from the comparison and outcome analysis is without a doubt. However, our plate extraction module is not very effective. This is primarily due to our input dataset. Even a human would have a difficult time identifying and reading the characters on the plates in some of the photographs. Even for license plates that were slanted or skewed, our algorithm performs fairly well if we ignore the low resolution and impractical input photos.

Our next objective is to create a comprehensive suite that can recognize the characters on a license plate from any input image when we have completed the implementation up to character segmentation. We may discover a number of new solutions to the issues identified by this research, which we will carefully test out and choose the most useful methods to increase the accuracy of our system. The most difficult aspect in the future is likely to be optical character recognition. It is a vast area, and there are just a few studies on it in many languages. None of which show enough promise to deliver a high level of accuracy and efficiency. Utilizing Google's open-source and well-maintained Tesseract OCR is another option we are thinking into. But doing so necessitates gathering a strong training dataset.

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