Automatic Car-License-Plate Detection using Vertical-Edge-Based Method

S. Giridharan¹, N. Marie Claude²

¹PG Scholar, Department of Computer Science Engineering
I.F.E.T College of Engineering, Villupuram, India

²Associate Professor, Department of Computer Science Engineering
I.F.E.T College of Engineering, Villupuram, India

Abstract: A fast method for car-license plate detection (CLPD) presents three main contributions. The first contribution is that we propose a fast vertical edge detection algorithm (VEDA) based on the contrast between the grayscale values, which enhances the speed of the CLPD method. After binarizing the input image using adaptive thresholding (AT), an unwanted-line elimination algorithm (ULEA) is proposed to enhance the image, and then, the VEDA is applied. The second contribution is that our proposed CLPD method processes very-low-resolution images taken by a web camera. After the vertical edges have been detected by the VEDA, the desired plate details based on color information are highlighted. Then, the candidate region based on statistical and logical operations will be extracted. Finally, an LP is detected. The third contribution is that we compare the VEDA to the Sobel operator in terms of accuracy, algorithm complexity, and processing time.

Keywords: Adaptive thresholding (AT), car-license-plate detection (CLPD), Sobel operator, vertical edge detection algorithm (VEDA).

1. Introduction

THE car-license-plate (CLP) recognition system is an image processing technology used to identify vehicles by capturing their CLPs. The CLP recognition technology is known as automatic number-plate recognition, automatic vehicle identification, CLP recognition, or optical character recognition for cars. The CLP detection and recognition system (CLPDRS) became an important area of research due to its various applications, such as the payment of parking fees, highway toll fees, traffic data collection, and crime prevention. Usually, a CLPDRS consists of three parts: license-plate (LP) detection (LPD), character segmentation, and character recognition. Among these, LPD is the most important part in the system because it affects the system’s accuracy.

There are many issues that should be resolved to create a successful and fast CLP detection system (CLPDS), e.g., poor image quality, plate sizes and designs, processing time, and background details and complexity. The need for car identification is increasing for many reasons such as crime prevention, vehicle access control, and border control. To identify a car, features such as model, color, and LP number can be used. In vehicle tracking systems, cameras are used and installed in front of police cars to identify those vehicles.

Usually, numerous vehicle tracking and pursue systems use outstanding cameras, and this leads to cost increment of the system in both hardware and software. Since many methods have been proposed in various intelligent transportation system applications, the CLPDRS is usually based on an image acquired at 640 × 480 resolution. An enhancement of CLPD method performance such as reduction of computation time and algorithm complexity, or even the build of the LP recognition system with lower cost of its hardware devices, will make it more practical and usable than before.

This paper proposed a method for CLPD, in which a web camera with 352 × 288 resolution is used instead of a more sophisticated web camera. In this paper, the web camera is used to capture the images, and an offline process is performed to detect the plate from the whole scene image. Vertical edge extraction and detection is an important step in the CLPDRS because it affects the system’s accuracy and computation time. Hence, a new vertical edge detection algorithm (VEDA) is proposed here to reduce the computation time of the whole CLPD method.

This paper is organized as follows. Section II introduces a brief of related work. Section III describes two parts. The first part discusses in detail our proposed approach to vertical edge detection, i.e., using an unwanted-line elimination algorithm (ULEA) and the VEDA. The second part discusses the proposed CLPD method. Experimental results and discussion are presented in Section IV. Section V draws our conclusions.

2. Related Work

The problem of automatic vehicle license plate recognition has been studied since 1990s. The first approach was based on characteristics of boundary lines. The input image was first processed to enrich boundary lines information by some algorithms such as the gradient filter, and this resulted in an edging image. The image was binarized and then processed by certain algorithms, such as Hough Transform (HT), to detect lines. In the literature, many license plate detection algorithms have been proposed. Although license plate detection has been studied for many years, it is still a challenging task to detect license plates from different angles, partial occlusion, or multiple instances.

License plate detection investigates an input image to identify some local patches containing license plates. Since a plate can exist anywhere in an image with various sizes, it is infeasible to check every pixel to locate it. Generally, it is
preferable to extract some features from images and focus only on those pixels characterized by the license plate. Based on the involved features, traditional license plate detection methods can be classified into three categories: color-based, edge-based, and texture-based. In what follows, we will review the related work in each category.

Color-based approaches are based on the observation that some countries have specific colors in their license plates. It is intuitive to extract license plates by locating their colors in the images. In test image is checked with a classifier of color model. Then, candidate regions from the classification results are verified with some post-processing to locate the plates. The problem of automatic vehicle license plate recognition has been studied since 1990s. The first approach was based on characteristics of boundary lines. The input image was first processed to enrich boundary lines information by some algorithms such as the gradient filter, and this resulted in an edging image. The image was binarized and then processed by certain algorithms, such as Hough Transform (HT), to detect lines. The color and textures of the license plate have also been used to identify the license plate but they seem to be aimless and ineffective, especially when the system has plates of different colors and sign patterns.

3. Proposed Method for Car License Plate Detection

3.1 Overview

This paper has three contributions: The VEDA is proposed and used for detecting vertical edges; the proposed CLPD method processes low-quality images produced by a web camera, which has a resolution of 352 × 288 with 30 fps; and the computation time of the CLPD method is less than several methods. In this paper, the color input image is converted to a grayscale image, and then, adaptive thresholding (AT) is applied on the image to constitute the binarized image.

![Figure 1: System Architecture Diagram](image1)

After that, the ULEA is applied to remove noise and to enhance the binarized image Next, the vertical edges are extracted by using the VEDA. The flowchart of the proposed CLPD method is shown in Fig.1

3.2 Preprocessing

Pre-processing which includes
- Converting image to gray scale
- Binarization

The input image consists of many colors and the image is processed initially to improve the quality and prepares it to next phases of the system. Since the image has different colors the system will convert the RGB images to gray scale images using NTSC standard method.

\[\text{Gray}=0.299\times\text{Red}+0.587\times\text{Green}+0.114\times\text{Blue}\]

In the next phase the gray image is filtered using median filter in order to remove the noise, while preserving the sharpness of the image. The filter used is a non-linear filter where it replaces each pixel with a value obtained by computing the median of values of pixels.

![Figure 2: Image Binarization a)Input Image b) Binary Image](image2)

Binarization technique is used for convert the grayscale image into binary image. Input images to license plate detection system contain unevenly distributed gray intensities, such as the images with poor contrast. Therefore, the crucial point is to use an effective technique for Binarization. Otherwise, the method would fail to extract the license plate region from the vehicle image correctly.

3.3 Unwanted Lines Elimination Algorithm

Thresholding process in general produces many thin lines that do not belong to the LP region. We can see that there are many long foreground lines and short random noise edges beside the LP region. These background and noise edges are unwanted lines. These lines may interfere in the LP location. Therefore, we have proposed an algorithm to eliminate them from the image. This step can be considered as a morphological operation and enhancement process. There are four cases in which unwanted lines can be formed.

In the first case, the line is horizontal with an angle equal to 0° as (−).
In the second case, the line is vertical with an angle equal to 90° as (\(|\)).
In the third case, the line is inclined with an angle equal to 45° as (/).
In the fourth case, the line is inclined with an angle equal to 135° as (\(\\)).

Therefore, the ULEA has been proposed to eliminate these lines. In this step, while processing a binary image, the black
pixel values are the background, and the white pixel values are the foreground.

Figure 3: ULEA Output

3.4 VEDA

The advantage of the VEDA is to distinguish the plate detail region, particularly the beginning and the end of each character. Therefore, the plate details will be easily detected, and the character recognition process will be done faster. After thresholding and ULEA processes, the image will only have black and white regions, and the VEDA is processing these regions. The idea of the VEDA concentrates on intersections of black–white and white–black. A $2 \times 4$ mask is proposed for this process, where $x$ and $y$ represent rows and columns of the image, respectively. The center pixel of the mask is located at points (0, 1) and (1, 1). By moving the mask from left to right, the black–white regions will be found. Therefore, the last two black pixels will only be kept. Similarly, the first black pixel in the case of white–black regions will be kept.

Figure 4: VEDA Output

The proposed mask has the size of $2 \times 4$ to fulfill the following two criteria.

1) In this type of a mask, it is divided into three submasks: The first submask is the left mask “$2 \times 2$,” the second submask is the center “$2 \times 1$,” and the third submask is the right mask “$2 \times 1$,” as marked in Simply, after each two pixels are checked at once, the first submask is applied so that a 2 pixel width “because two column are processed” can be considered for detecting. This process is specified to detect the vertical edges at the intersections of black–white regions. Similarly, the third submask is applied on the intersections of white–black regions. Thus, the detected vertical edge has the property of a 1 pixel width.

2) The number “2” points out the number of rows that are checked at once. The consumed time in this case can be less twice in case each row is individually checked.

3.5 HDDs Based on VEDA

After applying the VEDA, the next step is to highlight the desired details such as plate details and vertical edges in the image. The HDD performs NAND–AND operation for each two corresponding pixel values taken from both ULEA and VEDA output images. The NAND–AND procedure for this process. This process depends on the VEDA output in highlighting the plate region. All the pixels in the vertical edge image will be scanned. When there are two neighbor black pixels and followed by one black pixel, as in VEDA output form, the two edges will be checked to highlight the desired details by drawing black horizontal lines connecting each two vertical edges. First, these two vertical edges should be surrounded by a black background, as in the ULEA image in Fig. 4. Second, the value of horizontal distance $h_d$ represents the length between the two vertical edges of a single object. The $h_d$ has been computed using the test images. The $h_d$ value is selected to be suitable for removing long foreground and random noise edges that have not been eliminated earlier. This scanning process will start moving from left to right and from top to bottom. After all pixels are scanned, the regions in which the correct LP exists are highlighted, as shown in Fig. 5.

Figure 5: HDD Output

3.6 CRE

This process is divided into three steps as follows.

1) *Count the Drawn Lines per Each Row:* The number of lines that have been drawn per each row will be counted and stored in matrix variable $HwMnyLines[a]$, where $a = 0, 1, \ldots$ height-1.

2) *Divide the Image into Multigroups:* The huge number of rows will delay the processing time in the next steps. Thus, to reduce the consumed time, gathering many rows as a group is used here. Therefore, dividing the image into multigroups could be done using the following: $\text{how_mny_groups} = \text{height} / C$.

3) *Count and Store Satisfied Group Indexes and Boundaries:* Most of the group lines are not parts of the plate details. Therefore, it is useful to use a threshold to eliminate those unsatisfied groups and to keep the satisfied groups in which the LP details exist in. Each group will be checked; if it has at least 15 lines, then it is considered as a part of the LP region. Thus, the total number of groups including the parts of LP regions will be counted and stored. The remaining
groups after thresholding step should have the LP details. Therefore, their locations are stored. The final step here is to extract both upper and lower boundaries of each satisfied group by using its own index.

3.7 PRS

This process aims to select and extract one correct LP. The process is discussed in five parts. The first part explains the selection process of the LP region from the mathematical perspective only. The second part applies the proposed equation on the image. The third part gives the proof of the proposed equation using statistical calculations and graphs. The fourth part explains the voting step. The final part introduces the procedure of detecting the LP using the proposed equation. Below is the proposed pseudo code in which (12) is applied.

\[
\text{If } (\text{blckPix} \geq 0.5 \times \text{colmHght}) \\
// \text{i.e., } PRS = 50\%; \text{ the blckPix } \geq 0.5 \times \text{the column height of the correct region} \\
\text{Then} \\
PRS \text{ is determined, and } = 0.5 \rightarrow \text{ the current column is a part of the LP;} \\
\text{Else If } (\text{blckPix} \geq 0.4 \times \text{colmHght}) \\
// \text{i.e., } PRS = 40\%; \text{ the blckPix } \geq 0.4 \times \text{the column height of the correct region} \\
\text{Then} \\
PRS \text{ is determined, and } = 0.4 \rightarrow \text{ the current column is a part of the LP;} \\
\text{Else If } (\text{blckPix} \geq 0.3 \times \text{colmHght}) \\
// \text{i.e., } PRS = 30\%; \text{ the blckPix } \geq 0.3 \times \text{the column height of the correct region} \\
\text{Then} \\
PRS \text{ is determined, and } = 0.3 \rightarrow \text{ the current column is a part of the LP;} \\
\text{Else} \\
\{ \\
\text{The current column is not a part of the LP, and it belongs to background; Go to next column;} \\
\}
\text{End If}

4. Experimental Setup

Implementation Steps
1) The implementation steps can be summarized as follows.
2) The web camera is set to active profile “live” and is connected to a laptop.
3) The devices described in (step 1) are taken to an outdoor environment.
4) The web camera is focused on the car LP.
5) The distance between the web camera and the LP ranges from 2 to 4 m.
6) The web-camera pan angles are in between +20° and −20°, whereas camera tilt is set from 0° to 20°.
7) The captured samples contain different backgrounds and objects such as trees and two LPs.

Figure 6: Web-camera pan/tilt placement.

Figure 7: LPD by modifying the PRS value. (a) Plate area selection. (b) PD: $PRS \geq 0.5$. (c) Plate area selection. (d) PD: $PRS \geq 0.4$. (e) Plate area selection. (f) PD: $PRS \geq 0.3$.

5. Experimental Results

Here, the AT process will be evaluated first. Then, the accuracy and the computation time of the VEDA are compared with that of the Sobel operator. Finally, the performance of the proposed CLPD method is evaluated. To carry out this evaluation and analysis, The VEDA and the Sobel algorithm are separately used to extract vertical edges. In the first evaluation, the CLPD method has been built as follows: ULEA → VEDA → HDD → CRE → PRS → PD. In the second evaluation, the CLPD method has been built as follows: ULEA → Sobel → HDD → CRE → PRS → PD. Our proposed method has been tested on the laptop with the following specifications: Core 2 CPUs with 1.83 GHz and 1 GB of RAM. The program is running under Windows XP SP2 written in C++ language with an Open CV library.
6. Conclusion

The proposed method is mainly designed for real-time Indian license plate, in which its performance is faster than the performance of Sobel by five to nine times depending on image resolution. The VEDA contributes to make the whole proposed CLPD method faster. We have proposed a CLPD method in which data set was captured by using a web camera. To measure the efficiency, our method has been tested over a large number of images acquired under various illumination and weather conditions (sunny, cloudy, daytime, nigh time, rainy days...etc), and achieved a satisfactory results. Finally, the VEDA-based and Sobel-based CLPD are compared, and the findings show that VEDA-based CLPD is better in terms of the computation time and the detection rate.

7. Future Work

A lot of research has been performed on detection and recognition of license plate. Different researchers provided different methods and techniques for this process. However, every technique has its own advantages and disadvantages. Furthermore each country has its own license plate numbering system, colors, language of characters, style (font) and sizes. Even within the same country the license plate differs from state to state and in terms of types of License plate. In our future work, we will evaluate our approach on infrared images for license plate detection. We will also explore the potential of our approach in detection of logos and trademarks.

References


Author Profile

N. Marie Claude received his Bachelor of engineering degree from madras university, Chennai. Master degree from Sathyabama University, Chennai and working for his Ph.D degree from St. Peters University, Chennai. He is currently working as Associate professor in IFET College of Engineering, Villupuram. His research interest in pertain to Networking, Nano electronic devices, Digital signal processing, Digital image processing.

S. Giridharan received the B.E. degree in Computer Science and Engineering from the Shri Andal Alagar College of Engineering, Chennai, Anna University, Chennai, India, in 2012. Currently doing M.E. in Computer Science and Engineering in IFET College of Engineering, Villupuram, Anna University, India. His research interest includes Image Processing, Mobile Computing, Compiler and Design, Theory of computation, Data Structures and Algorithms.