Canny Edge-Detection Based Vehicle Plate Recognition

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Abstract

Vehicle plate recognition is an effective image processing technique used to identify vehicles' plate numbers. There are several applications for this technique which expand through many fields and interest groups. Vehicle plate recognition may be used as a marketing tool, for purposes of traffic and border control, for law enforcement, and travel. Many methods have been proposed to facilitate this technique. This study proposes an edge-detection method to enable a Plate Recognition System through practical situations, such as various environmental or meteorological conditions. Image processing tools are used to scan the plate area, resize it, and convert it toward a gray scale prior to filtering the image in order to remove small objects. The obtained objects are identified such that the numbers object is recognized. The details of the obtained image are controlled through the standard deviation of the Gaussian filter (sigma).

Keywords*: LPR, vehicle recognition, edge detection, access control, Gaussian filter*

1. Introduction

An important application of digital image processing is the vehicle License Plate Recognition (LPR) system. This system is widespread especially in terms of security and traffic installations. The technological conceptualization assumes that vehicles already have an identity displayed (the plate) and therefore, no additional transmitter or responder is required to be installed on the vehicle. A significant advantage of the LPR system is that it can retain an image record of a vehicle for further processes if needed. In addition, this technology does not require any extra installation per vehicle. Differing from other technological initiatives which may require a transmitter to be added on a vehicle or manually carried by a driver [1, 2, 3].

Based on the extracted plate number, the LPR system has a wide range of applications and options to create automated solutions for various problems. These applications may be utilized for a wide range of uses. For purposes of demonstration, below are five examples of its practical use. One use is for parking, in which the plate number is used to automatically enter pre-paid parks for members or calculate parking fee for non-members, optional driver face recognition can also be used to prevent car hijacking. The second is through access control, in which a gate automatically opens for authorized members in a secured area, thus replacing the assistance of a security guard. In this case, every time the gate opens it is logged in a database for future use, if necessary. The third is for purposes of tolling. The vehicles' plates' number is used to calculate a travel fee within a toll-road, or used to double-check the ticket. The fourth is for law enforcement use. The plate number is applied in order to produce a violation fine on speed or red-light systems. The fifth is for traffic control, in which vehicles may be directed to different lanes according to their entry permits. More related applications and approaches are discussed in [4, 5, 6, 7].

Due to the variety of applicable uses and their different approaches, the LPR also has several other known references, such as, Automatic Vehicle Identification (AVI), Car Plate Recognition (CPR), Automatic Number Plate Recognition (ANPR), Car Plate Reader (CPR), Optical Character Recognition (OCR), all of which are for vehicles [8, 9].

Such technologies are also exercised in identifying the plate number of a vehicle which enters a specific place. This process is accomplished by taking an image of a plate using a suitably located camera connected to an automated control system. As the plate number is recognized, the system is enabled based on the available database of the authorized plate's number.

This study is structured such that Section Two presents the Canny Edge-Detection method, Section Three discusses plate number recognition algorithm, Section Four embodies the simulation section, and the conclusion is presented in Section Five.

2. Canny Edge Detection

Edge-detection is a basic tool that is widely used within image processing. It is applied practically in applications such as object determination, in which feature detection aims to sharply identify certain objects of an image. Several edge-detection methods are widely used based on several possible optimization techniques. For example, error minimization, maximizing an object function, fuzzy logic, wavelet approach, morphology, genetic algorithms, neural network and Bayesian approach. Various edge-detection methods perform to wavering degrees of quality within altered conditions. Therefore, it is possible to apply multiple edge-detection algorithms.

The Canny Edge-Detector is an operator which uses a multi-stage algorithm to determine a wide range of edges in a noisy image as follows [10, 11];

1. Use the Gaussian filter $G\sigma\ (m,n)$ *to s*mooth out the image $f(m,n)$. This will reduce noise or unwanted details and textures as given in Eq.1

   $$g(m,n) = G\sigma\ (m,n) * f(m,n) \qquad (1)$$

   Where $G\sigma\ (m,n)$ is given as

   $$G\sigma\ (m,n)=\frac{1}{\sqrt{2\pi\sigma^2}}exp[-\frac{m^2+n^2}{2\sigma^2}] \qquad (2)$$

2. Compute gradient of $g(m,n)$ using any of the gradient operators to reach:

   $$M(m,n)=\sqrt{g_m^2(m,n)+g_n^2(m,n)} \qquad (3)$$

   and

   $$\theta(m,n) = tan^{-1}[g_n(m,n)/g_m(m,n)] \qquad (4)$$

3. Threshold M is given as:

   $$M_T(m,n)=\begin{cases} M(m,n) & if\ M(m,n) > T \\ 0 & otherwise \end{cases} \qquad (5)$$

   Where T is chosen, such that all edge elements are kept, most of the noise is suppressed.

4. Suppress non-maxima pixels in the edges of M_T obtained above to thin the edge ridges. To do so, check to see whether each non-zero $M_T(m,n)$ is greater than its two

neighbors along the gradient direction $\theta(m,n)$. If so, keep $M_T(m,n)$ unchanged, otherwise, set it to zero.

5. Threshold the previous result by two different thresholds τ_1 and τ_2 (where $\tau_1 < \tau_2$) to obtain two binary images T_1 and T_2. This T_2 has less noise and fewer false edges than T_1 but it also has larger gaps between edge segments.
6. Link edges segments in T_2 to form continuous edges. To do so, trace each segment in T_2 to its end and then search its neighbors in T_1 to find any edge segment in T_1 to bridge the gap until reaching another edge segment in T_2.

3. Plate Number Recognition Algorithm

The main objective of this study is to explore the ability of capturing and recognizing plate numbers of vehicles using a suitably fixed camera. The image would then be kept for further processing or may be compared against specific databases, such that if a plate number is matched to one already existing, then the system is enabled. The algorithm is based on clear and simple image processing tools and is summarized as follows:

1. Read and resize the image
2. Convert the image toward a gray scale
3. Receive the complement of the image and find the edges
4. Filter the image of small objects
5. Separate the image into objects
6. Recognition of the license plate

Each step of the algorithm procedure has its role, priority, and contribution toward having a comprehensive algorithm. This results in a satisfying plate recognition system. Reading the overall image is a starting point in order to construct the general impression of the plate itself. Resizing the image to match a systematic analysis approach is formed. Several edge-detection approaches may be used to obtain the plate of a vehicle [12, 13, 14, 15]. The edge-detection process leads to identifying various objects within an image. Therefore, using suitable filters, unwanted objects are easily removed and essential objects of the image remain. These objects are separated in such a way that a plate is familiarized, identified, and acquainted to its appropriate place.

4. Simulation

Simulation is performed for purposes of investigation. The priority steps of the LPR system is as follows:

1. Read and resize the image

A photograph of the license plate area is taken and the image is resized into an appropriate ratio. These values are chosen so that the width of the image is 600 pixels and the length is 400 pixels as illustrated in Figure 1.

Figure 1. Image of the Plate Area after Resizing

2. Convert the image toward gray scale

The image is smoothed by its conversion toward gray scale, enabling the system to find the edges of the image. This gray scale image is enhanced to facilitate the performance of the system. The grayscale and enhanced images are illustrated in Figure 2.

a) Gray Scale Image b) Enhanced Image

Figure 2. Gray Scale Image and Enhanced Image

3. Receive the complement of the image and find the edges

The complement of the image is obtained and is enhanced again. An edge-detection technique is used to acquire the edges of the required image for further actions. Canny Edge-Detection method has been used to find such values of the concerned image based on local maxima of the gradient of that image. The gradient is calculated using the derivative of a Gaussian filter. This method uses two thresholds to detect strong and weak edges and it considers the standard deviation of the Gaussian filter (sigma). This factor controls the amount of details of an image to be filtered. This is so when sigma increases, less details of the filtered image remain. The value of sigma has been chosen as 0.95 which proves to be a more than adequate choice in obtaining fair results as illustrated in Figure 3.

a) Complemented Image b) Edged Image

Figure 3. Complemented Image and Edged Image

4. Filter the image of small objects

The image is filtered and several objects are formed with various sizes. Small size objects have been removed. This is calculated by if the size of an object is less than a predefined threshold value. This value has been set to 280 pixels and so the remaining objects are considered as illustrated in Figure 4.

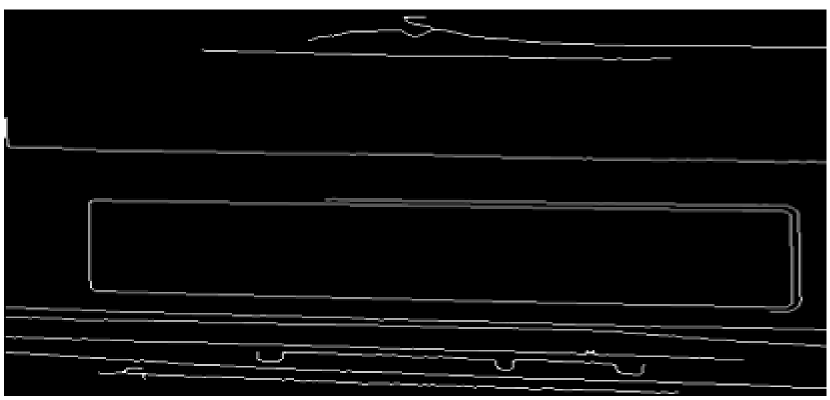

Figure 4. Filtered Image

5. Separate the image into objects

Objects are separated and each object has a specific characteristic that enables the system to know the plate-like object as shown in Figure 5. This step is essential in simplifying the remaining processes based on various separated objects within the image.

a) Non-Plate-Like Object b) Plate-Like Object

Figure 5. Non-plate-like Object and Plate-like Objects

6. Recognition of the license plate

In order to identify the license plate from those objects, an image consisting of objects is desired. A suitable description of the license plate is based on solidity, the ratio between the height and width, convex area, and bounding box. Accordingly, the plate can be identified by multiplying the plate object with the original image as illustrated in Figure 6.

Figure 6. Obtained Number on the Plate

5. Conclusion

Vehicle LPR has several applications. It also has several approaches and algorithms. Given an input image of a vehicle, an automatic recognition system is discussed leading to extracting the license plate numbers and its characteristics. Practical image processing tools have been used to enable the system in order to obtain the desired objects and so to identify license plate numbers. This proposed approach enables the system to zoom smoothly toward the exact frame of the plate. Therefore unwanted objects are easily removed and the license plate is recognized.

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