J. Vis. Commun. Image R. 36 (2016) 172–186

Contents lists available at ScienceDirect

J. Vis. Commun. Image R.

journal homepage: www.elsevier.com/locate/jvci

Automatic license plate detection in hazardous condition ☆

Samiul Azam [a,b,*], Md Monirul Islam [b]

[a] Department of Computer Science, University of Calgary, Calgary, Alberta, Canada
[b] Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

ARTICLE INFO

Article history:
Received 18 June 2015
Accepted 28 January 2016
Available online 6 February 2016

Keywords:
Automatic license plate detection
Hazardous condition
Rain streaks
Fog affected
Horizontally tilted
Low contrast image
Fourier transform
Radon transform

ABSTRACT

Automatic detection of license plate (LP) is to localize a license plate region from an image without human involvement. So far a number of methods have been introduced for automatic license plate detection (ALPD), but most of them do not consider various hazardous image conditions that exist in many real driving situations. Hazardous image condition means an image can have rainy or foggy weather effects, low contrast environments, objects similar to LP in the background, and horizontally tilted LP area. All these issues create challenges in developing effective ALPD method. In this paper, we propose a new ALPD method which effectively detects LP area from an image in the hazardous conditions. For rain removal we apply a novel method that uses frequency domain mask to filter rain streaks from an image. A new contrast enhancement method with a statistical binarization approach is introduced in the proposed ALPD for handling low contrast indoor, night, blurry and foggy images. For correcting tilted LP, we apply Radon transform based tilt correction method for the first time. To filter non-LP regions, a new condition is used which is based on image entropy. We test the proposed ALPD method on 850 car images having different hazardous conditions, and achieve satisfactory results in LP detection.

1. Introduction

Automatic license plate detection (ALPD) means extracting vehicle's license plate (LP) area from an image without human intervention. It is one of the important stages of automatic LP recognition (ALPR) system [1]. In an ALPR system, there are three major stages: (i) acquisition of a car image by an image capturing device; (ii) detection of the potential LP area from the image; (iii) feature extraction and recognition of characters from the LP area. Fig. 1 shows the basic organization of an ALPR system. The objective of an ALPR system is automatic identification of a vehicle by reading the LP data from an image or a video. In an ALPR system, stationary cameras are mounted on the road signs, street lights, buildings or highway overpass for capturing the image of the vehicle [2]. Then the captured image goes through a software system that detects possible LP location in the image, and converts the LP information into a computer readable format. The recovered identity of the vehicle can be used in real time or stored in the database for future use. An ALPR system has numerous real life applications, such as traffic law enforcement, identification of vehicles, traffic pattern analysis, automatic toll collection, automatic parking management, car access control and many more [2].

In an ALPR system, LP detection is the most crucial stage and the performance of the whole system highly depends on it [3]. In the detection stage, we need to deal with a number of important issues, such as (i) hazardous weather conditions (rainy and foggy); (ii) hazardous background (presence of non-LP objects in the background); (iii) low contrast image environments (indoor, night, blurry and uneven illumination); (iv) horizontally tilted LP in the image due to camera position. Collectively all these issues are identified as the hazardous image conditions. Fig. 2 shows some examples of car images in the hazardous conditions. All these issues make ALPD a challenging research topic. Earlier, many efforts have been made to develop a robust ALPR system, but they avoid most of the LP detection issues which make those systems very limited at the LP detection level. So a robust LP detection approach is still needed for making an efficient ALPR system. In this paper, we focus only on the automatic detection of LP area from a car image. We are not considering the image acquisition and the recognition steps of an ALPR system. The center of attention is different hazardous image conditions. Our target is to design an ALPD method that gives better performance for simple input image, as well as image having hazardous conditions.

The rest of the paper is organized as follows. In Section 2, we briefly describe several existing ALPD approaches and their

☆ This paper has been recommended for acceptance by Zicheng Liu.

* Corresponding author at: Department of Computer Science, University of Calgary, Calgary, Alberta, Canada.

E-mail addresses: samiul.azam@ucalgary.ca (S. Azam), mmislam@cse.buet.ac.bd (M.M. Islam).

http://dx.doi.org/10.1016/j.jvcir.2016.01.015
1047-3203/

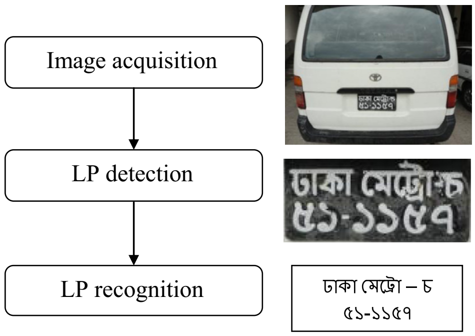

Fig. 1. Basic organization of an ALPR system.

Fig. 2. Examples of car images (a) in rain, (b) in fog, (c) at indoor, (d) at night, (e) having blur effect, (f) having tilted LP, (g) with background objects, and (h) without hazardous conditions.

limitations. The proposed ALPD method is introduced and explained in Section 3. Section 4 presents the experimental results and the performance of the proposed ALPD. Finally, we mention some concluding remarks and suggestions for the future work in Section 5.

2. Literature review

Over the last decade, many efforts have been made to solve the problem of detecting potential LP area from an image or a video. Different state-of-the-art methods apply different image processing approaches, techniques and algorithms to build their ALPD methods. To detect an LP area from an image, different features such as geometric feature, texture feature and color feature of the LP are utilized individually or jointly [3]. Hazardous conditions have effect on these features of an LP, and consequently increase the LP detection error. The presence of rain streaks in the image creates unnecessary irregularities and edge density. The low contrast environments (night, indoor, foggy and blurry) degrade the visibility of the LP texts, boundary edges of the rectangular LP, and the LP foreground–background color difference. That means it affects the geometric, texture and color features of the LP. Due to the camera position and angle, an LP region can be horizontally tilted in the captured image which affects the geometric feature of an LP region. Therefore, it makes difficulty in detecting the LP region based on geometric feature. In the captured image, there can be other objects, such as headlight, bumper and car logo along with the LP. The hazardous background creates ambiguity for an ALPD to select the original LP region. During our review, we find that the existing state-of-the-art ALPD methods do not consider all the hazardous conditions. Several state-of-the-art ALPD techniques are summarized in Table 1 with their underlying techniques, and limitations from the view of hazardous conditions. Besides that there exist several commercial ALPR systems [4–8] whose underlying technologies and performance rates are strictly confidential and beyond our capabilities.

In Table 1, we see that none of the existing ALPD methods are able to handle the issue of weather condition. The issue of horizontally tilted LP is considered by one [15] of them, but the solution is sensitive to character connectivity and noise. A few of them consider tilted LP during the ALPD, but tilt angle detection and correction approach is not presented there. All other methods consider zero-tilted or trivially-tilted LP, and they have no such special approach to handle the tilted LP. Most of the existing ALPD methods [10,12–14,20–22,25–27] consider input images having good contrast and illumination. So they do not have any contrast enhancement step in their ALPD. Only [16,18] use contrast enhancement approach to enhance overall contrast of the image which is not effective for highly low contrast (night and blur) LP regions. Several others [9,11,15,19,23,24,28–30] use input images having uneven illumination and other low contrast issues, but do not consider all the hazardous conditions. During filtering of non-LP regions from background, most of the existing methods use LP size, aspect ratio, and orientation as filtering conditions. In [10], Euler's number (total number of white objects minus holes) is used as a condition for filtering LP, but it fails when noise increases or decreases unwanted white objects. Some ALPDs [11,13–15,19,26] use counting of horizontal intensity transition and/or edge density as filtering condition without using any noise filter and contrast enhancement method beforehand. In [9,23], template matching is applied on sub-images to filter LP and non-LP, which is time consuming and fully depends on good collection of training sub-images. Word search approach is used in [27] which is also time consuming and country specific. Color of an LP can be used as a criterion for filtering LP [12,29], but it is sensitive to colored light, hard light and shadow. So additional filtering criteria are still needed for effective filtering. Overall, all the existing ALPD methods are very limited if the matter of hazardous image conditions are judged. Motivated by this fact, we propose a new ALPD method that effectively detects LP in the hazardous conditions. This ALPD system is invariant of LP color, location and language. It can be used in any existing ALPR system. The novel contributions of the paper are given as follows: (1) a faster rain-streak removal technique from image; (2) an improved contrast limited adaptive histogram equalization (CLAHE) using Tamura contrast value; (3) a new statistical binarization method for low contrast image; (4) a novel Radon transform based LP tilt angle detection and correction, which is not sensitive to character connectivity; (5) a new filtering condition based on the entropy measure of a non-LP region. The detailed explanation of the proposed ALPD is given in the next section.

3. Proposed method

The proposed ALPD method comprises of five stages:

1. Grayscale conversion, noise and rain effects removal.
2. Contrast enhancement and binarization.
3. Local counting filter and cropping connected components (CCC).
4. Tilt angle detection and correction.
5. Filtering non-LP regions.