Computers and Electrical Engineering 46 (2015) 539–553

Contents lists available at ScienceDirect

Computers and Electrical Engineering

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

# A two-stage character segmentation method for Chinese license plate ☆

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ARTICLE INFO

*Article history:*
Received 2 March 2014
Received in revised form 13 February 2015
Accepted 19 February 2015
Available online 29 March 2015

*Keywords:*
License plate character segmentation
Horizontal boundaries location
Template matching
A* path-finding

ABSTRACT

As a part of character recognition, character segmentation (CS) plays an important role in automatic license plate recognition (ALPR) system. In recent years, lots of methods on CS have been proposed and they work well on their own datasets. However, it is still challenging to segment characters from images with frame, declination and quality degradation because of noises and overlapped, connected or fragmented characters. In this paper, we propose a two-stage segmentation method for Chinese license plate. At the first stage, a novel template matching method is presented using a harrow-shaped filter (HSF) bank and minimum response. It finds the locations of the segmenting points between characters roughly. Then, the accurate segmentations between connected or overlapped characters are adjusted by a variant of A* path-finding algorithm at the second stage. Experiments on a challenging dataset including 2334 images demonstrate the effectiveness and efficiency of the proposed method.

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## 1. Introduction

With the rapid growth in the number of vehicles, it is of great importance to develop intelligent transportation system (ITS) to improve the management of high ways, toll stations and parking lots [1,2]. As one of the most important parts of ITS, automatic license plate recognition (ALPR) system generally consists of license plate localization (LPL), character segmentation (CS) and character recognition (CR). Among them, CS aims to locate the boundaries of each character accurately so as to segment the corresponding image patch for recognition. Hence, its performance has great influence on the whole system. During the past few years, a lot of researches have been done on CS. The existing methods can be divided into three categories: vertical projection (VP) based methods [3–6], connected component analysis (CCA) based methods [7–11] and template matching (TM) based methods [12–14].

Among them, the VP-based methods are the simplest and fastest. Characters are segmented directly by detecting valleys in the projection histogram. Thus, this kind of method is sensitive to noise and likely to fail in segmenting connected or fragmented characters correctly. In the methods based on CCA, character-like components are often detected and their positional relationships are utilized to segment the real characters. But in the case of connection or fragmentation, the segmentation will become difficult. Therefore, the performances of CCA based methods depend largely on the result of binarization.

By contrast, methods using TM are more robust to connection and fragmentation. Usually, a square wave having the same structure with standard license plate and a score function are used for matching. When there are noises at the left and right

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Associate Editor Dr. Eduardo Cabal-Yepez.
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http://dx.doi.org/10.1016/j.compeleceng.2015.02.014
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sides of the plate or severe adhesions between characters, the results given by these methods are far from satisfaction. Therefore, a more effective approach needs to be developed to solve those problems out.

In this paper, we propose a two-stage character segmentation method that takes full advantage of the arrangement structure of Chinese license plate. It consists of three main steps: image preprocessing, initial segmentation and precise segmentation. In the preprocessing step, the horizontal borders of frame are removed and vertical tilt is corrected on the binary image. Then, a bank of harrow-shaped filter (HSF) is deigned and convolved with the vertical projection in the initial segmentation stage, aiming to find the locations of segmenting points between characters roughly. Finally, the accurate segmentations between connected or overlapped characters are adjusted by a variant of traditional A* path-finding algorithm. The main contributions of our work are given as follows:

(1) CCA and horizontal scanning are combined to remove the horizontal borders of plate frame.
(2) HSF bank and minimum response are used for rough segmentation.
(3) The connected and overlapped characters are segmented on the basis of the variant of A*.

The rest of this paper is organized as follows. First, related work is presented in Section 2. Then, Section 3 gives a detailed description of the proposed method, including image preprocessing, initial segmentation and precise segmentation. In Section 4, we discuss and evaluate the experiment results, as well as a comparison of our results with several state-of-the-art methods. Finally, the work is concluded in Section 5.

## 2. Related work

In literature, many license plate character segmentation algorithms have been proposed [15]. Although it has been studied for many years, it is still a challenging task to segment characters on license plates with frame, declination and quality degradation. According to different methods mentioned in introduction, we will review the related work of each category.

For VP based methods, the peak-valley distribution in vertical projection histogram is explored. In [3], after removing the plate frame by horizontal projection, the binary image is projected vertically to find the largest space for locating the boundaries of each character by adding or subtracting the estimated character width. The work in [4] differs from [3] in locating the upper and lower boundaries of character region. The image is divided into many blocks in horizontal and each block is projected horizontally to get two sets of subsection lines. For each set, Hough transform is implemented on the midpoint of each subsection line to get the boundary line. So this method can deal with inclined plates. Studies in [5,6] mainly focus on the segmentation of connected and overlapped character. In [5], a morphological thickening algorithm and a morphological thinning algorithm are adopted, respectively. The method proposed in [6] uses an optimal pathfinding algorithm called A* [16], which is not only effective in accuracy but also efficient in time.

CCA is another popular technique used for character segmentation. Usually, connected components with the same aspect ratio as character or those recognized as characters are first extracted from the binary image, as presented in [7,8]. By analyzing the spacial relationships between them, characters undetected are segmented. Compared with blob detection by thresholding, maximally stable extremal region (MSER) detector proposed in [17] is more powerful and often adopted for text detection [18]. It is first applied for segmentation of license plate character in [9]. MSERs that meet some geometry features are considered as plate characters. The study in [10,11] make full use of MSERs in their license plate recognition system. Therefore, methods using CCA is robust to plate frame and invariant to tilt.

Utilizing the characters' arrangement on license plates, many methods base on TM are proposed as well. A recent work in [12] presents a variable-length template matching method, according to the characteristics of horizontal and vertical projections. Two sets of templates, one with single square wave and another with seven square waves, are designed and matched with the horizontal projection of horizontal gradient and vertical projection of vertical gradient image, respectively. The best matches are achieved at positions with maximal correlation coefficients. Miao [13] has proposed a novel usage of TM, in which midpoints of intervals on the vertical projection histogram are compared with those on the template, to distinguish

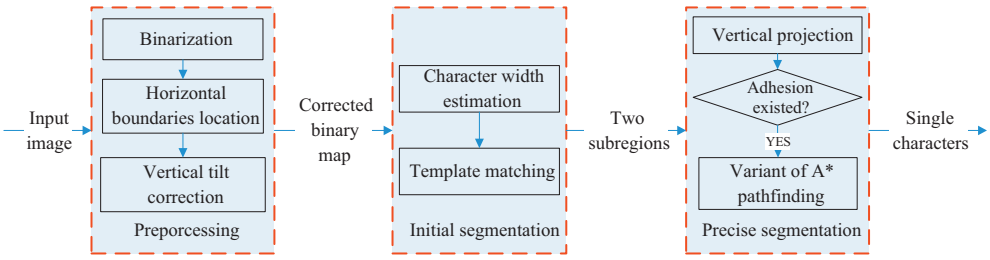


**Fig. 1.** Flowchart of our framework for character segmentation of Chinese license plate.

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