Reading Car License Plates Using Deep Neural Networks

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PII: S0262-8856(18)30015-5
DOI: doi:10.1016/j.imavis.2018.02.002
Reference: IMAVIS 3674

To appear in: *Image and Vision Computing*

Received date: 20 December 2016
Revised date: 21 February 2018
Accepted date: 27 February 2018

Please cite this article as: Hui Li, Peng Wang, Mingyu You, Chunhua Shen, Reading Car License Plates Using Deep Neural Networks, *Image and Vision Computing* (2018), doi:10.1016/j.imavis.2018.02.002

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***Abstract*—In this work, we tackle the problem of car license plate detection and recognition in natural scene images based on the powerful deep neural networks (DNNs). Firstly, a 37-class convolutional neural network (CNN) is trained to detect characters in an image, which leads to a high recall compared with a binary text/non-text classifier. False positives are then eliminated effectively by a plate/non-plate CNN classifier. As to the license plate recognition, we regard the character string reading as a *sequence labeling* problem. Recurrent neural networks (RNNs) with long short-term memory (LSTM) are trained to recognize the sequential features extracted from the whole license plate via CNNs. The main advantage of this approach is that it is segmentation free. By exploring contextual information and avoiding errors caused by segmentation, this method performs better than conventional methods and achieves state-of-the-art recognition accuracy.**

***Index Terms*—Car plate detection and recognition, Convolutional neural networks, Recurrent neural networks, LSTM**

I. Introduction

With the recent advances in intelligent transportation systems, automatic car license plate detection and recognition (LPDR) has attracted considerable research interests. It has a variety of potential applications in security and traffic control, and much work has been done on the topic of LPDR.

However, most of the existing algorithms work well either under controlled conditions or with sophisticated image capture systems. It is still a challenging task to read license plates accurately in an open environment. The difficulty lies in the extreme diversity of character patterns, such as different sizes, fonts, distortion, occlusion or blurring, and the highly complicated backgrounds, like the general text in shop boards, windows, guardrails or bricks.

Previous work on LPDR usually relies on some handcrafted image features that capture certain morphological, color or textural attributes of the license plates [1], [2]. These features can be sensitive to image noises, and result in many false alarms under complex backgrounds. In this paper, we tackle LPDR by leveraging the high capability of convolutional neural networks (CNNs) and recurrent neural networks (RNNs). CNNs consist of multiple layers of neurons, which can learn high-level features efficiently from a large amount of labeled training data. In our LPDR system, we view license plates as strings of text. A character CNN is applied firstly to examine the presence of characters, and a plate CNN is followed then to reject false alarms. This cascaded framework shows high discriminative ability and strong robustness against complicated backgrounds. As to license plate recognition, we formulate it as a sequence labeling problem. The car plate image is viewed as an unsegmented sequence. CNNs are used to extract image features. RNNs with connectionist temporal classification (CTC) [3] as the output layer are employed to label the sequential data. With this method, we do not need to deal with the challenging character segmentation task. The recurrent property of RNNs also helps to exploit the contextual information and improve the recognition performance. The overall framework of our LPDR system is shown in Fig. 1. The main contributions of this work are as follows.

- We propose a cascaded framework that uses different CNN classifiers for different purpose. To begin with, a 4-layer 37-class (10 digits, 26 uppercase letters plus the negative non-character category) CNN classifier (we denote it as CNN-I) is employed in a sliding-window fashion across the entire image to detect the presence of text and generate a text saliency map. Text-like regions are extracted based on the clustering nature of characters. Then another plate/non-plate CNN classifier (denoted as CNN-II) is adopted to reject false positives and distinguish license plates from general text. With this framework, our system can detect license plates in complicated backgrounds with both high recall and precision. Moreover, it can be used to detect license plates of various styles (e.g., from different countries), regardless of diverse plate colors, fonts or sizes.
- we develop a deep recurrent model which can read all characters in the license plate one-off. To the best of our knowledge, this is the first work that recognizes license plates without character segmentation. We extract features by CNNs from the whole license plate without pre-segmentation. Several layers of CNN features are concatenated together, which combine both local and global information. Bidirectional recurrent neural networks (BRNNs) with long short-term memory (LSTM) are employed to recognize the feature sequence. CTC is applied to the output of BRNNs to decode the character string in the plate. This approach takes advantage of both deep CNNs for feature learning and BRNNs for contextual information exploiting, and results in appealing performance.

The rest of paper is organized as follows. Section 2 gives a brief discussion on related work. Section 3 describes the details of license plate detection, and Section 4 presents the method on license plate recognition. Experimental verifications are followed in Section 5, and conclusions are drawn in Section

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