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Artificial intelligence technology in license plate recognition

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Abstract. Due to the importance of license plate recognition in many parts in human society, several methods are concluded and proposed in this article. In this work, artificial intelligence (AI) technology, deep learning, and neural networks are put into use in different aspects or modules of license plate recognition methods. Current methods can be divided into two categories, one is the traditional methods and the other is method using AI technology. Two-stage method is a typical example for traditional methods. In this work, other methods such as RT-LPDRnet method, which takes YOLO v5 into use, is an example for AI technology in license plate recognition. Now commercial license plate recognition generally adopts the method of end-to-end deep learning, while some methods of character segmentation first and then recognition are still worthy of study. In this work, three evaluation metrics are concluded to help evaluate the performance of previous methods. In addition, application of license plate recognition is proposed such as recognition in the parking lots, entrances and exits of expressway and electronic police system.

Keywords: AI technology, deep learning, license plate recognition.

1. Introduction

The license plate is the unique ID card of a vehicle with registration codes issued by the vehicle management authority after review, inspection and registration of the cars applying for license plates as stipulated by the national vehicle management regulations. And its particularity and importance determine that the license plate recognition system has become necessary and unreplaceable in urban intelligent traffic management system. License plate plays its role in identifying the identity of the vehicle and find the owner of the accident. Nevertheless, traditional license plate recognition methods have several drawbacks, such as the need for human resources, inefficiency, and high costs. Artificial Intelligence (AI) technology has the potential to enhance the accuracy and speed of license plate recognition, thus addressing these issues.

AI is defined as the ability of an intelligent agent to comprehend and learn from data, and subsequently utilize that knowledge to accomplish specific tasks and objectives [1-4]. Originated in 1943, after decades of development, AI has played an important role in today's scientific field and life. The last decade has seen a booming development of AI technology, due to the high-speed development and application of several information technology such as network, deep learning and big data. In 2012, the AlexNet neural network model designed by Alex et al. won the ImageNet competition, the first time in history that a model performed so well on the ImageNet dataset and

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ignited the enthusiasm for neural network research [5]. In 2015, to commemorate the 60th anniversary of the concept of artificial intelligence, the three giants of deep learning, LeCun, Bengio and Hinton (who jointly won the Turing Award in 2018), launched a joint review of deep learning [6].

There are already practical examples of license plate recognition. For instance, Fan et al. adapted the YOLO network for the recognition multi-directional license plates [7]. The Simplified steps are: Input image, License plate recognition, Rectification, License plate character recognition. After applying YOLO network to recognition, it works much more effectively. Lee et al. proposed a method for address the denoising and rectification problems, which means dealing with blurred license plate images. In traditional license plate recognition methods, solving the above problems is of high difficulty. They overcome those obstacles by designing a novel network, with which they can divide the image into small pieces and make it clearer and easier to recognize after special processing. As existing such methods almost only recognize the single-line LP taken from a frontal and horizontal angle. Xu et al. proposed a novel end to-end irregular license plate recognition (EILPR) to detect and recognize the LP of multi-line text or arbitrary shooting angles [8].

Due to the high importance of AI technology used in license plate recognition, it is necessary to make a review of this theme. The rest of the article is shown below, the second part is summary of the methods, the third part is the application and discussion, and the fourth part is conclusion.

2. Methods

2.1. Overview of the method

The current approaches to license plate recognition (LPR) can be broadly categorized into multiple types including one-stage LPR, two-stage LPR, Single Shot Multibox Detector (SSD) method, and Sequential Method [3]. The Sequential Method relies on sequential models to recognize the characters, while the Segmentation-based Method views LPR as a semantic segmentation task that produces recognition results through pixels instead of semantic tags. This paper provides a comprehensive review of various popular and effective LPR models, including concrete methods and examples, to demonstrate the state-of-the-art techniques in this field.

2.2. Models

2.2.1. Two-stage method

Early license plate recognition algorithms involved a two-stage process, with the initial stage consisting of character segmentation followed by character classification: character segmentation often used different manual algorithms combined projection, joining, and contours based on image components [8]. However, the quality of character segmentation was often adversely impacted by various factors such as input image noise, low resolution, blurring, or distortion, since binary images or intermediate representations were used as inputs. The second stage involved character classification through the use of optical character recognition (OCR) techniques, which is a critical part of recognition of license plates.

2.2.2. RT-LPDRnet

RT-LPDRnet, is a newly proposed method which uses network [7]. This deep learning method described relies on the integration of YOLO v5, Feature Pyramid Network (FPN), and Path Aggregation Network (PAN) techniques. The authors employed the FPN bottom as input to the license plate recognition module, which is sensitive to semantic information, while the PAN top served as input to the license plate detection module, which is sensitive to positional information. The authors tailored the function Map of the license plate area using information obtained from the detection module, including bbox and the four corners. The authors also used a sequence-to-sequence license plate recognition method and a connectionist temporal classification (CTC) loss function in their

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approach. The training process involved data enhancement methods such as flipping and scaling to optimize the performance of the modules.

2.2.3. Holistic position attention

In the special methods that the authors propose, a location network is used to produce an overall location attention map, each representing the position information of a character in the license plate [9]. Additionally, Semantic networks are used to produce semantic features, and location networks are used to generate location attention maps. The authors adopt an off-the-shelf network for common feature extraction and for implementing.

2.2.4. Automatic perspective alignment

The authors proposed a novel End-to-end Irregular License Plate Recognition (EILPR) to work out the detection and recognition of LP of multiline text or arbitrary shooting angles [10]. The special part of this method is that it combines LP detection and recognition into an overall structure, which is much more different from the traditional Two-stage method.

The proposed EILPR method includes three modules: LP detection network, APAN and 2D attention-based recognition network. The first module contains carrying out detection of plate bounding box and classification of plate. The second module APAN, which means Automatic Perspective Alignment Network, contains a key part where perspective transformation and mesh sampling is performed to calculate a fine LP feature map for recognition.

3. Evaluation metrics

3.1. Recognition rate

In practical applications, the recognition of license plates is crucial in various weather conditions, such as rain and snow, which can cause occlusion, tilting, distortion, and defacement of license plates. Additionally, the recognition algorithm must also support various license plate types and function accurately during both day and night time. The authors of this study have achieved an overall recognition rate exceeding 99%, demonstrating the algorithm's effectiveness and utility in practical scenarios.

3.2. Recognition speed

The recognition speed is a critical metric which shows if the license plate recognition system can meet the need for real-time recognition. For example, in the parking lot entrance management application, if the recognition speed is too slow, the entrance and exit can’t automatically lift and release the vehicle in time, which will seriously affect the normal passage of the vehicle.

3.3. Memory usage

The execution of an algorithm can consume a significant amount of memory resources. However, excessive memory usage may negatively impact other systems' normal operation or slow down the overall system's running speed. Therefore, minimizing the memory footprint of an algorithm is desirable.

4. Application and discussion

4.1. Recognition in the parking lot

The application of license plate recognition system in the exit of parking lots enables the automatic hourly charging of vehicles by capturing their license plate numbers and entry and exit times, in cooperation with the control of the automatic door.

The license plate recognition and charging system carry out authority management and fee management for entering and exiting vehicles. The fixed vehicle is authorized according to the license

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plate number, and once the license plate number expires, it is prohibited from entering and must be re-extended. Temporary cars are charged according to the time of license plate recognition, no expiration date judgment, automatic entry after entering the venue to identify the license plate, and charging according to the entry and exit time after exiting the field recognition of the license plate.

In comparison to the conventional parking lot card entry approach, the utilization of license plate recognition technology eliminates the need for parking and window access, resulting in superior B-end user experience. Additionally, the deployment of such technology reduces the costs associated with loss and consumption of IC cards within the parking lot, while also enhancing the traffic efficiency of C-end owners.

4.2. Recognition in the entrances and exits of expressway

This application in expressway makes license plate of the vehicle automatically recognized when the vehicle enters the vehicle. The time of driving is stored in the toll collection system, and the vehicle license plate is automatically recognized again when the vehicle is driven to the exit. Then the information is called according to the license plate information, combined with the information recorded at the vehicle entrance and exit to realize the toll management of the expressway. This function can realize automatic billing and effectively prevent cheating and avoid the loss of receivables.

4.3. Recognition in electronic police system

This application in real life is also known as traffic violation detection system, which is usually set at urban intersections. Several traffic violations which can cause serious harm to human life safety and social order are detected and license plate recognition is carried out on illegal vehicles. Then the picture record of illegal acts and license plate recognition results are used as law enforcement evidence for traffic violation punishment.

5. Conclusion

This study presents practical methods for utilizing AI technology, deep learning, and neural networks in license plate recognition systems. Additionally, this study proposes a framework for evaluating the performance of such systems and explores the practical applications of license plate recognition in real-world scenarios. License plate recognition technology has been playing a critical role in the process of urbanization over these years and it has been committed to advancing and applying license plate recognition technology in traffic management, particularly in urban settings. In the future continuous development process, license plate recognition technology will continue to upgrade, continue to play a major role.

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