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Revolutionizing law enforcement: The role of artificial intelligence in license plate recognition

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Abstract. This paper aims to offer a comprehensive review of the current state of the art in artificial intelligence (AI) as applied to license plate recognition. With the rapidly evolving nature of AI technology, deep learning approaches have gained popularity in license plate recognition, as exemplified by the success of AlphaGo. The diversity of AI in license plate recognition is notable, with numerous studies proposing systems that have achieved high accuracy in segmentation and recognition. The process of reading license plates is complex and involves several stages, including image capture, pre-processing, license plate identification, character segmentation, and recognition. Law enforcement widely uses automatic license plate recognition (ALPR) technology for detecting and preventing criminal activities, tracking stolen vehicles, and identifying suspects. Additionally, ALPR technology can monitor travel time on significant roadways, which can provide the Department of Transportation with useful data for efficient traffic management. Overall, this paper highlights the importance of AI in license plate recognition and its potential to revolutionize the field.

Keywords: artificial intelligence, image recognition, license plate recognition.

1. Introduction

License Plate Recognition (LPR), also referred to as Automatic Number Plate Recognition (ANPR), is a computer vision technology that leverages Optical Character Recognition (OCR) to automatically identify and recognize license plate numbers from images or videos captured by cameras. The widespread adoption of LPR systems in recent years can be attributed to their ability to automate the identification of vehicles and their license plates, thereby streamlining traffic monitoring and management processes for various stakeholders, including law enforcement agencies, toll operators, and parking management systems. However, identifying license plates can sometimes be difficult due to a variety of factors, including poor lighting conditions, distance, and the use of new technologies like tinted windows or license plate covers. Additionally, traditional methods of identifying license plates, such as manual inspection or video monitoring, can be time-consuming and error prone. Therefore, it is imperative to explore alternative method to enhance license plate recognition capabilities. In this context, Artificial Intelligence (AI) presents a promising solution. With advances in computer vision and machine learning, AI has the potential to facilitate the recognition of license plates even under challenging conditions. AI-powered license plate recognition systems can quickly and accurately read license plates from a distance, regardless of the lighting or weather conditions that are hard for human eyes to read. The use of AI in license plate recognition has the potential to improve safety and security

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on the roads, reduce traffic congestion, and streamline the process of vehicle registration and inspection. Employing cutting-edge technologies to better identify and track vehicles can foster a more effective and efficient transportation system that caters to the safety and convenience of all road users.

Despite the cold winter and warm spring, the field of artificial intelligence continues to evolve in a broader direction [1]. The increasing availability of data has further bolstered the popularity of deep learning approaches [2], such that computer scientists have developed AlphaGo, which can reach the "holy grail of AI research" [3]. The recognition of license plates is one area where AI has demonstrated notable diversity. Castro et al. proposed an embedded system for fast and accurate license plate segmentation and recognition using a single shot detector (SSD) based system. Their model has been evaluated on the Caltech Cars dataset and achieved a segmentation accuracy of 96.46% and a recognition accuracy of 96.23% [4]. Hendry et al. use You Only Look Once (YOLO)-darknet learning framework. Their license plate detection rate reached 98.22% and reached 78% in recognition accuracy [5]. Tham et al used deep learning and present a light and scalable IoT-based ALPR system [6]. The proposed system is mainly due to the limitation of current hardware processing power, so that the existing license plate recognition algorithm cannot be directly applied in Internet of Things (IOT). For Optical Character Recognition (OCR) of license plates the accuracy was 78.23%, while the authors' proposed system obtained a detection accuracy of 99.02% using Intel Movidius Myriad X [6]. Given the criticality and complexity of this area, this paper aims to conduct a comprehensive review of the current applications of AI in license plate recognition.

The following sections of this paper will delve into the various methodologies used in the integration of AI for license plate recognition. The subsequent section will examine the possible deployment scenarios and the inherent risks and limitations associated with AI-powered license plate recognition. Finally, the concluding section will recapitulate the content and present the concluding remarks deduced from the paper.

2. Method

2.1. Overview

The recognition of license plates is a complex process that encompasses various sequential steps shown in Figure 1. Initially, a picture of the license plate is captured using cameras or sensors located in various areas. The photograph is then pre-processed to enhance its quality and highlight the relevant region of the license plate. The pre-processed picture is then evaluated to identify the location of the license plate. After identifying the license plate region, the characters on the plate must be split, and each segmented character is detected using an Optical Character Recognition (OCR) technique. Following character detection, the identified characters are thread to improve the accuracy of the recognition process and rectify any errors. Ultimately, depending on the detected characters, a decision is taken, which may include validating the license plate against a database, initiating an action such as collecting a charge, or recording data for future use.

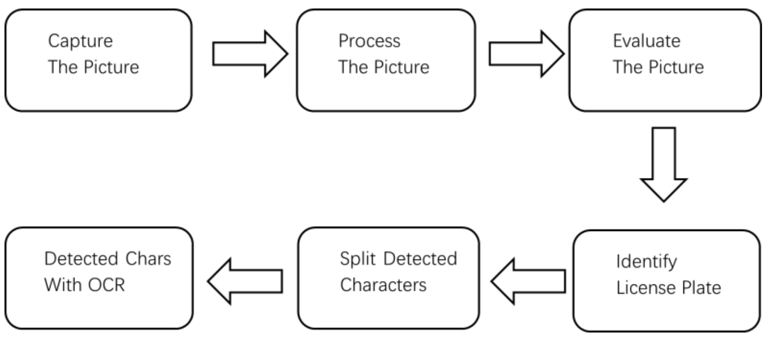

Figure 1. The general procedure of identifying the license plates.

2.2. Deep learning models

2.2.1. Faster RCNN-based method. Faster-RCNN, a deep learning-based object identification system, is used by Khan et al. to recognize vehicles. Faster-RCNN is made up of a region proposal network (RPN) that generates vehicle region ideas and a rapid R-CNN for vehicle identification and classification. The RPN contains foundation points to handle a wide range of vehicle detection circumstances, culminating in 9 anchor points per site. For each region, the RoI pool features are flattened into vectors and fed into two essentially related layers for vehicle/non-vehicle classification and rectangle coordinate prediction. The approach is taught using stochastic gradient descent momentum (SGDM), and the findings show that it beats other deep learning-based object detectors in terms of vehicle identification accuracy [7]. This research contributes to the growing body of work in the field of deep learning-based object detection and recognition, which has gained considerable momentum in recent years due to its potential to automate and enhance various real-world applications.

2.2.2. ALPR-based method. Henry et al. introduced a deep broad Automatic License Plate Recognition (ALPR) system that can reliably detect license plates from different nations. The proposed ALPR system consists of three stages: LP detection, unified character recognition, and international LP layout detection. The LP region is detected using a small YOLOv3 network architecture, and the attention network passes the LP region to the recognition network. To recognize all the characters written on the LP, the researchers utilized YOLOv3-SPP, a modified version of YOLOv3 that can handle multiscale and tiny objects. Moreover, the multinational LP layout identification algorithm relies on image processing techniques and can recover the right sequence of the LP number from multinational LPs by distinguishing between single line and double line LPs. The suggested ALPR system was tested on datasets from various countries, and the experimental results showed a significant improvement in terms of performance and speed compared to prior studies. Furthermore, the layout identification algorithm was assessed on a small sample of LPs from 17 different countries, and the outcomes confirmed the proposed ALPR system's applicability to international LPs [8].

3. Application and discussion

Automatic License Plate Recognition (ALPR) is a powerful tool that is widely applied in many places [9]. The most common use is through law enforcement to aid in investigations and enhance public safety. One of the primary applications of ALPR in law enforcement is in the detection and prevention of criminal activity. ALPR cameras can be strategically placed in high-crime areas, at border crossings, or in areas where specific criminal activities are known to occur. This allows law enforcement to monitor the license plates of vehicles passing through these areas and quickly identify those that are associated with criminal activity. ALPR systems can also be used to identify stolen vehicles or those associated with missing persons, making it easier for law enforcement to locate and recover them. ALPR technology can also be used to track the movements of suspects and persons of interest. Law enforcement agencies can use ALPR cameras to monitor the license plates of vehicles associated with specific individuals or organizations. This can help to identify patterns of activity and movements, allowing law enforcement to develop leads and gather evidence in an investigation [10].

In addition to its use in law enforcement, automatic license plate recognition (ALPR) technology can be applied to monitoring travel time on critical roadways. By installing ALPR cameras at various intervals along a given roadway, travel time information can be gathered and used to improve traffic management. Such information can enable monitoring of traffic flow, identification of congestion hotspots, and real-time implementation of traffic management strategies. For example, if ALPR technology detects a significant increase in travel time along a particular route, the Department of Transportation can make decisions on adjusting traffic signal timings or diverting traffic to alternative routes to alleviate congestion. This application of ALPR technology would be particularly relevant to heavily populated cities such as New York, Los Angeles, and Chicago, where traffic congestion is a pressing issue.

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4. Conclusion

In conclusion, the use of Automated License Plate Recognition (ALPR) systems has proven to be a valuable tool for both law enforcement and traffic management. By leveraging deep learning algorithms, such as the Faster-RCNN and YOLOv3-SPP models, ALPR systems have demonstrated high accuracy rates in license plate detection and recognition, allowing for efficient tracking and identification of vehicles. In law enforcement, ALPR has been utilized for various purposes, including the detection of stolen vehicles, locating wanted criminals, and monitoring the flow of traffic to aid in investigations. Additionally, ALPR has shown the potential in improving traffic management by monitoring travel times on key roadways and identifying congestion hotspots. The development of IoT-based ALPR systems, such as Tham et al.'s proposed system, highlights the potential for future advancements in this field. Overall, the continued evolution and deployment of ALPR systems in smart cities offer significant promise in improving public safety and enhancing transportation infrastructure.

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