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Advantages of Automated License Plate Recognition Technology

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Abstract: Automatic Number Plate Recognition (ANPR) is a technology that can be utilized by mall and movie theater parking management as well as toll booths on roads, expressways, etc. to expedite the toll collection process. Automated systems to retain vehicle information are becoming more and more important as the number of vehicles rises. It is imperative that communication be prioritized in order to effectively manage traffic and reduce crime. Number plate recognition is a dependable technique for automatic vehicle identification. With current algorithms, which are based on the concept of learning, developing adequate outcomes takes a long time and a lot of experience. An innovative use of machine learning is Automatic Number Plate Detection, which recognizes photos and transforms them into text. Using picture segmentation, the system locates, picks up, and extracts the vehicle's image and number plate. Afterwards, optical character recognition technology is used to identify characters in the retrieved image. This technology is used in military zones, apartment buildings, and traffic surveillance.

Keywords: Safety, Plate Number Detection, Machine Learning, Crime Reduction, Traffic Management, Recognition.

Review Paper

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I. INTRODUCTION

There was a notable increase in the quantity of automobiles on the road in the late 1900s. Since the data from license plates is generally used for applications like traffic monitoring, parking management, border monitoring, law enforcement, and other things, it takes a long time to identify license plates because there are so many cars on the road [1]. Systems for automatic number plate recognition (ANPR) are crucial for managing and monitoring traffic. By removing the number plate and reading the plate identity, which is the special identification number assigned to each car, they are able to recognize certain vehicles. Automatic traffic control, computerized toll collection, vehicle tracking and monitoring, border crossing, security, and many other uses are all possible with ANPR systems. Imaging hardware and computer vision algorithms must be combined to create an ANPR system. Algorithms for computer vision include character segmentation, plate orientation and size, normalization, and number plate localization. In addition to this, it includes optical character recognition pattern recognition techniques. Machine learning techniques are used to learn from input data to improve identification accuracy. The ANPR system may encounter a number of issues, including inadequate resolution, dim lighting, unclear inputs, plate occlusion, various text sizes, and various plate structures. In this study, we propose a machine learning-based method for Nepali license plate recognition that can identify a given plate's identity automatically. For many years, the issue of automatic number plate identification has been the subject of extensive research. In many nations, it has also been successfully used in real-world settings. However, there have only been a very small number of research done thus far on Nepali license plates. For character matching, the majority of them are based on basic distance measurements. Again, not enough study has been done on plate localization and segmentation to handle every circumstance [7]. The author claimed that when taking a license plate, there are a number of aspects to take into account, including whether to use hardware sensors or software-based change detection triggers to start the capturing mechanism. A license plate image of the proper size, or one whose pixel count is sufficient to allow alphanumeric characters to be seen in the image, must be included in the captured image. This can be established by the camera's distance from the license plate, the size of the CCD sensor that was used to take the photo, the camera's tilt or pan, and the focal length of the lens. Due to the prevalence of retro-reflective materials used in license plate manufacturing, the author also stressed the

use of infrared sensors and illumination sources to photograph license plates at night. The three steps below are typically used in literature to describe how to recognize license plates: i) identifying and removing the area containing the license plate; ii) segmenting the characters on the license plate; and iii) identifying each alphanumeric character [2]. Du *et al*., summarized the justification and the advantages and disadvantages of using boundary, texture, color, character size, or a hybrid of characteristics for extracting license plates from photos in their review work [3]. They discovered that for character identification and segmentation, the majority of researchers favored pixel connectivity, projection profiles, prior knowledge of characters, character outlines, or a combination of these techniques. They found that character recognition techniques varied widely depending on the underlying algorithms, including template matching, horizontal and vertical projections, the Hotelling transform, changes in foreground and background pixels, the Gabor filter, Kirsch edge detection, contour tracking, contour crossing, and topological features. These traditional techniques concentrate on a particular kind of license plate and the circumstances surrounding its collection. Several additional computer vision issues were also solved utilizing traditional learning techniques and handmade features, much like license plate recognition. Deep neural networks (DNNs), a new type of current neural network, altered this method of problem resolution. The invention of Alex Net in 2012 marked the beginning of the deep learning era and showed a notable improvement in the accuracy of object detection tasks in computer vision systems. Alex Net greatly beat traditional techniques with a 10.8% gain in the ImageNet Large Scale Visual Recognition Challenge (ILSVRC). Due to the disparity in performance, there is a lot of interest in finding and studying various deep-learning architectures for license plate detection and recognition. With training and testing data becoming more complex and difficult, as well as license plate recognition rates increasing and approaching human levels, deep learning algorithms' influence can be seen. Another advantage of DNNs is that a network designed for one data may be used directly on another data without changing the network as the features extracted by the network will be data dependent and hence do not require human intervention. The complete body of literature on license plate recognition methods is large and is mostly based on conventional methods that do not produce the best results [4]. The authors provided a thorough evaluation of these techniques in [2] and [3]. We cover the most cutting-edge techniques for automatic license plate identification in this book. We only discuss neural network-based approaches for recognizing license plates because deep networks have shown a remarkable capacity to surpass conventional machine learning strategies. We highlight the unique network types—convolutional, residual recurrent, or long-short-term memory—used in various earlier publications for the precise tasks of license plate identification, extraction, or recognition. The summarized information also lists some of the most popular data sets for comparison and discusses the findings from the papers under evaluation. We also provide an overview of how fog, motion, and the introduction of fake data affect the ability to recognize license plates. Finally, potential lines of inquiry for this field of study are given [4]. The number plate can be written in non-Roman script and varied typefaces under our suggested method. We employ the OCR (optical character recognition) method to identify characters from a license plate. Character segmentation and character recognition are the two components of OCR. Characters may be extracted from many fonts and non-roman scripts with this OCR technology. OCR accuracy is influenced by the image's quality, contrast, size, and kind of text font. We can employ image processing techniques to improve the image's quality in order to improve OCR [5]. The paper transportation sector uses image recognition technology to extract license plates from complex backgrounds, segment license plate characters, recognize characters, and build a machine learning non-license plate automatic generation algorithm that may increase the effectiveness of non-license plate recognition. The license plate training sample set may successfully accomplish the goal of effectively training strong classifiers due to its diversity and rapid creation rate. The license plate information classification accuracy and anti-interference capability are somewhat enhanced by utilizing a genetic method to optimize the BP neural network [6]. In this study, we outline many use scenarios in the area of automatic number plate identification to investigate the usefulness of synthetic data in industrial contexts. In all situations, synthetic data has the potential to enhance the output of the corresponding deep learning algorithms, greatly reduce the time and work required for data gathering and preprocessing, and completely remove privacy concerns in a sensitive area like automatic number plate recognition [8]. The main goal is to employ and combine various morphological procedures in order to efficiently recognize and translate the license plate of a certain car. This is based on a number of activities, including image enhancement, grayscale conversion, edge detection using bilateral filtering, and extracting the license plate number from the vehicle's photo. Following the completion of the aforementioned procedures, the segmentation method is now being used to locate the text on the license plate using OCR and template matching. This technique can rapidly and reliably identify the license plate number from an image of the car [9]. India has a population of about 1.3 billion people, and every individual there owns at least one vehicle. Given this, it follows that there must be more cars on Indian roadways than there are citizens living there. India is a diverse nation, and this diversity can be seen in the number plates' size, typeface, and other aspects in addition to the language they are written in. States have different definitions of diversity. Although the majority of drivers use English license plates, there is no set legislation regarding how a number plate should look, so some people tend to obtain license plates that

reflect their personal preferences. We developed a technique using Google Tesseract for character recognition and You Only Look Once version 5 (YOLOv5) for number plate detection to combat these issues [10]. A 4-stage ANPR method was proposed by Silva *et al*., [11]. They chose to perform vehicle detection first, as opposed to other ANPR models where license detection is the first stage. No car with a clearly visible license plate is so overlooked. Instead of building a model from scratch for vehicle detection, they chose to leverage an existing model (YOLOv2) based on specific criteria. A CNN called WPOD-NET, which was created to incorporate features from Yolo, SSD, and STN, is used to detect licenses. They developed their own LP characteristics-based YOLO network for character recognition (OCR), which is capable of accurately detecting LP. An ANPR approach with three sections—license plate extraction, character segmentation, and character recognition—was proposed by Shidore and Narote [12]. Various image preprocessing techniques, such as gray scaling, Sobel edge detection, and thresholding, are applied to a picture after it has been captured with a reliable ANPR camera in order to identify potential LPs. Following that, true LP is retrieved from the image using bounding box analysis. Integrating character region enhancement, linked component analysis, and vertical projection analysis are utilized for character segmentation. In character recognition, two steps are involved. Feature extraction and character normalization. 2) Character recognition with a classifier based on SVM. According to [12], the accuracy level for segmentation is 80%, while for recognition it is 79.84%. In order to collect tolls more quickly, Kulkarni *et al*., [13] suggested a 4-stage ANPR model [14], which is a blend of various techniques, specifically for Indian LPs. As in [14], a vehicle detection module is present, but license localization is carried out using a "feature-based number plate localization" that was specifically created for Indian LPs. Inductive sensors are used to capture the rear of the car as a result, and various pre-processing techniques are then applied to the acquired image. They have used a technique known as image slicing for segmentation in which the LP is scanned, sliced so that no white pixels are present, and then copied into a matrix. Statistical feature extraction is used for character recognition. Three parts make up the ANPR system that Kashyup *et al*., [15] suggested. A mixture of image processing methods were used before the number plate was extracted. The region props function is used to segment characters. The process of character recognition involves two steps: feature extraction and template matching for the actual recognition. Finding a small image section known as a template and comparing it to an identical template in the database is the process of "template matching." The technology in question has an accuracy rate of 82.6%. A system comparable to [15] was proposed by Devpriya *et al*., in [16]. The image is pre-processed by converting the RGB image to a grayscale image, followed by morphological operations, number plate detection, and Closing and Opening morphological analysis. Connected component analysis (CCA) is used in this instance to segment the characters [12]. Then, using template matching, each segmented character is identified, just like [17]. All phases of ANPR employ the YOLOv3 model, which is frequently employed for object detection [18]. Every application makes advantage of TensorFlow. Grayscale conversion is performed on the input photos. An annotated dataset is needed for LP detection. They have utilized LabelImg for this assignment to label the data so that the input image has a bounded box around the license plate, aiding in detection. YOLO models are used for character segmentation and recognition. The YOLO model's character recognition accuracy is 99%, compared to OpenCV's 93%. An artificial neural network (ANN)-based ANPR system based on Indian license plates was proposed by Tiwari and Choudhary [19]. Similar to previous ANPR systems, the acquired image is pre-processed using techniques including Gaussian filtering, wavelet transformation, and image binning. Next, the number plate is recovered, followed by character segmentation and character identification utilizing vector generation. An ANPR system with two stages—license plate detection and character recognition—was proposed by Naren Babu *et al*., [13]. For both detecting the license plate and identifying the characters on the license plate, they have trained a 37-class CNN single-YOLO model. Additionally, they were able to recognize the characters on the number plate with a 91% accuracy rate and detect the number plate with 100% accuracy. Machine learning is used in the proposed study to identify Arabic license plate numbers. The vehicle's license plate is photographed, and Arabic numeric characters are found on the plate by character segmentation and image processing. The method extracts the license plate area from the vehicle image after recognizing the license plate number area. The background color of the license plate designates the different types of vehicles: private vehicles have a white background, buses and taxis have a red background, governmental vehicles have a blue background, trucks, tractors, and cranes have a yellow background, temporary licenses have a black background, and the army has a green background. Both machine learning-based training and testing of Arabic number characters as K-nearest neighbors (KNN) and Google Tesseract OCR-based identification are used to identify Arabic digits from license plates. 90 photos from the internet and CCTV footage were retrieved and used to test the system. The suggested system successfully recognizes background color, Arabic number characters, and plate numbers, according to empirical results. The overall success rates of background color identification and plate localization have been calculated. Plate localization, background color detection, and Arabic number detection all have success rates of 97.78% overall, 45.56% in OCR, and 92.22% in KNN [20]. The development of an artificial intelligence system for automatic license plate recognition is the topic of the study. Character extraction is used to achieve excellent

license plate recognition accuracy on wide camera angles. Studying current license plate recognition methods and developing an artificial intelligence system that operates on wide-angle camera angles with the aid of cutting-edge machine learning and deep learning techniques are the problems at hand. Both hardware-based and software-based solutions were investigated and created as part of the project. Different datasets and competing systems were used for testing. Experiments, literature reviews, and case studies for hardware systems are the key research methodologies. The review of contemporary techniques led to the selection of the Mask R-CNN algorithm because of its excellent accuracy. The problem was stated, the possible solutions were identified and described, the primary algorithm was selected, and a mathematical foundation was provided. An accurate automatic license plate system was demonstrated and put into use in various hardware environments as part of the development process. The network was contrasted with current adversarial systems. Recall, precision, and F1-score were some of the different object detecting qualities that were calculated. The obtained results demonstrate that the designed Mask R-CNN algorithm system processes pictures with good accuracy at significant camera shooting angles [21]. The suggested method aims to create a capable automatic authorized vehicle identification system that utilizes the license plate of the vehicle. An infrared (IR) sensor is used to detect number plates, which aids in capturing good images from a camera. The most crucial and challenging task is taking pictures of moving automobiles. Using the R-CNN approach, character segmentation is utilized to extract the area of a vehicle's number plate from an image. Accurate character identification is accomplished using the optical character recognition (OCR) technique. The gathered information is then checked with the databases of the relevant authorities to look into specific information like the owner of the car, the location of the registration, the address, and so forth. Only the gate barricade is opened if the vehicle details match those in the database. This system will take into account road safety measures while minimizing criminal activity. The technology makes an effort to improve number plate detection's effectiveness and accuracy under climatic situations [22].

II. BENEFITS OF USING AN AUTOMATIC LICENSE PLATE RECOGNITION SYSTEM

Because there are so many cars on the road these days, automatic license plate recognition is used for a number of applications. Therefore, before proceeding, it is essential to weigh the advantages of using automatic license plate recognition. Some advantages to think about while purchasing an automatic license plate recognition system are compiled here. Thus, let's get started right now.

1) Additional safety

Deterrence is the primary outcome of the Automatic License Plate Recognition Solution. Usually, the knowledge that their license plate is being photographed and authenticated is enough to prevent criminal action in advance. Another advantage of ALPR is that the police can go through the collected data to find vehicles that may be suspect or that have been utilized in a crime. ALPR data can be used as evidence against a suspect and as a defense because it has to be brief. In addition, ALPR provides basic security by controlling employee parking permits and identifying vehicles that have been previously forbidden from your premises. Examples of this type of security include open workplace parking. An additional degree of security is offered by ALPR for both public and private use.

2) Automated service

Using automated license plate recognition technology to manage parking solutions is both practical and economical. In parking lots, they eliminate the need for parking wardens. They are more productive than most people and are able to provide a more dependable service because they are open around-the-clock and have very accurate readings. Additionally, they provide a non-confrontational parking option that has been helpful in several situations involving driver citations. Parking management teams often find that there is a good working relationship between traffic officers and ALPR, especially in the area of traffic and parking enforcement, where staff may rely on ALPR to provide vital information, decreasing their time on the streets.

3) Real-time advantages

Numerous industries benefit from ALPR because of the real-time imaging it offers. It used to take a while to register license plates and even longer to warn violators of traffic laws of their consequences. However, license plates may be swiftly recognized and cross-referenced with the database thanks to ALPR. After this, a penalty notice could be sent out as soon as 48 hours. Because these cameras are fast, illegal activity may be responded to quickly and undesired behavior can be reported without delay.

4) Greater Safety

Modern technology is used by automatic, customized ALPR systems, which have a 99% accuracy rate in identifying vehicles that are not authorized to be on the site. They therefore surely provide greater security and accuracy than manual examinations, which are prone to human error. ALPR systems provide you peace of mind since they are very good at identifying safety issues, identifying speeding drivers, and helping to correct them before a serious accident occurs.

5) Accurateness

Accuracy is essential in all areas of public safety and law enforcement. Errors can cost time that could be spent serving and protecting the community. The Automatic License Plate Recognition Solution enhances traffic patrolling by eliminating uncertainty. Alternatively, you may make a quick point of reference

to identify any noteworthy cars or drivers. Traffic cops face a never-ending list of challenges on the job. Their ability to accurately detect individuals and cars of interest can be hampered by a number of circumstances, including as the volume of traffic and the time of day. An ALPR system, however, is always able to close the gaps left by the limitations of the human eye.

6) Cost-effective

ALPR technology is not only more cost-effective but also easier to use and more efficient for parking lot management. This is a very innovative way to cut expenses and minimize the need for security guards. Businesses that detect individuals using their ALPR system who shouldn't be on their private property or who have stayed there for an extended period of time may also be subject to sanctions. This can bring in more money for the company and possibly even pay for this safety precaution [23].

CONCLUSION

The goal of the paper is to examine the theoretical foundations and practical challenges of automatic license plate recognition systems using a number of research publications [24]. An explanation is given of the advantages of utilizing an automatic license plate recognition system.

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