Design and analysis of car license plate detection system based on image processing for Iraqi vehicles

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ABSTRACT

Introduction: Due to the massive number of vehicles, especially due to the Industrial Revolution and the growing economy, the recognition of vehicle numbers or licenses has turned into a core technology for detection and monitoring applications. One of the protection methods is the ease of access to car information, especially automatic recognition. Therefore, the need for development in this field continued, and researchers continued to provide innovative methods based on the technological development prevailing in this era. . **Purpose of the study:** At present, license plate recognition technology still needs to improve its accuracy in positioning and very long recognition time, especially in the case of diversity in patterns and languages, where the license plate sometimes consists of letters and numbers from more than one language. In this paper, a software system was used to recognize the license plates of Iraqi cars. **Results:** The image whose information is to be detected is entered, enhanced, and then segmented, and the information is extracted for use. **Practical significance:** Automated Monitoring, Security Applications, Automated Toll Collection, Parking Management, Data Collection and Analysis, Technological Advancements and Real-Time Processing. **Discussion:** The novelty of this paper lies in the application of advanced methodologies that enhance the accuracy and efficiency of license plate recognition systems.

Keywords: Detection, Image Processing, License Plate, Segmentation.

Introduction

Accurately identifying and extracting the alphanumeric characters from vehicle license plates is the aim of a license plate detection system. Numerous applications, such as automated toll collecting, vehicle tracking, and traffic control, depend on this technology. Automatic license plate recognition systems have become integral to traffic management, law enforcement, and many administrative functions worldwide. However, the design and implementation of these systems must consider regional variations in license plate designs, languages , and environmental conditions. In Iraq, license plate designs vary greatly, including different fonts, colors, and arrangements, which poses significant challenges. The quality of captured images greatly affects the performance of the automatic recognition system. [1]. High-resolution cameras with adjustable shutter speed and exposure settings capture clear images of license plates. Cameras are strategically placed to capture images from different angles and in varying lighting conditions. Polarizing filters and infrared illuminators reduce glare and improve visibility in low-light conditions to improve image quality further [2].

Designing a car number detection system requires a set of features that enhance the accuracy and efficiency of the system, such as Visual recognition technology that can read numbers and letters on Iraqi license plates with high accuracy, with the ability to deal with font and color differences—applying image enhancement techniques such as noise removal, contrast enhancement, and lighting adjustment to improve image quality before the text recognition process. Ability to integrate with existing traffic monitoring systems and surveillance cameras to enhance system scope and effectiveness. Supporting Arabic scripts, and ensuring that the system can recognize Arabic letters and numbers used by Iraqi license plates. Requires an efficient system design to ensure a rapid response time, enabling it to be used in real-time in security surveillance systems [3]. Attention must be given to security to ensure that the system protects user data and respects privacy by implementing appropriate security protocols. It must also be ensured that the system can run on various devices, including desktop computers, mobile devices, and cloud servers. By focusing on these features, an integrated and effective system can be developed to detect Iraqi car numbers, enhancing security and public order [4-6]. Critical algorithms are used to accomplish tasks. Different algorithms, such as artificial intelligence algorithms and others, are spreading due to their advantages in improving the performance of advanced systems in the civil and military fields, especially communications, data processing, and image processing. Sometimes, the complexity aspect is considered, so relatively simple algorithms are built that simultaneously perform what is required [7-9].

Literature survey

Given the importance of vehicle number detection operations, several researchers have presented ideas and methods for extracting vehicle number information. The most prominent of these will be discussed as follows:

Zied Selmia et 2020 present a detection system of complex scenes for License plate-based mask region convolutional neural networks. The accuracy provided an approach of 97.9 % when applied to images for different environments [10]. Andre P. Calitz et al. Presenting the vehicle tracking system included real-time license plate recognition using different techniques and experimenting with different camera angles, with a success rate of 96% [11]. Nur-A-Alam

et al. 2021 present a system for detecting and recognizing car license plates using a convolutional neural network. The system consists of two stages, the first stage is to detect the license plate, and in the second stage, the license plate information is recognized by enhancing the image and increasing the accuracy by applying the super resolution method. The accuracy of the system arrives at 98% [12]. Nur Liyana Yaacob et al. in 2021 A system that aims to automatically recognize vehicle license plates at a campus gate to enable smooth traffic flow during peak hours where an image processing system is presented that works with access cards and gate remotes. Accuracy of plate recognition is 91.58% [13]. Hongru Chen et al. 2022 A convolutional neural network is used in a license plate recognition system. The system involves coarse identification, precise plate location, and character recognition. The system involves image recall for adaptive deconvolution processing, followed by Connected Component Analysis, linear fitting, and left-right regression. It is fed into a convolutional neural network for character recognition. The accuracy of this system arrives at 94% [14]. Khaled Hefnawy et al. in 2024, A license plate detection system is presented that addresses the problem of extreme tilt angle. The system includes three stages: plate detection and segmentation using a masked R-CNN model, plate perspective correction to obtain a clear and rectangular image of each plate, and vehicle number recognition using a Bidirectional Long Short-Term Memory framework model. The system was tested at Zewail City of Science and Technology and achieved an accuracy of 97% [15].

Number plate detection

Car number recognition systems have spread widely in traffic applications such as smart parking, toll, and security systems. Examples of Iraqi License Plate presented in Figure (1). In Iraq, there are many types of license plates; the basic types are: the first type issued after 2012 shown in Fig (1.A). The second type is that used in Kurdistan province shown in Fig (1.B). The third type is for government cars shown in Fig (1.C), while the fourth type will be standardized for all cars in the near future in Iraq shown in Fig (1.D). In recent years, license plate recognition has played a crucial role in developing smart cities as a monitoring system for vehicle management, stolen vehicle investigation, and traffic monitoring. Despite the success of number plate recognition applications, they face many challenges, such as traffic congestion, multiple plates, ambiguous signs and advertisements, tilted signs, in addition to blurry photos taken in bad weather conditions. And the night. These differences lead to false positives on plate detection and poor license plate recognition accuracy [3, 16].

With the increasing need for vehicle monitoring systems using license plate detection, the demand for vehicle image processing for traffic management has become a research field with many challenges. This is usually accomplished manually by a human assigned to this task or by automatic systems capable of recognizing vehicle number plates. There are many application areas where number plate identification can be used, which include vehicle parking, border control for military applications, tax control, or vehicle tracking. In vehicle parking, number plate recognition systems are used to count vehicles and how long they have been parked there. Vehicle numbers are saved in databases upon entry and identified upon departure. A new set of license plate images is created and matched with the databases, and the time difference is calculated to calculate parking fees. Other application number plate identification systems can

also be used for access control. Access control means allowing only authorized vehicles for individual employees. The application can be considered as follows: Tracking a vehicle's number plate for traffic monitoring is important [17].

(A) (B) (C) (D)

Fig. 1. Samples of Iraqi License Plate

The license plate recognition system uses image processing to identify automobile license plates. This technique is used in several applications relating to traffic and security. Currently, on-road and on-track license plate detection and identification systems are available. It is commonly utilized for driveway applications in parking lots and at space entrances. Many employ sensors to ensure the automobile stops at the proper spot before snapping a picture, then detect the license plate in the pre-arranged region. The plate will only be recognized if the car is positioned appropriately. Its primary flaw is this technology's ability to detect and scan a driver's license automatically. The system's efficiency is measured by calculating the Accuracy as in Eq. (1) [18].

$$\text{Accuracy} = (TP+TN) / (TP+TN+FP+FN) \quad (1)$$

Where: TP: True positive (correctly identified). TN: True negative (correctly rejected). FP: False positive (incorrectly identified). FN: False negative (incorrectly rejected).

One of these methods, image processing, deals with pictures and video clips captured from moving vehicles [19]. The license plate number is one characteristic that may be used to identify every car. Applications for a license plate recognition system include toll collecting, parking management, surveillance, traffic law enforcement, security control of restricted areas, and surveillance. The primary disadvantage of manual methods is reading inaccuracy caused by fatigue, even if human observation appears to be the simplest method for reading automobile license plates. This is the primary driving force for research into automatic license plate recognition. Severe imaging circumstances, including high/low illumination, complicated backgrounds, broken or filthy plates, and various distances and angles from which the automobile is scanned, must all be handled by a suitable system for this use. Character segmentation, character recognition, and license plate detection are the three primary components of a license plate recognition system. The first phase, license plate detection, is the most important of these processes because of the variety of data included in automobile photos. We give a quick overview of the key works in this field [20].

System design

In this section, the working principle of the proposed method will be explained, and its flowchart is presented in Figure (2) and the system parameters shown in Table (1).

After taking the image in the first stage, the image enhancement represents the second stage. The image is resized with a fixed resolution and then converted to gray form.

The third stage is the detection stage, which contains a set of operations to make the license plate image appear prominent. It includes noise removal, intensity enhancement, filling the holes, increasing the brightness, and making edges sharper.

The fourth stage is the Histogram value; the row and column histogram represent the sum of different values between neighboring pixels of the license plate image. The horizontal histogram is calculated by moving between the columns of the image, where the difference is calculated. It is added to the total sum of the differences if it exceeds a certain threshold. The next step is to calculate the vertical histogram, which is done by moving between the rows of the image and calculating the difference. In order to prevent loss of information during the calculation of the histogram, it is used low pass digital filter and assigns its threshold based average value of a histogram.

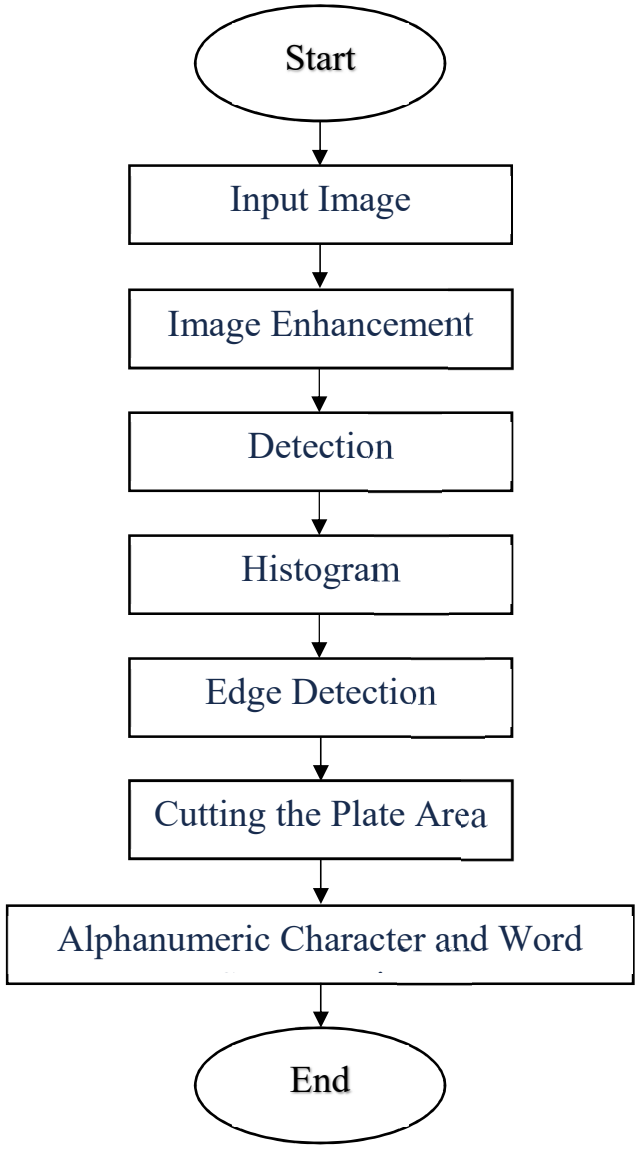

Fig. 2. Flowchart of the proposed system.

The fifth step is the edge detection-based Sobel method; Edges are produced with the highest gradient and represent the optimal edge detection with the lowest error rate. After performing the edge detection, remove the noise from the image, which represents the unwanted small objects such as small dust particles, screws, and nuts, which may lead to false detection. Then, the process of gap-filling is performed.

The sixth step is cutting the Plate Area: At this stage, the license plate area is cut. This stage introduces the segmentation process, which requires high accuracy and uses coordinates.

The seventh and last step is Alphanumeric Character and Word Segmentation. This step is the most complex because it is related to extracting letters, numbers, and words from a license plate, which is influenced by hindering factors such as noise, image contrast, image frame definition, and plate rotation. In order to extract license plate information, the plate is divided into sections based on information such as vehicle numbers, letters, and words. A Hough algorithm and template matching technique detect the numbers and words on a license plate. After this step, the number information will be clear for approval by the competent authority.

Table (1) system parameters

Type	Description
Input image	RGB
car numbers types	Iraqi car numbers
No. of samples	50
Software	MATLAB 2021b
System Output	TXT file

Results and discussion

In this work, the proposed algorithm was applied to 50 different samples of car numbers and gave an accuracy of up to 97% by using MATLAB 2021b. The working principle of the proposed system is to compare with samples of numbers and letters previously stored in the system as in Figure (3). The stages of detecting car numbers are shown below:

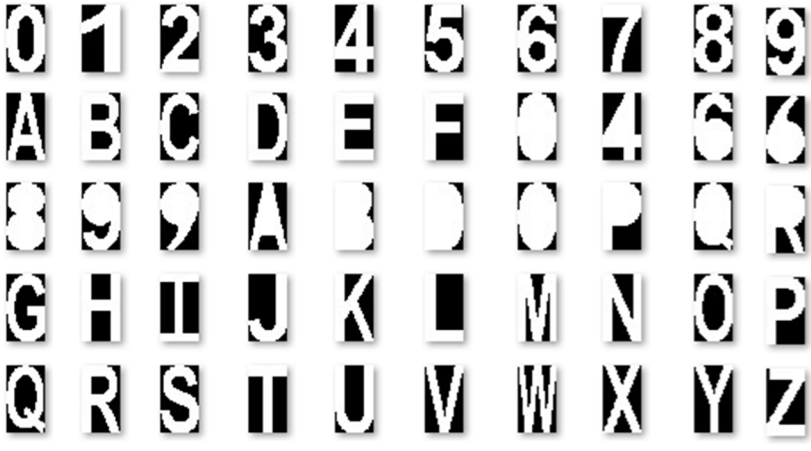

Fig. 3. Stored samples for comparison.

In order to read the license plate information, the image must first be read as in Figure (4). Then, the enhancement, such as resizing, converting to gray, and Applied Median filtering, dilates and erodes, as in Figure (5). In order to prepare the image for segmentation, it is converted into binary form and performed the required enhancement to ensure character isolation present in Figure (6). The final step is Alphanumeric Character and Word Segmentation, which shows the information on the license plate as in Figure (7)

Fig. 4. Input image

Fig. 5. Enhancement image

Fig. 6. Edged image

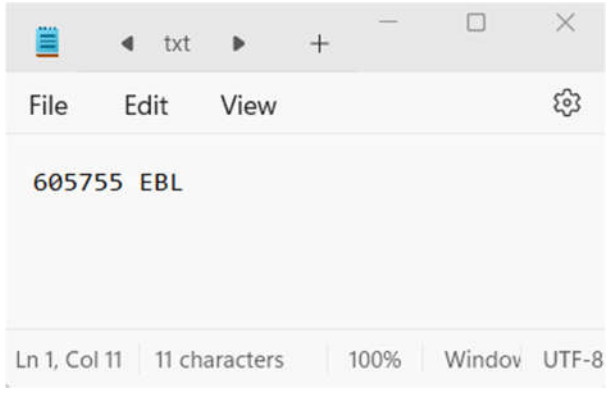

Fig. 7. License plate information

Challenges and Considerations

Environmental Factors: The system should be robust against variations in lighting, weather conditions, and vehicle speeds.

Plate Variability: Different regions have different license plate designs, which may require the system to adapt to various formats.

Real-Time Processing: The system should be optimized for real-time processing to handle moving vehicles effectively.

Conclusion

Due to the development and huge spread in the field of cars, the need for software systems to control and organize work is increasing. Researchers are continuing to improve different methods to identify car information. Designing a car license plate detection system using soft techniques in image processing involves a combination of image enhancement, edge detection, character segmentation, and optical character recognition. By leveraging advanced algorithms and machine learning models, the system can achieve high accuracy and reliability in various conditions, making it an essential tool for modern traffic management and vehicle monitoring applications.

This research presents an efficient and relatively simple system to detect car number information. This system is characterized by avoiding the complexity found in artificial intelligence algorithms.

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Разработка и анализ системы распознавания номерных знаков автомобилей на основе обработки изображений

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АННОТАЦИЯ

Введение: Из-за огромного количества транспортных средств, особенно из-за промышленной революции и растущей экономики, распознавание номеров транспортных средств или лицензий превратилось в основную технологию для приложений обнаружения и мониторинга. Одним из методов защиты является простота доступа к информации об автомобиле, особенно автоматическое распознавание. Поэтому потребность в развитии в этой области сохранялась, и исследователи продолжали предоставлять инновационные методы, основанные на технологическом развитии, преобладающем в эту эпоху. . **Цель исследования:** В настоящее время технология распознавания номерных знаков все еще нуждается в улучшении точности позиционирования и очень длительного времени распознавания, особенно в случае разнообразия шаблонов и языков, когда номерной знак иногда состоит из букв и цифр из более чем одного языка. В этой статье использовалась программная система для распознавания номерных знаков иракских автомобилей. **Результаты:** Изображение, информация о котором должна быть обнаружена, вводится, улучшается, а затем сегментируется, и

информация извлекается для использования. **Практическая значимость**: Автоматизированный мониторинг, приложения безопасности, автоматизированный сбор платы, управление парковкой, сбор и анализ данных, технологические достижения и обработка в реальном времени. **Обсуждение**: Новизна данной статьи заключается в применении передовых методологий, повышающих точность и эффективность систем распознавания номерных знаков.

Ключевые слова: обнаружение, обработка изображений, номерной знак, сегментация.

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