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RESEARCH ARTICLE

Optical System to Recognize Car Plate Ownership

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Abstract The process development of the image processing can solve the problem of detection and recognition of the license plate by taking pictures of the cars and then recognizing them. Most traffic applications rely on automatic vehicle plate detection in parking lots, border control, speed control, etc. In this study, a smart visual system was presented to identify car plates in the College of Science for Girls - University of Baghdad parking lot. The work included distinguishing the car plate and identifying cars, whether they belonged to the college or not. This process was based on the Cascade Classifier method based on the Viola-Jones algorithm, and a database for all car plate features was stored in a file using the proposed method. The recognized car was compared with the characteristics of the database using Oriented FAST and Rotated BRIEF then features were extracted using Histograms of Oriented Gradients. The license plate is recognized when matching features are employed using the matching feature's function. The results of congruence and discrimination were excellent and very highly efficient. The luminous intensity dependence is considered, as the work is based on the red band of the car's image.

Keywords: Detect Oriented FAST and Rotated BRIEF features, matching features, Extract Histograms of Oriented Gradients features, cascade classifier.

Introduction

Computer vision is a field of computer science, and it aims to build intelligent applications capable of understanding the content of images as humans understand them. Where the image data can take many forms such as scenes of sequential images (video) from several cameras, and data in several dimensions taken from the imaging device [1].

Detecting and distinguishing objects considered one of the basic tasks within the concept of computer vision [2]. It depends on identifying and defining these objects, whether these objects are in the form of images or video sequences [3]. Although these objects in the form of pictures are very different due to different perspectives with different sizes and lighting [4]. Among the applications of computer vision are the recognition of objects or people within an image, automated control (industrial robots, robotic vehicles), building objects or the environment (industrial examination), following an object moving within an image, and third-dimensional detection of a two-dimensional image or more [5].

Many previous studies focused on identifying car plates like: Ghassan Kh. suggested a system to recognize a specific car plate license in Iraq [6]. Image processing algorithms namely segmentation and recognition steps used to identify the letters and numbers within the license plate. They had difficulty recognizing the Arabic letters; therefore, they used a database template. Moreover, the noise was a problem and difficult to avoid. They used 30 images to test the system and the outcome results accuracy was 88%.

In 2019, Amit Kumar Thakur *et al*. presented a method for designing a mechanism for identifying and classifying Brazilian license plates using embedded neural networks [7]. The resulting device uses the

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Tiny YOLOv3 architecture to distinguish license plates in the captured image and to recognize characters using a second grid trained on refined and simulated images using real license plates. Experiments show that during the analysis LPR-SSD achieved a faster convergence rate. The accurate percentage for location and license plate label is 98% but after verification of sequence and character recognition accuracy is 99.1%. They proposed an improvement solution to the Convolutional Neural Network (CNN) method for license plate identification. The license plate pre-treatment standard reached 74.7% accuracy and 94.6%.

In 2020, Nui Din Keraf *et al*. showed a presentation of the development of an automatic vehicle identification system using NP recognition at POLIMAS. The method used to detect the plate number using pre-processing, and combination of Sobel Edge Detection and Laplacian Edge Detection technologies. Bound Box technology used to find NP and recognize characters. NP recognition accuracy was with an average of 87% [8].

In 2021, Imran Al-Shafei *et al*. studied the creation of a robust mechanism for detecting and recognizing the license plates of non-standard and transitional vehicles generally found in developing countries. To improve the character recognition efficiency of paintings drawn and printed with different styles and fonts is using multiple modern technologies including machine learning models. Their proposed method was tested on a large image data set consisting of eight different types of license plates from different provinces in Pakistan. The results showed that the proposed method achieves plate detection accuracy of 97.82% and character recognition accuracy of 96% [9].

This work aims to identify the car owner using the Cascade Classifier technology based on the Viola-Jones algorithm. The project consists of two parts. The first part, prepare a database of approved cars using Cascade Classifier technology. The second part, identify the car plate that gets in the gate by recognizing and detecting the car plate. The suggested algorithm isolates the car plate with green squares and compares it with the database. The features of each section in the image and the features of the database images are revealed using Detect Oriented FAST and Rotated BRIEF features. Then features are extracted from each clip feature and detect image using Histograms of Oriented Gradients feature extraction. Finally, these features are matched for the detected image segment and the database images. The results showed to whom the car belongs (from its owner) using the matching features technology with 100% accuracy.

Materials and Methods

The Viola Jones algorithm is considered because it has an effective method for detecting objects within video frame images in real-time. This algorithm consists of four steps: determine integral data, Haar features, AdaBoost algorithm, and Cascade filter. The integral data used to approach high speed in running time. Haar features are similar to the convolutional masks and have many shapes as shown in Figure 1 [10]. The difference in the sum of the two rectangular features gives the value of these features because they have the same set of data. While the sum that resulted from the three rectangular features located at the center. These data are used as input in the AdaBoost algorithm. The AdaBoost algorithm is a step of machine learning to detect an object within an image [11]. The weighting value of the data converts classification from weak in other methods to support the classification in this method. A Cascade filter is important because it combines all features professionally. The non-interested regions and interested regions recognized after cascading each region depending on high classifiers [12].

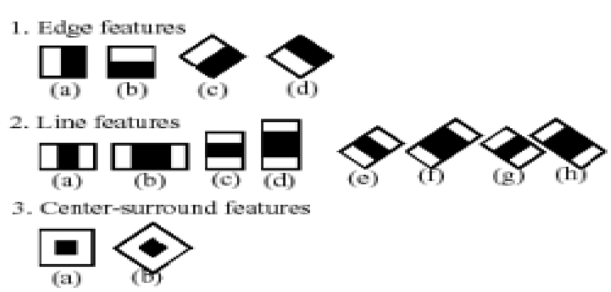

Figure 1. Viola-Jones features [12]

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The edge features are the fundamental Haar's features in different directions. While line and center features are related to the Viola-Jones features which are designed to speed up the output algorithm. All feature size is 24x24 pixels in a standard size to detect objects within an image [13]. The output of Haar's feature resulted from subtracting the sum values in both white and black squares.

$$\text{Pixel new} = \frac{\sum dark\ pixel}{dark\ pixels} - \frac{\sum white\ pixel}{white\ pixles} \quad (1)$$

AdaBoost algorithm carries out Haar's features and classifier training simultaneously, and the meaning of AdaBoost explained by Ada is adaptive and Boost from Boosting. It is considered an iterative process and trains multi-classifiers by the training set to assemble strong classifiers from the weak classifier. This algorithm was used to eliminate unnecessary data and used them as the training set. The threshold value used to know the eigenvalue of the data set if it is a high or low classifier then to choose an appropriate threshold value [14].

2.1 Detecting license plate features

Vehicle plate features detection techniques included the following steps:

- Detection Oriented FAST and Rotated BRIEF (ORB) Features

ORB algorithm is used to quickly get the attribute vectors for points of interest in the image then these attribute vectors are used to identify the objects in the image. It has two parts, the Features Accelerated Segments Test (FAST) algorithm for feature detection, and Binary Robust Independent Elementary Features (BRIEF) algorithm for describing and creating feature-revealing vectors. Oriented FAST and Rotated BRIEF algorithm begins by finding the interested areas in the image that named key points. In general, key points can be thought of as small areas in the image that have distinctive characteristics [15].

- Detection of Objects Using the Orb Detector:

Detecting an object (car plate) in different images resulting to divide the images into two groups.
The first group is training images, while the second group is inquiries images. Compare the essential points in the training image with those in the query image. The pair with the least number of differences is considered the best similarity. At the end of the running matching function, the best matching pair of core points are choos in the previous image [16].

- Extract Features Histograms of Oriented Gradients (HOG)

Feature detection algorithm, first developed by French researcher Dalal CVPR-2005 [17], used to describe the local gradient orientation and gradient intensity distribution characteristics of an image. This feature constitutes the feature represented by calculating the gradient trend histogram for the local area of an image. In an image, the appearance and shape of a local target can be well described by the distribution of the directional intensity of the gradient or edge. Its essence is: the gradient is statistical information, and the gradient is mainly located at the edge. Histograms of Oriented Gradients features extraction consists of several steps like color space normalization, gradient calculation, gradient direction graph, nested block graph normalization, and Histograms of Oriented Gradients features. Histograms of Oriented Gradients algorithms were programmed [18], developed, and designed using Matlab (2021) software, and the algorithm steps are:

Algorithm I: Create database
Input: Video clips
Output: save the license plates detected using the viola jones algorithm and the cascade classifier in a file called database
Start algorithm

- Detect objects using the Viola-Jones algorithm, the cascade object detector uses the Viola-Jones algorithm to detect car's plate, using Matlab function vision. CascadeObjectDetector('plat.xml')
- Load video clip and load positive folder and read frames then make crop for each frame and imresize image According to the distance of the car
- Determine manually threshold and size plat
- Detected plates in the bounding box in the images are extracted and recognized
- Print result for (TARGET or NOTARGET)
- Crop the green box images and choose 10 images contain car plate in the database file by code *imwrite*

End algorithm

Algorithm II: recognize the Owner's license plate-based ORB and Histograms of Oriented Gradients detect features
Input: Video clips
Output: The image that contains the green boxes, the image of each box, the image of the plate and then the images of the match with the database, the image of the plate that has been recognized
Start algorithm

- Detect objects using the Viola-Jones algorithm, the cascade object detector uses the Viola-Jones algorithm to detect car's plate, using Matlab function vision. CascadeObjectDetector('plat.xml')
- Load video clip and load positive folder and read frames
- Determine manually threshold and size plat
- Detected plates in the bounding box in the images are extracted and recognized
- Print result for (TARGET or NOTARGET)
- Select the image that contains the green boxes (nb: no. of green box) and choose a color band (1 red, 2 green, 3 blue, 4 gray). Show image of each green box.
- Call database using function image Datastore where function an *ImageDatastore* object manages a collection of image files, where each individual image fits in memory, but the entire collection of images does not necessarily fit.
- Make both the green box image and the images in the database equal in size.
- Detecting the features of each green box image and revealing the features of the database images using detect Oriented FAST and Rotated BRIEF Features where Detect Oriented FAST and Rotated BRIEF key points and return an Oriented FAST and Rotated BRIEF Points object.
- Extraction the features of each green box image and revealing the features of the database images using extract Features were Extract interest point descriptors
- Match Features between the features of each green box image and revealing the features of the database images using match Features where returns indices of the matching features in the two input feature sets
- Retrieve locations of corresponding points for each image.
- Determine the points of correspondence between the image of each green box and the images of the database.
- Extract features between the image of test plate image and Matching image in the database using extract HOG Features where Extract histogram of oriented gradients (HOG) features, the returned features encode local shape information from regions within an image. You can use this information for many tasks including classification, detection, and tracking.
- Match Features then show Matched Features then determine matching path
- show matching image (car plate)

End algorithm

Results and Discussion

Nikon camera D610 [19] used for filming the cars. This camera has 24.3MP full frame, 6 frames per second continuous shooting, and 2,016-pixel rgb ttl metering sensor.
The car owner was identified using Cascade Classifier technique based on the Viola Jones algorithm. The steps are explained in Algorithm (I) and Algorithm (II). The differentiation process was implemented in two parts.

Create a database of approved videos

The Cascade Classifier technology is based on the Viola-Jones algorithm. Its steps are explained in algorithm (I). Moreover, there are ten clips stored for each video and placed in a file that represents the database. Figure 2 represents the video clips adopted in creating the database, and each video has a unique letter name. Figure 3 represents the database.

Video (B) Video (z) Video (f) Video (m) Video (u) Video (v)

Figure 2. The reference videos for the employed stuff and used for comparison

At the entrance of the park, the car plate was identified and distinguished using the algorithm (I). The detection step implemented by the algorithm (II) after several sections (green squares) appeared in the tested image and they are compared with the database in Figure 2. The features of each clip in the image and the features of the database images are revealed using Detect Oriented FAST and Rotated BRIEF features. The features extracted from each segment of the detected image, and the features are extracted from the database using Histograms of Oriented Gradients features. Finally, features are matched between the detected image and the database. The detection is limited to a specific range of frames observed in the results of this process as shown from Figure 4 to Figure 9, where the car plate is recognized for frames between 100-200. The mx represents the number of points matched with the database.

Figure 3. License plates extracted using Cascade Classifier technique based on Viola Jones Algorithm.

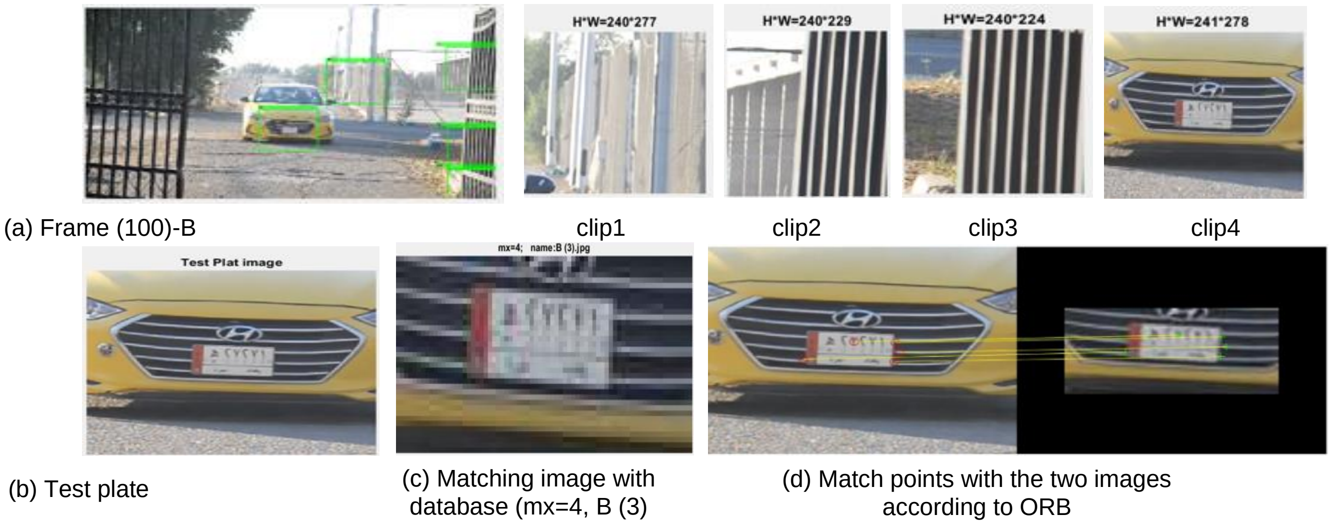
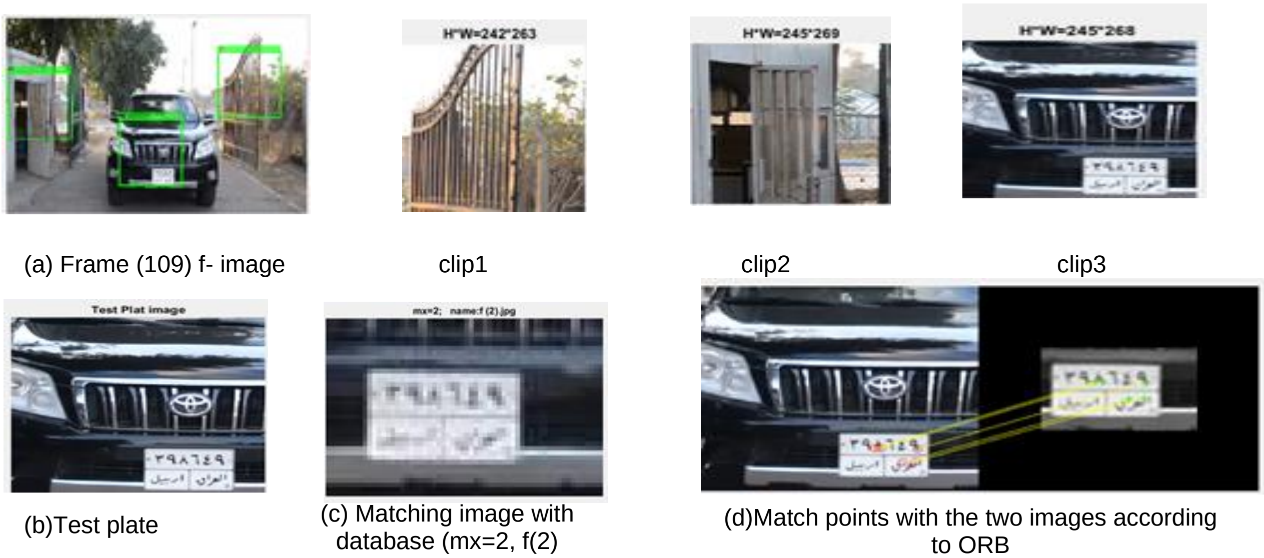


Figure 4. The identification of car license plate for the video (B) (a) cutting 100 frames into a number of clips with specific threshold (b) test image compared with the database (c) the matching image in the data base (d) match points of the features detected using Oriented FAST and Rotated BRIEF.

Also detected frames (125, 175, 200) where the matching points equal to (mx=11, B (8), mx=10, B (2), mx=7, B (6)), respectively. The mx is matching points, and B is matching image with database. Recognizing license plate for video (z) in the frame (100) was z (1), mx=4, frame (125) z (4) mx=3, frame (150) z (6) mx=3, frame (175) z (4) mx=3.

Figure 5. The identification of car license plate for the video (z) (a) cutting 100 frames into a number of clips with specific threshold (b) test image compared with the database (c) the matching image in the data base (d) match points of the features detected using Oriented FAST and Rotated BRIEF

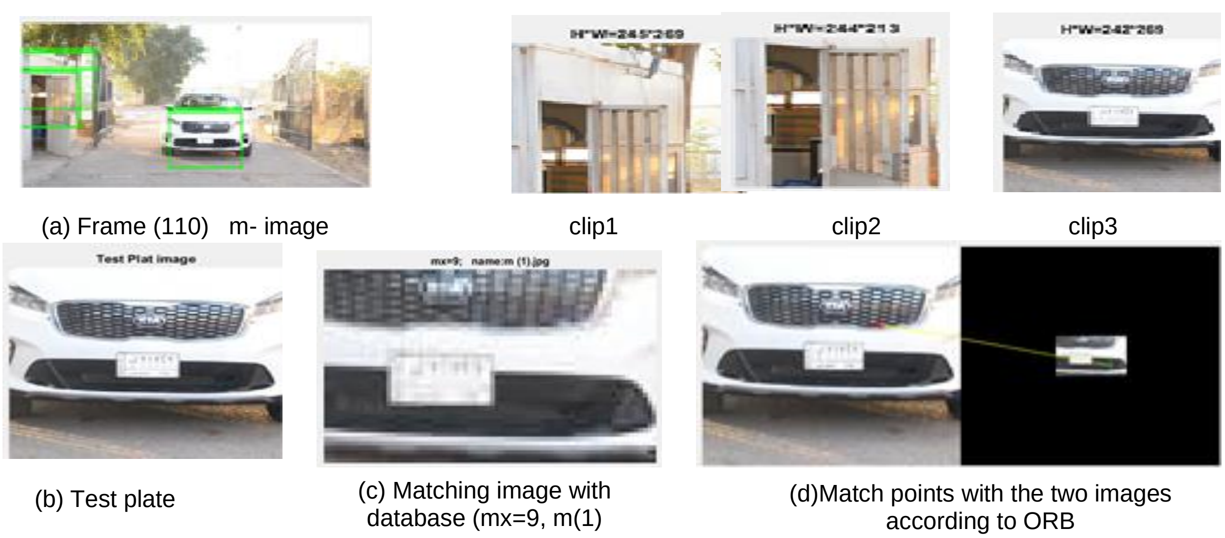


(a) Frame (109) f- image clip1 clip2 clip3

(b)Test plate (c) Matching image with database (mx=2, f(2) (d)Match points with the two images according to ORB

Figure 6. The identification of the car license plate for the video (f) (a) cutting 109 frames into a number of clips with specific threshold (b) test image compared with the database (c) the matching image in the data base (d) match points of the features detected using Oriented FAST and Rotated BRIEF

Recognizing the license plate for video (f) in database was in the frame (109, 116, 118), and mx=2, 3, 5 matching with image (f=2, 6, 6), respectively.



(a) Frame (110) m- image clip1 clip2 clip3

(b) Test plate (c) Matching image with database (mx=9, m(1) (d)Match points with the two images according to ORB

Figure 7. The identification of the car license plate for the video (m) (a) cutting 110 frames into a number of clips with specific threshold (b) test image compared with the database (c) the matching image in the data base (d) match points of the features detected using Oriented FAST and Rotated BRIEF

Recognizing the license plate for video (m) in database was in the frame (120, 130, 140, 150, 160, 170, 180), and mx=3, 3, 4, 6, 3, 4, 2, matching with image (m=4, 4, 1, 1, 7, 6, 10), respectively.

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(a) Frame (150) u- image clip1 clip2

(b) Test plate (c) Matching image with database (mx=4, u (7) (d) Match points with the two images according to ORB

Figure 8. The identification of the car license plate for the video (u) (a) cutting 150 frames into a number of clips with specific threshold (b) test image compared with the database (c) the matching image in the data base (d) match points of the features detected using ORB

Recognizing the license plate for video (u) in database was in the frame (170, 180, 190, 200), mx=3, 5, 3, 2 matching with image (u=7, 8, 10, 10), respectively.

(a) Frame (116) v- image clip1 clip2

(b) Test plate (c) Matching image with database (mx=2, v (3) (d) Match points with the two images according to ORB

Figure 9. The identification of the car license plate for the video (v) (a) cutting 116 frames into a number of clips with specific threshold (b) test image compared with the database (c) the matching image in the data base (d) match points of the features detected using Oriented FAST and Rotated BRIEF

Recognizing the license plate for video (v) in database was in the frame (128, 130, 131, 132, 138, 139), mx=3, 2, 2, 2, 2, 2 matching with image (v=3, 4, 3, 3, 4, 3), respectively.
Features of Oriented FAST and Rotated BRIEF points extracted for the test images with the database image shown in Table 1 for each video.

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Table 1. Features of Oriented FAST and Rotated BRIEF match points that were extracted using Histograms of Oriented Gradients

Features	Value video(B)	Value video(z)	Value video(f)	Value video(m)	Value video(u)	Value video(v)
Location	40×2 single	822×2 single	43×2 single	59×2 single	59×2 single	43×2 single
Metric	40×1 single	822×1 single	43×1 single	59×1 single	59×1 single	43×1 single
Count	40	822	43	59	59	43
Scale	40×1 single	822×1 single	43×1 single	59×1 single	59×1 single	43×1 single
Orientation	40×1 single	822×1 single	43×1 single	59×1 single	59×1 single	43×1 single

Our work was compared with previous studies, and the results of the accuracy of the work were as in the Table 2.

Table 2. Other studies compared used detection and recognition with accuracy percentage

No.	Accuracy percentage	Technique
1	Suggested cascade classifier-based viola-jones	The accuracy of Detection100% and an accuracy of character recognition 99.8%.
2	Used deep learning-based method for automatically detecting and identifying the Indian number (Roy, 2020).	The accuracy value increase of more than 95%.
3	using Connected Component Analysis and AdaBoost techniques (CCA) (Soon *et al*., 2012).	detect anomalies in still photos and video sequences with an accuracy of 98 percent and discriminate them with an accuracy of 95 percent.
4	Used a novel Artificial Neural Network technique (ANN) (Putra *et al*., 2015).	The accuracy 78.75 percent.
5	Used technique for developing an embedded neural network-based system for classifying and detecting Brazilian license plate images (CNNs) (Thakur and Kaviti, 2021).	The license plate pretreatment standard reached 74.7% accuracy and 94.6% CN.
6	Used NP recognition to propose the creation of an autonomous vehicle identification system (Keraf *et al*., 2020).	The average NP recognition accuracy is 87 percent.
7	use a variety of cutting-edge technologies, such as machine learning (ML) models(Shafi *et al*., 2021).	The findings revealed that the suggested technique achieves character recognition accuracy of 96% and plate detection accuracy of 97.82%.
8	use Template matching techniques for number plate recognition (Tavallali *et al*., 2017).	the accuracy reaches 80%.
9	used a SVM (Support Vector Machine) classifier with HOG (Histogram of Oriented Gradients) features	character recognition results show that 99% of the digits are successfully recognized, while the letters achieve an recognition rate of 95%.
10	(Yaseen *et al*., 2019).	proposed approach showed an average recognition rate of 85.56% and 88.86% on Iraqi and Malaysian datasets, respectively.

Conclusions

A license plate distinguishing was achieved within this study. The Viola-Jones method is used with the features of the Cascade Classifier, based on the detection of Oriented FAST and Rotated BRIEF features, matching features, and detection of Histograms of Oriented Gradients features. Several cars were examined in the lot of the College of Science for Women - University of Baghdad. The optical system must be at 1 meter or 2-meter height to get optimal results. The suggested system works with different environments like changing weather. The efficiency of the optical system to detect car plate license is 100%. The speed of the car, car plate license color, and car direction did not effect on the results.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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