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Detection and Recognition of Car Plates in Parking Lots at Baghdad University

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Abstract

A simple and smart algorithm was presented to recognize car plates in parking at the College of Science for Women, University of Baghdad, Iraq. The study consists of recording video clips of all cars parked in the selected area. The studied camera heights were1m and 2m, and the video clips were 19 and 30. Images were extracted from the video clip to be used for training data for the cascade method. Haar classification was used to detect license plates after the training step. Viola-jones algorithm was applied to the output of Haar's data for both camera heights (1m and 2m). The accuracy was calculated for all data with different weather conditions and local time recoding. The accuracy is 100% for all data in this study.

Keywords: Haar classifier, Viola-Jones, Adaboosting, cascade, and car plate detection.

الكشف والتعرف على لوحات السيارات في مواقف السيارات في جامعة بغداد

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الخلاصة

تم تقديم خوارزمية بسيطة وذكية للتعرف على لوحات السيارات في ساحة انتظار السيارات في كلية العلوم للبنات، جامعة بغداد، العراق. اشتملت الدراسة على تسجيل مقاطع فيديو لجميع السيارات الواقفة في المنطقة المختارة. يبلغ ارتفاع الكاميرا المدروسة 1 م و 2 م ومقاطع الفيديو 19 و30 مقطع فيديو على التوالي. يتم استخراج الصور من مقطع الفيديو لاستخدامها في بيانات التدريب على طريقة التعاقب. يستخدم تصنيف هار للكشف عن لوحات الترخيص بعد خطوة التدريب. تم تطبيق خوارزمية Viola-jones لإخراج بيانات هار لكل من ارتفاع الكاميرا (1 م و 2 م). تم حساب الدقة لجميع البيانات مع اختلاف الظروف الجوية والتوقيت المحلي. الدقة 100٪ لجميع البيانات في هذه الدراسة.

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1. Introduction

Recently, a significant focus has been on car license plate discovery and recognition technologies [1, 2], which include traffic violations and tolls to accident monitoring, vehicle health checks, traffic monitoring, stolen vehicle detection, gate control, etc. [3]. Due to the variety of conditions and types of license plates, the capacity to automatically detect and recognize plates is one of the essential instruments employed by police department organizations worldwide. Despite common opinion, license plate isolation and classification remain a difficult challenge [4]. The majority of existing options are fundamentally constrained. To extract relevant information from digital photos, digital image processing techniques have been deployed. Recently, computers have been employed to reduce crimes by detecting the captured objects from video frames [5-7].

Cameras are used on the street, specifically in traffic, to reduce the hazards of traffic jams, accidents, and responsibility, but image processing technology only identifies vehicles by their license plates [8]. Each vehicle has a unique license plate, so no external cards, tags, or transmitters must be recognized by a license plate. Car License Plate Recognition (LPR) has vital applications in modern life and is considered one of the regulations in different countries. LPR technique helps achieve the work, saves time, reduces cost, and provides high accuracy. It applies in many resources, such as in private garages and state institutions' control systems, providing security men's information, or searching for stolen cars[9].

Many previous studies focused on identifying and detecting car plates, whereas Syed Z. M. *et al*. (2017) [10] studied fully detecting and recognizing license plates. They used Convolutional Neural Networks (CNNs) algorithm, and different conditions (e.g., variations in pose, lighting, occlusion, etc.) were considered for long process training to avoid false recognition data. Ghassan Kh. A. (2018) [11] suggested a system recognizing a specific car plate license in Iraq. Image processing algorithms, like segmentation and recognition steps, were used to identify the letters and numbers within the license plate. They had difficulty recognizing the Arabic letters; therefore, a database template was used. The noise was a problem and difficult to avoid. Thirty images were used to test the system, and the accuracy of the results was 88%. Bydaa A. H. *et al*. [12] used Canny edge detection as part of three steps to detect and recognize car license plates. The three steps are localization, segmentation, and character recognition. The edge detection used in care license detection is used in the segmentation step. The suggested system performance was almost 92%. Tae-Gu Kim *et al*. (2021) [13] used closed-circuit television (CCTV) data to recognize car license plates depending on deep learning model training. Unfortunately, this model has a disadvantage with recognition in terms of low resolution and false results with a tilted car license plate. The CCTV images have a low-quality resolution and details. The authors presented a super-resolution generative adversarial network (SRGAN) model and the perspective distortion correction algorithm to overcome these problems. The character recognition algorithm YOLO v2 tested the output accuracy of their work, where the recognition accuracy rate was 8.8%.
Zahid *et al*. [8] presented an Automatic License Plate Detection study; the R-CNN algorithm and robust License Plate Localization Module were used to segment colors in HSV images; the results show an accuracy of 99.1%.

The motivation for this work came from the pandemic COVID-19. According to the World Health Organization protocol, keeping distance and reducing interaction between people is essential, leading to using computerized resources instead of humans to control everything, like online shopping, payment, booking, and parking.

This work used a digital camera to capture the car license plate at two heights (1 and 2 m). The recognition process starts with different distances until the accuracy reaches 100%. The car's rotation (tilted license plate) and various weather conditions and noise are considered within the recognition process. Four algorithms were used, the first algorithm was used to crop the image frame to select the car license plate, the second algorithm was used to label the cropped image, the third algorithm was used for the training data set, and the fourth algorithm was used to detect and recognize plates based on the Viola-Jones algorithm. The accuracy criteria show that the recognition car plate is 100% for both heights. The accuracy depends on the ratio of the detected license plates each second with the total number of license plates in a video clip.

2. Theoretical Concept

Viola-Jones algorithm is considered an effective method to detect objects within video frame images. This method is used in real-time to detect objects. The algorithm consists of four steps: determine integral data, Haar features, AdaBoost algorithm, and Cascade filter. The integral data was used to approach high speed in running time. Haar's features are similar to the convolutional masks, which have many shapes (figure 1) [14]. The difference between the sum of the two rectangular features gives the value of these features because they have the same set of data. At the same time, the sum that resulted from the three rectangular features is located at the center. These data are used as input in the AdaBoost algorithm, a step of machine learning to detect an object within an image [15]. The weighting value of the data converts classification from weak in other methods to strong classification in this method. The Cascade filter is important because it combines all features professionally. The non-interested and attractive regions are recognized after cascading each region depending on strong classifiers [16].

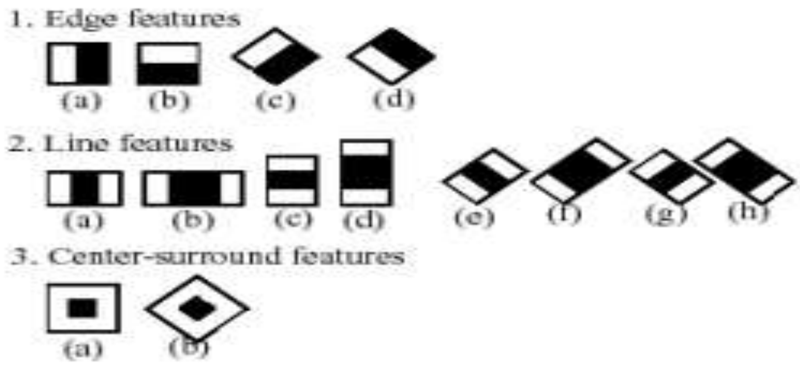

Figure 1: Viola-Jones features [17]

The edge features are the fundamental Haar’s features in different directions, while line and center features are related to the Viola-Jones features, designed to speed up the output algorithm. All feature size is 24x24 pixels in a standard size to detect objects within an image [18]. The output of Haar’s feature resulted from subtracting the sum values in white and black squares [18].

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

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 a training set to assemble a strong classifier from a weak classifier [19]. This algorithm is used to eliminate unnecessary data and used as a training set. The threshold value was used to determine if the data set's eigenvalue is a solid or weak classifier, then to choose an appropriate threshold value [20].

2.1 License plate detection algorithm

This study aims to design a smart system that works with high accuracy to detect license plates in the parking area and in real-time, as shown in figure 2. This work depends on the Viola-Jones algorithm, established by Paul Viola and Michael Jones [21]. The aim of using the Viola-Jones algorithm is to detect objects within the frame image. This algorithm was first used to detect a human face. Nowadays, the algorithm is popular in detecting objects in different applications because it is considered one of the machine learning algorithms. Its employment in the OpenCV library acts as a black box. The study included several algorithms that were programmed and developed using MATLAB (R2020a) language, as follows:

Figure 2: The cartoon shows the suggested method to record the car license plate.

2.1.1 Extracted Area (Algorithm I)

The extracted area of the car plate was distinguished in this algorithm to get the number of the video frames distinguished to calculate the accuracy rate. Cropping steps were used to eliminate unwanted data. This led to a change in the aspect ratio of the frame image.
Input: Video clips
Output: No. of frames cut out for the length of the video

Start algorithm

- *Read the video with the extension (vd.mov) Using the Matlab function (vedioreader) where Read video files.*
- *Calculate the length of the video(lv)*
- *The car is facing the camera when it gets into the park. Therefore, the plate area was selected manually for this study, and it is possible to make it automatically in the future. The cropping process was applied to the video clip to crop all frames using the Matlab function imcrop. These selected areas were studied later in the following algorithms.*
- *Store the divided frames in a particular folder using the instruction imwrite*

End algorithm

2.1.2 Image Label (Algorithm II)

Image labeler was used to label images in computer vision applications. Regions of Interest (ROI) have shape types like rectangular, polyline, pixel, polygon, and scene labels. These labels were used to interactively label data.
Input: The frames were obtained from the application of the algorithm.
Output: A file with the MATLAB extension contains all the input frames and delimits the region of interest.

Start algorithm

- *image datastore for image data where an ImageDatastore object controls a group of image files in which every picture fits in memory; however, the group as a whole does not. Use either the image datastore or datastore functions to build an ImageDatastore object. After the object is formed, you can use dot notation to specify ImageDatastore attributes and utilize methods to read and organize data.*
- **imageLabeler** Label ground truth in a collection of images, whereas imageLabeler Label ground truth in a collection of images.
- Save a file in MATLAB format(plat.mat)

End algorithm

2.1.3 Train Cascade Object Detector Model (Algorithm III)

Create training data for an object detector and Train cascade object detector model.

Input: positive folder contains frames from videos; the Negative folder contains different images and labeling files (plat.mat)

Output: training cascade file in XML format (plat.xml)

Start algorithm

- *Load positive folder and label file(plat.mat)*
- *Create training data for an object detector, using Matlab function objectDetectorTrainingData(gTruth)*
- *Load Negative folder and* Datastore for image data
- *trainCascadeObjectDetector(outputXMLFilename,positivefolder,negativefolder) writ-es a trained cascade detector XML file named, outputXMLFilename. An XML extension must be included in file name. Train a Cascade Object Detector for a more extensive description of how this function works.*
- Save a file in MATLAB format(plat.xml)

End algorithm

2.1.4 Viola-Jones Algorithm (Algorithm IV)

Detecting and recognition plates based on a Viola-Jones algorithm

Input: Video clips

Output: The frames through which the plate was determined and appeared in the form of a green box the size of the car plate (TARGET) or NO TARGET.

Start algorithm

- *Identify vehicles using the Viola-Jones method; the detecting objects detector detects a car's license plate using the Viola-Jones algorithm, using Matlab function vision.CascadeObjectDetector('plat.xml')*
- *Load video clip and load positive folder and read frames then make a crop for each frame and imresize image According to the distance of the car*
- Determine the threshold and the plat size manually because it relates to Viola-Jones method features. The correct value determines the false and accurate detection of the objects.
- Extract and recognize the detected plates in the bounding box in the images.
- Print result for (TARGET or NOTARGET)
- Calculate the accuracy, which equals the ratio between the detected plate's number and the total number of videos multiplied by 100%.

End algorithm

3. Results and Discussion

This study used MATLAB (R2020a 64bit) software to design and develop the proposed algorithms. The proposed system is located in the parking area at the University of Baghdad / College of Science for Women. Nikon camera D610 [22] was used, shown in Figure 3, which has a 24.3MP full-frame, six frames per second continuous shooting, and a 2016 pixel rgb ttl metering sensor.

Figure 3: Camera Nikon used in collecting data[22]

The proposed system is used at different road junctions as follows:

Although the suggested system works with any car plate number, the studied license cares were the new license type. Filming video clips were recorded on three consecutive days in the morning. The camera is fixed at 50 meters from the parking door and has two height setups of 1 m and 2 m fixed on a stand; the data are shown in Figures (4) and (5), respectively.

Clip (1) Clip (2) Clip (3) Clip (4) Clip (5)

Clip (6) Clip (7) Clip (8) Clip (9) Clip (10)

Clip (11) Clip (12) Clip (13) Clip (14) Clip (15)

Clip (16) Clip (17) Clip (18) Clip (19)

Figure 4: Different video films when the camera was at the height of 1 meter.

Figure 5: Different video films when the camera was at the height of 2 meters.

- Crop the video clips into several frames according to the length of the video using algorithm (I).

(a) Positive file (1000 Frame) for each camera height File for each camera height (b) Labelling all frames in positive

Figure 6: (a) positive file at each camera height (1 and 2 m) (b) Cropping and labeling the data

- Then store them in a file (positive File), which has 1000 frames containing the license plates of the video clips captured at each camera height (1 and 2 m). Later, apply the algorithm (II) to make labeling for the frames stored in the positive file and save it in a MATLAB file, as shown in figure (6).
- Training the data according to the algorithm (III), which includes the data of the labeling file that contains all the frames stored within the MATLAB extension for both heights, and uploading a negative file containing 1000 different images to get a file with XML extension.
- Recognize car plates for videos using the algorithm (IV), which includes cutting the video, uploading it, reading all the cut images, making specific cropping, and manually choosing a threshold.

- Determining the license plate (Target) and undetermined it (No Target), as shown in Figure (7) and Figure (8).

Figure 7: Detecting and recognition license plates in the video clips when the height of the camera is (1m)

From Figure (8), the accuracy of the detection process can be seen and it is 100%. Moreover, the recognition of the plate number is prominent.

Figure 8: Detecting and recognition license plates in the video clips when the camera height is (2m).

The detection ratio was calculated for each captured video, representing the ratio between the number of frames in which the license plate was detected and the total number of frames during each second (30 frames/ second), table (1 and 2). The threshold value is related to the Viola-Jones method. It is changing because of the object details like size. It is normal to have more than one value for the same study because the detection depends on the threshold value of the detection.

Table 1: Video clips details at camera height (1m)

No. of video clip	Length of video (lv)	No. of frames each sec	Threshold value	Detection rate	Test detection (True or False)
Clip 1	230	8	17	4/8	T
Clip 2	382	12	17	3/12	T
Clip 3	261	9	17	4/9	T
Clip 4	157	6	17	3/6	T
Clip 5	297	10	17	4/10	T
Clip 6	423	16	17	6/16	T
Clip 7	401	15	17	5/15	T
Clip 8	457	16	17	12/16	T
Clip 9	168	7	17	3/7	T
Clip 10	381	13	17	3/13	T
Clip 11	563	19	17	4/19	T
Clip 12	99	4	17	3/4	T
Clip 13	95	4	17	2/4	T
Clip 14	110	4	15	1/4	T
Clip 15	280	10	17	2/10	T
Clip 16	122	5	17	2/5	T
Clip 17	325	11	15	1/11	T
Clip 18	75	3	15	1/3	T
Clip 19	85	3	3	1/3	T

Table 2: Specifications of the video clips at camera height (2m)

No. of video clip	Length of video (lv)	No. of frames per second	Threshold value	Detection rate	Test detection (True or False)
Clip 1	106	4	30	3/4	T
Clip 2	165	6	30	1/6	T
Clip 3	133	5	30	1/5	T
Clip 4	150	5	30	4/5	T
Clip 5	172	6	30	5/6	T
Clip 6	624	21	30	10/21	T
Clip 7	122	5	30	1/5	T
Clip 8	109	4	30	2/4	T
Clip 9	598	20	30	17/20	T
Clip 10	130	5	30	4/5	T
Clip 11	89	3	30	1/3	T
Clip 12	136	5	30	1/5	T
Clip 13	144	5	30	2/5	T
Clip 14	158	6	30	5/6	T
Clip 15	226	8	30	1/8	T
Clip 16	96	4	30	3/4	T
Clip 17	281	11	30	4/11	T
Clip 18	278	10	30	6/10	T
Clip 19	63	3	30	1/3	T
Clip 20	157	6	30	2/6	T
Clip 21	331	13	30	3/13	T
Clip 22	240	8	30	2/8	T
Clip 23	168	6	30	5/6	T
Clip 24	173	6	30	2/6	T
Clip 25	451	6	30	3/16	T
Clip 26	181	8	30	1/8	T
Clip 27	324	11	30	6/11	T
Clip 28	162	6	30	2/6	T
Clip 29	198	8	30	7/8	T
Clip 30	93	4	30	3/4	T

Table 2 shows the detection percentage for each video at each second. The detection accuracy increase as distance decrease, which means the car is moving toward the camera. The imresize criteria value is changing proportionally with camera height from the ground. In this study, imresize criteria have values of 0.25 and 0.5 for 1 m and 2 m, respectively.

4. Conclusion

The detection of a license plate has been achieved using the Viola-Jones method with Haar features. Many cars checked in the park at the University of Baghdad. The suggested system setup used two heights at 1 m and 2m, and both show the same accuracy of 100%. However, a camera with 1 m height or low height is recommended to have a rectangle uniform shape. The different environments were considered within the study, and the suggested system is still working. It is recommended to check the license plate at a short distance and a perfect camera height. The camera position recommended being placed in the direct direction of the front car so that the detection and discrimination process became very efficient. The suggested system can work with car license plates in different countries with different number types or letters.

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