2022 2nd International Conference on Computing and Machine Intelligence (ICMI) | 978-1-6654-7483-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICMI55296.2022.9873776

Detecting License Plate Number Using OCR Technique and Raspberry Pi 4 With Camera

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Abstract— **In this paper, a system of car license plate number detection and recognition is proposed. The implemented system consists of four main stages: image processing, segmentation, noise removal and deep learning. A Raspberry Pi 4 device-aided python language and camera are used. After image pre-processing and segmentation, the system will detect the License plate from an image of a vehicle using YOLOv4 algorithm and Cascade Classifier with accuracy in YOLOv4 technique is 0.999, in Cascade Classifier with database of Russian numbers is 0.982 and in the Cascade Classifier with Indian numbers is 0.906. Then the characters of license plate have been extracted. The facility of an easy OCR library has been used to convert this picture to text characters. Then, the process of license plate recognition has been implemented step by step, using python, OpenCV, Numpy, and easy OCR libraries.**

Keywords— Raspberry Pi 4, python, YOLO (you only look once), OCR(Optical Character Recognition), CRAFT(Character Region Awareness for Text Detection).

I. INTRODUCTION

In the last few years, we have witnessed a high increase in computer vision applications. The availability of highly complex computational hardware and advanced machine learning and image processing techniques have made it possible to realize many real-time computer vision applications. A commonly used computer vision application is the detection and recognition of license plates [1]. The main object of this system is to detect the license plate from the given image/video frame and then extract and understand the characters from the license plate. These characters can then be saved in a text file or database. Such information can then be used for various applications, such as tracking and surveillance, automatic parking systems, etc.

Every vehicle is identified by using a license number plate specified on it. The objective of a vehicle license plate recognition system is to detect the presence of a license plate on a car in an acceptable amount of time latency and with high accuracy [1]. Generally, there are various steps involved in the development of license detection and recognition. Firstly, some preprocessing steps are conducted to make it more suitable for machine learning algorithms for detection and recognition with high accuracy. The pre-processing step includes processes like resizing images and noise removal by using denoising filters. In addition, the input color images are converted into grayscale images as color information is not much useful for license plate detection or recognition.

Once the preprocessing step is completed, image segmentation is applied. It is a process that will divide a digital image into numerous segments, or groups of pixels, depending on homogeneity criteria like color, intensity, or texture, to be able to locate and identify the required objects and boundaries in the image. In the context of license plate recognition, the image segmentation step is applied to obtain the region of interest, here the region of interest is the license plate. The main idea is to remove the rest of the image background and only keep the license plate which can then be fed into optical character recognition (OCR) system for converting the image characters into textual form. Fig. 1 shows an example of image localization.

Finally, the localized license plate region is fed into OCR for recognition. OCR is based on advanced artificial intelligence approaches, known as machine learning. Machine learning is a branch of computer science that mimics the human brain abilities to learn from data. There are various applications where machine learning is successfully applied, such as object detection [2], character recognition [3], remote sensing [4],[5], medical image processing [6]-[8] etc. includes machine learning (ML) and deep learning (DL). AI mimics the cognitive processes such as learning, applying, and solving complicated problems [9][10].

Various studies has exploited different techniques for license plate recognition. For instance, in paper[11] the system apply to images from many countries using YOLOv3, the system done efficiently with all countries images. The minimum accuracy obtained was 95%, while the best accuracy obtained was 99%. Similarly, the authors in [12] proposed a real-time and robust Chinese ALPR method in natural scenes. It can quickly and accurately detect and identify inclined and twisted LPs. Many comparative experiments were conducted on the challenging data sets they collected

In [13], authors proposed a robust model based for license plate recognition in complex scenarios, which is mainly composed of three modules: license plate feature extraction, license plate character positioning, and character feature extraction. It obtained a very high accuracy of 99.3%, which is evaluated on their benchmark dataset.

The use of a Raspberry Pi for automatic license plate recognition was proposed in [14]. The proposed method employed cameras with mounted on Raspberry Pi for extracting the information using OCR. The camera recorded photographs of license plates. The method employed segmentation followed by recognition for characters. The Raspberry Pi has verified the authentication.

Fig. 1 Example of image localization

In our proposed work, we also integrated Raspberry Pi 4 with AI techniques for automatic license plate detection and recognition. We used specifically YOLO algorithm which represent a deep learning model, and machine learning in CascadeClassifier for detection and recognition purposes.

The rest of the paper is organized as follows. Section II described the summary of the models and techniques used in this study. Section III provides details of the experimental results. Finally, the conclusion section completes the paper.

II. METHODOLOGY

For license plate recognition, various technologies and techniques are integrated. In this section, a compact summary of the components is provided as follows.

A- Hardware Description

In this phase, the extraction of a vehicle's license plate number from an original image will be done the reading of image using Raspberry Pi 4 and a camera of 2592 x 1944 pixels spatial resolution of images. The hardware used in this study is shown in Fig. 2

In any typical image, there are a large amount of redundant information such as background texture, and noise. It is not easy to recognize the number plate of a vehicle, so to solve this problem, an algorithm has been proposed to detect the area of interest inside of the license plate by following the next steps.

B- YOLO Algorithm

YOLOv4 is a deep learning model which has been successfully applied for object detection from input images. This model is used to capture a picture that includes the area of interest, which represent the license plate area [15]. You Only Look Once (YOLO) only needs to process an image once to perform detection a single neural network predicts bounding boxes, and class probabilities can be optimized end-to-end directly on detection performance.

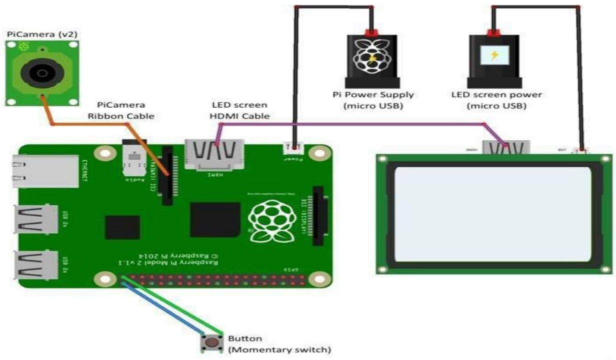

Fig. 2 Raspberry Pi 4 with camera

YOLOv4 algorithm as shown in Fig. 3, is based on the detection of objects in an image or video stream so it can detect any object needed. In this application, YOLO needed to detect only license plate and the other objects are not important in this application, such as car body. So, when YOLO detect the License plate, it can be used to recognize the characters with ease using OCR algorithm.

Dense connection Block: In convolutional neural networks, a block is a module that connects all layers (with matching feature-map sizes) directly to each other

Spatial Pyramid pooling is take an input image and use Conv layers to extract its feature map, then use the max pool of window size 1 to generate a feature set, then use the max pool of window size 2 to generate another feature set, and so on. Repeat this for n times and it have different feature maps in the height and width dimensions, forming a pyramid that help to collect all feature maps that extracted in first step (DenseBlock).

The YOLO algorithm that receive the image then do some image processing to extract feature from images then collect all these object and know what is object that the program need and what object will ignore.

C- Cascade Classifier

Cascade Classifier is an ensemble of multiple weak object classifiers that are positioned in order, with the output of one classifier being transmitted as additional

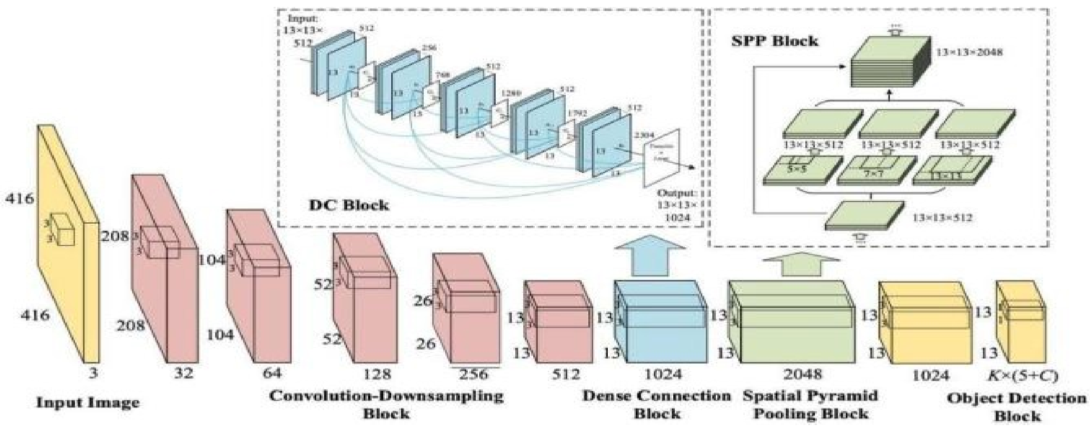

Fig. 3. YOLO algorithm processing stages.

information to the next classifier. This sequential working of the ensemble helps improve the accuracy of the classifier. It actually consists of the Haar Cascade, which is an effective way for face detection. This method was proposed by Paul Viola and Michael Jones [16]. The workflow of the Haar cascade classifier is shown in Fig. 4.

It is a machine learning-based approach where a lot of positive and negative images are used to train the classifier. The positive images contain the images which we want our classifier to identify and the negative images are the ones that contain everything else, in which we are generally not interested. This is also a drawback of this method as it requires samples of the object in which we are not interested. For license plate recognition, the Haar based Cascade Classifier has been used for Russian license plate number detection and recognition [17].

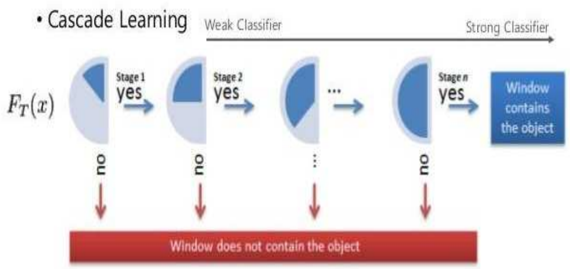

Fig. 4. Working of the Haar Cascade Classifiers

D- Optical Character Recognition

OCR allows us to extract textual information from images. It is highly useful as it can help obtain semantics from a scanned image as well as it can help process the textual information which can be further used for different purposes. There are various OCR engines. Some are open source and some are proprietary. TesseractOCR and EasyOCR are two popular open source OCR engines. In this study, EasyOCR technique has been used to implement the recognition of plate number. Essentially, the original target of OCR is to process document images acquired by desktop scanners, but in this application, it has been used for license plate recognition. The working of the OCR engine is shown in Fig 5.To the fact that the resolutions of scanned images give sufficient resolution, which can be used in car plate recognition efficiently [17],[18].

EasyOCR is a python based OCR library which extracts the text from the image. It's a ready-to-use OCR with 40+ languages. Within its library, EasyOCR does some pre-processing procedures (noise removal, segmentation, gray scaling, and so on) before extracting the text. The CRAFT algorithm is also used to detect the text. CRAFT is a scene text detection system that explores each character and converges amongst them to successfully find text areas. The workflow of EasyOCR engine is shown in Fig. 6.

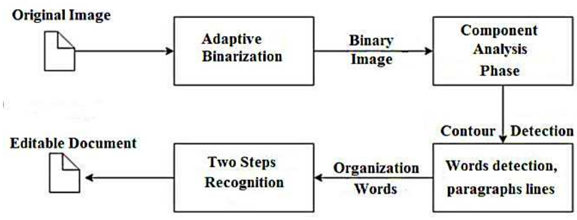

Fig.5 OCR processing structure

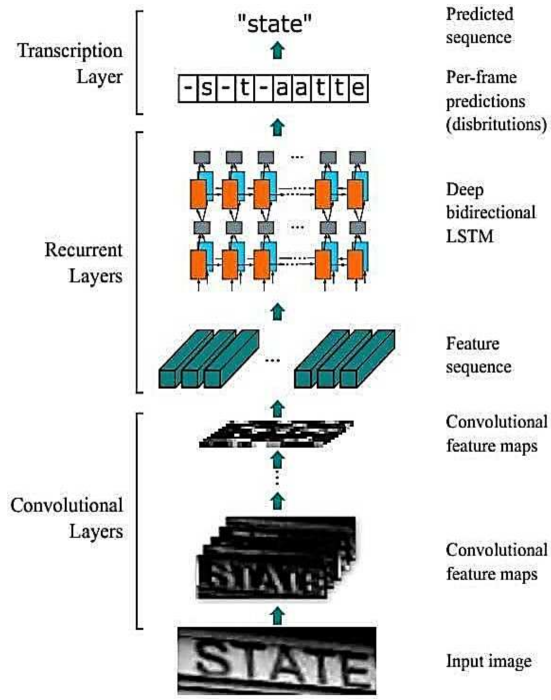

Fig. 6. EasyOCR engine workflow

The main objective of CRAFT is to localize the individual character regions and Connect the characters that were discovered to a text instance [19]. CRNN is used in the recognition model. LSTM and CTC are in charge of sequencing labelling (Connectionist Temporal Classification). The CTC is used to label unsegmented sequence data with RNN in this case.

In the system of EasyOCR library, there are +40 languages (letters and numbers), so the library will measure matching between the input image and the character in memory of library.

III. Experimental Results

To achieve best results in these techniques, Python language has been used and employ their main libraries to deal with digital images or video sequence ,also used hardware using Raspberry Pi4 with a camera module attached. OCR techniques usually used in scanning plane documents, in this application will used to read numbers from digital images that extracted by license plate detection.

The work has been done in [14] of license plate detection and recognition, which is carried by capturing the plate number of the vehicle, whether it is moving or not, using Raspberry Pi zero, OpenCV, and OCR. When YOLOv4 algorithm is applied on the dataset of license numbers from the European union, it is observed that the numbers will be extract correctly, as shown in Fig 7.

In this paper, we also used YOLOv4 algorithm by using images for license plate of Iraqi's cars with near distance between car and camera. shown in Fig 8. The experiments were repeated with distance more than 10m also the detection and recognition done correctly, as shown in Fig 9.

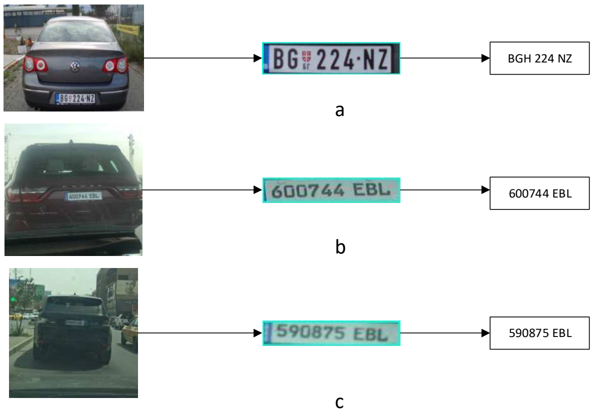

Fig. 7 Some sample results with YOLO algorithm

When CascadeClassifier with (IND) has been applied on same dataset of images ,licence plate extracted has been done correctly, shown Fig 8 and 9 but with distance more than 5m. In such as case the classifier fails to detect the license plate.

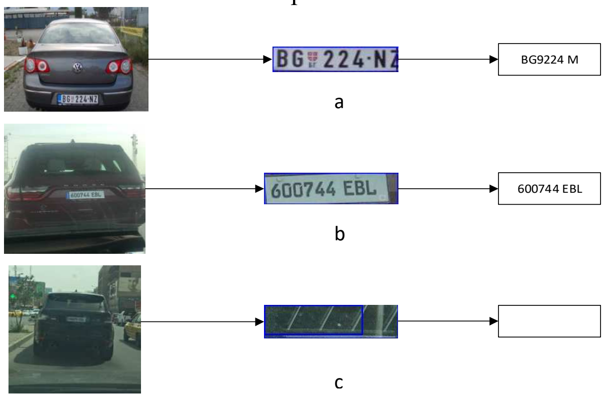

Fig 8. results with IND

When applied HAR Cascade Classifier with RND on same dataset of images has been done successfully, noting that the extracted image from license plate had more area than the license plate that can weak the result of read the number correct as shown in Fig 8

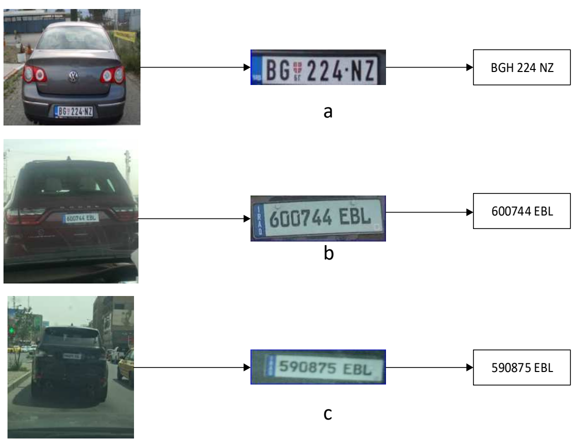

Fig. 9 results with RND

In the setup shown in Fig 10, the Raspberry pi is used in front of the face of car (toward the camera, as seen); the accuracy of finding numbers has measured in different location by changing distance between the camera and car from 1 to 10 meter from a to b. for a_c height of 1-2 meter, the effect of angle β will be neglected for low parallax value.

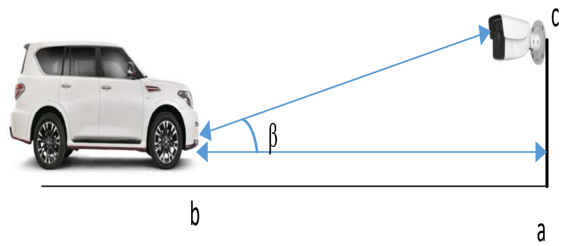

Fig. 9 Raspberry pi Camera setup

The proposed method was evaluated using precision, recall and F1 Score. These metrics are obtained using true positives (TP), true negatives (TN), false positives (FP) and false negative (FN).

$$\text{Precision} = \frac{TP}{TP+FP} \qquad (1)$$

$$\text{Recall} = \frac{TP}{TP+FN} \qquad (2)$$

$$F - \text{Measure} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}} \qquad (3)$$

It means we have 30 images for test, 10 images for each of YOLO, Russian and Indian. Its clear that at the distance under 6 meters, the YOLO4 outperforms the other techniques, at about 30%, but at the distance from 6 to 10 meters, the out performs, although the precision of them by average of 60% as shown in Fig 10 and table I

TABLE I. RESULTS OF ACCURACIES WHEN THE CAMERA ARE DIRECT LOCATION WITH CAR

Distance	Techniques of license plate detection		
	YOLO	***RND***	***IND***
1	0.984	0.719	0.7
2	0.996	0.727	0.732
3	0.973	0.718	0.699
4	0.991	0.711	0.674
5	0.867	0.695	0.645
6	0	0.659	0.654
7	0	0.607	0
8	0	0.6	0
9	0	0.82	0
10	0	0.93	0
Precision	100%	100%	100%
Recall	50%	99%	60%
F1 score	66.6%	99.4%	75%

TABLE II. RESULTS OF ACCURACIES WHEN THE CAMERA DIFFERENT WITH ANGLE 20

Distance	Techniques of license plate detection		
	YOLO	***RND***	***IND***
1	0.999	0	0
2	0.992	0	0
3	0.999	0	0
4	0.999	0	0
5	0.691	0	0
6	0	0	0

Distance	Techniques of license plate detection		
	YOLO	*RND*	*IND*
7	0	0.966	0
8	0	0.832	0
9	0	0.753	0
10	0	0.554	0
Precision	100%	40%	-
Recall	50%	60%	-
F1 score	66%	48%	-

From table above noticed that the IND failed when the camera be not direct with license plate , the RND when close from car can't give a correct result , but when the camera be little far from car it will can detect it, the YOLO have good accuracy but in near distances only.

Taking into account that the specification of Raspberry Pi camera in terms of still images, the camera is capable of 2592 x 1944 pixel static images, and also supports 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 video recording. So, the results greatly improved when choosing a high-quality camera.

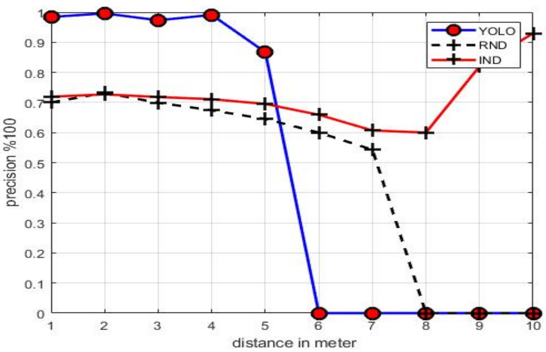

Fig. 10 Precision according to the distance with camera

V. CONCLUSIONS

In this paper, we developed an automatic license plate detection and recognition system. Combining image processing, machine learning and integrating Raspberry Pi can be useful for designing such systems. After detecting the license plate using YOLO algorithm, the license plate was passed to the EasyOCR engine for recognition. The OCR engine was able to recognize letters and numbers present on the license plate. The proposed method produced promising results with 99% accuracy for short distances with Raspberry Pi small camera, compared to other techniques which were not good enough in the same conditions. In the future, we would like to increase the processing speed of the automatic license plate recognition for multiple cars at the same time using parallel implementation of the method using multiple devices.

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