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Development of a Nigeria Vehicle License Plate Detection System

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***Abstract*— The importance of a license plate detection system cannot be overemphasized in intelligent transport systems. A license plate is a major component in most of the applications related to the intelligent transport system. Moreover, it is also a quite popular and active research topic in the field of computer vision and image processing. Different techniques and algorithms have been proposed to detect the license plate number from a vehicle image. Nevertheless, due to the variation in climate conditions, characteristics of the license plate, numbering system, colors, fonts, and size further work is still needed in this field to make the detection and recognition process accurate and very efficient. For these reasons, this paper presents a scheme for license plate detection using current image processing techniques. The developed scheme used images obtained from the Caltech database and our newly acquired Ahmadu Bello University (ABU) dataset. To detect the license plate, the acquired images were pre-processed to reduce the computational requirement of the developed scheme. The canny operation was performed to detect the edge of the pre-processed images then histogram equalization was applied to spread out the contrast of the image. Edged information was used to extract the region which constituted the license plate number and lastly Support Vector Machine (SVM) was used to distinguish the true license plate from other regions. The performance of the developed scheme was evaluated on the Caltech dataset and the ABU dataset. The experimental result shows that our model achieved a better detection rate accuracy than some existing methods.**

Keywords*— *Image processing, license plate, Histogram equalization, Edge detection, Support Vector Machine

I. INTRODUCTION

The role of Automatic licensed plate detection system (ALPDS) cannot be overemphasized in the world today, this is due to the important role it plays in an intelligent transport system with the development of the smart city. ALPDS is applicable in areas like automatic toll collection, access control, and traffic monitoring system.[4] .License plate number detection has attracted good research interest in academic and industrial communities. Although great progress has been made during the past decades. The first automatic licensed plate recognition system was established in 1976 at the police scientific development branch in the UK,[12] then, the functionality of the license plate recognition system was very limited. The initial intention of number plate recognition in Police Force is to prevent unlicensed and auto thefts. Police forces were provided with vehicles mounted with car plate recognition technology. In 2007 United States cooperated with the ALPR into the red light camera network technology to apprehend drivers whose vehicle drove passed the red traffic lights [10]. However, despite many algorithms that have been proposed for license plate detection systems, there are needs to develop more complex algorithms to tackle some challenges associated with license plate detection such as plate variation, size, color, font, occlusion, inclination angle, and environmental variation which includes change in illumination and background, weather conditions, lighting conditions, and even camera conditions may contribute to this problem. License plate detection uses basic image processing tools and computer vision techniques to successfully detect the exact position of a LP from a vehicle image.

II. SIMILAR WORKS DONE

Similar works have been carried out in the area of license plate detection. This review is carried out to understand the extent of research in this area, tools and approaches used. The knowledge gained facilitate this research work by using different tool and approach to get better result. The different system proposed in LP detection are based on different image processing techniques. Some techniques combines one or more approach to achieve a better detection performance while some opt for a machine learning algorithm. The techniques is based on the following edge information, texture base, color information, character based and morphological operations[13]. Although deep learning algorithm have been successful applied to license plate detecting tasks [7] they generally require a large number of training samples, seems there are no large dataset available it is difficult to improve the accuracy by using deep models. Many promising algorithms were proposed to perform similar tastdepite the unavailability of larger dataset[1]. Presented an automatic vehicle license plate detection and classification system using the colour information of the license plate, in their work vehicles were classified into government, commercial or private vehicles based on the colour of the plate. They applied various pre-processing operation such as grayscale conversion, mean filter to remove noise from the acquired images [14] proposed a license plate detection system using feature descriptor based on colour saliency features of the license plate to detect the region of the license plate on the vehicle image. In their work the input colour image is resized and converted to grayscale image. Sobel operator was used to detect the edges of the image and adaptive thresholding is applied to binaries the edge image. Finally, a line density filter which uses the edge information of the license plate was applied to extract the candidates' region.

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To distinguish the candidate region from other regions on the image, geometric attributes of the plate was used. To classify the final license plate region from the other detected regions a cascaded license plate classifier (CLPC) was used to classify the true license plate from the other candidates. [5] proposed a license plate detection algorithm using morphological opening and closing techniques. The method consisted of the following steps, pre-processing, adaptive morphological closing (AMC), local adaptive thresholding (LAT) and adaptive morphological opening (AMO). Histogram equalization is used to enhance the image contrast and AMO operation such as dilation and erosion is applied to disconnect region of weak junctions. The local adaptive thresholding(LAT) is used to segment the image. However, the proposed approach is not suitable for real time applications because of the time-consuming nature of the morphological operations. Other approaches have also been used, which represent a combination of two or more methods, named hybrid approaches.[10] Presented a license plate detection system that is capable of detecting a Bangla number plate using morphological operation and colour information of the license plate. In their work the input image was converted to binary image and then closing operation was used to fill the connected using, contour algorithm and aspect ratio was used to locate the license plate region while opening operation was used to dilate the image based on the structural element.Li and chan trained a cnn based on characters cropped from general text to perform character based LP detection. However, they achiesved a higher recall and precision rate than the previous approach in the expnse of large available datasets.

III. Proposed Method

The proposed experiment will be conducted on Matrix Laboratory (MATLAB) R2018b simulation used for image analysis. The following steps will be considered in carrying out the processes.

A. Algorithm

Step1. Image Acquisition-Capture the image through a digital camera and give it as an input to the process.

Step2. Converting of the Color image to a grayscale image

Step 3. Image Enhancement- Removing of noise using the median filter and equalizing the image contrast

Step 4. Edge detection- canny edge detector was used to find the boundaries that constitute the license plate region

Step 5. License plate localization by appending a fixed bounding box on the detected regions

Step 6. The license plate region is finally extracted based on the pre-defined features

Step 7. Final verification of the true license plates from other candidates.

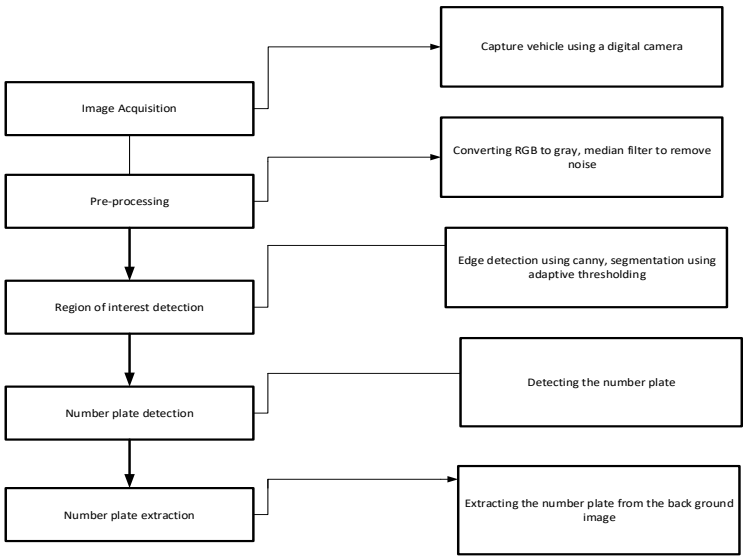

Figure 1: Flowchart of the proposed work

IV. Methodology

In this section, the materials and methods employed for the successful completion of this research are discussed. The methodology adopted for the development of vehicle license detection is also presented.

A. ImageAcquisition

The first stage of the license plate detection system is image acquisition. Images of the rear and front view of the vehicle are captured using a high-resolution digital camera. These images are captured at a resolution of 300 x 1508 pixels with a Nikon D40 camera specification. Other publicly available databases such as the Caltech dataset were also collated and used to evaluate the robustness of the proposed work. The ABU dataset contains 250 images of the front and rear view of the vehicle captured in Ahmadu Bello University and 350 images collated from the Caltech 101 dataset repository [3].

B. Image-preprocessing

To enhance the acquired image certain pre-processing operations are applied to the image thereby improving its quality to enhance the detection performance of the algorithm. These techniques are applied to remove shadows and noise from the image. However, the quality of the image is a major factor that guarantees the efficiency and accuracy of the algorithm [4]. The following pre-processing operations were applied to the image.

- **RGB to grayscale conversion:** Grayscale conversion is used to convert colored images to the grayscale image by calculating the value of the gray level [6].This technique is very important in the license plate detection system because using the original colored image increases the processing time of the algorithm and occupy more space on the system memory. The conversion was done using equation 1:[13]

$$Grayscale = (R \times 0.299 + G \times 0.587 + B \times 0.114) \quad (1)$$

where R, G, and B represent Red, Green, and Blue component respectively.

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- **Noise removal:** Noises in digital images are unwanted signals that cause distraction in the image. Image distortion is the most significant problem in image processing and can be caused by various types of noise such as Gaussian noise, Poisson noise, salt and pepper noise, etc.[2].However, the license plate is associated with salt and pepper noise which was removed using a median filter.

$$f(x,y) = median\{\, g(s,t\,)\} \qquad (2)$$

where f(x,y) is the filtered image g(s,t) represents the noisy image

- **Histogram equalization:** Histogram equalization is an image transformation technique that is used for detail enhancement. This technique computes a histogram of every intensity level in a given image and stretches it to obtain uniformly distributed intensities[7]. The output image will yield the image with uniformly distributed pixels than the original image.

$$s_{k=\frac{l-1}{N}\sum_{I=0}^{\kappa} n_i\, \kappa = 0,1,2,\ldots\ldots\ldots L} - \qquad (3)$$

where s_k is a new value for the transformed pixel. N and n_i are a number of pixels and number of the pixel with value$= i$, respectively.

C. Edge detection

Seems vehicle License plate is characterized by abundant edge information, the edges and boundaries of the license plates can be used to detect the position of the plate in a given image. This edge information was extracted by applying the canny operator. Other widely used operators such as Sobel, Pre with, Robert and laplacians are sensitive to noise. The proposed canny edge detector uses Gaussian function To smoothing or for the convolution of the original image thereby reducing the effect of the noise on the image.

D. Image localization

The main aim of this stage is to identify the exact location of the license plate region in the digital image, the result is a sub-image that contains only the vehicle license number plate. This can be achieved in two steps.

- Determining the exact location of the license plate using the edge information of the plate.
- Locating a large bounding rectangle over the license plate using the size, aspect ratio, and area of the license plate number.

E. Region of interest extraction

The region of interest is the area that constitutes the properties of a license plate, such a region is identified based on the size and shape of the object. A license plate is usually rectangular and mostly of a fixed aspect ratio and sizes, thus the distinct shape is considered when extracting the license plate true region.

F. Support vector machine

If the license plate area is to be found by using only the size and the aspect ratio, it cannot be detected accurately because objects with similar sizes and aspect ratios are detected together. Solve this problem a classification method is used to classify the detected regions. There are various classification algorithms to solve this problem. In this paper, SVM, which is one of the machine learning algorithms, is used to detect the license plate area.

V. Experimental Results

In this section, some experiments are conducted to demonstrate the effectiveness of the proposed model for the detection of the license plate number. All the experiments were performed on a core i7 computer running on Matlab 2018b. The experiments were conducted in two datasets containing 350 images obtained from the Caltech image reprository[3] and 250 vehicle images obtained from Ahmadu Bello University (ABU) dataset. The lack of a limited number of datasets hinders the application of some powerful deep learning models. In our experiment, we collected images of single and multiple vehicles captured under various environmental conditions. Samples images from the two datasets used for the evaluation of the scheme is depicted in Figure 1. The performance of the proposed method was evaluated using detection rate, precision and recall, and accuracy as the performance matrices.

A. Datasets

The images of the vehicle that made up the dataset are depicted in figure 2: these images contain vehicles captured under various environmental conditions, single and multiple vehicles, etc.

(a) Caltech Vehicle image (b) ABU Vehicle image (c) ABU Multiple images

Figure 2:Examples of acquired images from the Caltech and ABU dataset

B. Detection result

The process of license plate detection illustrated in Figure 3:shows the various steps in the license plate detection and the result of the detection rate is given in Table 1 with a comparison of other methods.

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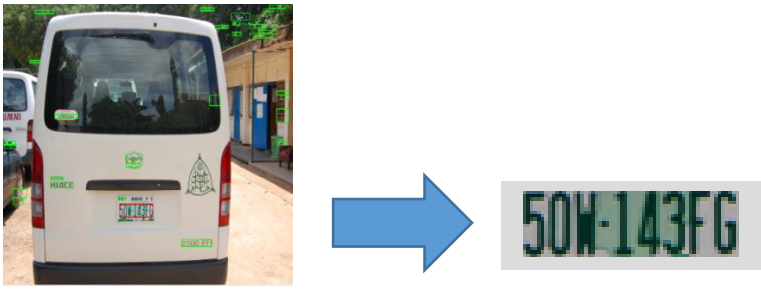
(a) Colored image (b) Grayscale image (C) binary gradient image using Canny Edged detector



(d) Identified region of interest (e) Extracted license plate number

Figure 4: Samples of the images of the Caltech and ABU dataset with the corresponding bounding boxes. The first row shows the detected license plate of the Caltech dataset while second rows show that of the ABU dataset. The green box represents the candidate region while the red box represents the detected region of interest.

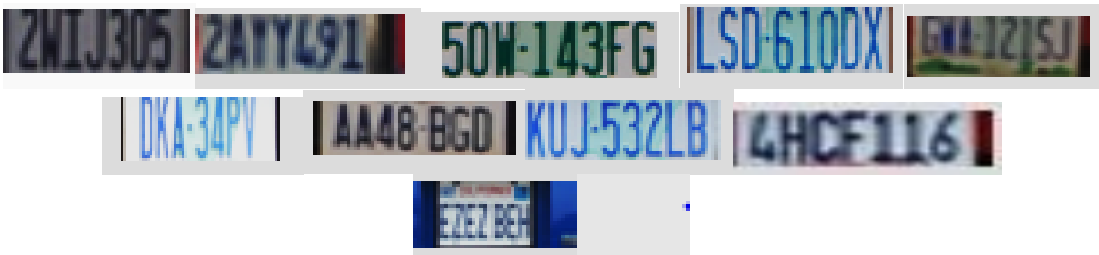


Figure 5: License plate from the two datasets properly extracted

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Table 1:Detection results obtained by the proposed system on the ABU and Caltech dataset

Dataset	DETECTION RATE (%)	EXTRACTION RATE(%)	PRECISION (%)	RECALL (%)
Caltech	98	100	96	92
ABU	96	100	98	97

We note that the algorithm achieved a detection rate of 98% when evaluated on the Caltech dataset and 96% when evaluated on the ABU dataset, likewise the extraction processes achieved 100% in extracting the number plate using both datasets. However, we can conclude that our algorithm performed well during the extraction process. Examples of some failed detection are depicted in figure 6:

Figure 6: Samples of failed detection

The failed detection was as a result of some factors such as the distance between the car and the capturing device, the illumination conditions. However, a fixed distance between the car and the camera would be able to solve this problem.

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VII. CONCLUSION

In this paper, basic image processing and computer vision tools were used to detect and extract the number plate from a given vehicle image. The license plate detection is the most important stage in an automatic license plate recognition system, its accuracy determines the overall performance of the system. Images of vehicles are acquired under various environmental conditions thus detecting the exact location of the license plate becomes a difficult task due to the varying weather, hence limit the functionality of the algorithm. The proposed algorithm consists of four stages: edge detection, candidate extraction, candidate verification using area and aspect ratio of the plate, and final verification method using a classical machine learning algorithm for classification of the license plate regions. The experimental results have demonstrated the effectiveness of the proposed in tackling this problem when a larger amount of data is not available for effective training of the classifier. Our approach is robust when tested on the dataset. However, standard data augmentation methods can be employed in-order to utilize deep learning architecture when there is a limited amount of dataset available.

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