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Development of a Nigeria Vehicle License Plate Detection System

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Abstract: The importance of license plate detection system cannot be overemphasized in intelligent transport systems. License plate is a major component in most of the applications related to 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 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 in order 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 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. Canny operation is performed to detect the edge of the pre-processed images then histogram equalization is applied to spread out the contrast of the image. Edged information is used to extract the region which constituted the license plate number and lastly Support Vector Machine is used to distinguish the true license plate from other regions. The performance of the developed scheme is 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: Edge detection; Histogram equalization; Image processing; License plate; Support vector machine.

1. INTRODUCTION

The role of automatic licensed plate detection system (ALPDS) cannot be over emphasized in the world today. This is due to the important role it plays in intelligent transport system with the development of smart city. ALPDS is applicable in areas like automatic toll collection, access control, and traffic monitoring system [1]. 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 [2]. However, the functionality of a 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 in cooperated the automatic license plate recognition into the red light camera network technology to apprehend drivers whose vehicle drove passed the red traffic lights [3]. 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 license plate from a vehicle image.

2. PREVIOUS WORK

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 tools and approaches to get better result. The different systems proposed in license plate detection are based on different image processing techniques. Some techniques combined one or more approach to achieve a better detection performance while some opt for a machine learning algorithm. The techniques are based on the following edge information, texture base, colour information, character based and morphological operations [4]. Although deep learning algorithm has been successful applied to license plate detecting tasks [5], they generally require a large number of training samples. Since there is no large dataset available it is difficult to improve the accuracy by using deep models.

Many promising algorithms were proposed to perform similar task despite the unavailability of larger dataset. Attah *et al*. [6] 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 operations such as grayscale conversion, mean filter to remove noise from the acquired images. Zhao *et al*. [7] 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 was 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. 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 which is based on Support vector machine was used to classify the true license plate from the other candidates.

Khan *et al*. [8] proposed license number plate recognition system that uses entropy-based feature selection. The developed architecture was built on the foundation of four principles selection of luminance channel from CIELAB colour space, binary segmentation, fusion of histogram of orientation gradient and feature classification using support vector machine (SVM). The system was reported to have 99.5% accuracy. Madhukar *et al*. [9] proposed a multiclass automatic car license plate recognition using SVM and optical character recognition (OCR). Their method adopted SVM for feature selection and identification while OCR was employed for recognition purpose. Fomani and Shahbahrami [10] proposed a license plate detection algorithm using morphological opening and closing techniques. The method consisted of the following steps, pre-processing, adaptive morphological closing, local adaptive thresholding (LAT) and adaptive morphological opening (AMO). Histogram equalization was used to enhance the image contrast and AMO operation such as dilation and erosion was applied to disconnect region of weak junctions. LAT was used to segment the image. However, the proposed approach was 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. A license plate detection system that is capable of detecting a Bangla number plate using morphological operation and color information of the license plate was presented in [11]. 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.

3. PROPOSED METHODOLOGY

The proposed experiment will be conducted using MATLAB R2018b used for image analysis.
The following steps will be considered in carrying out the processes.

Step 1. Image acquisition - Capture the image through digital camera and given as an input to the process.
Step 2. Converting of colour image to gray scale image.
Step 3. Image enhancement - Removing of noise using 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.

3.1 Methodology

In this section, the materials and methods employed for the successful completion of this research are discussed.

3.1.1 Image Acquisition

The first stage of license plate detection system is image acquisition. Images of rear and front view of 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 contain 250 images of front and rear view of vehicle captured in ABU. Figure 1 shows the various images of vehicle captured.

3.1.2 Image Pre-processing

In order to enhance the acquired image certain pre-processing operations are applied to the image thereby improving its quality so as 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 [1].

3.1.3 RGB to Greyscale Conversion

Grayscale conversion is used to convert colored images to the gray scale image by calculating the value of the gray level [12]. This technique is very important in license plate detection system because using the original coloured image increases the processing time of the algorithm and occupy more space on the system memory. Figure 2 shows the original coloured image and its respective grayscale image.

3.1.4 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 [13]. However, license plates are associated with salt and pepper noise, and to eliminate this noise a median filter is required and is given in Equation (1). The resultant of the noisy image and the filtered image is depicted in Figure 3.

$$f(x, y) = media\{g(s, t)\} \tag{1}$$

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

Figure 1. Acquired ABU vehicle image dataset

(a) (b)

Figure 2. (a) Original coloured image; (b) Converted gray image

(a) (b)

Figure 3. (a) Noisy image; (b) Filtered image

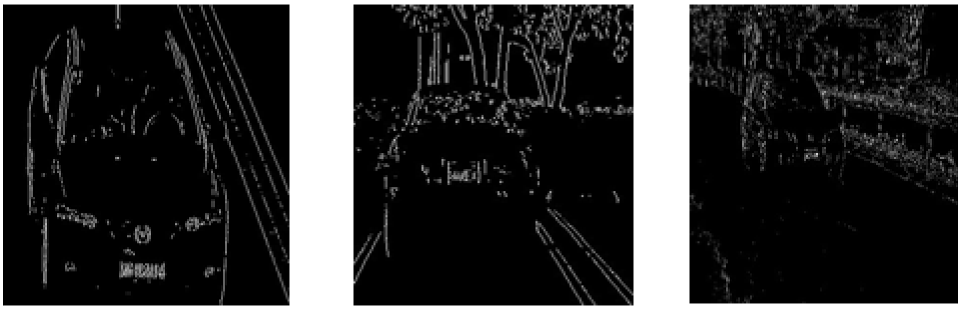

Figure 4. Edge detected image

Figure 5. Vehicle images showing the localized plate number as indicated by the red bounding box, while the green is the other candidate regions.

3.1.5 Edge Detection

Vehicle license plate are 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 canny operator. Other widely used operators includes Sobel, Prewith, 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 there by reducing the effect of the noise on the image. Figure 4 shows the effect of Canny edged detector on the selected vehicle images.

3.1.6 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.

a. Determining the exact location of the license plate using the edge information of the plate.

b. Locating a large bounding rectangle over the license plate using the size, aspect ratio and area of the license plate number. Figure 5 shows some results of image localization.

3.1.7 Region of Interest Extraction

The region of interest is the area that constitute the properties of a license plate, such region is identified based on the size and shape of the object. License plate are usually rectangular and mostly of a fixed aspect ratio and sizes, thus the distinct shape is considered when extracting the license plate true region, from the image in Figure 6. The long rectangular box is most likely the region where the plate number is found as the size, area and aspect region of that region depict that of a license plate. After the region of interest have been identify the license plate is extracted from the vehicle image by considering the basic characteristic of the plate number which includes the area, shape and aspect ratio. Figure 7 depicts the extracted plate number.

Figure 6. Region of interest identified in the image

Figure 7. Extracted license plate

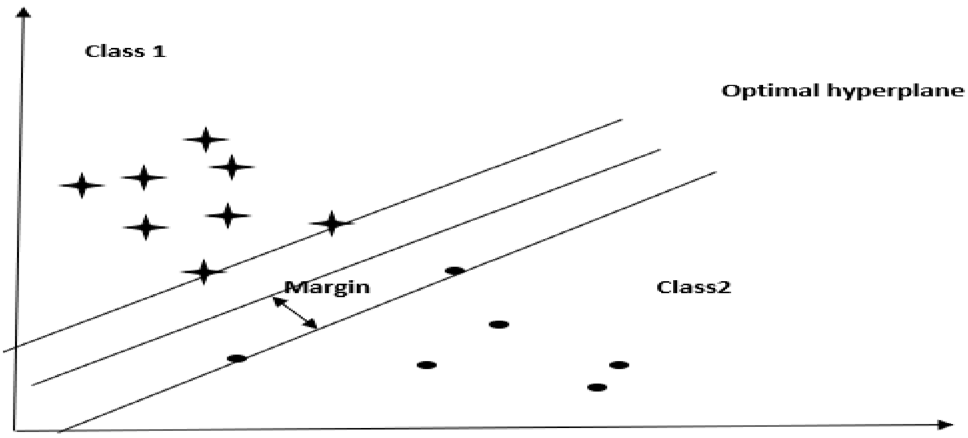

Figure 8. SVM structure

3.1.8 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 ratio are detected together. In order to 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 a machine learning algorithm is used to classify the license plate area. In a given image the support vector first identifies some unique sets of features from the image. These unique features are used to train the support vector machine and then it is tested for the rest of the images. Thus the dataset is divided into training and test dataset in a ratio of 70:30 respectively.

Generally, SVM are binary classifier that classifies a given dataset by computing the hyper plane, that is the decision function of the classifier. In other word, SVM is used to solve classical classification problem by finding the hyper link that separate the two classes or more. In this work, we classified two datasets which is differentiating a license plate image from a non-license plate image. Binary classifier simply classifies two groups based on the decision function. Figure 9 depict the structure of an SVM and how it can be used as a binary classifier to separate two distinct classes of data. From the diagram the two classes are separated by a hyper plane.

4. EXPERIMENTAL RESULTS

In this section, some experiments are conducted to demonstrate the effectiveness of the proposed model for the detection of 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 Caltech image repository [13] and 250 vehicle images obtained from ABU dataset. The lack of 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.

4.1 Datasets

The images of the vehicle that made up the dataset are depicted in Figure 9. These images contain vehicle captured under various environment condition, single and multiple vehicles. Figure 10 illustrates the various steps involved and the detection rate is given in Table 1 with a comparison of other methods.

4.2 Result of the Detection

The matrices used for the evaluation of the developed algorithm includes detection rate, accuracy, precision and recall. However, the following terminology was used to validate the matrices:

(a) Detection rate: This is the total number of license plates that are completely extracted without including any extra pixels of the number plate. It is depicted by the equation below.

$$Detection\ rate = \frac{number\ of\ plate\ correctly\ detected}{number\ of\ ground\ truth}$$

Figure 11 depict the result obtained by SVM classifier, it shows the predicted non license plate and license plate respectively.

(b) Precision and recall can be evaluated using the true positive, true negative and false positive values which are defined and given by

$$Precision = \frac{TP}{TP+FP}\ ;\ Recall = \frac{FN}{TP+FP}$$

where *TP* is the total number of license plates that are correctly recognized, *FP* is the total number of license plates that are incorrectly recognized as a license plate and *FN* is the total number of license plates that was actually a license plate but recognized as a non-license plate.

Table 1. Detection results obtained by the proposed system on the ABU and Caltech datasets

Datasets	Detection rate (%)	Extraction rate (%)	Precision (%)	Recall (%)
Caltech	98	100	96	92
ABU	96	100	98	97

(a) (b) (c)

Figure 9. Examples of acquired images from the Caltech and ABU dataset. (a) Caltech vehicle image; (b) ABU vehicle image; (c) ABU multiple image

Figure 10. Steps for detection. (a) Colored image; (b) Grayscale image; (c) Binary gradient image using Canny; (d) Identified region of interest; (e) Extracted license plate number

Figure 11. Predicted output

Figure 12. Samples of failed detections

It is noted 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 a 100% in extracting the number plate using both datasets. However, we can conclude that the algorithm performed well during the extraction process. Examples of some failed detection is depicted in figure 13. The failed detection was due to some factors such as the distance between the car and the capturing device, and the illumination conditions. However, a fixed distance between the car and the camera would be able to solve this problem.

5. 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, as 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 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 the deep learning architecture when there are limited amount of dataset available.

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REFERENCES

[1] Shan Du, M. Ibrahim, M. Shehata and W. Badawy, Automatic license plate recognition (ALPR): A state-of-the-art review, *IEEE Transactions on Circuits and Systems for Video Technology*, 23(2), 311-325, 2013.

[2] C. Saravanan, Color image to grayscale image conversion, *International Conference on Computer Engineering and Applications (ICCEA 2010)*, 2010, Indonesia, pp. 196–199.

[3] Y. LeCun, Y. Bengio, and G. Hinton, Deep learning, *Nature*, 521(7553), 436-444, 2015.

[4] Y. Yuan, W. Zou, Y. Zhao, X. Wang, X. Hu, and N. Komodakis, A robust and efficient approach to license plate detection, *IEEE Transactions on Image Processing*, 26(3), 1102-1114, 2017.

[5] P. U. Han, W. E. Han, D. Wang, and Y. Zhai, Car license plate feature extraction and recognition based on multistage classifier, *Proceedings of the International Conference on Machine Learning and Cybernetics*, 2003, China, pp. 128–132.

[6] A. B. Attah, A. P. Adedigma and A. M. Aibinu, Development of Nigeria vehicle license plate recognition and classification system, *Journal of Science, Technology, Mathematics and Education*, 12(2), 71-79, 2016.

[7] Y. Zhao, Y. Yuan, S. Bai, K. Liu, and W. Fang, Voting-based license plate location, *IEEE Conference on Intelligent Transportation Systems*, 2011, USA, pp. 314–317.

[8] M. A. Khan, M. Sharif, M. Y. Javed, T. Akram, M. Yasmin and T. Saba, License number plate recognition system using entropy-based features selection approach with SVM, *IET Image Processing*, 12(2), 200-209, 2017.

[9] R. B. Madhukar, S. Gupta and P. Tiwari, Automatic car license plate recognition system using multiclass SVM and OCR, *International Journal of Engineering Trends and Technology*, 30(7), 369-373, 2015.

[10] B. A. Fomani and A. Shahbahrami, License plate detection using adaptive morphological closing and local adaptive thresholding, *International Conference on Pattern Recognition and Image Analysis (IPRIA)*, Iran, 2017, pp. 146–150.

[11] Grayscale Images (Website), http://homepages.inf.ed.ac.uk/rbf/HIPR2, 2003 (Accessed 30.06.2019).

[12] A. K. Boyat and B. K. Joshi, A review paper: noise models in digital image processing, *Signal and Image Processing: An International Journal*, 6(2), 63-75, 2015.

[13] Caltech, Computational Vision (Website), http://www.vision.caltech.edu, 2019 (Accessed 30.06.2019).