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Morphological-based Detection and Extraction Algorithm for Nigeria Vehicle License Number Plate

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Abstract

This paper presents an algorithm for the detection and extraction of the Nigerian vehicle licensed number plate. In this work, images of stationed vehicles with negligible inclination captured with digital cameras of high resolution and shutter speed were used. Morphological based edge detection and blob extraction techniques were used to realize the algorithm. The performance of the algorithm was tested with seventy-three (73) images of both the old and the new Nigerian vehicle licensed number plates, taken under varying conditions, and an overall success rate of 84.9% was achieved.

1.0 Introduction

A vehicle license number plate recognition (VLNPR) system is a mass surveillance system that uses optical character recognition of images to read the license plates number on vehicles [1, 2, 3]. The recognition system employs the use of image processing technique, and it has wide applications in intelligent transportation system [4, 5]. The system is used in various security and traffic applications such as parking and other traffic management systems such as toll management, access, speed and border control, or tracking of stolen cars [1, 4, 6, 7].

A VLNPR system consists of a set of hardware and software components. The system can be realized in three basic modules, which are detection and extraction of the plate number module, character segmentation module, and character recognition module [3, 8]. The software component of the VLNPR system use a series of image manipulation techniques to detect, normalize and enhance the image of the number plate, and then use optical character recognition to extract the characters of the license plate. There are six primary algorithms that the VLNPR software may require to identify a license plate. These are [9];

i. Plate Localization, which is responsible for finding and localizing the plate on the picture.
ii. Plate orientation and sizing which compensates for the skew of the plates and adjusts the dimension to the required size.
iii. Normalization which adjust the brightness and contrast of the image.
iv. Character segmentation which finds the individual character on the plates.
v. Optical character recognition.
vi. Syntactical/geometrical analysis.

It is important to note that true system error rate is a product of its subsystem (image capture, license plate image extraction, and license plate image interpretation) error rates. Hence, image detection and extraction is an important section in the development of a VLNPR system, else character segmentation and recognition success rate will be reduced [1, 2, 7, 8]. In this paper, we present an algorithm for the detection and extraction of the Nigerian vehicle licensed number plate. It is interesting to note that the most vital and most difficult part of the VLNPR system is the detection and extraction module [7, 9]. Realizing this module usually pose some difficulties due to; the small area of the number plate in the whole image of the vehicle, influence of environmental factors on image(s) acquired, and different number plate's formats with varying characteristics of the license plate from country to country [4, 8]. Such plate characteristics which are the numbering system, colors of number plate, language of characters, style (font), and size of license plate [4], have made vehicle license number plate (VLNP) detection difficult.

Several models have been proposed. However, there is no one algorithm developed to detect all vehicle license plates in the world. Each of the models developed were unique to a particular region or country, and the method used largely affects the

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system performance index [6]. According to Liam [1], a lot of manufacturers of the VLNPR system have claimed 98% system reliability, although customers experience lesser success rate under perfect conditions of the new equipment. Other systems have also reported 60% – 80% reliability [1, 10]. According to Chirag [10], an overall system success rate of 61.36% was realized with pixel voting method, and 78.26% with local thresholding method in [11], while approximately 75.17% overall system success rate was obtained in [12].

2.0 Background of study

A vehicle license number plate is a metallic or plastic plate attached to a vehicle for identification purposes. In Nigeria, engraved on the plate are alphanumeric codes that uniquely identify the vehicle within the issuing region's database [13]. The Nigerian Vehicle license plate (NVLP) has a white background with some colored foreground. The foreground consists of some colored text (which may be green, blue or red depending on the category of the license plate) part of which is the license number. The new NVLP has light-green colored map of Nigeria at the centre of the white background and the foreground also has some green drawings at the bottom edge of the plate as seen in Fig. 1. All the objects on the number plates (NP) are characters too.

(a) The Old number Plate

(b) The New Number Plate

Fig 1: Templates of Nigerian Vehicle license number plate.

Although the number plates of vehicles are easily readable by humans, a VLNPR system cannot. For such a system, the number plate is only a gray picture defined as a two-dimensional function of x and y, where x and y are spatial coordinates. The first step in the process of number plate recognition, after image acquisition, is the detection of a number plate area.

Several methods have been proposed to detect and extract licensed number plate from vehicles images; ranging from simple statistical methods to neural network algorithms and genetic algorithms [3]. Some of these methods are briefly outlined. Chen [14] used texture information similar to that of the number plate to extract, and use auto-correlation based binary image and projection algorithm to verify true candidate plates. Heo [15] used group of lines forming rectangle to detect the plate region, and vertical edge density algorithm to extract the candidate plate. Oz-bay [16] used smearing algorithm to locate the number plate. Yu [17] used vertical edge detection and edge matching technique based on the plate model to extract candidate region. Faradji [18] used sobel vertical edge detection and vertical projection analysis to extract the candidate region, while fake candidates were deleted using compact factor. Najeem [8] used morphological operations to remove unrelated objects in the image, while dilation and erosion was used to extract the candidate plate areas. Extraction of candidate number plate was realized with bounding box analysis. Fake candidates were removed using the aspect ratio of the plate and horizontal cut in the number plate.

In this work, the image detection stage is realized with morphological based edge detection technique since the Nigerian vehicle licensed number plate (NVLNP) is a fixed rectangular metallic plate with characteristic dark colored characters on a white background. Connected component analysis also known as blob extraction technique was used to find and label connected regions in the license plate image, and connected component extraction technique was then used to filter out the license plate characters based on some heuristics.

3.0 Methodology

The image detection stage was realized with a morphological based edge detection technique, while the extraction was realized using connected component analysis (blob extraction) technique. These methods were used because of the characteristics of the NVLNP.

Three different cameras with resolutions 1.3MP, 2MP and 5 MP were used to acquire the images. The sizes of the acquired images varied from 734 x 552 pixels to 2592 x 1944 pixels. To ensure same processing time, all the images were resized to a dimension of 640 x 480 pixels. Images were captured in the RGB color mode and then converted to grayscale using an existing model expressed as in equ. (1).

$$Y = 0.2126R + 0.7152G + 0.0722B \quad (1)$$

Where Y is luminance (grayscale) part, R, G, B is red, green, and blue respectively.

The grayscale images were filtered using the morphological and Pyramidal filters to correct the effect of snow and noise from the images respectively. Both morphological filters were carried out for three iterations with a 3x3 structuring element.

The images were sharpened by applying a convolution filter with a kernel M_x expressed in equ (2), to make the edge features of the image pronounce.

$$M_x = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad (2)$$

The flowchart of the developed detection and extraction algorithm is shown in Fig 2.

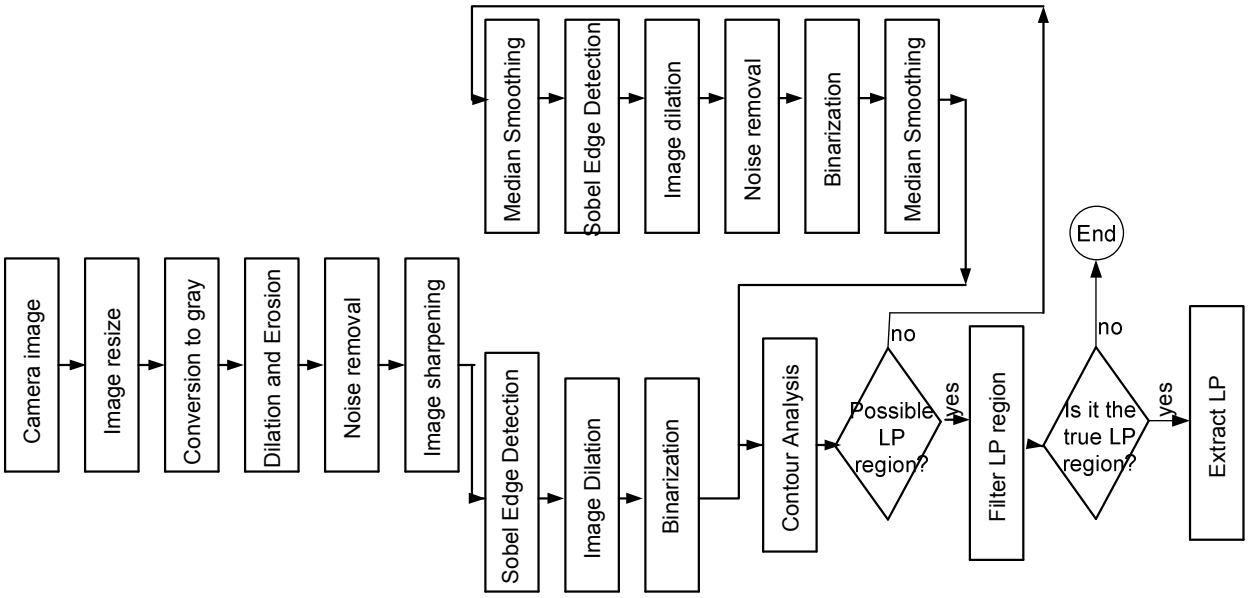


Fig. 2: Flowchart of detection and extraction algorithm

Contour analysis with polygon approximation was carried out on the image for possible detection of rectangular regions. The contours were filtered. If a license plate (LP) region is found, the coordinates were taken and mapped onto the original images from which the LP is extracted. Thereafter, blob extraction technique was used to filter out the LP characters based on the following heuristics;

- a number plate character should have a width between 15 and 60
- a number plate character should have a minimum height of 0.25 times the height of the number plate
- the top edge of the character should lie between 0.15 to 0.5 times the height of the number plate
- The bottom of the character should lie between 0.9 to 0.5 times the height of the number plate.

Apart from these heuristics, any rectangular region found to contain less than three characters were also rejected.
The system was developed and tested on an Intel® Dual-Core Processor CPU T2390 (@ 1.8GHz) with 2.00GB Memory. The image processing tools used in this work includes; Open CV - a free and noncommercial Intel® Open Source Computer Vision Library [19, 20], EMGU CV – a C# image processing wrapper for OPENCV [21], AForge.NET – an Image Processing Library [22]. The application was developed using MICROSOFT Visual C#, 2010 and the .NET Framework 4.0.

4.0 Results

In this work, the detection and extraction algorithm developed was tested with 73 samples of the NVLP (old and new) images. Only one of the images captured was presented in this paper for the purpose of illustration. The results obtained are presented in Figures 3 to 14.

Figure 3: The original image.

Figure 4: Grayscale Image

(a) Image after 3x3 SE Dilation

(b) Image after 3x3 SE Erosion

Figure 5: Effect of morphological Dilation and Erosion.

Figure 6: Result of down-sampling and up-sampling the image.

Figure 7: Sharpened image.

Figure 8: Result of applying the Sobel edge operator.

Figure 9: Result of image dilation after the Sobel edge detection.

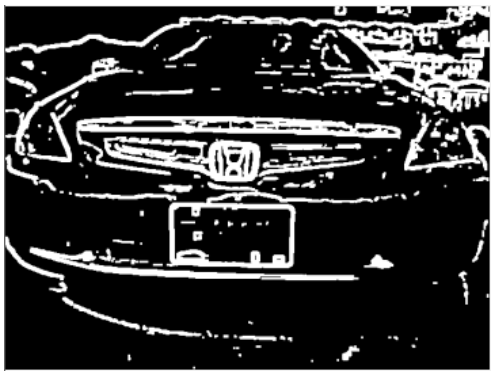


Figure 10: The result of SIS thresholding.

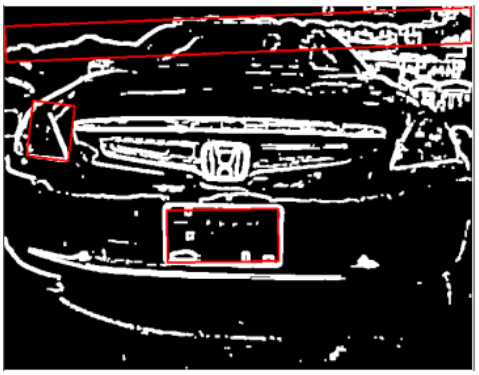


Figure 11: Result of contour analysis.

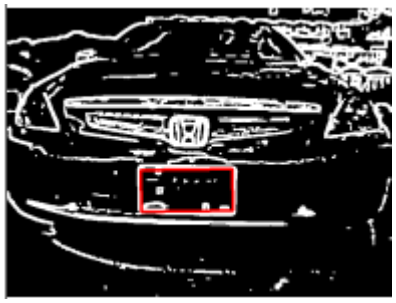
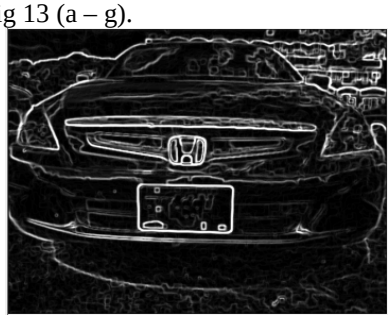


Figure 12: The detected rectangular region

The results of the second stage of the LP image processing are shown in Fig 13 (a – g).

(a) Result of median smoothing

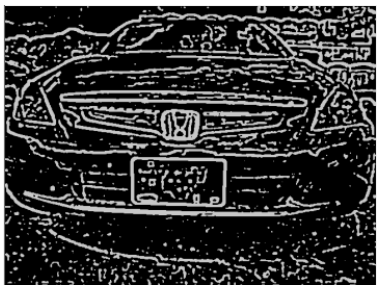


(b) Result of sobel edge operator

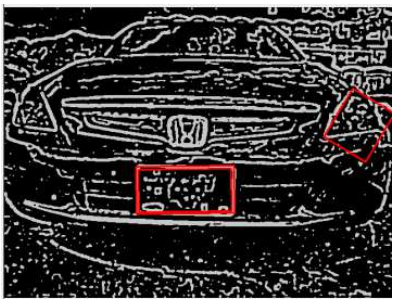
(c) Result of dilation

(d) Noise removal after dialtion

(e) Result of adaptive thresholding



(f) Result of median smoothing



(g) The result of contour analysis

Figure 13: illustration of second stage of the image processing steps.

Figure 14: The detected and extracted license plate

The performance of the system was analyzed and results shown in Tables 1 - 3. The average time for the detection process is summarized in Table 4.

Table 1: Overall performance results

Stage	No. of Samples tested	No. of successful test	No. of failed test	% Success Rate
Detection	73	62	11	84.9
Extraction	62	60	2	96.8

Table 2: Performance results based on Old NVLNP

Stage	No. of Old NVLNP Samples tested	No. of successful test	No. of failed test	% Success Rate
Detection	34	27	7	79.4
Extraction	27	25	2	92.5

Table 3: Performance results based on New NVLNP

Stage	No. of New NVLNP Samples tested	No. of successful test	No. of failed test	% Success Rate
Detection	39	35	4	89.7
Extraction	35	35	0	100

Table 4: Execution time for detection stage

Stage	Average time (seconds)
Detection	0.468

5.0 Discussion

The detection and extraction algorithm for the NVLNP was designed in two stages as shown in Fig 2. Each stage was followed by contour analysis. In stage one, after processing and sharpening the image (Figs. 4 – 7), the Sobel edge filter was applied to the image to detect the edges in the image (Fig. 8). The resultant image was then dilated, to improve the detection of rectangular regions as it increase the edges and ensured that edges close to each other are connected (Fig. 9). The Simple Image Statistic (SIS) thresholding technique was used to binarize the image (Fig. 10). Contour analysis with polygon approximation was then applied for possible detection of rectangular regions (Fig. 11). The contours were then filtered based on their areas, and any rectangular region whose area were less than or equal to 2500 pixels were rejected while those whose area were greater than 2500 pixels were further filtered based on aspect ratio. A range of 1.8 to 2.8 was chosen as an acceptable range for the aspect ratio of the license plates because of the two types of the Nigerian number plate: the old number plate and the new number plate. Any rectangular region that satisfies the aspect ratio condition is likely a license plate. However, the possibility of some rectangular regions satisfying these conditions and still not be a license plate was obvious, hence a heuristics approach was used to test each rectangular region based on the characteristics of the NVLPN e.g dark-colored characters on a white background, and the number plates are usually centralized vertically on the plate. The heuristics was applied. Once a candidate region (LP) is detection (Fig. 12), there is no need for the second stage. But if no license plate region was found at the end of this first image processing stage, the image was taken through the second stage of image processing, where the images are filtered with a median filter to smoothen the image but preserves the edge information (Fig.13a). The Sobel edge operator was then applied on the image followed by morphological dilation. The resultant image (Fig.13c) then went through further noise reduction by successive down-sampling and up-sampling using the Gaussian and Laplacian Pyramid filters respectively (Fig. 13d). Adaptive thresholding was then used to binarize the image (Fig. 13e). The image was further smoothened with a median filter (Fig 13f), and then contour analysis with polygon approximation was carried out (Fig. 13g). Each rectangular region found was then filtered just like in the first stage and the developed heuristics applied. Though this two step approach increased the time of detection of license plate, it improved the detection rate.

After a license plate region has been found, the coordinates were taken and mapped on the original image from which the license plate is extracted (Fig 14).

Out of the 73 images in the dataset used for testing the algorithm, the system was able to detect number plates in 62 images (see Table 1). Number plate detection failed in 11 images. These failures were as a result of poor lighting conditions (blur images), illuminations, and distractions some due to number plate deformation. In terms of the performance of the algorithm with the old and new NVLNP, the algorithm performed well with the new number plate, with 89.7% ability to detect the candidate region (number plate), and about 100% ability to extract the detected candidate region (see Tables 2 – 3). This high performance can be attributed to its newness, since all edges of the number plates were still very pronounced, and the rectangular shape still intact. The observed detection time was 0.468seconds.

6.0 Conclusion

The development of an algorithm to detect and extract the Nigerian vehicle licensed number plates (NVLNP) has been presented. The method proposed was able to carry out detection of number plate (candidate region) under varying environmental and lighting conditions satisfactorily, even though some of the captured images were dirty, and others with mechanical damages. The new NVLNP also recorded a high percentage success rate in both detection and extraction.
There were however difficulties in locating the candidate region if the colour of the car and the number plate background were same. In all, the performance of the algorithm was satisfactory.

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