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TEMPLATE MATCHING TECHNIQUE BASED ON CORRELATION ANALYSIS FOR RECOGNITION OF NIGERIAN VEHICLE LICENSE PLATE USING EDGE DETECTION.

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Abstract

Population increase in urban areas of Nigeria has led to a corresponding increase in the number of automobiles used for transportation. This has also led to an increase in traffic problems encountered on Nigerian roads. These problems include vehicle tracking and policing, control of restricted areas, vehicle theft, traffic offenders, enforcement of vehicle speed limits, and some more. Vehicle identification by the number plate is an image processing and computer vision technique that extracts the number plate from vehicles on the highway, process it, and identify the vehicle by the number plate. Vehicle license plate detection and recognition using edge detection and Template Matching is an image processing application that is useful for security purpose on Nigerian roads. The system developed here is capable of processing a captured image of a vehicle and process it to extract the license plate and recognize it. Sobel edge detector is used to preprocess the image. Connected components analysis is used to identify plate objects before character segmentation. Template matching technique is used to recognize the vehicle plate characters. In all, a total of 150 vehicle images were used in the experiment. The license plate location stage has a success rate of 98.6%, character segmentation is 98.6%, while plate recognition success rate is 97.9%. the system can be used for real time system and is developed with Matlab.

1.0 Introduction

Automatic Vehicle License Plate Recognition Systems have various application domains and due to this fact, it is gaining attention in transportation and security systems. It can be used by Nigerian law Enforcement Agents to track vehicles on the highway. In highly restricted areas, the system can be used for granting access or otherwise. Nigerian Road Safety Commission can use the system to monitor the registration of vehicles and renewal of vehicle particulars while on the highway. Character recognition is an important aspect of computer vision in pattern recognition systems and Artificial Intelligence (AI), that are designed towards recognizing objects by characters Such systems could be handwritten character recognition systems [1, 2], Optical Character Recognition (OCR) [3], and Vehicle License Plate Recognition Systems [4, 5, 6, 7]. In Intelligent traffic Engineering domain, Vehicle License Plate Recognition is very crucial due to the fact that computer systems must have a means of identifying plate characters after preprocessing a vehicle image. In this domain, the image of vehicle is first captured using a video camera positioned along the road. The image is transformed through various preprocessing operations such as edge detection [6, 7, 9, 10], image filtering [8] and Connected Components Analysis (CCA) before the plate characters are finally segmented from the processed image of the vehicle. Various approaches could be used for the recognition of segmented vehicle plate characters such as Artificial Neural Networks (ANN) [9, 11, 17], Fuzzy Multilayer Neural Networks [12], Support Vector Machines and so on, each of them with various recognition rates. In this paper, template matching technique for recognition of vehicle license plate characters is proposed and implemented.

2.0 Review of Related Works

There are various recognition methods for characters classification among which are ANN, Fuzzy recognition systems, and support vector machines (SVM). These methods had been applied to Nigerian vehicle License Plate Recognition systems. In [13], a Laplacian of Gaussian (LoG) operator was used in edge detection combined with template matching for recognition. The proposed system recorded a very encouraging result of 90% for character recognition. While the method is good and can locate areas where edges are present and can also test wider area around a pixel for discontinuity, it often fails to detect corners, curves and where intensity level varies (high illumination gradient) and some characters on vehicle plate have curves and corners. In [14], a system was proposed to process and recognize vehicle license plates. The success rate of the system was 91% for license plate recognition. The research success rate is encouraging but a major setback in the research is the use of Otsu binarization technique which had been successfully implemented but experiment shows that a lot of computation is required in the steps to Otsu binarization technique. In addition to this, a lot of time is required to train dataset in the neural networks approach to recognition in the proposed work. These factors limit the application of the research in real-time systems. In [15], an edge detection system using mathematical morphology with neural network for recognition of vehicle license plates was proposed. Just as in the work of [14], time spent on training neural network can be a major hindrance to the suitability of the research to real-time systems. In [16], an edge-based method with Otsu thresholding was proposed. The determination of the threshold in an adaptive way is good for cases of image with uneven illumination. While it achieved a good recognition rate of

92% with shortest time recorded, the threshold techniques adopted can be improved upon in order to make the proposed system suitable for real time system. In [9], a three-stage artificial neural networks based Nigerian Vehicle License Plate Recognition system was proposed. The work was very successful especially with vehicle number plates having no dirt and captured in a very favourable condition. While the average recognition rate was 94%, the work was limited just as in the above cases in the adoption of Otsu thresholding which is time consuming with bigger images and limits the application of the system in real time situation. In this proposed work, we seek to improve on previous works by adopting adaptive threshold technique for to binarize image, combined with template matching for recognition because template matching is very fast and has a high recognition rate especially in binary images as supported by [16].

3.0 Methodology

The research work was carried out in the following stages: Image acquisition, grayscale conversion, Edge detection, License plate location, Plate segmentation, Character segmentation, and character recognition. The system architecture is presented in Figure 1.

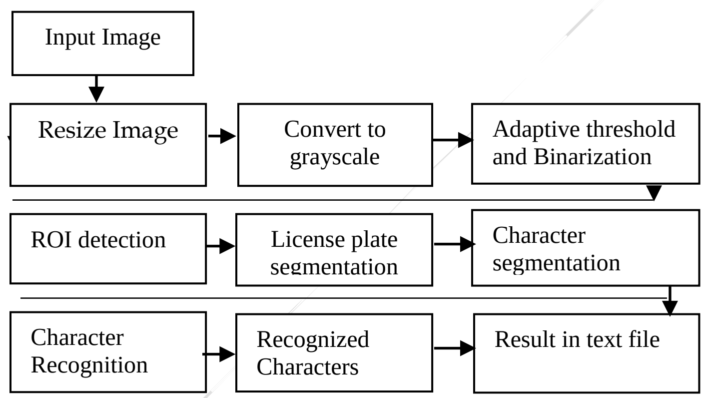


Figure1.0: System Architecture

3.1 Input Image

The input image was captured with a camera of high resolution of 720 x 1280 HD. The image was automatically resized to a dimension of 640 x 480 to speed up processing. The original vehicle image is presented in Figure 1.0.

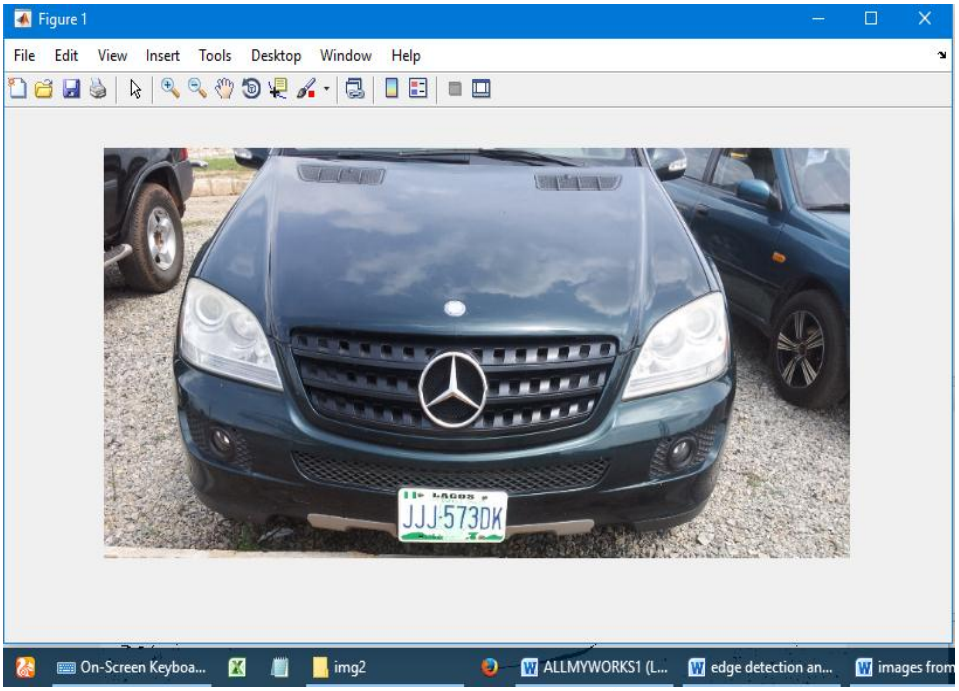


Figure 2.0: Captured Colour Image.

3.2 Conversion to Grayscale

The resized image is converted to grayscale image as preparation for the next stage of processing which is filtering and edge detection.

3.3 Filtering and Binarization

Periodical convolution of the function *f* with specific types of matrix **A** to detect various types of edges in the vehicle image. Image filtering was done using Equation (1).

$$f'(x,y) = f(x,y) * A[x,y] = \sum_{i=0}^{w-1}\sum_{j=0}^{h1} f(x,y).A[\mathrm{mod}_w(x-i), \mathrm{mod}_h(y-j)] \qquad (1)$$

Where *h* and *w* are the image dimensions of the image *f*. A[x,y] represents the pixel in row x and column y in a matrix A. *f(x,y)* is the original image and *f'(x,y)* is the filtered image. * is the convolution operator. In order to detect horizontal and vertical edges, the filtered image $f'(x,y)$ is convolved with matrices N and M as presented in Equation 2 and Equation 3.

$$N = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \qquad (2)$$

$$M = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \qquad (3)$$

The convolution matrices N and M are used to detect the edges in the image. N is used to detect horizontal edges while M is used to detect vertical edges.

3.4 Sobel Edge Detector

Sobel edge detector employs a pair of 3x3 matrices. The first of the matrices is used for evaluation of the vertical edges in the image and the second one is used for the evaluation of horizontal edges in the image. Equation (4) represents the matrix for detecting horizontal edges.

$$G_x = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad (4)$$

Equation (5) represents the matrix for detecting vertical edges.

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

The size of affected pixel is calculated by using the formula in Equation (6) and Equation (7) along the x and y directions.

$$G = \sqrt{G_x^2 + G_y^2} \quad (6)$$

The approximate size can be calculated by

$$|G| = |G_x| + |G_y| \quad (7)$$

The edges in the vehicle image is presented in Figure 3.0.

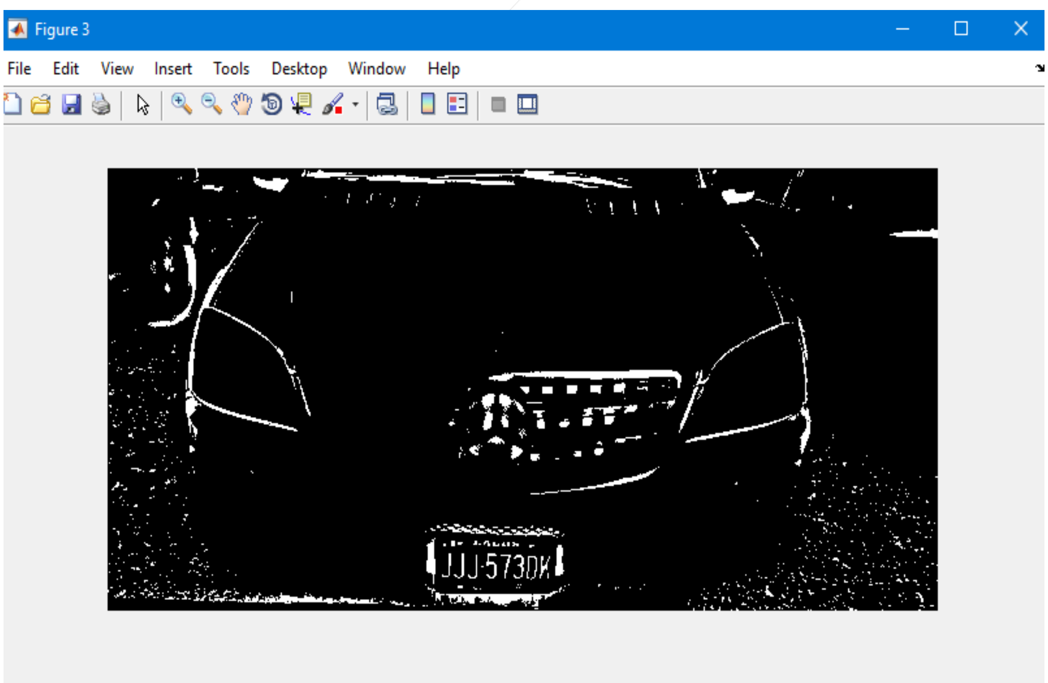


Figure 3.0: Binary Image

3.5 Region of Interest Detection

The image is first complimented. Background of the image has colour white while the foreground has colour black by simple morphological operation. The region of interest is the region that contains the vehicle plate in the binary image. All objects that are connected are identified using connected components analysis (CCA). The identified objects are presented in Figure 3.

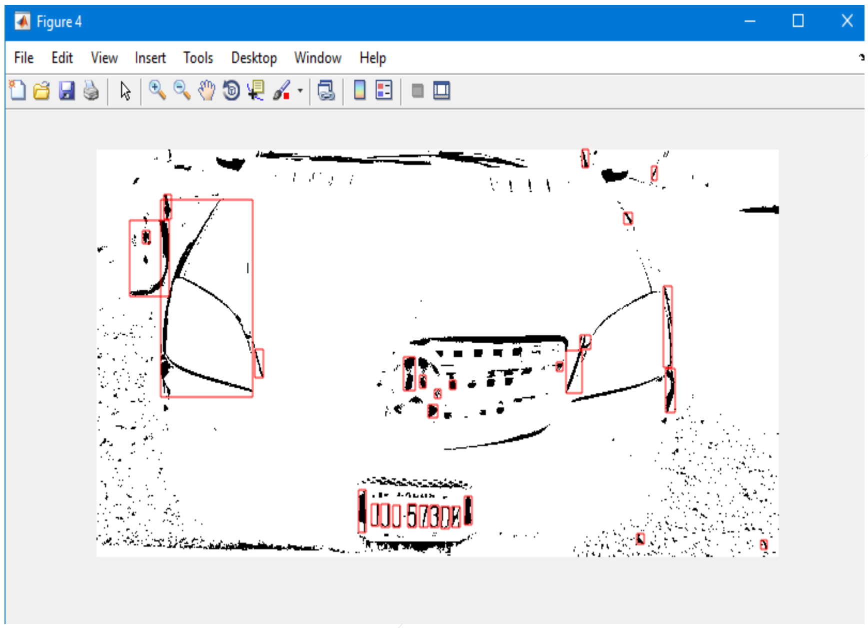


Figure 3: Connected Objects

The objects are further analyzed using geometric features of the connected objects such ad dimension of heights and width of the objects. The area that contains the vehicle plate is computed from the image for further analysis.

3.6 License Plate Segmentation

The next stage is the segmentation of the license plate area. Bounding box is used to locate the area that contains the vehicle plate, and the dimension of the bounding box is used to crop the vehicle plate area. The dimension of the area is then used to crop the plate area from the original resized image in section 3.1. The reason for doing this is to get a better image for analysis. The segmented plate region is presented in Figure 4.

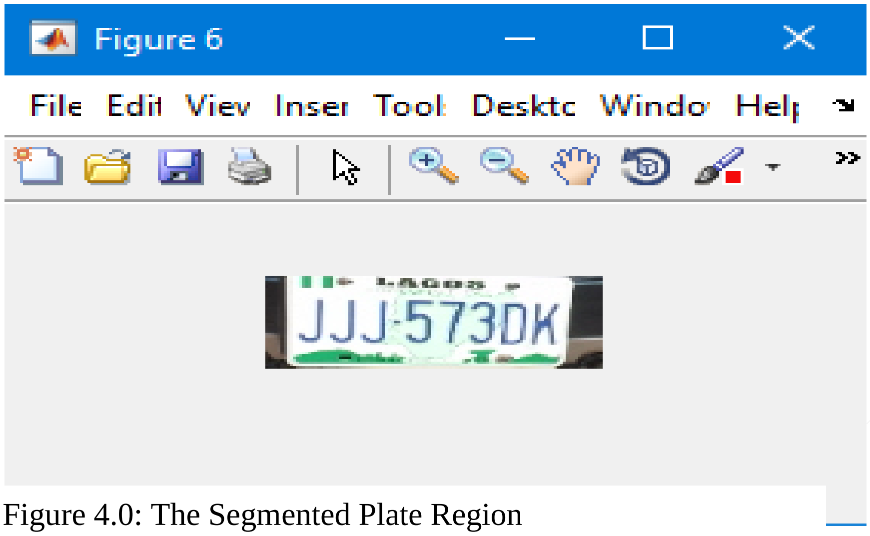


Figure 4.0: The Segmented Plate Region

The segmented plate region was binarized and the objects in the plate region located by using connected component analysis (CCA) proposed by [18]. The result of the thresholding is presented in Figure 5 and it is clear that the image contains some information that is not needed to segment the characters from the plate. The next task is to remove the unwanted parts of the segmented vehicle plate prior to character segmentation. First the plate is scanned both horizontally and vertically to calculate the positions where we begin to have characters in both horizontal and vertical directions.

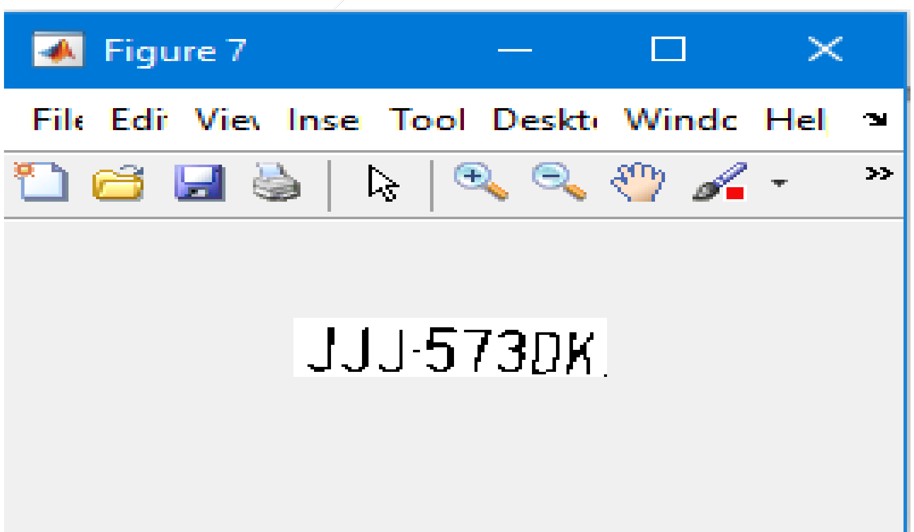


Figure 5.0: The Threshold Image

3.7 Character Segmentation

The image is inverted and bounding box is then used to locate the boundary of each character in the vehicle plate. The characters located is presented in Figure 6. The characters are then segmented using the boundary of each bounding box.

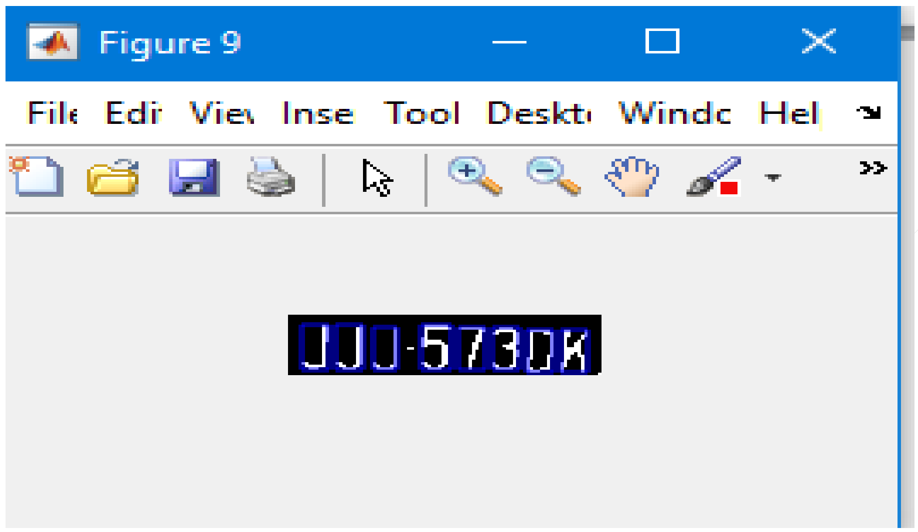


Figure 6: Character segmentation

Samples of characters segmented from other vehicle plate used in the experiment is presented in Figure 7.0.

Figure 7.0 : Samples of Segmented Characters

3.8 Character Recognition

Template matching by correlation analysis method is applied to the characters that have been separated for identification of the characters. A single numerical entity that describes the degree of semblance or relationship between two entities is known as the correlation coefficient. The

Normalized Correlation used is presented in Equation 8.

$$\eta(x,y)=\frac{\sum_{i=0}^{n-1}(x_i-\bar{x}).(y_i-\bar{y})}{\sqrt{\sum_{i=0}^{n-1}(x_i-\bar{x})^2.\sum_{i=0}^{n-1}(y_i-\bar{y})^2.}}$$

(8)

Where:

x is the template binary image

$\bar{x}$ is the mean in the template image

y is the input image

$\bar{y}$ is the mean in the input image

n is the number of pixels in the image, i.e. n = template image $size = columns * rows$

η is the correlation coefficient between the template and the source image.

The value of the correlation coefficient η is such that $-1 \leq \eta \leq +1$. In the proposed model of this research work, the pixels values of template characters (A-Z,0-9) of size 20×10 are stored in a vector with different locations for each character or letter in the template set. For example, location 1 stores the matrix representing character A, and location 3 for B. The identification process for recognizing the characters then goes on like:

(i) Get the value of correlation coefficient (η) computed between character matrix and template character matrix.

(ii) The maximum value of (η), that is, $\max(\eta)$ and the location of the matrix of the template

(iii) Look for the character stored in that location in the vector and display the output.

After correlation and matching, the output is presented in Figure 8.

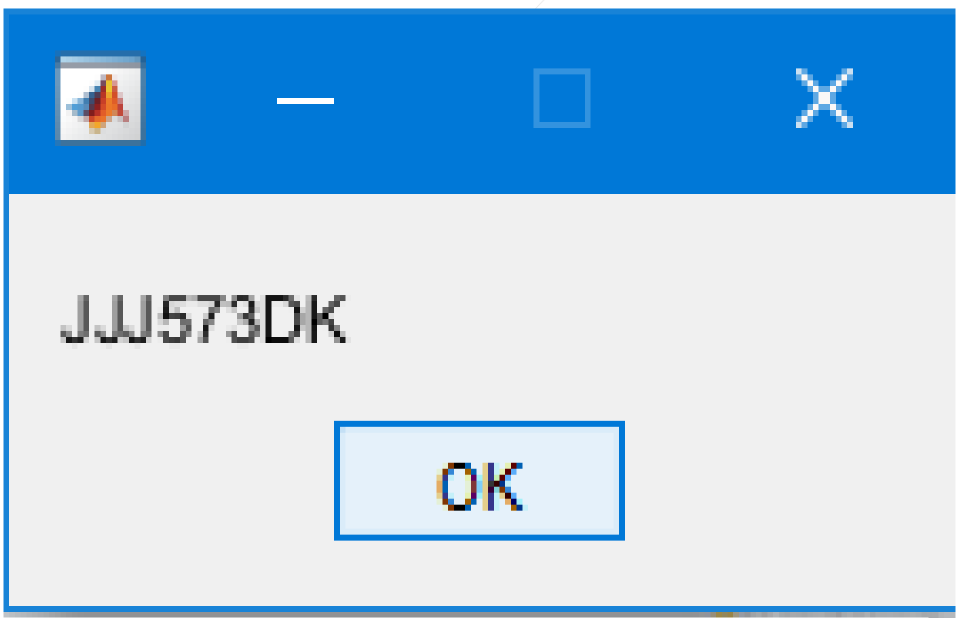
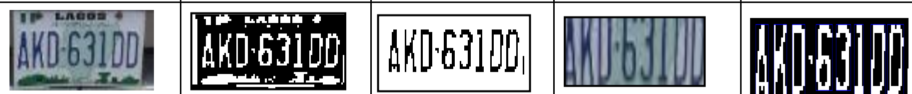
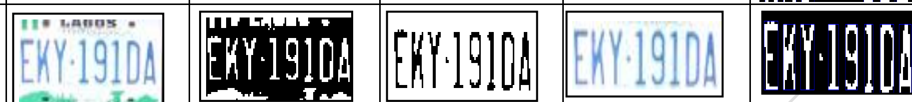


Figure 4.14: Recognized Plate Characters

Some other samples of vehicle plates used in the experiment is presented in Table 1

Table 1: Samples of Car Plates and Their Results.

Car Source image	Located plate	Binarized plate	Segmented plate	Segmented colour plate	Segmented characters	Recognized number plate
						LAW 210AA
						JJJ 573DK
						AKD 631DD
						EKY 191DA
						KJA 367DD
						KJA 618DA
						ADK 260AA

Pattern analysis was done in order to improve the efficiency of the template matching technique. In order to get around the problem of mismatching characters such as O with 0, pattern analysis of the number plate sequence was carried out. A typical recognized plate can be represented syntactically as presented in Equation (9).

$$K = \left(k^{(0)},\ldots,k^{(n-1)}\right) \qquad (9)$$

Where k is a sequence of letter and number. A syntactic pattern K is a set of *n*-tuple of sets is presented in Equation (10).

$$K' = \left(k'^{(0)},\ldots,k'^{(n-1)}\right) \qquad (10)$$

where $k'^{(i)}$ is a set of all allowed characters for *ith* position in a given vehicle plate. Typical examples of Nigerian plates such as ADK 234 AA will have the pattern represented as presented in Equation (11).

$$K' = \begin{pmatrix} (A,B,\ldots,Z),(A,B,\ldots,Z),(A,B,\ldots,Z), \\ (0,1,2,\ldots.9),(0,1,2,\ldots.9),(0,1,2,\ldots.9), \\ (A,B,\ldots,Z),(A,B,\ldots,Z). \end{pmatrix} \qquad (11)$$

For a plate number 51A 15 FG used by institutions, the pattern is presented in Equation 12.

$$K' = \begin{pmatrix} (0,1,2,\ldots.9),(0,1,2,\ldots.9),(A,B,\ldots,Z), \\ (0,1,2,\ldots.9),(0,1,2,\ldots.9),(A,B,\ldots,Z), \\ (A,B,\ldots,Z). \end{pmatrix} \qquad (12)$$

In order to get the right pattern for a plate, the syntax of the recognized plate characters is detected based on Equation (9) to Equation (12). The pattern analysis detects the pattern of the plate characters and select the correct pattern that matches it. The pattern analysis inspects locations where letters are not allowed and vice versa in the plate under consideration. Any letter found in wrong location is replaced with the most similar number. In this case, letter B can be replaced by number 8, letter O can be replaced by number 0, letter Z can be replaced by number 2 and so on. The pattern analysis of the plate was discovered to significantly increase the recognition rate of the template matching recognition method because all cases of variance were successfully removed. The result is then stored in a text file.

4.0 Results and Discussion

A total of 150 vehicle images containing vanity plates were used in the experiment which constitute the dataset. False detection are cases where the algorithm detects stickers or other objects on the vehicle that resembles a vehicle plate number in the input image and process it. Missed detection are cases where the algorithm failed to detect the presence of vehicle plate number in the input image. This could be due to faded colour of the vehicle plate number. The detection rate of vehicle license plates is presented in Table 1.0.

Table 1.0: Number Plates Detection Success Rate.

Dataset	Correct detection	False detection	Missed detection	Correct detection rate
150	148	1	1	98.6%

The result for character segmentation rate is presented in Table 2.

Table 2.0: Character Segmentation Success Rate.

Dataset	Correct seg.	False	Missed	Correct seg. rate
148	146	2	0	98.6%

The result for character segmentation rate is presented in Table 3.

Table 3.0: Character Recognition Success Rate.

Dataset	Correct plates recognized	False recognition	Correct recognition rate
146	143	3	97.9%

In the course of the experiment, it was discovered that template matching technique was very fast since no extra processing was required such as training and testing as in ANN. With binary images it produced a better result than colour images.

5.0 Conclusion

In conclusion, vehicle license plate recognition can be used to improved security on Nigerian highways if deployed. Furthermore, traffic light breaches by vehicle owners can be easily detected and punished if the system is deployed on Nigerian highways. The system is useful for security agents because it will enhance the daily works as it relates to security on Nigerian highways. However, a major problem encountered in the experiment is a case where two vehicles were captured together by camera. The system failed to extract the two license plates. It is therefore suggested that future efforts should be geared towards techniques to process and identify cases of image with two license plates.

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