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Automatic Recognition of Nigerian Licensed Vehicle Plate Number using Matlab

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ABSTRACT
This paper focuses on the recognition of Nigerian licensed plate numbers using template matching. There are three stages in this work; in the first stage, the image of a licensed plate is loaded in Matlab, converted to grayscale and binarized using 'Otsu'. It is then filtered, filled and resized. In the Second stage, segmentation was done by identifying blobs, cropping them out using machine vision border-box feature and then resized to $\mathbf{42 \times 24}$ pixels – same as the templates. Finally, Template matching was done using the 'sum of absolute differences' technique. The recognized licensed plate characters were displayed in a command window. This system promises to be of high accuracy provided the templates are properly constructed. Finally, the system was tested on five different plate numbers with character recognition accuracy ranging from 75% to 93.75% while a modified algorithm gave accuracies of 93.75% to 100%.
Keywords: Licensed plate recognition, Image Processing, Thresholding, Segmentation, Template Matching, Sum-of-Absolute-Differences.

INTRODUCTION

The need for licensed plate recognition in the modern day cannot be overestimated. With a growing population and growing number of cars, licensed-plate issuing and traffic offenders have also increased. As a result of these, it is essential to have efficient traffic monitoring, billing and ticketing systems with smart integration to data centers. In this project, a system was designed to identify Nigerian licensed plate characters, Figure 1.0, via image processing methods. The images used were obtained in normal ambient lighting and good picture clarity. The system is applicable in government quarters such as Road Safety Service or Vehicle Inspection Offices and other public parks. The private-commercial license plate type usually consists of eight characters and in very rare cases seven characters. For eight characters, the first two characters are alphabets, the next three characters are numbers

after which another set of three alphabets representing the local government area of the registered license plate number. In overview, majority of the plate numbers look like: $AA\,123-XYZ$ or $SM\,393-EPE$. Samples of Nigerian licensed plates are shown in Figure 1.0 below.

Figure 1.0: Nigerian License Plate

Plate number recognition has been researched by numerous authors and various approaches have been developed to achieve same. Methods include the use of morphological features and neural networks. According to Saleh Basalamah [1], the earliest works on recognition of Saudi plate numbers were done by Sarfraz, Zidouri [2] from King Fahd University of Petroleum and Minerals in 2003. They worked on the development of a license plate recognition system robust to light fluctuations and tilt of the license plate. Template matching was then employed to identify plate number characters using squared differences. 76% localization accuracy and 81% character recognition accuracy was achieved. G.T. Sutar [3] and Rathore [4] presented similar method. [3] made use of the optical character recognition algorithm while [4] emphasized the need for accurate 'pre-processing' of the license plate image using dilation, sharpening, brightness-adjust, noise removal and connection of broken lines. These pre-processing made Rathore's approach robust to poor image quality.

A licensed plate recognition system based on real time and with the use of LabView NI Vision tools for Saudi Arabia was developed by Y.K. Al-Audah et al. [5]. They made use of the camera vision system by National Instrument (NI-CVS) and the developed technique was valid for plate numbers from Gulf cooperation council countries with both Arabic and English letters. An average success rate of 94% was achieved and a processing time of 100ms per plate was recorded. Not much has been done in adapting image processing techniques for Nigerian license plates. A study on Nigerian plate numbers was carried out by Najeem et al. [6]. In [6], the number plate extraction system for was designed using morphological operations, connected component analysis, sobel filter, and support vector machines for recognition. A segmentation accuracy of 80% and recognition rate of 79.84 %

was reported. Similarly, S. Adebayo et al. [7] developed an automatic vehicle identification system. Licensed plate feature extraction with a classification algorithm based on hidden Markov model (hmm) was employed and the proposed system was proven to have a recognition rate of 98%. With a population of over 140million [8], the number of cars in Nigeria necessitates the automation previously mentioned licensing and vehicle inspection tasks.

METHODOLOGY

In this work, license plate recognition was achieved using template matching. The approach is summarized below:

i. Image Acquisition: Image capture (snapshot) and saving to file.
ii. Image Processing: filtering, resizing, conversion, cropping.
iii. Image Segmentation: blob analysis, character localization.
iv. Template Matching: for character recognition using 'sum of absolute differences' technique.

One of the fundamental steps in achieving this task is by first thresholding the image. Thresholding is basically the process of classifying pixels to a binary state (binarization) based on the bimodal distribution of the pixels. Black (darker) pixels are characterized with binary values closer to 0 while white (lighter) pixels on the other hand have values close to 255. When a threshold is fixed, pixels with intensity above the threshold become white and those below become black [10]. Mathematically, the process of binary classification can be described as in (1)

$$c[u,v] = \begin{cases} 0, I[u,v] < t \\ 1, I[u,v] \geq t \end{cases} \quad \forall (u,v) \in I (1)$$

I represents the image, c is the classifier, t is the threshold while u and v are the pixel axes corresponding to the familiar x and y.After binarization, all pixels are represented in two levels '0' for black and '1' for white. Basically, the process of binarizing an image is the process of converting it to black-and-white. The bimodal distribution shown in Figure 2.0 is the histogram of an image.

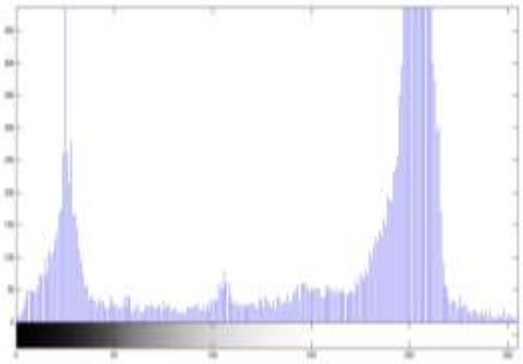

Figure 2.0: Pixel distributions of an Image

Otsu developed a method for selecting optimal threshold value [11]. The next operation is image segmentation. Image segmentation is the process of partitioning an image into application meaningful regions or objects with the aim of separating pixels that represent objects of interest from other pixels in the scene [12]. Achieving this involves classification which is a decision process applied to each pixel. Finally, template matching is the simple comparison of pixel values between two or more images to highlight regions of similarity or otherwise. According to [14], there are various methods of achieving template matching such as sum of absolute differences (SAD), sum of squared differences (SSD) and normalized cross-correlation (NCC). Each of these methods has varying levels of computational complexity as shown in equations (2)-(4) respectively.

$$SAD = \sum_{(u,v)\in I} |I_1[u,v] - I_2[u,v]| \quad (2)$$

$$SSD = \sum_{(u,v)\in I} (I_1[u,v] - I_2[u,v])^2 \quad (3)$$

$$NCC = \frac{\sum_{(u,v)\in I} I_1[u,v] \cdot I_2[u,v]}{\sqrt{\sum_{(u,v)\in I} I_1^2[u,v] \cdot \sum_{(u,v)\in I} I_2^2[u,v]}} \quad (4)$$

The top down methodical approach or algorithm for the recognition of license plate is now discussed. The Algorithm is as follows:

Load Image:
Resize Image to global value of 100x250 pixels,
Convert Image from RGB to Grayscale
Convert Image from Grayscale to Binary Image
Use disk type structuring element to filter image

Label blobs in image and count:
Fetch properties of all blobs

Plot green box over all blobs
Remove blobs touching boundary of image
Remove blobs with area less than 270 pixels and area greater than 800 pixels
Assign label of filtered image to variable 'address label' Dimension of address label: 8x1; representing total number of eight characters to be detected Assign each label of blobs as objects in variable b1, b2, b3, b4, b5, b6, b7 and b8.

Derive properties of object in 'b1'
Fetch coordinates of the border-box
Plot red rectangle on object 'b1'
Crop object 'b1' with respect to dimensions of border-box
Resize resulting image to dimensions 42 x 24 (same as template)
Return each segmented object to variable 'b1boxd'
Repeat steps i-v for remaining blobs b2-b8

Obtain Templates
Store template images (Bitmap, 42x24pixels) into variable names A, B, C…Z, one, two…zero.Display all objects processed so far for check

Matching Template with Objects
Attach segmented image(b1) with each template
Compute the sum of absolute differences (SAD) of each attachment
Determine the minimum SAD value, the minimum sad value represents the best match. Display the corresponding alphanumeric value of the best match and repeat steps i-v for b2-b8.
Print all results to command window.

RESULTS AND DISCUSSION

This section presents the results obtained. Matlab and Machine Vision toolbox by Peter Corke [14] was used for the implementation of the algorithm described in section 3 above. Figure 3 below highlights the stages of the algorithm.

Figure 3: (Left to Right), License Plate, License Plate resized, License Plate in Grayscale, License Plate Binarized, License Plate Filtered, Blobs identified.

Figure 4: Segmented characters

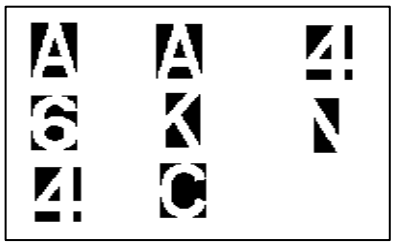

Figure 5: Corresponding template images that would match the segmented characters based on SAD.

Table 1 below summarizes the results obtained for 3 different plates out of a pool of 20.

Table 1: Results

Plate	License Number	Results	Score	Accuracy (%)
1- Kano	AA464KNC	AA464KNL	7.5	93.75
2- Lagos	SE249KJA	SEZ49KJA	7.5	93.75
3- Lagos	SM700FST	SM7DDFST	6	75

The errors were mainly as a result of problems with the template font. The font on the templates did not have exact match with those on the license plate. The dissimilarity introduced pixel-matching problems at the curved edges of characters such as 'C' and 'L', 'D' and '0', '2' and 'Z'. For instance, letter 'C', Figure 6, on the license plate was interpreted as 'L' because of the larger number of pixels at the edges (thickness) of 'L', resulting to higher match and a lower SAD value. The open source template font type should be replaced with new templates that perfectly capture the fonts on Nigerian license plates.

Figure 6: (Left to Right), 'C'-Template character, 'C' License plate character and 'L' Template character.

In order to overcome the template-font challenge, we made use of prior knowledge to correct some of the errors. Since the first two and last three characters in Nigerian license plates are alphabets and the middle three are numbers, the algorithm is modified to search the templates for only alphabets or numbers with respect to the current segmented character under analysis. In Figure 3, the first character is a letter, thus the algorithm would search letter templates only for the first character thereby minimizing to a great extent the possibility of recognizing a letter as a number or vice versa.

The modification results into the response provided in Table 2.

Table 2: Results with Modified Algorithm

Plate	License Number	Results	Score	Accuracy (%)
1- Kano	AA464KNC	AA464KNL	7.5	93.75
2- Lagos	SE249KJA	SE249KJA	8	100
3- Lagos	SM700FST	SM700FST	8	100

The scoring was based on the following. 1 point for each correct character recognized, 0.5 for each character recognized with template mismatch and 0 for each character wrongly recognized. A total of 8 points is available for an eight-character license plate.

CONCLUSION

In conclusion, recognition of Nigerian license plate numbers was achieved using template matching based on 'sum of absolute differences' technique. A total of 20 license plates were tested with accuracies between 75% and 100%. The errors were as a result of template-object font mismatch as mentioned previously. This can be solved by creating new templates using same font as those obtainable on the license plates and by modifying the algorithm. It took an average of 2seconds to detect the eight characters in the license plate.

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