

An Improved Method for Tanzania Number Plate Location and Segmentation Based on Mathematical Morphology and Regional Features of an Image

Isack Bulugu¹, Pei Zhijun²

^{1,2}Tianjin University of Technology and Education, Department of Electronics Engineering,
Liulin Eastern Road, Hexi District, Tianjin 300222, P.R. China

Abstract: In the Automatic Number Plate Recognition System (ANPR), Plate Number Location and Character segmentation are very important parts of an ANPR system before Recognition part. In this paper, plate number localization and character segmentation using mathematical morphological approach and regional features of images are discussed from the proposed ANPR system of vehicles in Tanzania. The proposed algorithm consists of three main modules: Pre-processing (cutting and resizing, convert RGB image to grayscale image, image binarization use Otsu method), Finding Region of Interest (morphology opening to remove noises & dilation operation, measure properties of image regions to find candidates), License plate exactly location (finding the LP angle & rotating LP, cut exactly LP region). The Character segmentation also consist three parts: Eliminate incrimination of the binary using boundary features, removes impurities using regional features and morphological process, and divide character into sub-images. The results show an average of 98% successful plate number localization and segmentation for proposed ANPR system in a total of 200 images captured from a complex outdoor environment in Tanzania. Implementation was done using MATLAB Version 7.11.0 (R2010b).

Keywords: Automatic number plate recognition (ANPR), Plate number location, Character segmentation, MATLAB.

1. Introduction

Generally, an automatic Number plate recognition (ANPR) system is made up of three modules: license plate localization, character segmentation and optical character recognition modules. The two most important are number plate location and Character segmentation modules. Below is the flowchart diagram of a proposed Automatic number plate algorithm for Tanzanian vehicles (Fig.1), only two modules were considered as shown below.

various types of plate, broken edges, the plate is small, dim lighting, the images are fuzzy. In this paper, we proposed improved method for the Tanzania ANPR system, which considered for the specific characteristics of Tanzania plate numbers, we tested for the vehicle images, which obtained from the actual system, the images have different background, such us illumination, angles, sizes and types, distance from camera to vehicles, light conditions in Tanzanian environment.

An intelligent license plate localization and recognition system today will be required to operate robustly in environments with complicated backgrounds and light intensity variations. To deal with such problems, researchers have proposed various solutions to address these problems. For example, Kim, S. et al [1] proposed a method based on edge extraction for license plate localization in images taken in poor lighting conditions. It consists of two steps. The first step involves the search of candidate regions from the input image using gradient information and the second step determines the plate area among candidates and adjusting the boundary of the area by introducing a plate template. On the other hand, Sarfraz, M. et al [2] utilized vertical edge detection and filtering which is then followed by vertical edge matching in the localization of Saudi Arabian license plates. As it is observed that images have more horizontal lines than vertical lines, this approach reduces computation time by detecting only vertical lines. In [3] and [4], additional edge extraction based approaches are discussed.

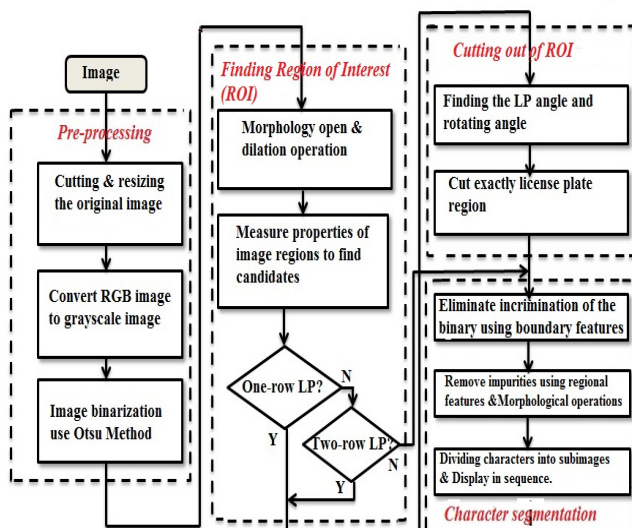


Figure 1: Flowchart diagram of a proposed Automatic number plate algorithm for Tanzanian vehicles

The most common methods used for an ANPR system using captured digital images are through the implementation of edge extraction, histogram analysis, morphological operators and Hough Transform. But, most of these methods work under controlled conditions, their image data were not collected in Tanzania and have some restricted in cases:

2. Feature of Tanzania License Plate Numbers

Numberplates ofTanzaniadate back to at least 1933 inTanganyikaand to the 1950s inZanzibar. They are the same size as their British counterparts and used the same font until the late 1980s. Mainland Tanzania and Zanzibar use slightly different formats [5]. In the 21st Century, the letters and

numbers were swapped and the preceding 'T' was returned, with yellow background and black characters (digits A to Z.) & numerals (0 to 9). This type also divided in two subtypes (one-row LP and two-row LP) in the figures below.

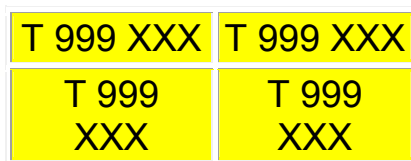


Figure 2: Tanzania plate number formats.



Figure 3: Tanzania plate numbers

3. An Overview of the Proposed Algorithm

The program is designed for automatic number plate recognition of the following characteristics.

- Tanzanian Cars
- Rectangle plate
- A plate with one or two line of characters
- Arrangements of letters and numbers is L NNN LLL
- Different ambient conditions

When an image is loaded into a program, it has a different resolution depending of the hardware. To reduce the required computational time, the size of the picture is decreased. The reduced smaller picture is used in the processing until the final ROI (Regional of Interest) is found.

During processing, the information about each pixel is sometimes reduced to only be the black/white intensity or binary value, depending on what the next algorithm requires in order to save memory and improve efficiency. The next step is to divide the image, into sub images as many as characters are recognized. The image pre-processing prior to final segmentation is essential to not confuse impurities with possible characters and successfully return the number of characters with their corresponding images. Finally, the Optical Character Recognition (OCR) algorithm works by comparing the segmented characters, with the predefined templates of the typeface used in the license plates of today. The templates are compared by calculating the normalized cross correlation. At this point, the algorithm has met all its objectives. Remove the plate from the original image, to segment into characters that make up each image and to associate them to the proper character of the template.

4. Number Plate Localization

Prior to the previous sections, the license plate localization process involves three stages: pre-processing, finding region of interest (ROI) and cutting out of ROI. Basically, all process is just a combination of morphological processes with a modified Hough Transform approach. To be able to work with morphological processes, it is normally more

convenient to convert the original RGB image into a grayscale image and subsequently into a binary image. The Otsu's global thresholding method [6] is applied in this system to convert the grayscale image into a binary image. This technique suggests minimizing the sum of within class variances of the object and background pixels to establish an optimum threshold. The result of this global thresholding method will normally yield binary images.

This technique suggests minimizing the sum of within class variances of the object and background pixels to establish an optimum threshold. The result of this global thresholding method will normally yield binary images as shown in Figure 4.



Figure 4: Outcome of Otsu Thresholding Method

As shown in Fig. 4, it can be clearly seen that the characters of the license plate have been properly segmented from its background. This is then followed by the execution of various morphological processes and the modified Hough Transform approach on the binary images.

4.1 Morphological process

The morphological processes which are applied onto the image aim to refine the image until the location of plate number. By removing all unrelated objects in the image and ensure that the characters on the license plate are well preserved. However, to ensure that the algorithm is robust enough to cater for characters of varying sizes and scale, a number of morphological processes will be applied to the image. This is performed to ensure that loose upper and lower limit is specified for each process. Based on the measured properties of the objects, it will be checked upon the relevant upper and lower limits specified to determine whether it remains or is to be removed from the image. There are three main morphological processes applied to the image. The width, height and number of holes of each individual object of the binary image are checked. Those exceeding the specified upper and lower limits will be removed from the image. This is then followed by the fill, clear boundary objects and small objects removal processes. Fig.5 clearly illustrates these processes.

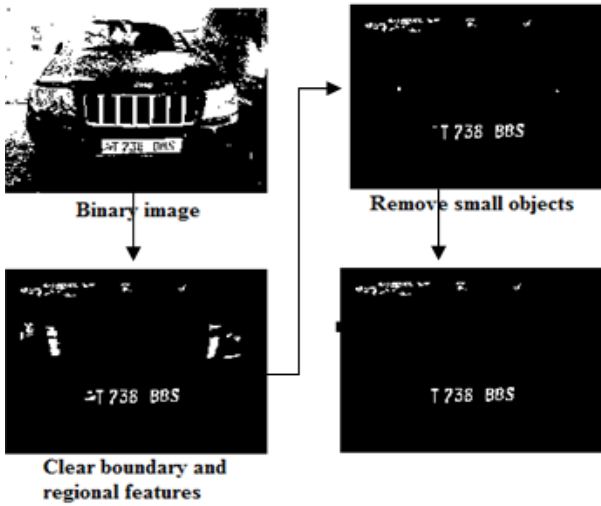


Figure 5: Morphological process flowchart

4.2 Modified Hough Transform Approach

Normally, the Hough Transform is used to locate the vertical and horizontal borders of a license plate. This is clearly illustrated in the work of Tran, D. D. et al [7]. In this system, the focus has been directed to the characters of the license plate instead. In most cases where Hough Transform is applied, the input image is normally an edged image. Then, the horizontal and vertical lines of the license plate borders will be located. However, in this system, an edged image will not be required. In contrast, the Hough Transform is directly applied onto the resultant output of the morphological processes such that the features of the characters are preserved. Here focus is on the characters on number plate, smoothing edges and contours to delete them. When subtracting the original image fig 6(a) with (b) to obtain information which is a plate number as shown in fig 7. Then subtract fig 6 (c) with (d) to get fig 8 further process in character segmentation stage.

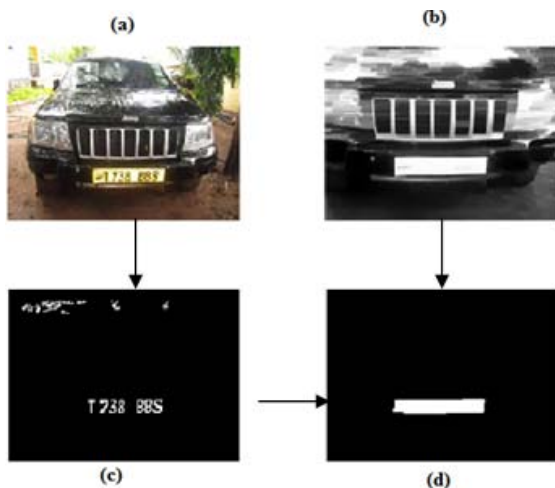


Figure 6: Some stages of modified hough transformation to extract number plate

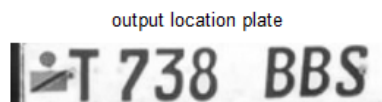


Figure 7: Subtracting the original image fig 4(a) with (b) to obtain image of a number plate



Figure 8: Result after subtracting fig 4 (c) with (d)

5. Character Segmentation

The bridge between license plate extraction and optical character recognition modules is Character segmentation. Its main function is to segment the characters on the chosen candidate region such that each character can be sent to the optical character recognition module individually for recognition. Looking closely at the black characters which fall on a yellow background on Tanzanian license plates indicate that thresholding will be a very convenient tool for the purpose of character segmentation. On the other hand, the license plate localization module has already been working with binary images. Firstly, we apply the method of Otsu to work with a binary image. This procedure selects the optimal level for thresholding depending on the intensity levels of each image. Then we eliminate the inclination of the binary image using features of higher object found in the image. We note this orientation and we apply rotation with this angle in the full picture. Remove impurities larger and smaller than the measurements of a character through the characteristics of each region and morphological operations until there are only seven objects (maximum characters in a plate). Divide those characters that are together because of previous operations or conditions of the image and original registration. In this loop must be especially careful because dividing the object, the number of them grows, which must be extended in the right place to show and recognize the characters in order and not to alter the sequence of registration. Finally, remove impurities that were created by segmenting characters. For a complete system after character segmentation it's followed by character recognition.

It would be easy if temperature matching is used, Wu, C. et al [8] and Naito, T. et al [9] adopted the template matching method which can be easily implemented. However, to deal with the number of variations found on the characters across different license plates will require the segmented character to undergo some preprocessing steps such as normalization and skew correction. These additional steps prove to be beneficial as it greatly reduces the required computation time. For example, Sarfraz, M. et al [2] improves the template matching by normalizing the characters prior to template matching. The more advance techniques include the use of neural networks [9, 10] and self-organizing maps [11].

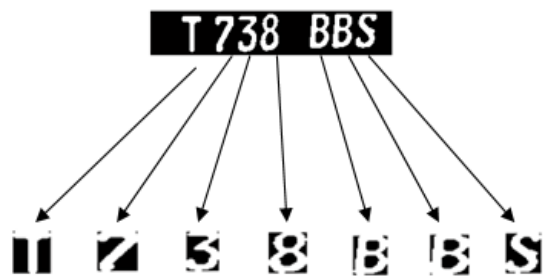


Figure 9: Show the result segmented characters

6. Experimental Results

We implemented experiment with PC Intel(R) Core(TM) i5-2450M CPU @2.50GHz, RAM 2.50 GB, Windows 7 ultimate 32-bit Operating System and MATLAB Version 7.11.0 (R2010b). We tested for 200 vehicle images, which obtained from the actual system, these vehicle images are have different background, such as illumination, angles, sizes and types of LP, different distance from camera to vehicles, light conditions in Tanzanian environment. There are two types of the size of the images in RGB true-color image was tested 680x640 pixels. The results of our method and the previous works show in Table 1. The average rate of accuracy is 98%, comparison with previous methods; our results are more exactly, some example of the experiments show in Fig. 10.

Table 1: Experimental Results Table

<i>Method</i>	<i>Proposed method</i>	
Number of Images	One-row LP	Two-row LP
	100	100
Average rate of accuracy	98%	

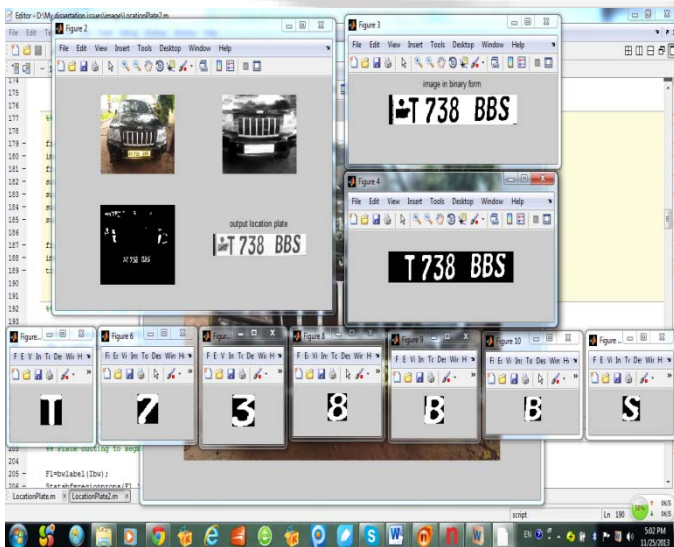


Figure 10: Sample of experimental results

7. Conclusion and Future work

This paper proposed an improved ANPR algorithm for Tanzanian plate numbers. The paper discussed the two main parts of the proposed algorithm: plate number localization and character segmentation using mathematical morphological approach and regional features of the image. We tested for 200 Tanzania vehicle images, which obtained from the actual system, the average rate of accuracy of our method is 98%, and some of our results presented. In the development of this system to ply for Tanzanian vehicles in mind, the proposed ANPR system has taken a different approach to identify the location of the license plate through the combination of morphological processes and a modified Hough Transform approach which focus on the characters features rather than the borders of the license plate. Although the system was operated using digital images taken from a camera, it can be easily applied to an actual system.

Further work is underway to implement the algorithm into a complete intelligent system which consists of a camera for capturing images from the road. Also it will consist of a third party software such as Microsoft access to create and maintain a database of registered vehicles. This intelligent system will not only help in traffic monitoring but also in commuter safety, law enforcement and commercial applications in Tanzania.

Acknowledgment

This work is supported by the National Natural Science Foundation of China under Grant No.61071204 and it also partially supported by Research Start Foundation of Tianjin University of Technology and Education under Grant No. KJY1312.

References

- [1] Kim, S., Kim, D., Ryu, Y., Kim, G., "A Robust License Plate Extraction Method under Complex Image Conditions", Available: <http://ieeexplore.ieee.org/exproxy.lib.monash.edu.au/iel5/8091/22457/01047833.pdf?tp=&arnumber=1047833&isnumber22457> (Accessed: 27 October 2013).
- [2] Sarfraz, M., Ahmed, M. J., Ghazi, S. A., "Saudi Arabian License Plate Recognition System", 2003 International Conference on Geometric Modeling and Graphics, 16-18 July 2003, pp.36-41.
- [3] Ozbay, S., Ercelebi, E., "Automatic Vehicle Identification by Plate Recognition", Available: http://www.oletc.org/ole_tctoday/0415_licplate.pdf (Accessed: 23 October 2013)
- [4] Shapiro, V., Dimov, D., Bonchev, S., Velichkov, V., Gluhchev, G., "Adaptive License Plate Image Extraction", Available: <http://ecet.ecs.ru.acad.bg/cst04/Docs/sIIIA/32.pdf> (Accessed: 26 October 2013)
- [5] Wikipedia "vehicles registration number in Tanzania", http://en.wikipedia.org/wiki/Vehicle_registration_plates_of_Tanzania (Accessed: 20th November, 2013)
- [6] Otsu, N., "A Threshold Selection Method from Gray-Level Histograms", IEEE Transactions on Systems, Man, and Cybernetics, Vol.9, No.1, 1979, pp.62-66.
- [7] Tran, D. D., Duong, A. D., Tran, L. H. D., "Combining Hough Transform and Contour Algorithm for Detecting Vehicles' License Plates", Proceedings of 2004 International Symposium on Intelligent Multimedia, Video and Speech Processing, 20-22 Oct.
- [8] Wu, C., Lei, C. O., Chan, H. W., Tong, S. K., Ng, K., "A Macao License Plate Recognition System", Proceedings of 2005 International Conference on Machine Learning and Cybernetics, 18-21 Aug. 2005, vol. 7, pp. 4506-4510.
- [9] Kwasnicka, H., Wawrzyniak, B., "License Plate Localization and Recognition in Camera Pictures", Available: <http://www.ci.pwr.wroc.pl/~kwasnick/download/kwasnickawawrzyniak.pdf> (Accessed: 23 July 2013).
- [10] Sirithinaphong, T., Chamnongthai, K., "The Recognition of Car License Plate System and its Core Techniques", IEEE International Conference on

Vehicular Electronics Safety, 14-16 Oct. 2005, pp. 42-45.

- [11] Chang, S.-L., Chen, L.-S., Chung, Y.-C., Chen, S.-W., "Automatic License Plate Recognition", IEEE Trans. on Intelligent Transport. Sys, Vol. 5, No.1, pp. 42-43. (2004)

Author Profile



Isack Emmanuel Bulugu received the B.sc (Honor) Electronic Science and Communication from University of Dar es salaam (UDSM), Dar es salaam, Tanzania in 2008. Presently a Masters Student of Signal and Information Processing in Tianjin University of Technology and Education (TUTE) Tianjin, P.R. China, 2011-2014. Currently, he works at University of Dar es salaam as a Teaching Assistant.

