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Vehicle Plate Number Detection and Recognition Using Improved Algorithm

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Abstract
The growing Tanzanian population currently estimated to be 48 Million people and their use of vehicles as means of transport has kept increasing making enforcing traffic rules and regulations among road users a major challenge. This calls for a need to have an automated system that monitors the motorists with a pre-defined sense of intelligence. A Vehicle Detection and Recognition Algorithm which can provide automated access to relevant information to a number plate from information systems containing and managing databases on vehicle and their movements is required. This paper presents work on developed algorithm that localizes plate area, extract and segment character, and finally recognizes and interprets registration number from vehicle image. MATLAB R2012b Simulation software with Image Processing toolbox is employed. HSV color space image, morphological and statistical analysis operations were integrated and employed to a vehicle image to compute plate number area. In segmentation the properties like aspect ratio, extent, and area ratio were important measurement parameters. Finally, the template matching database and statistical character extracted from car image was correlated to recognize alphanumeric character to deduce car registration number.

Keywords— Character extraction, Detection algorithm, Recognition algorithm, Morphological matching, Template matching

1 INTRODUCTION

TANZANIA population has double since 1988, with a currently estimated population of 48 Million people[1, 2] whose use of vehicles as means of transportation and number of vehicles has largely increased and keeps increasing. The vehicles usage includes; personal, public and/or business use. With this rapid increase, enforcing traffic rules and regulations among road users becomes particularly difficult because of their habit to disregard them. This calls for a need to have an automated system that monitors the roads users with a pre-defined sense of intelligence. There is no such system implemented in Tanzania in public roads, hence an algorithm is proposed that can automatically detect a vehicle plate number, isolate it from the rest of the car image, and recognize the plate's alphanumeric characters is required.

Since, Vehicle number plate is the only unique code for vehicle identification in any country database; it is an important resource for accessing data of the owner and other relevant information from the country information systems held at Tanzania Revenue Authority data bank. The United Republic of Tanzania has variety of number plate's registration standards a sample of which is shown in Fig. 1.

Therefore, the information from number plates can be used for laws enforcement, road toll data collection, weighing bridges, police barriers, etc. It may also be used to facilitate other automated processes like automatic opening/closing of gates, keep a time record on the entry or exit of vehicles, parking lot payment calculations [3]. Therefore, by simply thinking number plate, one can imagine other applications such as traffic control, journey time management, carjacking protection and border control because image is worth than thousands word.

Fig. 1 Sample of Tanzanian Number Plate

Vehicle Number Plate Detection and Recognition (VNPDR) has a wide range of applications since the plate number is the primary, most widely accepted, human readable, mandatory identifier of motor vehicles. VNPDR provides automated access of the contents of the number plate form computer systems managing databases and processing information of vehicle movements.

This paper is arranged as follows: section II is literature reviews, III experimental results and discussion and VI conclusion.

2. LITERATURE REVIEWS

2.1 Introduction

From literature review a lot have been done and employed to improve the system performance and various researches carried out in this area. Technically, the technology is a challenging research area which has been enabled by innovation in computers and sophisticated high resolution infrared cameras. This made easier image processing techniques applicable to analyzing and extracting important features for plate numbers detection and recognition [4, 5]. The literature reviews looked at Image pre-processing, number plate detection and extraction, character extraction and segmentation, and finally recognition and interpretation.

2.2 Image Acquisition and Pre-Processing

Image acquisition is performed by high end IR cameras, placed at strategic positions to avoid obstacles in order to obtain accurate images. Image acquired by camera always reflect the camera settings; among many include color and hue, saturation and value or brightness (HSV) whereby essentially an image can be in its natural form or slightly altered. It was noted that, color images are complex in space and time.

Pre-processing aims at image enhancement and restoration. This process eliminates noise, highlight edges and improve the overall quality of an image. In image pre-processing an image goes through among many procedures grey-scaling, dilation, erosion, and filtering and edge enhancement [4, 6]. Converting natural color images, to HSV color space, to grey scale and then to binary is important as it reduces time and space complexities. This concept was express by Reshma [6, 7] and Kim et tal [7].

2.3 Number Plate Detection and Extraction

Number plate extraction is a process of localization of number plate region(s) from car image. Localization select right feature that will provide best results in number plate recognition stage. This is a difficult task due to the enormous variations of shapes, sizes, color of a car, illumination conditions, texture and orientation of number plate in car images. Therefore, in order to have reliable number plate detection algorithms, in such dynamic environments, several choices have to be considered.

Several features that could be deployed to extract a rectangular shape of number plate from a car image included color feature, aspect ratio, and texture edge density and shape/size of ROI, but for better detection rate the combination of features could provide more reliable solution. HSV color space and integral image properties could also be employed to locate the coordinates and position of yellow number plate and non-yellow number plates. From Liu et tal and Kim et tal [8, 9] HSV enables one to find out the four coordinates of a rectangular shape containing English like symbols or texture from which X and Y coordinates, Width and Height could be extracted.

The process of number plate area detection and extraction involved three stages of finding area of interest (ROI), filtering out background and removals of false objects, and lastly computation of connected components which provided best results of required region of interest. In the process of locating the regions of Interest the HSV method was applied. MATLAB function was used to find the coordinates o (x, y, width, height) to provide the regions of interest. The masked image was computed using MATLAB functions to obtain rows and columns of our region of interest.

Summation of mask from HSV process and mask from Morphological process provided the best results for computing connected components. The connected components were computed to provide the actual plate area position or coordinates of the region of interest. The properties of ROI including bounding Box, area of object, aspect ratio, extent, coordinates and perimeter of the object were considered to find the connected components. By combining all the above properties it is possible to provide best results at later stage of segmentation and recognition.

Finally, statistical analyses were applied to find the connected components to be used to locate number plate accurately. This was performed to ensure that the global boundary was maintained, by providing upper and lower limit of a ROI Left and Right limit of a ROI.

Dimensional properties of rectangle shape or objects using morphology methods of dilation, erosion and fill; were also used by other researchers to increase correct plate localization [3]. In these methods the region that passed through the qualifiers, and also passed as a number plate, its boundary box coordinates were used to crop the original image and obtain the number plate only. The qualifier checked if the area of a region was not less than specified threshold and length of the aspect ratio is within the limits (2:1 and 4.6:1 for our case).

Fig. 2 Yellow and white reflector with single and double rows number plates

The number plate detection and extraction returned four entries [X, Y, Width and Height] which could deal with adjustment of ROI because the image may contain angle.

From the above methods, it was possible to eliminate the disturbances of the fake objects whose structure and components were similar to the vehicle number plate, but did not match plate fixed color and coordinates. This new idea of combining several properties enabled maximized recognition rate and efficiency. The idea assumed that the white number plate area was situated somewhere between those black rows, hence by finding the largest vertical arrays of white pixels, it was possible to detect the left and right edge of the number plates.

2.4 Character Extraction and Segmentation

From literature Character Extraction and Segmentation is the most difficult part of detection and recognition process [10]. The factors that made the processes difficult included image noises, space mark, plate orientation, illumination variance, character arrangements and plate frame. Traditional character segmentation includes those based on extraction of connected components; segmentation based on thresholding, segmentation based on region-growing and may others[11].

The image that passed pre-processing stage for number plate recognition that was localized in previous sections was examined to extract individual components from rectangular area. Character extraction algorithm consists of global and local searching. In global searching the objects borders classify which part is enclosed with connected components while removing or erasing all smaller parts of the borders. The local searching algorithms were required to label individual connected pixel (objects) white objects of the inputs image. The black objects were conceived as background. The widest labeled black objects must be the borders [12].

The character extraction aspect of image analysis seeks to identify individual components or objects within the image. Character extractions operate in two dimensions and therefore any derived description of objects within the image should contain all relevant shape and size information originally contained within the stored image. There are two types of rectangular Tanzanian number plates; one with two rows and other of a single row see figure 2. Both types of number plates contain seven characters, but its rectangular shape has different aspect ratio.

The character extraction and segmentation algorithm was required to determine the region boundaries of sub-images within the image. The plate area had to be sectioned into several objects to provide the sub-regions of interest. The aim of this function was to divide and extract the components which were most likely objects to be characters (Letters and Numbers) and left the rest of other unwanted components[9, 10].

The parameters to be considered to extract the individual candidates from localized rectangular plate were

aspect ratio, extent, ratio of component area to the plate area, ratio component bounding area to the plate area of the letters and numbers present in the in the plate. The measurement of above properties or parameters was important factor of the recognition algorithms for subsequently manipulations of car image.

The choice of character to be derived from image influenced the effectiveness of interpretation stages in the detection and recognition algorithms. Therefore, a set of character should be identified that could help to uniquely indicate the key differences between the hopefully objects that would be uncounted constrained environment of algorithms.

2.5 Character Recognition and interpretation

Character recognition was most important task in recognizing number plate. The recognition of character has been a problem because there is a lot of possibility that character produced from previous stage may differ from that in the database. The same character may differ in shape size and style, which could result in false character, affect effectiveness and increase complexity of the system. This section looks at the algorithms which were used to classify and then identify the individual characters. The recognitions were based on extracted features.

Recognition of characters had been a big task which received much attention [13-15] in the field of pattern recognitions and image processing. Some previous researchers who contributed in recognition and interpretations of characters proposed methods like Markov model, neural network approaches, statistical pattern recognition, chain code, template matching and many others [16]. Each of these methods has advantages and disadvantages dependent on the working environments.

This was the core of this research; the processor to recognize snapshot captured by camera, and return a text representation of the detected image. This was the software aspect of the system which runs on standard PC hardware and could be linked to other applications or databases. It first used a series of image manipulation technique to detect, normalize and enhance the image and finally optical character recognition to extracts the alphanumeric from the license plate.

Vehicle number plate detection and recognition algorithms work was based on assumptions made and it is these assumptions that determined the weight of advantage and disadvantages in respect to algorithm's level of accuracy and robustness. Due to the varying characteristics of the license plate among countries/regions further research is needed in this area [17-19]. Therefore, for better detection rate, accuracy and robust algorithms, the combination of features and method can be used to provide more desirable results.

3. Experimental results and Discussion

The overall design processes of VNPDR followed the procedures based on MATLAB R2012b software. Some function, script and command were required to perform VNPDR operations. MATLAB R2012b Simulation software has Image Processing toolbox which was necessary when working with images. The whole process of vehicle number plate detection and recognition could be achieved using a procedure as explained below.

3.1 Image Acquisition and Pre-Processing

After loading the image to the software the first stage in detection and recognition of number plates was to perform image pre-processing that consisted of image enhancement and restoration processes for quality improvement.

These were:

RGB to gray scale: conversion of natural color to gray scale image (rgb2grey()).

RGB to indexed image: representation of color image in a practical way. It stored image as two matrices. The first matrix was instruction and second was color map command [X map] = rgb2ind() was applied.

HSV color space conversion: conversion of Natural color to HSV. RGB image was not preferred in detection and recognition process because it was not stable when light conditions varied (hsv=rgb2hs ()).

Filtering: The media filter to eliminate the unwanted noise from the acquired image command medfilt2 (). The fig.3 shows the procedure applied for pre-processing

3.1.1 HSV color space

Natural color or original RGB was not used in localization of plate number; instead HSV was preferred because it was stable when light conditions varied. Therefore, it was easier to detect and recognize number plate with varying color or for similar parts of color values of a plate region.

In MATLAB R2012b Function rgb2hsv () was used for color conversion image between the RGB and Hue, Saturation, Value (HSV) color space. The HSV color space was often used for picking colors (eg paint or ink) from color wheel or palette because it corresponded better to how people experienced color than RGB color

space.

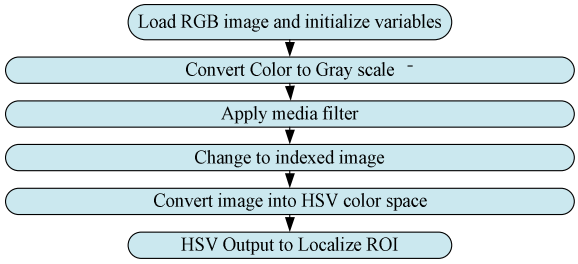
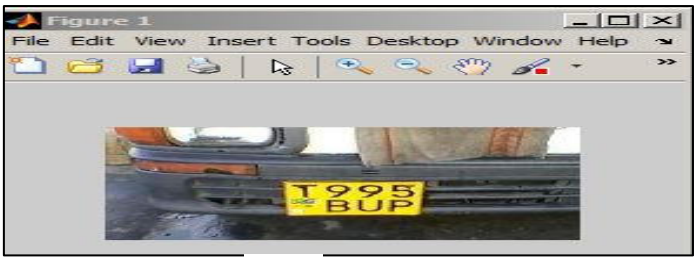
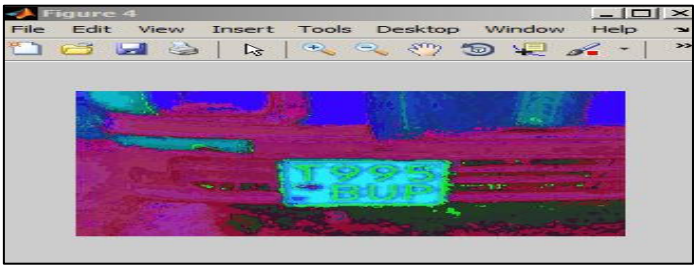


Fig. 3 Flow chart to show image pre-processing

As shown in Fig. 4; Hue, Saturation, and Value or brightness helped to indicate exactly location of plate area in the car image. When working on pre-processed image, it was important to put emphasis on for quality enhancement and restorations.



a



b

Fig. 4 (a) show original images and (b) show HSV image.

3.2 Number Plate Area Detection and Extraction

The process of number plate area detection and extraction involved three stages of finding area of interest (ROI), filtering out background and removals of false objects, and lastly computing of connected components which provided best results of required region of interest see Fig. 5.

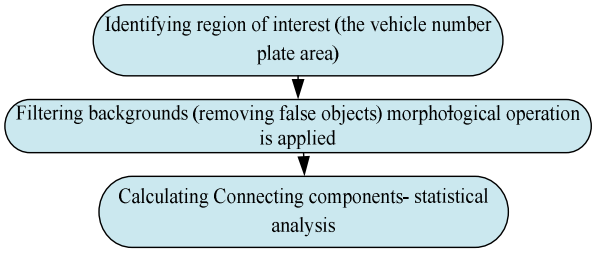


Fig. 5 Sequential flow chart to compute ROI

The masked image was computed using function (dim (1), dim (2)), where dim (1) computed rows and dim (2) computed columns. MATLAB 2012b experiment simulated to test loop to obtain the mask that consisted of regions of interest (ROI) with seven objects as shown in fig.6. Algorithm flow chart indicated in fig. 5 and fig. 7 was applied to compute ROI. Thereafter, the coordinates and position of number pates were located. The algorithm in fig.8 determined the four coordinates of the rectangular shape which contained English like alphanumeric character that was extracted as [X, Y, Width and Height]. Image shown in fig.6 indicate exactly

the plate number area. The HSV color space image, morphological and statistical analysis operations were integrated to compute plate number area which was region of interest (ROI).

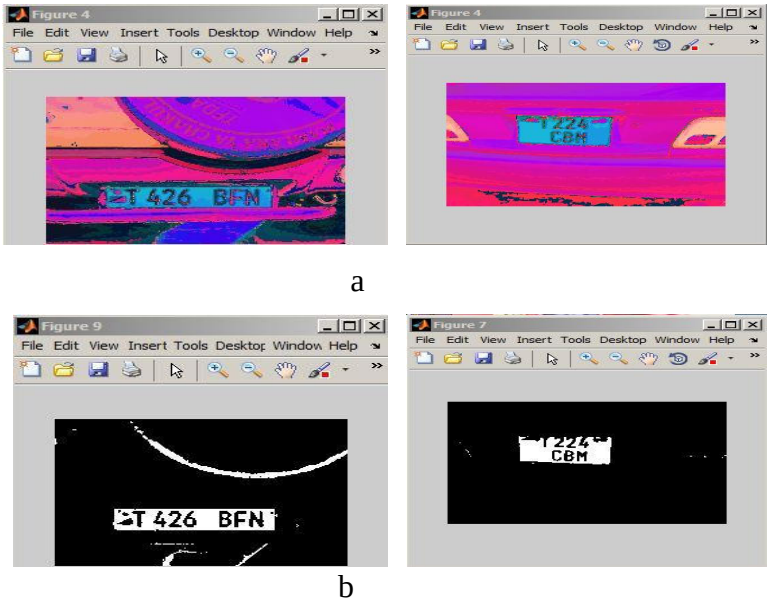


Fig. 6 (a) & (b) number plate area for single and two rows

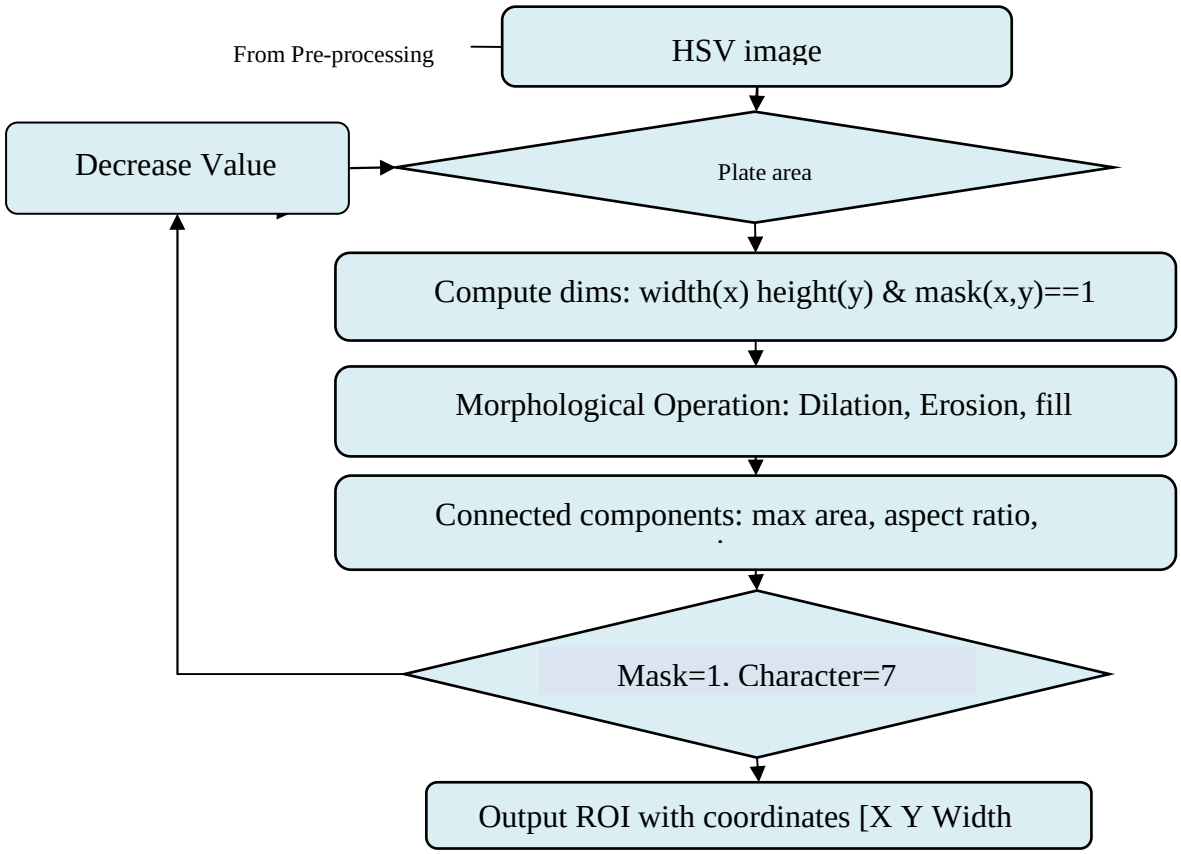


Fig.7 shows flow chart output ROI coordinates

3.3 Character extraction and Segmentation

3.3.1 Experimental Analysis

The experimental analysis, cropped image of public or private vehicle which contained 7 characters, arranged in single row or double rows was fed to segmentation stage. Character extraction algorithm involved global and local boundaries searching. The character segmentation algorithm (s) was processed repeatedly while reducing the threshold value until seven (7) connected components (objects) were found see fig. 8.

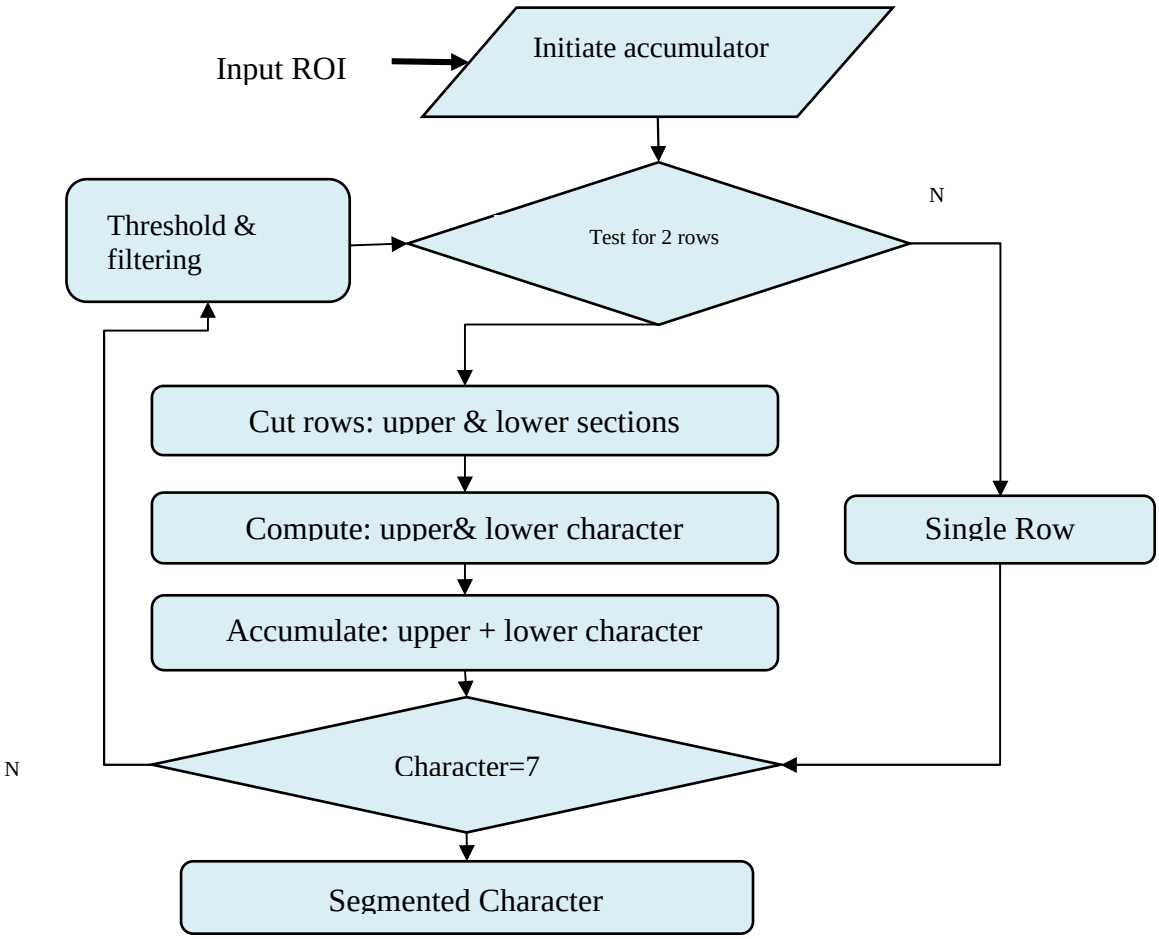


Fig. 8 Flow chart which returns segmented character

The design of algorithm to recognize plate that started with single letter followed by 3 numerical and completed with recognition of 3 letters. An algorithm could test for double rows or a single row. If the output was for double rows, the number plate was cut into upper and lower sections to maintain integrity of registration number.

The criterion used to divide the plate into two parts was to ensure that, the plate did not cut the characters. The row with minimum pixels was found; in the middle of two rows there was minimum whitish or reversed black pixel which has be used to achieve this purpose. That means result of upper and lower rows would sum up to form 7 characters, whereby the upper row contained 4 characters and lower rows contained 3 characters. The output from single row also produced 7 characters at global boundary, that were identified from left to right side of number plate whereby no cut action was applied.

3.3.2 Results

The algorithm detected either a single or a double rows number plate format using aspect ratio techniques. Double rows format was define with aspect ratio less than 2.2. The threshold value was applied to reduced components into separated characters. At threshold, all unwanted sub-objects were filtered out from the objects of interest which was seven alphanumeric characters. The output of this experiment which has JPEG format and 42x24 pixels was fed to recognition stage for interpretations.

3.4 Character Recognition and Interpretations

3.4.1 Experimental analysis

The character recognition algorithm developed was demonstrated using MATLAB R2012b. The simple matrix database template of each letter and number made of 18 fonts was created alone with algorithm. The database contained letters A to Z and numbers 0 to 9 English like that are used in Tanzanian numbering system.

Before matching processes, the acquired image from source were processed and read as a JPEG. Therefore, in recognition stage the extracted character from segmented image was differentiated from background.

Template matching

For experimental purpose, the template matching database and character extracted from car image was correlated to recognize letters and numbers. For this case an extracted character were correlated with template database which are made of 0 to 9 numbers and A to Z English letters. The size of each character image was normalized according to the size of characters stored in the database see fig. 9. Here each character was fitted to 42 x 24 was correlated for maximum match.

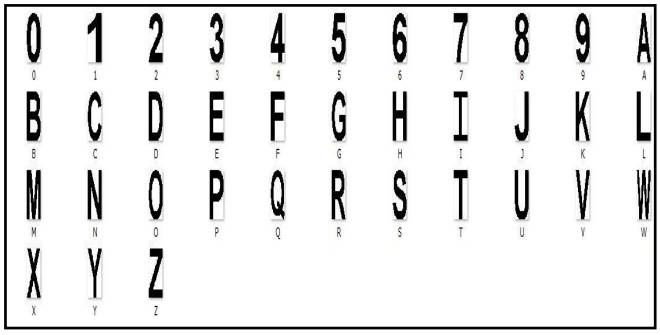


Fig.9 template database

3.4.1 Result

The developed algorithm recognized the characters and presented them as text. The method used was to compare the extracted characters with the database called templates. The recognition was done by comparing each extracted character to all the templates in the database and the one with maximum resemblance was picked.

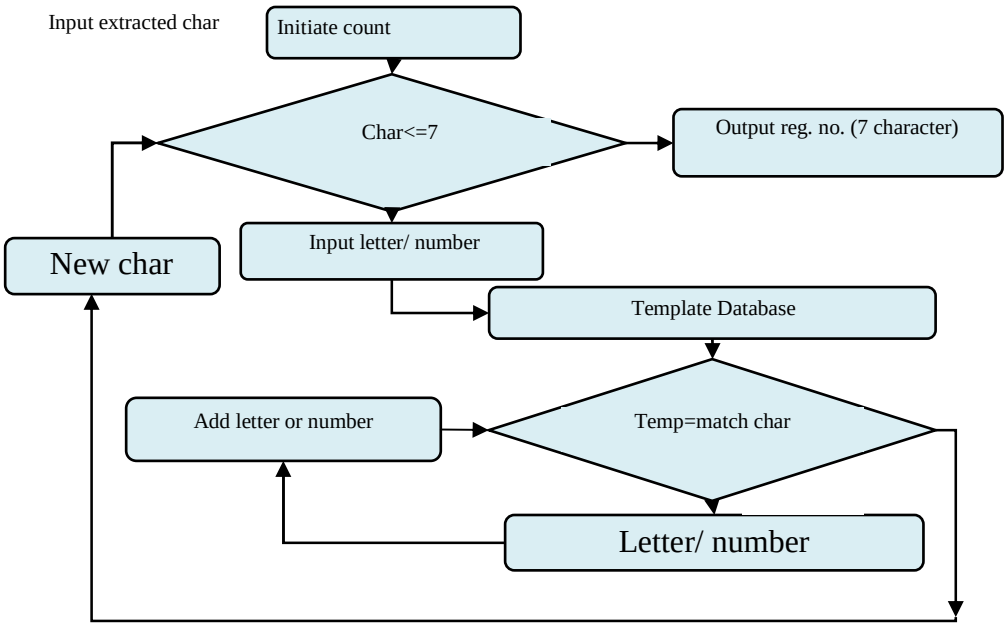


Fig. 10 Flow chart output the registration number

Each extracted character was correlated to its maximum corresponding pixel in the template. The character was validated when the maximum match was achieved. In the validation process, if the seven characters present in the number plate and characters present in the character database matched then validation was successful and authorization was given to that particular vehicle for security and automated applications. Fig.11 and fig.12 shows recognized registration number using developed algorithm as implemented in MATLAB

R2012b. the registration number is located on top of image.

(a) (b) (c) (a)

Fig. 11 (a), (b), (c), and (d) recognized registration number on top of image.

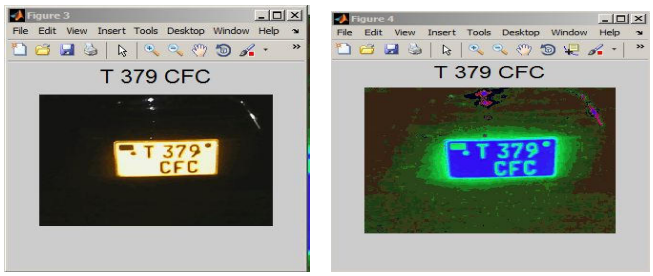


Fig. 12 Recognized registration number.

4. CONCLUSIONS

The concept introduced of using multiple factors to improve reliability of number plate recognition schemes has been successfully tested for both single row and double number plates used in Tanzania. The process of taking the image and processing timely. It has been shown that number plate detection algorithms require an effective sets of hardware and software components to be implemented. Tests made showed that set of processed input image helps to recognizes number plate character from car image background independent of location, size or orientation of the objects, so that the variation in number plate position and orientation can be accommodated.

The output of this research can help to cut down human resource cost and increase overall efficiency of transportation and traffic monitoring sector. It can also support fighting against crimes and offenses like terrorist and blacklisted vehicles. In summary in can be applied in a number of enforcement applications.

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