Tropical Journal of Science and Technology, 2(1), 38-48, 2021
ISSN: 2714-383X (Print) 2714-3848 (Online) Available online at credencepressltd.com
DOI: 10.47524/tjst.21.6

Automated number plate recognition system

Emina E. Etomi[1] and [2]Donatus. U. Onyishi
[1]Federal University of Petroleum Resources (FUPRE), P.M.B. 1221, Effurun, Nigeria
Corresponding Email**:** [1]etomiemina@yahoo.com
Email: [2]onyishi.donatus@fupre.edu.ng.

Abstract
Automatic Number Plate Recognition (ANPR) system is an automated mass surveillance method that uses several Digital Image Processing (DIP) technique and Optical Character Recognition (OCR) on images to read and identify vehicle registration plates. ANPR has yielded multiple positive results in practical applications such as: access control, traffic law enforcement, inventory and property management, security systems surveillance, parking space allocation, and road traffic surveillance. The automatic number plate recognition system (ANPR) developed in this research work focused mainly on number plate localization and licence plate extraction from an image for possible application in different areas. It achieves this by using several OpenCV digital image processing (DIP) technique developed with python to bring about image segmentation from which some image segments were tested for characters, so that the length of character found on each segment with similar properties becomes the key towards localizing and cropping off the region with the actual vehicle licence plate. Some properties of characters that was used to isolate the possible licence plate are the fact that characters of the licence plate have corresponding image height, width, aspect ratio etc. using these pixel properties it was possible to filter off unwanted contour lines/curves that stands out as noise while localizing the actual region of the image having the plate number. Once the region was obtained OCR was used via a trained template for several character styles to obtain the text format of the licence plate. The work developed had a plate localization accuracy of 100% and 90% read accuracy.

Keywords: Automatic number plate recognition, digital image processing, optical character recognition, openCV

1.Introduction
As a result of the growing number of vehicles on the road, with each having different plate numbers and their use in crime perpetration, amongst others, it became imperative for the development of an automated electronic system of vehicle identification through the recognition of vehicle numberplate (Haines, 2009). This automated electronic system usually called Automatic number-plate recognition (ANPR) is a technology that uses Optical Character Recognition (OCR) on images to read vehicle registration plates to create vehicle location data, it uses existing closed-circuit television, road-rule enforcement cameras, or cameras specifically designed for the task (Wikipedia contributors, 2020).

ANPR have different areas in which it can be applied or used. It is used by police for law enforcement purposes; with this the police can automatically check for registered vehicles or stolen vehicles (NPPC, 2016). Also, ANPR have been deployed as electronic toll collection on pay-per-use roads, by the government as way of revenue collection (Anuja1, Anusha, Dharshini, Muruga, & Radha, 2017). It has also been applied in the area of gathering statistical data of movement of traffic along highways. ANPR have been applied in some homes/offices to manage vehicle access control in to its garage/premises. It has also been used to create database of stored images captured by the ANPR camera and extraction of the text from the image of the licence plate for possible crime investigation (Hamed, 2016) (Ganesh & Kailash, 2015). The ANPR technology has become so important through the years since its invention and first application in the UK in 1979 and in recent time has been greatly integrated into many aspects of human life which will be discussed shortly.

1.1 Law enforcement

In law enforcement the ANPR system is very important and can be used any of the following instances: Operational Response- As a vehicle approaches an ANPR camera; the camera captures the vehicle number plate (VNP) and instantly checks it against the police database records of vehicles of interest (VOI) (Avadhut & Digambar, 2017). In a situation where the VNP matches with VOI on the database VOI Police officers is dispatched to intercept and stop the vehicle, check it for other supporting evidence and make arrests where necessary.

Information and Intelligence- In this case ANPR are useful in spotting and monitoring of VOI linked to cases in relation to national security, terrorism, or has been linked to organised crime (David & Meghann, 2012). So that as these VOI passes they are closely monitored by investigation team.

Investigations- ANPR systems have been used for recording vehicles passing by, including vehicles that are not of interest as at the time of the recording but such recordings may become useful in appropriate circumstances for the purpose of investigation. ANPR usage in this manner has proven to be important in the detection of many offences ranging from locating stolen vehicles, locating vehicles without insurance, solving cases of terrorism and organised crime (Avadhut & Digambar, 2017).

In Australia, the Department of Justice (Victoria) and State Police Forces use both the fixed and mobile ANPR systems for the identification of unregistered and stolen vehicles (John & Hornsby, 2017). The fixed type of ANPR system had its first trial in Australia in 2005 by the New South Wales Police Force Highway Patrol (John & Hornsby, 2017), while the mobile ANPR system also known as MANPR was rolled out in 2009 (Wikiipedia Contributors, 2021) (Akila, Sabitha, Jayamurugan, Teveshvar, & Vignesh, 2019). The MANPR had three infrared cameras fitted to its Highway Patrol fleet. Both the fixed ANPR and MANPR were used to identify disqualified or suspected drivers and persons of interest with outstanding warrants.

In different parts of the world such as Austria, Belgium, Dubai (UAE), France, Italy Spain, UK etc. ANPR systems are used for speed limit enforcement (Akila, Sabitha, Jayamurugan, Teveshvar, & Vignesh, 2019). The ANPR system measures the vehicle speed by tracking vehicle travel time between two fixed points and calculating the vehicles average speed.

Another area of application of the ANPR is in providing perimeter security. Private ANPR has service application for valet/recognized customer and VIP recognition, logistics and key personnel tracking. In the US, though private facilities cannot access government or police watch list, they develop private database for match against customers, VIP, critical personnel or banned person list (Wikiipedia Contributors, 2021).

1.2 How ANPR system works

A typical ANPR system works using an ANPR camera to capture the image of a vehicle number plate (VNP) (Anci, Bhuvaneswari, Haritha, Krishnaveni, & Punithavathisivathanu, 2019). To trigger this capture of the VNP, the ANPR camera is triggered either by the use of electronic hardware with sensors such as IR sensors or motion detection software tied to the ANPR camera (Rajvanshi, 2015). Though exiting CCTV camera can be used but better results are often achieved by the use of special ANPR cameras (Williams, 2016). Once the VNP has been captured, the image is passed through a digital image processing (DIP) software which locate the position of the number plate in the captured image and extract the letters and characters so that they can be identified by the use of Optical

Character Recognition (OCR) software (Dhiraj & Gaikwad, 2014). The extracted data is then saved and checked against a database for a positive match. If there is a match for example the ANPR system can open a barrier at a highway toll (Shilpi & Vishal, 2017), or even issue an immediate warning to the police about a stolen car or Unregister Car Of Vehicle Of Interest (VOI) Or Even Carry Out A Specified Function For Which Is Has Been Designed.

One area of keen interest is the identification of vehicle number plate of which is the focus of this work. Such identification can be carried out on either a stationary or moving vehicle depending on the level of sophistication of the developed algorithm and camera property selected. The number plate often detected is used to query a database in order to obtain relevant information or to carry out an action such as granting access to a restricted environment. Such database may contain a range of information from pre-stored history of vehicle usage, location, owner information, traffic offences, tickets etc. Such details are often used by the police for surveillance to mitigate criminal activities and to locate vehicles in advanced countries of the world.

Anisha and Rekha, 2016 used MATAP software for ANPR in their research a mat template containing image of A-Z and 0-9 was added to a mat file to enable the system to recognise alphanumeric characters captured. After which, the image containing these alphanumeric characters was read and converted to greyscale image. It was then further converted to its binary equivalent and stored in its data set to enable comparison with extracted alphanumeric characters from VPN image. To extract the alphanumeric character of the VNP a similar process was used to obtain the binary out of the VNP from the image of the vehicle. Firstly, the input image is changed to greyscale and on the grey scale image procedure of morphological scanning is actualized that checks the image and identify the VNP from the auto body. The VNP then went through slit segmentation to obtain the individual character which was then coordinated with the existing dataset. The most extreme coordinated was identified as the final result. With this method the researchers were able to show that the developed system can utilize image processing techniques for recognising the vehicle (VNP) from the database stored in computer by user. They claimed the system worked agreeably with a wide variation of conditions and distinctive sorts of number plate. The system was actualized and executed in Matlap. It is important to point out that though their research was able to recognise the 26 alphabets and 0 to 9, the research did not point out the nature of the algorithm used in creating the image classifier used for the OCR nor the confidence distribution for the characters obtained in other for them to showcase/quantify the accuracy of the ANPR system developed. With this there is no way to truly evaluate the accuracy of the research work carried out. Also, the number of test cases the ANPR system was tested on was not stated in their work.

In a similar work by Muhammad T.Q and Muhammad Asif in 2009, an ANPR system that combines software and hardware model for the detection of number plate was developed. The software model consists of a series of algorithm implemented in MATLAP 7.0.1. It consists primarily of three stages, these are: Capture image, extract the plate from the image and recognise the number from to extracted plate. To achieve the first stage of image capture a USB camera captures a frame in RGB format as a result of the action of an IR sensor that senses approaching vehicles. The second stage extracts the number plate from the image of the vehicle. It achieves this by the of a yellow search algorithm to locate the region of interest (ROI), since the

official number plate of Sindh has yellow background and black alphanumeric characters. If a yellow value pixel is located the pixel value is set to 1 and otherwise to 0. So that the image obtain after the yellow search algorithm is in black and white. The resulting ROI is then filtered using two different techniques. The first technique removes all white patches on the boarders of the image while setting it to 0 (Black). The second technique uses pixel count method to filter off white pixels not having a predefined number or threshold value while converting it to 0, so that the resulting ROI image will contain just the vehicle number plate. To conclude the second` stage, a smearing algorithm was used to find the first and last white pixel starting from the top left corner. This enabled obtaining of the vehicle number plate and hence the cropping of the ROI. The third and final stage uses OCR recognise every character of the number plate. This is made possible by inverting the output image of the second stage so that the alphanumeric characters are in white and the background is black. Next, line separation process was applied to the row and column to bring about separation of individual characters. The separated individual characters are then stored in variables. The stored character is then compared against the complete alphanumeric database using OCR. Finally, the characters together form a string that is compared against a database for vehicle authorisation.

The ANPR system developed successfully detects the Sindh standard vehicle number plates in various day conditions and shows high detection and recognition rate. They pointed out that the distance is a factor that affects the size of the image and consequently the accuracy. Also the OCR used a correlation method for the character recognition and the probability of the recognition can be calculated. But their research paper did not show these calculated value of confidence of the character recognised or the detected number plate rather they pointed it out as an improvement that can be made to the work. The developed ANPR system is computationally inexpensive and can be implemented for real time vehicle identification system.

Arulogun and Amusan, 2015 on their paper vehicle licence plate recognition using edge detection and neural network divided ALPR system into five distinctive sections. They are: image acquisition, pre-processing, plate extraction, character segmentation and character recognition. Image acquisition stage uses a digital camera to capture a coloured image of a vehicle. The captured images were taken both at day light and night for processing. The captured images are then fed to the pre-processing stage that converts the coloured image in RGB format to grayscale images but in NTSC standard method. The grayscale image then goes through a median filter that calculates the median value of the pixel and replaces pixel valve with the median equivalent. This non-linear filter removes noise from the grayscale image while preserving its sharpness. The plate extraction stage performs the process of plate localisation on the image to identify pixels that does not belong to the region of the image having the licence plate. It uses horizontal and vertical localisation phase to locate both horizontal and vertical segments of the number plate. The operator used to bring about this is the Sobel mask edge detection for vertical and horizontal line filtration. Next is the character segmentation stage, this stage recognizes the isolated characters and dividing the extracted license plate into individual character images, the character in each number plate can be identified clearly. This process was divided into character region enhancement, noise removal and projection analysis. The final stage for their ALPR system is the character recognition stage, this stage involved the recognition of characters previously extracted from the

licence plate. They used Artificial Neural Network (ANN). To increase recognition efficiency for alphanumerical characters that looks similar e.g. “0” as “O”, “2” as “Z” and “8” as “B”, they used two separate ANN, each having the same architecture but different input numbers.

The results from their research paper is quite promising as it shows a 97% accuracy for extraction of vehicle licence plate, 96% for character segmentation and 98% for recognition of character of the 200 plate numbers tested.

Another work on ALPR for the detection of traffic violations pointed out ten steps for licence plate identification (Parul, Kritika, Mohd, & Vinita, 2018). In the first stage they used a digital camera to capture a coloured image of the vehicle from either the front or rear. At the second stage, they converted the colored image in to grayscale image. This was done by separating the 24-bit value coloured image to the RGB (red, green, blue) components, so that the resulting image is an 8-bit gray value. Next stage, they implore the use of dilation, this process of dilation brightens the gray scale image and prevent erosion of small dark spots on the image that may hold vital information due to rapid intensity change in the image. At the third stage to shrink the image regions they applied erosion using the Matlap “imerode” function. The fourth stage involved Morphological processing which is for the purpose of edge detection to preserve the structural properties. This was done using Sobel filter with the Matlap function “imsubtract”. The fifth stage involved sharpening and brightening of the image by the process of convolution. At the sixth stage a process of thinning was applied to bring about character isolation and removal of foreground pixels from binary images. Once the processing of thinning is achieved, stage seven involves the use of rectangular bounding box to connect regions comprising of al pixels present in it. Stage eight they dealt with character segmentation, which involved extracting characters from the licence plate and passing the characters through OCR module. The ninth and final stage of their work was the use OCR to process the characters to obtain a text character. This involved scanning the text character by character and then translating it into character codes.

2. Methodology of proposed ANPR

The ANPR system developed here is based on Optical Character Recognition OCR using OpenCV and it was written in python. Figure 3.1 depicts the flow diagram for the extraction of vehicle licence plate to text. In this work a total of 20 Nigerian vehicle licence plates obtained randomly on the internet and a mobile phone camera where tests by the developed algorithm.

By running the developed python script in PyCharm IDE, a coloured image file in jpg or png format containing the vehicle is converted to gray scale image (Figure 3.2 and Figure 3.3 contains the original image & gray scale image). This is the first step in the process of the extraction of the vehicle licence plate since its difficult processing coloured images. At this point in other to localize the area of the vehicle image containing the licence plate an image thresholding technique was used to convert the gray scale image into its binary form (See Figure 3.4). Next, all contours contained in the vehicle image is obtained from the thresholded image by the use of the opencv function for contours.

Since the image contour obtained contains both images from the background (noise) as well as alphanumeric characters from the licence plate, it was therefore necessary to differentiate between the actual characters of interest from the noise on the background of the image. This was achieved by passing the contours obtained through a function that distinguish character from background noise. The function developed

used the following contour properties: area, aspect ratio, width, and height of the image as criteria for filtering off images that are non-potential characters. This was based on the fact that pixels containing the alphanumeric characters of the licence plate will have an approximate dimension similar to one another which will not necessarily be contained within the noise from the background. At this stage all characters having similar dimension were made to have same colour (Figure 3.7) and a bonded rectangle was used to group them together as seen in figure 3.8. With this, each of these groups were then cropped from the original image and the same process is repeated (i.e converting the RBG image to gray scale, gray scale to threshold image & threshold image to contour) to obtain the image contour. Each group having matching character was then passed through an OCR check (A-Z and 0-9 for a match) to evaluate and compute the length of string it contained. While the matched character with the longest string is selected as the potential licence plate region and cropped. Finally, the potential licence plate text is printed on the original image as shown in Figure 1.

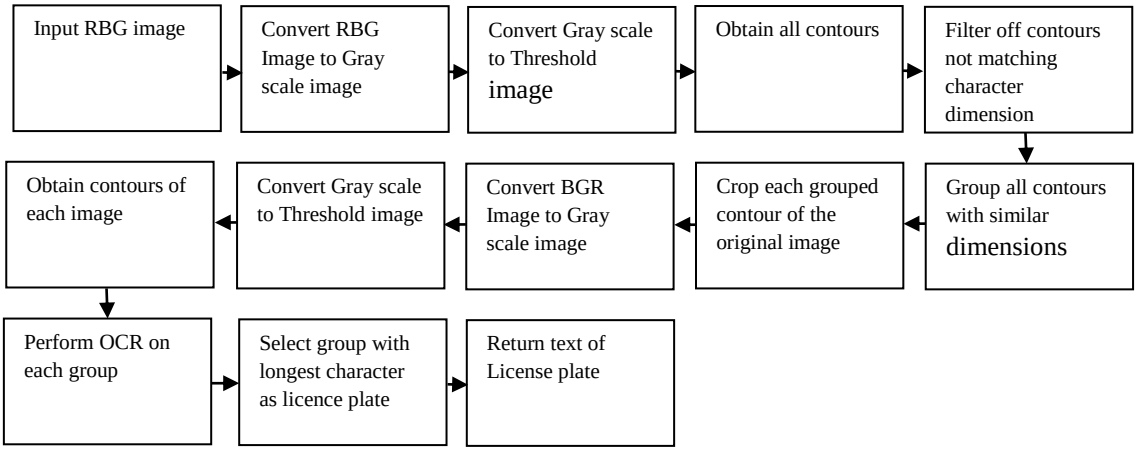

Figure 1: Block diagram of proposed automatic number plate recognition system

The results of each stage as contained in the bock diagram in figure 3.1 for a single image processed are shown from in figure 2 to 9.

Figure 2: Original image

In Figure 3 the image depicts the gray scale equivalent of the BGR original image.

Figure 3: Gray scale image

The threshold input image of the gray scale image and the resulting threshold image is shown in Figure 4 having just two colours, white and black.

Figure 4: Threshold and Canny edge image

The image in Figure 5 shows all the contours from the threshold image of the vehicle.

Figure 5: All contours

Figure 6: Filtered contours with defined dimensions (Area, weight, and height)

Figure 7: Grouping similar contours

Figure 8: Highlighted plate number contour

Figure 9: Cropped plate number and text of licence plate

3. Results

A total of 20 license plates were tested on the developed program code written in python. The code supported the following file formats: jpeg, png, jpg, tiff, tif. The various images used for this work were taken in different illumination conditions by different cameras. The images were also taken at different distance to the car, with different image sizes, background colours. A summary of the result is contained in Table 1.

Also for all 20 images the code was tested on, the code was able to localise and crop the plate number with 100% accuracy.

Table 1: Result of proposed number plate extraction

Total number of vehicle images	Total number of accurate read	Success rate (Efficiency)%
20	18	90

3.Discussion of results

A total number of 20 images having vehicle plate number were processed by the program developed. Each was inputted one at a time in to the python script. The developed code had a 100% success rate of localisation of all 20 number plate tested. It can be seen from Table 1 that the total number of accurate read is 18, making the success rate to be 90%. The success or rather the accuracy of

each read is dependent on the generated trained file from OCR that was developed for the work. This trained file using KNN technique had an accuracy of 98%. It is therefore not out of place to see a success rate that is not above this figure.

For the two plate numbers that could not be read accurately, the OCR picked up "Z" as against "2" and X as against "K". The process therefore works better with some font than others.

Figure 10: Image of wrongly read image

Conclusion

The algorithm developed in this work for the extraction of Nigeria plate number proved quite effective and efficient. It had 100% accuracy for licence plate localization but a read accuracy of 90%. All images tested were for images of stationary vehicle. It was not tested for vehicles on motion. Both of these valves are for image under different illumination conditions.

Future work on ANPR system will bring in improvements that enable the generated plate number to be used to query a database. Such database can be MySQL or MongoDB etc. which will allow for large storage of driver's particulars and vehicle data. With the output tied to a database this system can be used as an automated process for managing a large number of vehicle user profiles as well as access control. MongoDB is a cloud-based database system that can be used to make the system universal. So that vehicle whose number plate is extracted can be tracked universally from anywhere in the world through the internet via the database.

Another area of improvement is the use of Microcontrollers and microcomputer circuits such as Raspberry pi, Arduino, ESP32, NVIDA etc. This will allow the control the ANPR control its input/output port final control elements likes "gates" thus enforce access control through the open/close action.

References

Akila, K., Sabitha, B., Jayamurugan, R., Teveshvar, M., & Vignesh, N. (2019). Automated License Plate Recognition System, using Computer Vision. *International Journal of Engineering and Advanced Technology (IJEAT) , 8* (6), 1878-1881.

Anci, M., Bhuvaneswari, M., Haritha, N., Krishnaveni, V., & Punithavathisivathanu, B. (2019). Design of Automatic Number Plate Recognition System For Moving Vehicle. *International Journal of communication and computer Technologies , 7* (1), 001-005.

Anisha, G., & Rekha, B. (2016). Automated Car Number Plate Detection System to detect far number plates. *IOSR Journal of Computer Engineering (IOSR-JCE) , 18* (4), 34-40.

Anuja1, P., Anusha, R., Dharshini, M., Muruga, D., & Radha, D. (2017). Electronic Toll Collection Using Automatic Number Plate Recognition. *International Journal of Latest Trends in Engineering and Technology* , 001-005.

Arulogun, O., & Amusan, D. (2015). Vehicle License Plate Recognition Using Edge Detection and Neural Network. *International Journal of Science and Research (IJSR) , 4* (4), 3158-3161.

Avadhut, S., & Digambar, A. (2017). Automatic Number Plate Recognition and IoT Based Vehicle Tracking. *International Research Journal of Engineering and Technology (IRJET) , 4*, 1503-1507.

David, J., & Meghann, C. (2012). *Automated License Plate Recognition (ALPR) Use by Law Enforcement: Policy and Operational Guide Summary.* U.S. Department of Justice.

Dhiraj, Y., & Gaikwad, B. (2014). A Review Paper on Automatic Number Plate Recognition (ANPR) System. *International Journal of Innovative Research in Advanced Engineering (IJIRAE) , 1* (1), 88-92.

Ganesh, R., & Kailash, J. (2015). Extraction of Vehicle Number Plate. *International Journal of Innovations in Engineering and Technology (IJIET) , 6*, 386-390.

Haines, A. (2009). *The role of automatic number plate recognition surveillance within policing and public reassurance.* University of Huddersfield.

Hamed, S. (2016). Proposal for Automatic License and Number Plate Recognition System for Vehicle Identification . *International Conference on New Research Achievements in Electrical and Computer Engineering* , 001-005.

John, G., & Hornsby, T. (2017). *Automatic Number Plate Recognition (ANPR) Technology Not To Be Underestimated*. Retrieved from Stacks Law Firm: https://www.stacklaw.com.au/news/criminal-law/automatic-number-plate-recognition-anpr-technology-not underestimated/?utm_source=Mondaq&utm_medium=syndication&utm_ campaign=LinkedIn-integration

Muhammad, T., & Muhammad, A. (2009). Automatic Number Plate Recognition System for Vehicle Identification Using Optical Character Recognition . *International Conference on Education Technology and Computer 5* , 335-338.

NPPC. (2016). *Automatic Number Plate Recognition*. Retrieved from National Police Chiefs' Concil.

Parul, A., Kritika, C., Mohd, K., & Vinita, K. (2018). Implementing ALPR for detection of traffic violations: a step towards sustainability. *International Conference on Computation Intelligence and Data Science , 132*, 738-743.

Rajvanshi, P. (2015). Automatic Number Plate Recognition- Approch for Detecting the Vehicle Number Plate, . *National Conference on Cloud Computing & Big Data.* , 83-89.

Shilpi, C., & Vishal, S. (2017). Matlab Based Vehicle Number Plate Recognition. *International Journal of Computational Intelligence Research , 13* (9), 2283-2288.

Wikiipedia Contributors. (2021). *Automatic Number Plate Recognition*.

Retrieved from Wikipedia: https://en.wikipedia.org/w/index.php?title=Automatic_number-plate_recognition&oldid=1001393833

Wikipedia contributors. (2020, April 16). *Automatic Number Plate Recognition*. Retrieved 2021, from Wikipedia:https://en.wikipedia.org/w/index.php?title=Automatic_number-plate_recognition&oldid=1018055473

Williams, J. (2016). *5 Difference of Technology between CCTV and ANPR*. Retrieved from Houston Systems Private Ltd.: https://www.houstonsystem.com/blog/5-differences-of-technology-between-cctv-and-anpr