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# License Plate Recognition System: Localization for Kenya

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*Abstract*
*This paper describes the development of a reliable and accurate License Plate Recognition (LPR) system. In view of its potential application in traffic monitoring systems and highway toll collection, LPR systems have recently attracted considerable interest as part of an Intelligent Transport System. While much commercial work has been done for Iranian, Korean, Chinese, European and US license plates, little work has been done for developing country LPR systems [Jameel 2003].*
*In general LPR consists of four stages; Image acquisition and processing, License plate extraction, License plate segmentation and License plate recognition. This paper utilizes algorithms for the extraction stage, based on vertical edge detection. The segmentation stage is performed using two algorithms: division by eight and the horizontal and vertical projection profile also known as the peak to valley method. Finally two approaches of performing recognition are investigated, namely, template matching and artificial neural networks, particularly the multilayer perceptron.*
*The system was implemented using Matlab 7.6 (R2008a), Microsoft Visual Studio and Wamp Server tools. The performance of the system on about seventy real images resulted in a predictive accuracy of about 86.99% using the template matching recognition algorithm after segmenting with the peak to valley method.*
*Due to time and resource constraints, this application was not able to cater for foreign and special license plates. However, its development is a big step forward in*

*our country Kenya in terms of technology and if deployed to the different application areas, it would be of great benefit. This is in terms of revenue collection and enforcing security.*

*Keywords*
*Plate Localization, Connected Component Analysis, Segmentation, Vertical Projection Profile, Template Matching, Peak to Valley, Optical Character Recognition.*

## 1. Introduction

License Plate Recognition: License Plate Recognition (LPR) is an image processing technology used to identify vehicles by their number plates. In view of its potential application in traffic monitoring systems and highway toll collection, LPR systems have recently attracted considerable interest as part of an Intelligent Transport System. The first invention of the Automatic Number Plate Recognition (ANPR) was in 1976 at the Police Scientific Development Branch in the UK. Prototype systems were working by 1979 and contracts were let to produce industrial systems, first at EMI Electronics then at Computer Recognition Systems (CRS) in Wokingham, UK [Wikipedia 2009]. In this paper we present an LPR system as an application of computer vision which is concerned with the theory for building artificial systems that obtain information from images [Wikipedia 2009]. There are different algorithms that have been used in the process of license plate recognition for different countries. The reason is that climatic conditions e.g. winter, type of plate, alphabet etc. for different countries vary. One algorithm could work very well for a given country's plate but very poorly for another. We address the problem of an LPR system for a typical developing country Kenya's, license plates.

Application of LPR Systems: There are numerous applications of license plate recognition systems for any given country. They include highway electronic toll collection, automatic parking attendant e.g. in banks, hotels, airports and fleet vehicle compounds, customer identification enabling personalized services e.g. in golf clubs, leisure centers, petrol station surveillance, speed limit enforcementand security among others. The following section illustrates the application of such systems [Jameel 2003].

Law Enforcement: In this case the license plate is used to produce a violation fine on the speeding vehicles, illegal use of bus lanes, and detection of stolen or wanted vehicles. A speeding car's image can be caught by a traffic camera and the image sent to the system for processing to try and identify the particular car. The violators are presented with the image of the vehicle as well as the speeding information as proof.

Parking: The LPR system is used to automatically enter pre-paid members and calculate parking fee for non members by comparing entry and exit times. So, a vehicle will be recognized as it enters the parking lot and it's information as well as time is stored. During exit, the car is recognized again and its fee is calculated.

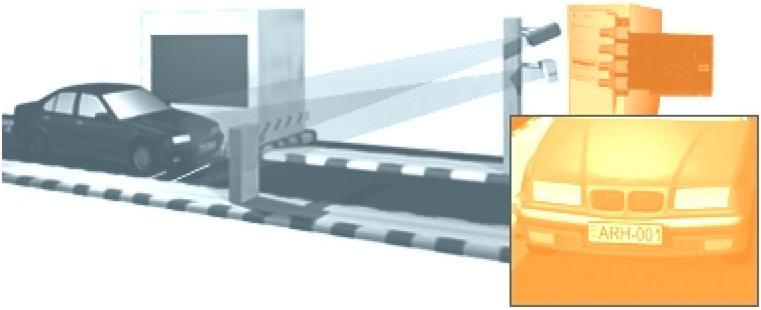


*Figure 1: How an Automatic LPR works*

Automatic Toll Gates: Manual toll gates require a person to stop so as to pay an appropriate tariff. In an automatic system, the vehicle does not need to stop. As it passes the toll gate, it would be automatically classified in order to calculate the correct tariff.

Border Crossing: This application can be used assist in registry of entry or exits to a country and can be used to monitor border crossings. Each vehicle is registered to a central database where additional information can be added.

**Similar existing applications**

Malaysian Vehicle License Plate Localization and Recognition System:
This system was developed based on digital images and could be easily applied to commercial car park systems for the use of documenting access of parking services, secure usage of parking houses and also to prevent car theft issues. The license plate localization algorithm was based on a combination of morphological processes with a modified Hough Transform approach and the recognition of the license plates was achieved by the implementation of the feed-forward back propagation artificial neural network [Ganapathy and Lui 2007].

Visicar, A neural network based artificial vision system for license plate recognition:
This is a neural network based artificial vision system able to analyze the image of a car given by a camera, locate the registration plate and recognize the registration number of the car. The main features of the system presented are: controlled stability-plasticity behavior, controlled reliability threshold, both off-line and on-line learning, self assessment of the output reliability and high reliability based on high level multiple feedback. It has an OCR engine [Draghici 1997].

## 2. Methodology

The development of the number plate recognition system was achieved using a streamlined iterative and incremental software process. This involved a combination of software engineering techniques Rapid Application Development (RAD) and the spiral model. Unified Modeling Language (UML) was used to model the detailed requirements of the system.

Global System Architecture: The overall License Plate Recognition system is based on a three-tier architectural framework where the top tier is the GUI-enabled client interface of the standard-alone application. This top tier interacts with the middle tier that comprises the image pre-processing module and the actual recognition module.

This middle tier can be viewed as the engine of the NPRS application. It receives user input, processes and after the plate has been recognized, it is stored in the database. The database is used to store the path to the image and the license plate that has been found after recognition. These images have high storage requirements that would result in slow response time due to the time it takes to retrieve them from the database. The images were therefore stored directly on a specified folder to minimize retrieval overheads.

## 3. Implementation

A License Plate Recognition system has four major stages:
Image Acquisition and Processing: Acquisition of images for this application was done using a Nokia N95 8GB phone which has a camera resolution of 5Mega pixels. Still images instead of real time image capturing were used due to limitation of resources.

The image processing stage was accomplished by first cropping the 1024 by 768 pixels image to a smaller size. Image pre processing techniques such as changing to grayscale, binarizing were then used on the cropped image. Further processing was done by performing median filtering [Schulze 2001], dilation and erosion

[Mathworks 2009]. The image was then smoothened using convolution after finding the vertical edges using the sobel operator.
Plate Localization: The main focus of performing image processing was so as to prepare the image for further processing which is plate localization. Due to the fact that car images have more horizontal edges as compared to the vertical edges, the vertical edges were used to find the plate region. Connected Component Labeling [Fisher et al. 2003; Eddins 2007] technique was used to filter out the irrelevant objects in the image. From the various experiments performed, it was found out that Kenyan plates have certain specific properties in terms of the vertical edges and the distance between the two edges of a license plate. The properties that were used to eliminate irrelevant objects in the binarized image included the area, aspect ratio, distance and the angle between the edges found. This stage resulted in finding the license plate region.

However, it is important to mention that this is the most difficult part of the application. The main drawback being that standards for license plate are lacking, some are very old and therefore the important objects in the image are not easy to retrieve.
License Plate Segmentation: Segmentation for this application was done using two methods; peak to valley (horizontal and vertical projections) [Jameel 2003] and the divide by eight algorithms (new- based on the characteristic of Kenyan license plates that have seven characters and a space which could fit one character). The horizontal projection which is the sum of the pixel values along the rows was used to remove the noise at the top and bottom of the extracted plate. Vertical projection or the sums along the columns was used to find the characters in the plate found. The peaks represented the characters while the valleys show the white region between the characters. Segmentation was then performed based on the peaks and valleys. The divide by eight technique was used because Kenyan plates have seven characters and a large space large enough to be a character between the third and the fourth characters. The fourth segment was discarded. This method would however not work for those plates with less or more than seven characters.

Optical Character Recognition: The final stage after segmentation is character recognition. This was performed using two methods namely template matching [Wing Yi 2003; El-Adawi et al.] and neural networks (the multilayer perceptron) [Mathworks 2009].

Template matching was performed using two sets of templates. One set was made up of perfect characters which were downloaded. The second was prepared from the images that had been collected. The use of two sets was done to achieve better accuracy. A correlation function was used to compare the match between the character segment and the templates in the database. The character that returned the highest match was output as the recognized character. A point worthy of note is that the number and letter templates were separated to reduce the error rate.

The multilayer perceptron was also used to implement the recognition module. This was done for comparison purposes. This was so as to find the best performing algorithm. The perceptron was designed to have one input, output and hidden layers. Two perceptrons were designed. These include the number and letter perceptrons. The reason for this was to improve the accuracy and avoid ridiculous results such as a letter being recognized as a number.

The hidden layer for the number perceptron had 40 neurons while the letter perceptron had 67 neurons. These numbers were settled at after conducting various tests and it was found that they returned the best results.
Figure 2 and 3 illustrate the image processing stage where a still image is fed to the system as input and various processes such as cropping, binarization and connected component analysis are carried out.

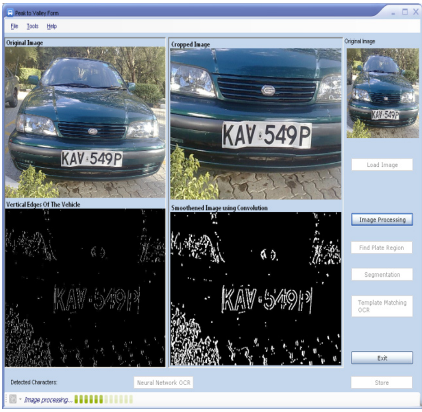


Figure 2: Image Processing

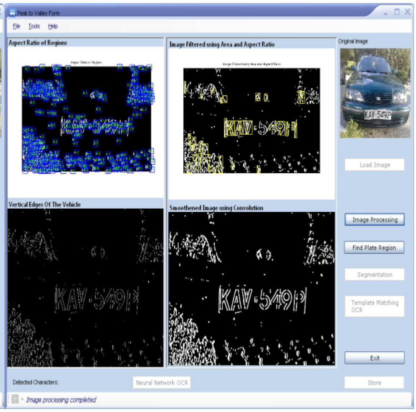


Figure 3: Image Processing

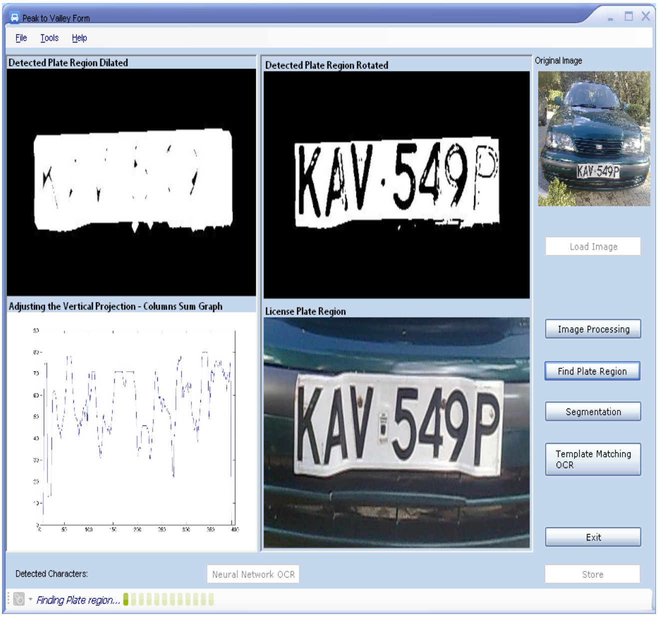


Figure 4: Plate Localization

Figure 4 illustrates the plate localization stage where the objects in the image are filtered based on certain criteria leaving our object of focus, the license plate region.

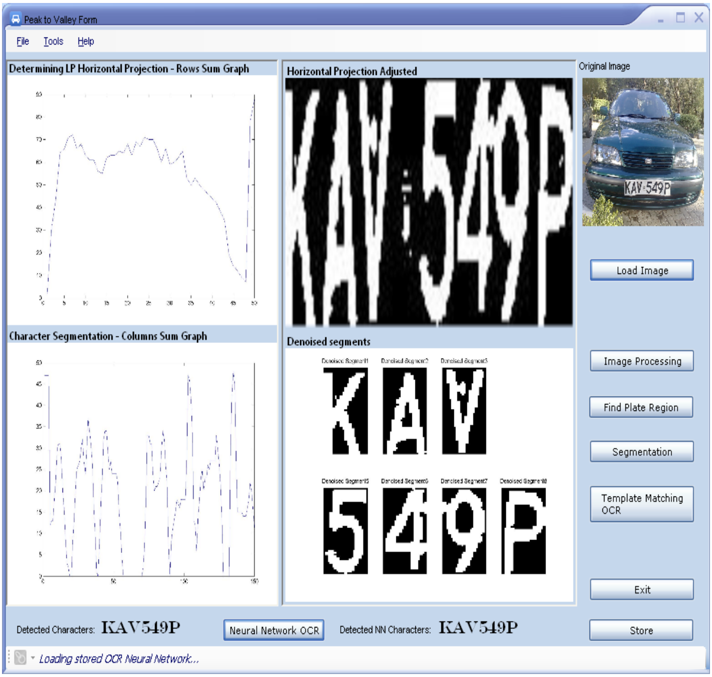


*Figure 5: Segmentation & Recognition*

Figure 5 show the final stages of the system output where the plate region found is segmented and recognition performed. Detected characters on the left are those found using the template matching OCR algorithm while those on the left are using the multilayer perceptron.

## 4. Results

The performance of the LPR application was determined in several ways:

Compare the results of the recognition stage after doing segmentation using the peak to valley method. Approaches used were: template matching and artificial neural network.

Compare the results of the recognition stage after doing segmentation using the divide by eight algorithm. Approaches used were: template matching and artificial neural network. The number of images used to test the application were around one hundred.

The analysis performed on the performance between the two segmentation methods, showed that that the peak to valley method led to better recognition results as compared to the divide by eight algorithm. The predictive accuracy of the template matching after segmentation using peak to valley algorithm was found to be 86.99% while that of using the divide by eight was 84.22%. The artificial neural network was found to perform poorly in comparison since it had an accuracy of 79.10% after segmenting using the divide by eight method. The results of segmenting using the peak to valley method gave the poorest results of 70.36% after recognition using the artificial neural network (see Figure 6 below).

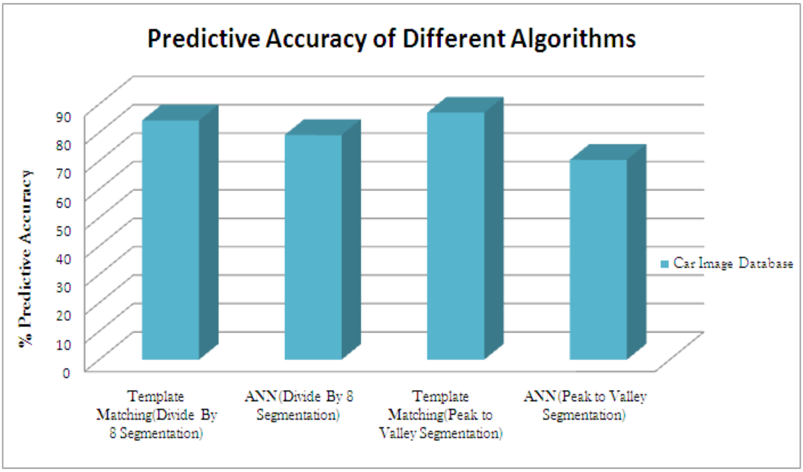


*Figure 6: Predictive accuracy graph*

The images were fed into the application straight from the phone used to capture them, no manual processing was involved.
The accuracy indicated by the above graph was per plate and not per character. Due to resource constraints, it was not possible to compare the performance of this application with others that may be existing and could be localized. However, it is important to mention that the reason different countries and regions have developed LPR systems is due to the fact that weather conditions among other aspects that influence accuracy come in to play and as we know, they vary. Also the character fonts, number, how they are combined differs greatly from one country to another. This is why this application was developed specially for the conditions and rules specific to Kenya.

It is also important to note that most of the time, inaccurate results occurred when old car images were processed. This is because it was difficult to locate the plate region as a result of faded and scratched characters on the plate. Other cases of misclassification that were prevalent included the characters F and P, E and F, K and X, 5 and 6 and G and C. However, having two sets of templates improved the results.

The diagram below is an example of a scratched plate that was successfully extracted from the image. The characters 8 and S were however misclassified since after finding connected components, the two characters resulted into more than one object, hence KAU762ST result by the best algorithm. Fig. 8 illustrates a processed image with no vertical edges found, hence it is not possible to extract the plate region.


*Fig. 7: Scratched Plate*

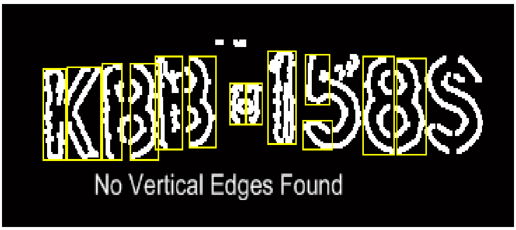


*Fig. 8: Vertical Edges not found*

**5. Conclusion and Future work**

License plate recognition applications are important applications which have hardly been embraced in developing countries such as Kenya. There are numerous possible areas of deployment for such applications which could lead to improved efficiency and reduced corruption cases if they were used by the City Councils to automate the task of manning parking lots, toll stations and border crossings. Business premises would also experience improved security if they deployed this system since it would be able to regulate the car owners who gain entry into their premises' car parks.
Improvements that can be done to this system would be incorporation of recognition of foreign number plates such as the red and blue plates. It would also be efficient if it was interfaced with a camera that captures images and processes in real time.

Since in this system the images were captured from the front of the vehicle with the main application area being deployment at exit points, in future, it would be of more benefit if the system could process images captured from different angles.
It has been observed that different algorithms perform better given different conditions and plates. This is why there is ongoing research of the best performing algorithm overall that can suit different environmental conditions. Some interesting alternative algorithms that would be probable to explore include the feature detection methods of SURF and SIFT.

Embracing this technology would lead to enhanced security and better revenue collection by premises owners and local governments, hence more funds available for community development among other benefits. Image processing technology has great potential as it can be used in a variety of tasks to provide localized solutions for developing countries such as Kenya as this paper has outlined.

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