Automated Number Plate Recognition Using Hough Lines and Template Matching

Saqib Rasheed, Asad Naeem and Omer Ishaq

***Abstract*— Automatic number plate recognition (ANPR) is an image processing technique used to identify the vehicle and its owner by its license plate. This technology is used as a method of electronic toll collection on pay-per-use, by various law enforcing agencies and monitoring traffic activity such as red light adherence in an intersection. This paper presents a robust method of license plate detection and recognition based on Hough lines using Hough transformation and template matching for Islamabad standardized number plates cars. The proposed ANPR technique consists of two main modules: (I) License plate detection module using Canny detector & Hough transformation. (II) License number recognition module using template matching. Experiments have been conducted on 102 samples on Islamabad standardized number plate cars images. These images were taken from different scenes under various illumination conditions.**

***Index termss:* Automated Number Plate Recognition, Optical character recognition, Hough Transformation.**

I. Introduction

Automatic Number Plate Recognition (ANPR) is a mass surveillance method that recognized the vehicle registration number from an image, captured by a camera. It uses optical character recognition (OCR) to read the license plate. ANPR was invented first time in 1976 at a police station situated in united Kingdom. Prototype systems started working in 1979, and contracts were awarded producing commercial systems. This technology is used by various security and traffic applications such as entrance of highly restricted areas for security like Parliament house, Supreme court, Military zones, or any other sensitive organization. These systems are also used for the traffic prospective gathering traffic flow statistics, finding stolen car, controlling access to car parks, like in parking area vehicle number plates is used to calculate duration of the parking. When a vehicle enters in the parking area, number plate is automatically recognized and stored in database by the ANPR system. When vehicle later exits from the parking area, number plate is again recognized by the ANPR system and the total time of parking is calculated by pairing with the first-one stored in the database. The difference in time is used to calculate the parking fee. Automatic number plate recognition systems can be used in access control. For example, this technology is used in many organization to allow access to only authorized vehicles to enter in the organization parking area and keeping other intact, it can also be used for tool collections from vehicle passing through different cities or bridges etc. [1].

Much research work has been done in automatic number plate recognition but all the previous work done is for a particular country or state or province. The system adopted in one country or province or state has poor performance of detection of license plate or it does not detect at all when a vehicle enters different country or state or province. Even if the system is able to detect the license plate it fails to recognize the characters and numbers on the license plate as different format is adopted by every country or state or province. Recently work done [2] recognizes only Sindh (Pakistan) number plate and fails to recognize Islamabad (Pakistan) number plate due to different format of the license plates. Some of the systems uses neural networks which requires large training data [3][4][5]. In the same way the boundary guided knowledge followed by template matching for automatic vehicle identification was proposed by Johnson and Bird [6] which fails to detect small original boundaries or edges and it consider noise also as a boundary. Optical character recognition is proposed by Morgan and Johson [7], but time consuming in recognition of characters. Neural Networks using fuzzy logic was proposed by Nijhuis , Ter Brugge and Helmholf [8] detects car license plate using neural network which also require training data. Fahmy [9] proposed BAM neural network for number plate reading, which also requires a large training data. Based on color image was proposed by H.J. Kim, D.W. Kim, S.K Kim, J.V Lee and J.K. Lee [10] is also a time consuming technique. Genetic algorithm based segmentation to extract the plate region was proposed by Kim [11], but it requires much time for processing. Neural network is used for color extraction and characters are recognized by template matching proposed by E.R.Lee, P.K kim and H.J.Kim [12] which needs a large training data set. Only vertical edges using Hough transform to extract vehicle license plate was proposed by Kim [13] has poor segmentation results. As many car images have vertical edges at the place of radiator, using Hough Transformation is very sensitive to deformation of plate boundaries, which results in large processing times.

Manuscript received July 23, 2012; revised August 10, 2012. Submitted on July 23, 21012.

Saqib Rasheed is working as a faculty member in Department of Computer Science, Air University, E-9 complex, Islamabad, Pakistan (Contact: 092-51-9262557, e-mail: saqib.rasheeed@mail.au.edu.pk)

Asad Naeem is Head of department of Computer Science, Air University, E-9 complex, Islamabad, Pakistan (e-mail: asad.naeem@mail.au.edu.pk)

Omer Ishaq is working as a faculty member in Department of Computer Science, Air University, E-9 complex, Islamabad, Pakistan (e-mail: omer.ishaq@mail.au.edu.pk)

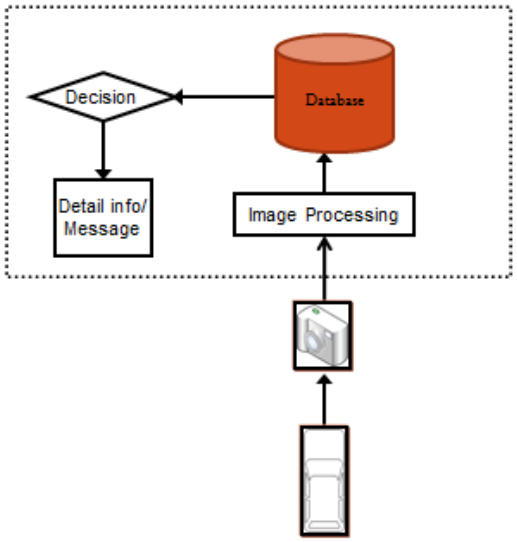


Figure 1: Basic Working of ANPR

The proposed method of ANPR is a light weight and a robust method which recognizes Islamabad standard number plate at real time under illumination conditions. The basic working of proposed ANPR system is that a car approaches where camera is installed, image is capture by the camera and passed to the ANPR system.

The number recognized by the ANPR system is compared with the database and decision is taken accordingly. Whereas proposed ANPR technique consists of two main modules: (I) License plate locating module using Canny detector and Hough transformation (II) License number recognition module using template matching to recognize individual character with the help database stored for each and every character (A to Z) and number (0 to 9). When vehicle number is recognized successfully it is compared with the database and information of particular vehicle is shown along with the owner of the vehicle and if it fails to do so the system shows miss match message. The basic working of the proposed ANPR is shown in the figure 1. The rest of the paper is organized as follow. Section II will discuss ANPR model, Section III will discuss results and section IV will discuss conclusion and future works.

II. Proposed Method of ANPR

The algorithm proposed in this paper detects and recognized vehicle license plate automatically. The input of the system is an image taken by the camera from a distance of 4 to 5 meters. The proposed ANPR technique consists of two main modules: (1) License plate locating module using canny detector and Hough line (2) License number identification module using template matching to recognize individual character with the help database stored for each and every character (A to Z) and number (0 to 9). The proposed algorithm is mentioned below and architecture of the proposed method is shown in figure 2.

Proposed Algorithm

[1] Load image.
[2] Pre-processing of the image.
[3] Licence plate detection.
(3.1) Edges identification using Canny detector.
(3.2) Identifying only horizantol & vertical edges using Hough transfromation.
(3.3) Extracting vehicle licence plate.
[4] Recogination of characters.
(4.1) Cutting the upper & lower part of the identified plate.
(4.2) Dilation operation to seprate the characters.
(4.3) Making blocks of size 38 x 20 for template matching.
(4.4) Matching two alphabets by cross-correlation.
(4.5) Matching three numbers by cross-correlation.
(4.6) Getting the ASCII values through OCR of 2 alphabets & 3 numbers.
[5] Number Identifyied.
[6] Compare with database stored.
[7] Message displayed.

The proposed ANPR system reads an input image taken by the camera and passes it to the pre-processing unit. The main operation of pre-processing unit is to eliminate noise caused in digital images during image acquisition (digitization) and transmission, imaging sensors can be affected by ambient conditions, interference can be added to an image during transmission. Image pre-processing unit attempts to restore images that have been degraded due to any one or more reasons.

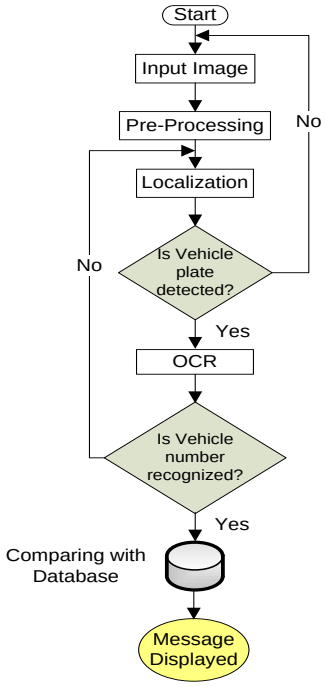


Figure 2: Architecture of ANPR

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

This unit identifies the degradation process and attempt to reverse it. It is similar to image enhancement, but more objective. The image having noise can be shown by the equation (1).

$$g(x,y) = f(x,y) + n(x,y) \quad (1)$$

Where $f(x,y)$ is the original image, $n(x,y)$ is the noise term can be caused by any factor and $g(x,y)$ is the resulting noisy image pixel.

A. Pre-Processing Unit

To enhance the image structure in computer vision, Gaussian smoothing is a spatial filtering used as a pre-processing unit to remove adaptive noise present in the image. As it is used to blur the images, remove details and noise from the image. The sources of noise in digital images arise during image acquisition (digitization) and transmission. Imaging sensors can be affected by ambient conditions; interference can be added to an image during transmission. The input gray scale image is convolved with Gaussian so we can remove unwanted details and noise from the image. Gaussian blur 2-d is shown in equation 2.

$$g(x,y) = \frac{1}{2\pi\partial^2} e^{-\frac{i^2+j^2}{2\partial^2}} \quad (2)$$

Where *i* will be the distance calculated from origin in horizontal axis, *j* will be the distance calculated from origin in vertical axis, whereas Gaussian distribution standard deviation is ∂. A convolution matrix is built by using the values of Gaussian distribution so it can be applied in original image. The new value of each pixel is set to a weighted average of neighborhood pixel. The original pixels will be allocated the highest weight and smaller weight will be allocated to the neighboring pixel. A smoothed image will be produced, preserving boundaries and edges better than other.

B. License plate detection

License plate detection module is further divided into the following subtasks.

1) Identifying edges using canny detector: The canny detection algorithm runs in five steps as mention:

[1] Smoothing: Remove the noise by blurring.

[2] Finding gradients: Where the gradients of the image have large magnitudes those edges are marked.

[3] Non-maximum suppression: Only local maxima are considered to be the edges.

[4] Double threshold: Potential edges are determined by fixing the threshold, which in our case is 0.5

[5] Edge tracking by hysteresis: The end edges are determined by deleting all edges that are not connected to a very true (strong) edge, as shown in Figure 3 (b).

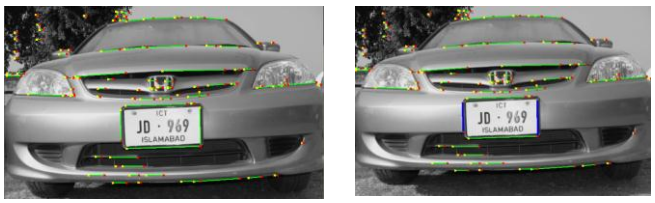
(a) Captured Image (b) Identifying edges using canny detector

Figure 3: Captured & Edges identified Image using canny detector

All the real edges in the picture are considered even some of the edges in the background, like edges of tree or fence are also detected and we get an edge map as shown in figure 3(b). By considering these edges number plate of the vehicle is extracted by using Hough transformation

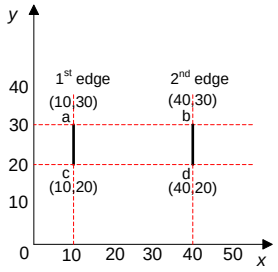
2) Hough Transformation

The Hough transform (HT), is a powerful global method for detecting edges. It transforms between the Cartesian space and a parameter space in which a straight line (or other boundary formulation) can be defined. So using Hough transformation all the strong edges vertically and horizontally in the image are identified as show in the figure 4 (a). When all the strong edges are identified then vertical edges are differentiated from horizontal edges as shown in the figure 4 (b). Now using Euclidean distance all the vertical edges are grouped and checked which of the two edges have same or almost same *x & y* coordinates (starting and ending points), are identified. There are two points for each edge. For 1st edge point *'a'*(10,30) and point *'c'(10,20),* for 2nd edge point *'b'* (40,30) and *'d'*(40,20) as shown in figure 4(c). Horizontal dotted line shows that point *a* & *b* have same height on y-axis and in the same way horizontal dotted line shows that point *c* & *d* also lies on same height regarding y-axis. So considering these two edges and discarding all other edges, point *a* is joined with point *b* and in the same way point *c* is joined with point *d*, which yields vehicle number plate identification as shown in figure 4 (d).



(a) Identifying strong vertical and horizontal lines (b) Identifying only vertical lines

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)



(c) Edges having same or almost same X & y coordinates

(d) Vehicle number plate detected

Figure 4: Vehicle number plate detection

C. Characters & number recognition using template matching

As the proposed method is working only on Islamabad standardized number plate, so for efficiency, the top and bottom part of the extracted number plate is cut off, because it has detail of the city and every Islamabad standardized vehicle number plate has same format. Before starting of recognition algorithm the characters are normalized into blocks containing no extra white space. This character separation is done by dilation operation. Smearing is applied in vertical and horizontal direction to find the character regions as shown in figure 5(b). Each character is cut off into block of size 38 x 20 by finding starting and ending point of the characters as shown in figure 5(c).

(a) Image involving only plate

(b) Locations of plate characters

(c) Individual characters

Figure 5: Dilation Operation of characters.

This is done for template matching the characters and numbers stored in database, which are 26 + 10 = 36 in total (A to Z and 0 to 9) and input image, extracted from vehicle image must of same size 38 x 20 blocks. After normalization the next step will be template matching. We are left with two characters and three numbers to match with the templates already stored in the database. So starting with two characters to find the best match of extracted image and template stored in database cross-correlation method is adopted. It is an efficient technique used for image recognition developed by Horwowitz [14]. Highest cross-correlation coefficient between the images yields a best match. The normalized cross-correlation between the two images is defined as by the equation.

$$R(i,j)=\frac{\sum_{x}\sum_{z} EI(x,y)TI(x-i+(M+1)/2,z-j+(N+1)/2)}{\left[\sum_{x}\sum_{y} EI(x,y)\right]^{1/2}\left[\sum_{x}\sum_{y}\left|\ TI(x-i+(M+1)/2,z-j+(N+1)/2)\ \right|^{2}\right]^{1/2}} \quad (3)$$

Where $EI(x,y)$ and $TI(x,y)$ for $1\leq x \& 1\leq y$ are two discrete images, extracted number plate image and template image stored in database, i = 1,2…….N, j = 1,2……M and where M and N are odd integers Serak.o, Ergun.E[15]. When the template match perfectly it gives high cross correlation, the proposed system gets the ASCII value of that template, for example the first character 'J' its ASCII value is '01001010' is saved and the system moves on to next character. If the system fails to match first character it goes back to step 4. This fail occur when characters are destroyed due to noise in the image. This noise can be caused during image acquisition (digitization), Imaging sensors can be affected by ambient conditions, Interference can be added to an image during transmission or the characters on the vehicle license plate is damaged due to any reason. If the system successfully recognizes two characters than it moves on to match three numbers and recognized them through their ASCII value. Figure 6 shows templates and there ASCII values which are matched.

01001010 01000100 00001001 00000110 00001001

Figure 6: ASCII values of alphabets & numbers identified

When all the numbers are matched and recognized through Optical character recognition (OCR) technology. This number can be used by any organization as per its requirement.

III. Results

Experiments have been performed to test the proposed ANPR system. The system is simulated in Matlab 7.9.0 on Core 2 Duo 2.93Ghz PC. These images were taken from:

1. Different scenes in which other objects were also present.
2. Various locations like streets, roadside and parking lots.
3. These images were taken from the length of 4 to 5 meters distance.
4. The size of the input image is 640 x 480.

Table I:Performance of proposed ANPR system.

Units of ANPR system	Total number of cars	Total number of correct detection	Percentage of Accuracy
Vehicle Plate Extraction	102	96	94.11%
Vehicle Numbers Recognition	96	87	90.62%
		Total percentage of accuracy	**89.70%**

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Overall 102 images were taken from different scenes under various illumination conditions. The results of proposed ANPR system is shown in table1. The proposed method successfully locates vehicle number plate from 96 images and was unable to locate from 6 images. So the success rate is 94.11%. Now the remaining 96 images were sent for alphabet and number recognition using template matching and 87 images were successfully recognized and 9 images were failed in this effort. So the success rate is 90.62% of Optical character recognition. Combining both the success rates, the overall performance of proposed ANPR is 89.70% for Islamabad standardized number plate. The localization time taken by the proposed ANPR is 0.3 sec and OCR is 0.6 sec. Total time taken by proposed ANPR from input image to the recognition of the vehicle number is 0.9 sec for a single image. The major failure of ANPR system was images have noise due any one or many reason as discussed previously or image is taken from a far distance. Some of the simulation results are shown in figure 7.

(a) Captured images

(b) Localization

MC758 **JT828**

(d) OCR

Figure 7: Localization & OCR

IV. Conclusion and Future Works.

In this paper we have presented a novel method for detection and recognition of Islamabad vehicle number plates. The proposed technique of Automated number plate recognition is divided into two modules, one license plate localization module using Canny detector and Hough lines, second license number recognition module using template matching although the system is customized to handle specific format number plate of a specific country. We believe that the proposed technique can be used for multinational car license plate especially in localization of the number plate. Since characters and numbers are used for most of the countries license plate so OCR technique of recognition of characters is applicable to any similar license plate with the change in the templates stored in the database. We are planning to run the proposed algorithm on GPU to improve the efficiency.

V. References

[1] Optasia Systems Pte Ltd, The World Leader in License Plate Recognition Technology, *Sourced from: ww.singaporegateway.com/optasia*, Accessed 22 November 2008

[2] M.T Qadir, M.Asif, Automatic number plate recognition system for vehicle identification using optical character recognition, *International conference on education technology and computer*, 2009.

[3] J. W. Hsieh, S. H. Yu, and Y. S. Chen, Morphology based license plate detection from complex scenes. *16th International Conference on Pattern Recognition (ICPR'02),* pp. 79–179, 2002.

[4] V. Kasmat, and S. Ganesan, "An efficient implementation of the Hough transform for detecting vehicle license plates using DSP's, *IEEE International Conference on Real-Time Technology and Application Symposium*, Chicago, USA, pp. 58- 59, 2005.

[5] S.H. Park, K.I. kim, K. Jung and H.J. Kim, Locating car license plate using Neural Network, *Electronic Letters*, Vol. 35, No. 17, pp. 1474 –1477, 1999.

[6] A.S. Johnson, B.M. Bird, Number-plate Matching for Automatic Vehicle Identification, *IEE Colloquium on Electronic Image and Image Processing in Security and Forensic*, Aprl, 1990.

[7] R.A. Lotufo, A.D. Morgan, and AS. Johnson, Automatic Number-Plate Recognition, *IEE Colloquium on Image Analysis for Transport Applications*, V01.035, pp.1-6, February 16, 1990.

[8] J.A.G. Nijhuis, M.H. Ter Brugge, K.A. Helmholt, J.P.W. Pluim, L. Spaanenburg, R.S.Venema, M.A. Westenberg, 1995, Car License Plate Recognition with Neural Networks and Fuzzy Logic, *IEEE International Conference on Neural Networks*, 1995

[9] M.M.M. Fahmy, Automatic Number-plate Recognition Neural Network Approach, *Vehicle Navigation and Information System Conference*, 30,Aug- 2 Sept, 1994

[10] H.J. Kim, D.W. Kim, S.K. Kim, J.V. Lee, J.K. Lee, Automatic Recognition of Car License Plates Using Color Image Processing, *Engineering Design & Automation*, 3(2), pp. 215- 225, 1997

[11] S.K. Kim, D.W. Kim, and H.J. Kim, A Recognition of Vehicle License Plate Using a Genetic Algorithm Based Segmentation, 3*rd IEEE International Conference on Image Processing*, V01.2., pp. 661-664, 1996.

[12] E.R. Lee, P.K. Kim, and H.J. Kim, 1994, Automatic Recognition of a Car License Plate Using Color Image Processing, *International Conference on Image Processing (ICIP'94)*, Vol. 2 pp.301-305, 1994.

[13] H.S. Kim, et al. Recognition of a Car Number Plate by a Neural Network, *Korea Information Science Society Fall Conference*, Vol. 18, pp. 259-262, 1991

[14] M.Horowitz, Efficient use of a picture correlator *J. Opt. Soc. Am*, vol.47, pp.327, 1957.

[15] Serkan.o and Ergun.E " Automatic Vehicle Identification by Plate Recognition", World Academy of Science, Engineering and Technology, ,9 2005

ISBN: 978-988-19251-6-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)