Journal homepage www.jzs.uos.edu.krd
Journal of Zankoi Sulaimani
Part-A- (Pure and Applied Sciences)

Iraqi Kurdistan Vehicle License Plate Recognition System based on Client-server Network

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Article info

Original: 20 February 2016
Revised: 13 July 2016
Accepted: 16 October 2016
Published online: 20 March 2017

Key Words:
License plate detection; Character recognition, Client-server network, Edge detection, Haar Transform, Bounding box, Correlation, Color histogram

Abstract

Vehicle license plate recognition (VLPR) system has a wide range of applications in real life, such as parking lots, private and public entrances, theft and border control. This paper presents a system overview of client-server license plate recognition system for vehicles in Kurdistan Region of Iraq besides, the vehicle type and city in each plate is identified. The client/server model consist of two components called client-side and server-side. The images are provided by the client side and will be sent over the server to be processed. The process of license plate recognition is done in the server side with the integration with the Matlab software. The proposed recognition system is developed based on digital images and the main component of the system consist of: preprocessing, license plate detection, segmentation and recognition process. A preprocessing step using image enhancement, filtering, and adaptive thresholding is employed. For localizing and extracting the license plate region, Haar wavelet transformation and edge detection algorithm are used. license plate number segmentation is carried out using bounding box based morphological operations and finally color histogram technique and correlation coefficient based similarity measurement are used for recognition task. The experimental results show that our proposed system for the license plate detection and recognition process have obviously higher recognition accuracy rate.

1. Introduction

In the recent years, it has been seen that the number of vehicles has increased dramatically because of the rapid rate of growth of the urban population and the power of purchasing becomes stronger. With this increase, the researchers presented different methods to detect the numbers and characters inside the license plate of various types of vehicles. AVLPR is a technique that involves in the areas of computer vision and image processing used in a wide range of applications such as law enforcements, access control, tracing of stolen vehicles, toll collection, parking management, traffic violations, and etc. Automatic vehicle license plate recognition (AVLPR) was invented in 1976 and the first working prototype system was implemented in the United Kingdom in 1979 [1]. The hardest part of any AVLPR system is the detection of the vehicle license plate region, which directly affects the overall accuracy and efficiency of whole AVLPR system. In the presence of image noise, blurring in the image, uneven illumination, dirt, rain, dim light and foggy conditions make the task even more complex [2]. License plate recognition algorithms are mainly divided into image preprocessing, license plate detection, segmentation of the numbers and recognition process of segmented number within the license plate, and each part may contain several steps. The main purpose of this work is to design and implement a system to detect the license plate of a vehicle and recognize the characters from the region containing a license plate under Iraqi Kurdistan conditions. In this work, we also

employ a client server network model to simplify generating training images and to reduce computational requirements on client side. Unlike related systems, we use portable computer only as input and output interface; all functions of license plate detection and recognition are done by the network server.

2. Related Works

In the research works, many license plate recognition systems based network have been proposed. Although vehicle license plate recognition has been extensively studied in recent years, it is still the most challenging task to detect license plates in open environment. Not much work has been done on detecting of the license plates for Iraqi Kurdistan, while much work has been done for US, European, Indian, Chinese, Korean and Iranian license plates. Abbas M. et al. [3] proposed a method to identify vehicle license plates in Kurdistan region of Iraq using correlation of GFVs and Wrapper Sub Eval technique to reduce the dimensionality of features vectors has been used. To evaluate the system's accuracy GFVs has been computed on SVM, K-NN with accuracy of 96.72. There is some relevant work on license plate recognition based client server network: A hybrid technique based client server architecture for Iraqi license plate recognition is proposed in [4] it is relying on support vector machines SVMs with bee colony optimization algorithm BCOA. Lajish V. L et al. [5] proposed a mobile phone based, client-server architected, license plate recognition system. Image. The Author use the state of the art image processing and pattern recognition algorithms tuned for Indian conditions to automatically recognize non-uniform license plates.

In [6], the authors describe a vehicle classification system based sensor network. The authors presented design and implementation of two such systems: a vehicle classifier based on acoustic signals and a license plate identification system using a camera. In [7] Authors given system for a license plate localization for Iraqi cars using morphological and statistical features extracted from the segments of the image. Sarfraz, M. et al. [8] proposed new algorithm for localization of Saudi Arabian license plate utilizing both vertical edge detection and filtering which is then followed by vertical edge matching. Pujianto Y. et al. [9] presented a system based on discrete cosine transform (DCT) and radial basis function network (RBFN) to recognize Indonesian private vehicle with character recognition in each plate with accuracy 96%. Musab M. et al. [10] multi objective particle swarm optimization (MOPSO) and connected component analysis (CCA) has been proposed to extract Sudanese vehicles license plates. In [11] Authors P. SaiKrishna presented a simple morphological operation, filtering and finding connected components for localization of Indian car number plate. Although this paper will focus on Iraqi Kurdistan vehicle license plates, each country has its own rule on vehicle license plate designing. The following section will give some important knowledge about the type and design of Iraqi Kurdistan vehicle license plates.

The rest of the paper is organized as follows: Section 3 constitutes an introduction about the Iraqi Kurdistan vehicle registration number plate. The client-server network architecture is described in details in Section 4. Section 5 present the vehicle license plate recognition system. Experiments and discussion are presented in Section 6 and conclude in Section 7.

3. Kurdistan Vehicles License Plate

The Iraqi Kurdistan vehicle registration number plates are license plates attached to a vehicle for official identification purposes. The Iraqi Kurdistan vehicles license plates can be categorized in a number of types according to differences in plates background color and characters color, the license plate is color-coded according to the type of vehicle being licensed, some of the plate types are represented in Table 1.

Table-1. Kurdistan vehicle plate types

Vehicles Type	Characters Color	Background Color
Private vehicles	Black	White
Commercials (Passenger)	White	Red
Commercials	Black	Yellow
Governmental	White	Blue
Temporary plates	Red	White
Army	Yellow	Green

In Iraqi Kurdistan cities, the license plate is rectangular in shape with size 20 × 40 centimeters with ratio of width to length of 1:2 (Figure 1). The plate has been divided into three segments; the first one in the upper part, that contains numerals (0 to 9 numbers) written in Eastern Arabic numerals. The other two segments in the lower part, which divided by a vertical line, one on the right this segment contains the name of the country 'IRAQ' written in Arabic letters, and the other segment on the left side contains the city (Erbil, Sulaymaniyah, and Dohuk) names written in Arabic letters.

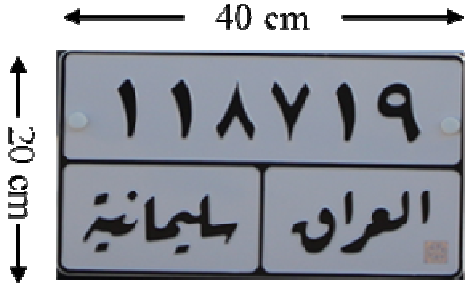

Figure 1: Format of Kurdistan private license plate

4. Client-Server Network Architecture

In this section, the client server network design is presented for implementing VLPR system. The whole system splits the license plate recognition tasks between the client and the server. The client side implements only input and output operations related to image acquisition, image transmission and display of the results while, the server side performs complex and accurate license plate detection /recognition task. Overall client server architecture system is shown in Figure 2 and further explanation is provided as follows:

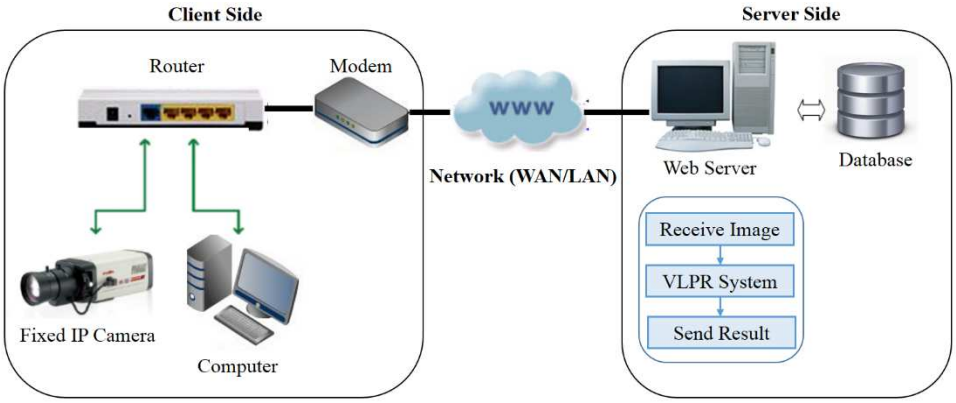

Figure-2: Client server architecture system

In client side an electronic device (fixed IP camera) that can be used to capture the acquired images plugs directly into a network router, and is not reliant on a computer to work. Image data from the fixed IP camera is transmitted through the network, and can be securely viewed at a remote location. An IP camera requires a high speed connection (such as DSL), a router, and an Ethernet cable. A computer desktop, equipped with a fixed IP camera that can be used to send saved images directly to the server via Internet and directly receive the information about displaying the identification result. The major components on the server side include hosting Web Server, VLPR system and database. A server is required to host the application. This application will transmit and receive data over the Internet. VLPR system part is developed using Matlab which it is integrated with the server. A database system can be created, which contains the information related to vehicles that are used for searching and identification task.

The flowchart in Figures 3 shows the client and server side processes. The basic mechanism works like this; the client application requests the user to trigger the IP Camera to capture the image of the vehicle license plate. Once the image is captured, the image is saved on client computer then pushed to the server for recognition process. On receiving image data from the server, the server software converts image from

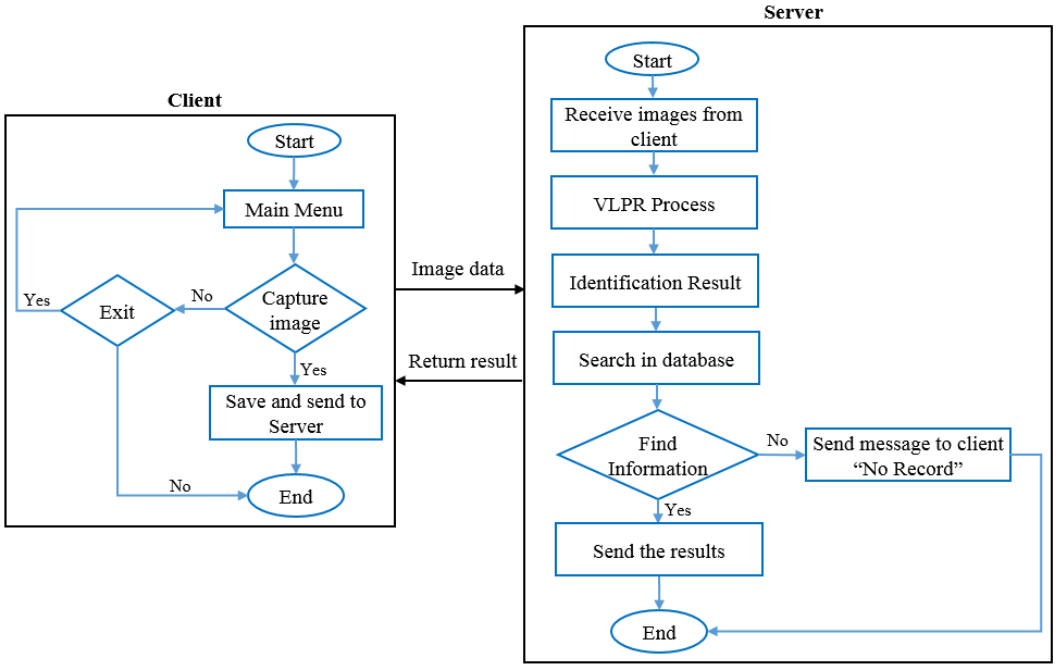

Figure-3: Design flow for client server processes

RGB to grayscale format and runs VLPR system. A system to identify the license plate number, city and type from image forms the heart of this system and is demonstrated in detail in Section 5. When the vehicle license plate has been successfully identified, the data will be used to find the information related to the vehicle in the database. If the vehicle does exist in the database, a text message includes the relevant information and results obtained from a VLPR system will be directed to the client computer. Otherwise, a "No Record" message will be sent to the client. Finally, the client software displays the obtained information as a text message to the user.

5. Vehicle License Plate Recognition System

The proposed system is designed on server side for Iraqi Kurdistan vehicle license plate recognition task. The system components take care of vehicle image pre-processing, license plate detection, character segmentation and finally license plate character recognition. The flowchart of the proposed VLPR system is shown in Figure 4. The following subsections, present each step in detail.

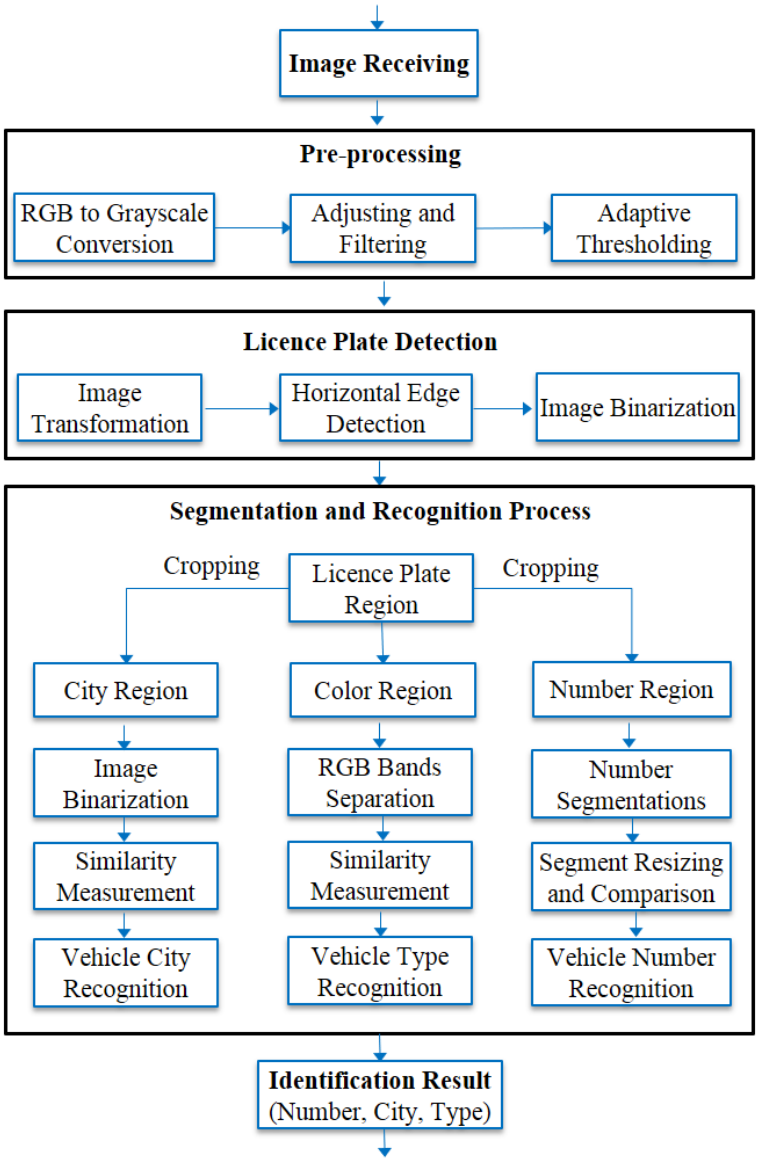

Figure-4: Framework of proposed Kurdistan VLPR system

5.1 Pre-processing

Pre-processing step plays a significant role, which directly influences the accuracy and efficiency of the subsequent steps. It is a process where the RGB input image has to be convert to gray scale image, the image is adjusted, the noise is eliminated, and dynamic thresholding has been applied.

5.1.1 RGB to Gray Scale Conversion

The input vehicle image is a colored image represented by 3-dimensional array contains a large amount of color information, thus it requires a large disk storage space, spend a lot of system resources when processing, and will decrease the speed of system performance. Therefore, the original color image has been converted to a 2-dimensional gray-scale image using the standard NTSC conversion formula (1), as shown in Figure 5 and 6.

$$\text{Gray} = 0.299\text{R} + 0.587\text{G} + 0.114\text{B} \qquad (1)$$

Figure-5: Original color image

Figure-6: Gray-scale images

5.1.2 Image Enhancement and Filtering

After converting color image into grayscale, image enhancement is achieved by performing the adjustment on grayscale image to increase the contrast of the image by mapping the values (to new values) such that, by default, 1% of the data are saturated at low and high intensities. Then, two-dimensional median filter algorithm (Equation 2) has been applied for smoothing and removing unwanted background noise of the grayscale image. In this case, best results were obtained for 3 × 3 filter window. Figure 7 and Figure 8 represents the image enhancement and filtering, respectively.

$$y_i = median\,\{x_i \mid j = \ \ i-k, \ldots\ldots\ldots\ldots, j+k\} \qquad (2)$$

Figure-7: Image enhancement

Figure-8: Image filtering

5.1.3 Contrast Limited Adaptive Histogram Equalization

Contrast limited adaptive histogram equalization (CLAHE) is the technique, used for improve the visibility level image or video using histogram equalization. In this work dynamic thresholding (CLAHE) on the intensity image has been performed on the image is shown in Figure 9 to identify dark pixels in gray-scale images and to increase the intensity level range of the license plate. Mathematically it can be represented as in equation (3).

$$g(x,y) = \begin{cases} 1, & f(x,y) \geq T \\ 0, & otherwise \end{cases} \qquad (3)$$

Where $, f(x,y)$ is the original grayscale image, $g(x,y)$ is the threshold output image and T is the threshold value obtained?

Figure-9: Adaptive Thresholding

5.2 License Plate Detection

The basic step in recognition of vehicle number plate is to detect the license plate region. In this section, the candidate license plate region has been detected with use of an image transformation technique, edge detection and horizontal projection, and then among these areas, license plate area is extracted.

5.2.1 Image Transformation

Image transformation in digital image processing used to convert images from the spatial domain into the frequency domain. The Haar transformation technique is applied for enhance the edge here since it is the simplest wavelet transform coding mostly used in signal processing or digital image processing. Two-dimensional DWT decomposes the grayscale image into four regions called wavelets and this decomposition known as the resolution of the grayscale image. These regions consist of: one low-frequency LL (approximate component), and three high-frequency regions, namely LH (horizontal component), HL (vertical component), and HH (diagonal component), respectively. Figure 10 shows the result of Haar transformation on contrast enhanced gray scale image, in this work HL sub band has been chosen for vertical edge detection the simplicity and effectiveness in capturing the image sharp edges is the reason of selecting the Discrete Haar Wavelet Transform (DHWT).

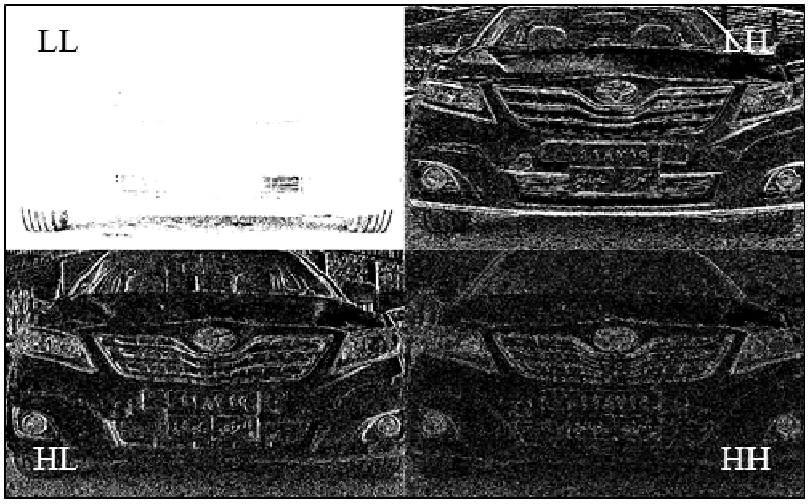

Figure-10: Image Transformation (DHWT)

5.2.2 Edge Detection

Edge detection is fundamental technique for feature detection. In general cases the outcome of performing edge detection technique is an object boundary with connected curves. In this phase edge of an image has

been detected by canny operator and result of applying canny operator on vertical component regions (HL) to binarized image is shown in Figure 11. The canny method is more robust algorithm for edge detection compared to other methods that finds edges using the canny approximation.

Figure-11: Edge detection applying canny operator

5.2.3 Plate Region Detection

The aim of this step is to extract the vehicle license plate region from the original image. After edge detection using canny operator, the horizontal projection has been calculated to detect the actual license plate area. From above steps, the row and column indices of plate area have been calculated. With the help of indices, license plate is extracted from original image accurately. The extracted vehicle license plate image is shown in Figure 12. In addition, with row and column indices the upper part and left lower part of license plate image have been extracted to identify vehicle type and city.

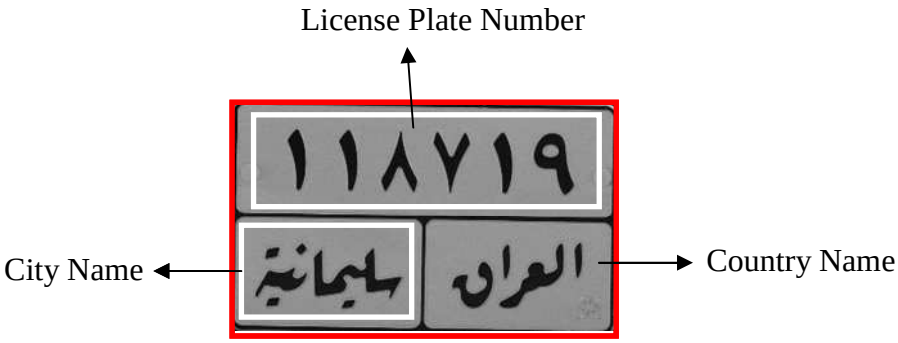

Figure-12: Extracted vehicle license plate

5.3 Recognition Process

5.3.1 License Plate Number Segmentation and Recognition

Segmentation is one of the most significant steps in the license plate number recognition. After extracting the upper part of license plate, all the Arabic numbers are segmented and extracted individually from the license plate for recognition process. At the beginning of Arabic numbers extraction step and for accurate numbers segmentation first extracted license plate is converted into binary image, then the bounding box technique was used to get the coordinates of the smallest rectangle surrounding the numbers. The dilation process was

performed to the image using classical dilation for separating the numbers from each other. Dilation process can be mathematically expressed [12] in equation (4).

$$X \oplus B \triangleq \{ x : B_x \cap X \neq \varphi \} \qquad (4)$$

Where ***X*** is the object and ***B*** is the structuring element.

After these operation, the numbers were cropped out individually from the license plate. Those extracted numbers are resized into a known template size and stored into a database for recognition process. After segmenting the numbers on the plate image, each segmented number pixels are compared with all numbers (0 to 9) with a set of template using correlation (Equation 5). The template with the maximum correlation coefficient corresponding to the image defines its identity. The extracted numbers are then recognized and the output is the license plate number. In this case the returned license plate number was: 118719. Figure 13 shows the procedure of license plate number segmentation and recognition system.

$$Correlation = \frac{\sum_i \sum_j (A_{ij} - \bar{A})(B_{ij} - \bar{B})}{\sqrt{(\sum_i \sum_j (A_{ij} - \bar{A})^2)(\sum_i \sum_j (\boldsymbol{B}_{ij} - \bar{B})^2)}} \qquad (5)$$

Where $\bar{A}$ mean2 (A), and $\bar{B}$ mean2 (B).

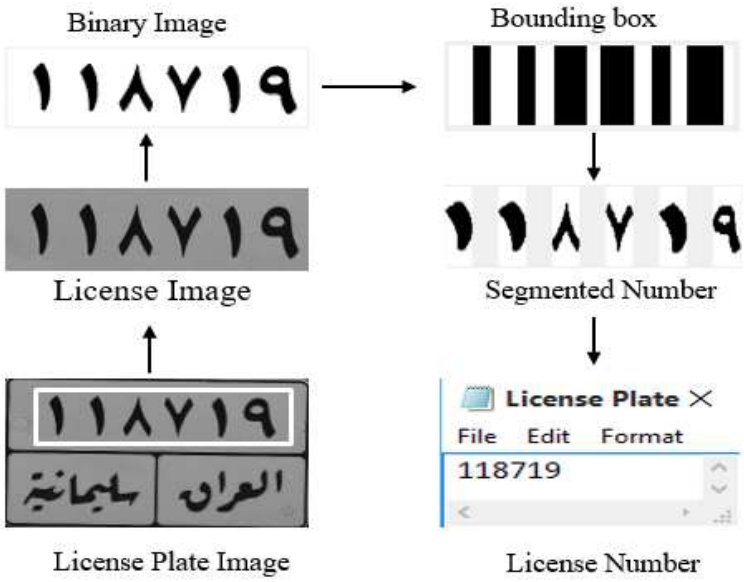

Figure-13: License plate number segmentation and recognition system.

5.3.2 Vehicle Type Recognition

In Kurdistan a background color of license plate (Figure 14) refers to type of vehicles (private, taxi, etc.). For identifying the type of Kurdistan plates that are in six categories: 1) Private plates in white background, 2) Commercials (Passenger) plates in red background 3) Commercials plates in yellow background, 4) Governmental plates in blue background, 5) Temporary plates in white background, and 6) Army plates in green background are known. In this step, the type of vehicles has been identified by analyzing the segmented license plate image using color feature extraction technique based on color. As a first step in this stage, the extracted license plate which is a double-indexed image (M x N) resulted by the previous stage will be converted to (M x N x 3) RGB image. The color features have been extracted from license plate image by using color histogram technique. Once the histograms have been created, city-block distance

formula has been used as the similarity measure for comparing the license plate image histogram with database images. By applying the previous steps, the type of vehicles has been identified.

Figure-14: Kurdistan plate categorization depends on background colors

5.3.3 Vehicle City Recognition

In this step, the city of vehicles has been recognized by extracting the left lower part from the license plate image. The extracted image is converted into binary image then template matching is performed after resizing the extracted image into the same size. Several similarity measuring techniques are defined in the literature. In this work correlation coefficient based similarity measure is used to compare the extracted image with a set of template that were known before (Figure 15). By rely on this base, two similar images in the same weight upon each other can deposit. This process is expected to be able to succeed in identifying city of vehicles efficiently and accurately.

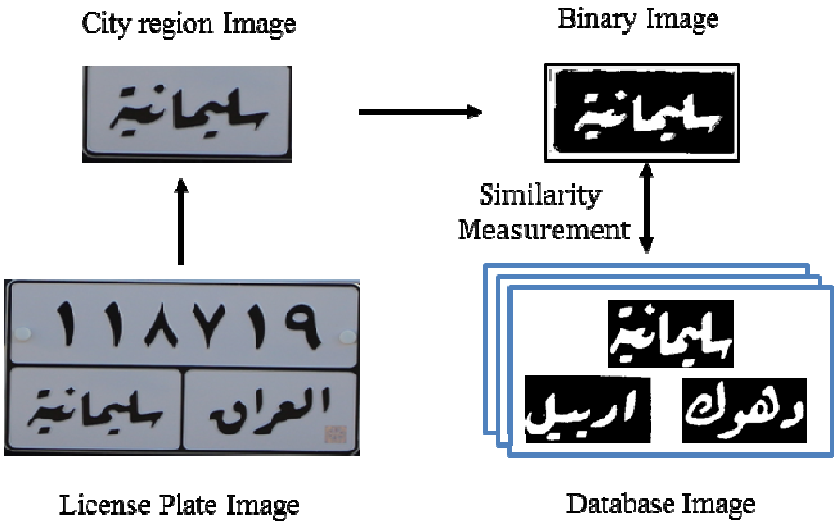

Figure-15: City recognition process

6. Experiments and Discussion

Performance evaluation of the proposed VLPR system based client-server network has been done on Intel (R) Core (TM) i5-4570S CPU@ 2.90 GHz with 4 GB RAM (client) and Intel (R) Core (TM) i7-2630QM CPU@ 2.00 GHz 2.00 GHz with 4 GB RAM (server). The implementation of the VLPR system will be developed using MATLAB R2014b software. It will be integrated with the server. Also use the graphical user interface (GUI) to build up a graphical display to run the system on client/server side. The database that will be used in the experiments contains 200 frontal color images collected from different types of vehicles captured with canon EOS 700D 18.0 MP digital SLR camera which has resolution 2304×3456 pixels taken from fixed distance, with JPG format. The input of the model is the original image of the vehicle in RGB

scale resized into 640 x 480 pixels. The proposed system is robustness against parameters such as: the different size plate image, various illumination and weather conditions, injuries and pollution of plate image. As practical results that are implemented on the collected images, in the image that license plate area is recognized correctly. After license plate detection process three experiments have been conducted. In first experiment image binarization, bounding box, and dilation techniques are used for segmentation and extraction process. The outputs of this experiment are images of each Arabic number within the license plate. After the individual numbers are extracted, these extracted numbers are compared with a set of template using correlation for recognition the license plate number. Second experiment is to identify the type of vehicles using the color histogram technique and city block distance metric for similarity measurement. Third experiment is to identify the city of vehicles using image binarization and correlation coefficient for comparison between extracted image and the images in template. The experimental results, show that the detection success rate is about (82%) and the accuracy rate attained is (98.5%) for the recognition process.

7. Conclusion

Building vehicle license plate recognition system based client-server network is needed to monitor movement of vehicles in our environment in order to maintain law, order, security and public safety. This paper proposes system based client-server network to detect of Kurdistan vehicles license plate and number recognition, in addition the vehicle type and city in each plate has been identified based on digital image processing. The experimental results show that our proposed system for the license plate detection and recognition process with a higher accuracy rate. This new model provides a good direction for the future development of automatic number plate recognition on mobile wireless device in Kurdistan of Iraq.

References

[1] Pushpendra S. C., and V. K. Govindan, *"Localization of License Plate using Characteristics of Alphanumeric Characters"*, International Journal of Computer Science and Information Technologies, Vol. 5, No. 3, pp. 3407-3409. (2014).

[2] Veena M.N, Arpitha K.S., and Vasudev T., *"Performance evaluation of different automatic seed point generation techniques for segmentation of indian vehicle number plate"*, International Journal of Computer Engineering and Technology (IJCET), Vol. 6, Issue 5, pp. 36-46. (2015).

[3] Abbas M. Ali, Shareef M. Shareef, and Tarik A. Rashid, *"Automatic License Plate Recognition in Kurdistan Region of Iraq (KRI)"*, JZS Vol. 17, No. 3. (Part-A). (2015).

[4] Majida Ali Abed and Hamid A. Abed Alasadi, *"New hybrid SVMS-BCOA architecture for Iraqi vehicles license plate recognition"*, European Journal of Computer Science and Information System, Vol.3, No.1, pp.73-86, (2015).

[5] Lajish V. L, Sunil Kumar Kopparapu, *"Mobile Phone Based Vehicle License Plate Recognition for Road Policing"*, (2015).

[6] Jan Frigo, Vinod Kulathumaniy, Sean Brennan, Ed Rostenz, Eric Raby, *"Sensor network based vehicle classification and license plate identification system"*, IEEE INSS 2009, Pittsburgh,PA, (2009).

[7] Nada N. Kamal and Loay E. George, *"A Localization System for Car License Plate*", International Journal of Scientific & Engineering Research, Vol. 4, Issue 6. (2013).

[8] M. Sarfraz, M. J. Ahmed, and S. A. Ghazi, *"Saudi Arabian license plate recognition system"*, in Proc. of International Conference on Geometric Modeling and Graphics, pp. 36-41. (2003).

[9] Pujianto Y., Samuel L., Sutrisno, and Dion K., *"Recognition of Indonesian Vehicle Registration Plate by Discrete Cosine Transform and Radial Basis Function Network"*, International Journal of Information and Electronics Engineering, Vol. 5, No. 4. (2015).

[10] Musab M. Bagabir, Siti Mariyam S., Mohammed E., Ali Ahmed, *"Multi Objective Segmentation for Vehicle License Plate Detection with Immune-based Classifier: A General Framework"*, International Journal of Computer Applications Technology and Research, Vol. 4, Issue 4, pp. 322 - 326, (2015).

[11] P. Anishiya, and Mary J., *"Number Plate Recognition for Indian Cars Using Morphological Dilation and Erosion with the Aid of OCRs"*, International Conference on Information and Network Technology IPCSIT Vol.4, IACSIT Press, Singapore, (2011).
[12] Dhawal Wazalwar, Erdal Oruklu, Jafar Saniie, *"A Design Flow for Robust License Plate Localization and Recognition in Complex Scenes"*, Journal of Transportation Technologies, Vol. 2, pp. 13-21, (2012).