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ALTINBAŞ UNIVERSITY

ELECTRICAL AND COMPUTER ENGINEERING

# IRAQI VEHICLE LICENSE PLATE DETECTION AND RECOGNITION SYSTEM FOR THE NEW PLATE STYLE

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# IRAQI VEHICLE LICENSE PLATE DETECTION AND RECOGNITION SYSTEM FOR THE NEW PLATE STYLE

by

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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Sufian Ibrahim Ali

# DEDICATION

Praise be to my creator Allah before everything. This thesis is dedicated to my parents for their love, endless support and encouragement. I would also like to thank all my family for their support, love and everything.

I would like to express my sincere appreciation to my supervisor, Assist. Prof. Dr. Cagatay Aydin, for his directions and accurate notes to complete this work.

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# ABSTRACT

## IRAQI VEHICLE LICENSE PLATE DETECTION AND RECOGNITION SYSTEM FOR THE NEW PLATE STYLE

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Vehicle license plate recognition system has taken an important role in numerous daily life applications such as parking lot management, traffic controlling, etc. LPR which is based on image processing, is utilized to recognize any vehicle identity. The proposed system is developed for new style of Iraqi license plate character recognition. In order to detect the vehicle type, recognizing the colored bar on the plate is employed in this system. Furthermore, an optical character recognition algorithm with template matching by segmenting each character on the plate individually is used which results in 89.5% success rate of the proposed algorithm for overall system.

**Keywords**: OCR, optical character recognition, Iraqi vehicles license plate detection and recognition system, template matching, LPR, Arabic characters recognition.

# TABLE OF CONTENTS

**Pages**

## LIST OF TABLES

**Pages**

# LIST OF FIGURES

**Pages**

# LIST OF ABBREVIATIONS

CPR : Car Plate Recognition.

OCR : Optical Character Recognition.

CCA : Connected Component Analysis.

LPR : License Plate Recognition.

ANPR : Automatic Number Plate detection and Recognition.

RFID : Radio-Frequency Identification.

HMV : hidden Markov Modeling.

LSFPO : Least Square Fitting with Perpendicular Offsets.

VNPD : Vehicle Number Plate Detection.

NPR : Number Plate Recognition

RGB : Red, Green, Blue.

LPD : License Plate Detection.

IVLPR : Iraqi Vehicle License Plate Recognition.

# 1. INTRODUCTION

## 1.1 BACKGROUND

Public transportation system is developed rapidly, automatic vehicles detection and recognition has taken a great role in numerous applications such as parks managing, traffic controlling, Detect the stolen vehicles etc. The automatic number plate detection and recognition (ANPR) was found firstly, in the United Kingdom by the police scientific development branch in 1976. However, it took more interest in the last decade. An important role is played by an automatic car number of plate detection and recognition system. OCR is applied in LPR to detect and recognize the cars for different purposes. Also, it contains the concepts of image processing such as representation techniques and feature extraction. We can use the vehicle plate detection and recognition system in many fields. For example, control of parking area and borders control. OCR is a system to recognize the hand writing and printed words. It gives the machine the ability to characters recognition automatically, by using optical recognition mechanism [1]. In this work template matching technique is used in OCR which a system that used for character recognition or alphabet and words by comparing two images of them. Template matching method is used to recognize the template image which is existed in the given input image.

These days the number of used vehicles has increased significantly in the world. The dramatic rise in traffic has become a major cause of concern among the population, especially those living in urban cities and capitals. This significant increase in the number of vehicles made it difficult to monitor, classify and regulate the movement of these vehicles. It is also difficult for the competent authorities in the country to implement some laws and to monitor all cars in the street. These government agencies are responsible for the detention and punishment of vehicles that break the rules and laws. If we do research into security violations and look for the methods used by the offender to do their bad planning, we will begin to understand the reality of the situation and how the vehicles are part of the problem, especially in countries with security and administrative problems, as well as mismanagement such as some Arab countries, especially Iraq. Vehicle identification also plays an important

role in national security and border control. Figure 1.1 shows an example. Many organizations need to classify vehicles based on their numbers to obtain sufficient data to plan ahead and remedy existing problems. Vehicle identification can also be used in a vehicle park, control vehicle access to restricted area and to detect stolen cars more efficiently. License plate detection consider as an important stage in an LPR system, [2].

There are around 355 million commercial vehicles and 947 million passenger cars registered worldwide, but according to 2006 stats there are 248 million commercial vehicles and 678 million passenger vehicles [3] . This means there is an increase of 35% in commercial vehicles, while the increase of passenger's vehicles reaches to 39.6%. If the increase continues in the same rate, then we will see around 1.7 billion of registered vehicles in use worldwide [4]. This shows us the importance of developing a system that can identify vehicles accurately and effectively. This system effectively contributes in organizing the vehicle traffic and keeps the road as a safe place for people. Each vehicle in the world traveling on the roads must contain a vehicle number to become legal. The license number is written on the license plate and this plate is mounted on the body of the vehicle. The license plate is often installed on the back or on the front of the vehicle. License plate recognition is an integrated system consist of hardware and software that takes the symbols from the license plate and then extract them to text. This text can be handled by a computer using an ASCII [5]

**Figure 1.1:** Shows an example of security check point without human effort depend on VLPR.

Vehicle detection and recognition System has the ability to extract vehicle information by analyzing the image of the vehicle plate. Several studies have been conducted to develop this area can be classified into two classes: active and passive.

- *Active*: laser and radio frequency techniques are used Here to read vehicle license plate. The radio frequency technologies RFID is placed in a traffic location and vehicle license plate information can be read and recognized from remote distance. The cost of these systems is very high. They are used in situations where there is the error is un acceptable.
- *The passive*: works to obtain a picture of the vehicle's plate to be processed in order to extract the car information. In this system the efficiency of the identification depends entirely on the quality of the image where the intensity of light, noise and distance from

the vehicle can make the recognition of vehicle identity is difficult and the result is incorrect. This system mainly depends on the recognition of the vehicle license plate as the unique thing that determines the identity of the vehicle. However, it can be easily manipulated [6]. According to Calgary police, license theft rates have increased by 80% in 2015 compared to 2014 [7]. The statistics of traffic police in Iraq indicate that, only in Baghdad, the capital of Iraq, the cases of theft of vehicle plates is increased significantly. The number of stolen plates reach to 2000 plates. In 2015, more than 800 cars were stolen only in Baghdad.This is a significant increase which has a direct impact on the situation in the country. Usually, this stolen plat is used to do suspicious works [8].

## 1.2 STAGES OF VEHICLE PLATE RECOGNITION SYSTEM

- *Plate region detecting and extracting*: At this stage, the vehicle plate is selected, extracted and separated from the rest of the picture details. Many processes are taken during this stage such as applying the noise filtering, colour adjusting, segmentation and so on. Recognition of vehicle plate details depends directly on the accuracy of the detection [9].
- *Plate image characters recognition*: This process comes after extracting the vehicle plate area, the individual characters such as letters and numbers must be extracted and prepared for recognition. Characters recognition of the vehicle plate is the main process in this stage.

## 1.3 IRAQI VEHICLES LICENSE PLATES

The style of the Iraqi vehicles license plates has changed over time. There is a new model of vehicle number plates used in Iraq and is the latest form as shown in Figure 1.2. This model consists of a column with a colour in the shape of a rectangle located at the left of

The plate which define the type of the vehicle, as well as the word Iraq written in the English language inside the rectangle itself. There are two rectangles next to the coloured column, one above the other. The first one contains the vehicle number and a separate character.

Under the same rectangle, the number of the vehicle is written in English with same separate character written in English, but in small size. The second rectangle at the bottom contains the of area which the vehicle belongs, all written in Arabic.


**Figure 1.2:** Example of the new shape of the Iraqi license plate.

According to the rules of the Iraqi Ministry of the Interior: The shape of the license plate is rectangular with dimensions (320 × 160) millimetres used for the vehicles (Cars and agricultural vehicle, construction and specialized vehicle). And (200 x 120) millimetres for the motorcycle and the vehicle, which is recorded temporarily [10].

## 1.4 PROBLEM STATEMENT

The first challenge is to recognize Arabic letters and numbers in a license plate for Iraqi vehicles because of lack of research in this area. The identification and detection of the license plate from all image that has large number of unimportant details is one of the most important steps in the process of recognizing the license plate. Also, there are some important problems that affect the process of recognizing vehicles license plates which are; vehicle and the license plate have the same colour, lighting conditions during the process of taking the picture by camera. Also, the components that used to fix plate in the body of vehicle, such as bolts, is unpredictable and this may affect the process of segmentation. Also, old or damaged license plates, peel-off paint and the presence of some impurities in the license plate are directly affects the process of identifying license plates.

## 1.5 AIM OF THESIS

This thesis has two main objectives: the first one localization of the license plate and the second one recognition of the characters in the Iraqi vehicle license plate to produce a strong and accurate system to detect and recognize the license plate that installed in Iraqi vehicles. This system uses a database containing images of Iraqi vehicles that taken as part of the research work in this thesis to examine the efficiency of the system. The researcher takes images by using digital camera and taking in account the angle from which the image was taken, the lighting conditions, colour of the plate, status and dimensions of the plate with its location. The license plate is handled regardless of the background colour.

# 2. LITERATURE REVIEW

Zhidong and others, represented a Robust, Language-Independent OCR System which was a technique for getting a symbol from scanned printed text to be processed. Authors in the proposed system used optical character recognition OCR system as well as hidden Markov modeling HMV technique for processing each letter. Offline module of OCR was used here This technique was applied on many languages to recognize their characters such as English, Arabic and Chinese. Much of the previous research has used one language in dealing with the HMV model such as English language. But, the challenge for researchers here was to use more than one language in the HMV model. The proposed system consists of basic parts where OCR consists of two main parts: training and recognition. The recognition system and training used the same preprocessing and feature extraction. Each frame used feature vectors for feature extraction. Here time considered as an independent variable. There was a difference in the system applied to the characters of different languages. At the end, the authors discovered that there are systems that can deal with more than one language. This requires a different set of data to be trained on the system based on the HMM model that works in the optical character recognition system OCR. It is also possible to obtain accurate results through training even with degraded data [11].

Sarfraz and others, proposed a special system for automatic license plate recognition to recognize characters included in Saudi Arabian license plates. High resolution digital camera used in the proposed system to capture vehicles image. A segmentation algorithm for characters and extraction algorithm for the license plate were proposed here. The proposed method passed through some steps started with capturing image. Then, convert the captured image to gray scaled image. While the stage of license plate extraction they used vertical edges detection. After that removing the Undesirable parts of image by using seed-filling algorithm. After the process of image filtering, the next step is vertical edge matching. Width to height ratio of Saudi Arabian license plate used by vertical edge matching for finding the part that could be license plate region. Finally, the process of recognizing the characters had two main parts, Individual characters normalization and use Template Matching to recognize

alphabets and numerals. There are some factors that negatively affect accuracy such as bolts and nuts which are found on the plate. The system accuracy was tested on about 610 real vehicles image that captured under various conditions. Every picture had size of 640×480 pixels. The results were 96.22% for plate extraction, 94.04% for segmentation and 95.24% for recognition showed that the system is quite effective [12]. Regarding to the good percentage of character recognition accuracy, the same techniques is used in my project for Iraqi license plate character recognition .

Dep and others proposed an efficient method for correcting vehicle license plate tilt. They proposed an algorithm for modifying recursive labeling to detect license plate region and overcome the weakness of detecting license plates when the license plate and the vehicle have the same color. For example, black plate installed in black car. Also, authors in this paper took in account the vehicle license plate tilt correction. The suggested method passes through some steps, start with converting the input image of vehicle HSI color space. Then, the color details of the plate are used for candidate plate regions. Then, the license plate geometrical details are taken for classification such as area, aspect ratio are extracted and other details. To solve the problem of the weakness of detecting the license plate boundaries, they used algorithm of modified recursive labeling in proposed method. The next step is fitting the region of the license plate to straight line based on Least Square Fitting with Perpendicular Offsets (LSFPO). The rotation angle that required is estimated and this is done after obtaining the line slope. After that, to correct tilt the picture is rotated in horizontal direction. While, vertical direction correction is done by inverse affine transformation. In this paper, Hough lines intersection is used to detect vertexes and candidate LP boundaries. The final step, recognition of characters of the license plate. The proposed system is defeated when the input image has motion blur. Many images of license plate in different conditions were used to test the performance of the proposed method. Around 200 images of Korean license plate were used here [13].

While, Mohsin and others, suggested a system that used ELMAN Neural network for automatic recognizer for Iraqi license plates. The proposed system consists of several stages. Detection of the license plate edge stage used Sobel operator. While Median filter used here

in preprocessing stage for deleting noise or unneeded parts of input image. After that, thresholding is used for picture banalization. Firstly, plate style must be checked if it is written vertically or horizontally this is done by counting the number of pixels that has value 1 in every column then, separate numbers from characters in the stage of segmentation. In the recognition stage they used two of Elman neural networks in their proposed method. The first one to recognize the ten numbers from zero to nine. However, the second one used to recognize the nine province names. In this paper, there are 6 tested province names with three words, which are: (فحص, العراق and مؤقت). We should note that in the enns there are 256 neurons for input, 20 neurons for hidden and 10 neurons for output layers. The proposed system used the longest text part of any word to reduce the input data in the system, such as, the Arabic word "البصرة" is contains three parts which are "البصر" ,"ا" and "ة". In this Situation "البصر" is chosen because it the longest section of the word and the other province names do not have the same part or in other mean it is unique part. Authors did not discuss any rotation algorithm as well as localization algorithm in this paper. 21 samples were used to test the performance of the proposed system. The test image was taken under several conditions such as different illuminations, different distance and different types of license plate. For segmentation the system achieved around 85% correct results while, it achieved around 67% correct recognition [14]. I consider it as an important study that I get benefit from it by using the longest text part of any word to reduce the input data in the system to detect the governorate of license plate of vehicle. As well as I use in my thesis Sobel operator for edge detection.

Ganeshmoorthy and others, presented an OCR recognition system using both of feed forward and back propagation neural network. The suggested methodology was presented for automatically recognizing the symbols and numbers that inter to the system as an input. It can be used for different application. MATLAB was used perform the suggested system. A neural network used in the character and number recognition stage. Training the network is done by applied the algorithm of feed forward back propagation. Then convert characters into numeral text. This algorithm achieves good results [15]. Regarding to the provided results that achieved in the study by using MATLAB. I use MATLAB the run my project.

To obtain a detected image of the vehicle license plate by digital cameras, S. Kranthi and others, suggested a great method of identifying specific information for the number plate by processing the image. There are multiple algorithms used to process the image. The suggested method in this paper for identifying the characters in the license plates is called Automatic Number Plate Recognition (ANPR)."License Plate Localization" strategy is used. Among several different strategies the proposed technique was adopted on two important strategies. The first one is mechanical edge detection technology. Which means selecting the license plate from the different details within the image. Depending on the color gradient within the image to locate the license plate and define its border from the existing details. While the second strategy involves the application of different filters on the image to improve image quality and processing it, as well as taking important features .These strategies are used to create an ANPR framework in a good way. Many applications based on ANPR. Especially systems that use digital cameras to follow the movement of vehicles and its activity in the roads. These images taken by the digital camera contain all the image details including the license plate frame .Firstly, the algorithm is used to detect the license plate and extract it from the image. Then the character recognition algorithm is used to obtain the information and details contained in the license plate. Image quality affects the accuracy of the results. Therefore, high-resolution digital cameras were used to obtain the required data from the license plate .This study is important. I use in my project the same method for edge detection by defining the contrast in the colors between the objects in the digital image. This will help to provide good results in my research [16].

Hamad and others suggested the automatic number plate recognition method. The aim is to select the persistence of algorithms on random images. The license plate is localized as well as recognize the characters from the non-important details inside the plate through this method. The cameras use infrared lighting to be able to take pictures at any time of the day. There are many different techniques used in this method to localize the plate as well as the segmentation of the characters inside the plate to be recognized. In order to locate the license plate within the image, edge techniques are used as well as morphological techniques. In

order to segment and recognize characters, artificial neural networks are used to provide good results. However, this system has some weaknesses, such as poor lighting, image capture angle, color contrast and low image quality. This system cannot handle video. This is a custom system only to handle the static image. Moving car image Cannot be handled as well as cannot split characters in twisted pictures. All this leads to a weak recognition rate in this way. This method mainly focused on testing algorithm stability on snapshots images [17].

Sivanandan and others proposed an algorithm for identification of Indian Vehicle license plate automatically. Also, they presented a method for character segmentation for Devanagari license plate. This system consists of many steps. The input picture start converting to gray picture in the preprocessing step to prepper it for applying median filter to get rid noise in picture. The next step was license plate extraction, this is done by applying vertical edge detection. Also, a morphological operator is applied because it has the ability to focus on specific shape in captured picture. To detect the car plate a rectangular box is used as a structural element. After this step, it is needed to fill the holes that existed after opening by using the morphological operation. Then, to extract the correct region of license plate, the coming picture must be filtered out. Then the detected region of license plate is cropped and make it suitable by using rotation. Next step is segmentation of row and column Sequentially to separate each row individually and then separate characters in each row. The final step in the proposed system is character recognition. They used here Optical Character Recognition OCR techniques for recognizing characters of the license plate by comparing each character with character patterns stored in the database using template matching. The proposed system was tested over small number of datasets [18]. These steps consider as a common steps of license plate detection and recognition by using OCR that I am using in my project to detect and recognize the Iraqi vehicle license plates. By taking the image and then extract the required region, which contains the information of the license plate and then apply the system of OCR to identify the characters. With some filters that applied to purify the image and make it suitable for key steps.

Taha and others proposed a system to recognize Arabic printed text by using optical character recognition. In the proposed system, the suggested method was used to segment the printed Arabic text. Also, separate the Arabic characters individually after that recognizing the characters by extracting the clear features for each. Specific database fields are used to be compared with the clear features for recognizing Arabic printed characters. This database contains Arabic letters written in Time New Roman font. However, the proposed system achieved a great experimental result with high accuracy when it was tested on varies sizes of many fonts beside Time New Roman font. A technique was developed in this work that based on very powerful descriptor, 'junction line' recognize characters. The technique of segmentation was developed in this proposed work based on the knowledge of the beginning and end of the characters where the proposed algorithm proves a high accuracy in determining the character boundaries. Arabic characters are also divided here into eight different groups. The Arabic letters are also divided into eight different groups. This means that each group is searched separately. The competition is happening in one group instead of the total number of letters to reduce errors. Four major steps had formed the proposed system, start with image acquisition and preprocessing, then segmentation then, feature extraction and finish with classification. The proposed method achieved accurate results [19].

According to the accurate results obtained by the proposed method, I am using the same method of identifying characters that included in Iraqi vehicle license plates. This is done by creating a database containing Arabic characters (Letters and Numbers) symbols and comparing them with the shape of the symbols inside the plate to identify the vehicle information by using a template.

In 2013 Yadav and other, proposed a new methodology for localization of vehicle license plate. The presented methodology is based on wavelet decomposition for localizing the license plate. The proposed method used to get the details of license plate in its pre-processing stage as well as localization. This methodology is accurate. This is due to the use of wavelet decomposition regardless of the processing algorithm that already proposed. After applying the proposed method, the localized license plate is used as an input for (OCR)

which recognizes characters on the license plate and convert them to text. The methodology was applied for localization of Indian license plates to test the effectiveness of the proposed method [20].

In 2014 Sutar and Shah proposed a Number Plate Recognition (NPR) system by using an improved segmentation. This system presented to be used instead of the manual entry system. Image segmentation is used here to get the region of vehicle number plate. After that the extracted characters is compared with the records on a database. The proposed system based on two major techniques which are, image segmentation in an Image to get the region of the plate and optical character recognition (OCR) technique that used for the plate character recognition. The proposed system passes through many steps start with vehicle image capturing, then vehicle plate localization, then character recognition by using Optical character recognition technique and it finished with comparing the output data with the records on a database. MATLAB used her to process the images. The tests of the proposed system presented a great result and it showed that the system is reliable and can work even with variable lightening conditions. Also, it can be used in highly restricted areas. This system detected and recognized the number of vehicle plate with an accuracy of 39% [21].

Shami et al have proposed an algorithm for extracting characters from images in the vehicle license plates detection and recognition system. Three types of features are extracted which are calculate the number of conversions, calculates the ratio quantification of white and black, and binary feature. There has been a lot of research done to develop the process of identifying characters to produce accurate results, despite the difficulty of dealing with these systems. Here the test was done on the images in a real environment. The OCR technique is used here. Optical character recognition executes through the process of matching weights for recognizing the characters. Manual selection is used in this method, which is the most important thing in this technique because it helps to obtain a good accuracy in the recognition of characters. By selecting each line manually and then, each individual character is selected separately in same line. This method combines several stages in the way of recognizing characters. There are standard forms of characters stored which are used for comparison and the final characterization mainly based on them. In order to obtain final results, these stored

forms are compared with manually selected characters. This technique has been applied in some countries, such as KSA (kingdom of Saudi Arabia). The license numbers are written in English. It was applied to a small number of data sets and the results were at a good level of accuracy for the proposed technique. Unlike many other traditional methods. It is also worth mentioning that the technique was applied to a number of Lebanese vehicles Which hold plates with English numbers and the results was good at a good level of accuracy, about 95% [22]. Due to the high quality of OCR technology that used here. I use OCR in my project to extract license plate information for Iraqi vehicles. The application of OCR is the last step in my project.

Karwal and others presented a Vehicle Number Plate Detection (VNPD) System for Indian Vehicles. The proposed system was depended on template matching. The proposed method used for Indian vehicles number plates to recognize its characters, it was efficient method. Indian vehicles license plates are written in Indian letters and numbers which is similar to Arabic letters and numbers. The main goal of this algorithm is to process scaling and recognition problems of the characters position. Authors in this paper showed that to maintain vehicle information, it need to use automated systems. The proposed method depends on two main techniques, which are template matching with Normalized cross correlation technique and Otsu's method for threshold partitioning technique. In this paper the correlation between the templates is maximized for reducing the Scale variance between the characters. There are some factors effect on the accuracy of recognition for example quality of the picture, unclean plate, and the similarity in some character shapes. The proposed method tried to deal with those problem. An algorithm is proposed to cope with scale variance by using template matching with normalized Cross Correlation. It was applied and tested in India for Indian number plate vehicles. It achieved a great results accuracy of 98.07 % [23]. It is a very important study because it used Otsu's techniques. I use Otsu's method for threshold partitioning technique in my project.

In 2016 Abbas and others presented the Iraqi cars license plate detection and recognition by using edge detection and templates matching correlation. This proposed system consists of two basic steps. The first step is performed in the working environment. Two sensitive sensors are used here. They connected to a digital camera. This camera automatically captures a digital image of the vehicle. The image is then converted to the computer for processing. The second step of the proposed system is to process the image and get the important information required from license plate. That is done in five main stages, beginning with the image preprocessing. Here the size of the image is determined to fit the required size as well as the colors are converted in the gray system image. Then in the second stage, the license plate is selected from among the many details that are not important inside the image, using an accurate system called edge detection technique to take the required information. Then the required information is extracted and the numbers, letters and words are separated by using the Otsu's and Hough transforms technique. To reach the final stage in which numbers, letters and words are matched with the templates stored using the alphabetical matching technique and to transfer them to a special file quickly and accurately [24].

It is an important study because they used edge detection and templates matching correlation. I am using the same techniques for Iraqi cars license plate detection and recognition in my project.

Omran and Jarallah, proposed an automatic Iraqi license plate recognition system. The proposed system can distinguish between the three different styles of Iraqi car license plates. Recognizing each styles of Iraqi car license plates were done based on the Iraqi plate size. The proposed system used (OCR) for recognition of characters by segmenting every symbol and word and convert them into a text. Otsu's thresholding technique was used in proposed methodology to Convert the image of LP to binary. The proposed system software of getting information from license plate pass through many steps, start with detecting the location of the plate and the second step is segmentation, by separating each characters of license plate individually. Final step, use correlation and apply template matching for recognizing the plate symbols. MATLAB is used to perform software in the proposed system. This system

presented good results by testing more than 40 image of license plates. The results were 87.5% for getting the region of plates and 85.7% for character recognizing. The system performance achieved 86.6% [25].

I am using the Iraqi last version of Iraqi license plate to recognize the car identity based on the colored line on the plate.

# 3. THEORETICAL BACKGROUND

## 3.1 INTRODUCTION

Theoretical background that related to LPR proposed system is presented in this chapter with the relevant concepts of image processing, such as image segmentation. The proposed system has three major steps. Firstly, importing inputs: NPR system inputs is taken by the associated camera which take the needed videos that contained vehicles to be recognized. While the second step is Plate Detection: Here the licence plate is selected and isolated from the rest of the unwanted details of image and make it suitable for the next step by localizing the plate region from the whole image [26]. Finally, Vehicle licence plate recognition: The plate number plate image is taken here to be enhanced and suitable for recognition by applying optical character recognition system (OCR) to recognize each character individually. Mechanism of process shown in Figure 3.1. The main concepts and equipment that mainly related to these steps will be taken in this chapter.

## 3.2 IMAGE PROCESSING FUNDAMENTALS

Image processing is the process of dealing with images by using mathematical operations as well as getting help of any signal processing form for which input is an image. That can be achieved by three major steps of the technique of processing:

- Processing of digital image
- Processing of optical image
- Processing of analog image

The techniques of image processing always, deals with photo with two-dimensional signal and prepper it to apply the standard processing techniques in it. Image Processing techniques can also deal with images with three dimensional signals [27].

## 3.3 FORMATS OF IMAGE FILES

A lot of file formats are used to store images in files and get it again from these files. There are standards file format which are widely used nowadays in digital image processing. The most common standards of image file format are listed below:

- (.jpg): Joint Photographic Experts Group. It is the most popular one.
- (.gif) GIF Graphics Interchange Format.
- (.mpg) Moving Picture Expert Group.
- (.bmp) Bit Map.

## 3.4 MATLAB

MATLAB means matrix laboratory which is an environment for numerical computing. Functions plotting is done by using MATLAB matrix manipulation, algorithms implementation, user interface creation and a lot of other functions. MATLAB R2016a version is used for this project. [28]. The image formats supported by MATLAB are: BMP, HDF, JPEG, PCX, TIFF and XWB.

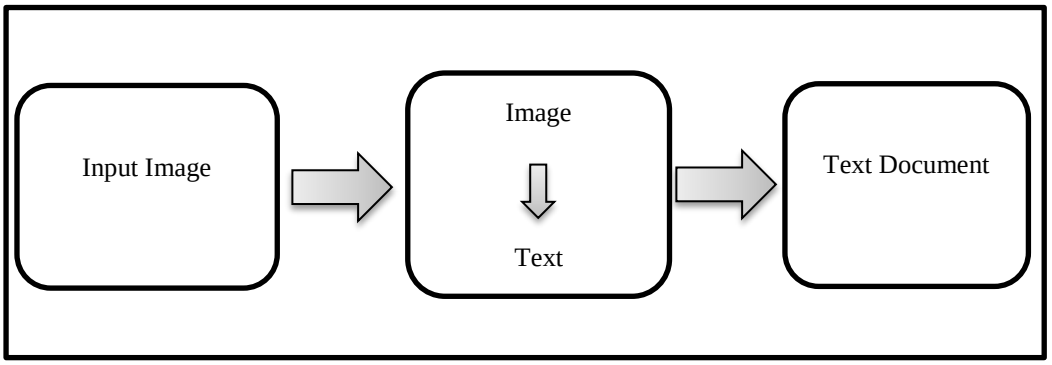



**Figure 3.1:** Optical mechanism.

## 3.5 TYPES OF MATLAB IMAGES

There are four types of MATLAB digital images that used in image processing. It depends on the values of existing pixels. In the process of character recognition, three type of image are used. The first three types of image are used in this study which are RGB format, GRAY format and binary image by starting with the RGB type then convert it to GRAY type and then convert it to binary type to be suitable for processing and apply a various of filters for enhancing image. Convert between these known types can be done by using MATLAB [29]. These types are:

- RGB Format
- GRAY Format
- Binary image
- Indexed image

### 3.5.1 RGB Format

To see and recognize things we need light which helps to distinguish the colours. By understanding colours help human to distinguish between things such us, trees and buildings and others. As well as for the dealing with coloured digital images there is a need to understand light as well as colours. In RGB type, there are three main colours: red, blue and green as shown in Figure 3.2. Secondary colours come from the integration of the main colours together. For example:

- Mixing Green and Blue present Cyan
- Mixing Green and Red present Yellow
- Mixing Blue and Red present Magenta

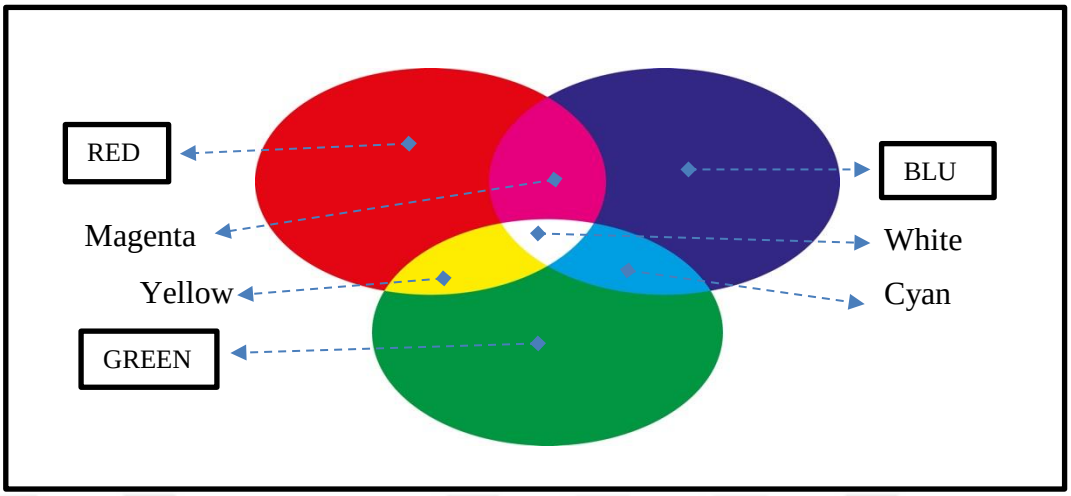



**Figure 3.2:** RGB format.

So, we can get large number of colures by mix up the main colours of RGB with each other. RGB type is an image represented by three-dimensional matrix (X1, Y1, Z1). Each pixel in image is come by mix up the three main colours (Red, Green, Blue) to present the suitable colour [30].

R, G and B have a specific value with range between 0 to 255. Red colour can be got by give the value of 255 to the red pixels, with value (255,0,0). While (0, 255, 0) provides green. White colour comes from (255,255,255). However, black colour comes from (0,0,0). This type of images is shown in Figure 3.3 below:

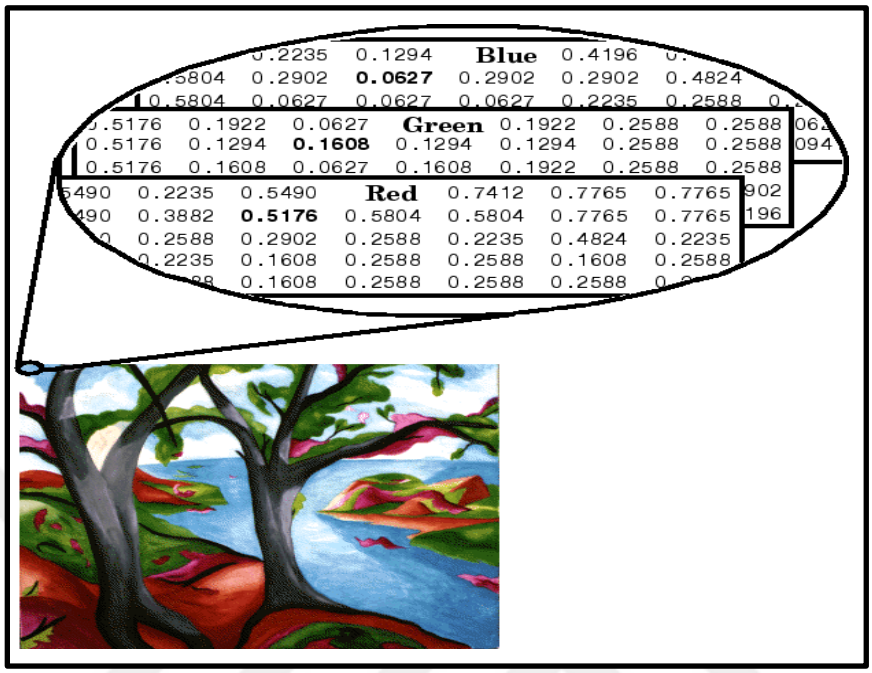



**Figure 3.3**: RGB image

### 3.5.2 GRAY Format (Gray Scale Image)

It is a digital image represented by a two-dimensional array within a range of (0,1). zero represents black color, while the value one represents white color. The values between them represent a gray gradient according to the image. MATLAB convert RGB image to Gray scale image by using the formula [31]:

$$Gray\ image = 0.2989 * R\ +\ 0.5870 * G\ +\ 0.1140 * B \tag{3.1}$$

Figure 3.4 illustrates this type of images:

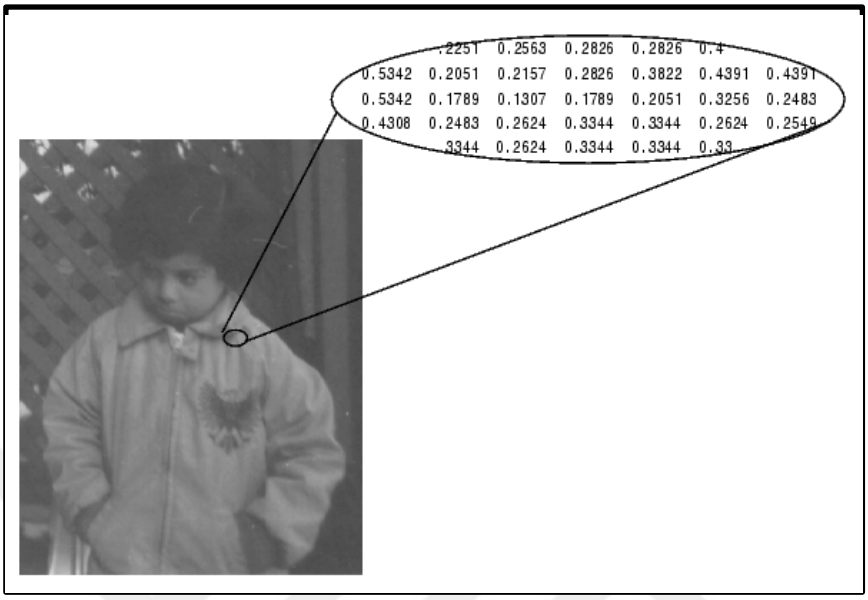



**Figure 3.4**: Gray scale image.

### 3.5.3 Binary Image

It is an image represented by a two-dimensional matrix with values of a numeric type. Each pixel has only two probable values (0, 1). The Zero value represents black, while the One value represents white colour. Binary image has only one bit per each pixel as shown in Figure 3.5 below [32]:

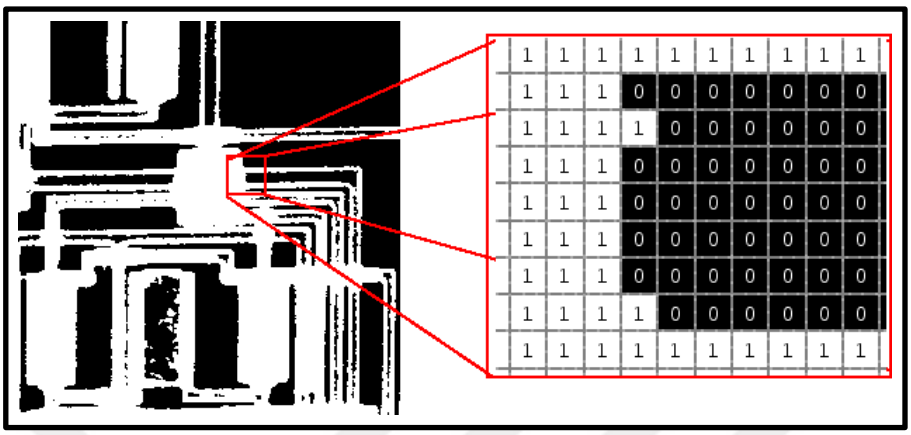



**Figure 3.5**: Binary image.

### 3.5.4 Indexed Image

It is an image represented by two matrices. The first matrix is two-dimensional matrix and it is called Index. However, the second two-dimensional matrix is called a colormap. The colormap matrix contains all the colours that are probably be existed in the image. The three columns of colormap matrix contain green, red and blue. While Index matrix contains the image pixels that indicate the colours in the colormap matrix. Each pixel holds an integer indicating a line in colormap matrix [33]. Figure 3.6 illustrates this type of image:

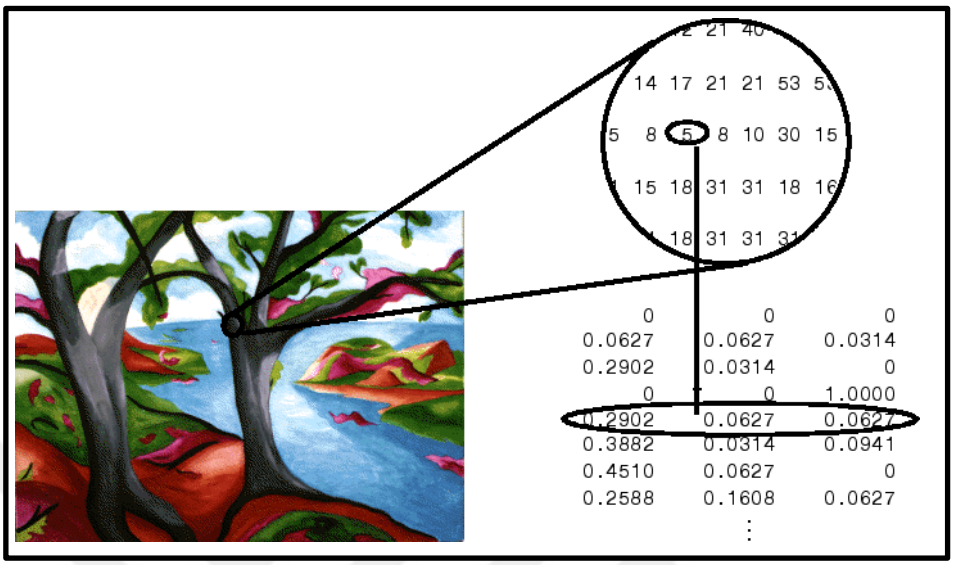



**Figure 3.6:** Indexed image.

### 3.5.5 Uint8 Image

This type is used to reduce the memory space and to speed up image processing instead of double image.

## 3.6 IMAGE ENHANCEMENT

Image enhancement is one of the most important and popular processing steps in the digital image processing field. Image enhancement techniques are used by deleting noise, adjusting colours, or adjusting light intensity. The main objective of image enhancement techniques is to manipulate any image so that the resulting image is better than the distorted image of a particular application. The combination of effective techniques used in image enhancement plays a key role in image enhancement processes to transform it into an image that can be analysed by machine or human. Extraction of information stops short of the image enhancement definition for digital image analysis and objects analysis. As an example, the

object out line edges of picture are confirmed by the high-frequency filtering in the system of image enhancement. For example, in the system of an image hatchment, the high-frequency filtering confirms the outline edges of objects in an image this. The enhanced Image edge is used as a machine input which may affect the outlines of the edges to be used for analysis. Image edge enhanced would then benefit as a machine input that would affect the edges outlines, and perhaps make measurements of the outline form and size. Nowadays, there is no specific theory for general unifying in the system of image enhancement due to the image quality. Also, there is no specific standard that has ability to avail, such as image enhancement processor layout standard. Assortment of techniques is taken here to achieve the use and benefit of image analysis and the supervision refinement of people [34] as shown in Figure 3.7 below.

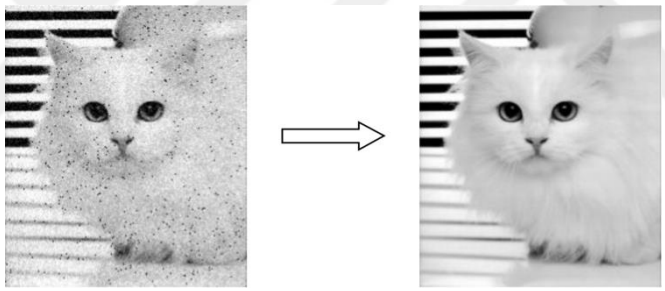


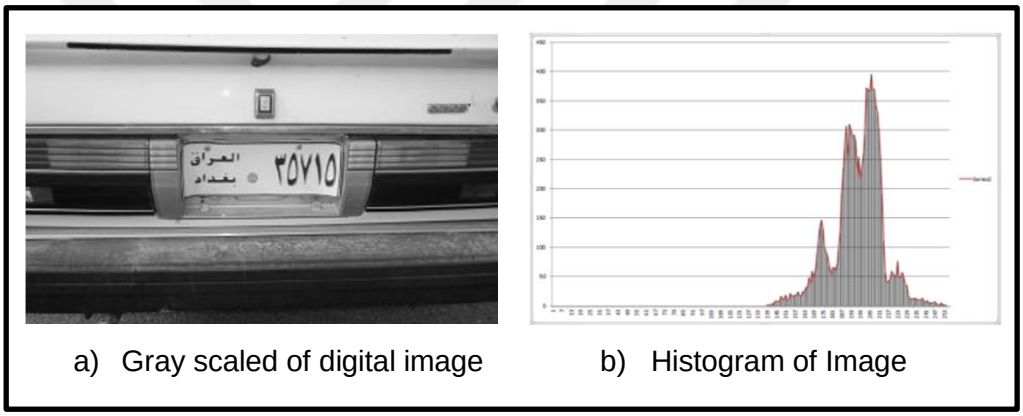
**Figure 3.7**: Image enhancement.

## 3.7 IMAGE HISTOGRAM

Image histogram means the relative frequency for the existence of deferent grey levels in the selected image. So, the main goal of image histogram is to give well description of the selected image. That depends on the way the graph is distributed and in case it is wide or narrow [35]. The histogram of the greyscale image contains the histogram of its grey levels, which gives a graph of selected image that contains times number of each grey level happens

as shown in Figure 3.8. Many types of information that can be got by dealing with image histogram. For example:

- The grey levels of the selected dark image as well as the hence the histogram, would be clustered at the lower end.
- While in selected bright image, the grey levels would be focused in the upper end of histogram image.
- While if we deal with a well contrasted image, the grey levels will be distributed appropriately over a large range of range [36].




a) Gray scaled of digital image b) Histogram of Image

**Figure 3.8**: Gray image and it's histogram.

## 3.8 IMAGE SEGMENTATION

It is a very important step in image processing. Segmentation is used to partition the image into separated and homogeneous regions. Here the image is divided into parts and the specific elements will be identified and isolated from other parts of the image. Image segmentation helps to:

- Discover things and shapes in an image such as, lines, squares, or rectangular

- Detect things such as, cars, trees, vehicles, or bridges.

Some algorithms are applied to improve the image and achieve the best case for the images we deal with to be suitable for processing [36].

There are many techniques of segmentation in digital images, which are:

### 3.8.1 Region Growing Technique

Region growing means the process of groups pixels into the larger regions in the digital images. By dealing with the procedure of growth process a homogeneous region can be got in digital images. It would be start with a seed that already selected. The neighbour pixels which have same attributes such as, texture and colour, would be gradually gathering. It is a frequently process, each seed pixel grows frequently to forms various regions by processing every pixel in it. The growth process stops when no more points can be added to the region. The growth process continues working until process all pixels and no more points can be added to the same region [37].

Seed filling algorithm is used here in this thesis. Seeding algorithms start with preselected a seed pixel as a seed point and other pixels gradually gathering [38].

### 3.8.2 Boundary Detection Technique

This is an important technique that developed by some researchers. To achieve this technique there is ability to split the image into parts with the same attributes. These parts of the image are determined by detecting the boundaries of these parts, which distinguish one of the parts from the other. Edge detection techniques are used to find out the boundaries of these parts. The edge is formed by combining pixels that have the same attributes and separate between two regions in the image [39].

### 3.8.3 Thresholding of Image Technique

Thresholding is a process of converting the input image to segmented of binary image as output. It considers as a fast method and it is common method and cheap comparing with

other segmenting techniques. This method depends on the pixels classification that belongs to a particular pattern taken from the background pixel pattern and a set of pixels of the object pattern belongs on the density level. The graph is used here to specify the border based on the grey pixel density in the same image [40].

## 3.9 EDGE DETECTION

Edges are the boundaries between different textures. Edge detection depends on edge information taken from the relationship between elements within the image. If the image element does not resemble with the second element in its side, there is no edge. But if there is a big difference between the elements means there is an edge. The brightness of the edges is higher than the rest of the image. Some edge detection operations are called edge direction as well as edge magnitude. So, edge detection is based on recognizing the sharp discontinuities between elements in the digital image. The discontinuities mean the extreme change in the intensity of the pixels that shows the objects boundaries in digital image. We can find a large number of operators of edge detection, every one of these operators is designed to detect a special kind of edges in the image. Edge detection methods detect the edges by convolving digital images with the operator (a 2-D filter). This operator is very sensitive to the large gradients in digital image. There are several factors that are taken in account in the techniques of detecting the edge such us, Edge orientation, Noise environment, Edge structure and edge shape. Horizontal, vertical, or diagonal edges can be detected with more accuracy by improving the operators. One of the problems facing edge determination is dealing with noisy images. Dealing with noisy images needs operators with large scope, to get enough data to detect noisy pixels in digital image [41]. There are several common techniques in detecting the edge, which are listed in the following.

### 3.9.1 Sobel Operator

It is one of the edge detection methods. The operator in this method contains a pair of (3×3) convolution kernels. One kernel is simply the other rotated by 90°. Figure 3.9 demonstrate it. Sobel operator is considered as the one of the best techniques of edge detection. It provides

a good result and that shows by experiments, clearly. Regarding to that, Sobel operator technique is used in my project, for edge detection.

| | | |
|---|---|---|
| -1 | 0 | +1 |
| -2 | 0 | +2 |
| -1 | 0 | +1 |

GX

| | | |
|---|---|---|
| +1 | +2 | +1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

GY

**Figure 3.9**: Masks used by Sobel operator.

Kernels here are used to respond completely to edges which are running horizontally and vertically belong to the grid of the pixel so one kernel of both perpendicular orientations. The input image gets the kernels by applying it separately, for providing gradient component separate measurements of the component in each orientation, these are called (gy and gx). After that to find the absolute magnitude of the gradient, gy and gx can be merged together in every point the gradient orientation [41]. The magnitude of the gradient can be got by:

$$|\mathrm{G}| = \sqrt{Gx^2 + Gy^2} \tag{3.2}$$

Typically, an approximate magnitude is computed using:

$$|\mathrm{G}| = |\mathrm{Gx}| + |\mathrm{Gy}| \tag{3.3}$$

It is much faster to compute.

$$\emptyset = \arctan(Gy \,/\, Gx) \tag{3.4}$$

### 3.9.2 Gradient Based Edge Detection

This method based on the directional change in the digital image as well as the intensity of image color. To detect edges in images, gradient based edge detection techniques achieve it by finding the first derivative into the digital image in both minimum and maximum edges [42].

### 3.9.3 Robert's Cross Operator

The concept of Roberts Cross operator is very close and similar to Sobel operator method. It achieves a simple, quick to compute and 2-D spatial gradient measurement on the digital image. The estimated absolute magnitude of the spatial gradient of the input image at every point is represented by the values of the Pixel in that points in the output. The pair of (2×2) convolution kernels is represented the contains of the operator. Here we have one simply kernel while the others are rotated by 90° [41]. It is presented in Figure 3.10.

| | |
|---|---|
| +1 | 0 |
| 0 | -1 |

GX

| | |
|---|---|
| 0 | +1 |
| -1 | 0 |

GY

**Figure 3.10**: Masks used for Robert operator.

### 3.9.4 Prewitt's Filter Method

Prewitt method is one of the edge detection techniques. It detects the edges in digital image based on the approximation of Prewitt to the derivative. It looks for the points where the gradient of the digital image has the maximum value to returns edges at those points that have the maximum gradient [43]. As shown in Figure bellow:

| | | |
|---|---|---|
| -1 | 0 | +1 |
| -1 | 0 | +1 |
| -1 | 0 | +1 |

GX

| | | |
|---|---|---|
| +1 | +1 | +1 |
| 0 | 0 | 0 |
| -1 | -1 | -1 |

GY

**Figure 3.11**: Masks for the Prewitt gradient edge detector.

### 3.9.5 Laplacian Method

This method looks for the zero crossings in the second derivative in the digital image for recognizing edges. Here the edge has the shape of one-dimensional of ramp as well as an edge has the one-dimensional shape of a ramp and counting image derivative that can reveal its location to be detected as clear edge [42].

### 3.9.6 Laplacian of Gaussian

The Laplacian is an edge detection method. It is a 2-D isotropic measure of the 2nd spatial derivative of the digital image. The Laplacian of an image focus on the fast intensity change area. It usually used for edge detection process. In this method the operator use image with single graylevel as input while the other graylevel image is provided as output. In Laplacian of Gaussian we have to detect the discrete convolution kernel because the input digital image is showed as a set of discrete pixels, which can approximate the second derivatives of

definition of the Laplacian [44]. There are two popular small kernels which are shown in the Figure 3.12.

| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 4 | -1 |
| 0 | -1 | 0 |

| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 4 | -1 |
| 0 | -1 | 0 |

**Figure 3.12:** Discrete approximations to the Laplacian filter.

## 3.10 COMPARISON BETWEEN EDGE DETECTION ALGORITHMS

We have an image of a girl converted into a gray image scale, used to compare between three types of edge detection techniques. To get best results of detecting Iraq car plate we use Sobel operator edge detection technique. A comparison of edge detection techniques to the child's image shows the original image in Figure 3.13, and finally, we compare the edge detection technology to the image shows in Figure 3.14. Sobel operator and Prewitt edge detection consider as the better techniques of edge detection. The Prewitt technique is same to Sobel. However, the difference is found in spectral response. Sobel have slightly superior noise-suppression characteristics, an important issue when dealing with derivatives. The experiments results show that Sobel edge detection technique is better than the Prewitt edge detection technique. Regarding to that, Sobel operator technique is used in my project, for edge detection of the selected image.


**Figure 3.13:** Used image for edge detection analysis (Child.png).

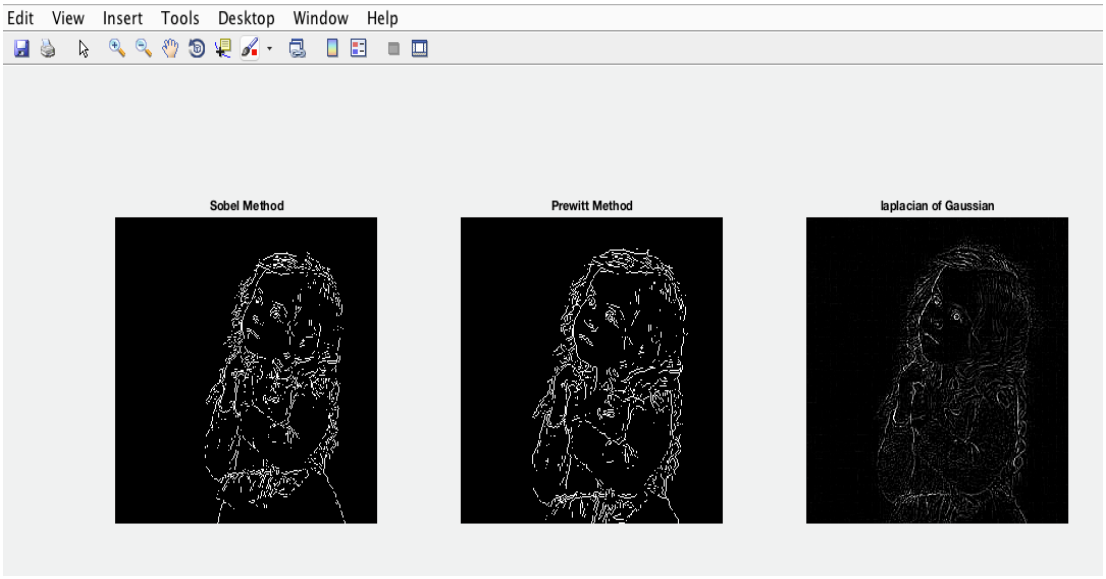



**Figure 3.14:** Comparison of edge detection techniques; Sobel Method, Prewitt Method and Laplacian of Gaussian.

## 3.11 LICENSE PLATE RECOGNITION STAGES

1. *Pre-processing***:** Many problems face license plates recognition systems. So, it needs a set of processors to solve these problems. Pre-processing is the first step to improve image quality and make it suitable for the next stage. During this phase, a certain filter is applied to enhance and improve the dark areas inside the image and make characters and edges of the plate darkened also, separate the colours of image as well as. The background from the highlights.

2. *License plate localization*: Here the license plate is located. The result of this process is a second image that contains only the license plate, excluding the other non-important images. This is done in two steps
    - Localisation a large bounding rectangle over the license plate
    - Determining the exact location of the license plate.

3. *Character segmentation*: This point is used for segmentation of symbols from original plate. Character Segmentation used to make image suitable for the next step by giving a set of monochrome images for each candidate character in the plate. This is done by some steps such as presenting a binary image from the original image and enhance image by remove noise from it. Also, a specific filter is applied to make sure there is no two characters are merged.
4. *Character recognition***:** The main point of this stage is to recognize and classify the received binary image that came from the previous stage which contains all characters [45] Optical character recognition (OCR) is used to recognize the letters and numbers of Iraqi vehicles plate. OCR is applied to convert input digital image to computer text that can be edited. The letter, number and other characters cannot be edited. They are made of tiny pixels which are make the shape of character in the image. OCR consist of two types which are, offline recognition and online recognition. In offline recognition the image or a scanned form of the document is used as source image, while in online recognition the successive points are provided as a time function as well as the strokes

order are available. Offline recognition is use in this study [46]. Figure 3.15 Represents the License Plate Recognition Stages.

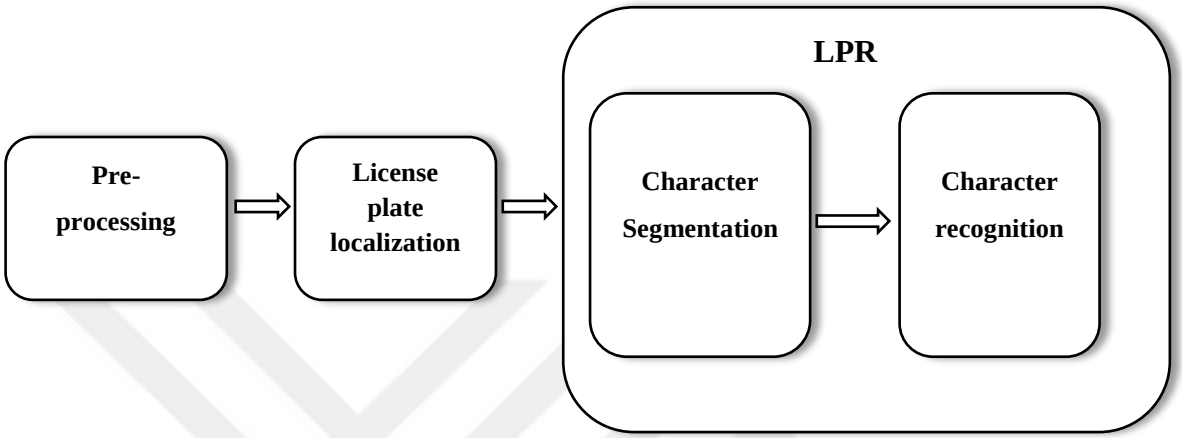



**Figure 3.15:** Stages of license plate recognition.

## 3.12 RECOGNITION OF ARABIC CHARACTERS

The recognition of document content is the computer ability to recognize the variance among individual characters and words. Optical character recognition is the process of extracting the text from image to text which can be edited to prevent retyping. There are many applications of this recognition, such as: it is used in the postal mail as an automatic sorting and editing old documents. There are two models of Character recognition: online and off-line [47].

- In *online* model, the process of character recognition occurs during the writing process by using the pen digitized trace.
- While in *off-line* model, off-line recognition deals with previously written documents of scanned images.

There are Many languages contain Arabic characters. For example, Jawi, Persian and Urdu. A few researches have been done to improve the character recognition of Arabic handwritten

compared to Chinese and Latin character recognition of handwritten. Arabic script has some Challenges. It is a bit difficult compare to English and some other languages. There is no upper and lower case in Arabic. It consists of 28 characters. Each one has two or four shapes and that based on the position of the letter in the word. It is written from right to left. Arabic characters and their shapes are shown in Table 3.1.

**Table 3.1:** Forms of Arabic character

| No | Name | Isolate | Beginning | Middle | End |
|---|---|---|---|---|---|
| 1 | Alif | ا | - | - | ـا |
| 2 | Baa | ب | بـ | ـبـ | ـب |
| 3 | Taa | ت | تـ | ـتـ | ـت |
| 4 | Thaa | ث | ثـ | ـثـ | ـث |
| 5 | Jeem | ج | جـ | ـجـ | ـج |
| 6 | Haa | ح | حـ | ـحـ | ـح |
| 7 | Khaa | خ | خـ | ـخـ | ـخ |
| 8 | Daal | د | - | - | ـد |
| 9 | Dhal | ذ | - | - | ـذ |
| 10 | Raa | ر | - | - | ـر |
| 11 | Zaa | ز | - | - | ـز |
| 12 | Seen | س | سـ | ـسـ | ـس |
| 13 | Sheen | ش | شـ | ـشـ | ـش |
| 14 | Saad | ص | صـ | ـصـ | ـص |
| 15 | Dhad | ض | ضـ | ـضـ | ـض |
| 16 | Tta | ط | طـ | ـطـ | ـط |
| 17 | Dha | ظ | ظـ | ـظـ | ـظ |
| 18 | Ain | ع | عـ | ـعـ | ـع |
| 19 | Ghain | غ | غـ | ـغـ | ـغ |
| 20 | Faa | ف | فـ | ـفـ | ـف |
| 21 | Qaf | ق | قـ | ـقـ | ـق |
| 22 | Kaaf | ك | كـ | ـكـ | ـك |
| 23 | Laam | ل | لـ | ـلـ | ـل |
| 24 | Meem | م | مـ | ـمـ | ـم |
| 25 | Noon | ن | نـ | ـنـ | ـن |
| 26 | Haa | ه | هـ | ـهـ | ـه |
| 27 | Waaw | و | - | - | ـو |
| 28 | Yaa | ي | يـ | ـيـ | ـي |

The fourth, fifth and sixth show the shape of letters based on their position in the word. Dots play a great role in Arabic letters. Some of Arabic letters are similar to each other but we can recognize them by check the number and position of dots in the letter. For example, three characters such as (ح، ج، خ) have same shape. However, we can recognize them depend on the existence of dots and the position of them [48].

## 3.13 OPTICAL CHARACTER RECOGNITION

To extract characters from image and convert them to text that can be handled by computer. Symbols, numbers and letters are recognized through several important steps including segmentation, feature extraction and classification. Handwritten recognition has two types, on-line and off-line recognition [49]. OCR takes great and important interest in industry and in academic research. Here we will put the basic ideas for optical recognition of the characters.

This technology allows the user to convert characters which are contained in digital images or PDF files into understandable and editable texts that can be edited by using computer and it can be displayed on-line. OCR is a metamorphosis that simulates human ability to understand and read texts but with less accuracy [50].

Because of their importance since ancient times humans have tried to develop machines to mimic some of his movements and help him in his functions. One of the most important functions is to read documents and texts that contain different patterns or forms of texts.

OCR has transformed the dream into a reality where it allows us to convert various types of documents from optical documents captured by the scanner or text within the digital image to editable and searchable texts. Text recognition systems have become one of the most successful technological applications, but they still cannot reach human accuracy.

OCR performs automatic recognition, which means collecting external data, such as letters, sound or video, and converting them into a computer to begin processing and analyzing it without human interference.

Automatic identification can be made using different techniques that are used in different applications. There are other important technologies, and their noteworthy applications such as vision systems, radio frequency, speech recognition, barcode magnetic strip and optical mark reading. Those techniques were used widely in last decades.

The printed or handwritten characters can be recognized but the performance depends directly on the quality of the input information. Figure 3.16 shows the different areas of character recognition.

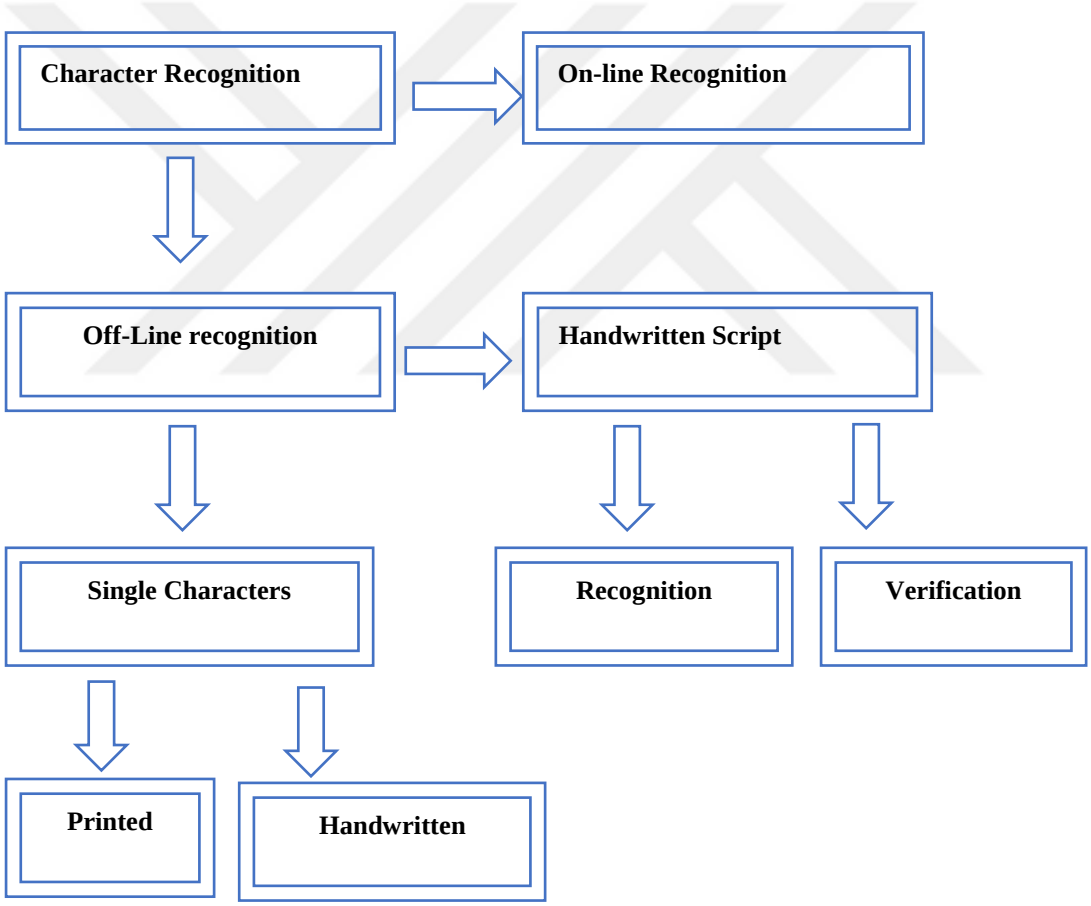



**Figure 3.16**: Different areas of character recognition.

## 3.14 TECHNIQUE OF OPTICAL CHARACTER RECOGNITION SYSTEMS

The key concept of patterns automatic recognition is to give an information to the machine about the patterns class that may occur and what their shape. The machine teaching is done by giving characters examples to the machine contain all different classes and patterns. Machine builds prototype depend on these examples of each class of characters. Numbers, letters and some special characters like question marks, commas and different symbols are the OCR patterns. The unknown symbols are compared to previously given prototype and assigned to pattern or class that gives the best match during recognition.

Typical system of OCR contains many components as shown in Figure 3.17 [51]. Firstly, digitize analog document by using an optical scanner. Secondly, extract each character through segmentation process after locating regions that contain texts. Then pre-processed the extracted symbols, eliminating noise for facilitating feature extraction. After that, to find the identity of each symbol, compare the extracted features with prototype of symbol classes obtained through a former learning phase. Finally, contextual information is used to rebuild numbers and words of the original text.

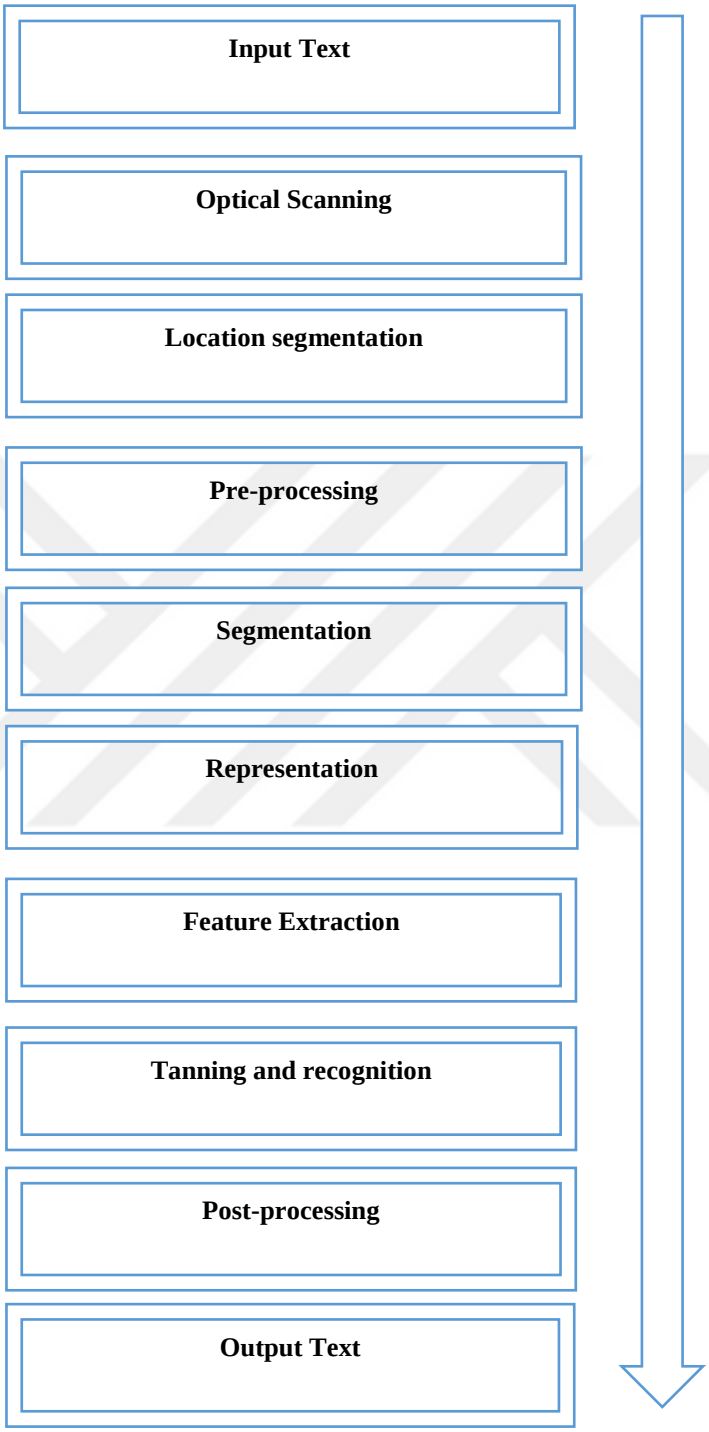



**Figure 3.17**: OCR System components.

As a briefly present these steps are:

i. *Optical scanning:* Digital image of original document is captured in scanning process. In Optical Character Recognition optical scanners are used which contain sensing device and transport mechanism that converts the light intensity into grey levels. Printed documents contain black prints on a white background. The process of performing OCR multilevel image is converted into bi-level black and white image known as thresholding. It is done on scanner to computational effort and save memory space. The process of thresholding the threshold process is important as the recognition results are fully based on the bi-level image quality. A static threshold is used in which the gray levels under this limit are black and the above levels are white. For a high contrast document with a uniform background, the predefined fixed threshold can be. However, documents encountered in practice have rather large range. In this situation there is a need for anew modern methods for thresholding to get new results. The local document properties such as brightness and contrast effect on the best thresholding methods. However, these methods usually based on multilevel scanning of document which need more memory as well as computational capacity.

ii. *Location segmentation:* The second component of OCR is location segmentation. Segmentation define elements of the image. It is important to locate regions in document which contain printed data and distinguish them from graphics and figures. As an example, when performing an automatic mail that sorting through envelopes address. It must be located and separated company logos and stamps, before recognition. The most algorithms of OCR take the word and segment it into isolated characters and recognized them individually. Usually segmentation is done by isolating each connected symbol separately. It is easy to perform but problems may occur when characters touch or if they consist of several fragmented parts. Key problems of segmentation:

    - The process of distinguishing noise from text.
    - Misinterpreting graphics and geometry with text and vice versa.

- The process of extraction of touching and fragmented characters.

iii. *Pre-processing*: The third component of Optical Character Recognition is pre-processing. Data taken in many steps must undergo processing to make them unusable. Images taken with the scanner often contain noise. Or the letters may be unclear or broken and this leads to a weak process of identification and recognition. Some of these problems are eliminated through pre-processor by doing smoothing digitized characters. Filling eliminates gaps, the small breaks and holes in digitized symbols. Pre-processing contains normalization with smoothing side by side. The normalization is used to get symbols of regular size, rotation and slant. The correct rotation can be found based on its angle. The pre-processing component aims for producing easy data to the OCR systems for accurate work. Pre-processing is a very important activity to be performed before analyzing actual data. The key aims of pre-processing can be mentioned as:

iv. *Noise reduction*: writing instrument and optical scanning device introduce noise and this causes disconnected line segments, gaps and bumps in lines, filled loops, and others. The distortion including rounding of corners, local variations, dilation and erosion is Possible problems. It is important to eliminate these defects before actual processing of the data [52]. The techniques of noise reduction can be categorized in three main points:

   - Filtering
   - Morphological operations
   - Noise modeling.

v. *Compression*: The compression techniques of classical image convert image from the space domain into domains which are not suitable for recognition. The OCR compression needs space domain techniques to preserve the information of shape. There are two available techniques of compression
   - Thinning
   - Thresholding.

vi. *Data normalization*: The main goals of normalization methods are to obtain standardized data and remove the variations of the writing by getting stand shape of letter [52]. As in Figure 1.6. The most commonly methods that used for normalization are:

- Size normalization.
- Slant normalization.
- Skew normalization and baseline extraction.
- Contour smoothing.

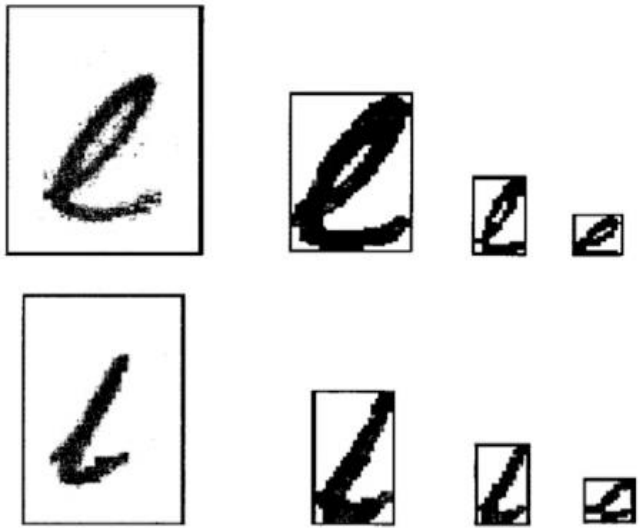


**Figure 3.18**: Character normalization.

vii. *Segmentation*: A clean symbol image is given from the pre-processing level. That means the previous stages produced high compression, a good amount of shape information, and normalized image has low noise. Is the fourth component of OCR. In this stage subcomponents of character image are presented by segmenting it. Segmentation is one of the most important stages because of the extent that can be

reached in various lines separation in the characters affects the recognition rate directly. There is an Internal segmentation is used which isolates curves and lines in the cursively written symbols. The problem of cursive symbols segmentation is still unsolved. However, a variety of techniques have emerged in the past and many great methods have developed, there are three categories of character segmentation strategies which are: Implicit segmentation, Mixed strategies and Explicit segmentation.

(a) *Explicit segmentation*: Here the segments will be defined depend on symbols like properties. Dissection is performing the process of cutting up the symbol image into useable components. Symbol image is analyzed by dissection without using a fixed class of the information of shape. The matching of general properties of the segments with those expected for valid characters is used as the criterion for good segmentation. The available methods depend on the dissection of the symbol image use:

- White space and pitch
- Vertical projection analysis
- Connected component analysis
- Landmarks

The linguistic context can be used by the explicit segmentation for subjected to evaluation.

(b) The second strategy is implicit segmentation which is depend on recognition. It looks for the image for components that matches the predefined classes. The recognition confidence with syntactic or semantic correctness of the all result is used to achieve the segmentation. Two classes of methods are used in this approach:

- Firstly, methods that segment a feature representation of the image.
- Secondly, methods which make some search process. The second class goes toward to segment symbols into units without use of feature-based dissection algorithms. The image is divided systematically into many overlapping pieces

without regard to content. The key principle is to use a moving window of non-fixed width to perform sequences of tentative segmentations and it will be confirmed by OCR. In the first class by classification of subsets of spatial features collected from the image as a whole this method segments the image implicitly.

(c) The third strategy is some mixed strategies which a mix of explicit and implicit segmentation. The system will apply a dissection algorithm on the symbol image. However, the intent is to over segment for cutting the image into several places such that the boundaries of correct segmentation are included through the cuts made. Then, system looks for the optimal segmentation by evaluation of subsets of the cuts that made. To choose best promising segmentation every subset tend to segmentation hypothesis and classification is brought to bear to evaluate the different hypothesis. The system formulates the segmentation problem as catch the shortest path of a graph that formed by binary and gray level document image. The mixed strategies give good results compared to implicit and explicit segmentation strategy methods [52].

viii. *Representation*: is the fifth stage of OCR. In any recognition system image representation has a key role. In order to avoid extra complexity and to rise the algorithms accuracy in recognition systems, more compact and representation of characteristic is needed. For this purpose, some features are extracted for any class to recognize it from the rest of classes. However, keep invariant to differences of characteristic within the class. Because of the most of recognition systems. The representation methods of character image are divided into three main groups: (a) geometrical and topological representation. (b) statistical representation and(c) global transformation and series expansion

(a) *Global transformation and series expansion*: transformation or series expansion is compact encoding that provided by the coefficients of the linear combination. With the global transformation and series expansion. Deformations like translation and rotations are invariant. Some popular methods of transform and series expansion in OCR are:

- Moments.
- Fourier transforms.
- Karhunen loeve expansion.
- Gabor transforms.
- Wavelets.

(b) *Statistical representation*: It is an important point in representation. The original image reconstruction is not allowed in Statistical representations. However, it is used for decreasing the dimension of the feature set in case of ow complexity and high speed. The popular statistical features that use in character representation are:

- Projections.
- Zoning.
- Crossings and distances.

(c) *Geometrical and topological representation***:** geometrical and topological features can represent the various global and local properties of characters with high tolerance to distortions and style variations. Geometrical and topological representation may also encode some information about the object structure or may provide some information about what kind of components that make the object [53]. The topological and geometrical representations can be categorized as:

- Graphs and trees.
- Extracting and counting topological structures.
- Measuring and approximating the geometrical properties.
- Coding.

ix. *Feature extraction*: is the sixth stage of OCR. The main goal of feature extraction is to capture the key characteristics of symbols. Feature extraction is very difficult problem of pattern recognition. Actual raster image is the better forward way of describing characters. Another way is extract important features of symbols but without taking

the non-important attributes. There are three technique groups for extraction features which are (a) distribution of points (c) structural analysis. (b) transformations and series expansions ease of implementation, use, noise sensitivity, and deformation are used to evaluate the different groups of features There are two standers used in this evaluation which are: (a) robustness that means considering the following factors: noise, style variation, distortions, translation and rotation (b) practical usage with take in account the implementation complexity, independence and recognition speed. There are some popular feature extraction techniques which template matching and correlation, transformations, distribution of points and structural analysis. Classification is another job of feature extraction. Classification is the process of getting each character and compares it with the correct character class. OCR use two important models of classification which are decision structural methods and theoretic. When deciding on class membership the relationship between the characteristics may important. As an example, if we get the information of character that has one vertical and one horizontal stroke the character may be either 'L' or 'T. So to distinguish characters the relationship between two strokes is required.

x. *Training and recognition***:** are the seventh OCR stage. Pattern recognition methodologies are used in OCR systems which detect an unknown character into a predefined class. The following approaches of pattern recognition are used to investigate The OCR they are neither necessarily independent nor disjointed from each other, which are: (a) Template matching, (b) Statistical techniques, (c) Structural techniques (d) anns.

   (a) *Template matching:* The features can be as simple as the gray-level image frames with individual characters complicated as graph representation of character primitives. The easier method of OCR is depending on matching the prototypes that already we have against the character to be recognized. Generally speaking, the operation of matching presents the degree of similarity between two vectors. For example, shapes, group of pixels, curvature and others in the space of feature. Three classes can be included in matching techniques which are:

- Direct matching.
- Deformable templates and elastic matching.
- Relaxation matching.

(b) *Statistical techniques*: The statistical decision functions and a set of optimality criteria which maximizes the probability of the observed pattern given the model of a certain class concerned by the statistical decision theory. The statistical techniques are mainly depending on three main assumptions which are:

- The feature distribution set is Gaussian or in the worst-case uniform
- Each class has a sufficient statistic available
- Given block of images {I} one is able to extract a set of features {fi} ∈ F; i = {1, . . ., n} which represents each distinct class of patterns.

(c) *Structural techniques*: The recursive description of a complex pattern in terms of simpler patterns based on the shape of the object was the initial idea behind the creation of the structural pattern recognition. Symbols in OCR systems are described and classify by using These patterns. It is supposing that the character of primitives that extracted from writing are quantifiable and the relations among them can be found [54]. The methods of structural that applied to the OCR problems which are:

- Graphical methods.
- Grammatical methods

xi. *Post-processing*: is the eighth stage of OCR. Error detection, grouping and correction are the popular activities of post-processing. Many ways can be used to enhance the accuracy results of OCR.one of them is to use more than one classifier to classify the image. Then many methods can be used to combine the results of classifiers. Also, contextual analysis can be enhanced to improve OCR results. Document context and the geometrical of the image are used to help in minimizing the error chances. Another approach to improve the final result of OCR is to use the Lexical processing that depend on dictionary and Markov models [55]. Normal symbol recognition in text has a result which is a set of individual symbols but, there is not enough information

contained in the characters. These individual symbols are with each other making up words and numbers. The word and numbers are established by associating those individual character with each other. The characters which are close to each other grouped together. The grouping is possible because of the distance between letters is less small than the distance between words [56]. The real problems are with handwritten symbols. To some extent, recognition systems give good results. However, we cannot get results that reach to 100% correct identification of all characters even with the best recognition systems. Context is used to detect and correct errors. To achieve that, there are two major points:

- *Firstly*, use dictionaries with highly efficient correction method and detection of errors. In case of error in the word, it will be looked up in a dictionary. However, searches and comparisons take a lot of time in the dictionary methods and this reflects the flaw of this method.
- *Secondly*, uses the possibility of Sequential characters appearing with each other. In this situation, rules defining syntax of word is used to perform that. The possibility of two or more characters that coming close to each other in sequence can be taken in account and used to find errors. As an example, for English language the possibility of h coming before k in same word is zero and if such a situation is found an error is mentioned [57].

## 3.15 TEMPLATE MATCHING TECHNIQUE

In this work Template Matching technique is used in OCR which a system that used for character recognition or alphabet and words by comparing two images of them. Template matching method is used to recognize the template image which is existed in the given input image [58]. In this work Template Matching method is used to overcome the problem in character recognizing which is difficult to recognize the characters without using any techniques specially the characters of Iraqi vehicle license plate. Template Matching is also

used to reduce the number of operations of comparing images of character templates because of the number of characters in the plate is relatively limited and fixed. The next steps are implemented by the algorithm of template matching:

1. From the detected string system select the character image.
2. Convert the size of the image to be fit with the size of the first template is rescaled.
3. Compute the matching metric.
4. Store the highest match that found. If it is not matching repeat again the previous step.
5. Then system store the index of best matching of recognized characters.

System will extract then, the value of the data that has already got from the images [59].

Cross-correlation template matching is performed by measuring the distance (squared Euclidean distance).

$$\mathbf{d}^2\, f, t(\mathbf{u}, \mathbf{v}) = \sum_{x,y} [f(x,y) - t(x-u, y-v)]^2 \tag{3.5}$$

Here "f" represents the input image while "t" represents the template image. The sum is over x, y under the window including the feature "t" positioned at (u, v). In d2 expansion

$$\mathbf{d}^2\, f, t(\mathbf{u}, \mathbf{v}) = \sum_{x,y} [f^2(x,y) - 2f(x,y)t(x-y, y-v) + t^2(x-y, y-v)] \tag{3.6}$$

∑t2(x-u, y-v) is a constant term. So, If the term ∑f2 (x, y) is early constant, then the remaining cross-correlation term.

$$\mathbf{c}(\mathbf{u},\mathbf{v}) = \sum_{x,y} f(x,y)\, t\,(x-u, y-v) \tag{3.7}$$

It represents the similarity measure between the feature and the image [60].

## 3.16 SOME OF OPTICAL CHARACTER RECOGNITION SYSTEMS APPLICATIONS

OCR systems helped people in many of their jobs in life and There are many areas of applications existed. Some of important and popular applications will be listed:

(a) *Verification and identification of Signatures*: The signature is represented as a pattern that compared with signatures which stored in the database. This application of OCR is commonly used in banking. This system mostly used to define the writer identity.

(b) *Automatic read of number plate*: in fact, there are a few systems that used for cars to automatically read the number plates despite its importance in the public life of people [56].

(c) *Automatic cartography*: character recognition has a great problem in recognize symbols from maps. Because of characters are not organized and they are intermixed with graphics, text is not printed in a straight lines and symbols contains many fonts or even we can find handwritten.

(d) *Aid of blind*: this is very important application on OCR because of The suffering of the blind in reading. So, with this system blinds have the ability to understand printed documents [61].

# 4. IMPLEMENTATION

This chapter provide the implementation of the Iraqi license plate detection and recognition. Every stage of the system is presented in detail. With the necessary figures that related to each process. The Iraqi license plate detection and recognition system can be divided into two main processes, the licence plate detection and the character plate recognition system by applying OCR. To implement the system, MATLAB is used here because it is considered as a powerful and quicker software tool than C and C++. As well as MATLAB has a library functions of image processing which facilitates work.

## 4.1 SYSTEM COMPONENT

The pre-processing part is very important because it make the digital image suitable for the next part of the image processing which is Iraqi license plate detection and extraction to make it suitable for the next part of the system which is character recognition by applying the optical character recognition system (OCR) to convert the information in the Iraqi license plate image to editable text by identify the number of the vehicle and which governorate that vehicle belong to, as well as the type of the vehicle if it personal, carry, governmental, or taxi vehicle (خصوصي، حمل، حكومي، تكسي) by checking the coloured line on the plate. Finally, the system checks the accuracy of the recognition system by detecting the type of vehicle based on the coloured line in the plate where the white line refers to the personal vehicle (خصوصي), while the red line refers to the taxi vehicle (تكسي), but the blue coloured line means it is governmental vehicle(حكومي), and the yellow coloured line means it is a carry vehicle(حمل). Table 4.1 demonstrate that.

**Table 4.1:** Iraqi vehicle types.

| No, | Vehicle type. | Character of the coloured line. |
|---|---|---|
| 1 | Personal Vehicle | White |
| 2 | Governmental Vehicle | Blue |
| 3 | Taxi Vehicle | Red |
| 4 | Carry Vehicle | Yellow |

The proposed system provides two results of the same vehicle type. The first one gets from the text in the plate and the second result comes from the coloured line. To check the accuracy, the proposed system compares between the two results. If the two reading gives the same result that mean it is correct. Otherwise there is a problem. These steps are shown in Figure 4.1. The licence plates of the types of Iraqi vehicles that used in the project is shown in Figure 4.2.

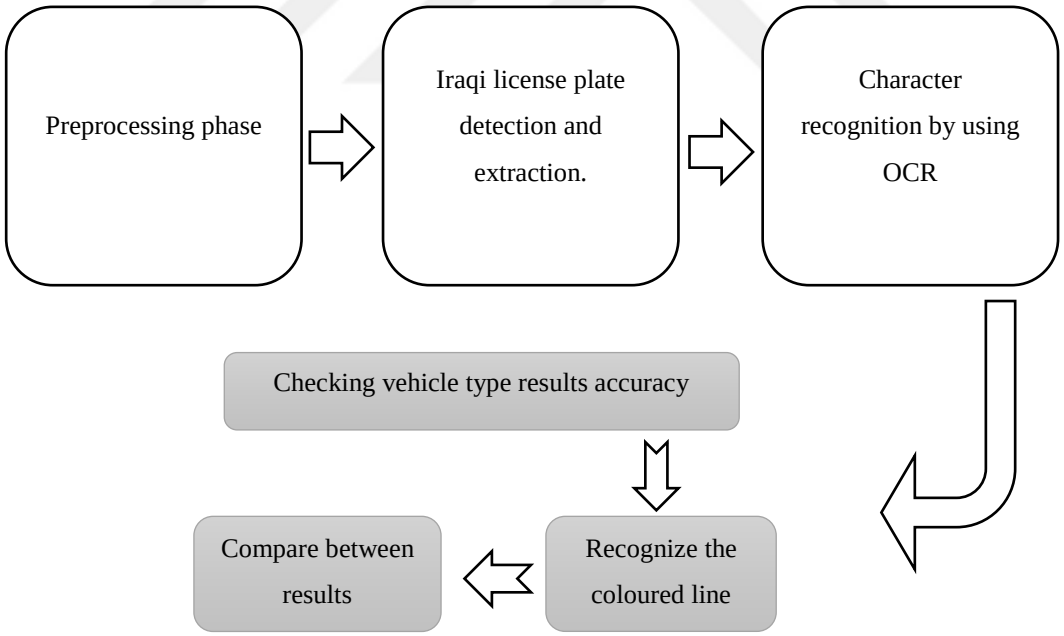



**Figure 4.1:** Main components of the system.


a. Personal


b. Taxi vehicle


c. Carry


d. Governmental vehicle

**Figure 4.2:** The Iraqi vehicle types.

## 4.2 IMAGE READING

It is the first step of the proposed method. The input digital image to the character detection and recognition system is a coloured image of licence plate which has the format (jpg). The original input image contains the license plate with many unneeded details such as the car the body of the car as shown in Figure 4.3. When the original digital loaded it will be ready for processing.


**Figure 4.3:** The original RGB input image (19.jpg).

## 4.3 CONVERT RGB DIGITAL IMAGE TO GRAY DIGITAL IMAGE

It is the first processing step in the proposed system. In this step the input RGB image is converted to gray scale to be easy and better dealing with pixels. Red, Green and Blue are the contains of the coloured image which are not used in the proposed system. If MATLAB deal with coloured image that means it deal with three 3-dimensional RGB. So, it converted to array of 2-dimensional gray scale image. Figure 4.4 shows the 2-dimensional gray scale image. MATLAB function rgb2gray (); is used to convert from RGB to Gray. MATLAB convert RGB image to Gray scale image by using the formula:

$$Gray\ image = 0.2989 * R\ +\ 0.5870 * G\ +\ 0.1140 * B \tag{4.1}$$


**Figure 4.4:** Gray scale image.

## 4.4 CONVERTING GRAY IMAGE TO BINARY IMAGE (BINARIZING)

In this step the gray scale image is converted to binary image by thresholding. In binary images, 1 refer to (White pixels) while 0 means it is (Black pixels). The output binary image has the values of 0 (black) for the pixels in the input gray image with luminance less than level and 1 (white) for all other pixels. Figure 4.5 shows the binary image. MATLAB is used the function bellow to convert from gray to binary.

*Im2bw ();*

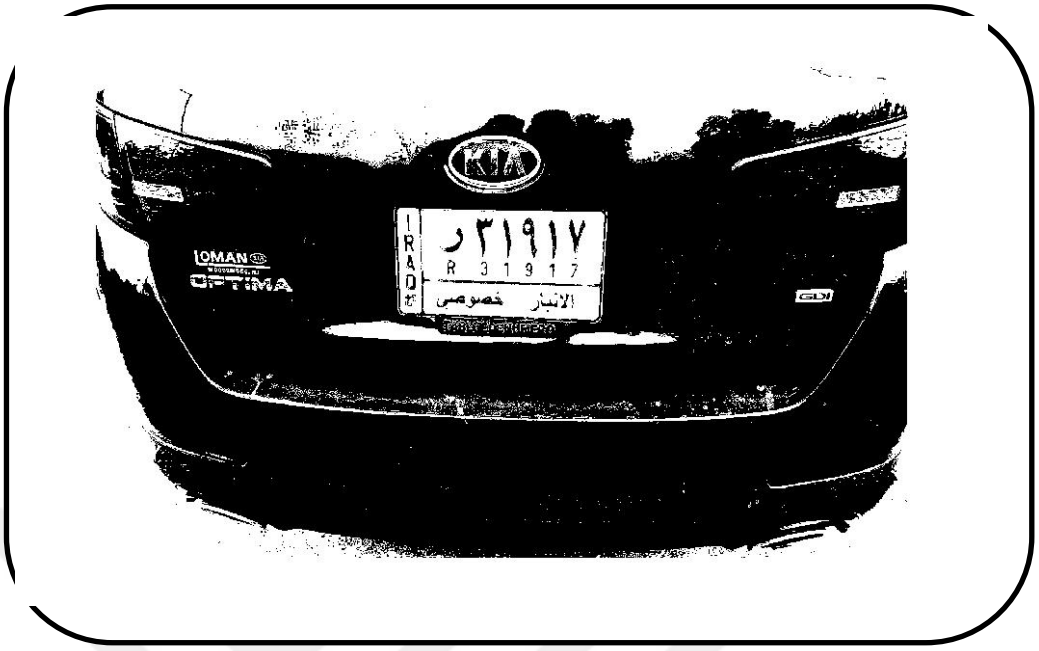



**Figure 4.5:** Binary image.

## 4.5 EDGE DETECTION

Sobel edge detection method is used for detecting the edge points in the selected digital image. The main reason for using Sobel edge detection method, it provides good results with binary images. The licence plate is only the important region in all image, so we just need to deal with the edges of the selected digital image. To achieve it we need first, to convert the original image from RGB to gray scale then binarize it. With MATLAB we have the ability to calculate the various intensities in the selected binary image. All pixels that have values more than a certain threshold will be white, while all pixels that have values less than a certain threshold will be black. We have thus as it were a binary image. The edge algorithm of detection is used in binarized gray scale image as in Figure 4.6 shows the results.

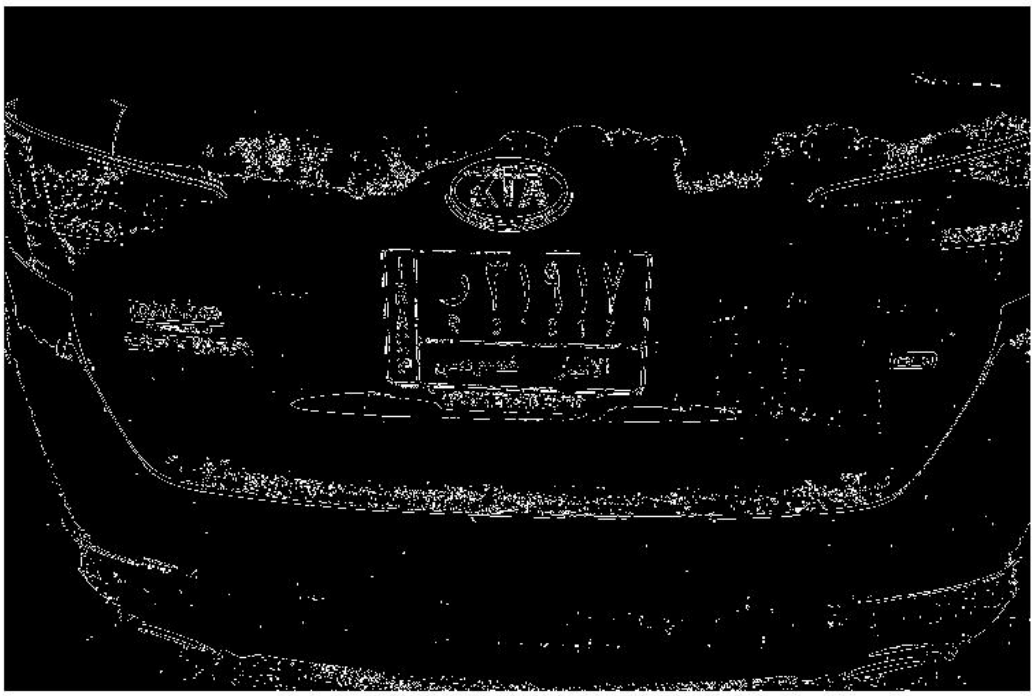


**Figure 4.6**: Sobel edge detection.

## 4.6 IMAGE LABELLING

It is the operation of detecting the connected components in the selected digital image and make each one a unique label. It is used to detect connected regions in binary digital images to give labels for each object in the image as shown on Figure 4.8. MATLAB use function "bwlabel ();" for labelling. It is shown clearly in Figure 4.7.


**Figure 4.7**: Labelled image.

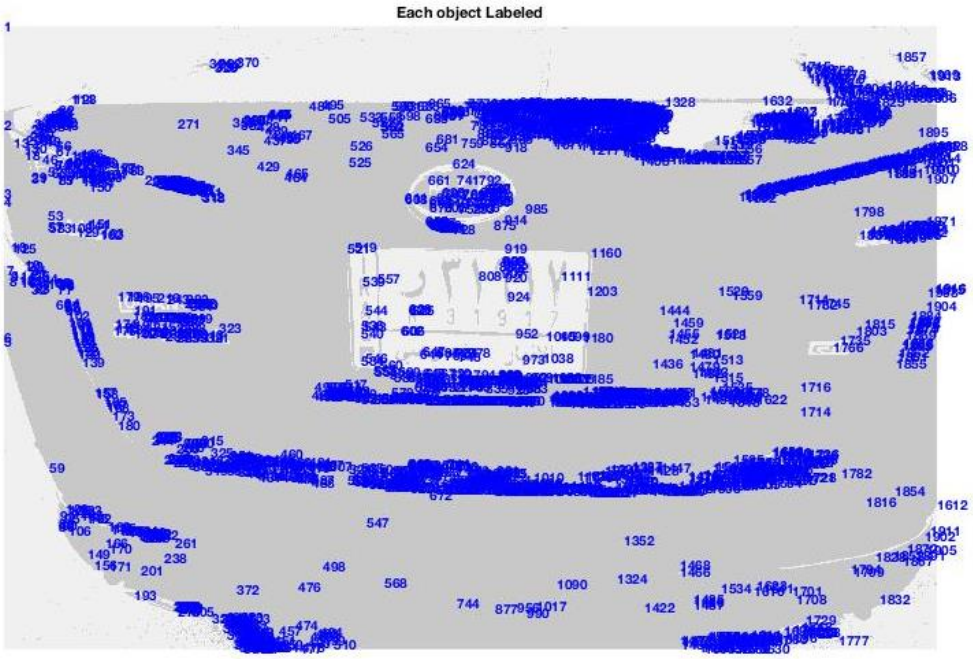



**Figure 4.8**: Each object labelled.

## 4.7 IMAGE DILATION

Dilation used to enhance the selected digital image. It enhances the object by adding pixels to the boundaries of the image objects. It deletes the erosion pixels on the boundaries of the object based on the shape and size of the structuring object which is used for image process. Figure 4.9 demonstrate it.


**Figure 4.9**: Dilated image.

## 4.8 HISTOGRAM (HORIZONTAL AND VERTICAL HISTOGRAM)

In this step we are going to do horizontal and vertical histogram processing. Digital images have a boundary like a big break. Histogram represents a chart explain the fluctuating quantities amount above the specified series. Horizontal and vertical histogram are used to detect the Iraqi license plate which deal with the column-wise and row-wise histogram correspondingly. Histogram means there is an addition of the variations in the Gray scale values into the pixels, row-wise and column-wise of the selected digital image. Horizontal histogram is the operation deals with every column of the digital image. In every column, operation start with the second pixel after the topmost pixel and count variance amongst 2nd and 1st pixel. If the variance goes beyond the specific verge, it will be put in an entire edition of variances and the operation will shift down for counting variance amongst 2nd pixel and 3rd pixel. This process continues until termination of a column and then count all addition of variances among adjacent pixels. At the end, the operation forms an array comprising column-wise addition. Same operation is provided for determining the vertical histogram. However, rows are replaced instead of columns [62].

- *Horizontal histogram***:** is used to write the correct region in horizontal edge processing. Firstly, each pixel in every column is collected then the maximum of column average of including white pixels then the image put in gray scale as the contrast in gray value between successive pixels exceeds a certain limit. Then, there is a result matrix contains all column totals. So, this operation is used to detect the write region in horizontal edge operation. We already have a calculated beforehand threshold. However, if the number of white pixels per column is above a calculated beforehand threshold, that means some regions are the horizontal position of the license plate. We get several bearable results. In case there are several possible regions selected, we will continue working with the widest. Horizontal histogram is shown in Figure 4.10 a.
- *Vertical histogram***:** here the operation is to not take number of white pixels in each column but take the number of times the differences of pixel to it is neighbour in the same row. In our process the rows include the Iraqi license plate have many differences pixels. Vertical histogram is shown in Figure 4.11 a.

The Iraqi licence plate can be detected from unneeded element in the selected digital image after horizontal histogram and vertical histogram.

## 4.9 PASSING HISTOGRAM THROUGH A LOW PASS FILTER

Low pass filtering is used to clear the selected digital image from high spatial frequency noise we use it for smoothing digital images, reducing the intensity variation amount between one pixel and then resulting in minimizing noise in images [63]. However, there is a drastically changes in the histogram values between consecutive rows and columns. So, to avoid losses in the important information in next steps, it is better to reduce such a drastic change in the histogram value. For that, the vertical and horizontal histogram is passed through the low-pass filter. In this operation, the average of each histogram value is taking in account the values on it right-hand side as well as left-hand side [64]. This operation is performed on both vertical histogram and the horizontal histogram.

Low-pass filter uses to filtering out unwanted regions in an image which means select Iraqi licence plate region from whole digital image. When the histograms passed the through a low-pass filter. Low-pass filter start removing unwanted areas from the digital image. Where the unneeded areas refer to the rows and columns with low histogram values. A section of image that involve the little variations between neighbouring pixels refers to the low histogram value. Since the area with Iraqi license plate has a plain background which contains alphanumeric characters, there is a very high difference in the neighbouring pixels, particularly at the characters edges and number plate [65]. This result is presented in a high value of histogram for this part of a digital image. Passing horizontal histogram through low pass filter is shown in Figure 4.10 b, while passing vertical histogram through low pass filter is shown in Figure 4.11 b.

## 4.10 THRESHOLDING

It is an important operation in the proposed system. It is a specific value that has couple of regions on its either side, greater than the value of threshold or smaller than the threshold. When we want to make some conversion on each pixel in the digital image then the

transformation function may be a thresholding operation. So, when the value of a pixel is more than the specific value of thresholding, will take a fixed value. Where if it's less than the specific value of thresholding, it will take another specific value. Here we deal with gray scale image, so it has a pixel's value range from 0–255. Threshold is used here to classify these pixels into groups based of their values. Digital image here is divided into two groups based on their values if it upper or lower threshold. So, pixel values of images that have the pixel values between 0–127 to black (0) while values between 128–255 to white (255). It means the result image must be binary image. Thresholding with horizontal histogram is shown in Figure 4.10 c, while thresholding with vertical histogram is shown in Figure 4.11 c.

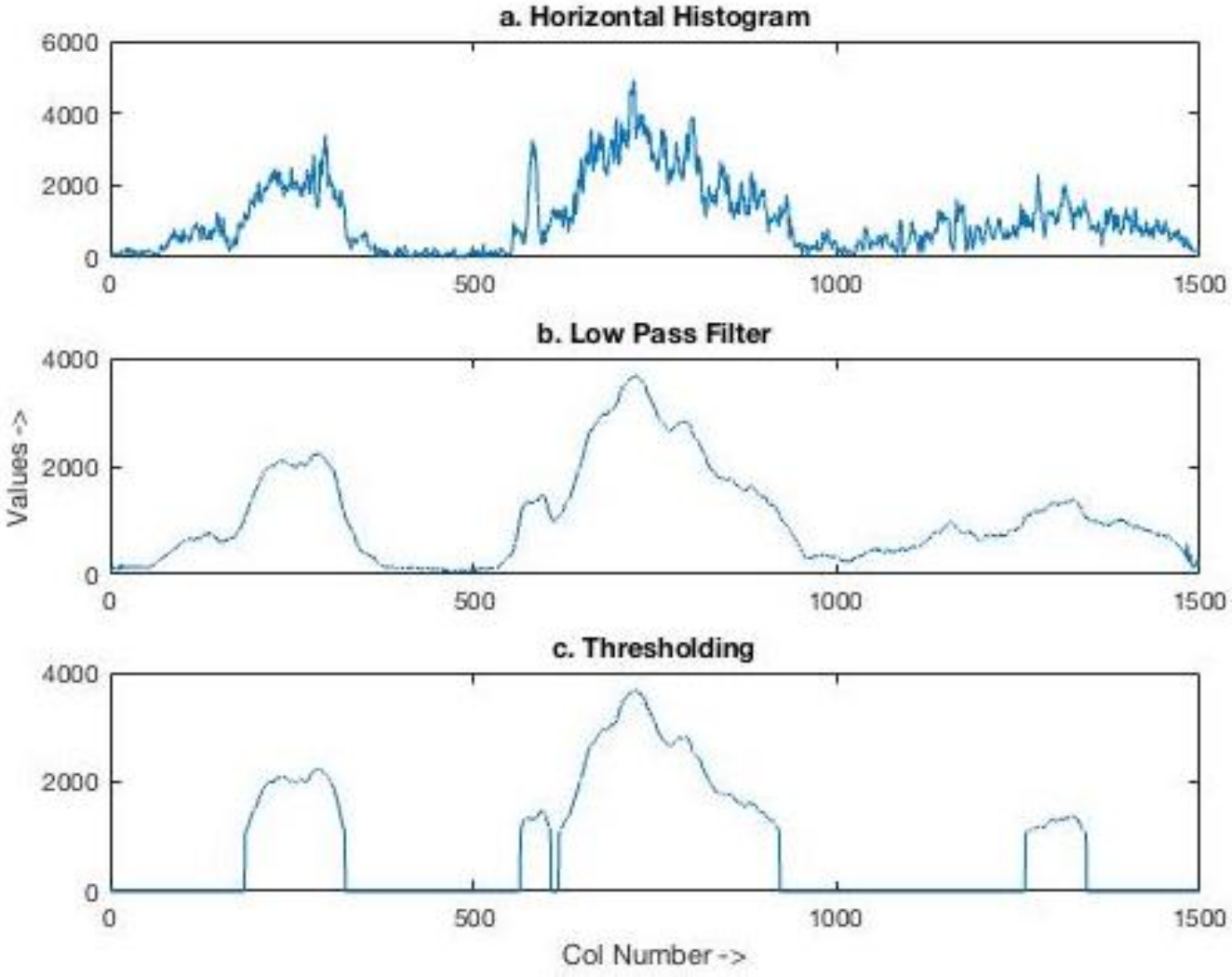



**Figure 4.10:** LP detection and extraction processes with; a. horizontal histogram, b. low pass filtering, c. thresholding

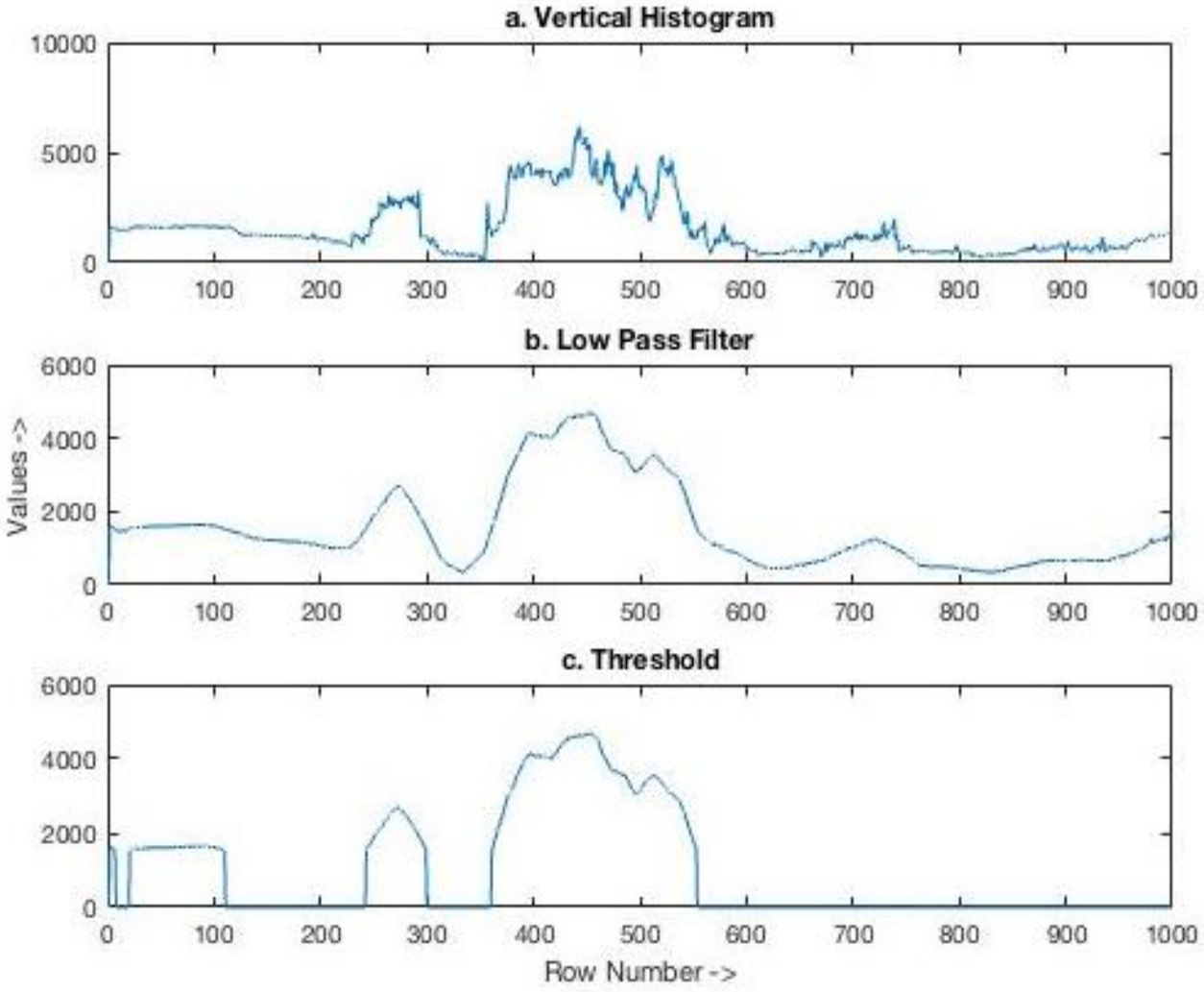



**Figure 4.11:** LP detection and extraction processes with; a. Vertical histogram, b. Low pass filtering, c. Thresholding

## 4.11 IRAQI VEHICLES PLATE RECOGNITION

In this step, the OCR system is implemented. New digital image is taken with new dimensions resulting from the histogram calculations. After that, the background of the image is separated from its objects. This is done by applying some image processes (converting the image to binary, calculating the edges of the image, using some filters to clean the image from some distortions). Then the label is given to the resulting image after the processors. Components of OCR is shown in Figure 4.12.

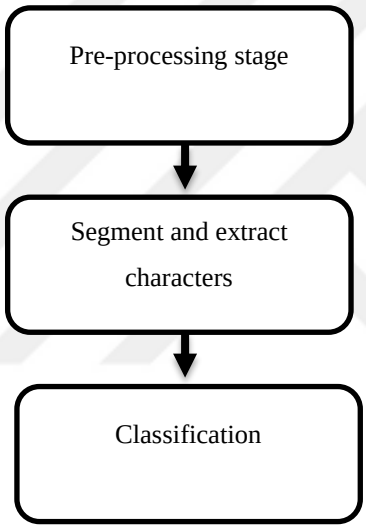


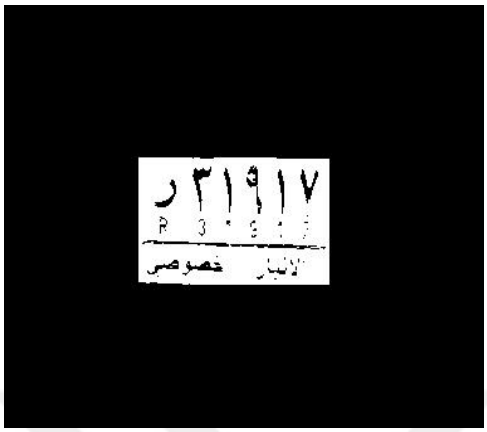

**Figure 4.12:** Components of OCR system.

OCR algorithm then takes the resulting car plate and compares its characters with the images and symbols which generated from the assigned database, where the compatibility ratio is calculated and the upper value of the correlation between all the correlation pixels is taken for the two images and the corresponding image is taken. The objects resulting from the plate are also compared with the bar derived from the input image which the plate coloured line by calculating the maximum value of the pixels and comparing them with known colour values. For example, white (the maximum value is between 200 and 255) for white pixels.

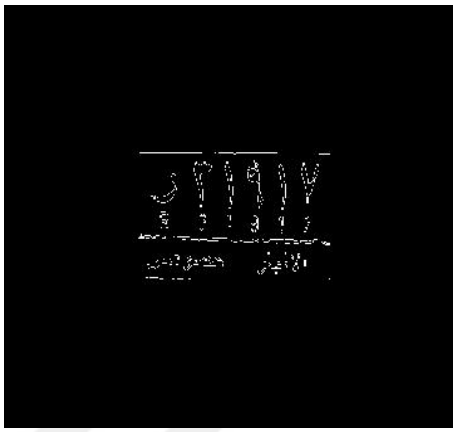
Thus, the bar is exposed to the plate and compared with objects, the matching image is displayed, and if it is mismatched, the rejection image is displayed.

### 4.11.1 Pre-processing

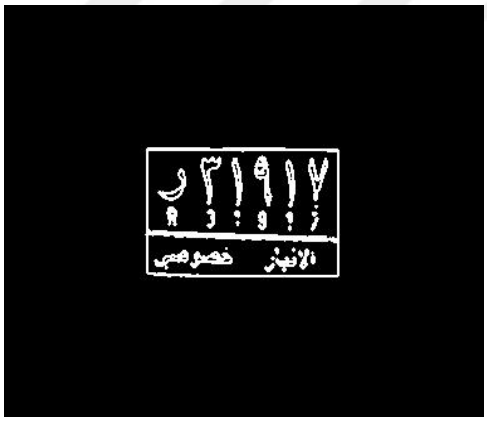
In plate recognition system, the pre-processing step enhance digital image of the car plate which already extracted. Binary image of the car plate region is the input of this system as shown in Figure 4.13 a. The input image is provided from license plate region detection and extraction step. Noise is minimized in this step. The output of this step is a binary image which is prepared to be input for the next, segmentation process and extraction process. In this stage image is resized to be fixed for all processing and plate edges of binary image is detected by using Sobel method as shown in Figure 4.13 b, then apply dilation to enhance image by adding pixels to boundaries of objects in image as shown in Figure 4.13 c Also, filing gabs by applying a special filter, Figure 4.13 d.



a. Binary image.



b. Edge detection.



c. Dilated image.

d. Filling gaps.

**Figure 4.13:** Pre-processing operations.

### 4.11.2 Segmentation and Extraction of Plate Characters

The goal of this step is to find each character (numbers and letters) that located on the plate image and extract them. The region with the same region is assumed as a separate character. By using this operation, the separated characters are segmented then extracted. The function bwlabel () is used to label object in the binary image which is shown in Figure 4.15. Region that has one label is considered as an object. So, each separate character considers as an object that will be segmented and then extracted as a character. The system may face a problem such as segment some regions that are not character. So, to avoid this type of problems, a threshold value is set on characters size. The pixels with value less than the value of threshold pixel is cancelled without segmentation. Thresholding will minimize segmentation of unwanted regions onto the plate image and reduces the process number of comparisons.

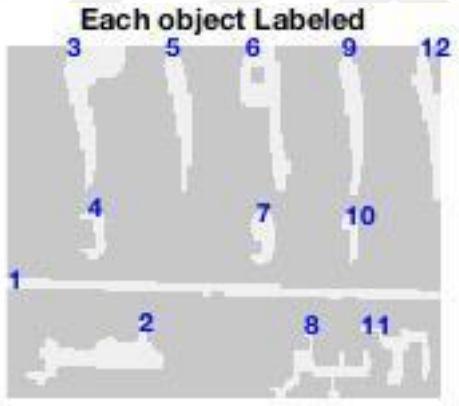



**Figure 4.14**: Labelled plate image.

### 4.11.3 Character Recognition

After Iraqi license plate characters is extracted separately, it must be recognized and assigned to right class of character. It is achieved by comparing vector of feature to the various models then take the right chose by detecting the closest match. The techniques of template matching are used here to recognize characters by comparing the input character with a group of template images from every class of the character.

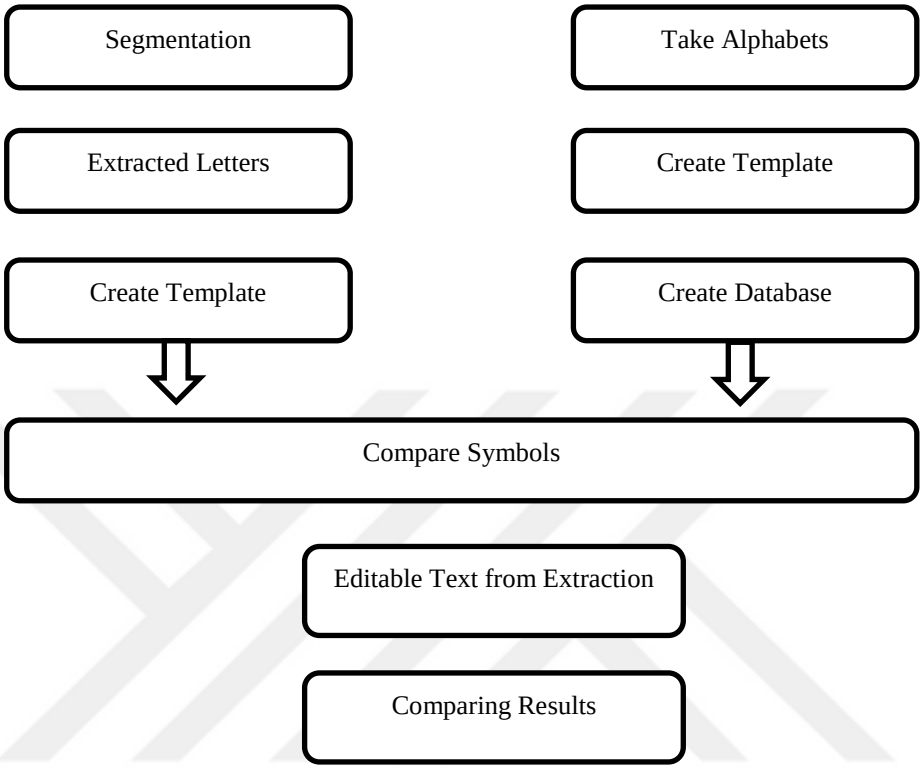



**Figure 4.15:** OCR process.

So, character recognition process goes through four main steps:

- *Create database of template*: Creation of format database is necessary done before the process of plate character recognition. The template database is created based on the style of the text of Iraqi license plate. Where the data base here contains alphabets ( أ - ي) which is Arabic alphabets and the Arabic numbers (٠-٩) which means (0-9).
- *Compaction*: Character that segmented are stored in the memory, and every one of them is compared to every symbol of template that already created. The identification of character is done according to the similarity value. Correlation approach is used to find the similarity between character that belong to input image and the template

image. The function of MATLAB that used here is corr2 (). It used to compare both images then returns a value between 1 to -1. If the value near to 1, it means the images are more likely to match and be similar while, if it near -1 it means less likely to be similar. The templates that created are built by taking the characters from plate image and to increase accuracy various characters are made for a same class character. Template matching technique is choosing because of the plate character are standardized. All characters in the plate have the same size and font and this will reduce the work that needed to classify character to same class. Some of the template samples used in system template are shown in Figure 4.16. The class of the character is selected after, the process of comparing input image with the symbols of templates. It considered as good match if the values of the comparison approaching to '1'are then characters that recognized are displayed.

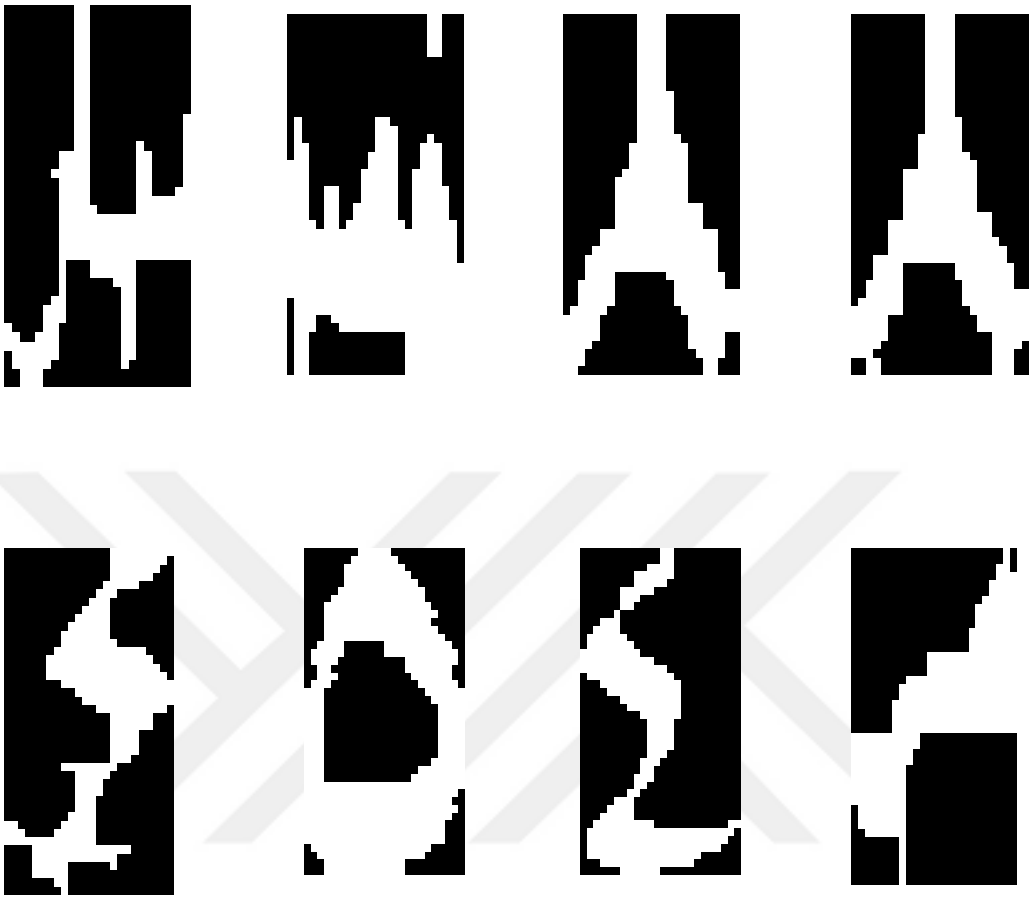


**Figure 4.16**: Sample of template images.

- *Repeat steps***:** this process is still repeated till all the characters that already segmented from the plate image are recognised.
- *Comparing Results*: by detecting the type of vehicle that found based on the vehicle type filed in the Iraqi license plate. Type filed in the Iraqi license plate contain the type of vehicle which written in Arabic. As well as the colored bar in the plate refer to the type of the plate (Red, Blue, yellow, White). This colored bar is analysis to get another result of the vehicle type. That means we have two results. Comparing between tow results obtain if they are matching or not to increase accuracy of the results, and then display approved image if they are matched or display rejected if they are not matched

as shown in Figure 4.17. Plate information is displayed in Figure 4.18. The MATLAB interface that shows the result of Iraqi license plate detection and recognition system is built by MATLAB GUI. It is shown in Figure 4.19.


**Figure 4.17:** Display the comparing results.


**Figure 4.18:** Plate characters recognition.

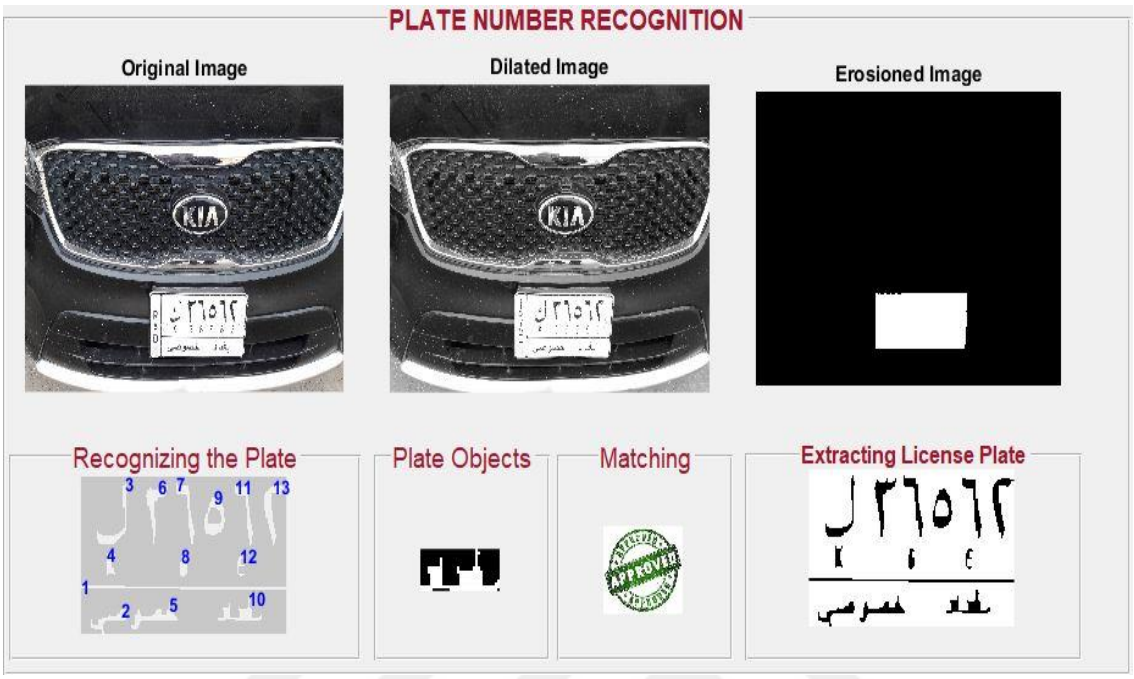



**Figure 4.19:** Iraqi license plate detection and recognition system interface.

# 5. PROJECT RESULT AND THE DISCUSSIONS

## 5.1 INTRODUCTION

A set of images are used as samples to test the Iraqi license plate detection and recognition proposed system. There are two kinds of results which are the detection of the plate region and extraction result while the second kind of results is the character recitation by using OCR system.

## 5.2 PLATE LOCALIZATION AND EXTRACTION

Static snapshots of Iraqi vehicles were captured for the purpose testing. The new style of Iraqi vehicle plates has been adopted. The plates of private vehicles, taxi, carry vehicles and governorate vehicles is used here. The total number of the images that used as a sample is (71) image (50 image for Iraqi vehicle plates and 21 images for European car plates). The final result of the test can be summed up as shown in Table 5.1. The flowing formula uses to calculate the percentage of the result accuracy,

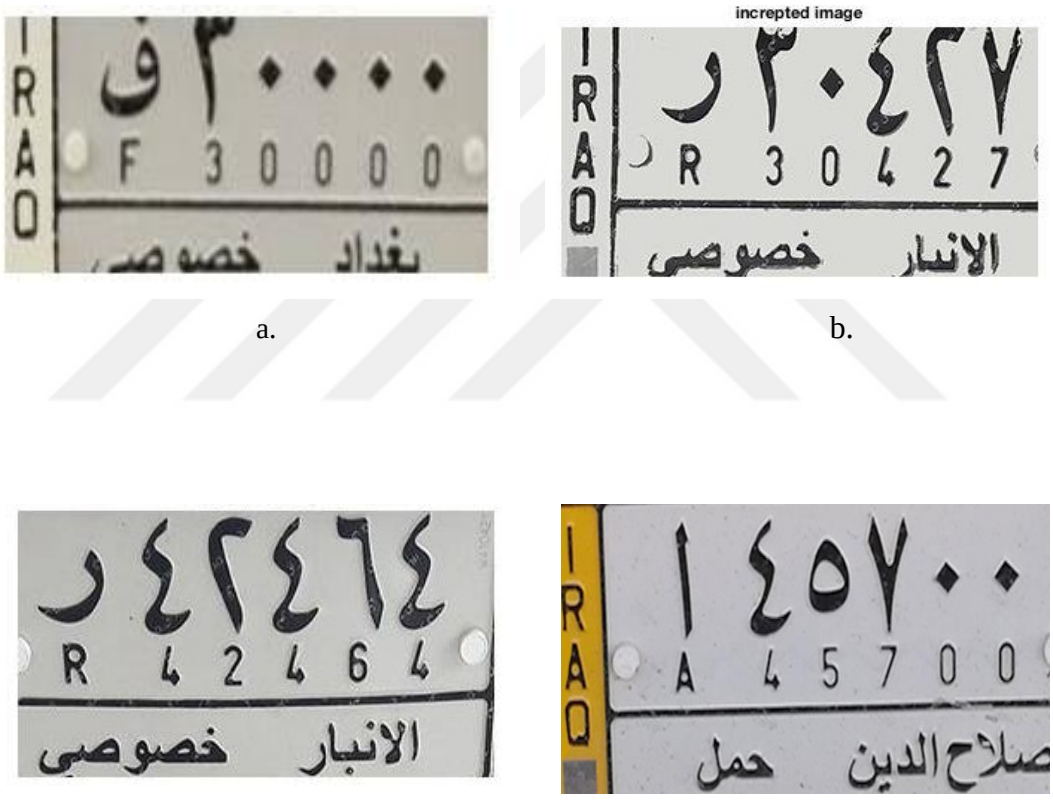
$$\boldsymbol{Accuracy}\% = \frac{Total\ number\ of\ plates\ that\ \ detected\ correctly}{Total\ number\ of\ plates} \qquad (5.1)$$

This formula is used for results percentage calculating of all components of the proposed system.

**Table 5.1:** The test results of detection and extraction of the plate region.

| | |
|---|---|
| Total number of the vehicles plates images that used. | 71 |
| Total number of detected and extracted plate regions images (Iraqi and European plates) | 68 |
| Total number of vehicle plates images which failed to be detected and extracted. | 3 |
| Total number of the Iraqi vehicle plates images which used. | 50 |
| The number of Iraqi plate regions images which detected and extracted, correctly. | 48 |
| The number of Iraqi plate regions that fail to be detected and extracted, | 2 |
| Total number of the European vehicle plates images which used. | 21 |
| The number of European plate regions images which detected and extracted, correctly. | 20 |
| The number of European plate regions that fail to be detected and extracted. | 1 |
| Percentage of the Iraqi LP regions that detected and extracted, correctly. | 96% |
| Percentage of the European vehicles LP that extracted, correctly | 95.2% |
| Percentage of total LP images which failed to be detected and extracted. | 4.2% |
| Weighted accuracy of the detected vehicle plates | 95.7% |

Some reasons cause failure in plate extraction which are the brightness and contrast of the image as well as the distance from camera. Images extraction process have high chance to fail if it with low contrast because of there will be more noise in binary image. Also, the second reason in extraction failure is the increases in distance so, the vehicle plate area will be small. This problem can be reduced by setting a specific value of distance between the vehicle plate and the camera and that the distance should not be large. Some of samples that extracted correctly as well as which failed are shown in the Figures 5.2 and Figure 5.3.




a. b.

c. d.

**Figure 5.1**: a, b, c, and d represent samples of correctly extracted plates.


a. b.

**Figure 5.2:** a and b, represent samples of incorrect extraction.

## 5.3 DETECTION OF EUROPEAN COUNTRIES CAR PLATES

Some samples of license plates that belong to some European countries have successfully detected. We have used 21 samples and the algorithm almost detected the plates. Some examples of car plate regions detection from some countries of Europe plate images which used to test the system. An example is shown in Figures 5.3, 5.4 and 5.5. The Iraqi car plates are different from the car plates of the European countries, because the Iraqi plates almost square, while the European car plates are considered as long rectangle. Also, the license plates of Iraqi cars are also more complex than the European ones. Although, the proposed system has built to detect the car plates of Iraqi vehicles and its success in detection European car plates, it can recognize only the Arabic characters of the plates. Incorrected detection of European car plate is shown in Figure 5.6.


**Figure 5.3:** Sample of European car to test the detection system.

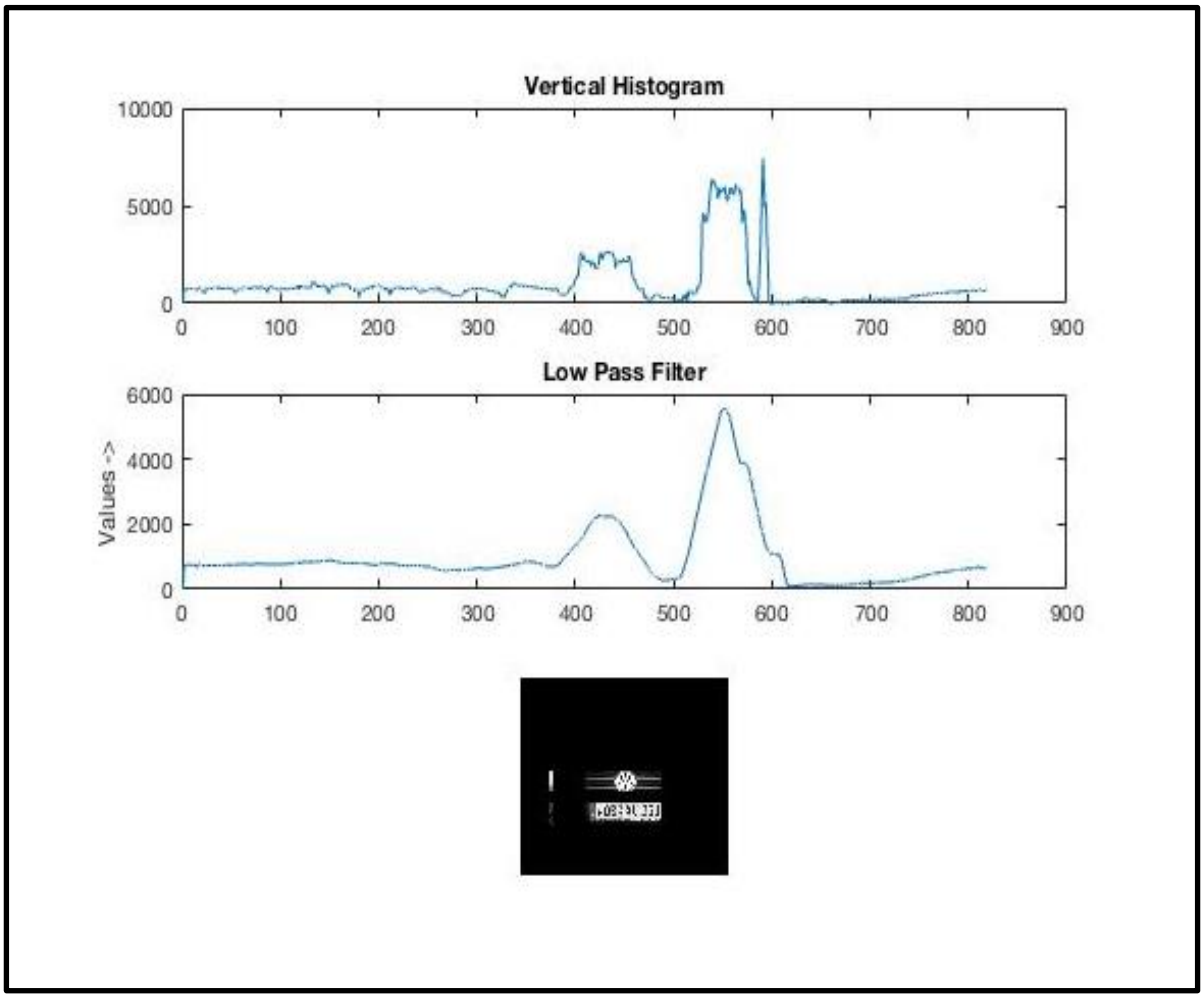



**Figure 5.4:** Car plate detection.


**Figure 5.5:** Detected and extracted the European car plate.


**Figure 5.6**: Incorrected detection of European car plate.

## 5.4 CHARACTER RECOGNITION SYSTEM

Extraction of plates effects directly on the accuracy of the OCR in the plate recognition system which means that if there a fail in the extraction of the plate region, it will present a wrong input to the OCR system, so OCR then present wrong output. The same Iraqi car plate samples that used for the purpose of plate extraction, are used also to check the OCR recognition accuracy rate. Extracted image used as input for OCR, it contains the characters (numbers, vehicle governorate ،vehicle type in Arabic and coloured line). The OCR results are summarized in the Table 5.2, while the overall recognition of Iraqi vehicle plates recognition system accuracy is contained in Table 5.3.

**Table 5.2:** OCR system test result

| | |
|---|---|
| Number of used plates to test the system. | 50 |
| Number of plate areas that detected and extracted correctly. | 48 |
| Number of characters in each plate. | 8 |
| Total number of characters in all plates. | 400 |
| Number of correctly recognized characters. | 368 |
| Percentage of characters that recognized correctly. | 92% |
| Number of coloured lines that recognized correctly. | 47 |
| Percentage of plates that have 100% recognition. | 86% |
| Percentage of plates that have 100% recognition. (Without colour bar) | 86% |
| VNDR System performance. | 90.8% |

This process cannot be compared to other techniques because there is no set of unified rules or even unified dataset that can be used to test the system. The sample of image that already used to test the system will listed in the flowing Table. The accuracy of the system is shown in the last column. The overall recognition rate of Iraqi vehicle plates character recognition system is contained in Table 5.3.

**Table 5.3:** Tested results of the system.

| Plate Samples | Plate Region detection | Recognized numbers of plate | Governorate recognition | Vehicle type recognition based on the Arabic word. | Vehicle type recognition based on the coloured line | Matching | System achievement Percentage |
|---|---|---|---|---|---|---|---|
| Image 1 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 2 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 3 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 51 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 5 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 6 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 7 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 8 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 9 | No | 0 | No | No | No | No | 0% |
| Image 10 | Yes | 3 | Yes | Yes | Yes | Yes | 80% |
| Image 11 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 12 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 13 | Yes | 3 | Yes | Yes | Yes | No | 70% |
| Image 14 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Image 15 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 16 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 17 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 18 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 19 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 20 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 21 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 22 | Yes | 2 | No | No | No | No | 30% |
| Image 23 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 24 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 25 | Yes | 4 | Yes | Yes | Yes | Yes | 90% |
| Image 26 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 27 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 28 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 29 | Yes | 3 | Yes | Yes | Yes | Yes | 80% |
| Image 30 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 31 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 32 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 33 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Image 34 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 35 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 36 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 37 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 38 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 39 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 40 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 41 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 42 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 43 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 44 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 45 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 46 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 47 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 53 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |
| Image 49 | No | 0 | No | No | No | No | 0% |
| Image 50 | Yes | 5 | Yes | Yes | Yes | Yes | 100% |

## 5.5 EVALUATION

Based on experiments, the following information is deduced:

i. 71 image of plate region are used for the experiments. (50 image for Iraqi vehicle plates and 21 images for European car plates).

ii. Localization of the Plate is achieved on 95.7 % of Images (68 out of 71).

iii. The accuracy of OCR system for all the characters of plates is 92%.

iv. 43 Images have 100% recognition rate by OCR out of 71.

v. Two images have a wrong detection, while seven images have a failure in all or only in some characters of the plate. There is a failure in recognition the vehicle governorate in three images, as well as there are three cases of reject matching. There is a fail in recognizing of the type of vehicle in three pictures.

The failure encountered in the testing of the CPR system can be expressed as two kinds; Plate area detection and extraction failure and OCR system failure. Since the system of Iraqi vehicles license plates character recognition depends primarily on the accuracy of the detection and extraction of the car plate region, any error in this process will lead to wrong result. The main reason that problems in plate detection is the effect of the surrounding. The edges of the environment in the image which is outside the vehicle is displayed too, which means so many edges of the environment can be displayed in order so, it is very difficult to adjust the region of the car license plate. Also, in this case the detection result of the car license plate is not accurate.

In this case the solution of this problem should not a software solution in the program of the plate detection system. However, it should be in the application of the program. When applying the system of LPD license plate detection, camera should be positioned. It should not be far from the plate. The camera angle should also be set so that the image should

contain the license plate without containing the unneeded details which belong to the environment surrounding the car by taking some image to fix camera. Also, it can ensure that the horizon is not visible. Therefore, the algorithm will deal only with the image of the car without the impact of the external environment, which means easy to locate the car plate from the rest of the image details.

The failure encountered in the testing of the CPR system can be expressed as two kinds; Plate area detection and extraction failure and OCR system failure. Also, there are some reasons cause the failure of the car plate area detection and extraction, such as the quality of the image. The accuracy of the system is affected directly by the quality of the image. System gives accurate results with high quality images. And the angle between the vehicle and the camera also effects algorithm of the extraction, because the difference in angle provides difference in the illumination level and the reflection of light may minimize the quality of the image, so that reduce the rate of the extraction. The distance between the camera and the car plate is another reason that effect the rate of the extraction of the system. However, it is not a big problem because it can be adjusted by using some techniques. But in this thesis, the distance between the camera and the car plate that used to take the snapshot is almost constant.

OCR failure is the second kind of system failure which also can be divided into three kinds, plate extraction failure, character segmentation failure and classification failure. The first kind lead to total failure in the OCR system. This kind of failure will move the wrong region of image as input to the OCR, so the final output will not be correct. The second type of OCR failure is segmentation failure which is done because of the failure in the algorithm of segmentation. This failure can be also divided into two parts, mistake in the segmentation of unwanted symbols by considering it as a character. This error is occurred when the closed or connected objects are considered as a single region in the image. This problem can be reduced by setting a specific rule for object, so it can be segmented as a character or not. And the second part of segmentation failure is the mistake in segmenting of unneeded objects in digital image. It is done when system segmented unneeded details of image along with the characters. As an example, the result of segmentation is influenced highly by the bolts

location that used to fix the plate on the body of the car. The third kind of OCR Failure is the classification Failure which face the system when classifier recognizes a character wrongly. The performance of OCR is affected by the errors in classification of segmented character to the correct class of the character. This kind of error occurs when the characters are classified, wrongly when comparing correlation value of them. As an example, the Arabic letter "د "may be classified wrongly as "ر "because of some unfavorable details in some parts of the letter "د ".

## 5.6 CHAPTER SUMMARY

Generally, from previous results, the following can be inferred. The recognition accurate of the Iraqi car plate recognition system CPR is affected directly by the input image quality as well as character recognition system. Plate area extraction operation cause most of the errors in the CPR system while the errors that happen in the optical character recognition system OCR are segmentation of character error. So, it can be summarized that the accuracy of car plate recognition system CPR is influenced directly by two modules. Firstly, detection and extraction of the plate area. Secondly, the process of character segmentation and extraction.

## 5.7 IVLPR SYSTEM DISCUSSION

The achieved results are good compared to the recent study conducted by Omran and Jarallah in 2017 in the Iraqi car license plates detection and recognition, where they introduced a system that give performance of 87.5% of extraction of plate region system, as well as it achieved 85.7% of the recognition system. 40 images of Iraqi vehicles were used in this study [66]. The proposed system in this work achieved a performance of 95% of extraction of plate region system. 71 images were used to test the proposed system included images for Iraqi and European cars. Also, it achieved 86% for recognition system. This is an improvement in the system of detection and recognition of Iraqi license plates.

This system did not achieve 100% accurate results for several reasons, including the external environment such as the presence of dust and the noise on the plate negatively affect the accuracy of the results. In addition to the angle of image capture, the distance between the

license plate and the camera and the brightness and contrast of the image affect the accuracy of the results. There is a failure in the program that reduces the accuracy of the results. There are reasons in the program led to reduce the accuracy of the results, including the small number of templates that used which affects the accuracy of the character recognition. Also, there is a segmentation failure which is done because of the failure in the algorithm of segmentation when a mistake in the segmentation of unwanted symbols occurs by considering it as a character.

There are two ways to increase system accuracy, internal and external. In the first way, to increase the accuracy of the character recognition should increase the number of the character templates that are compared with segmented character. One of the problems faced the program is the poor quality of input image, which negatively affected the accuracy of the system. To increase the accuracy of the system, certain filters must be used to fix the poor quality of the input image such as the Adjust filter. To reduce the problem of segmentation failure, a specific rule for object should set, so it can be segmented as a character or not. That will be led to achieve better results.

While the external way to improve the accuracy of the system is to fix the distance between the camera and the plate. Also, the captured image should be taken from specific angle and should use a good quality camera.

# 6. CONCLUSION

In this thesis work, a new car plate recognition system for Iraqi car plate is presented. The system consists of two main steps which are: plate region detecting and plate region extracting and characters recognition on the plate image.

In the first step the techniques of image processing are incorporated to achieve best results. Pre-processing part uses the technique of median filtering with gray scale conversion. To detect the region of the car plate, system uses (CCA) connected component analysis to analyse every region and rate the possibility to be considered as a plate region. The technique is based on focusing on recognizing and then segmenting the white areas. At the end the properties of image structure are used to recognize the plate region form image candidate regions.

The second main step of the car plate recognition system is plate characters recognition. The input of this step is the extracted image which contain the plate region that comes from the previous step. Characters recognition accuracy depends mainly on the extracted image. Character recognition system identify the characters in the plate. For this thesis optical character recognition system (OCR) was used to recognize the characters on car plate image. Here characters need to be segmented separately and it is done by using connected component analysis (CCA). Then system uses the technique of template matching for characters classification to classify the characters to the right character class. The characters of the Iraqi car plate are standard, so the technique of template matching was preferred for shorten the work and it helps the technique of template matching for better working. In addition, the license plate recognition system (LPR) recognize the characters to detect the identity of the car. It also recognizes the colour bar in the license plate to define the vehicle type. A comparison of the type of car written in Arabic and the type of car indicates by the colour bar. This helps to improve the accuracy of the results by providing more than one result.

The failure of the system of Iraqi car plate detection and extraction primary occurred by the variance in illumination. The variance in illumination present a region with brighter than car plate region which lead to wrong plate region detection. That means the variance in illumination effects the connected component analysis (CCA) technique which in turn affects the final result. Also, the failures in optical character system (OCR) is caused by the noise in the car plate characters. For example, location of the plate bolt, characters fading, Polluted plate and the dusty atmosphere, especially with the large number of dust storms in Iraq.

Digital camera should be located at a fixed distance from car number plate, for providing an appropriate range to the pixels count in the car licence plate area and to make them almost constant in nature which help in improving the system performance. The angle between the camera and the car plate must also be considered.

## 6.1 FUTURE WORK

These parts can be improved to enhance the car plate recognition system performance.

a. Enhance the process of the car plate area extraction, by adding a new feature as a unique feature to car plate area.
b. Using filters for enhancing the quality of the input digital image of the vehicle to enhance the quality of image and handle the remote image problem.
c. Expand the system Iraqi vehicle plate detection and recognition to deal with all types of Iraqi vehicles.

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