

LIBYAN VEHICLE LICENSE PLATE DETECTION AND RECOGNITION
USING RADIAL BASIS FUNCTION

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To my God, Allah 'azza wa jalla
Then to my beloved parents, wife, son and siblings ...

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ABSTRACT

An integrated vehicle plate detection and recognition system generally aims to detect the license plate (LP) and recognize its characters. The process basically includes LP detection, LP extraction, character segmentation, feature extraction and recognition. Due to its wide range of applications such as traffic management, security etc., and this topic is intensively researched especially in the field of image processing. Furthermore, the differences in systems, colours, backgrounds, foregrounds, font and style of the license plates from one country to another add more problems and challenges for new researches. Although various detection and recognition methods that have been proposed in the previous studies, their performances especially in terms of accuracy are fallen short, and room for improvements is still wide open. Thus, this thesis presents an integrated approach for detecting and recognizing Libyan license plates based on Radial Basis Function Neural Network (RBFNN). The method begins with the preprocessing of the image using edge detection and morphological operations. In the detection stage, connected component analysis is used to locate unique objects, from which the unwanted objects are removed using the filtering process. Geometric and Global features are used to prepare the identified objects before their classification as Plate and non-Plate using RBFNN. In the recognition process, for character segmentation, a simple template is derived to extract and differentiate digits and Arabic words, as the Arabic word is not segmented into individual letters like digits. The outputs are improved using median filtering and connected component analysis. Statistical and structural features are used in feature extraction, while the classification is performed using RBFNN. The performance of the proposed method is evaluated and tested using 200 frontal images of Libyan national license plates. Experimental results have shown that the proposed method has produced convincing results with accuracy rates of 93% and 91% for detection and recognition, respectively, and has also outperformed the colour-based approach.

ABSTRAK

Sistem pengesanan dan pengecaman plat kenderaan bersepadu secara amnya bertujuan untuk mengesan kedudukan nombor plat (dirujuk sebagai LP) dan seterusnya mengecam aksaranya. Pada asasnya, proses ini merangkumi pengesanan LP, pengekstrakan LP, segmentasi aksara, pengekstrakan ciri-ciri dan pengecaman. Disebabkan luasnya aplikasi dalam bidang tersebut seperti pengurusan trafik, keselamatan dan lain-lain; justeru inilah yang membuatkan topik ini dikaji secara intensif terutamanya dalam bidang pemprosesan imej. Walau bagaimanapun, perbezaan dari segi sistem, warna, latar belakang, latar depan, fon dan gaya nombor plat bagi satu negara dengan negara yang lain menambahkan masalah dan cabaran kepada kajian baru. Walaupun terdapat perbagai kaedah pengesanan dan pengecaman yang dicadangkan oleh kajian terdahulu, prestasinya terutama dari segi ketepatan adalah kurang memberangsangkan, dan ruang untuk penambahbaikan masih terbuka luas. Oleh itu, tesis ini mengemukakan pendekatan bersepadu untuk mengesan dan mengecam plat nombor negara Libya berdasarkan Rangkaian Neural Fungsi Asas Radial (dirujuk sebagai RBFNN). Kaedah dimulakan dengan pra-pemprosesan imej menggunakan pengesanan tepi dan operasi morfologi. Pada peringkat pengesanan, analisis komponen tersambung digunakan untuk mengesan kedudukan objek unik. Kemudian, objek yang tidak diinginkan disingkirkan melalui proses penyaringan. Ciri-ciri geometri dan global digunakan untuk menyediakan objek yang telah dikenalpasti sebelum diklasifikasikan sebagai Plat dan bukan-Plat menggunakan RBFNN. Semasa proses pengecaman, bagi segmentasi aksara, satu templat ringkas diterbitkan untuk mengekstrak dan membezakan digit dan perkataan Arab memandangkan perkataan Arab tidak disegmenkan kepada huruf-huruf individu seperti digit. Output dipertingkatkan menggunakan penyaringan median dan analisis komponen tersambung. Ciri-ciri statistik dan struktur digunakan dalam pengekstrakan ciri-ciri, sementara pengklasifikasian pula dilakukan menggunakan RBFNN. Prestasi kaedah yang dicadangkan ini dinilai dan diuji menggunakan 200 imej hadapan nombor plat nasional negara Libya. Keputusan eksperimen menunjukkan bahawa kaedah yang dicadangkan memberikan keputusan yang meyakinkan iaitu 93% dan 91% masing-masing dalam pengesanan dan pengecaman, dan seterusnya mengatasi prestasi kaedah yang berasaskan warna.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF APPENDICES	xv
1	INTRODUCTION	1
	1.1 General Background	1
	1.1.1 Libyan License Plate	5
	1.2 Problem Statement	10
	1.3 Project Aims and Objectives	10
	1.4 Scope of Research	11
	1.5 Research Significance	11
	1.6 Research Contribution	12
	1.7 Thesis Organization	12
2	LITERATURE REVIEW	13
	2.1 Introduction	13
	2.2 Image Acquisition	14
	2.3 Image Pre-Processing	15
	2.4 License Plate Detection	16

	2.5 Character Segmentation	20
	2.6 Character Recognition	22
	2.7 Radial Basis Function (RBF)	24
	2.8 Arabic and Non-Arabic Countries License Plate	29
	2.8.1 Saudi Arabian License Plate	29
	2.8.2 Chinese License Plate	30
	2.8.3 Malaysian License Plate	31
	2.9 Summary	31
3	RESEARCH METHODOLOGY	33
	3.1 Introduction	33
	3.2 License Plate detection and Recognition process	34
	3.2.1 Image Acquisition	34
	3.2.2 Image Pre-Processing	35
	3.2.2.1 Grayscale Transformation	36
	3.2.2.2 Edge Detection	36
	3.2.2.3 Image Dilation and Filling Interior Gaps	38
	3.2.3 License Plate Detection	41
	3.2.3.1 Connected Component Analysis	41
	3.2.3.2 Filtering	43
	3.2.3.3 Feature Extraction	45
	3.2.2.4 RBF Training	51
	3.2.3.5 Testing	53
	3.2.4 LP Recognition	53
	3.2.4.1 LP Extraction	54
	3.2.4.2 Character Segmentation	54
	3.2.4.3 Character Recognition	62
	3.2 Testing and Evaluation	71
4	RESULTS AND ANALYSIS	72
	4.1 Introduction	72
	4.2 The Data Set for Training and Testing	72
	4.3 Image Pre-Processing	74

	4.4 LP Detection	94
	4.5 LP Recognition	106
	4.6 Evaluation	112
	4.7 Summary	115
5	PERFORMANCE COMPARISON	117
	5.1 Introduction	117
	5.2 Comparison on LP Detection	117
	5.3 Comparison on LP Recognition	123
	5.4 Summary	126
6	CONCLUSION AND FUTURE WORK	128
	6.1 Introduction	128
	6.2 Conclusion	128
	6.3 Future Work	129
	REFERENCES	131
	APPENDICE	139

LIST OF TABLES

TABLE NO	TITLE	PAGE
2.1	A Comparison between RBF NN and Back Propagation	26
2.2	A Comparison between RBF NN and other approaches	28
3.1	Feature vector extracted from Figure 3.8	51
4.1	Detail of dataset	74
4.2	Result of the Proposed Method	109
4.3	Result of the proposed method	113
5.1	Performance comparison of license plate detection	122
5.2	Number grouping proposed by Almustafa et al (2011)	124
5.3	Performance comparison of license plate recognition	125

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
1.1	RBF NN in Time Series Modeling (Weihua, 2009)	3
1.2	RBF NN in Pattern Classification	4
1.3	Centers and Widths in RBF NN	4
1.4	Front National Libyan LP	6
1.5	Rear National Libyan LP	6
1.6	Samples of Libyan Special LPs	7
1.7	Sample of Saudi Arabian and Iranian LP	8
2.1	Four and eight connected pixels	21
2.2	(a) RBF (b) Standard NN	25
2.3	Saudi License Plates	29
2.4	Chinese Licence Plate	30
2.5	Malaysia License Plates	31
3.1	VLPR System Block Diagramme	34
3.2	Image Preprocessing Steps	35
3.3	Steps of LP detection process	41
3.4	Component Connected analysis applied on binary image (left) and the resulting image	43
3.5	Simple filtering process using threshold values (threshold1=3 and threshold2=12)	44
3.6	Mapping the component of candidate LP for feature extraction	45
3.7	Illustration of feature extraction step	47
3.8	Sample of input image for feature extraction	50
3.9	RBFNN Training	52
3.10	Recognition steps	53

3.11	LP Extraction	54
3.12	Steps involved in character segmentation	55
3.13	Two kind of license plate in Libya	56
3.14	Flowchart for processing the license plate	57
3.15	Template for one-line and two-line license plate of Libya	57
3.16	Example of cropped LP with size 500x1000px. Digit part and Arabic word is separated using proposed method	59
3.17	Algorithm for Differentiating Between a Number and Arabic Word	60
3.18	Component Labeling	62
3.19	Types of feature extraction	63
3.20	The bounding box of hyphen (a), digit (b) and Arabic word (c)	65
3.21	Numbers in 4 x 2 Matrixes (Weihua, 2009)	66
3.22	Statistical features extricate from digit 3	67
3.23	Feature Patterns of Two Numbers, 3	67
3.24	Features for Numbers	68
3.25	Structural features	70
4.1	Image Dataset Samples with One and Two Lines LP	73
4.2	The Original Color Image	75
4.3	The Gray-Scale Image	75
4.4	The Binary Gradient Mask Obtained After Applying Sobel Operator	76
4.5	Result of edge detection on different scenario	77
4.6	The Dilated Gradient Mask	81
4.7	Resulting image after dilated gradient mask	82
4.8	The Image with Filled Holes	85
4.9	The Filtered Image	89
4.10	The image after smoothing	90
4.11	Finel result of pre-processing	91
4.12	Result of acceptable white area on close distance scenario	95
4.13	Shows result of acceptable candidate of LP on	

	medium distance scenario	96
4.14	Result of acceptable white area on far distance scenario	98
4.15	Extracting information from dilation image with respect to white areas	99
4.16	Classification as “Plate” and “no Plate” During Training	100
4.17	Comparison extracted pattern on before and after normalization step	101
4.18	Extracted feature vectors on testing data	102
4.19	Extracted feature vectors on testing data	104
4.20	The Output of RBF result on testing data	105
4.21	Extracted LP	106
4.22	LP before and After Noise Removal	107
4.23	Inverted LP	107
4.24	Character Segmentation	108
4.25	Feature Extraction applied LP Table 4.1 Components and their Patterns	109
4.26	RBF output	111
4.27	RBF output on digit, hyphen and Arabic word	112
4.28	The Error onus Result	114
5.1	General overview of license plate detection of proposed method (a) and Zheng et al. method (b)	118
5.2	Result of proposed method and Zheng et al. method	119
5.3	Comparison of proposed method and Zheng et al. method in terms of distance problem	121
5.4	Line processing algorithm applied on digit image	123

LIST OF APPENDICES

APPENDICE	TITLE	PAGE
A	List of Publications	139

CHAPTER 1

INTRODUCTION

1.1 General Background

The advancement of technology has lead towards the changes in people's lifestyle such as, in the usage of transportations. According to the automobile rating there are about 806 million cars on roads in 2007 and believe it is increasing in a daily manner (Sarfray, et al., 2003). This new phenomena has led towards a need of security and management on the vehicles that people own.

The safety issue has been the main focus of automobile manufacturers in order to minimize the occurrence and unwanted consequences. Improvements in both roadway and also automobile security have steadily reduced over these years. Nevertheless, important aspects, which would be an advantage in managing this important factor, are considered crucial. One such identified solution is the known automatic vehicle detection and recognition. With the collaboration from the rapid technological development in the field of image processing on safety aspect, which is done through the extraction and recognition of a vehicle's license plate (LP) from a digital image. Automatic vehicle plate detection and recognition are among the key techniques applied in most of the traffic related applications such as searching for a stolen car, road traffic monitoring (Feng et al., 2008), monitoring a vehicle entering an area (Fei & Mei, 2010), in finding the owner and other information about the vehicle, access gate control, automatic parking lots access control, border crossing

control, speed limit enforcement, security, and customer identification enabling personalized services are all possible uses (Sarfraz, et al., 2003).

The Vehicle LP Recognition (VLPR) is a popular and dynamic research topic in the image processing domain due to its wide use in potential applications over the last few decades (Ali Tahir et al., 2010). Apparently, with the constantly increasing traffic on roads, there is a need for intelligent traffic and management system, which does not only detect and track a vehicle but also is able to identify it. The real-time LP recognition is an important element in automatic traffic monitoring and law enforcement of traffic. However, the process involves, requires integration of multiple version of ICT and this is a challenging process (Sarfraz et al., 2003).

The real-time LP recognition assisted in the identification of a vehicle entering into secure premises. Undoubtedly, LP recognition is urgently needed in countries that pointed with critical issues related to automobile security and management.

Eventually, LP detection and recognition include two separate processes and the research on these two related processes has always been performed separately. Different methods, techniques and algorithms have been developed and applied in these two processes (Anagnostopoulos et al., 2006; Huaifeng et al., 2006; Othman Khalifa et al., 2007; Oz & Ercal, 2005). However, detection and recognition phases can be improved in the process phase by applying new techniques, because the ever-declining cost of hardware devices, increasing speed of computing and ubiquity of embedded devices on the other hand, it is always encouraging to apply new solutions for betterment of the security profiling.

The physical and font characteristic of LP vary from country to country and even within the same country. A handful research has been applied in this concern particularly in countries such as Libyan LP. As in for this particular reason, this research is related with the automatic detection and recognition of license plates for Libyan's vehicles concerning security and management. The edge detection and

basic morphology tools were applied in order to detect the LP in an image form, similar to studies Hongliang & Changping,(2004), to use the large difference in contrast between the LP and its background. Edge detection is used because of its usability forms. However, it is also very sensitive and may detect different unwanted edges. Therefore, morphological methods (Nomura et al., 2005) were added as a support system.

The basic form of RBF Neural Network (NN) comprises of three layers: an input layer of source nodes connected to the environment, a hidden layer, and an output layer with linear nodes (Weihua, 2009) as shown in Figures 1.1 and 1.2. The nodes of the hidden layers represent clusters in the input space.

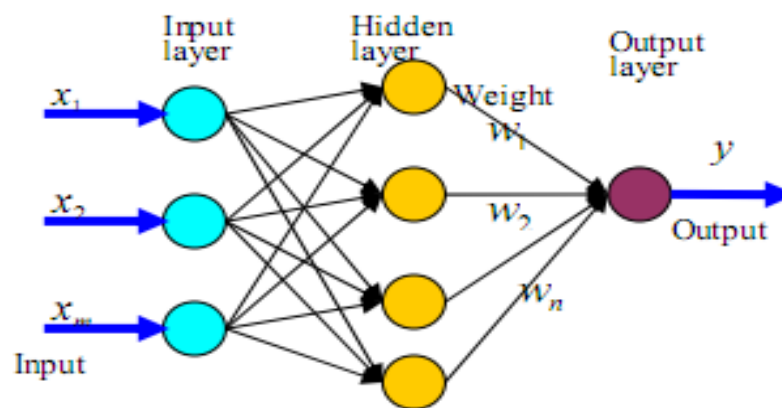


Figure 1.1 RBF NN in Time Series Modeling (Weihua, 2009)

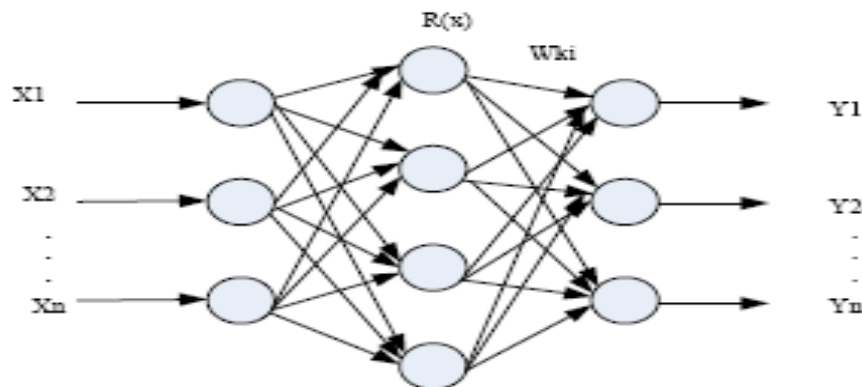


Figure 1.2 RBF NN in Pattern Classification

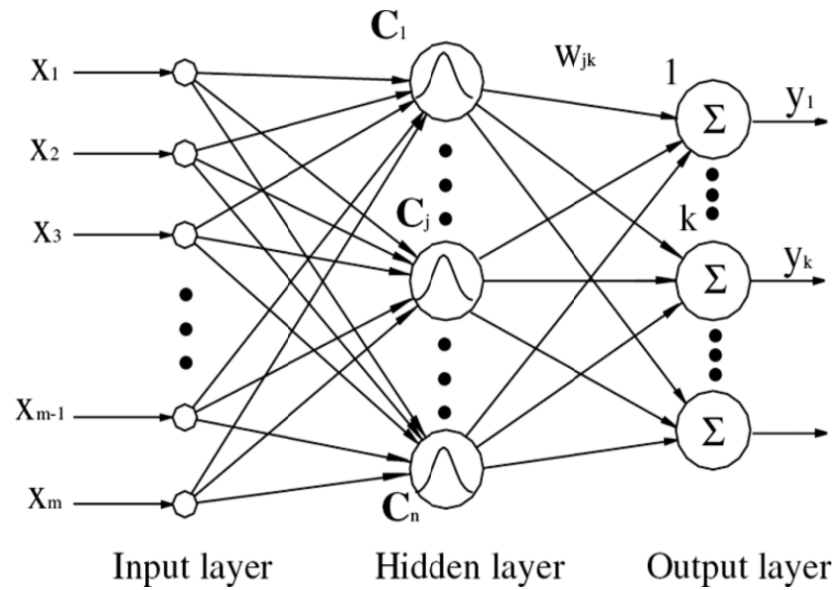


Figure 1.3 Centers and Widths in RBF NN

The hidden units are known as radial centers and is represented by the same vector as input units, if the input units are closed to it the output would be the maximum and vice versa. The output layer supplies the response of the NN (Maria, et al., 2010). Therefore, RBF NN is considered in this research based on it is success from previous studies (Baoming, 2010; Li Bo et al., 2008; Diego et al., 2006; Weihua, 2009). Moreover, the main benefit of RBF NN compared to the binary features is that RBF NN creates an approximate function that smoothly varies and is distinguishable. Apart from that, some learning techniques for RBF NN modify the centers and widths. The centers and Widths of RBF NN are represented as C_i and W_{ij} in Figure 1.3. These nonlinear methods easily fit the target function (Weihua, 2009). The transformation from input space to hidden layer is non-linear while, from hidden layer to output layer is linear (Maria et al., 2010). Thus, RBF NN is a mapping function, which is mapped from non-linearly separable space to linearly separable space.

1.1.1 Libyan License Plate

A Libyan LP has different elements: Arabic characters, monogram, flag and numbers. Generally, the Libyan license plates can be divided into two categories:

- i. National License Plates (as shown in Figure 1.4).
- ii. Foreign License Plates (as shown in Figure 1.6 (c)).

The front national LP has characters written in one line in tricky font, whereas the rear LP has characters written in two lines. The national LP (see Figure 1.4) has black characters and numbers with a white background. The problem is that some people use the rear LP at the front as shown in Figure 1.5. For foreigners, the characters and numbers are black in color and the font is the same as the national LP but the background has two colors, blue and white, see Figure 1.6 (c). For head of state, the LP uses a different font for characters and numbers, which are written in red with white backdrop, the flag and the slogan (see Figure 1.6 (a)-(b)). Black characters with red background in dissimilar fonts are used for diplomats (see Figure 1.6 (d)).



Figure 1.4 Front National Libyan LP



Figure 1.5 National Libyan LP



Circa 2001, Head of State

(a)



Circa 2001, Head of State

(b)



Circa 1997, Foreigner's Vehicle,
(Number 43 in blue field indicates Sweden)
Picture by Amir Glad

(c)



1980's Diplomat

(d)

Figure 1.6 Samples of Libyan Special LPs

Secondary, the font of text written on Libyan LP is far more complex as compared to Saudi, Egypt and other Arabic countries as well as the dimensions and shapes of the Libyan LP.

Previously, several researches have been conducted on Arabic LP detection and recognition (Sarfraz et al., 2003; Zidouri & Deriche, 2008); this research is unique as compared to the previous researches in a number of ways. Firstly, the Libyan LPs make use of Arabic words with numbers written in English as compared to LP of Egypt, Saudi Arabia or other Arab countries where numbers are also written in Arabic as shown in Figure 1.7.



Figure 1.7 Samples of Saudi Arabian and Iranian LP

Each country has its own LP numbering system with consideration of characteristics such as: colors, language of characters and style (font) and sizes including difference from state to state in terms of types of LPs. Moreover, there are countries, which do not yet have an automatic VLPR system. Apart from that, the environmental and physical conditions of the LP are also affected in overall

processes. Due to these reasons, research on the LP detection and recognition process is still ongoing.

There are many known methods for LP detections such as binary image processing, grey-level processing, colour processing (Anagnostopoulos et al., 2006), (Anagnostopoulos et al., 2008), fuzzy logic, texture analysis, genetic algorithms, using edge statistics and Hough transform (Anagnostopoulos et al., 2006; Kamat et al., 1995), plate colour (Shyang-Lih et al., 2004), learning-based approach, corner detection, wavelet transform, colour space distance, combining colour information with a texture feature and sliding windows concept (Fei & Mei, 2010). Each of these methods has its own merits and demerits. The physical characteristics of an LP such as shape, symmetry, width to height ratio, colour, grayness, spatial frequency, and change in intensity values are also important to be considered as these characteristics compose complex stages for character recognition.

In the process of character segmentation for LP, different techniques such as projection, morphology and relaxation labeling are suggested by (Shyang-Lih et al., 2004). For character recognition iterative and non-iterative techniques can be used as genetic algorithms, artificial neural systems, fuzzy c-means, support vector machine, marked processes and finite automata, which processes though providing excellent accurate results, they are time intensive (Shyang-Lih et al., 2004).

Vehicle LP detection is also a complex process because of brightness conditions, visual phase, image clouding and mingled figures issues (Fei & Mei, 2010). The angle, quality of image and variation in brightness are the factors, which may degrade the performance of the location algorithm (Fei & Mei, 2010) are also considered.

Apart from that, issues with colour, unstable information (Eun Ryung et al., 1994), as well as not accurate in a natural scenario cannot detect multiple license plates (Fei & Mei, 2010) poses serious issues. Texture edge based methods are widely used to locate plate candidates under different lighting conditions. These

methods use the fact that there are characters in the plate, so the area contains a rich edge and texture information. In these methods, a learning-based method is very efficient in many scenarios. Different LP features are learned from samples to extract License plates.

The segmentation of images with different backgrounds is a good method but reliability may pose further issues. There are many kinds of algorithms on digital LP recognition (Matas & Zimmermann, 2005) such as statistical pattern recognition and the artificial neural network method.

1.2 Problem Statement

As more and more vehicles are being stolen in Libya, it is extremely important to make enhancement on this urgent situation for vehicle documentation purposes. Although there is a large amount of commercial software available for number plate identification, is not applicable in Libya because of differences in the language (Arabic), characters and background colors of the number plates. Furthermore, some of the existing approaches have low recognition accuracy, long processing time and give inaccurate results in case of bad input. Furthermore, considerable researches have been carried out for English, Chinese and French car plate detection and recognition (Bai et al., 2010; Shapiro et al., 2006; Xu et al., 2003). However, there were no previous studies have been done for Libyan LP detection and recognition in the literature. This would be mainly due to the reason of different styles of Libyan LP.

This research is concerned with the detection and recognition of Libyan License plates, therefore the problem statement of this research is:

How to improve detection and recognition process of Libyan license plates with high accuracy?

1.3 Project Aims and Objectives

Along with identifying and extracting the license plate, this research also aims to recognize the characters of vehicle license plates. The objectives of this research are outline as follows:

- i. To locate car vehicle LP from vehicle image using Radial Basis Function Neural Network.
- ii. To differentiate between Arabic text and English numerals in vehicle license plate.
- iii. To recognize the vehicle LP numbers.

1.4 Scope of Research

The following points describe the scope of this research:

- i. Focus only on the Libyan License plate.
- ii. This research deals with only National License plates.
- iii. The detection is performed only on the front image of the vehicle.
- v. Only the purposes of images of parked cars were captured.
- iv. Computing time is beyond of this research scope.

1.5 Research Significance

This research entails in the exploration on the process of detection and recognition of Libyan LP. Initially, from the entire image, the region of interest (license plate) is located and extracted. Then, it is forwarded for further processing, such as character segmentation, feature extraction and recognition. This research is

concerned with the detection and recognition of Arabic word, and it deals with Arabic license plates.

1.6 Research Contribution

The contribution from this research, which is based on the proposition of a new method for License LP by using RBF NN, combining two recently proposed methods for features extraction is useful in many areas such as:

- i. The results from the identified LP will be beneficial for car uses when dealing with stolen cars, or in any emergency related action required.
- ii. The knowledge acquired from this research will serve as a good platform for enhancement purpose in Libya.
- iii. This research is also important in the authority level, especially in the Transport Ministry of Libya, which will be able to detect any past criminal related vehicles, to ensure peace and harmony of Libya.

1.7 Thesis Organization

This thesis consists of six chapters. The first chapter introduces the study, problem background, aims and scope of the research. Chapter two details state-of-the-art critical literature review regarding LP detection and recognition. Research methodology of the proposed technique is presented in Chapter three. Chapter four presents results and discussion and the comparisons are presented in Chapter five. Finally, the conclusion and future work is discussed in Chapter six.

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