AUTOMATIC ROAD SIGN IDENTIFICATION SYSTEM WITH ROBUSTNESS TO PARTIAL OCCLUSION

BY

NURSABILLILAH BINTI MOHD ALI

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Kulliyyah of Engineering
International Islamic University Malaysia

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ABSTRACT

In recent years, automatic road sign identification system has attracted numerous research works with the possibility of using in autonomous or driver assistance system (ADAS). Research in road sign identification with occlusion, however is still lacking. Many existing techniques up to now that have been developed algorithms with the existence of occlusions produce inaccuracy that needs to be improved. Even though the occurrences of road signs with presence of occlusion are small, yet it is problem that needs to be addressed. An intelligent system for road sign identification that incorporated several different algorithms is proposed in this research to solve the problems. The algorithms consist of proposed HSV and RGB colors in detection part and ANN and PCA techniques in recognition part. The proposed algorithms are able to detect the three colored images of road sign namely Red, Yellow and Blue. These algorithms are then compared with each other to evaluate their performance. The hypothesis of this research is that road sign images can be used to detect and identify signs involved existence of occlusions and rotational changes. Each sign features are extracted using global feature extraction technique whereby the vertical and dimension size of sign are fixed to a standard size. These input features are used to be applied into neural network according to feed forward neural network technique using backpropagation training function. The sign image can be easily identified by the PCA method as it has been used in many application areas. Based on the experimental result, it shows that the HSV is robust in road sign detection with minimum of 88% and 77% successful rate for non-partial and partial occlusions images rather. For successful recognition rates using ANN can be achieved starts from 75-92% whereas PCA is in the range of 94-98%. The combination of HSV color-based detection and PCA generated faster processing time of *2.1s* per frame for the overall identification process. The occurrences of all classes are recognized successfully is between 5% and 10% level of occlusions using PCA, whereas only 5% level of occlusions successful recognized using ANN.

ملخص البحث

في السنوات الأخيرة، وقد اجتذب التلقائي تحديد علامة شبكة الطرق أعمال البحث عديدة مع إمكانية استخدام نظام المساعدة في الحكم الذاتي أو سائق) أداس .(البحث في تحديد علامة الطريق مع انسداد، ولكن لا يزال غير موجود .العديد من التقنيات المتاحة حتى الآن التي وضعت خوارزميات مع وجود انسداد تنتج عدم الدقة التي تحتاج إلى تحسين .على الرغم من أن الحوادث من علامات الطريق مع وجود انسداد صغيرة، ومع ذلك فهو مشكلة تحتاج إلى معالجة .ويقترح نظام ذكي لتحديد علامة الطريق التي أدرجت عدة خوارزميات مختلفة في البحث على حل المشاكل .خوارزميات تتكون من HSV المقترحة والألوان RGB في جزء وتقنيات الكشف ANN و PCAجزئيا الاعتراف .الخوارزميات المقترحة قادرة على الكشف عن الأنواع الثلاثة القياسية من الصور الملونة وهي الأحمر والأصفر والأزرق .ثم يتم مقارنة هذه الخوارزميات مع بعضها البعض لتقييم أدائهم .فرضية هذا البحث هو أنه يمكن استخدام الصور علامة الطريق لكشف والتعرف على علامات التي تساعد في وجود انسداد والتغيرات التناوب .ثم يتم استخراج كل الميزات باستخدام علامة عالمية تقنية استخراج الميزة حيث يتم إصلاحها حجم الرأسي والبعد من علامة إلى حجم قياسي .وتستخدم هذه الميزات المدخلات ليتم تطبيقها في الشبكة العصبية وفقا لإطعام قدما العصبية تقنية الشبكة باستخدام وظيفة العكسي التدريب .كما هو معروف PCA تقنية استخراج الميزة التي تقلل حجم الأبعاد .يمكن تسجيل الصورة التي تم تحديدها بسهولة من خلال طريقة PCA كما تم استخدامه في العديد من مجالات التطبيق .استنادا إلى النتائج العملية، فإنه يدل على أن HSV قوية في كشف علامة الطريق مع الحد الأدنى من88 ٪ ومعدل نجاح77 ٪ للصور انسداد جزئي وغير جزئية بدلا من RGB تجزئة اللون .يمكن لمعدلات الاعتراف ناجحة باستخدام ANNأن يتحقق يبدأ 75 حتي92 ٪ في حين PCA هي في حدود98-94 ٪ من .يتم التعرف على الأحداث من جميع الطبقات بنجاح ما بين5 ٪ و10 ٪ من مستوى انسداد باستخدامPCA ، في حين فقط5 ٪ المستوى من انسداد ناجحة معترف بها باستخدام.ANN

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion; it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Mechatronics Engineering).

.....
Nahrul Khair Alang Md Rashid
Supervisor

.....
Yasir Mohd Mustafah
Co-supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Mechatronics Engineering).

.....
Amir Akramin Shafie
Internal Examiner

.....
Hadzli Hashim
External Examiner

This dissertation was submitted to the Department of Mechatronics Engineering and is accepted as a fulfilment of the requirement for the degree of Master of Science (Mechatronics Engineering).

.....
Md Raisuddin Khan
Head, Department of
Mechatronics Engineering

This dissertation was submitted to the Kulliyyah of Engineering and is accepted as a fulfilment of the requirement for the degree of Master of Science (Mechatronics Engineering).

.....
Md. Noor Salleh
Dean, Kulliyyah of Engineering

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Nursabillilah Binti Mohd Ali

Signature ..... Date .....

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Affirmed by Nursabillilah Binti Mohd Ali

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Signature Date

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LIST OF ABBREVIATIONS

1D	One dimensional
2D	Two dimensional
3D	Three dimensional
ADAS	Autonomous driver assistance system
ANN	Artificial neural network
fps	Frames per second
GUI	Graphical user interface
HMM	Hidden markov model
HSI	Hue, saturation and intensity
HSV	Hue, saturation and value
MLP	Multi layer perceptron
MSE	Mean squared error
PCA	Principal component analysis
RGB	Red, green and blue
ROC	Receiver operating characteristic
SCG	Scaled conjugate gradient
SVM	Support vector machine
TP	True positive
YCbCr	Lighting, blue and red chroma

CHAPTER ONE

INTRODUCTION

1.1 MOTIVATION AND INTRODUCTION

In recent years, a lot of researches on road and traffic sign identification have been done in order to develop completely autonomous vehicles. However, there are many difficulties that the researchers went through during the implementation. One of them is hard to understand the situation and the direction of the vehicles in complex environments. Based on visual information by drivers, an alert driving task will determine the successful detection and identification of the road signs. Road signs give vital information about the conditions of the road. There are varieties of road signs utilized on the road and they are different in color and shape to represent restrictions, prohibitions, warnings and obligation. Normally, the road sign is presented according to the color, form and symbols (Malik et al., 2007; Chourasia and Bajaj, 2010; Lim et al., 2010; Abukhait et al., 2012).

Road sign must be properly placed at important locations and property of them is ideally needed to ensure adequate updating and maintenance. A road sign identification system can potentially be developed as a part of intelligent driving assistance system that continuously monitors the driver, the vehicle and the road. For instance, it can be used to inform the driver in time about upcoming decision points regarding navigation and potentially risky road situations (Loy and Barnes, 2004; Oruklu et al., 2012).

Road sign detection and recognition have been widely implemented in many application areas and methods. For instance, it helps to improve the road sign

identification system due to safety system is such an important thing in avoiding any dangerous circumstances that might happen. In addition, road sign recognition with partial occlusion has rarely been implemented. The existing research normally focused on another aspect of sign detection such as detection of certain colors of signs, pedestrians and the difficulty of navigating the vehicle's lane. Other systems are able to only give warnings to drivers when they exceed the speed limit.

This dissertation describes about detection and identification of road sign that demands new technologies and functionalities leading to robust road sign identification system. These concerns are mainly on proposed algorithms, segmentation, pre-processing using large database and the performance rates of experiments conducted.

1.2 BACKGROUND

The dissertation aims to develop a road sign identification system that is able to detect and identify road signs involved with occlusions at different angles. The discipline for extraction of two dimensional (2D) and or three dimensional (3D) information from one or more images of interest can be defined to as Computer Vision (Chellappa et al., 2005).

According to Fleyeh (2004), the road signs that are viewed in front of the car may not realized by drivers because of their different perceptions and lack of self-consciousness. Hence, automatic road sign identification is an important system that can be implemented to assist the drivers to have a safe journey. There are many types of road signs that can be studied and it varies according to countries. Drivers must notice the information on the road signs while driving and ready to react accordingly in hazardous condition.

Detection and identification of road sign is an important element in autonomous car. It also alerts drivers so that they can focus on driving. Improving the existing techniques for both detection and identification processes will help to overcome the difficulties in the identification process because the signs conditions may be found blur, rotated, and hidden by objects that are possible to be implemented (Malik et al., 2007; Zakir et al., 2010).

Although many work has been done in computer vision to enhance existing road sign identification, there are many issues still open and deserved further research. Among those issues as discussed earlier, the ability of the detection system and the performance rate in the recognition stages are the most important part (A. de la Escalera, J. M. Armingol et al., 2001).

1.3 PROBLEM STATEMENT AND ITS SIGNIFICANCE

As the number of cars increased, the probability of accidents to occur will also increase. In 1997, there were 9,141,357 vehicles recorded in Malaysia and the total number of accidents was 215,632. In 2007, the number of registered vehicles was 16,825,150 cars in 2007 and the number of accidents increased to 363,314. Three years later, 414, 421 accidents was reported by Malaysia Institute of Road Safety Research (MIROS).

Over the past 30 years, based on statistic, in 1974 the total number of accidents had reported from 24,581 cases to 328,264 cases in 2005, boosting more than 135% of accidents rates (Mustafa, 2005).

A statistic of accident cases reported from the Royal Malaysian Police (RMP) shows that the number of road accidents and deaths increase over the last 3 decades. Factors that contributed to accidents involved the driver itself, roads conditions,

conditions of the cars, bad weather and lighting reflections. In fact, when the traffics are congested, the tendency for accidents to occur is also high.

Since road sign is one of the major contributors to accidents, the state of road sign should be improved. Road sign detection and identification system could assist drivers to be more aware of road regulations. The system will read and gather the road signs information and alert the driver. Apart from alerting drivers about the road sign, autonomous road sign detection and recognition could also be useful for autonomous vehicle navigation such as in the Autonomous Driver Assistant System (ADAS).

Typical road sign images are shown in Figure 1.1 (a) to (f). A complex image may include people, vehicles with different colors, a number of shops and a number of road signs on the road. Fundamentally, if a person was asked to point out the road sign in the image, they can do this easily. However, we require a system that can detect and identify the type of the signs so that it may assist us in driving. (Figure 1.1(a) and (b)).

Signs may get disoriented and rotated which might be difficult to be recognized by the system such as shown in Figure 1.1(c). The presence of obstacles in scenes, such as trees, buildings, vehicles and pedestrians or other objects may occlude part of the sign. (Figure 1.1(d)).

The size of sign in frame will determine the distance rate between the camera and the location of the sign. The further the camera that captured the road sign is, the smaller the sign in the image will be. It looks small and blur if the image is taken from a long distance. Sometimes people put a sticker or write on the sign board may change the features and meaning of the sign shapes. (Figure 1.1 (e) and (f)).

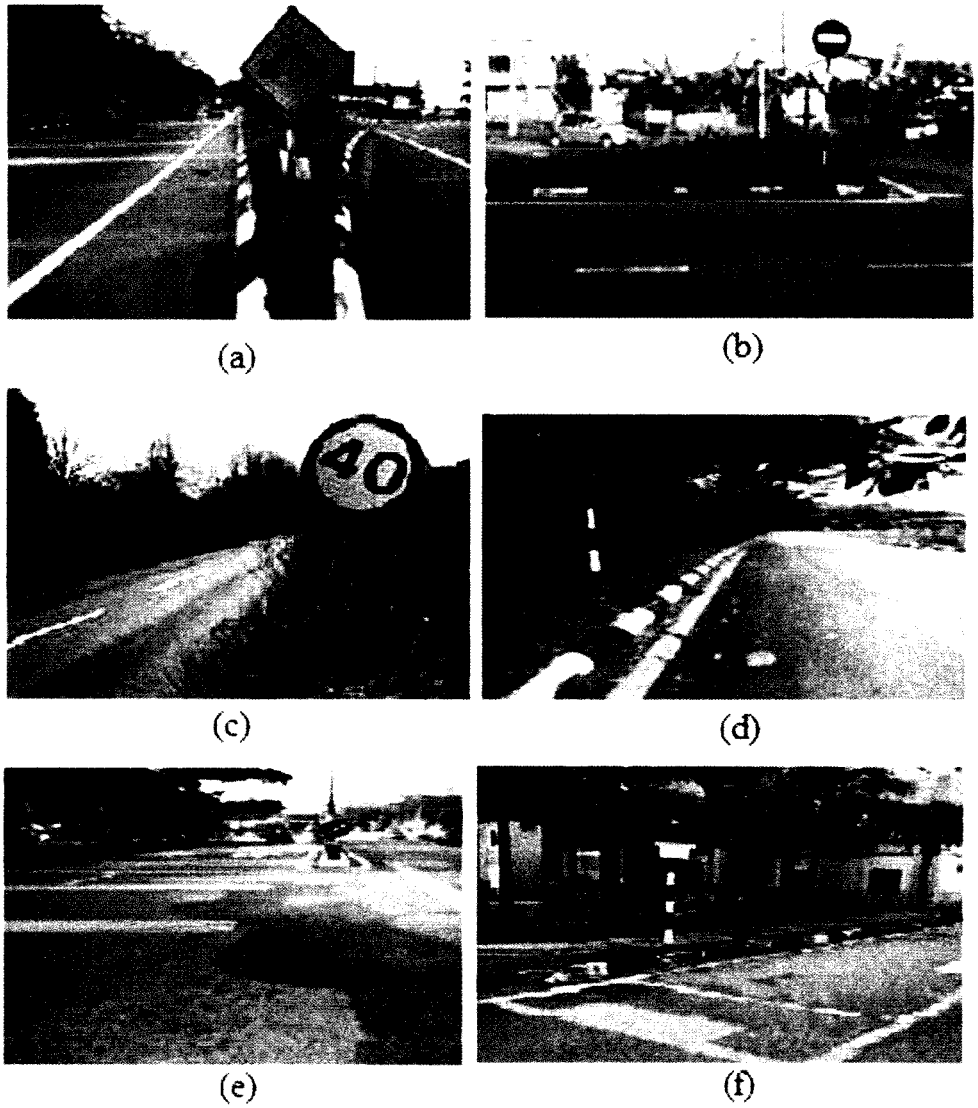

Figure 1.1 Road sign image. (a) complex scene, (b) blur image, (c) rotated sign, (d) partial occlude sign, (e) position and distance of camera affect the sign image, and (f) sticker on the sign board.

1.4 RESEARCH OBJECTIVES

The objectives of the research are:

1. To develop image processing algorithm for a road sign detection.
2. To develop intelligent model for road sign recognition.
3. To develop a user friendly system that integrates road sign detection and recognition algorithms in identifying occluded road sign images.

4. To test and evaluate the performance of the system.

1.5 SCOPE OF RESEARCH

In this research, the focus is on road signs used in Malaysia. Sign identification is based on color and shape. A total of 12 types of road signs were used to form 403 images for detection and 600 images for recognition. These images were captured using a camera between distances 10 to 15 meters. These images were taken at night and daytime involving illumination and rotational changes as well as partial occlusions. The road sign is being detected through a proposed image processing algorithm that would search for pixel based on red, blue and yellow color. The algorithm has also the capability to detect more than one road sign in an image.

For road sign recognition process, two processes are implemented in automatic offline basis namely feed forward Artificial Neural Network (ANN) and Principal Component Analysis (PCA). For the purpose of this research, experiments conducted involve to rotation or scaling and partial occlusions of images.

1.6 RESEARCH METHODOLOGY

The research methodology adopted to achieve the objectives is:

1. Literature review:

   Existing and current techniques for image detection and recognition are surveyed. The technique used of feature extraction for classification and recognition also has been investigated to be suited in the research.

2. Development of road sign detection algorithm:

   Implement an automatic system or software with Graphical User Interface (GUI) that will be used as a platform to be incorporated in the work. Two

color models are being used in the image processing phase; Hue, Saturation and Value (HSV) and Red, Green and Blue (RGB). The objective is to detect the location of road sign from the sample image based on red, blue and yellow color. The developed algorithm requires database of image data sets taken from various places and captured by the camera to be used in this research.

3. Development of feature extraction technique:

   Global feature extraction technique is employed to extract the sign feature from 2 dimensional (2D) to one dimensional (1D) standard size. These data are used for developing recognition model in the next phase.

4. Development of road sign recognition algorithm:

   An intelligent road sign recognition using ANN and PCA is implemented with the purposes of classifying and recognizing partial occlusion signs according to its class.

5. Development of road sign identification system:

   Based on the detection and recognition algorithms, the sign is then identified according to its class. It will indentify a correct class if the input feature is slightly similar to the output or vice versa even tough in partial occlusion situation.

6. System evaluation:

   System processing speed between individual colored signs using HSV and RGB color-based methods are evaluated and compared. The recognition processing speed using both ANN and PCA techniques are evaluated and the performances are compared. Lastly, the percentage accuracy of detection and recognition processes are stated as well.

Figure 1.2 illustrates the flow chart of the research methodology used as a guide to this research.

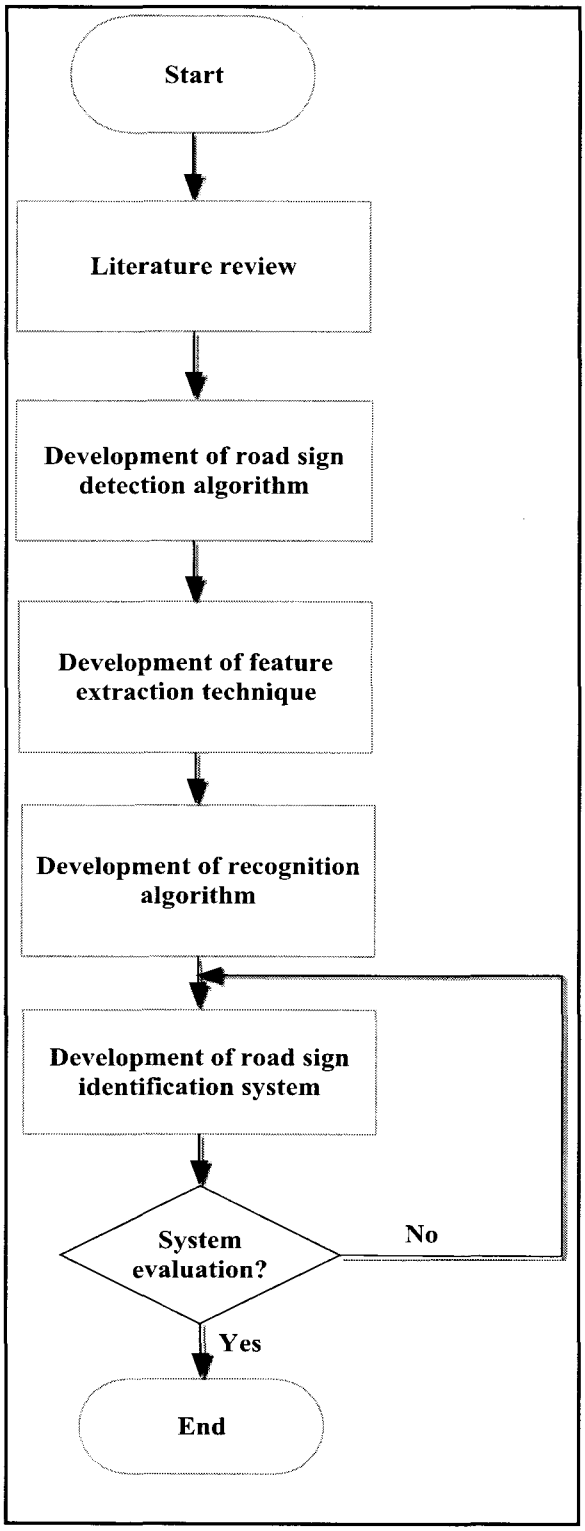

Figure 1.2 Flow chart of research methodology

1.7 DISSERTATION ORGANIZATION

This dissertation consists of five chapters. This dissertation is organized as follows: Chapter One comprises introduction, objectives of the research and problem statement. Chapter Two introduces literature review of the road sign detection methods, including the research done with the existing features extraction technique. Recognition approaches using ANN and PCA are also discussed in this chapter. Chapter Three presents the process flow of color segmentation technique in developing intelligent algorithms of detection stage, feature extraction technique and recognition processes in detail. Chapter Four describes the processing speed of detection, recognition stages and the accuracy of the proposed system by conducting experiments using training and testing dataset based on the system software and hardware selection. It is also devoted the occurrences of recognizing signs according to the percentage of occlusion marks on each sign classes. Chapter Five concludes this dissertation and proposes possible future works to further developing the technique of road sign detection and recognition.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

In recent years, road sign identification has become amongst the popular research in computer vision (Baró 2009). In the last decade, there have been a lot of developments involving robust and fast computation algorithms that are definitely challenging to the researchers to develop regarding road sign detection and recognition. Thus, it is important to design and develop a new algorithm that can improve the existing ones. Road signs are designed to be used as a guidance or information for drivers and road users. They are also used to inform drivers about the present situation of the road and provide vital information for navigation of vehicles (Prieto and Allen, 2009). They generate levels of quality and safe journey by following the rules and concepts that have been implemented in designing road sign properties. This chapter intends to review existing works related to road sign detection and recognition. Methods related to detection and classification stage is being described and discussed. Feature extraction technique for dimensional size reduction is also discussed. This chapter also discusses several methods on road sign recognition using intelligence system techniques. Lastly, based on several findings on the literature review, a conclusion according to highlights technique is made.