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MULTI ROAD MARKING DETECTION SYSTEM FOR AUTONOMOUS CAR USING HYBRID- BASED METHOD

KHAN BAHADUR SHAH

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By

KHAN BAHADUR SHAH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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DEDICATION

This thesis is dedicated to Almighty Allah and his noble messenger Prophet Muhammad (s.a.w.)

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

MULTI ROAD MARKING DETECTION SYSTEM FOR AUTONOMOUS CAR USING HYBRID- BASED METHOD

By

KHAN BAHADUR SHAH

April 2018

Chairman : Marsyita Binti Hanafi, PhD
Faculty : Engineering

For at least two decades, the development of autonomous systems has led to the development of embedded applications allowing to improve the driving comfort and safety. One of the embedded systems that received great attention is road detection system, that operates using road markings detection algorithm. To date, the issue on detecting road markings under various imaging conditions has not been tackled yet. Generally, the road markings detection is performed on road images extracted from videos that were recorded using a camera, which was placed inside a vehicle at a fixed position. In this thesis, a road markings detection system that tackle the problems of detecting road markings under various weather and illumination conditions is proposed. The proposed system consists of a combination of Inverse Perspective Transform method, an image enhancement method and edge detection method. The Inverse Perspective Transform method was used to convert images, which were extracted from the recorded videos to bird's-eye view images, while an image enhancement method, namely Contrast Limited Adaptive Histogram Equalization (CLAHE) was used to tackle various illumination conditions and Sobel edge detection method for detecting the road markings. Experimented on Large Variability Road Images database (LVRI) that consists of 22,500 road images, which were extracted from videos recorded around Selangor and Kuala Lumpur and T. Wu dataset that consist of 1208 road images, which were extracted from videos recorded around California, the proposed algorithm performed satisfactorily. With an accuracy of 96.53% using LVRI and 99.33% using the T. Wu datasets, the proposed algorithm able to detect almost all types of road markings. The types of road markings available in the LVRI and T. Wu datasets are forward arrow, left-side arrow, right-side arrow, lanes and signs printed on the road that are under various imaging conditions, including complex background and occlusion. In addition, the proposed algorithm outperformed the algorithm introduced by T. Wu. However, the algorithm has difficulty in detecting road markings painted in soft yellow color.

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Hence, in future, the algorithm will be improved by incorporating HSI color analysis with the aim of tackling the problem of detecting road markings that are painted in soft yellow color.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SISTEM PENGESANAN PELBAGAI TANDA JALAN BAGI KERETA BERAUTONOMI MENGGUNAKAN KAEDAH BERASASKAN HIBRID

Oleh

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Sekurang-kurangnya dua dekad, pembangunan sistem autonomi telah membawa kepada pembangunan aplikasi terbenam yang membolehkan untuk meningkatkan keselesaan dan keselamatan memandu. Salah satu sistem terbenam yang mendapat perhatian besar adalah sistem pengesanan jalan, yang beroperasi menggunakan algoritma pengesanan tanda jalan. Pada masa kini, isu barlcenaar dengan tujuan menghasilkan sistem pengesanan tanda jalan di bawah pelbagai keadaan pasgimejan masih belum ditangani lagi. Secara Umumnya, pengesanan tanda jalan dilakukan pada video yang dirakam menggunakan kamera, yang diletakkan di dalam kenderaan pada kedudukan tetap. Dalam tesis ini, sistem pengesanan tanda jalan yang menangani masalah mengesan tanda jalan di bawah pelbagai keadaan cuaca dan keadaan pencahayaan dicadangkan. Sistem yang dicadangkan ini terdiri daripada gabungan kaedah Transformasi Perspektif Inversi, kaedah peningkatan imej dan kaedah pengesan pinggir. Kaedah transformasi pospecktif inver digunakan untuk menukar imej yang di elcstrak daripada video yang dirakam kepada ke dalam imej pandangan mata burung, mangsalah kaedah peringkatnya gambar, iaitu Contrast Limited Adaptive Histogram Equalization (CLAHE) digunakan untuk menangani pelbagai keadaan pencahayaan dan kaedah pengesanan pinggir Sobel untuk mengesan tanda jalan. Eksperimen pada data Pangkalan Data Large Variability Road Images database (LVRI) yang diretakkan daripada video yang dikara selirat sanga dan kuala lumpur, da pangkalan data T. Wu yang tadiri daripada 22500 imej jalan yang diekstrak daripada video yang dirakam sekitar California, algoritma yang dicadangkan dilaksanakan dengan memuaskan. Dengan ketepatan 96.53% menggunakan LVRI dan 99.33% menggunakan dataset T. Wu, algoritma yang dicadangkan dapat mengesan hampir semua jenis tanda jalan. Jenis jenis tanda jalan yang terdapat dalam kumpulan LVRI dan T. Wu adalah anak panah ke hadapan, anak panah ke kiri, anak panah ke kanan, lorong dan tanda yang dicetak di jalan dimana di bawah pelbagai keadaan pengimejan, termasuk latar belakang yang kompleks dan

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yang terdapat dalam kumpulan LVRI dan T. Wu adalah anak panah ke hadapan, anak panah ke kiri, anak panah ke kanan, lorong dan tanda yang dicetak di jalan dimana di bawah pelbagai keadaan pengimejan, termasuk latar belakang yang kompleks dan oklusi. Di samping itu, algoritma yang dicadangkan mengatasi algoritma yang diperkenalkan oleh T. Wu. Walau bagaimanapun, algoritma mempunyai kesukaran untuk mengesan tanda jalan yang dicat dengan warna kuning lembut. Oleh itu, pada masa akan datang, algoritma akan diperbaiki dengan memasukkan analisis warna HSI dengan tujuan untuk menangani masalah mengesan tanda jalan yang dicat-kan dengan warna kuning lembut.

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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TABLE OF CONTENTS

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LIST OF TABLES

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LIST OF FIGURES

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LIST OF ABBREVIATIONS

RMD	Road marking detection
RANSAC	RANdom SAmple Consensus
RGB	Red-Green-Blue
HSI	Hue-Saturation-Intensity
YCbCr	Green (Y), Blue (Cb), Red (Cr)
CMYK	cyan, magenta, yellow and key (black)
SHT	Standard Hough Transform
IPM	Inverse Perspective Mapping/ Transform
MSER	Maximally Stable Extremal Regions
SVM	Support Vector Machine
HOG	Histogram of Oriented Gradients
OCR	Optical Character Recognition
NCC	Normalized cross correlation
ANN	Artificial Neural Network
RMD	Road Markings Detection
CLAHE	Contrast-limited adaptive histogram equalization
AHE	Adaptive histogram equalization
HE	Histogram equalization
LVRI	Large Variability Road Images' database
ROI	Region of interest
HT	Hough Transform
PSNR	Peak Signal to Noise Ratio
MSE	Mean Square Error
TDR	True Detection Rate
FDR	False Detection Rate
TP	True Positive
TN	True Negative
FP	False Positive
FN	False Negative

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CHAPTER 1

INTRODUCTION

1.1 Background

A vehicle that is able to navigate without human intervention is known as autonomous car [1]. Self-navigation and the detection of surroundings can be executed using various advanced control system that operate based on sensors and computer vision. The advanced control frameworks translate sensor data to distinguish suitable route ways (navigation paths), and in addition obstacles and applicable road signs [2, 3].

The development of autonomous systems has introduced an improvement in the development of devices and security frameworks for various applications, such as pedestrian detection [4], obstacle detection and tracking [5], road visibility measurement [6], road departure warning systems [7] and road marking system [8]. To date, the demand of producing autonomous car from the industry has made the road markings detection system becomes an important field of study. Road markings are defined as lane borders markings and painted arrows on the road surface. In the area of self-driving vehicles and driver support technologies, broad strategies have been developed to detect road markings keeping in mind the end goal to enhance driving safety. The methods used by the existing road markings detection systems can be categorized into two classes, to be specific sensor-based techniques and vision-based techniques. The existing sensor-based road marking detection systems were developed using various types of sensors, namely radar and infrared sensors, inductive loop, and microwave detectors. However, the main issue with these sensors is high installation and maintenance cost. The problem is tackled by introducing video sensors, which are inexpensive and slightly affected by traffic disruption [9].

Besides, road markings detection system is likewise a standout amongst the most vital wellspring of data used to reconstruct a local perception guide of a situation encompassing an Ego-vehicle. In fact, this data gives relative vehicle area data to all other perception systems, in particular obstacles, street signs, street boundary, which are otherwise called road and lanes properties. Consequently, the system must be as robust as could be expected under the circumstances. In addition, it also appears that the idea of automation in driving is likely an answer for diminishing the measure of street wounds because of auto crashes. Hence, to drive automatically or partial automatically, the road markings detection is very important, as it provides a critical information for both automatic or partially automatic driving assistant system. However, the information to be provided should be accurate and certain to accomplish some manoeuvers, for example, path (lane) changes or generate safe way arranging [10].

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1.2 Problem Statement

According to World Health Organization, around 1.25 million people die each year due to road traffic accidents, that is one person is killed every 25 seconds [11]. In that survey, it is also reported that road traffic accident is one of the major cause of death among young generation, ranging from 15–29 years and 20 to 50 million people suffer non-fatal injuries, with many incurring a disability as a result of their injury [11]. In Malaysia, the total number of road deaths from 1997 till 2014 is ranging from 6302 to 6674 [12]. The factors that contributed to road death may due to veered off the road. Hence, a significant amount of studies on automatic road markings detection systems have been conducted in order to provide solution to this problem [4-8]. However, most of the research on lanes or arrow marking detection focus on road images captured during daylight with less traffic condition or no traffic at all. It is also showed that detecting lanes and arrow simultaneously on the road images under various conditions is a difficult task and has not been fully addressed yet. The proposed techniques in this thesis follow several strategies to tackle the problems of detecting road markings that are captured during day and night. The following are the problems need to be tackled.

i. The problems of detecting road markings under various illuminations, scales and occlusions during busy traffic, which include detecting road markings day and night with the present of shadows projected by trees, buildings, overhead road, rain and snow.
ii. The problems of detecting different types of road markings which includes numbers and words painted on the road and curve lane.

1.3 Aim and Objectives

The aim of this research is to develop a reliable automatic road markings detection system and the objectives of this research are as follows:

i. To identify the methods that can be used to detect different types of road marking under various imaging conditions.
ii. To design an algorithm that able to detect different types of road under various imaging conditions.
iii. To develop a road markings detection system that able to detect different types of road markings.
iv. To evaluate the performance of the developed road markings detection system.

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1.4 Scope of the Study

The scope of the study involves the following details.

i. Development of a road markings detection system that able to detect various types of road markings under various imaging conditions, such as variation in illuminations, occlusions and weather conditions using a combination of Inverse Perspective Transform, Contrast Limited Adaptive Histogram Equalization (CLAHE) and Sobel edge detector.
ii. Evaluation of the performance of the proposed algorithm using two datasets, namely Large Variability Road Images database (LVRI) and T. Wu dataset [13].

1.5 Research Contribution

i. Introducing a large road images database, known as Large Variability Road Images database (LVRI) that consists of 22500 road images. The images were captured under various imaging conditions that include shadow, occlusions and various road markings scales during busy traffic.
ii. Introducing a robust road markings detection algorithm that able to detect various road markings under various imaging conditions with high accuracy.

1.6 Thesis Outline

In Chapter Two, a literature review is presented. The overviews of existing works on the road markings detection, including the advantages and disadvantages were discussed. The methods used in the proposed algorithm were discussed in Chapter Three. Chapter Four presents the experiment results and finally, the conclusions and future works in Chapter Five.

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