LANE DETECTION SYSTEM FOR AUTONOMOUS VEHICLE USIGN IMAGE PROCESSING TECHNIQUES

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DECLARATION

I hereby declare that the thesis is based on my original work except for the quotations and citations which have been duly acknowledge.

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ABSTRACT

A completely autonomous vehicle is one in which a computer performs all the tasks that the human driver normally would. This would mean, to go to a specific destination, a driver will just has to key in the desired destination and the system will be enabled automatically by the computer. From there, the car would take over and drive to destination with no human input. The car would be able to sense its environment and change maneuver and speed when necessary. A system for road marking detection has been set up during the course of this master's thesis project. In the development of the software, images acquired from a front looking video camera mounted inside the vehicle were used.

The problem of using computer vision to develop lane detection system for autonomous vehicle is road marking characteristic. Since the strongest characteristic of a road marking image are the edges, the road marking detection step is based on edge detection. For the detection of the straight edge lines, a Radon based method was chosen. Due to peak spreading in Radon space, the difficulty of detecting the correct peak in Radon space was encountered. A Radon peak detection algorithm was developed based on two values, R and θ. These values make the system robust to the different types of road marking such as continuous road marking, discontinuous road marking and road with shadow.

The performance of the road marking detection algorithm was investigated over several different short image sequences. The different sequences included normal country road driving, a number of different road marking configurations, such as continuous, intermittent and combinations of and images with shadows. The system performs well during the experiments within the difference road condition state above. The work done in this thesis can be used as a starting point in the development of for example a lane departure warning system. The potential of such a system is further increased by merging information retrieved from images with information from the vehicle such as vehicle speed, steering angle and acceleration.

ABSTRAK

Sebuah kenderaan berautomasi lengkap menggunakan komputer untuk menjalankan segala tugas yang sebelum ini dilakukan oleh manusia. Ini bermakna pengguna hanya perlu memasukkan destinasi yang ingin di tuju dan sistem akan diaktifkan oleh komputer. Kemudian, kenderaan akan mengambil alih tugas pengguna dan memandu ke destinasi yang dikehendaki tanpa memerlukan input daripada pengguna. Kenderaan berkebolehan untuk mengesan persekitarannya dan mengubah pemanduan serta hadlaju secara automatik. Untuk thesis master ini, sebuah sistem telah dibangunkan untuk mengesan garisan di permukaan jalan raya. Sistem ini menggunakan imej yang diperolehi daripada paparan hadapan kamera video yang diletakkan di dalam kenderaan.

Masalah yang timbul apabila menggunakan penglihatan komputer untuk menghasilkan sistem pengesanan lorong ialah karakteristik bagi sesuatu garisan. Memandangkan kekuatan karakteristik bagi imej garisan di permukaan jalan raya ialah bucunya, maka proses pengesanan garisan adalah lebih tertumpu kepada bahagian bucu sahaja. Kaedah Radon dipilih untuk proses pengesanan bucu. Dengan menggunakan dua nilai iaitu R dan θ, puncak di dalam ruang Radon telah dikenalpasti. Nilai-nilai ini menyebabkan sistem yang dibangunkan adalah kuat terhadap beberapa jenis garisan di permukaan jalan raya seperti garisan sambung, garisan putus-putus dan garisan yang mempunyai bayang-bayang.

Prestasi algoritma pengesanan garisan telah dikaji melalui beberapa turutan imej pendek. Imej ini termasuklah imej yang diperolehi daripada beberapa jenis konfigurasi garisan di permukaan jalan raya seperti garisan sambung, garisan putus-putus dan gabungan antara keduanya serta imej yang mempunyai bayang-bayang. Daripada eksperimen yang di jalankan, prestasi sistem ini adalah memuaskan terhadap kesemua konfigurasi garisan yang tersebut di atas. Kerja yang terkandung di dalam thesis ini merupakan langkah awal untuk membangunkan atau menghasilkan sistem; sebagai contoh sistem amaran. Potensi sistem ini meningkat dengan menggabungkan perolehan maklumat daripada imej dengan maklumat daripada kenderaan seperti kelajuan kenderaan, sudut stering dan pecutan.

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LIST OF ABBREVIATION

ROI	Region of interest
FOV	Field of view
CCTV	Closed-circuit television
CCD	Charged-coupled device
AVI	Audio video interleave
DV	Digital video
Thinning	Iterative removal of region boundary pixels
Filtering	Pre-processing method that use a small neighborhood of a pixel in an input image to produce a new brightness value in output image
Smoothing	Suppress noise

CHAPTER I

INTRODUCTION

1.1 Background and Motivation

Automobile manufacturers have developed and are continuing to develop systems for cars that extenuate the driver's burden to monitor and control all aspects of the vehicle. In the last decades in the field of transportation systems a large emphasis has been given to issues such as improving safety conditions, optimizing the exploitation of transport network, reduce energy consumption and preserving the environment from pollution. The endeavors in solving these problems have triggered the interest towards a new field of research and application such as autonomous vehicle driving, in which new techniques are investigated for the entire or partial automation of driving tasks. These tasks include: following the road and keeping within the correct lane, maintaining a safe distance among vehicles, regulating the vehicle's speed according to traffic conditions and road characteristics, moving across lanes in order to overtake vehicles and avoid obstacles, finding the shortest route to a destination, and moving within urban environments.

A completely autonomous vehicle is one in which a computer performs all the tasks that the human driver normally would. Ultimately, this would mean getting a car, entering the destination into a computer and enabling the system. From there, the car would take over and drive to destination with no human input. The car would be able to sense its environment and make steering and speed changes as necessary. So, to develop an autonomous vehicle it will involve automated driving, navigating and monitoring systems. This project only focused exclusively on the lane detection technique in the navigation system.

1.2 Problem Statement

The increase of driving safety, comfort and efficiency are goals connected with the development of systems for guidance of road vehicles. The most important task to be solved in this process is to guarantee the save motion of the vehicles in the lanes of a road. For that, components are developed which use camera and additional sensor technology to supervise the areas in front of the vehicle as well as, if necessary, at the back of or at the side of the vehicle. They use evaluation technology to recognize existing lanes. On this basis, assistance function for several driving tasks can be offered, as for instance, keeping and changing the lane or in connection with obstacle detection systems reaction on obstacles within a lane. Dangerous situations are signaled optically or acoustically to the driver. Additionally, data about the behavior of the driver can be taken into account in order to distinguish between intended and unintended actions. There are two problems that need to understand, analyze and solve in order to design and develop the system for guidance of road vehicles;

1. Forward vision sensor and data acquisition system because it provides information of the road;

    - Detect the lane of the road in front of the vehicle.
    - Detect the lane by a single image without prior knowledge regarding the lane position.

2. Lane detection and tracking on highway and regular road because, it provides the input of the vehicle steering command;

    - Determine the location of lane boundaries in a sequence of consecutive images.

1.3 Objective

In the autonomous vehicle control, the driving commands from a human driver are replaced by a controller that generates these commands from the information it gets as its input, in this case visual information from a camera mounted on the mobile vehicle. The objective of this project is to develop and design a lane detection system based on image processing techniques.

1.4 Project Scope

This project used a single video camera as an input sensor for the vehicle, so it will not covered all the tasks of autonomous vehicle driving system. The scopes of this project are:

1. Analyze video data and capture the image frame by frame.

2. Detect and track the desire lane of straight highway.

3. Analyze and understand the condition of the lane marking (white lines on dark pavement of the road) by extracting all necessary information from the image of the road.

1.5 Delimitations

This system should be able to detect road line marking under the following conditions:

1. Highly visible road markings with high contrast between road and road markings. Unstructured roads such as gravel roads, without road markings will not be taken into consideration here.

2. Good weather conditions, such as daylight and clear or cloudy weather. There are no requirements on the system to process data, which has been collected under poor visibility conditions such as heavy snowing, dense fog and rain or during night-time driving.

3. Structured roads with painted centre road markings, such as country roads and motorways. However, the system is not required to produce data in city traffic, complex road scenery, roundabouts, intersections and motorway exits.

4. There are no real-time considerations, so the collected data can be processed off-line.

1.6 Outline of the Thesis

In this **CHAPTER I: INTRODUCTION**, a brief description of the system is presented, followed by a presentation of the problem statement an objective of the system. The outline of the rest of the thesis is as follows.

In **CHAPTER II: LITERATURE REVIEW**, an overall assessment of different theories connected to the system is presented to the reader. A choice of methods for road marking and detection are examined.

The **CHAPTER III: METHODOLOGY** covered the system design and implementation processes to implement this project. The system design subheading covered the work or process flow of this project and it explained the goals and function for each subsystem. In implementation processes subheading, it covered the methods, techniques and approaches of lane detection process.

In **CHAPTER IV: EXPERIMENTS AND RESULTS**, the results of performance of the system is presented.

A conclusion about the performance and limitation of the system is found in **CHAPTER V: CONCLUSION.**

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Autonomous driving functionalities can be achieved acting on infrastructures and vehicles. Enhancing road infrastructures may yield benefits to those kinds of transportation, which are based on repetitive and prescheduled routes, such as public transportation and industrial robotics. On the other hand, it requires a complex and extensive organization and maintenance, which can become extremely expensive in case of extended road networks for private vehicles use. For this reason, the system that is expected to be achieved on a short-term basis can only be vehicle-autonomous. In this review only selected components of autonomous vehicle driving control system are considered, while road infrastructure, inter-vehicle communication, satellite communications and route planning issues are not covered.

2.2 Image Acquisition

The key element in autonomous vehicle driving system is a sensor, which can provide information to the electronic control unit. The sensor gave information to the controller and then the controller will determine where the path is located with respect to the vehicle. Each sensor that available to perform this task has different accuracy and ease of implementation. Some sensors require changes to the roads themselves while others can be used on existing roads.

2.3 Cameras

The camera is used to take images of the roadway in front of the vehicle and sometime in rear, left and right side of the vehicle. Image processing is then performed to extract information from the image about the look-ahead distance, lane angle and vehicle location on the road. This type of sensing is behaving like human driver eyes. The camera sees ahead and then sends the information to the controller, then the controller make steering adjustments based on how the road is behaving up ahead. The low-cost and widespread use of video cameras makes them very suitable for this type of application. Another type of camera worth mentioning is the infrared (IR) camera, which is sensitive to heat and hence suitable in driver assistance systems, such as night vision applications, because animals and humans are easily detected in the image. However, since the road and road markings emit the same heat, there is no contrast between the road and the road markings in images obtained from IR-cameras [10].

2.3.1 Infrared

Infrared sensors have been used to detect lane marking which is the white lines on dark pavement of the road. This sensor used infrared light, which is emitted from LEDs under the vehicle. The light is reflected by the white line and absorbed by the dark pavement. Sensors detect the light that is reflected back and then the location of the white line is known. This method assumes that the vehicle is to follow the white line [8].

2.3.2 Magnetic

This method is very similar to the use of infrared sensors but it based on a magnetic field. Magnetic sensors work by detecting the presence of a magnetic field, which is embedded on the road. Sensors under the vehicle detect magnets embedded in the roadway [8]. To use this sensor it requires major changes to the infrastructure because most roads do not have magnets embedded in them.

2.3.3 Radar

The principle of radar is quite similar with infrared technology but it used different energy or medium to detect the road. This sensor used RF signal. The RF signal is emitted towards the road and then it redirected back by a reflector stripe. When the sensor received the reflected signal, it will determine the position of the road. Then the position information is send to the controller so the controller will act [4].

2.3.4 Camera Mounting

There are a number of possible positions where a camera can be mounted on a vehicle and the choice of placement is primarily determined by the requirements of the system. In many safe driving applications and in experimental studies with test drivers, it is important that the camera is placed where it does not interfere with the driver [1]. An unobtrusive placement could for example be behind the windshield on the rear-view mirror, integrated into the side view mirrors or on the roof of the vehicle.

2.3.5 Field of View

The field of view (FOV) is the area seen by the camera. According to Gangyi [2], the road markings closest to the vehicle are of greatest interest for boundary detection. To achieve high accuracy in detection data and calculations, the focus in the FOV should hence be on the road marking closest to the vehicle. This is obtained by tilting the camera forward. In AURORA, a lane departure warning system, a wide angle camera has been mounted on the side of the vehicle, facing the ground, to capture a rectangular area just beside the vehicle [3]. The lane offset of the vehicle can be determined in this way, and a warning is generated if the lane marking is crossed. This is in line with the lane departure and drowsy driver detection system developed by Ziegler et al. [4] where the camera is mounted on the windshield. In addition, a number of problems, related to camera perspectives which include the horizon, can be avoided with a tilted camera mounting.