PID CONTROLLER FOR AN AUTONOMOUS PARALLEL SELF-PARKING SYSTEM USING LABVIEW

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MAY 2008

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drives)"

Signature :

Supervisor's Name : Puan Aliza Che Amran

Date : 5/5/2008

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Fakulti Kejuruteraan Elektrik
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"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

Signature :
Name : TEOH WEN XIN
Date : 05-05-2008

For my lovely parents

ACKNOWLEDGEMENT

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Lastly, I am sincerely grateful for my family because they have encouraged me on completion of this project report.

ABSTRACT

This project is to design a combination of hardware and software of an autonomous parallel self-parking system. The aim of this project is to build hardware with ultrasonic sensor and the driver circuits and write program to analyze, process and control the hardware to perform parallel self-parking system. The model of hardware model is a car prototype which is built in with DC motor and servo motor. Ultrasonic sensor is used to measure the distance between the parking space boundary and car prototype. The software, LabVIEW 7.1 and an additional PID toolkit are used to design a PID controller that controls the car via USB-6009 DAQ card. In the early chapters, the previous works on designing a system to perform parallel parking are discussed. The methodology of this project is described and discussed comprehensively later on. The results with the LabVIEW programme are thoroughly discussed with settings in detail. The observations and investigations are discussed lastly for future review.

ABSTRAK

Projek ini adalah untuk merekabentuk gabungan daripada perisian dan perkakasan bagi sistem letak kereta selari yang automatik. Matlamat projek ini adalah untuk membina perkakasan dengan pengesan ultrasonik dan litar pengawal serta mewujudkan satu program untuk menjalankan analisis, pemprosesan dan pengawalan perkakasan untuk melaksanakan letak kereta selari secara automatik. Model perkakasan ialah kereta mainan yang mempunyai motor DC dan motor servo. Pengesan ultrasonik digunakan untuk mengukur jarak di antara halangan dan kereta. Perisian yang digunakan ialah LabVIEW 7.1 dengan PID toolkit untuk mewujudkan pengawal PID yang mengawal perkakasan dengan USB-6009 kad DAQ. Kerja terdahulu dalam merekabentuk system letak kereta selari yang automatik dibincangkan dalam bab 2. Seterusnya, perkaedahan untuk menjalankan projek ini dibincangkan dengan teliti. Keputusan yang didapatkan dengan program LabVIEW dibincangkan. Dalam bab yang terakhir, penyelidikan dan pemerhatian akan dibincangkan untuk kajian pada masa depan.

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LIST OF ABBREVIATIONS

ADC	-	Analogue to Digital Converter
CMOS	-	Complementary metal–oxide–semiconductor
DAC	-	Digital to Analogue Converter
DAQ	-	Data Acquisition
DC	-	Direct Current
DDR	-	Double Data Rate
FIR	-	Finite Impulse Response
GND	-	Ground
I/O	-	Input and Output
ISO	-	Industry Standard(s) Architecture
LabVIEW	-	Laboratory Virtual Instrument Engineering Workbench
LVDS	-	Low-Voltage Differential Signaling
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
NI	-	National Instruments
OEM	-	Original Equipment Manufacturer
OrCAD	-	Oregon Computer Aided Design
PC	-	Personal Computer
PCB	-	Printed Circuit Board
PCI	-	Peripheral Component Interconnect
PXI	-	PCI Extensions for Instrumentation
PID	-	Proportional Integral Derivative
PWM	-	Pulse Width Modulation
PV	-	Process Variable
RC	-	Radio-Controlled
SP	-	Setpoint
TTL	-	Transistor-Transistor Logic
USB	-	Universal Serial Bus
VI	-	Virtual Instrumentation

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

This project is titled “PID Controller for an autonomous parallel self-parking system using LabVIEW”. The aim of the project is to design a combination of hardware and software to perform parallel self-parking system.

1.1 Objectives

- To design a PID controller to analyze and control car movement
- To construct controller circuit for ultrasonic sensor
- To construct DC motor and servo motor driver circuit
- To integrate hardware and software to perform parallel self-parking system with minimum error

1.2 Scope

- Construct controller circuit for ultrasonic sensor
- Examine ultrasonic ranging system
- Construct driver circuit for DC motor and servo motor
- Design PID controller to analyze signal from ultrasonic sensor and to send signal to DC motor and servo motor for accurate car movement
- Combine hardware and software to perform parallel self-parking system

1.3 Problem Statement

Parallel parking is a suffering to many drivers. Sometimes parking a car in a space is restricted by the driver's skill at parallel parking. Squeezing car into a tiny space is a vital skill since the parking space is limited especially in big cities. When someone parallel parks, it may block a lane of traffic for at least few seconds and even a minute. Thus, it can lead to traffic tie-ups and collision or scratches of car. Fortunately, technology can give an alternative solution to remove difficulty of parallel parking – autonomous parallel self-parking system. Just imaging that the user just simply push a button and sit back, the car will perform parallel parking into tight space without collision and waste of time. Therefore, this project aims to develop the algorithm for the controller to be employed to a car prototype with the intention to transfer the technology to a real car for solution of the parallel parking problem.

CHAPTER II

LITERATURE REVIEW

2.1 Literature Survey and Previous Research

Nowadays, many researches about parallel self-parking had been done to alleviate the driving burden and enhance safety in next-generation passenger vehicles. The automatic parallel parking problem has previously attracted a great deal of attention among researchers. Current approaches to solving this problem can be classified into two main categories: (1) the path planning approach, where a feasible geometry path is planned in advance, taking into account the environmental model as well as the vehicle's dynamics and constraints, and then control commands are generated to follow the reference path; (2) the skill-based approach, where fuzzy logic or neural networks are used to acquire and transfer an experienced human driver's parking skill to an automatic parking controller. There is no reference path to follow and the control command is generated by considering the orientation and position of the vehicle relative to the parking space. The usage of ultrasonic sensors for driver parking aid systems is popular. It is also possible to use these sensors for designing intelligent types of these driver parking aid systems that will generate the parking maneuvers automatically. Some commercial research studies are also done by the car manufacturers.

One of the studies about this subject is done in the München Technical University of Germany by Daxwanger and Schmidt. In this study the acquisition and transfer of an experienced driver's skills to an automatic parking controller is performed. The interesting part of this study is the way of taking input information and approaches to cloning the skills of an expert driver. A CCD video image sensoris employed to collect data from the environment. The image sensor is composed of a gray-scale CCD camera which is combined with an aspheric mirror to perform an inverse perspective mapping of the scene in front of the vehicle. By the help of this set-up a 4 m x 4 m field of view is obtained. An integrated sensor-processing unit is also utilized to generate a gradient image of the view to process data. No other information, such as the vehicle position relative to the goal location, is needed as extra input. In this study two approaches clone the skills of an expert driver are proposed and compared. A human driver is able to demonstrate his skills by parking a car in the parking bay instead of explicitly describing his information processing while generating an adequate steering action from visual information for parking. Imitating this "black-box" behavior and using the same obvious inputs and outputs leads to direct neural control architecture as the first approach. On the other hand, the expert driver may be able to describe his parking strategy roughly in terms of linguistic rules, which leads to a parking strategy that can be implemented by means of a fuzzy network as the second approach. A robot vehicle, which has car-like 3 kinematics with one steering wheel and a driven rigid axle, is employed to get the experimental performance of the control architectures. The results are satisfactory with a cost of high signal processing requirements of the input data. [1]

This is a research about self-parking system which had been done by University of California, Berkeley. In this study, the students create a sensor package and an associated algorithm to autonomously parallel park an automobile. This system is designed for integration into the drive and steering systems of the vehicle and requires no user input once activated. A car prototype equipped with sensors and a digital signal processor (DSP). Infrared sensors relay obstacle distance measurements in real-time to a central processor, which calculates position relative to the obstacle and adjusts steering accordingly. The distance travelled by the car is monitored by an optical shaft encoder, mounted to the main drive shaft of the vehicle. The ideal parking maneuver is pre-programmed into the DSP, and is executed upon the determination that the vehicle has arrived at the proper starting location. [6]

Another interesting project about parallel self parking system is performed in Florida State University, Tallahassee, FL, USA. They develop and experimentally demonstrate a robust automatic parallel parking algorithm for parking in tight spaces.

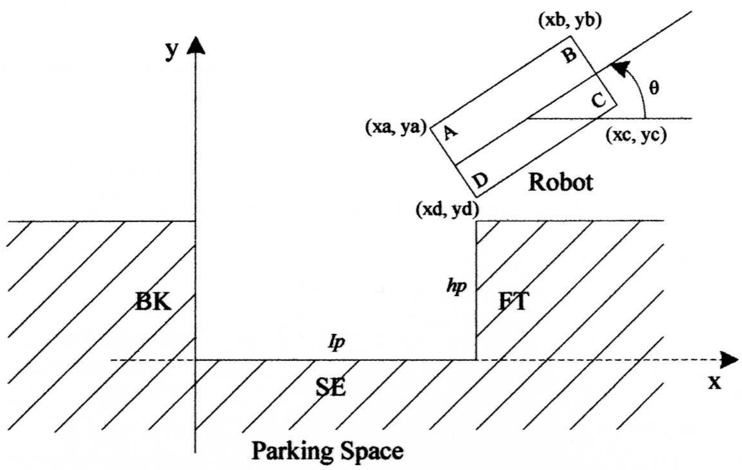

Figure 2.1: Maneuvering space and the local coordinate system [3]

Novel fuzzy logic controllers are designed for each step of the maneuvering process. The controllers are first demonstrated by simulation using the kinematic model of a skid steering autonomous ground vehicle (AGV). They are then demonstrated experimentally on a skid steering AGV and it is shown that the developed algorithm has the ability to parallel park AGVs in tight spaces under both vehicle localization errors and parking space detection errors. This paper also presents a genetic fuzzy system which uses a genetic algorithms learning ability to determine effective parameters for the developed fuzzy logic controllers. The genetic fuzzy system is used to tune the fuzzy logic algorithm for both a skid steering AGV and a front-wheel steering AGV. [3]

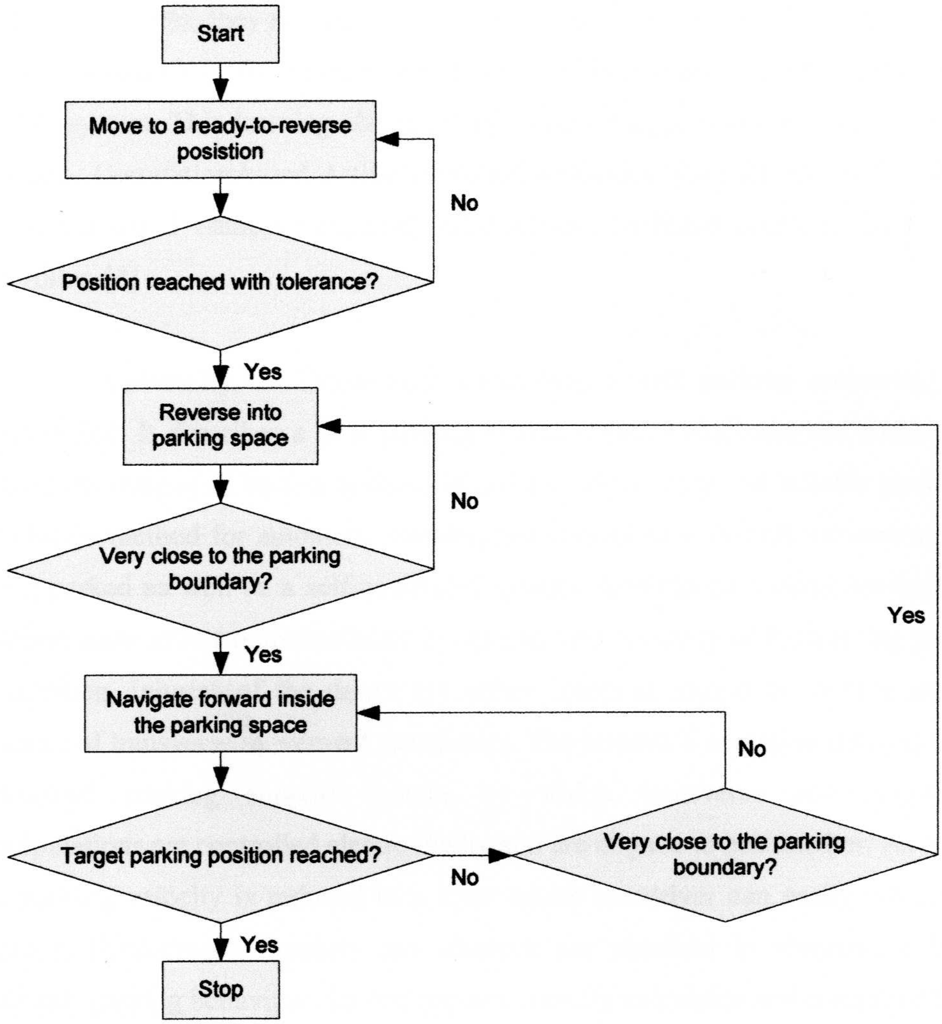

Figure 2.2: Flowchart of parallel parking algorithm [4]

Another related project was developed in the Praxitèle European Project. The SEVA system (Autonomous Vehicle Parking Simulator) implements a robust control system for autonomous vehicle parking based on a FSA (Finite-State Automata) and also based on FSA obtained from trained J-CC ANNs (Jordan Cascade-Correlation Artificial Neural Networks). The research on this project was implementing a car simulator including proximity sensors model (infrared sensors), kinematics model and simulated actuators used to control speed and steering wheel. The initial version of this simulator – SEVA-A (Automata based Vehicle Simulator) was based on Finite-State Automata (FSA) used to control the vehicle. The implemented FSA was hard coded using a set of user specified rules to determine state transitions between car states (e.g. searching for space, positioning, aligning). In order to improve the system robustness, they started to study how to introduce practical experience (learn from experience) in the system, and thus providing some learning ability to the control system. This learning ability of the system was provided through the use of Cascade- Correlation based Artificial Neural Networks. They developed the SEVA-N (Neural based Vehicle Simulator) substituting FSA based controller by an ANN controller. [4]

In University of Technology Darmstadt, a self parking technology was deleveloped. It describes a new parking system which overcomes the weak-nesses and disadvantages of known systems in order to allow easy and reliable parking. It involves a method for automatic steering and control of a vehicle movement while being parked as well as a self-controlled system. Established parking methods and systems show minor reproducibility in velocity and accuracy of the parking process. In addition, injuries of the driver are rather common caused by sudden and fast changes of transverse movement parameters. The presented invention delivers a fully automated parking support system by which transverse and longitudinal manipulations are controlled electronically and are aligned to one another. As a result the parking velocity is reduced to a level where the driver can easily monitor the process. Furthermore, scarcely any changes are obtained in comparison to the "natural" parking behaviour, i.e. the process is easily calculable and controlled by the driver.

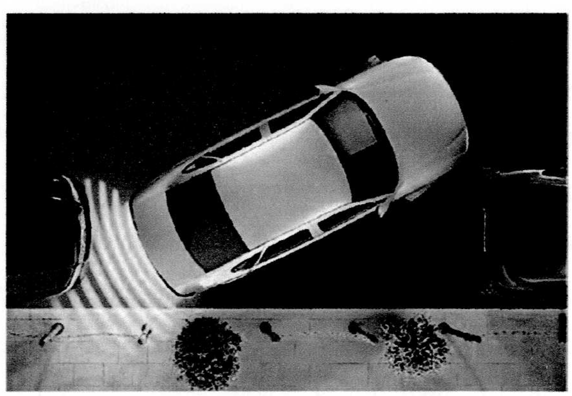

Figure 2.3: Sensor based self-parking system [5]

Displacement measurement or set trajectory is constantly updated by a predictive controller. Hence, the parking process is constantly controlled and corrected. Established sensors for the side, back and front measurements at the vehicle are applied. Ultrasonic, radar, microwave and mm-wave technology can be used. For additional distance measurements magnetostatic wheel speed and pinion sensors are deployed. Steer, break and drive control are adjusted by common actuators like torque ac-tutor, ESP hydraulic and electrical engine management system, just to name a few. Reactions of the system are restricted in dynamic and are easily monitored. This is caused by the usage of steer angle interaction for the calculation and implementation of the transverse guidance. Signal processing of the sensor values and calculations of the odometry are done by an inventive control unit. The set distance or rather setpoint is calculated by means of the longitudinal movement parameter against the transverse movement parameter. The velocity of the longitudinal movement is fixed against the transverse movement parameter which results in limited values. The system can solely be used for the longitudinal guidance with the effect of being low-priced. In this case the moderate forward or backward movement is only continued when the right steer angle is adjusted. [5]

A fuzzy logic control algorithm for self parking of a model car has been developed and an embedded controller hardware has been designed by the Middle East Technical University using PIC. The model car chassis consists of a DC motor actuated traction system and a servomotor actuated steering mechanism. Position data and parking place data is obtained by a sensory system. A stepper motor driven rotary table is designed and assembled to the model car chassis for positioning of the sensory system. The controller hardware includes all the required peripherals for interfacing to the motors and sensory system. A visual computer program running in PC environment is developed in order to simulate the control characteristics of the fuzzy logic algorithm. The program allows the user to generate fuzzy sets and fuzzy set members and allows the user to define membership functions and fuzzy rules. Once an appropriate control characteristic is obtained, all the parameters can be exported to a file in order to be downloaded to the controller. [2]