# FUZZY LOGIC 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 : 5/5/08

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This Report is Submitted In Partial Fulfillment Of Requirements For The Degree of Bachelor In Electrical Engineering (Power Electronics and Drives)

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 OON KAR WENG

Date 05.05.2008

For my beloved Family

# ACKNOWLEDGEMENT

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Thank you for your all useful advices to make my project a successful one.

# ABSTRACT

This project is to design and develop a hardware and software of an autonomous parallel self-parking system by using Fuzzy Logic controller. When a parking place is found, it can perform parallel parking with minimum error. The hardware is the car prototype, which built in with DC motor and servo motor to control the movement of the vehicle. An external driver circuit is used to generate a Pulse Width modulator Signal (PWM) to control the angle of the servomotor. Ultrasonic sensor is used to measure distances between two cars so that the car manages to park in line between two cars. The software used is LabVIEW 7.1 and an additional, PID toolkit, to designs a Fuzzy Logic Controller that controls the car via USB DAQ card. When a suitable park space is found, a signal will be triggered and the controller will now control the car to be maneuvered safety into the parking space with minimum error and less time. In the first and second chapters is discuss about the previous work had be done about this project. Then methodology is described the method that trying use in this project. The result is about the software and hardware design, and also the setting for the overall system. Lastly discussion and conclusion are discussed about the future review.

# ABSTRAK

Projek ini adalah untuk mereka dan membentuk satu perkakasan dan perisian untuk menletak kereta dengan sendiri dengan mengunakan pengawal Fuzzy Logic. Apabila satu tempat letak kereta dijumpai kereta akan letak kereta dengan kesilapan yang minimum. Dalam projek ini perkakasan adalah kereta prototaip yang mempunyai motor DC dan motor Servo untuk mengawal pergerakan kereta prototaip tersebut. Satu litar pemandu luar digunakan untuk menjanakan PWM dan mengawal sudut motor Servo. Sensor ultrasonic digunakan untuk mengukur jarak di antara dua kereta supaya kereta dapat diletak selari diantara dua kereta. Perisian yang digunakan adalah LabView 7.1, dan perisian tambahan PID Toolkit, digunakan untuk mereka pengawal Fuzzy Logic untuk mengawal kereta prototaip melalui National Instrument USB DAQ card. Apabila satu tempat letak kereta yang sesuai dijumpai, pengawal akan mengawal kereta prototaip letak kereta ke dalam ruang letak kereta dengan selamat dan menjimatkan masa. Dalam bad satu dan bad dua membincang tentang kerja yang terdahulu untuk projek ini. Seterusnya perkaedahan menbincangkan kaedah yang rancang digunakan dalam projek ini. Keputusan adalah tentang perkakasan dan perisian, dan juga cara yang digunakan dalam projek ini. Dalam bad terakhir, perbincangan dan kesimpulan dibincang untuk kajian masa depan.

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| | | |
|---|---|---|
| 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 |
| NI | - | National Instruments |
| OEM | - | Original Equipment Manufacturer |
| Op-amp | - | Operational Amplifier |
| OrCAD | - | Oregon Computer Aided Design |
| PC | - | Personal Computer |
| 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

## 1.1 Project Objective

The objectives of this project are:

- To generate control signals controlling signals to DC motor and servo motor to navigate the car prototype from LabView via USB DAQ card.
- To investigate and design the ultrasonic sensors ranging arrangement on the car prototype.
- To design and develop a Fuzzy Logic Controller using LabView to perform parallel self-parking with minimum error.

## 1.2 Scope of Project

- Design a Servo motor and DC motor controller.
- Build a Virtual Instrumentation (VI) on LabView to control the DC motor and Servomotor.
- Build an ultrasonic sensor circuit and examine the ranging system.
- Design a Fuzzy Logic Controller using LabView.
- Construct of car prototype with the combination of hardware and software.

## 1.3 Problem Statement

Nowadays parallel parking is an ordeal for many drivers, but with parking space limited in big cities, squeezing your car into a tiny space is a vital skill and it can lead to traffic tie-ups. But fortunately, technology gave a solution to us – autonomous parallel self-parking system. Imagine if you find a perfect parking spot then simply press a button, sit back, and relax, the car can perform parallel parking automatically.

Self-parking cars can also help to solve some of the traffic problem in dense urban areas. When someone wants to parking the car in to a parallel parking space, they often block a lane of traffic for a least a few seconds. If they have problems getting into the spot, this can last for several minute and seriously disrupt traffic. So self-parking technology would prevent many of these mishaps.

# CHAPTER II

# LITERATURE REVIEW

## 2.1 Background of Autonomous Parallel Self-parking

Autonomous parallel self-parking system is an autonomous car maneuvering from a traffic of lane into a parking space to perform parallel parking. The automatic parking aims to enhance the comfort and safety of driving in constrained environments where much attention and experience is required to steer the car. The parking maneuver is achieved by means of coordinated control of the steering angle and speed which takes into account the actual situation in the environment to ensure collision-free motion within the available space.

## 2.2 Current Technology

On the Lexus LS, the *Advanced Parking Guidance System* uses computer processors which are tied to the *Lexus Intuitive Park Assist* (sonar warning system) feature, backup camera, and two additional forward sensors on the front side fenders. The *Intuitive Park Assist* feature includes multiple sensors on the forward and rear bumpers which detect obstacles, allowing the system to sound warnings and calculate optimum steering angles during regular parking. These sensors plus the two additional APGS sensors are tied to a central computer processor, which in turn is integrated with the backup camera system to provide the driver parking information.

When the *Intuitive Park Assist* feature is used, the processor(s) calculate steering angle data which are displayed on the navigation/camera touch screen along with obstacle information. The *Advanced Parking Guidance System* expands on this capability and is accessible when the vehicle is shifted to reverse (which automatically activates the backup camera). When in reverse, the backup camera screen features APGS buttons which can be used to activate automated parking procedures. When the *Advanced Parking Guidance System* is activated, the central processor calculates the optimum parallel or reverse park steering angles and then interfaces with the *Electric Power Steering* systems of the vehicle to guide the car into the parking spot. [1]


Figure 2.1 : Lexus LS 460L control panel in park assist mode [1]

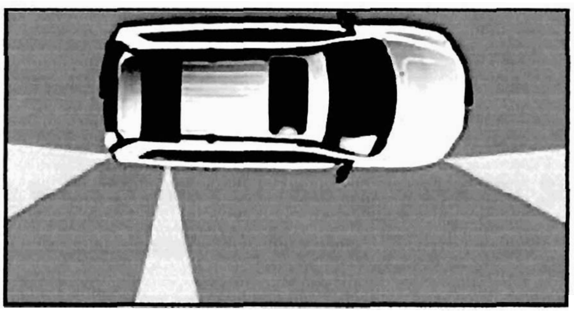

Figure 2.2 : Range of ultrasonic sensor [1]

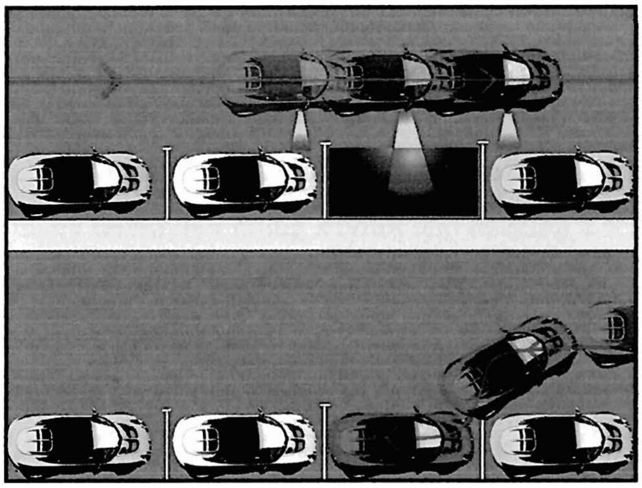

Figure 2.3 : How the parking system works. Sensors measure space size, and then the car backs into spot. [2]

In 1992, Volkswagen employed self-parking technology in its IRVW (Integrated Research Volkswagen) Futura concept car. The IRVW parked with full autonomy - the driver could get out of the car and watch as it parked itself. A PC-sized computer in the trunk controlled the system. Volkswagen estimated that this feature would've added about $3,000 to the price of a car, and it was never offered on a production model

In 2003, Toyota began offering a self-parking option, called Intelligent Parking Assist, on its Japanese Prius hybrid. Three years later, British drivers had the option of adding self-parking to the Prius for the equivalent of $700. So far, seventy percent of British Prius buyers have chosen this feature. Toyota plans to introduce the self-parking Prius to the United States in the near future, but no date has been set. [2]

## 2.3 Literature Survey and Previous Research

Nowadays by the help of improvements in computer technology, automatic control of local vehicle maneuvers to obtain a self-parking action is no more a fantasy. There are many researcher doing studies and develop a self parking strategy. The studies about self-navigating cars and mobile robots is important because of the similar control techniques that are used.

One of the studies about this project is perform in Tottori University of Japan by Ohkita. In this study fuzzy control theory is used for controlling an autonomous mobile robot with four wheels for parallel parking and fuzzy rules are derived by modeling driving actions of the conventional car. Six ultrasonic transducers are used for recognizing the position and attitude of the robot. A stepper motor is also employed to control and move the sensors to keep the suitable angle to the wall for preventing the occurrence of dead angles. The configuration of the supersonic transducer units of this study is presented in Figure 2.4

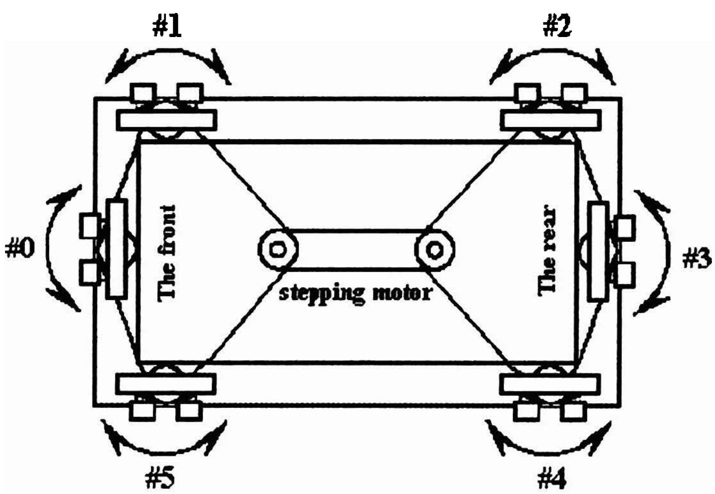


Figure 2.4 : Configuration of the ultrasonic transducer units [3]

In the study of Ohkita, three microprocessors are used for calculations and peripheral access. This kind of architecture seems bulky when combined with the number of the sensors. But using so many sensors has an advantage of an increase in sampling rate of the input data when compared to a positioned single sensor system. The fuzzy reasoning of the system is composed of three fuzzy rule group searches with three, five and seven rules respectively. The active rule group is 4 determined according to the current state of the mobile robot. The performance of this system is satisfactory except the behaviors of the system during the absence of the walls. To overcome this problem, utilization of gyro-sensors and a CCD camera is recommended by the authors. [3]

Another study is the study of Fraichard and Garnier a motion control architecture for a car-like vehicle intended to move in dynamic and partially known environments is presented. The system is designed as a fuzzy controller and it is implemented and tested on a real computer-controlled car, equipped with sensors of limited precision and reliability. A Motorola VME bus with an MVME 162 CPU board (68040 processor) is employed as the controller of the vehicle. Three servo-motors and a three-phase controller are driven with this board. The steering wheel is controlled with one of the servo-motors, the other two are used for the brakes. The three-phase 5 controller is used to drive the electric motor of the car for traction. The steering angle is measured with an optical encoder and two optical encoders are also mounted on the rear wheels to obtain the longitudinal velocity of the car and a motion estimation. The system is equipped with a range measurement system of 14 Polaroid 9000 ultrasonic sensors whose layout is presented in Figure 2.5 [4]

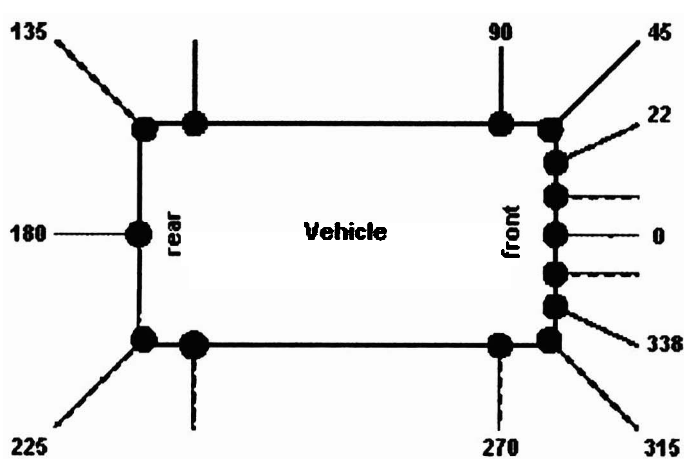


Figure 2.5 : Layout of the ultrasonic sensors [4]