UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A Model of Parking System by an Application of Programmable Logic Controller

Thesis submitted in accordance with the partial requirements of the
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By

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JUDUL: A MODEL OF PARKING SYSTEM BY AN APPLICATION OF PROGRAMMABLE LOGIC CONTROLLER

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I hereby, declare this thesis entitled "A Model of Parking System by An Application of Programmable Logic Controller" is the result of my own research except as cited in the references.

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ABSTRACT

As the economy of a nation is getting stronger, more people can afford to buy their own cars. This is a common situation in developing country such as Malaysia. The increase number of car owners had causes problems such as road congestion and difficulties in parking the car due to limited number of car parks or parking lots. Example of these conditions can be seen in large cities or towns. One example of a conventional car park is by reserving a big piece of land where all the parking lots are on the ground level outside a building. Another type of conventional car park is the multi storey car parks where it is build underground or above the ground intended to reduce parking space. The weakness of these existing parking systems is that it requires the car drivers a lot of time to search for an empty parking lot hence wasting the car's fuel. In some modern countries, they had already developed an alternative to counter this problem by building an automated parking system. The system will automatically park the car into the parking lot without being accompanied by the driver or passenger. The driver will enter a garage and leave the car there for the system to do the parking. Then, when the car owner want to retrieve their car, they will command the system to automatically sent there car back into the garage so they can exit the car park facility. In this project, a model of a parking system by an application of programmable logic controller (PLC) will be developed. The purpose is to give an overview on how a PLC works to control and automate a given system, in this case the parking model. The study will begin by understanding the basics of PLC and then applying the knowledge in automating the mechanism of the parking model. When the model is completed, analysis such as model operation analysis and emendation of the PLC ladder diagram will be carried out until the desired operation is achieved.

ABSTRAK

Peningkatan jumlah pemilik kereta persendidrian menyebabkan masalah kesesakan lalu lintas dan kesukaran mencari tempat letak kenderaan. Satu contoh tempat letak kenderaan konvensional ialah penyediaan satu tanah lapang berdekatan dengan suatu fasiliti. Manakala contoh yang lain pula, ialah binaan tempat letak kereta bertingkat yang mungkin dibina di bawah tanah atau di atas paras tanah untuk tujuan pengurangan luas tempat letak kereta. Kelemahan tempat-tempat letak kenderaan ini ialah pemandu perlu menghabiskan banyak masa untuk mencari tempat letak kenderaan yang kosong dan ini juga akan meyebabkan penggunaan minyak kereta yang berlebihan. Di sesetengah negara-negara maju, mereka telah mewujudkan suatu alternatif untuk menyelesaikan masalah ini dengan mewujudkan suatu sistem letak kenderaan otomatik. Sistem tersebut akan menyimpan kenderaan secara otomatik tanpa kehadiran pemandu kenderaan tersebut. Pemandu akan membiarkan kenderaannya di dalam garaj dan sistem akan menyimpan kenderaan itu di tempat letak kenderaan. Kemudian, apabila pemandu itu mahu mengambil semula kenderaannya, beliau akan mengarahkan sistem untuk memanggil kenderaannya dan akan diletak kembali di garaj supaya pemandu itu boleh keluar dari fasiliti letak kenderaan itu. Dalam projek ini, sebuah model tempat letak kereta yang menggunakan alat pengawal logik berprogram (PLC) akan dibina. Tujuannya ialah untuk memberi gambaran secara keseluruhan bagaimana sebuah PLC boleh mengawal tempat letak kereta secara otomatik. Kajian akan bermula dengan memahami asas-asas PLC dan mengaplikasi pengetahuan tersebut dalam mengawal mekanisma model letak kereta tersebut. Akhir sekali, apabila model sudah siap dibina, analisa akan dilaksanakan seperti analisa berkenaan operasi model dan pengubahsuaian pengaturcaraan “ladder diagram” sehingga operasi yang dikehendaki tercapai.

DEDICATION

For my beloved mother and father.

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Lists of Abbreviations, Symbols, Specialized Nomenclature

PLC	-	Programmable Logic Controller
CAD	-	Computer Aided Drawing
VMT	-	Vehicle Miles Traveled
HC	-	Hydrocarbon
CO	-	Carbon Monoxide
NO2	-	Nitrogen Oxide
CO2	-	Carbon Dioxide
ASRS	-	Automated Storage and Retrieval System
RISC	-	Reduced Instruction Set Computer
IEC	-	International Electrotechnical Commission
PSC	-	Progressive Sequence Controller
DC	-	Direct Current
AC	-	Alternating Current
NO	-	Normally Open
NC	-	Normally Close
SPST	-	Single Pole Single Throw
SPDT	-	Single Pole Double Throw
DPST	-	Double Pole Single Throw
DPDT	-	Double Pole Double Throw
LED	-	Light Emitting Diode
V	-	Volt
OL	-	Opened Loop
CAM	-	Computer Aided Manufacturing
I/O	-	Input and Output

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CHAPTER 1
INTRODUCTION

1.1 Background

An automated parking system is where the vehicle will drive into a garage and the driver will leave the vehicle in the garage. Then the system will automatically park the vehicle into the parking lot. After that, when a driver want to retrieve their vehicle, they will communicate the system via a console next to the garage to request their vehicle and so the vehicle will be position into the garage. Finally, the vehicle will easily drive out without wasting too much time unlike the conventional way of parking.

There are many types of automated parking facilities available in the market such as Robotic Parking, Unitronics and Rothary Parking Storage. These companies used various types of concepts to improve their speed of parking and retrieving the vehicles and also increasing the volume of parking lots. Their accommodation usually range from several hundreds to several thousands vehicles in one car park facility. Sometimes, the automated parking facilities are built inside a main building such as hotels, restaurants or shopping plaza. While, some car parks are built as a single structure.

For this final year project, an automated parking model will be fabricated to stimulate the system by using the programmable logic controller (PLC). The model will only accommodate two car models at a time just to showcase how the system works. The project begins with information seeking about PLC application and automated parking. Then, designing the model and modeling with computer aided drawing (CAD) software.

After that, the project will continue with PLC programming, model fabrication and finally testing and analyzing the model.

By the end of this project, hopefully the fundamentals in automation primarily in the application of PLC can be understood. Other than that, this project will educates how to develop a highly automated instrument or device by using the basic blocks in automation such as sensors, actuators, relays and PLC. Moreover, this project provides a platform to appreciate the technical knowledge which been learnt by implementing it towards accomplishing the project. This final year project is an exposure for dealing with real life problems by applying the trial and error process to overcome the obstacles and difficulties.

1.2 Problem Statements

Nowadays, the increased number of road users had caused not only traffic congestion but also problems in finding a parking vacancy. This situation is can be experienced by drivers in the cities or probably in the suburbs where an empty parking space is very hard to find. Normally, the conventional metro parking requires the driver to go up level by level until an empty parking space is noticed by the driver. This situation is very much time wasting and also waste of costly fuel. The conventional metro parking requires a larger land area but accommodates fewer vehicles compare to the automated parking system capability.

1.3 Objectives

The objectives of this project are:

1) Modeling a new parking system that is practical for small area.
2) Applying the PLC technology in controlling the automated parking model.

1.4 Scope of Work

The project emphasis on designing a model of an automated parking system which minimizes parking area size but maximize the parking space. Then, later on in the project, a concept of the parking system will be fabricated based on the design. Implementation of the programmable logic controller (PLC) will be made in to the model to automate the system. Finally, testing of the model and analysis will be carried out on the developed system.

CHAPTER 2

LITERATURE REVIEWS

2.1 Automated Parking

The automated parking system is not a new technology, whereas advance countries such as America, Canada, Japan and most European countries had utilized the advantage of automation in their parking facilities. A lot of research had been done to show the importance of automated parking system and also improvement of the system effectiveness.

Gerhard Haag (2004) had published an article specific about automated parking system. The title of the article is "Automated Parking: The Technology and its Impact on Urban Areas". The article's contents begin with stating the important of automated parking nowadays and show mathematical analysis how automated parking can save space compare to conventional parking. The result of the calculation is shown below:

Automated Parking = 1050 Cars (115,000sf)
Conventional Parking Lot = 700 Cars (245,000sf)

The research also consists of an interview with the two experts in this field. The first one is James Clifford Greller from Voorhees Transportation Center, Rutgers University, New Brunswick New Jersey. The second one is Professor Darius Sollohub from New Jersey Institute of Technology. Both of the interviewee agrees very well with the development of automated parking in urban planning.

Gerhard Haag (2004) also considered the environmental issues in the research. He stressed on the excessive carbon monoxide gas emission by the vehicles when parking at a conventional parking facility. The implementation of automated parking system will counter this problem because the system uses electricity only to operate. A calculation to proof this statement is shown below:

Assumptions:

Taking into consideration the number of cars and lot size for a conventional garage:

- 924 car garage
- Footprint = 150' x 270'
- 8 levels
- Use of express ramps
- Assuming one turn per day per stall
- Average Vehicle Miles Traveled (VMT) (assuming travel to mid point at 4^{th} level) per car per day to park and to exit = 5280': ([2x 240'+ 2x 90'] x 4 levels) x 2 for entry & exit
- Assuming 275 days /year

Conservatively speaking:

The total average number of vehicle miles traveled (vmt)/yr = 254 100 miles/year (5280' x 924 cars = 4,878,720 feet (divided by 5280'/ mile) = 924 miles/day x 275 days = 254 100 miles/year.)

Conversion to pollutants emitted per year:

- Taking an average for an "average" passenger car and an "average" light truck.

Hydrocarbons: 3.3 grams / mile = 838,530 grams = 1,847 lbs. of HC / year

Carbon Monoxide: 25.5 grams / mile = 6,479,550 grams = 14,272 lbs. = 7.136 tons of CO / year

Nitrogen Oxides: 1.7 grams / mile = 431,970 grams = 951 lbs. of NO_2 / year

Carbon Dioxide: 1 pound / mile = 254,100 lbs. or 127 tons of CO_2 / year

Gasoline: 0.05 gallon/ mile = 12,705 gallons gasoline / year

The research done by Gerhard Haag (2004) also emphasis on design and mechanical elements that had been applied in automated parking such as electro mechanical, hydraulics, pneumatic and linear motor. Below is the list of automated parking system available nowadays. The pictures of these mechanisms can be referred at appendix B:

a) Double stacker: It is easy to install, inexpensive when used in small number of lots, requires very careful parking, not suitable for extreme exterior climates condition, it is not useful for all types of car and it requires the removal of the bottom car if the upper car is needed by an operator.

b) Triple stacker: It is similar to a double stacker but with one more extra platform.

c) Paternoster: It has small footprint of about 22 X 25 feet, it is a niche market product, it is has limited parking spots between 24 and 32 per system, all cars needed to be shifted to access a single car and creates consumption of energy, wear out movable parts and noise.

d) Pallets system: It is a moveable stable plate and the vehicle will be place on it, no machinery needs to touch the car, all pallets are identical and thus the machinery does not need adjustments to handle various size, any dripping from the car such as oil and melted snow will captured onto the pallet and so it protects the machinery and other vehicles, it is design with drive-in guidance and has a wheel stopper incase the driver forgot to pull the handbrakes and it is sufficient to accommodates of most automobile with dimensions of approximately about 7 X 9 feet.

e) Comb system: an alternative to the pallet system. A gripper will grabs the rear and front tires capturing the vehicle to be transported into the parking lot.

f) Stacker crane system: A ‘stacker’ is guided on rails mounted to the foundation slab as well as on the roof and houses a lift inside a mechanism to push and pull the cars from the tower into the slots and reverse. It has been used successfully in the last 40 years in automated storage and retrieval system (ASRS). However the stacker can only handle one vehicle at one time. It is suitable for garage with 40 to 100 accommodations.

g) Shuttle/carrier technology**:** It is an upgrade to the old stacker crane system. It has multiple different devices around 10 to 50 platforms and can handle high peak traffic numbers. It is suitable for garage which handles above 1000 accommodations.

h) Chess parking**:** This is the most efficient parking available. The platforms is moved by air cushion or linear motors where the magnets were installed underneath the moving pallets and the stators were installed in fixed positions along the x and y directions and are this able to pull the platform along these different directions. Some chess parking uses electro mechanical devices such as sprockets, pulleys and etcetera. The main advantage is the high degree of space saving leaving only a small percentage of unused parking spaces per level.

i) Round parking silo**:** It provides the shortest possible distance from the entering area to the storage space and it typically provides for a stronger structural shell since a round shape will practically eliminate the possibility of the structure bending. It is not strong from a space savings viewpoint.

j) Spiral Climber**:** The machinery in the middle is arranged such that four cars can be handled at once. The levels are not horizontal, but arranged in a continuing winding spiral. Each loading station has a different elevation in order to access the

different storage locations. Typically, on the entrance level there are several Entry/Exit stations located so that each of the 4 machines can load/unload vehicles simultaneously.

2.2 Programmable Logic Controller (PLC)

The PLC or known as the brain of an automated systems or machineries will be the vital component in this project. Therefore, a thorough research and self-study about the PLC is required before using and implementing it to the project.

2.2.1 Introduction

Programmable logic controller or famously known as PLC is an electronic device used in automation of industrial process. A PLC obtains input data, processes it, and produces output data. Connected to sensors and actuators, PLCs are categorized by the number and type of inputs and outputs (I/O) ports they provide and by their I/O scan rate. Typically Reduced Instruction Set Computer (RISC) based and programmed in an International Electrotechnical Commission, IEC 61131 programming language. A PLC is designed for real-time use in rugged, industrial environments. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements and can withstand harsh condition such as:

a) Extended temperature ranges
b) Immunity to electrical noise
c) Resistance to vibration and impact.

Before the PLC, control, sequencing, and safety interlock logic for manufacturing automobiles was accomplished using relays, timers and dedicated closed-loop controllers. The process for updating such facilities for the yearly model change-over was very time