# DEVELOPMENT OF AUTOMATIC PARKING SYSTEM

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BEKM
2009

" I hereby declared that I have read through this report entitle Automatic Parking System and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering ( Mechatronic )."

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Date : 13 - 5 - 2009

AUTOMATIC PARKING SYSTEM

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A report submitted in partial fulfillments of the requirements for the Degree of Bachelor in Electrical Engineering (Mechatronics)

**Faculty of Electrical Engineering**
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**2009**

"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 : Muhamad Faiz b Abu Hassan.

Date : 20th Octber 2008

To my beloved mother and father

**ACKNOWLEDGEMENT**

Alhamdulillah, thanks to the Almighty Allah with his permission, I finally have finished my Final Year Project within the time given.

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## ABSTRACT

Since the automobile was invented approximately 100 years ago, it has rapidly multiplied to numbers approaching nearly same with the human population in this world. The car has become a consuming passion for millions while also presenting a difficult issue for planners and public officials alike. When the number of car is rapidly increasing every year, there is one major problem and most encountered at the high density population country such as Europe or Japan which is limited land area for vehicle parking space. The idea of automated parking is the most suitable today because it addresses several issues and solution that cannot be achieved from the conventional parking. It is not surprising that early experimentation with automated parking was undertaken in central Europe and Japan, because of the high density of population and the extreme scarcity of land. The Automatic Parking System prototype that have been studied and built in this project was an automatic system that enables user to park six vehicles automatically using the minimum land space. This systems use a servo motor. It consist of two major elements, the mechanical part (hardware development) which is function as the main structure of this prototype and electrical part which is consist of PIC16F877A, limit switch, Light Emitting Diode (LED) and normal switch. This prototype has a single degree of freedom. The programming code for the PIC is build by using the PIC microcontroller software (MicroC compiler for PIC) which is using the C language as the command language. The PIC16F877A will execute the program that has been loaded to its memory. The rotation of the motor that control the rotation of the parking space is determined and controlled under command program. A suite of arrayed limit switch is used to determine the availability of the parking lot. LEDs at the control panel are used to show available parking lot to the user. Green LEDs show available parking lots while red LEDs show unavailable parking lot.

# ABSTRAK

Semenjak penciptaan kenderaan pada 100 tahun yang lepas, jumlahnya telah meningkat mendadak sehingga bilangannya hampir sama dengan jumlah populasi manusia. Kenderaan telah menjadi suatu keperluan yang penting kepada manusia pada hari ini. Walau bagaimanapun, peningkatan bilangan kenderaan yang berterusan tahun demi tahun telah menimbulkan beberapa masalah. Masalah kekurangan kawasan lapang untuk menyimpan kenderaan menjadi masalah utama apabila fenomena peningkatan mendadak bilangan kenderaan terus berlaku pada hari ini. Idea penciptaan sistem parkir automatik adalah sangat bertepatan pada masa kini kerana ia dapat menyelesaikan beberapa masalah di mana sistem parkir biasa gagal menyelesaikannya. Tidak menghairankan apabila kajian tentang sistem parkir automatik ini telah dimulakan oleh Eropah dan Jepun kerana negara ini mempunya bilangan penduduk yang ramai. Prototaip sistem parkir automatik yang telah dikaji dan dibina untuk projek ini adalah sistem yang membolehkan enam kenderaan disimpan dengan mengambil kawasan simpanan yang minimum. Sistem ini menggunakan motor servo. Ia mengandungi dua bahagian utama iaitu bahagian bahagian mekanikal yang menjadi struktur utama prototaip dan bahagian elektrikal yang melibatkan penggunaan mikropengawal PIC16F877A, suis penghad (limit switch), LED dan suis tekan. Prototaip ini mempunya satu "darjah kebebasan". Keseluruhan sistem prototaip ini dikawal oleh mikropengawal PIC16F877A. Kod program untuk mokropengawal dibina menggunakan perisian MicroC di mana ianya menggunakan bahasa C sebagai bahasa arahan. Mikropengawal yang digunakan akan memproses arahan daripada kod program yang telah dimasukkan ke dalam memorinya. Kod program ini berfungsi untuk mengawal darjah pusingan motor servo. Suis penghad (limit switch) digunakan untuk mengenal pasti ruangan parkir yang kosong dan mempunyai kenderaan. LED pada panel kawalan sistem berfungsi untuk menunjukkan ruang parkir yang kosong dan sebaliknya kepada pengguna. LED hijau menunjukkan ruang parkir kosong manakala LED merah menunjukkan ruang parkir yang mempunyai kenderaan.

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| | | |
|---|---|---|
| 0 | - | Degree |
| D, d | - | Diameter |
| DC | - | Direct current |
| ms | - | Milliseconds |
| µs | - | Microseconds |
| V | - | Volt |

# CHAPTER 1

# INTRODUCTION

This project is titled as "Automated Parking System". The aim of the project is to design a prototype of automatic parking system by using the PIC16F877A microcontroller.

## 1.1 Objectives

To get a clear view about the purpose of the project, several objectives has been stated.

- To design a prototype of automatic parking system using the PIC16F877A microcontroller.
- To construct an electrical circuit for servo motor, PIC microcontroller and control panel.
- To assemble the C code programming in order to create an automatic and intelligent parking system.
- To understand and able to obtain the programming and design skill such as C programming language, AutoCad, Multisim and WinPic800 software.

## 1.2 Scope

Generally, every project has its own scope to ensure the project will always meet its objectives. In order to complete this project, several scopes has been stated.

- Study the C programming code in order to create a compatible program for the parking system.
- Study and familiarize about the PIC16F877A microcontroller
- Determine and study the suitable sensors for the system.
- Combine hardware and software to perform the automated parking system.

## 1.3 Problems Statement

The automated parking system have been developed in growth city at Europe such as New York City, Boston, Philadelphia, Miami, Ft. Lauderdale or even at Japan in east region. The first fully automated parking system was proposed by Gerhard Haag, a German born engineer and architects to overcome problems such as:

- Insufficient of land space.
- Lack of parking area.
- Problem searching own car at conventional parking area.
- Lack of security (many cases such as snatch, kidnapping or even murder happen at conventional parking area).
- Increasing of land value.
- Increasing of car break-ins at conventional parking area.

## 1.4 Literature Survey and Previous Research.

Many researches about automatic parking had been done nowadays to alleviate the traditional parking problems. As the first person who invented and had a patent on an automatic parking system, Gerhard Haag states that the current approaches to solve this problem can be classified into two main categories:

1. The mechanical parking approach or stacker technology, where the parking process will be done by mechanical devices without human intervention. Auto-Stackers history of manufacturing excellence began more than 30 years ago.
2. The automated parking approach, where the fully automated system is implemented to the mechanical parking approach by a software program specifically written for this system that controls the movement of all transport devices.

In the past decades, hydraulic lifts or stacker systems were developed from mount a lifting machine on a flat surface. Typically these stackers are used in residential garages and use vertical space where horizontal or flat space is limited. The machine lifts up one vehicle on a platform and a second vehicle will be parked under the one that is lifted. Basically, this system provides space for two cars in one parking space and it can be referred from the Figure 1.1 and Figure 1.2. Three parking spaces can be created by stacking the cars in a design where one space is down and one is up and one in the middle such as in Figure 1.3 and this system also can be created with quad stacker such as in Figure 1.4. The main characteristics of this parking system basically are:

1. Recyclable.
2. Easy to install
3. Inexpensive when used in small number of lots
4. Not suitable for extreme exterior climate conditions
5. Requires very careful parking
6. It is not useful for all types of cars
7. It requires the removal the bottom car if the upper car is needed by an operator

Figure 1.1: The classic double stacker.

Figure 1.2: The double stacker installed inside a building.

Figure 1.3: Triple stacker.

Figure 1.4: Quad stacker parking.

The main distinction between mechanical and automated is the introduction of electronic processors (computers), software and logic which enables them to handle and command more complex systems and devices with multiple types of machines. These machines very often simultaneously perform multiple tasks. These systems are appropriate for larger facilities with several hundred to thousands of parking spaces. Typically, the only human interface is the storage and retrieval request by the patron (the user) requesting either the parking (storage) or the retrieval of the vehicle from the control room. The automated system performs the tasks necessary to fill these requests by itself and without human assistance.

After the new inventions that have been made to the mechanical parking system, the first automated parking system has been created which is called paternoster system or carousel parking system. The paternoster system is composed of serial parking spots on an endless vertical chain that looks like a thin rectangular Ferris wheel. This design enables user to park 5, 6, 7, 8, 10, or 12 vehicles in the space of only two. There is no need for a parking attendant because users just insert the key and press their parking space number and the pallet will rotate either clockwise or counter clockwise. However, the paternoster system has several disadvantages such as noise, power consuming and not fully automatic. Several researches must be done to the system and this system is needed to be upgraded. The example of the paternoster system can be seen at the Figure 1.5 and Figure 1.6.

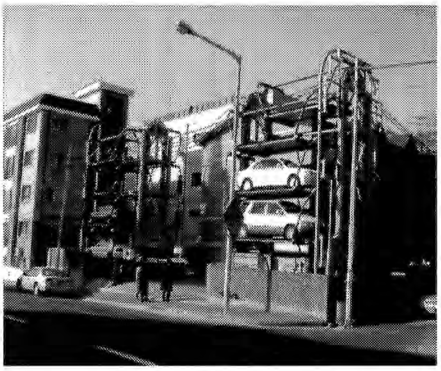

Figure 1.5: The Paternoster System.

Figure 1.6: Control room for Paternoster System.

After the invention on paternoster system took place as the leader in the automated parking system, several type of automated system have been researches and developed to increase the efficiency of the parking system. One of the systems that have been developed was the pallet system.

A pallet is basically a substitute platform onto which the vehicle is driven. It is not fixed like concrete decks. It is a moveable stable plate. Several problems were solved with this development:

1) The stable platforms, usually cast-in-place concrete, were now replaced by a movable and flexible plate, with dimensions of approximately about 7x19 feet it sufficient to accommodate the dimensions of most automobiles.
2) No machinery needs to touch the car since the pallet is picked up from underneath itself after the car has been parked on the top of the pallet.
3) The differences in car sizes, wheel dimensions, wheel basis, front and rear overhangs and the tire width ranging from five to fifteen inches could be handled by a properly designed pallet. Differences do not represent any barrier. As long as the vehicle fits onto the pallet, the vehicle is now protected from any contact as the machinery touches the pallet from below and the pallet is always bigger than the vehicle itself. No other element

inside the garage comes close to the car. If this would ever occur, the pallet is there to protect the vehicle from any lateral contact.

4) The major advantage is that the pallets on which the cars rest are identical. Thus the machinery does not need adjustments to handle various sizes. The pallets have the same fixed dimensions and are moveable.

Another important feature inherent with the introduction of pallets is that any dripping, either from the engines, the fuel tanks or the snow and salt residuals from the environment are now being captured by the pallets. They protect other machinery, other vehicles and the structure from this debris. The pallets themselves are easily washed when dirty and any debris can be easily collected and disposed of properly. The washing of palettes can be automated as well. The figure of the pallet can be referred from the Figure 1.7.

Figure 1.7: Stack of four pallets on top of each other.

Some system designers, in countries where automated parking has become common place, have chosen not to use pallets but instead use tongs or so called grippers which grab the tires from the front and the rear thus capturing the vehicle for transport. A so called trolley drives underneath the car and swings eight tongs out under each tire in such a way as to capture all the tires front and back and then move the vehicle. This system can be referred from Figure 1.8.

Another pallet-less system is the Comb System. The name explains it. It is a twofold comb, one stationary and the other comb moving between the fingers of the stationary comb during lifting thus capturing the tires of the vehicle and moving it through the system to its designated parking space. The name stems literally from the comb. This system can be clearly illustrated as taking two combs and moving them offset to each other through themselves and can be referred from Figure 1.9.

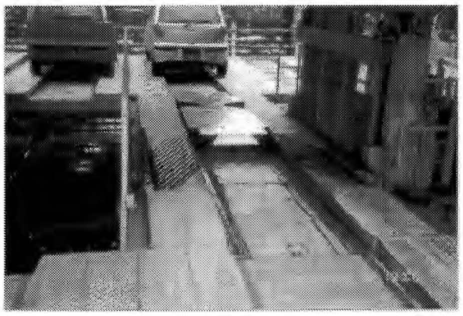

Figure 1.8: Tongs system.

Figure 1.9: Comb system.

Besides the Tongs and Comb system, the stacker technology has been invented for the parking system. The Stacker Crane technology stems from the warehousing technology and has been used since the 1960.

Figure 1.10 shows the transporting tower in the middle aisle and one half of the rack structure to the left of it. The tower, also called stacker is guided on rails mounted to the foundation slab as well as on the roof and houses a lift inside with a mechanism to push and pull the cars from the tower into the slots and reverse. This type of machinery has been used in the last 40 years very successfully in the automated warehousing industry and is also known as Storage and Retrieval System or SRS.

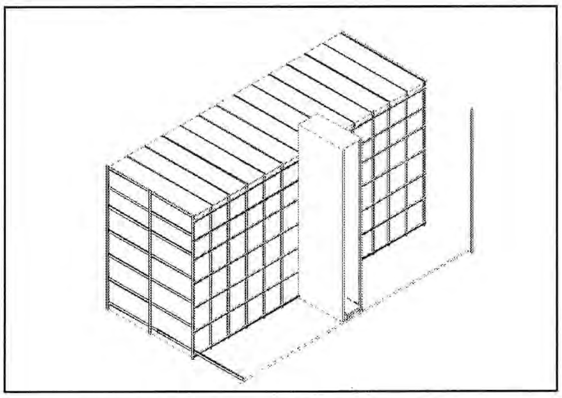

Figure 1.10: Structure of Stacker Crane Technology.

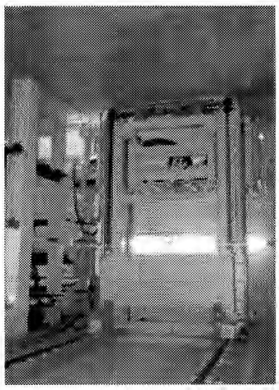

Figure 1.11: Stacker moves a vehicle.

Since the stacker can lift a single car for each car parking or car retrievement process, another system has been developed. Shuttle or carrier technology creates the new concept of fast automatic parking. This technology was developed in the early 1990 and is a combination of the old stacker systems and the assembly line technology of the automobile manufacturers as seen in Figure 1.12, 1.13, and 1.14. The major difference to the stacker system is the number of process that can be done at one time. Ten to fifty different devices can move simultaneously in one automated parking facility. This system design allows for multiple movements simultaneously and also provides considerable redundancy. Redundancy means that in case one of these machine units is out of operation, another machine can take over the tasks for this one unit. This makes sure the garage patrons will be served all the time. Another important feature of this design is the handling of peak traffic or throughput of the system. This design enables automated parking to achieve very high peak traffic numbers not attainable with earlier systems. Depending on the configuration and the size of the system, throughput numbers of up to one thousand cars per hour and more can be achieved.

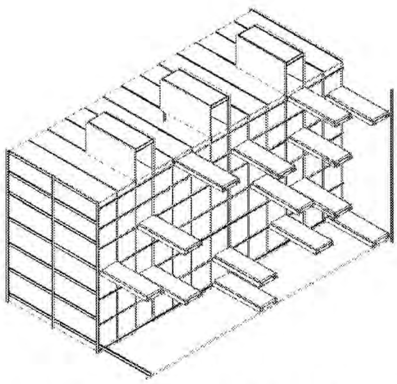

Figure 1.12: Structure of Shuttle/Carrier Technology.

Figure 1.13: Vehicle retrievement process.

Figure 1.14: Vehicle storing process.

Shuttle or Carrier Technology gives several advantage which is shows it efficiency and suitable to be used nowadays.

1. Each elevator and cart is operated independently on each level, entry and exit is quick. Retrieval time of a vehicle is less than two minutes.
2. Low noise and vibration. Elevators never touch guide rails, use of urethane rollers minimize noise when transferring pallets from elevator to carts and then to parking slot.
3. Entry and exit is very quick and convenient. Each system built in turntable on each elevator to turning the vehicle forward or backward within the short time.
4. Completely equipped with multiple sensors and triple safety devices. A self malfunction diagnostic control provides user with an excellent level of safety and reliability.
5. Has the capability of holding cue memory when multiple patrons come to retrieve their vehicles during rush hours.

Another intelligent invention for the automated parking system was the Round Parking Silo System. The round form is very appealing in some respects but not strong from a space savings viewpoint. The round form does, however, have several positive aspects. 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. In underground applications, the earth pressure is easily taken by the round membrane. The cylindrical form has many advantages such as:

- Better stability/ firmness.
- Better resistance to earth (underground).
- Faster access to parking spot.
- Smaller volume.
- Economical consumption of material.

These advantages do not work for any height, or size of cylinder. Typically the diameter is determined by the machinery in the middle and one parking space on each side resulting in a diameter of slightly over 60 feet. This will result in twelve parking spaces per level as shown on the Figure 1.15. The diameter is limited due to the geometry of the vehicles forming an inner circle. When we increase diameter of garage we increase the:

- Linear edge of a ring (number of cars).
- Manipulative area with a square.
- Volume of a garage given a square.

The height of the cylinder is not limited from a construction point of view but more from an operational aspect. The higher (or deeper in the case of an underground application) the cylinder becomes, the more time it takes for the single vehicle transport machine to store or retrieve the cars. A typical cylinder height of ten levels is common. It may be economical to build several round garages in a group close together with a limited diameter.

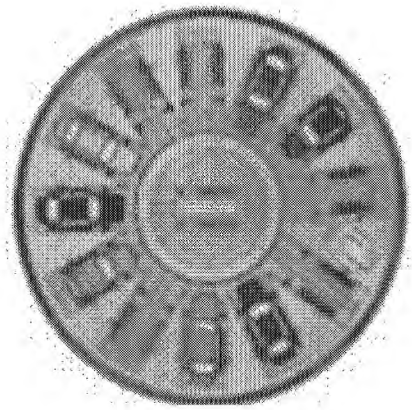

Figure 1.15: The Round Parking Silo System.

The Round Parking Silo System gives several advantages in building cost, stability and reduces the time for parking and retrieves a vehicle. However, with this design, only one car can be move in or out. Hence, a new design of silo parking is developed by the engineer which is takes the same structure but there is additional features that make the silo system become more efficient.

The Spiral Climber System takes a place after the redesign of silo system. This is a specialty derivation of the round form. The machinery in the middle is arranged such that four cars can be handled at once as showed in Figure 1.16 and 1.17. The actual machine servicing the storage locations has four loading stations (machines) each at 90 degree angles from the machine in the center. The loading stations reach and withdraw from a surrounding spiral which contains the spaces for the vehicles. The levels are not horizontal,