INTELLIGENCE MULTIPURPOSE VACUUM

Liong Kin Fei

Bachelor of Mechatronics Engineering
May 2010

ACKNOWLEDGEMENT

I would like to express my deep and sincere gratitude to my supervisor, Mr Mohd Shahrieel Bin Mohd Aras. His wide knowledge and his logical way of thinking have been of great value for me. His idea and personal guidance have provided a good basis for me to complete this report. I wish to thank my housemates for helping me in completing this report and for all the emotional support and caring they provided. I also would like to thank my fellow course mates for their knowledge and idea sharing and help me complete this project. I am indebted to Universiti Teknikal Malaysia Melaka (UTeM) for providing equipments, devices for my project. Lastly not to forget, I wish to thank my parents and all family members, who support and care for me all the times.

ABSTRACT

This project is to design and develop an "Intelligence Multipurpose Vacuum" using PIC Microcontroller. This project combines the knowledge of microcontroller, electric and mechatronic. The objective of this project is to design and develop Intelligence Multipurpose Vacuum that combines a children vehicle with a vacuum cleaner. The children vehicle can be operated manually or automatically using a PIC controller. Children will determine the motion of children vehicle if the vehicle is operated manually. The operation area of vacuum is really relying on the children. Children will control the direction and speed of vehicle by the handle and pedal. PIC controller will control the motion of children vehicle if the vehicle is operated automatically using obstacle sensor and microcontroller. When obstacle sensor detects an obstacle, it will send signal to microcontroller. Microcontroller wills feedback output signal relatively to DC motors to change the direction of motors. The pulse width modulation will control the speed of DC motors to generate the changes of vehicle direction. Therefore the children vehicle can avoid against obstacle in front. Vacuum is a single system and its do the cleaning work either in manual or automatic mode when turning ON by people.

ABSTRAK

Projek ini adalah untuk mereka bentuk dan menghasilkan *Intelligence Multipurpose Vacuum* dengan menggunakan PIC *microcontroller*. Projek ini mengabungkan kemahiran dan pengetahuan berkenaan dengan *microcontroller*, elektrik dengan mekatronik. Objektif projek ini adalah untuk menghasilkan satu penyedut serba guna digabungkan dengan kenderaan mainan kanak- kanak. Kenderaan kanak- kanak boleh beroperasi secara manual ataupun automatik dengan menggunakan system pengawalan PIC. Kanak- kanak boleh mengerakkan kenderaan secara manual jika kenderaan mainan berada dalam keadaan normal. Kawasan operasi yang dirangkumi vacuum ditentukan oleh pergerakan kenderaan yang dipandu kanak- kanak tersebut. Jika kenderaan mainan bergerak dalam keadaan automatic PIC pengawal akan mengawal pergerakan kenderaan mainan melalui pengesan objek penghalang. Apabila alat pengesan mendapati adanya objek penghalang, ia akan menghantar satu isyarat kepada *Microcontroller* lalu menghasilkan satu isyarat keluaran kepada DC motor supaya menukar pergerakan kenderaan tersebut. *Pulse width modulator* akan mengawal kelajuan motor dan menyelaraskan pergerakan kenderaan tersebut. Maka kenderaan main dapat mengelakkan daripada terlanggar dengan objek penghalang. Vacuum akan bertindak sebagai system asing dimana ia boleh berfungsi sama ada dalam keadaan manual ataupun automatik.

LIST OF CONTENTS

CHAPTER	TITLE	PAGE
	Acknowledgement	i
	Abstract	ii
	Abstrak	iii
	Table of Content	iv - vi
	List of Figure	vii - viii
	List of Table	ix
	Nomenclatures	x - xii
1	INTRODUCTION	1
1.1	Objective	1
1.2	Scope of Project	2
1.3	Problems Statement	3 - 4
2	LITERATURE REVIEW	5
2.1	Journal Review on Low Cost Sensory Based Intelligent Vehicle Algorithm	5 - 8
2.2	Random Walk Application for Autonomous Vacuum Cleaner Robot	9 - 10
2.3	Journal Review on Robovac (Autonomous Robotic Vacuum Cleaner)	11
2.3.1	Reshaping	11
2.3.2	Sensors	11
2.3.3	Battery	12
2.3.4	Suction	12
2.3.5	Motors	12
3	PROJECT METHODOLOGY	13
3.1	Search and Purchase Components	14
3.1.1	Children Vehicle	14
3.1.2	Vacuum Cleaner	15

CHAPTER	TITLE	PAGE
3.1.3	General Purpose Battery	15
3.1.4	RC Servo Motor	16
3.1.5	PIC MicroController	16 - 17
3.1.6	Obstacle Sensor	17
3.1.7	SK40C Enhance Start Up Kit	17 - 18
3.1.8	Voltage Regulator	18
3.1.9	Capacitor	18 - 19
3.1.10	Stripe Board and DIP Socket	19
3.2	Design and Modification	20
3.2.1	Mechanical Assembly	20
3.2.2	Electronic Assembly	20 - 22
3.2.3	PWM Mode of PIC16F877	22
3.2.4	PIC Program to Control PWM	23 - 24
4	RESULT	26
4.1	Basic Operation	26 - 27
4.2	Simulation Using Proteus 7 Professional	28
4.2.1	No Detection on Both Obstacle Sensors	29
4.2.2	Right Sensor (SW1) Detect Obstacle	30
4.2.3	Left Sensor (SW2) Detect Obstacle	31
4.2.4	Both Obstacle Sensors Detect an Obstacle	32
4.3	Turning Angle of Servo Motor	33 - 34
5	ANALYSIS AND DISCUSSION OF RESULTS	35
5.1	IR01A Sensor Setting	35 – 36
5.2	RC Servo Motor Setting	36 – 39
5.3	Modeling of Functional Circuits of Project	39 – 42
6	CONCLUSION AND RECOMMENDATION	43
6.1	Conclusion	43
6.2	Recommendation	44

CHAPTER	TITLE	PAGE
	REFERENCE	45
	APPENDIX A	46
	APPENDIX B	47
	APPENDIX C	48
	APPENDIX D	49
	APPENDIX E	50

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	The Avoidance Procedures	6
2.2	Procedure of Avoidance Algorithm	8
3.1	Flow Chart of Project Methodology	13
3.2	Picture of Children Vehicle	14
3.3	Picture of Vacuum Cleaner.	15
3.4	Picture of General Purpose Battery	15
3.5	Picture of RC servo motor C55R	16
3.6	Picture of PIC16F877A	17
3.7	Picture of Obstacle Sensor	17
3.8	Picture of SK40C	18
3.9	Picture of Voltage Regulator	18
3.10	Picture of Capacitor	19
3.11	Picture of Voltage Regulator Stripe Board and DIP Socket	19
3.12	Layout of Microcontroller Circuit Board Built on Proteus	21
3.13	Layout of DC Motor Driver to Control Motors Direction	22
4.1	Schematic Diagram of the Project on Proteus	28
4.2	PWM Signal Display for Condition 1	29
4.3	PWM Signal Display for Condition 2	30
4.4	PWM Signal Display for Condition 3	31
4.5	PWM Signal Display for Condition 4	32
4.6	Turning Angle at 90 Degrees	33
4.7	Turning Angle at 45 Degrees	33
4.8	Turning Angle at 135 Degrees	34
5.1	Turning Angle of Servo Motor	37
5.2	Rotation Angle of Servo Motor for Calculation	38
5.3	Full Schematic Diagram of Project on Proteus	40

FIGURE	TITLE	PAGE
5.4	Separation Board for Relay, Voltage Input/ Output and Common Ground	40
5.5	IR Sensor with no Obstacle Detection	41
5.6	IR Sensor Detect Obstacle with Sensing Range 10 cm	41
5.7	Positioning of Batteries underneath the Seat	41
5.8	Positioning of Handy Vacuum at Chassis Bottom	42

LIST OF TABLES

TABLE	TITLE	PAGE
1	Current Consumption	10
2	Algorithm Battery Time	10
3	Ghant Chart for Project Planning	25
4	Motion of Steering Wheel Varies on Input Signals	27
5	Absolute Maximum Rating	33
6	Product Specification for Cytron RC Servo Motor	37

"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 Mechatronics Engineering"

Signature : .....

Supervisor's Name : ENCIK MOHD SHAHRIEEL BIN MOHD ARAS

Date : 12/5/2010

INTELLIGENCE MULTIPURPOSE VACUUM

LIONG KIN FEI

This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree of Bachelor In Mechatronics Engineering

Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

APRIL 2010

"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 : LIONG KIN FEI

Date : 12/05/2010

CHAPTER 1

INTRODUCTION

In order to fulfill the requirements for the award of Bachelor Engineering in Mechatronics, Undergraduates are required to make a final year project on PSM. Undergraduates will have to choose a topic and make a project on their own that related to Mechatronic field in order to enhance the knowledge and skills practice of student in solving problems through research. The objectives of PSM are training student to use their wisdom and skills, to applied it's on a scientific project. It also can enhance ability of student to think objectively, technically and analytically in order to identify and solve problems systematically. It will boost student confident and to be independent while facing problems during research.

A throughout research has been carried out to do this project. There have been a few types of Intelligence Multipurpose Vacuum in market. The idea of my PSM project is to fit a vacuum cleaner on a children vehicle. The purpose of this project is to make a vacuum cleaner that can operate either manually or automatically, and at the same times children can enjoy riding the children vehicle. A microcontroller is used to control the children vehicle when it is operated on automatic mode. Vacuum cleaner will do the cleaning work while kid is riding on children vehicle. Eventually children are helping their parent to clean up the house while they are playing.

1.1 Objectives

There are a few objectives to be achieved for the proposed. The main objective is to design and develop an Intelligence Multipurpose Vacuum that can really work. The idea is to make a vacuum cleaner that can operate without supervision and handle by people. There is a need to design and develop a new dimension of vacuum

cleaner that different than others exiting product. Therefore, the project is decided to be making children vehicle consist of vacuum cleaner. The vacuum cleaner can operate on its own even- though children vehicle is operated manually or automatically.

The next objective is to provide a new housekeeping method to household. House keeper can save their time cleaning the floor by using Intelligence Multipurpose Vacuum that can operate manually or automatically. When the system is operating manually, children will having fun riding vehicle and at the same time the vacuum cleaner is doing cleaning work. Eventually children are helping their parent to do the cleaning work. When the system is switched to automatic mode, the vehicle will operate via microcontroller functional. It doesn't need extra supervision or handle by house keeper.

Another objective is to design and develop a multipurpose toy that different to conventional toy. Intelligence Multipurpose Vacuum can be an interesting choice for parent as children toy. A multipurpose toy will be a very suitable gift for their children. In term of wasting time, the children can help cleaning up the floor while riding children vehicle. Indirectly, we are educating children the sense or cleanliness and the important of having a clean surrounding.

1.2 Scope of Project

For this Intelligence Multipurpose project, there are some scope and speculation that take to consideration. The main part children vehicle is suitable for children of ages between 2 to 5 years old. The vacuum cleaner bag is ease dissemble and is limited to specific size that fix into children vehicle. The design and modification on children vehicle is to enable a microcontroller board to be added and can't be programmed by others. The battery usage is base on 12 volts battery life spends. Safety precautions and side effects of product is conducted base on children similar to ages approved. Cost consideration and commercialize value won't take to account because it is just a product prototype and it need further improvement.

To startup this project, research on the main parts of this project have to be carried out. Children vehicle and vacuum cleaner have been the main consideration.

A pedal control motor children vehicle will be the main body of this project. The speed of vehicle is estimated at low speed of 5 kilometers per hours. A handy vacuum with features like small capacity with big suction power, various suction attachments, convenient operation, elegant and bionic design, and less noise is used.

The main concern for this project is to design and fix the vacuum cleaner into the children vehicle that comfort to user and save for the children. Vacuum cleaner has to be fix on the bottom of the main body in order to lets the suction power is maximum and the noise is filtered. The heat and wind are dispread through blower to surround at the back of main body. The electronic part is insulated and packed to prevent electric shock and reliability of product.

1.3 Problems Statement

There have been few types of intelligence multipurpose vacuum introduce to the market. Product likes automatic vacuum robot manufactured are smart and efficient. It is needless to do much improvement to these products. Therefore, there is a need to find out another dimension of matter that we can tackle on automatic vacuum cleaner.

When refer to the problem statement of this purposed project, the problem course that can be stated is children like to play with conventional vacuum cleaner. Children can easily get attracted with the sound produce by conventional vacuum cleaner. The curiosity in children will motivate them to play with the conventional vacuum even though the thing looks stranger to them. When children are out of parent supervision, accident could happen on them such as hand stuck into the nozzle, children fall to the fall.

The most famous automatic vacuum robot also may cause similar problems to the children. Robot vacuum which is a round shape automatic motion mechatronic device, mostly look like a toy. The automatic motion of robot vacuum will surely attract the children heart. Children will simply pick the vacuum robot up and start playing with the robot vacuum. Kids might dump it and damage the robot vacuum. That will cost a lot of money for their parent in order to buy a new one. A robot vacuum is much expensive compare to conventional vacuum.

The automatic vacuum robot only has a single operation mode. The automatic vacuum can only operating automatically. The automatic vacuum can't help when a vacuum is needed to work manually. Parent has to buy both types of vacuum cleaner to cleaning up their house depend on usage mode.

CHAPTER 2

LITERATURE REVIEW

For the literature review, general knowledge and references are gained from various sources. The main sources for this project are through books, internet articles, and journals. Base on these articles and journals that read, a few literature reviews will be make on selected journals with details and descriptions about autonomous robotic vacuum and its applications that related to my final year project.

2.1 Journal Review on Low Cost Sensory Based Intelligent Vehicle Algorithm

This journal are mainly describes the new methods of Routing and Avoidance Algorithm for intelligent vehicle. The vehicle is navigated using an artificial intelligence algorithm together with avoidance system to perform desired action. Parts of this journal that related to my project are well explained and described. Vehicle autonomous system is describe as the ability of the vehicle to make the decision, sense, navigate and control to learn and react against the surrounding environment. Thus, the autonomous system must be real- time and embedded with sensor systems, computation and control system, and navigation system. While the avoidance system is describe as an essential capability of intelligent vehicle to detect and avoid obstacles. In order for the vehicle to perform motion that avoid collision through uncertain area variety of sensors are used. Ultrasonic sensors are used to detect object in front, left and right of the intelligent vehicle.

The major parts related to my project are the avoidance and driving module. The avoidance and driving module's function is to move the vehicle and avoiding the obstructers. The avoidance algorithm is the motion control algorithm that is sensor-based system. The algorithm begins with detecting obstructer that is found in front of

the car. This avoidance algorithm is divided into two parts. For the first part, the data from sensors are considered as the object detector around the vehicle. This can help the car avoid any crash and stay in appropriate distance. The sensors used in this part are SRF04 Ultrasonic sensors, CMPS03 Digital Compass Module, and Encoders. Three Ultrasonic sensors are used to determine the distance between the car and the objects. Another part is to measure the distance that the car moves and its heading direction. Encoders are used to count the distance that the can have moved. Compass Module is used to find the headed direction of the car.

The avoidance procedures are described as below:-
Step A, the system will automatically generate path for the car to move.
Step B, the car finds obstructer on its path.
Step C, Obstructer Avoidance Algorithm will corrupt to avoid obstructer.
Step D, The car will continue running until it cannot detect any objects.
Step E, the car will recompute again in order to navigate itself back to its path.

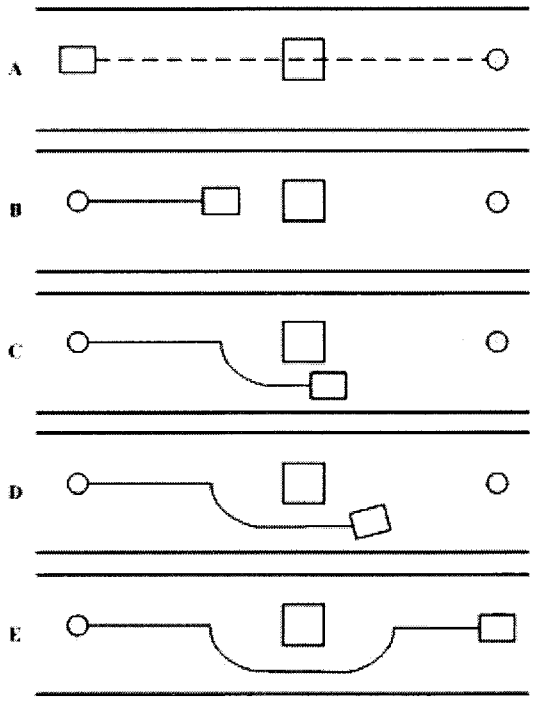

Figure 2.1: The Avoidance Procedures.

The avoidance system consists of the high speed system on chip controller with parallel computing ability and ultrasonic sensor. Ultrasonic sensor will continuously spread out it beams to detect objects on its route as the vehicle moved. The avoidance system will be triggered once object appear on the route. The procedures of the avoidance algorithm are divided into 3 situations. First situation is when the obstacle is in front of the vehicle, the vehicle will avoid to the right. The second situation is when the obstacle is appearing in front or right side of the vehicle, the vehicle will avoid to another direction, which mean vehicle will turn left. The third situation is when the obstacle blocks the road or wall, the vehicle will move backward, and then it will map the blocked path on the temporary map, and recomputed its route again. The procedure of the avoidance algorithm is shown as below:-

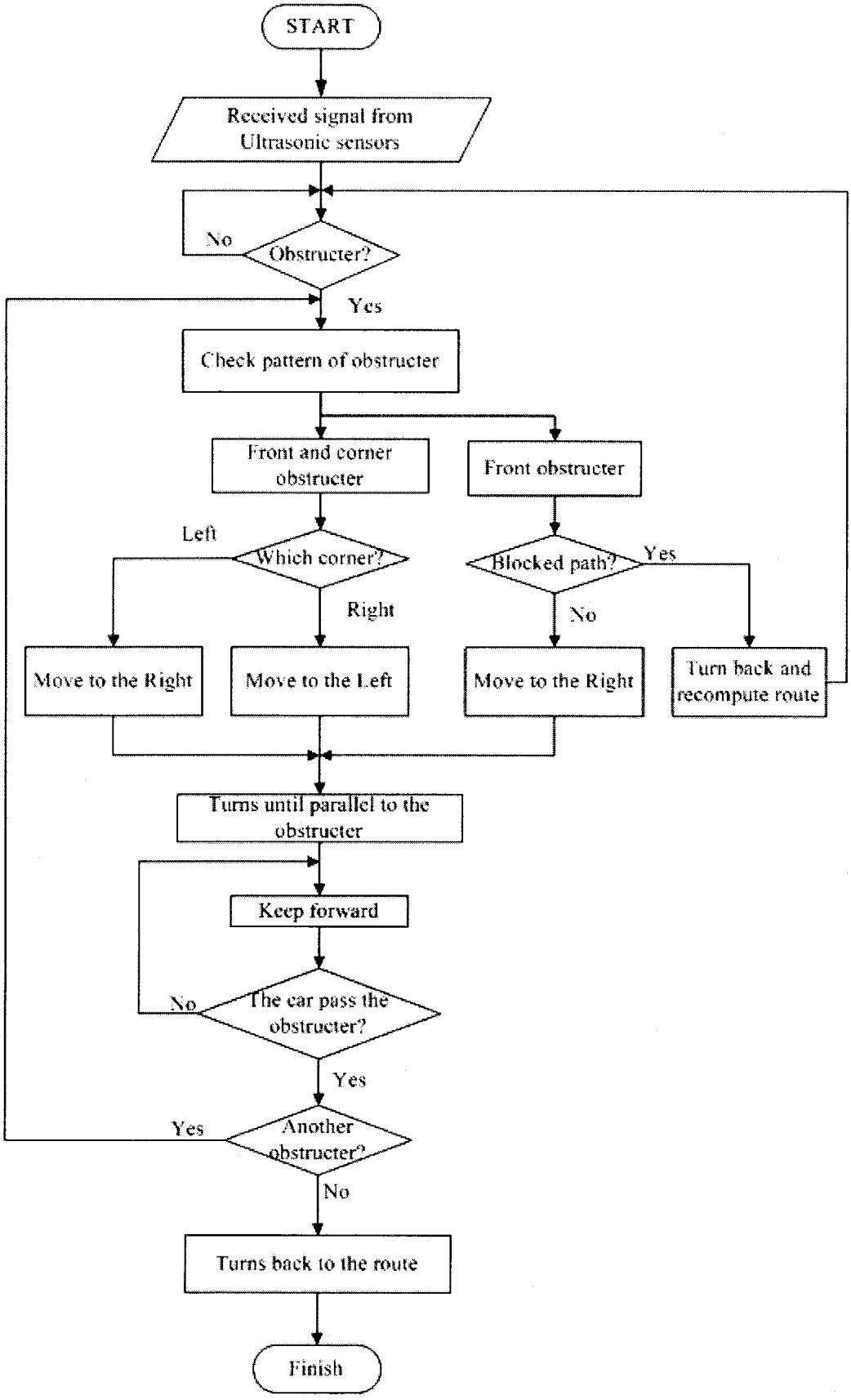

Figure 2.2: Procedure of Avoidance Algorithm.

2.2 Random Walk Application for Autonomous Vacuum Cleaner Robot

This paper describes the method of direction employed to the automated vacuum cleaner for cleaning process. Base on this journal, Random walk is describe as a random procedure comprising of an array of distinct steps of circumscribed length. Mathematical properties of Random Walks vary greatly depending on the magnitude in which the walk occurs.

The write had applied the random walk algorithm into robotic vacuum cleaner. The robotic vacuum is composed of several components designed to meet the specifications of the project. The whole system of this project comprises generally hardware with little of microprocessor programming. It consists of the following circuits; contact switches and IR sensors, digital random noise source, battery monitor, IR transmitter and receiver, square wave generator, delay timer, power supply, voltage regulator, and current limiter, vacuum, geared DC motor for the brush, stepper motor and driver, and battery. The whole system of this project comprises generally hardware with little of microprocessor programming.

Some important components will be derived from the whole components describe on this journal that may implemented to my final year project.

- Main Driving System: The driving systems of the robotic vacuum are the stepper motor with gear assembly and the PWM stepping motor driver. The stepper motor with gears was used in this project as it has a more precise and repeatable position control and ideal to the robotic vacuum application.
- PWM Stepping Motor Driver: The PWM Stepping Motor Driver eliminates the major disadvantage of a stepper motor which is the power loss as the motor is revved up. The PWM circuitry keeps the current drawn by the motor constant at all speed.PWM technique assures efficient power utilization.
- Infrared Receiver: The IR receiver is a significant part of the system, it is the reference of the microcontroller that would give signal if the IR signal is received from the charging station. Two receiver circuits are used that serves as left and right signal that will be the navigating reference for the system to reach the home base.

- Digit Noise Source: The circuit generates digital random numbers. These random numbers are fed to the microcontroller to determine the angle of rotation by the robot whenever it hits an obstacle or detects a cliff. It also determines whether the robot will rotate left or right.
- Obstacle & Cliffs Sensors: This part of the system is the combined circuits of the contact switch for the obstacles and the IR sensors for the cliff detection. Contact switches with a supply of 5 volts are used to detect an obstacle or a wall. When the signal is high, the microprocessor will generate random signal as the basis of the motors to head to another direction. The cliff detection circuit is a combination of a phototransistor and infrared emitter to detect cliff or edges that keep vacuum cleaner from falling.
- Power Supply: The main power supply of the robot has 4 different voltage level outputs which are 5V, 6V, 9V, and 12V. It uses 4 different voltage regulator ICs for the desired regulated output voltage. These are 7805, 7806, 7809, and 7812.

Table 1: Current Consumption

System Description	Current
Vacuum Cleaner and Dirt Agitator System	4.5 A
Circuits with Stepper Motor	0.86 A
Total Current Consumption	5.36 A

Table 2: Algorithm Battery Time

Navigation Algorithm	Time
Random Navigation	30 mins
IR Signal Search for Recharging	15 mins
Total Battery Life	45 mins

2.3 Journal Review on Robovac (Autonomous Robotic Vacuum Cleaner)

This paper describes the researches make by the writers to improve the efficiency of robotic vacuum cleaners in the market. These robotic vacuum cleaners are expensive and inefficient in terms of cleaning time and cleanness. The writers identify and design their robotic vacuum cleaner base on problems statement solving and customer requirements issue. The gold of design is to create a robotic vacuum cleaner that matches the requirements and solving matters for the customers.

The writers try to improve the overall cleaning efficiency by making some conceptual designs changes to robotic vacuum cleaner. Based on the information gathered the members have identify and stated the areas of improvement to five section. The five sections are shape, sensor, batteries, suction, and motors.

2.3.1 Reshaping

The original shape of robotic vacuum cleaners in the market which are disk shaped. Thus it can't cover the corners of rooms and maximize the cleaning process due to its shape. The new design for the shape of the vacuum is going to be a square with rounded edges. Having a square will get the corners to be cleaned much better and the rounded edges will allow the vacuum to have the same mobility to work its way through tight spots. We will be compromising some mobility in changing the shape to a square with rounded edges. It will be able to clean corners and along walls better then a circle shaped vacuum. The writers will keep the area and height of the square vacuum about the same as the circle to allow the vacuum to clean under most beds, chairs and couches.

2.3.2 Sensors

Dirt Sensors are used to detect the amount of dirt entering the vacuum. The important of dirt sensors are because dirtier areas must be cleaned for a longer time. The speed of the vacuum will be decrease to make sure the areas are clean up properly at the end of cleaning process.

Obstacle Sensors used by the team are microscopic bumpers as its has better