CORPORATION ROBOTS

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ABSTRACT

Nowadays, various robots are built to perform multiple tasks. Multiple robots working together to perform a single task becomes important. One of the key elements for multiple robots to work together is the robot need to able to follow another robot. This project is mainly concerned on the design and construction of the robots that can follow line. In this project, focuses on building line following robots leader and slave. Both of these robots will follow the line and carry load. A Single robot has a limitation on handle load capacity such as cannot handle heavy load and cannot handle long size load. To overcome this limitation an easier way is to have a groups of mobile robots working together to accomplish an aim that no single robot can do alone.

ABSTRAK

Saat ini, pelbagai robot dibuat untuk menjalankan banyak tugas. Beberapa robot bekerja sama untuk melakukan satu tugas menjadi penting. Salah satu elemen kunci untuk robot ganda untuk bekerja sama adalah keperluan robot untuk bisa mengikuti robot lain. Projek ini terutama berkaitan pada reka bentuk dan pembinaan robot yang dapat mengikuti garis. Dalam projek ini, menumpukan pada pembangunan baris berikut pemimpin robot dan budak. Kedua-dua robot akan mengikuti garis dan membawa beban. Sebuah robot tunggal mempunyai had-had dalam menangani kapasiti beban seperti tidak dapat menangani beban berat dan tidak boleh menangani beban saiz panjang. Untuk mengatasi keterbatasan ini cara yang lebih mudah adalah memiliki kumpulan robot mobile bekerja sama untuk mencapai suatu tujuan bahawa tidak ada satu robot boleh melakukannya sendiri.

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LIST OF SYMBOLS

V	-	Voltage
+	-	Positive
-	-	Negative
I	-	Input
O	-	Output
ICP	-	In-circuit debugger
CCP	-	Capture - compare
PWM	-	Pulse – width modulation
PSP	-	Parallel slave port
RPM	-	Rotation per minute
IR	-	Infra red

LIST OF APPENDIXS

CHAPTER 1

1.1 Introduction

Mobile robots are becoming more heavily used in environments where human involvement is limited, impossible, or dangerous. These robots perform some of the more dangerous and laborious human tasks on Earth and throughout the solar system, many times with greater efficiency and accuracy, saving both time and resources. There exists a Nomad robot used to do all mission in Mars. This mobile robot is a nice application for having new knowledge in the space, but the inversion it is very expense and very complex in design: It requires several capabilities to operate in many environments. The cost was over 1.6 million dollars. If it has problem or fail, all the work will stop. An easier and cheaper way, is to have a groups of mobile robots working together to accomplish an aim that no simple robot can do alone. An ideal application for groups of heterogeneous robots working together, like a society of insect, can accomplish the same mission that one robot. Using simpler mobile robots doing specific task, is less expensive, more reliable and it can reach the same aims of one robots. Some examples of applications are in manufacturing, medicine, space exploration and home. The nature of work environments requires the robotic systems be fully autonomously in achieving human supplied goals. One approach to designing these autonomous systems is to develop a single robot that can accomplish particular goals in a given environment. The complexity of many environments or works may require a mixture of robotic capabilities that is too expensive to design into a single robot. Additionally, time constraints may require the use of multiple robots working simultaneously on different aspects of the mission in order to successfully accomplish the objective. In cases, it may be easier and cheaper to design cooperative teams of robots to perform the same tasks than it would be to use a single robot. Then, it is possible to build teams of heterogeneous robots that can work together to accomplish a mission, where each robot has different architecture performing different task in a collaborative manner. Any of this group of robots needs reliable communication among them, in such way that the robots will be able to accomplish their mission even when no robot failures occur. The multi robot system required some knowledge of capabilities of its team-mates, before the start of the mission. The team of robots can be model observing the natural behavior of insects. They form colonies with individuals that perform different roles in function of the needing of the community. Using this model, it is possible to have colony of robots with some robots in charge of some responsibilities to work with others in a cooperative way to do same tasks, in a collaborative way, to communicate each other to be more efficient or to take decisions in a collective way, etc. in the same form as natural insects. This colony has to have "nest" where the some robot assigns to others what to do, and other robot that receive orders from human and communicate him the results. It is necessary to formulate, describe, decompose, and allocate problems among a group of intelligent agents; to communicate and interact; to act coherently in actions; and to recognize and reconcile conflicts. In this presentation is focusing in colony of robots. This implies to merge several disciplines such as mobile robotics, intelligent agents, ontologisms, semantics, as well as automatic control, models of communities, communication, and others ones, to have control of a society of robots working together in a collaborative and cooperative way in a non structured environments [1] . Design and construction of Mobile Robot requires a broad range of engineering skills such as electronics design, mechanical design, program design and how the student approach complex engineering problem. To build this project we need know how to build the sensor circuit, comparator circuit, controller circuit and motor driver circuit then we connect them together as showing in Figure 1.1

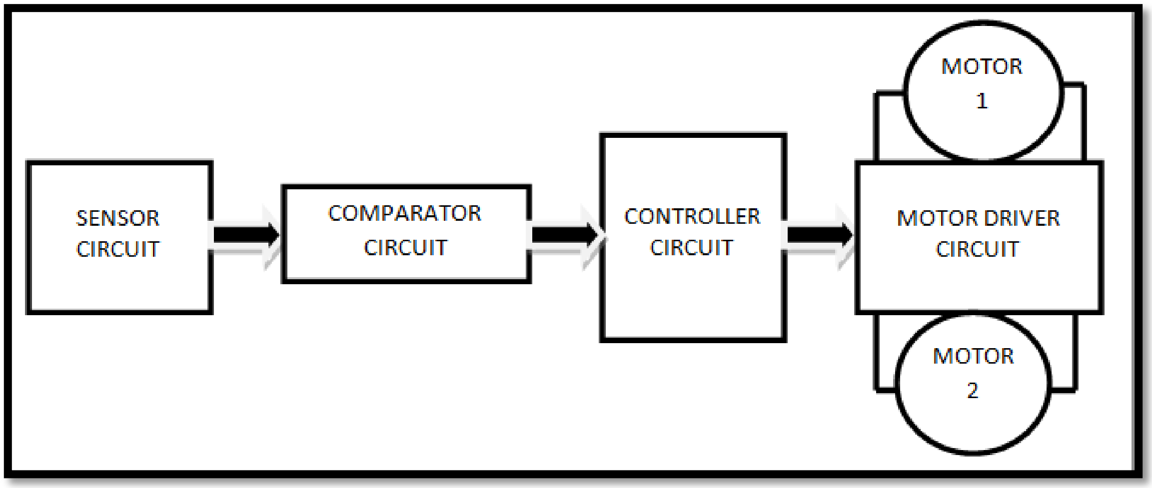

Figure 1.1: Block diagram of mobile robot

A mobile robot is divided into two main parts, namely the software and hardware. For the software, PIC16F877A micro controller will be use for system controller for this robot. While on the hardware side, a circuit will be built and connected to sensors and motors. For this project a better of reflective sensor is to use Infrared Light (IR) and NPN transistor, as less much interferences. The control has 6 modes of operation, turn left/right, forward/reverse, and stop. The actual action is caused by controlling the direction/speed of the two motors (the two back wheels), thus causing. Two motors as an output will control by motor driver that connected to the PIC16F877A

1.2 Problem statement

A Single robot has a limitation on handle load capacity such as cannot handle heavy load and cannot handle long size load. To overcome this limitation an easier way is to have a groups of mobile robots working together to accomplish an aim that no single robot can do alone. The problem statement of this project is how to develop corporation robots.

1.3 Objectives

In this master project the objectives divided into:

1- To design single line following robot as leader.
2- To design second line following robot as slave robot.
3- To develop a programming code suitable for both robots to follow the line.

1.4 Scope of project

Scope of this project proposal is:

1- Develop two following line robots. In which the first robot as leader and the second robot as slave.
2- The robots controller developed by using PIC16F877A microcontroller that is program with assembly language.
3- Use DC motors as actuators with suitable motor driver.

1.5 Organization of project

Chapter one: Discuses the introduction (problem statement, Objectives, Scope of project and Organization of project)

Chapter two: Discuses the literature Review

Chapter three: Discuses the methodology

Chapter four: Concluding the results and Discussion

Chapter five: Conclusion and recommendations

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews some of previous work on development of single and corporation robots.

2.2 Development of road vehicle convoy system

A final year project entitled "Development of a road vehicle model for road vehicle convoy system" [2] was conducted at Faculty Electrical Engineering (FKE), University Technology Malaysia in 2007. In this project, two small scale car-like robots were developed. One is the leading vehicle and another is the following vehicle. The following vehicle could follow the leading vehicle in straight line.

Both vehicles in this project utilize PIC 18F454 microcontroller (MCU) as the “brain” for both vehicles. The following vehicle utilizes ultrasonic sensor (R40-16 & T40-16) to detect and measure the distance between the leading and the following vehicle. When the ultrasonic sensor sends a wave with certain frequency and received it back through reflection after hit the obstacle, the information was sent to the PIC microcontroller. The Microcontroller then perform calculation to obtain the distance between the vehicles and follow the vehicle. The C programming language was used for the programming part in this project. The MPLAB IDE version 7.43 with C18 compiler support C language programming.

The robot follower in [2] has a numbers of limitations. Firstly, the following vehicle cannot follow the leading vehicle when the leading vehicle turn left or right from the straight line. Besides, the following vehicle could not avoid any obstacle or collision. The following vehicle also could not vary its speed in accordance to the distance between the vehicles. It can travel at a constant speed only.

2.3 Low Cost Sensing for Autonomous Car Driving on Road

Figure 2.1 HANS Vehicle

According to [3], a car-like robot equipped with a system called HANS, is able to navigate in an autonomous and safe manner, performing trajectories similar to the ones carried out by human drivers. The system was successfully tested in both simulations and in a laboratory environment using a mobile robot to emulate the carlike vehicle. As a result, this autonomous car can follow the front vehicle in curve road. Besides, this mobile robot also can follow the road, keeping the car in the right lane, maintaining safe distances between vehicles, and avoiding collision. For this mobile robot, it is assumed that there are no cars driving faster than the HANS vehicle which means that no cars will appear from behind.

HANS in [3] uses a low resolution web camera located in the centre of the vehicle behind the rear-view mirror and a set of sixteen sonar sensor. The key role of the camera is to act as a vision system. It is used to detect the side lines that bound the traffic lanes, the position and orientation of the robot relative to these lines, and the vehicles driving ahead and determining their lane and distance to the robot.

The sixteen sonar sensor was arranged to build up a occupancy grid as shown in figure 2.2. This strategy is to reduce the influence of sonar reflections. Each sonar sensor will form up one cone and each cone is divided into zones. The distance of each zone is defined from the robot. Obstacles lying over a region of the occupancy grid contribute to the voting of the cells. The zone with the highest number of measurements (votes in a sense) is considered as being occupied by obstacle. Sonar sensors are also used to detect emergency stopping conditions. With combinational of camera and sonar sensor, the perception of environment also can be mapped for the robot making autonomous decision.

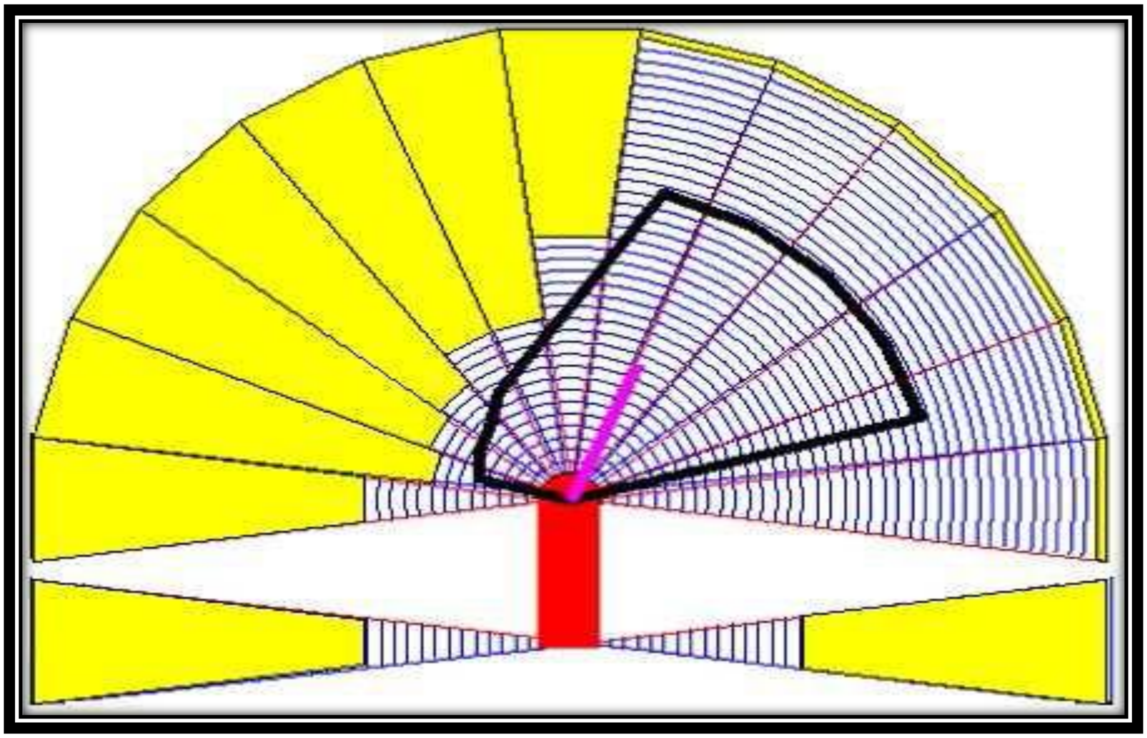

Figure 2.2**:** Occupancy Grid

2.4 Leader/Follower Behavior using ultrasonic transmitter and receiver

Figure 2.3 shows two robots that are performing the leader and follower behavior. The robot is called Maxelbot [4]. In figure 2.3, one of the robots acts as the leader and another robot act as follower in the following behavior. The leader uses the ultrasonic transmitter to transmit a signal through the parabolic cone. The purpose of the parabolic cone is to transmit the signal at 360 degree to the surrounding. The three receivers of the following car will catch the signal transmitted from the transmitter. Then the following car will perform mathematical calculation based on the distance of three receivers from the transmitter. Base on the calculation result, the follower predicts the distance and angle of leader relative to the follower.

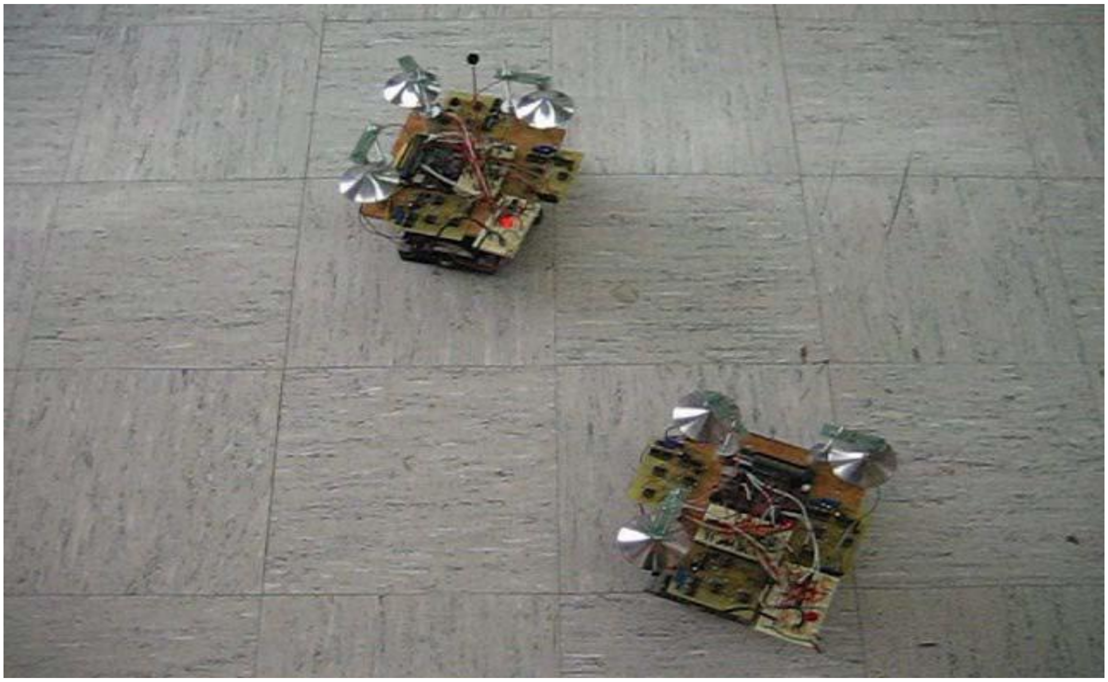

Figure 2.3 : Maxelbot

Limitation of this project is that the effective distance that can be measured by the follower from the leader is about one meter only. Once the distance of the leader is more than 1 meter from the follower, the follower cannot follow the leader.

The advantage of this method is that the cost of the hardware is relatively low when compared to the vision system base method. Beside, the robot is more robust when performing the following task in multiple obstacles environment compared to following system utilizing IR sensors only.

2.5 Scale Invariant Feature Transform (SIFT) algorithm

In [5], a robot was constructed to follow human or another robot using the vision system. The vision system in this project utilized the SIFT algorithm as shown in figure 2.4. In this algorithm, the robot uses the feature extracted from the training image of target to track the target. Firstly, it uses the SIFT algorithm to recognize the target. After the target is recognized, it estimates the position of the target. Then it uses the PID controller to control the motor to maintain the minimum distance between the follower and the target.

Figure 2.4: Robot Follower Using SIFT Algorithm

There are a number of limitations of this method for following behavior. The 3.5 meter effective distance for the recognition system is adequate for a small robots operating indoors, but would not be adequate for larger outdoor platforms. Additionally, direct pursuit of the leader’s current position is quite impropriate and does not work well in complex environments. PID control loops were time consuming to properly tune, and the performance of the simple robot platform limits the applicability of the system as implemented to wider applications.

The advantages of this system are: Firstly, the immunity to orientation and occlusion problems made the system easy to use. Object recognition also allows for the implementation of a wide variety of different behaviors based upon a set of different trained objects, opening the way for new avenues of human robot cooperation. And despite the image recognition software iterating at only 2Hz, the controllers were able to perform adequately for the task. With the application of increased processing power to the problem, robot control performance would improve.

2.6 The X80 Robot

Figure 2.5 shows the image of the X80 robot. According to [6], the X80 robot has 4 Infrared sensors and 3 sonar sensors to perform the following task. It is used to pursuit the direct position of leader robot. The position of each sensor is arranged as shown in figure 2.6. The following task is heavily depending on the IR sensors only. The other 3 sonar sensors are used only to perform the checking on the measurement of distance return by the IR sensors.

Figure 2.5: X80 ROBOT

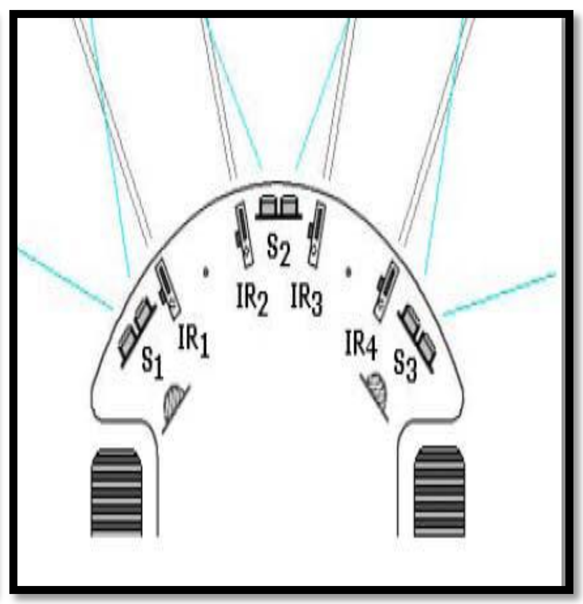

Figure 2.6 :IR sensor on X80 robot

The limitation of the robot is that this robot can only perform the following task in free space. The follower will lost the target if it is operating in the space full of the obstacles. Besides, it may also easily lost track of the leader robot. Another limitation is that the follower robot needs to stop during turning direction when the leader robot turns direction.

Despite its limitation, the X80 robot can follow the leader robot at low speed in free space.

2.7 Raccoon

RACCOON is a vision-based system that tracks car taillights at night as described in [7]. The RACCOON system was developed at Carnegie Mellon University. The prototype was built and integrated with RACCOON system. This system enables the autonomous vehicle to chase the leading car effectively under low light condition.

According to [7], this project was inspired by following reason:

a) The road cannot be seen clearly at night.
b) Unlit landmarks cannot be detected so corners and intersections have to be negotiated based solely on the observed actions of the lead vehicle at night.

Problems above make the following vehicle cannot detect the leading vehicle clearly at night using normal vision system and algorithm. In normal algorithm, the taillights can be easily extracted from a dark background. After the extraction, the autonomous car steers toward the taillight of lead vehicle. The autonomous vehicle may follow the lead vehicle successfully with this algorithm.

However, this algorithm fails when lead vehicles turns to follow winding road. When this scenario occurs, the computer controlled may steer towards taillights of lead vehicle and then results in corner cutting. These problems can be solved by using RACCOON system.

Under RACCOON system autonomous car, the image sensor can build a global map in real time that contains the position of lead vehicle based on the location and separation of the taillights (taillights of car) in a sequence of video images. Only one color camera was used as sensor. RACCOON is creating an intermediate map structure which records the lead vehicle's trajectory. The path is represented by points in a global reference frame. After that, the Computer controlled vehicle is steered from point to point to follow lead vehicle's trajectory. The autonomous vehicles can follow the lead vehicle at any desired speed to keep the lead vehicle's taillights in sight. Using this approach, the autonomous vehicle steers around corners and obstacles rather than through them.

CHAPTER 3

METHADOLOGY

3.1 Introduction

This chapter explains the methods used to implement this project. The first one is to identify and understand the flow of operation system. The project development consists of two stages. The first stage is assembling the project. Meanwhile at the second stage is troubleshooting and taken the data of each part of the project.

3.2 Project procedures

The procedure of the project as shown in figure 3.1 represented in the form of flow chart. In the earlier stage, there will be a lot information gathering activities where consists of many important information for the project. This project started by doing the research with previous work which is related to the current project and understanding the basic concept of the line following robot and also to obtain an idea of the progress that has been achieved so far in the project.

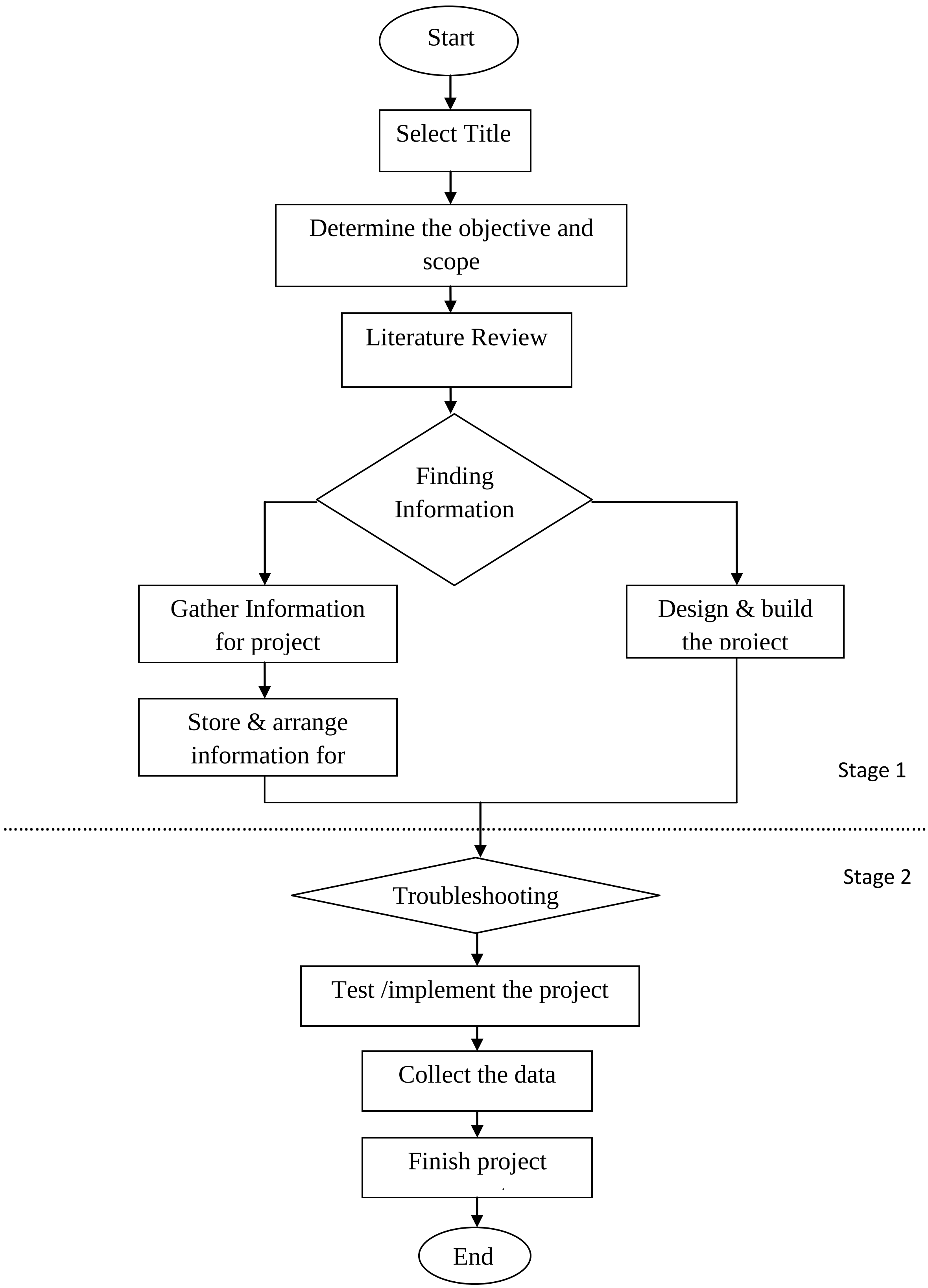

Figure 3.1: Overall of the project

3.3 Design process

To develop a project, it will start by introducing a typical development cycle in the most general terms. Then it will focuses on the particular aspects that pertain to the design of logic circuit. The flowchart in figure 3.2 depicts a typical design process.

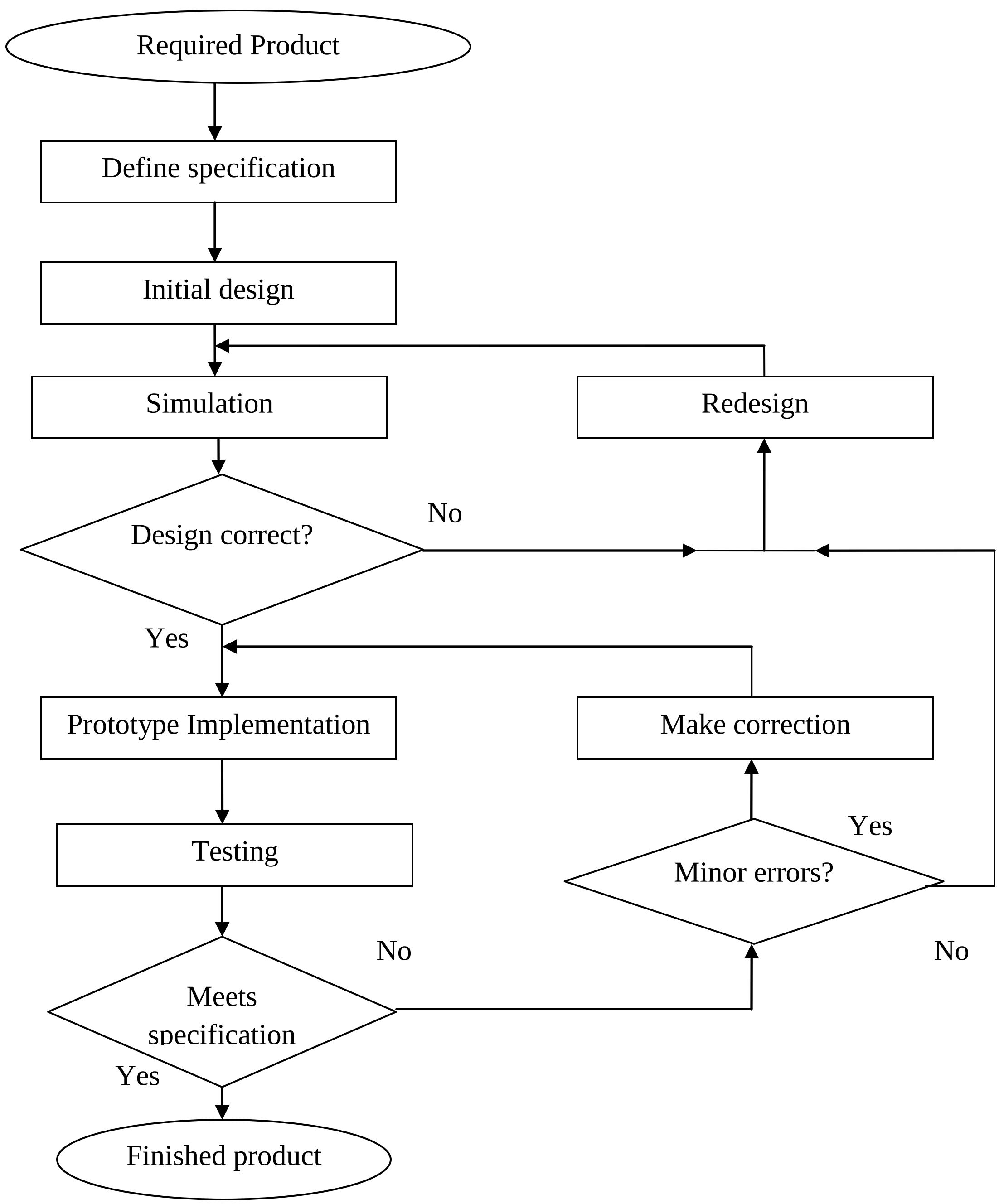

Figure 3.2: Flowchart of design process

3.4 Design Prototype

This project consists several blocks such as:

1) Sensor
2) Comparator
3) Processor Unit
4) Motor Driver

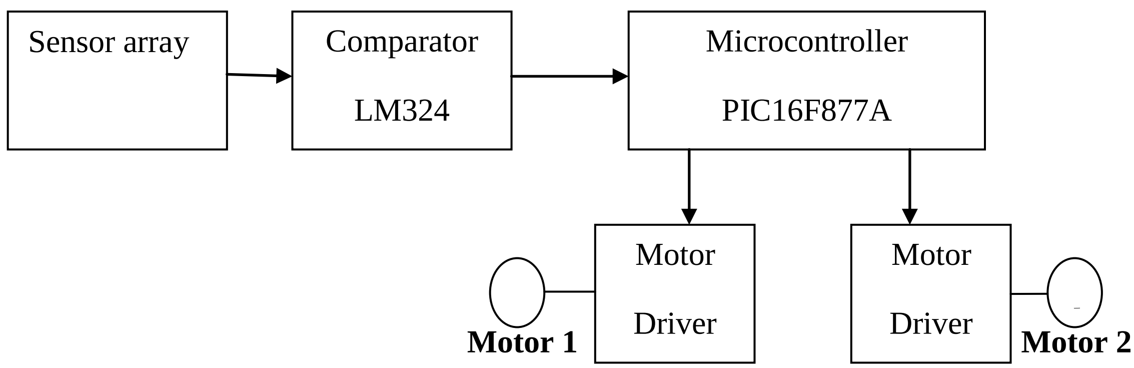

Figure 3.3: block diagram of line following system

3.4.1 Control system

The electrical circuit of the project are compared the analog signal received from sensors and then transmit the result to the processor in digit ‚0‛ or ‚1‛ and some of them send the analog signals to the processor ought to convert them to digital form.

3.4.2 The sensor

In this project, mobile robot uses 4 IR LEDs (Tx) and 4 IR sensors (Rx) with distance between the two sensors is 15mm. the first Rx receives an analog signal that depends on the intensity of light reflected by the black line of emitted beam by the Tx. These signals are sent to the comparator LM324 with creates digital signals(0 or 1) that are sent to microcontroller PIC.

Hence, the distance between sensors and ground surface is important and it is more important than how to put sensors near each other. The distance between sensors and ground surface must be 2 to 10mm and the distance between each sensor is depend on the line width.

Mobil robot used four pair of sensors as shown in Table 1.

Table 3.1: sensor arrays

Tx1(left)	Tx2(center)	Tx3(center)	Tx4(right)
Rx1(left)	Rx2(center)	Rx3(center)	Rx4(right)

In this project the sensor will work as an input to microcontroller and the data will be processing before microcontroller sending it to the output part which is motor driver that will drive the dc motor. Infra red sensor (IR sensor) is a sensor that compatible with the concept of mobile robots. This sensor is use to sure that the robot will move in its own path by detect the line. IR reflectance sensors contain a matched infrared transmitter and infrared receiver pair as shown in figure 3.5.

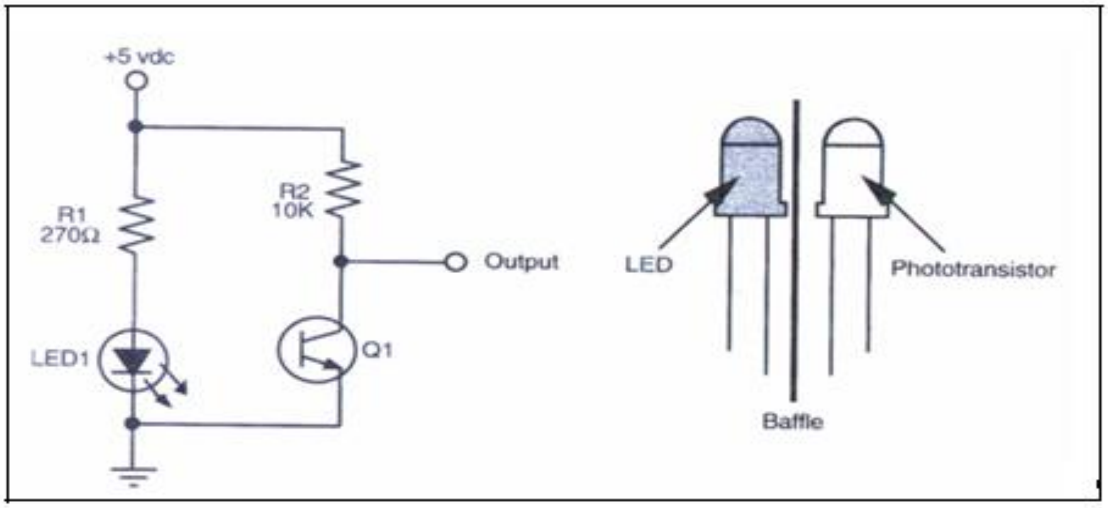

Figure 3.4 : The basic design of IR sensor

These devices work by measuring the amount of light that is reflected into the receiver. Because the receiver also responds to ambient light, the device works best when well shielded from ambient light, and when the distance between the sensor and the reflective surface is small(less than 5 mm). IR reflectance sensors are often used to detect white and black surface. White surface generally reflect well, white black surface reflect poorly.

IR LED emits infrared radiation. This radiation illuminates the surface in front of LED. Surface reflects the infrared light Depending on reflectivity of the surface, amount of light reflected varies. This reflected light is made incident on reverse biased IR sensor. When photons are incident on reverse biased junction of this diode, electron-hole pairs are generated, which results in reverse leakage current. Amount of electron-hole pairs generated depends on intensity of incident IR radiation. More intense radiation results in more reverse leakage current. This current can be passed through a resistor so as to get proportional voltage. Thus as intensity of incident rays varies, voltage across resistor will vary accordingly [8]

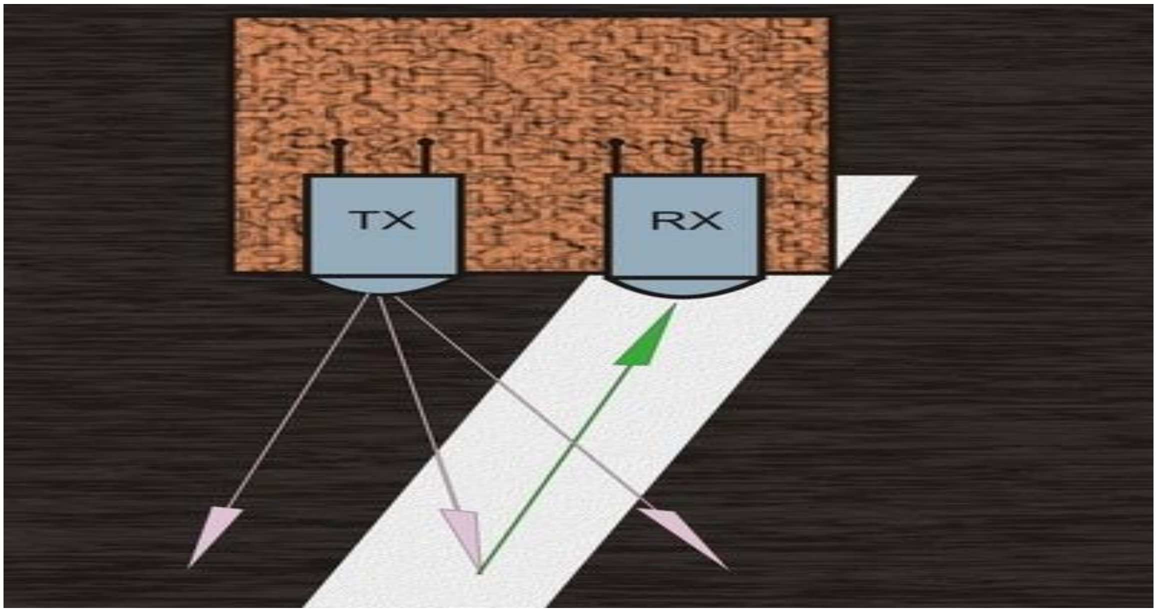

Figure 3.5: infrared reflection

3.4.3 The comparator and sensor circuit

A comparator circuit compares two voltage signals and determines which one is greater. The result of this comparison is indicated by the output voltage. If the op-amp's output is saturated in the positive direction, the no inverting input (+) is a greater, or more positive, voltage than the inverting input (-), all voltages measured with respect to ground. If the op-amp's voltage is near the negative supply voltage (in this case, 0 volts, or ground potential), it means the inverting input (-) has a greater voltage applied to it than the no inverting input (+).

The received signals from the sensors are analog and converted to the digital form**.** Therefore, the circuit can be designed to send the sensors signals to the processor, directly. Hence, the processing time can be managed just by using an external comparator. LM324 is a good comparator that is used in this project. One LM324 can support four sensors.

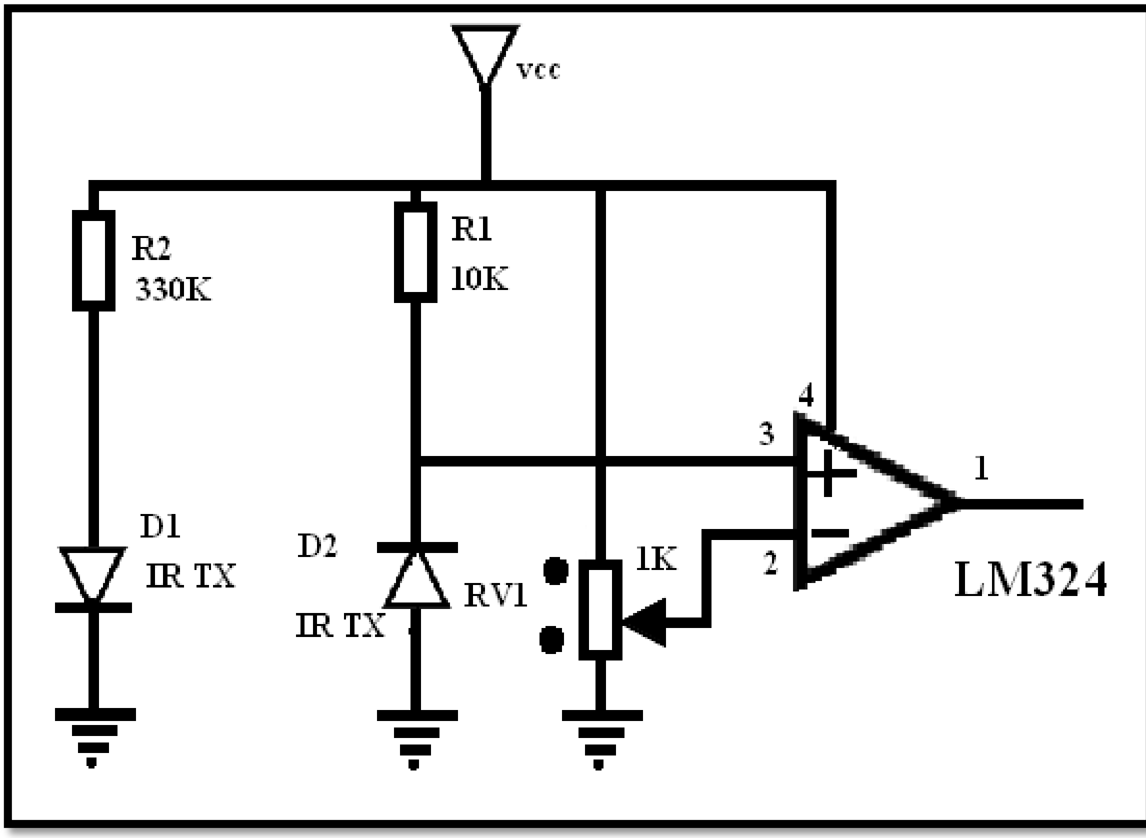

Figure 3.6: schematic of comparator and IR sensor circuit

3.4.4 The Processor Unit

A microcontroller is single chip used to control other devices. It was developed out of the need for small, low power systems. One could describe a microcontroller as a mini computer. This is because microcontrollers typical do not have the expandability or performance that microprocessors have. The primary role of these microcontrollers is to provide inexpensive, programmable logic control and interfacing to external device. Thus, they typically are not required to provide highly complex function. But they are capable of providing sophisticated control of different application.

The microcontroller can provide, in a simplified form, all the main elements of the conventional microprocessor system on one chip. As result, less complex applications can be designed and built quickly and cheaply. A working system can consist of microcontroller chip and just a few external components for feeding data in and out, and generating the clock.

In this project, PIC16F877A was used as processor**,** PIC16f877A is a good flash microcontroller that has many features a 40-pin and 5 input-output (I/O) ports. This flash microcontroller may be programmed and erased instantly, without the need for a UV light sours, to speed program testing. Reprogram ability offer a highly flexible solution today's ever- changing market demands, where product updates and modification are routinely carried out in the field. Port A consists of 6 pins which can be set up as either digital I/O or analog inputs. Port B is an 8 pin port which can be used for both digital I/O operations and in-circuit debugger (ICD) operations. Port C, on the other hand, is a 5-pin multi-functional port, which can be used for digital I/O, as capture-compare (CCP) input, or pulse-width modulation (PWM) output.

Port D is an 8-pin port, which can be used for both digital I/O as well as parallel slave port (PSP) functions. Finally, port E is a 3-pin port, which is used for external memory connections.

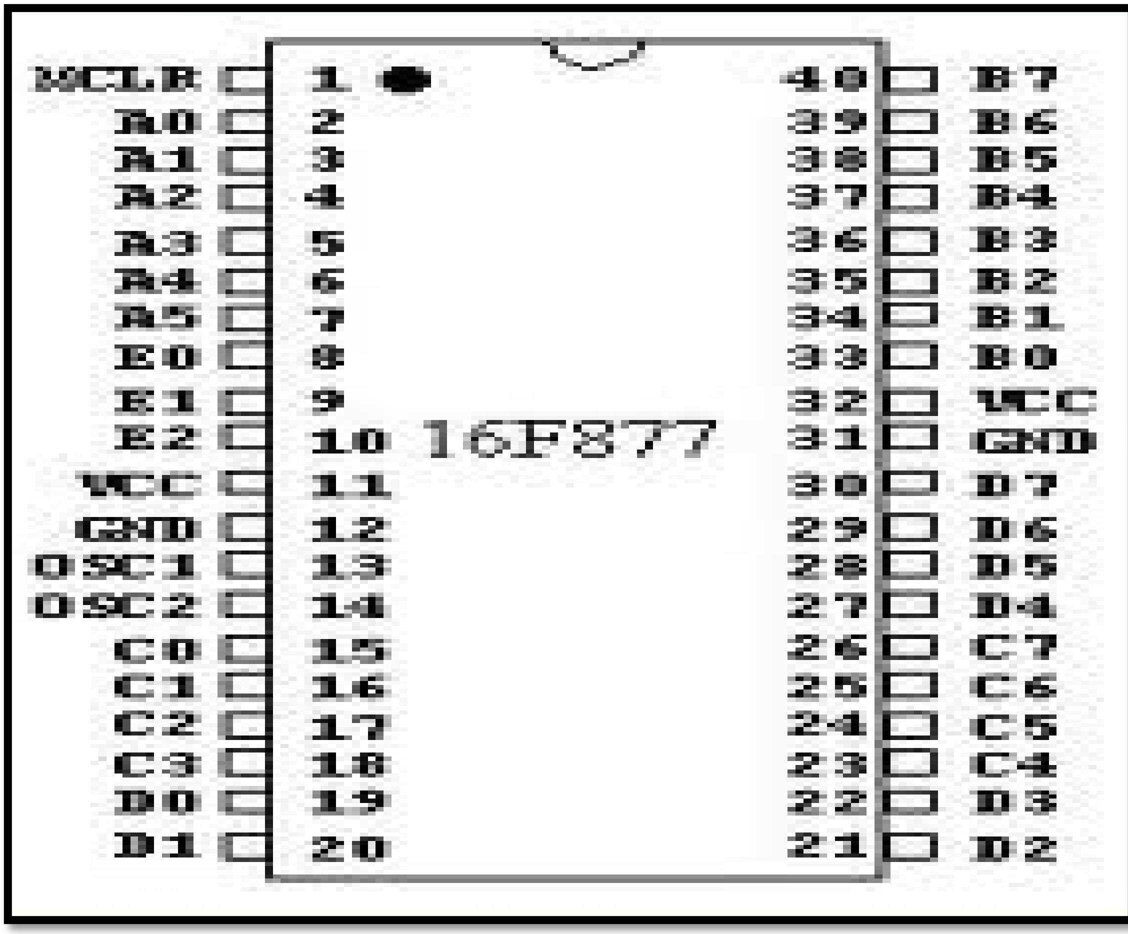

Figure 3.7: Microprocessor Unit

The PIC16F877A microcontrollers carry a large memory array, which can be divided into three types:

- Flash program memory
- EEPROM data memory
- Data RAM

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