Design and Development PIC-Based Autonomous Robot

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Abstract— **Recently, mini robots in the form of pets, cleaners and others are available in market. Robots are utilized for many applications to assist human-being. The purpose of this project is to develop an autonomous robot that can move on itself without continuous human guidance. This autonomous robot is overall in two parts: Electronic parts and mechanical parts. Electronic parts are the controller board, infrared sensors and ISD 2560 ChipCoder. The controller board consists of microcontroller PIC 16F877A, power supply unit and motor driver ST L293D. The mechanical parts are the gear-box with DC motors and the case of the robot. When the robot is ON, it will sound "Autonomous robot ON" and move forward. When it senses obstacle in front, it will sound "Obstacle at front, reversing" and reverse then turn right before it continues to move forward. When it senses obstacle at right, it will sound "Obstacle at right, turning left" then turn left and when it senses obstacle at left, it will sound "Obstacle at left, turning right" then turn right before it continues to move forward. As a result, this robot is useful as a guide for blind people as it is also economic.**

Keywords—**Autonomous robot, PIC 16F877A microcontroller, Winbond ISD 2560 Chipcoder**

I. INTRODUCTION

In this technologically advanced area, future engineers intend to replace human workers with smart devices and systems in our daily routine to speed up work and improve process flow and production. In recent years, the area of mobile robotics has become very active in both research and development. There are two reasons for this. First, mobile robots with both mobility and manipulability have a better potential than other kinds of robots in replacing human beings in the manufacturing and service industries. Second, the recent advances in computer and sensor technologies have made it feasible to develop new and useful mobile robots [3].

The purpose of this project is to develop an autonomous robot. Autonomous robots are robots which can perform desired tasks in unstructured environments without continuous human guidance. Many kinds of robots are *autonomous* to some degree. Different robots can be autonomous in different ways. A high degree of autonomy is particularly desirable in fields such as space exploration, where communication delays and interruptions are unavoidable [1].

A fully autonomous robot in the real world has the ability to:

- Gain information about the environment.
- Work for months or years without human intervention.
- Travel from point A to point B, without human navigation assistance.
- Avoid situations that are harmful to people, property or itself
- Repair itself without outside assistance [1].

The next step in autonomous behavior is to actually perform a physical task. A new area showing commercial promise is domestic robots, with a flood of small vacuuming robots beginning with Roomba Vacuuming Robot [1] [2] in 2005. While the level of intelligence is not high in these systems, they navigate over wide areas and pilot in tight situations around homes using contact and non-contact sensors. Both of these robots use proprietary algorithms to increase coverage over simple random bounce.

The next level of autonomous task performance requires a robot to perform conditional tasks. For instance, MobileRobots' security robot can be programmed to detect intruders and respond in a particular way depending upon where the intruder is [2].

Mobile robotics is a relatively new research area that deals with the control of autonomous and semiautonomous vehicles. There are some important differences between the requirements of traditional fixed robotic installations and the requirements of mobile robotic systems. One of it is the environmental uncertainty in which the vehicle might operate in. For fixed robotic systems, a small workspace can usually be engineered to facilitate the task being undertaken. For mobile robotic systems, it is difficult to engineer the environment where the system needs to operate in because the world is dynamic and unpredictable. This required improved sensor technology and the ability for the system to cope with uncertainty. The design of mobile robotic systems considers the ability to carry all necessary resources such as power sources and all of the sensing and processing hardware within the mobile itself [1].

Figure 1. Mobile robots (clockwise from top left): Hearing Robot [5]; Serving Robot [6]; Line Tracking Robot [7]; Roomba Vacuuming Robot [2].

Before this, almost all autonomous robots do not have the ability to play real sound. Buzzer is used to produce sound instead of playing real sound. The example is Autonomous Flocking & Singing Robot which only uses buzzers as the sounding part. It uses two buzzers of different frequencies: 600 Hz and 2.5 kHz [4]. So in order to overcome this problem, survey based on IC that can store sound is done.

Therefore, this report will discuss about the electronics, mechanical and software design of the autonomous robot.

II. SYSTEM DESIGN AND DESCRIPTION

In this project, the development of Autonomous Robot is divided into two main sections, the electronics design and mechanical design as shown in Figure 2. The heart and mind of this robot is the PIC 16F877A microcontroller. The PIC 16F877A can be program using the PicBasic Pro compiler. The motor used is the Tamiya Twin-Motor Gearbox. The robot is equipped with the obstacle-avoidance ability which uses the infrared sensors. Then the robot can play pre-recorded messages. Those pre-recorded messages are stored in the Winbond ISD 2560 Chipcorder.

Firstly the robot will sound "Autonomous robot on" and move forward when it is power on. When it senses obstacle at right, it will sound "Obstacle at right, turning left" while when it senses obstacle at left, it will sound "Obstacle at left, turning right". The robot will continue to move forward if the obstacles are clear. If the robot senses the obstacle in front of it, it will sound "Obstacle at front, reversing" and reverse for 2 seconds, then it will turn right before it continues to move forward.

A. Autonomous Robot Controller Board

The autonomous robot controller board is designed around the PIC 16F877A, which contains 5 Input/Output (I/O) ports with 33 I/O pins. Those ports are port A, B, C, D and E. By using the sophisticated 16F877A, the robot controller board uses fewer components that would have been required in the past. This microcontroller can be reprogrammed because it uses flash read-only memory for program storage. This makes it ideal for experimenting because this chip does not need to be erased with an ultraviolet light source every time new program is uploaded.

The controller board is shown in Figure. It contains a power supply unit, a PIC 16F877A and a motor driver, L293D. The power supply unit is a combination of a L7805CV, two 1μF capacitors and a 100μF capacitor. 9V input voltage is supplied to the power supply unit and the output is 5.03V.

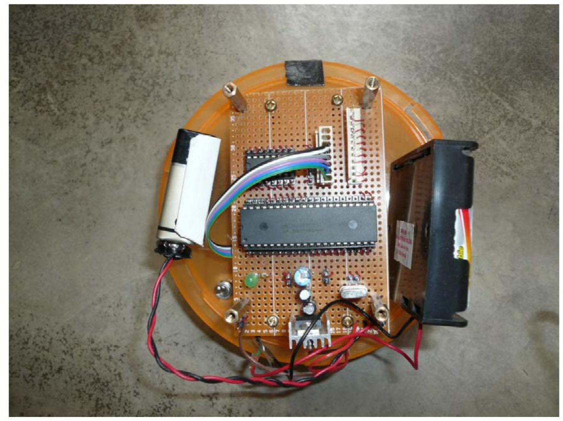


Figure 2. Autonomous robot controller board

Pin 1, 11 and 32 of the 16F877A are connected to the Vcc while pin 12 and 31 are connected to the ground. Pin 13 and 14 are connected to a 8 MHz oscillating crystal. Port D is used to control the motors through the motor driver L293D. Port B pin 0 and 1 are used for the right motor while port B pin 2 and 3 are used for the left motor. Port B pin 0, 1, 2 and 3 are connected to Input 1, 2, 3 and 4 of the L293D. Enable 1 and 2 are always enabled by connecting them to the Vcc. Then the supply voltage for motors, 6V from a combination of 4 AA batteries, is connected to pin 8 and 16 of the L293D. Pin 4, 5, 12 and 13 are grounded. Output 1 and 2 are connected to the right motor and Output 3 and 4 are connected to the left motor.

B. Infrared Sensors

In order to enable the robot to avoid obstacle, various sensors are considered before installing them to the robot. After comparing those sensors, infrared sensor is best suited for the robot. The main reason for using infrared sensor is it enables the robot to efficiently avoid the robot at a range before the robot crashes them. Infrared sensor is also low cost compared to the other sensors. The drawback for infrared sensor is the less effective to sense when the obstacle is a dark and soft object.

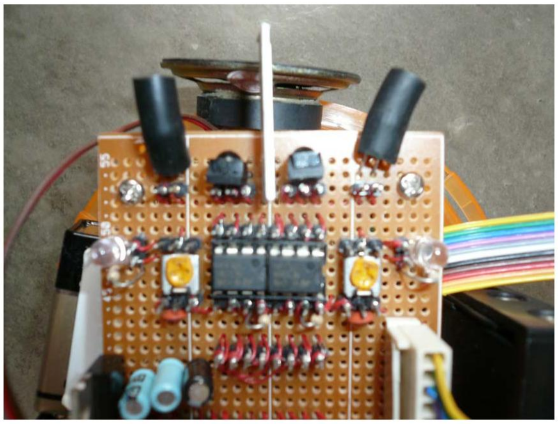


Figure 3. Left and right infrared sensors

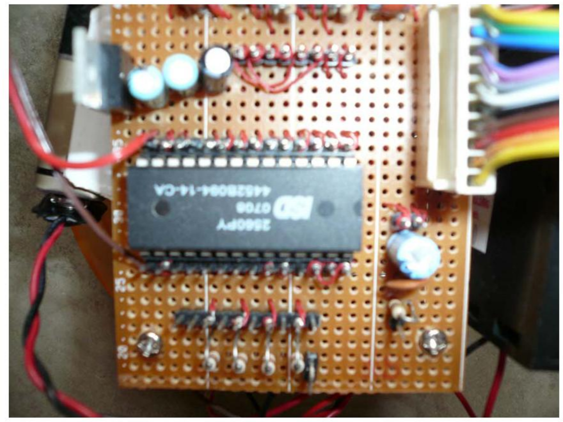


Figure 4. Winbond ISD 2560 ChipCoder

There are two infrared sensors on this robot: right infrared sensor and left infrared sensor. Each infrared sensor consist an infrared emitter and an infrared receiver. The infrared emitters are emitting at the frequency generated by the 555 Timer. The infrared beam can be checked through the camera lens. Each infrared emitter is covered by a PVC rubber pipe so the infrared beam will only focus at front. Whenever the infrared receivers detect the infrared beam bounced back from the obstacle, it will produce an output "0". The outputs of left and right infrared receivers are connected to port C pin 0 and 1 of the 16F877A. The infrared detection range is set to 8cm which is sufficiently for the robot to avoid obstacles. The detection range must not be set to far because the robot will be too sensitive to the environment.

C. Speech IC

After considering various technologies used to implement the message archive function, i.e., analog tape loop devices, traditional digital to analog conversion techniques, personal computer voice recorder systems, and stand alone analog recording devices, we have decided to use the Information Storage Devices, Inc. ISD2560 ChipCoder Device.

The ISD 2560 device contains built-in audio signal processing, a microphone preamplifier, a 500 mw audio output amplifier, and a simple level or edge-triggered interface (user selectable). This makes it possible to use in applications ranging from single chip stand alone designs to multiple chip microprocessor control designs. In addition, all control pins to the 2560 are internally debounced and driven by a high precision internal clock that reduces the external parts count considerably. The ISD 2560 has large total storage with small array sizes, 60 seconds with 1,000 locations.

The address of the ISD 2560 is determined by pin A0 to A9. Either one or both MSBs (A8 and A9) are taken low will set the ISD 2560 into address input. For this project, the messages are recorded on the other circuit while the circuit on the robot is for playback function only. P/R* (pin 27) is taken high for playback function while low for record function. Four addresses are selected: (MSB-LSB) 0000000000 (0 second), 0010000000 (12.8 second), 0100000000 (25.6 second) and 1000000000 (51.2 second) to store the messages. Only four address pins (A9, A8, A7 and A6) are selected to be connected to the PIC 16F877A because each recording durations is adequate to record each message directly save more I/O ports of the microcontroller for future enhancement. Address pins A0 to A5 are grounded. CE* (pin 23) is also connected to the microcontroller because each '0' logic given will trigger the ISD 2560 to play the corresponding message.

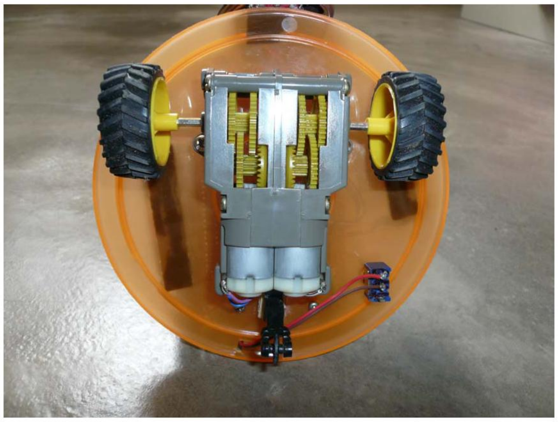
D. Power Requirement

Two independent power sources are required for this robot. Four 1.5V AA batteries are used to supply 6V for the motors and 5V for the infrared receiver through a voltage regulator. Another 9V battery is the used as the power supply for the controller board with the voltage regulated to 5V.

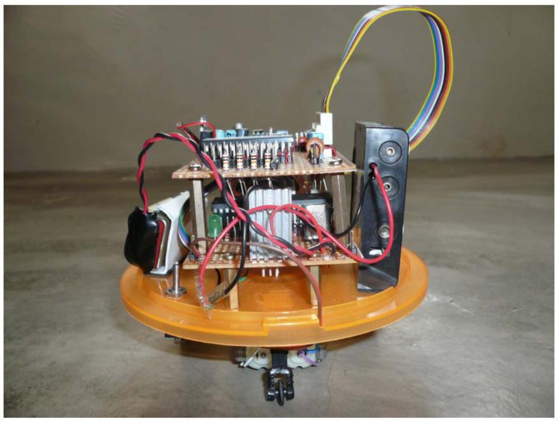
E. Robot Chassis

In order to reduce cost, an idea of using recyclable material to construct the chassis of the robot has come to mind. Therefore, after surveys are done and collection of material is made, case of CD-R is chosen to be constructed into the chassis of the robot. Reason of choosing the case of CD-R is firstly the case is easily obtained. Then the space of the case is also sufficiently to install the controller board and the twin-motor gearbox as it is also hard enough to protect the controller board from external pressure.

The robot is designed two layered. The upper layer is the infrared sensor and the ISD 2560 Chipcoder. Then the lower layer is the controller board which is attached to the chassis of the robot. Board spacers are used to space between the upper and lower board and between the lower board and the chassis of the robot. Those board spacers are 1" and ½".



(a)



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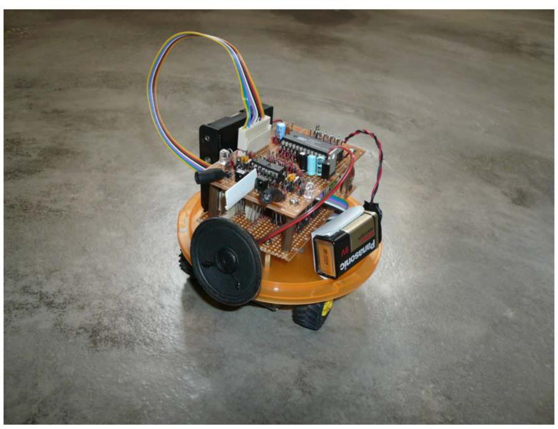

(c)

Figure 5. (a) Tamiya Twin-Motor Gearbox with truck tires; (b) Rear view of the autonomous robot; (c) Autonomous robot

III. SOFTWARE

A microcontroller is nothing without software to run it. To program the PICs, a binary file of coded ones and zeros is required. In this project, the programming language used is PicBasic. Although PICs usually has to be programmed using assembly language, it is possible to program the PIC using PicBasic because of the availability of the compiler. It will convert the PicBasic language to assembly language that PIC is recognizable.

PICBASIC PRO Compiler is developed by MicroEngineering Labs. The programming language makes it quick and easy to program Microchip Technology's powerful PICmicro microcontrollers.

The BASIC language, which is English-like, is much easier to read and write or more understandable than Microchip assembly language. Example of the language is IF..THEN..ELSE..ENDIF which directly shows the antecedent and consequent of the program.

First, to start using the PICBASIC PRO Compiler, we must run the MicroCode Studio. Then we press CTRL+N for a new editor. Type of PIC microcontroller and oscillator frequency must be defined at the beginning of the program. In this project, PIC 16F877A is the microcontroller and 8 MHz crystal is used as the oscillator. Then, we will set the ports or pins of PIC 16F877A to input or output by using TRIS command followed by defining the pin names (VAR command). Then we can begin to write the program.

After we have finished writing the program, we need to save the program in .pbp file. Then only we can compile the program. During the compilation, errors of the program will be detected. If errors occur in the program, the compilation will be terminated. The error will be listed. After the error has been undone and if there is no more error in the program, then only the compilation will be completed. Three files (.ASM, .HEX and .MAC) will be generated in the same location of the .pbp file after compilation. .HEX file will be used to be programmed into the PIC 16F877A.

In order to program the .HEX file into the PIC 16F877A, melabs Programmer is used. The melabs USB Programmer and melabs U2 Programmer connect to a PC USB port or powered USB hub.

First, we run the melabs programmer software by selecting melabs Programmer from the Start menu. *Melabs Programmer* and *meProg-Configuration* windows will appear. On the *Melabs Programmer* window, firstly we must select the type of PIC we are using. For this project, PIC 16F877A is selected. Then we press CTRL+N to reset the software followed by CTRL+O to open the .HEX file that will be programmed into the microcontroller. On the *meProg-Configuration* window, we set the Oscillator to HS, Watchdog Timer to Disabled, Power-up Timer to Enabled, Brown-out Reset to Disabled, Low Voltage Programming to Disabled, Flash Program Memory Write to All, Code to Not Protected and Data EEPROM to Not Protected.

After that, PIC 16F877A is inserted into the programmer socket. Then connect the cable between the programmer and 8-40 ZIF Adapter to the proper connector on the adapter for the number of pins (-40 pins). Blank Check and Erase are necessary if the target PIC still contains previous program. Then after the PIC is blank, we will program the .HEX file into the PIC by clicking Program.

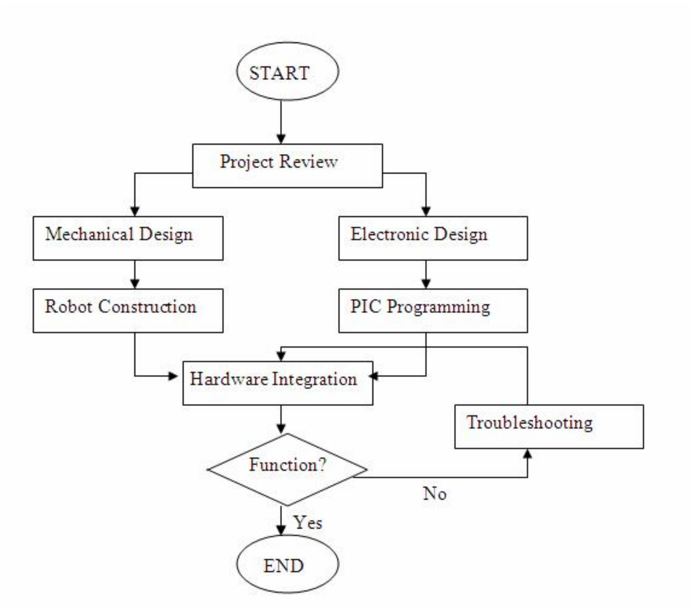

Figure 6. Flowchart for the development of autonomous robot

IV. CONCLUSION

As a conclusion, this autonomous robot is basically low cost. This robot can move forward and react to avoid obstacles with the corresponding messages are played. The messages played by the robot are also clearly heard. We can

utilize this robot as the guide for blind people and as toy for children. This concludes the construction and programming of the autonomous robot.

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