ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
Tome IV (Year 2011). ISSN 2067-3809

N. A CHOWDHURY[1], Md. Anayet Ullah PATWARI[2]

DEVELOPMENT OF MICROPROCESSOR BASED CONTROLLING UNIT FOR FLEXIBLE CONTROL OF A ROBOT STRUCTURE

ABSTRACT:
Robots, specially self-controlled robots are part and parcels of flexible manufacturing system. Most robots are designed for special purpose automated task in manufacturing processes. Robot building blocks, such as controls, motors, drives etc. are standardized to a high degree that keeps the costs down on a competitive level for special made machines. The objective of this project was to design, construct, and to test hardware and software to create a micro-controller based robot platform for flexible movement of a robot. This paper demonstrates the implementation of Pulse Width Modulation technique and usage of Infrared signal in robots using microcontroller. Initially an obstacle detecting device was made using infrared signal. Depending upon the responses of the obstacle detector the robot is able to change its direction in such a way that the obstacle is avoided. After that Remote Control feature was added for easy controlling of the robot base. This designed base will be coupled with robot body for automated guided functions within a manufacturing system.

KEYWORDS:
Self-controlled Robot, Microprocessor, obstacle detection

INTRODUCTION

A robot has a mechanical body and an electronic nerve system to drive it. Robot allows easy reprogramming capability to adapt to varying task requirements and can support flexibility by solving diverse tasks in cooperation with human operators. For the robot to do some useful work it is required to make a program with some kind of intelligence. This can vary from hardware logical circuits implementing some early robots to low-level reflex code on micro-controllers used in many small robotics projects. Many research works [1-5] are going on for the development of robot. In launching the robotic system, system engineering and design consideration have been made and several alternatives [6-8] to robot such as manual operation, semi-mechanization and special purpose hard automation have been addressed. Self-controlled robots are equipped to navigate a flexible guide path network that can be easily modified and expanded. A self-controlled robot system can vary in size from a short, simple layout to a complex layout with computer integration automatically interfacing with other automated manufacturing equipment. SRS systems consist of several components: the base i.e. the legs or wheels, navigation system, a controller which is usually a computer, the connection between the computer and the sensors and motor. Though the application of self-controlled robot ranges from small robotic arms in automated industries to the robots used in searching perimeters in security systems or the robots used in climate research of north or south poles, they are mainly used in those industries where the system is fully automated.

In complicated robotics systems, the control system can go up to advanced neural network [9-10] control systems running on powerful microcomputers networked together. These are all contributing to a steady increase in the capabilities of robot. Robots currently under development may widely be used in the factory, mining, defense, and nuclear and offshore industries. The developed countries are successfully using robots and automated machineries in their important industries. Nowadays countries like Japan, USA, and China are making successful use of robots in their car industries, pharmaceutical industries. They are also building intelligent and recreational robots like 'ASIMO' and 'AIBO; and considering these cases it won't be so long when robots will do household works, like cooking, cleaning, even bringing the newspaper. Recent developments in robotic applications have shown a trend towards precise and high speed motion to accomplish a specific task. However, the efficiency of the available industrial robots is severely reduced by the complexity of their operation.

In mathematical terms, the planning and control of robot motion is a very heavy computational burden to be executed in real-time. Problems in the control of robots arise from the vast computational complexities associated with the mathematical formulations, in addition to the need for appropriate adaptive control methods to achieve the required precision and speed. The aim of this research work is to develop a new microprocessor based robot for performing multi-operation in manufacturing systems. To avoid collision an obstacle identifying modules has been incorporated in the designed system. The present work has two different parts, in which part one was mainly for the construction of the robot body [11] and part two was focused on developing the base of the robot for flexible control. This paper is mainly focused on the development of the control system of the base of the robot by microcontroller.

FEATURES OF SELF-CONTROLLED ROBOT

1. *The base of the robot is powered by two dc motors. The car can move forwards, backwards, turn left and right at required angles by rotating the motors at different rates.*
2. *The path of the base car is controlled by an on-board microprocessor through an installed path program.*
3. *The source and destination positions of the base car on the microprocessor can be specified. The microprocessor gives the car the necessary directions.*
4. *There are infrared signal generators on the robot. If there is any obstacles present on the way, the infrared signals will be reflected by the obstacles.*
5. *There are signal receivers for infrared signals. When infrared signals are received, the signal receiving circuit gives input to the microprocessor. The microprocessor then stops the dc motors and the robot stops.*
6. *When there is obstacle on the left, the robot turns right and when the obstacle is on the right, the robot turns left according to the signals received.*

Mechanical design:

A four wheeler is used in this study (as shown in Figure 1) because of its proper balance. A differential gear was designed and manufactured to control the driving wheels. Two dc motors are used along the axes of the front and rear wheels because of its easy use and low cost. The drive is given to the rear wheels. Direction of movement is fixed by rotating the front wheel and rotating movement is given by another dc motor.

Position of motors

- *The driving motor is placed in the axis of the rear wheel. It has a support from the body of the car. A counter balance on the opposite side would have been needed if it was a three wheeler.*
- *The direction changing motor will be at the axis of the front wheel.*

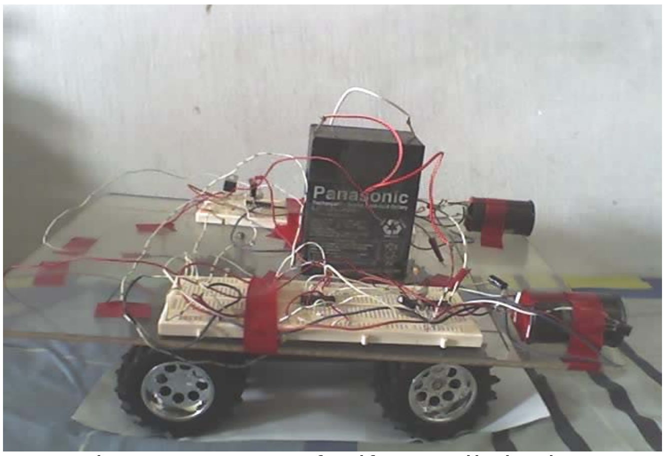

Figure 1 Features of self-controlled Robot

ELECTRICAL CONTROL OF SELF-CONTROLLED ROBOT BASE

The designed robot base is a wheel-mounted carriage which may be programmed to travel along a predetermined path between two locations upon which a robot hand can be mounted. The robot can also be used as an alternative to conveyors and cranes for transporting materials, components and tools between manufacturing centers. The flexibility of this robot lies in its ability to be easily programmed to travel along alternative routes. Most moving robots are guided "off-board" by inductive wires which are either concealed underground or adhered to the factory floor surface in the form of metallic strip. Kinetic power is usually provided by on board electrical batteries. Route programming is commonly achieved via on board local intelligence. Many robots also incorporate sensors which can detect location, cargo and collision and other handling. Flexible as they are, the majority of robot's are constrained to the routes of the inductive wires and thus cannot truly be described as free ranging. However, more sophisticated versions are now being developed, most of these are based on principle of software-programmable routes, which are thus very easily changed and are infinitely variable popular guidance system utilizes laser signals, ultrasonic and navigation via gyroscopic detection. The electrical system can be divided into several parts: Power supply system, Microprocessor interfacing circuit, IC controlled signal generator and IR LED based signal sending circuit, Signal receiving circuit

Power supply system:

Power supply system is a very vital part in the robot. The choice of suitable power supply system ensures the proper functioning of robot. Due to major constrains it is very difficult to select the proper power source. Power supply system for the dc motors and driving circuits: The power of robot is supplied from on board power supply system. The current design of our robot contains two dc motors of 5V each. So it is easily possible to supply the power from two separate 9V battery. This type of 9 volt DC battery is available in market and cheap in price consideration. Using rechargeable battery is a better option. In that case a charger will be needed. The charger will convert AC current to DC current through an adapter *and supply 8.5~9 V to the battery. But for the smooth functioning of the motor a lead-acid battery was used to power the two motor. The motors were selected such that the power supply circuit remains as simple as possible.*

Power supply for the circuits:

The ultimate goal of this work is to make a real robot which will operate wirelessly and without any external control. Arrangement needs to be made to power the signal sending and receiver circuit. The usual power required to run the circuits are very low-5V would be sufficient. This power is also possible to be supplied from available DC battery in the market.

DC motor:

DC motors can be viewed as electric motors without commutators. Typically, all windings in the motor are part of the stator, and the rotor is either a permanent magnet or, in the case of variable reluctance motors, a toothed block of some magnetically soft material. All of the commutation must be handled externally by the motor controller, and typically, the motors and controllers are designed so that the motor may be held in any fixed position as well as being rotated one way or the other. Most steppers, as they are also known, can be stepped at audio frequencies, allowing them to spin quite quickly, and with an appropriate controller, they may be started and stopped "on a dime" at controlled orientations.

The Motor Controller:

For the movement of the robot two DC motors are used. One motor is connected with the front wheel, which controls the left-right movement of the robot, and one motor is connected with the rear wheel, which controls the forward-backward movement. Figure 2 show pin configuration of the motor controller.

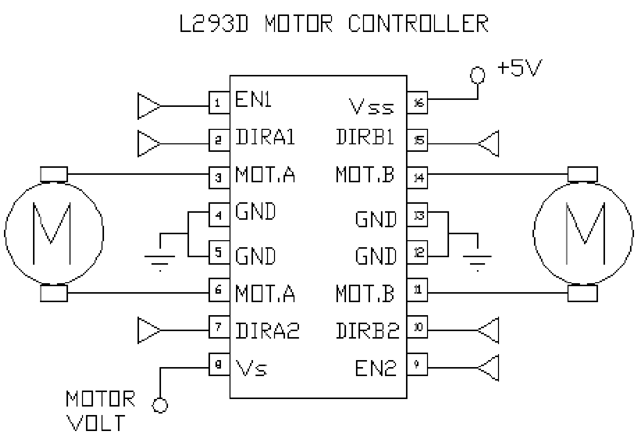

Figure 2. Pin configuration of L293D motor driver IC

SIGNAL GENERATING AND SENDING SYSTEM

Signal is generated by PIC16F84A. This signal is send through resistors and transistor. The signal is send by an infrared LED. This infrared signal, if reflected by obstacle, will be received in the receiver module. The IR LEDs are placed on the front right and left sides.

Signal receiving system:

Signal is received in the receiver module. Two receiver modules are used to receive the signal which is reflected by the obstacles. When the receiver module receives or gets the signal it gives input to the microprocessor. In the microprocessor the program is written in such a way that when it gets signal from the receiver module, it can detect the obstacle near the robot. Then it takes decision as quickly to give input to the motor and the robot instantly stops there and changes its direction. For the generation of the clock speed for the microprocessor, an oscillator is used.

Signal Functions:

For the obstacle detection system, infrared light instead of ultra-sonic sound, which is emitted from an IR-LED is used and if there is any obstacle within its range the light will reflect back and an IR-receiver module will pick up the signal. Then the receiver module will send the signal to a microcontroller which will compare received signal with the sending signal. And if the frequencies of the two signals match then the microcontroller will come to a decision that there is an obstacle nearby and give an output to the brain which will come to a decision to avoid the obstacle. Figure 3 shows the circuit diagram of the controller.

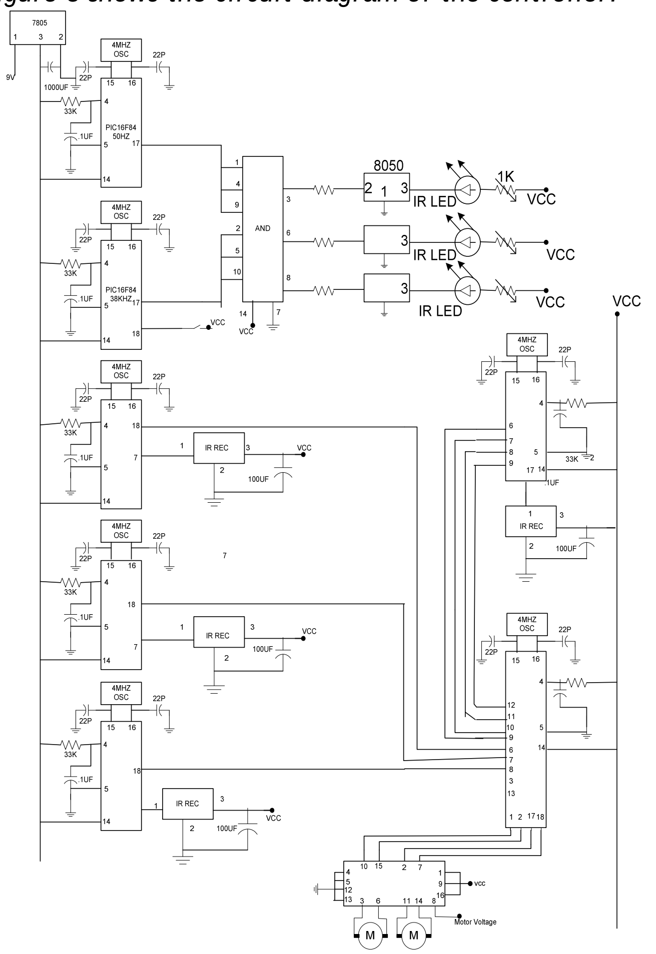

Figure 3: Circuit diagram of the designed controller

SOFTWARE IN ROBOT

Obstacle detection software was made based on the flow diagram shown in figure 4, which will enable the featured robot to detect the obstacle and control the movement of the robot. Any obstacle will be detected and the robot can change its direction to avoid collision.

Software description:

The functionality of the software can be described in a few lines:

- *Start moving forward*
- *If the LEFT sensor is triggered, the rear motor will stop shortly & front motor will start and the front wheel will turn RIGHT (the robot will stop shortly and then will turn right)*
- *If the RIGHT sensor is triggered, the rear motor will stop shortly & front motor will start and the front wheel will turn LEFT (the robot will stop shortly and then will turn left)*
- *If both sensor triggered then the robot will stop*
- *Go back to moving forward*

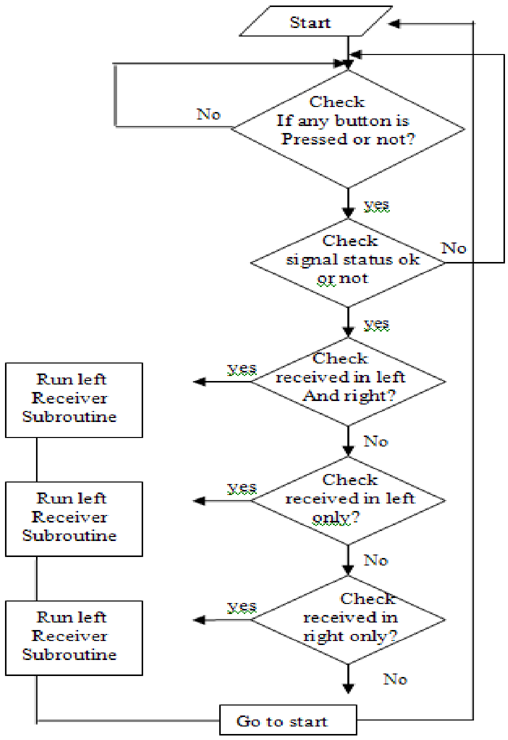

Figure 4: Flow chart for obstacle detection system

CONCLUSIONS

A micro controller robot base was designed and manufactured for flexible control of the robot structure used for the manufacturing system loops. The flexible movable controlled base of the robot may help to perform many automated task during manufacturing processes. An obstacle detecting device was introduced using infrared signal so that the robot body can change its direction to avoid collision.

REFERENCES

[1.] Ikuo Mizuuchi, Masayuki Inaba and Hirochika Inoue, Adaptive pick-and-place behaviors in a whole-body humanoid robot with an autonomous layer based on parallel sensor-motor modules, Robotics and Autonomous Systems, Volume 28, Issues 2-3, 31 August 1999, Pages 99-113

[2.] Satoru Goto, Tatsumi Usui, Nobuhiro Kyura and Masatoshi Nakamura, "Force free control with independent compensation for industrial articulated robot arms" Control Engineering Practice, Volume15, Issue 6, June 2007, Pages 627-638

[3.] Fusaomi Nagata, Tetsuo Hase, Zenku Haga, Masaaki Omoto and Keigo Watanabe, "CAD/CAM-based position/force controller for a mold polishing robot Mechatronics, Volume 17, Issues 4-5, May-June 2007, Pages 207-216

[4.] Zhongxu Hu, Chris Marshall, Robert Bicker and Paul Taylor Automatic surface roughing with 3D machine vision and cooperative robot control, Robotics and Autonomous Systems, In Press, Accepted Manuscript, Available online 15 February 2007

[5.] S. Purwar, I.N. Kar and A.N. Jha Adaptive control of robot manipulators using fuzzy logic systems under actuator constraints, Fuzzy Sets and Systems, Volume 152, Issue 3, 16 June 2005, Pages 651-664

[6.] K. Mitobe, G. Capi and Y. Nasu, A new control method for walking robots based on angular momentum, Mechatronics, Volume 14, Issue 2, March 2004, Pages 163-174

[7.] E.Muehlenfeld, Robot vision by a contour sensor with associative memory, Pattern Recognition, Volume: 17, Issue:1, 1984, Pages:169-176.

[8.] J Porrill, S. B. Pollard, T. P. Pridmore, J. B. Bowen, J. E.W. Mayhew and J.P. Frisby, TINA: a 3D vision system for pick and place, Image and Vision Computing, Volume 6, Issue2, May 1988, Pages 91-99.

[9.] Toshio Tsuji and Yoshiyuki Tanaka, 2005, On-line learning of robot arm impedance using neural networks Robotics and Autonomous Systems, Volume 52, Issue 4, 30 September 2005, Pages 257-271

[10.] Sahin Yıldırım, Adaptive robust neural controller for robots Robotics and Autonomous Systems, Volume 46, Issue 3, 31 March 2004, Pages 175-184

[11.] N. Absar & Anayet U Patwari, "Designing and Controlling of a Pick and Place Robot" proceedings of the 5th International Mechanical Engineering Conference & 10th Annual Paper Meet, The Institution of Engineers (IEB), Bangladesh, Mechanical Engineering Division, pp 211-216, 30 Sept-02 October 2005.

AUTHORS & AFFILIATION

N. A CHOWDHURY[1],
Md. Anayet Ullah PATWARI[2]

[1-2] DEPARTMENT OF MECHANICAL & CHEMICAL ENGINEERING, ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT), Board Bazar, Gazipur-1704, DHAKA, BANGLADESH

ACTA TECHNICA CORVINIENSIS
– BULLETIN of ENGINEERING
ISSN: 2067-3809 [CD-Rom, online]