Computer Controlled Robotic Arm using Mechanical Reconfigurable Blocks

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***Abstract* – This paper presents the interface between a computer and the robotic arm which is made up of mechanical blocks, by using a wireless module which causes the movement of the robotic arm as per the commands given on the computer. Robotic arms are used in lifting heavy objects and carrying out tasks that require extreme concentration and expert accuracy. This study mainly focuses on the accuracy in control mechanism of the arm while gripping and placing of objects. A design has been proposed to replicate an industrial robot arm with a reach in a three dimensional space which could pick and place objects specified. The cylindrical coordinate system consists of the three dimensional space access mechanisms. A cylindrical sector of a fixed radius and height and limited rotation is the operating domain. A two jaw angular gripper will be of use to grip the object firmly with a precise stress. The gripping precision could be defined for objects within the specified dimension of the object. The object stress is controlled. The system facilitates autonomous object detection within its limitations. Within the working frontiers, a user interface is incorporated with the system for human input feed on the desired destination. The targeted destination is specified in terms of height, radius and angle. In addition the destination can be provisioned along with the orientation of the object. The final completed project will consist of a robot arm with three degrees of freedom, computer controlled electronics, software to teach and control the arm.**

Keywords: Robotic Arm; Mechanical reconfigurable modules; Wireless module; Computer Application; Pick and Place.

I. INTRODUCTION

The roots of the concept of modular reconfigurable robots can be traced back to the “quick change” end effector and automatic tool changers in computer numerical controlled machining centres in the 1970s. Here, the end of a robotic arm could be easily swapped out with the help of a common connection mechanism using mechanical blocks or modules.

Since then the concept of modular robotics has taken birth into the development of robots which can often be reconfigured and take the shape of any other object and could be used for various applications.

Mechanical reconfigurable robots are built from modules, which are a kind of robotic cell. Each module is a simple robot containing all the on-board components required to create a robot. In addition, a module has a way of communicating with other modules and active connectors that allow it to connect to neighbouring modules and disconnect from them again. The actuators on-board allow a module to move itself with respect to connected, neighbouring modules or to move a neighbouring module. Since all the modules of the robot can do this, the robot as a whole can change its shape. This, the basic concept of changing its shape is what sets reconfigurable robots apart from all other types of robots.

II. LITERATURE REVIEW

In this chapter we are going to concentrate on the history and the types of the robotic arm and the gripper as to where it has been used before and in which field it has been utilized as per its working and applications. Also a brief description of the computer application and the wireless module has been highlighted in this chapter.

A. Review on Robotic Arm

Robotic arm is a type of mechanical arm, with similar functions to a human arm, which is usually programmable. Types of robot arms depend on their range, working capability and reach. Cartesian robot is used for pick and place work, plotting and handling arc welding. Its range is mostly 2 dimensional. Cylindrical robot operates in a cylindrical co-ordinate system, it can be used to do the operations more precisely and accurately, furthermore it also has a wider reachable range. Spherical robot works on the polar coordinate system. It has to parallel rotary joints to provide flexibility in a plane. Basically a Cartesian robot is mainly used when we are considering an application such as a pick and place application.

B. Review on Robotic Arm Gripper

Gripper is an end-of-arm device often used in material handling applications. Generally, the gripper is a device that is capable of generating enough grip force to retain an object while the robot performs a task on the part such a pick-and-place operation. Any gripper must be capable of performing the task of opening and closing with a prescribed amount of force. An angular gripper is used when there is a need to get the tooling out of the way. The advantage for an angular gripper falls on its simple design and only requires one power source for activation. A parallel gripper is used for pulling a part down inside a machine because the fingers fit into small areas better. The parallel type grippers have an advantage that the centre of the jaws does not move perpendicular to the axis of motion. Thus, once the gripper is centred on the object, it remains centred while the jaws close.

C. Review on Computer Application & Wireless Module

The computer application basically to be used is Visual Basic. Any other application as per the designer can be used. Visual Basic was designed to accommodate beginner programmers. Basic GUI applications can be made using Visual Basic. The various versions released in the past have now come down to its 6th version of its family. Visual Basic is a software application used to interface it to any hardware.

The wireless module is mostly preferred to be a ZigBee module. As a whole, ZigBee is a low-power and low-cost wireless mesh network standard. Hence the low cost allows the technology to be widely deployed in wireless control and monitoring applications and the low power usage allows longer life with smaller batteries. It is basically used for wireless communication over long distances.

III. MECHANICAL CONSTRUCTION OF THE ROBOTIC ARM

In the previous chapters we have mainly concentrated on the history and the actual meaning of reconfigurable robots. This chapter mostly concentrates on the basic building of the robotic arm and the various components and the modules that will be using for making the robotic arm. Also a separate power supply has been designed in order to boost the current required for the functioning of the servo motor as described in this chapter.

A. Servo Motors

A servo motor is a DC motor combined with some position sensing parts. Servo motors have 3 wires coming out from the motor. For power there are two lines and the third line is a control input. At the input a pulse width signal applied which tells the motor to what position it should be moved to. The internal structure of a servo motor consists of a DC motor, a gear train, limits stops and a potentiometer for position feedback. The robot axes are monitored by the robot arms using servos and its components for position and velocity. If we consider the types of servo motors there are AC servo motors as well as DC servo motors available.

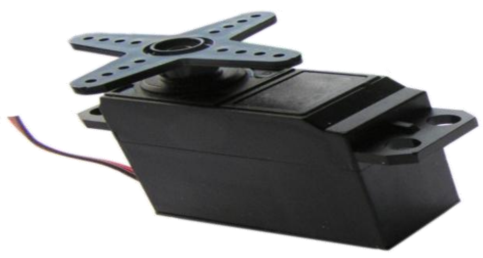

Figure 1: Servo Motor.

B. Servo Control

A pulse width modulated signal is fed through the control wire. An equivalent voltage is generated by the pulse width that is compared with that of signal from the potentiometer in an error amplifier.

The servo motor can be moved to a desired angular position by sending PWM (pulse width modulated) signals on the control wire. The language that the servo understands is that of pulse position modulation. A pulse width which is varying from 1 millisecond to 2 milliseconds in a repeated time frame is sent to the servo for around 50 times in a second. The angular position is determined by the width of the pulse.

For example, a 1 millisecond pulse moves the servo towards 0°, 2 milliseconds wide pulse would take it to 180°. The pulse width for in between angular positions can be interpolated accordingly. Thus a 1.5 milliseconds wide pulse will shift the servo to 90°.

The behavior of the servos differs based on their manufacturer. A sequence of such pulses (50 in one second) is required to be passed to the servo to sustain a particular angular position. It can retain the corresponding angular position for next 20 milliseconds when the servo receives a pulse. So the servo must be fed with a pulse in every 20 millisecond time frame.

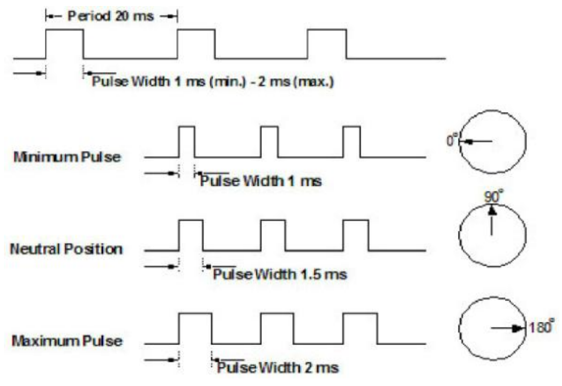

Figure 2: Servo Control Mechanism.

C. Basic Servomotor Bracket Assembly

The Servomotor is fitted into the block in the following manner. This is just the figure of one basic module. Many such modules can be interconnected to form a robotic arm.

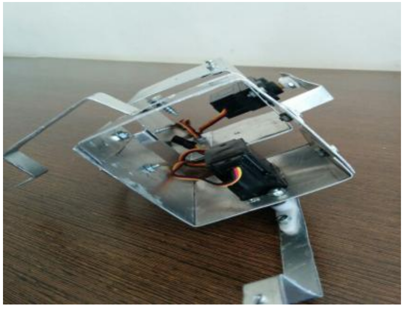

Figure 3: Servomotor module.

IV. ELECTRONIC DESIGN

A. Microcontroller Atmega16

ATmega16 is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. The Atmega16 microcontroller is based on enhanced RISC (Reduced Instruction Set Computing). They execute most of the instructions in one machine cycle. This controller can work on a maximum frequency of 16MHz. Microcontroller ATmega16 has 16 KB programmable flash memory, EEPROM of 512 Bytes, static RAM of 1 KB. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000 respectively. The microcontroller ATmega16 is a 40 pin microcontroller. It has 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD. Also ATmega16 has various in-built peripherals like USART, ADC, SPI, JTAG etc.

B. Wireless Module

ZigBee is a specification for a suite of high level communication protocols used to create a personal area networks built from small, low-power digital radios. Even though ZigBee are low-powered, these devices can transmit data over long distances by passing data through intermediate devices to reach more distant ones, creating a mesh network. ZigBee is used in applications that require only a low data rate, secure networking and long battery life. They usually have a defined rate of 250 Kbit/s, very well suited for periodic or intermittent data or a single signal transmission from a sensor or input device. ZigBee have a wide range of transmission that usually varies from 30m to up to 1km.

C. Power Supply Design

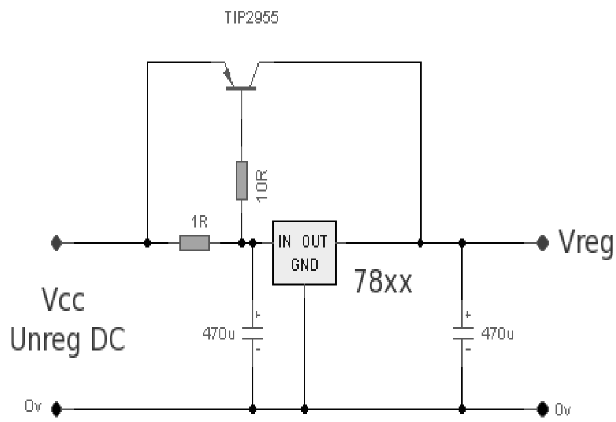

Figure 4: Power Supply Design.

The circuit shown above is the basic current booster power supply model which can be used to increase the current capacity that the servo motor requires in lifting the various modules in the robotic arm. The torque capacity of the servo motor needs more current for it to function properly and hence a power booster circuit is required for its operation.

V. SOFTWARE ARCHITECTURE

The previous chapter was all about the hardware that is going to be used. In this chapter we mainly focus on the software part related to the computer application and programming that is going to be used in the project. The application basically stands forth as the interface between the robotic arm and the computer.

A. Visual Basic

Visual Basic was designed to accommodate beginner programmers. Both simple and complex GUI applications can be created. A programmer can develop a simple program without writing much code. Visual Basic provides many interesting sets of tools in building exciting applications. It's simple language. Things that may be difficult to program with other language can be done in Visual Basic very easily. The answers to your programming problems can be found out much more easily than other programming languages. In comparison to other languages, Visual Basic has the widest variety of tools that you can download on the internet and use in your programs.

B. Visual Basic Computer Application

In our project we basically use visual basic to develop a GUI based application which we will be using to interface the robotic arm with the computer. The front panel of our project is made through the normal drag and drop buttons that are available in the panels available in visual basic. The figure shown below is the basic visual basic pop up screen that opens once you open visual basic software.

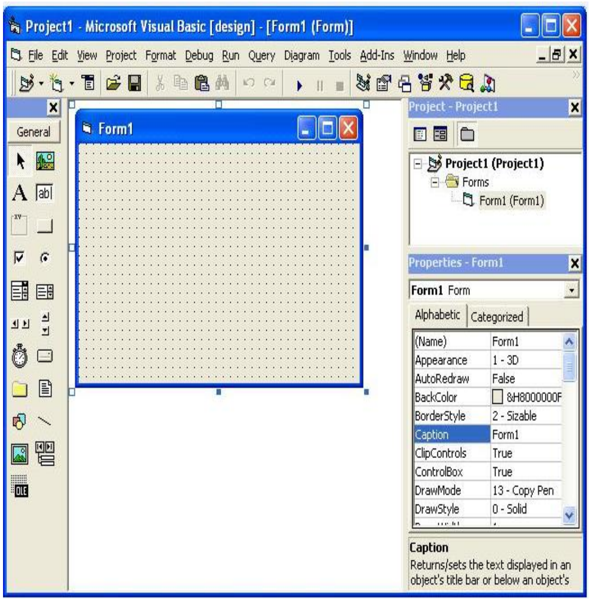

Figure 5: Visual Basic Software.

The Form1 block shown in the above figure is the window where you drag and drop the various icons or boxes that are needed to build your application. One such example is shown in figure below.

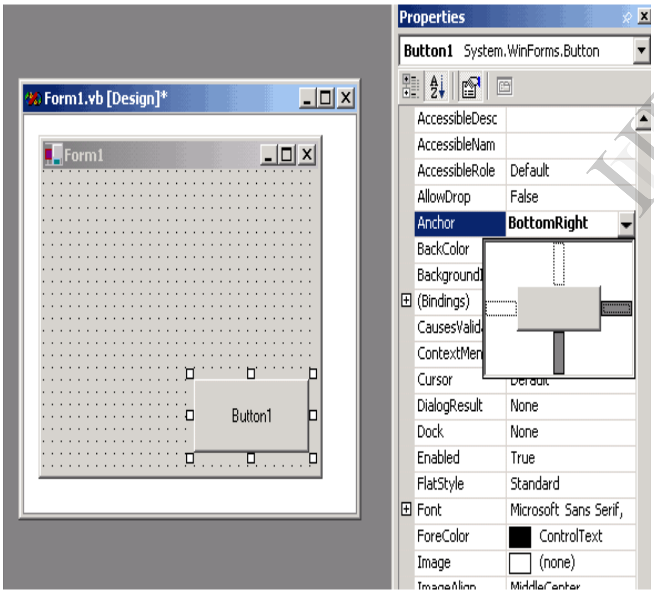

Figure 6: Form1 Window.

The Button1 box is dragged and dropped onto the Form1 window as shown in the figure above. In the same manner various icons can be dragged and dropped to form the application you want to create.

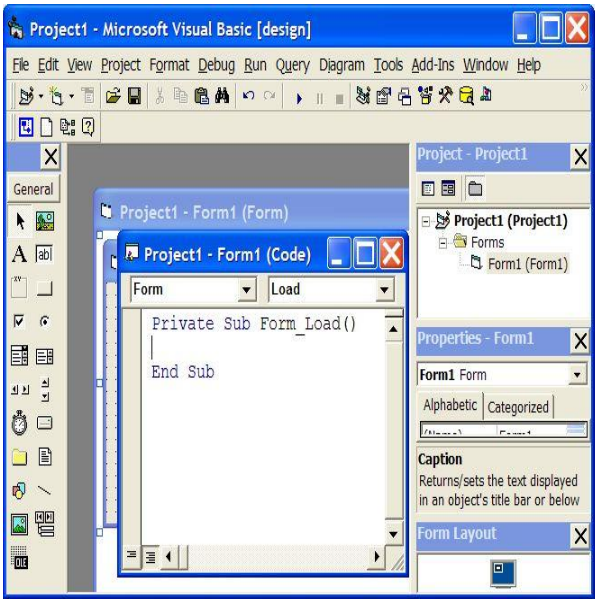

Figure 7: Form1 (Code) Window.

The code for visual basic is designed as per the single click or double clicks or the variations that are available in the coding process. The coding is the basic visual basic coding used and it is typed in the Form1 (code) window as shown in the fig. 7. These all windows play an important role in development of the actual application that will be required in our project. The actual application build for the interface between the robotic arm and the computer is as shown in the figure below.

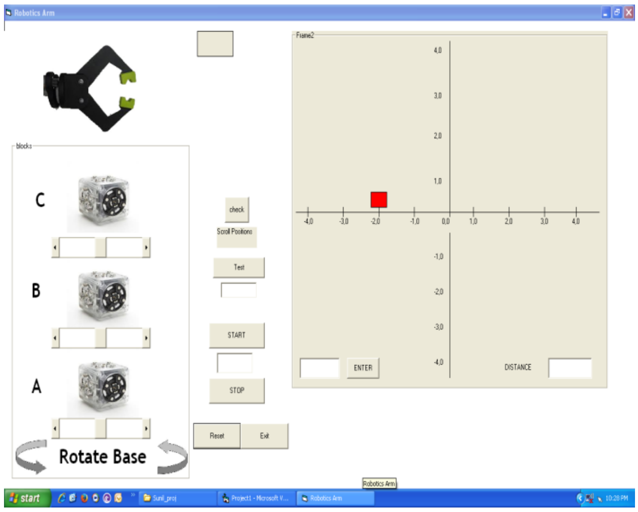

Figure 8: Visual Basic Application.

In the above figure we see three blocks named A, B, and C that have been placed in the form of a robotic arm. There is a gripper attached at the top to complete the design of the arm. Just next to the arm we see blocks such as START, STOP, RESET and EXIT. These blocks have been programmed in such a way as to control the functioning and movement of the robotic arm. On the extreme right hand side is the (x,y) co-ordinates that have been plotted with the red box denoted as an object. Considering the robotic arm to be at the initial position (0,0), the work of the robotic arm is to calculate the distance at which the obstacle is placed and pick it from that position and place it to another position. The pick and place co-ordinates will be defined in the visual basic application itself. If at some instant the pick co-ordinates are given too far and the robotic arm cannot reach the obstacle, the application created will then calculate the distance and then decide how many more blocks will be required to pick and place it to its destination. Another figure is shown below in which the object is placed at another position.

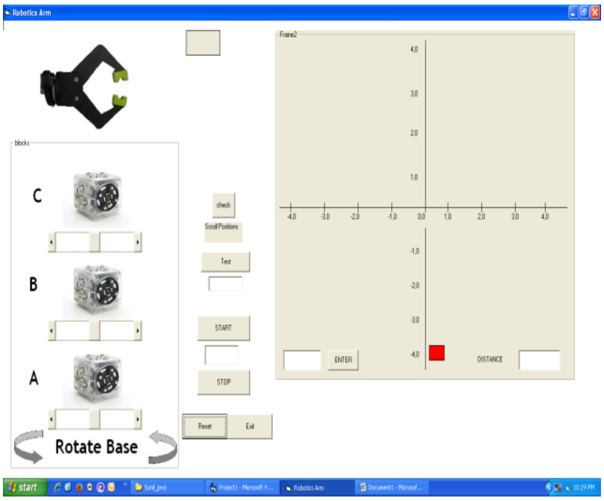

Figure 9: Visual Basic Application(1).

VI. FUTURE WORK AND CONCLUSIONS

In our project we have noticed a lot of current is required for the operation of the servo motor as the base servo requires a lot of torque capacity and hence the current increases. Servo motors having maximum torque capacity can be used which will help in the proper functioning and movement of the robotic arm. Instead of giving the co-ordinates of the object to pick and place it, a wireless camera could be attached to the gripper to detect the object and further pick and place it. Arduino UNO boards can be used for the same project to enhance its working even more.

Our project has successfully been simulated and the results have been obtained. We have constructed a robotic arm using mechanical modules and interfaced it wirelessly to a computer by creating an application on visual basic. Hence commands on the application causes the movement and the functionality of the robotic arm.

VII. RESULTS

The following figure shown below is the robotic arm that has been made by using separate modules. Each servo motor has been attached to each module which causes the motion of the neighbouring modules by the servomechanism. The gripper shown above the robotic arm is basically used for the pick and place application. The software architecture has been described in the fifth chapter along with the respective figures based on the application.

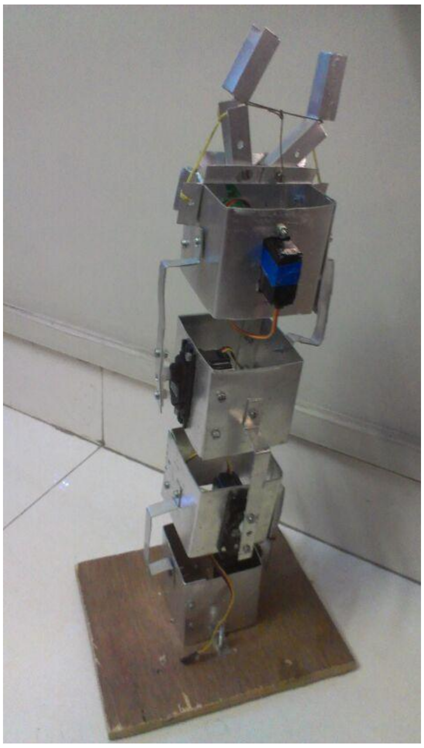
Figure 10: Robotic Arm

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