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Performance Analysis of Optimized Robotic Arm

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Abstract: Today technology is developing in the same direction in line with rapidly increasing human needs. The work done in order to meet these needs makes life easier every day, and these studies are mainly concentrated in Automation. The aim is to reduce human efforts and increase the efficiency is the primary objective of the renewed interest in this domain. This would be possible by adopting Robotics at the industrial level in large scale to achieve maximum success. The machines can perform repetitive work with better efficiency when compared to humans. Moreover the machines can work round the clock without any problems and achieve the desired targets. They can also help us performing jobs which are detrimental to human lives. In this paper, we would be concentrating on the Robot Arm, which can be controlled by an outside user or perform predetermined commands. The controlling would be possible with the help of Bluetooth Module or Joystick. The movement of the Robotic Arm would be supported by Dc Motors& DPDT switches. It is controlled by Aurdino Uno microcontroller & Stepper Motor MG995 as the heart of the project.
Keywords: Robotic Arm, Joystick, Aurdino Uno, Stepper Motor MG995, Robotic Gripper

Introduction

Robotics deals with the design, construction, & operation of machines which can replicate human work with better efficiency. It has gained importance in the modern era since it requires less cost to operate than a human labor to perform the same task; also once programmed robotic machine would perform better than human labour. There are many different versions of robotics being developed based on the need of the industry [1]. The Industries which are upgrading to Robotics includes Automobiles, Manufacturing, HealthCare, Construction and many more. Time and man force are the main constrains for completion of task in large scales, automation is playing an important role to save human efforts in most of the frequently carried works e.g. most of the industrial jobs like assembly, welding, container filling painting, etc [2]. The industries are turning towards computer based monitoring of tasks mainly due to the need for the increased productivity and delivery of the final products with maximum quality and efficiency. This leads to better profit margin and helps in overall survival in the market by capturing a large chuck of the market share.

But due to high cost of Industrial Robots, SME(s) are not able to procure and develop in this throat-cutting competition. This has led to many SME(s) bleeding in market and ultimately losing to those with better technology and deep pockets [3].

Thus we are introducing a robotic arm which is capable of picking up and placing the objects, which would allow the SME(s) to adapt to the technology at Low cost. The arm would be controlled via Aurdino Uno board with Stepper Motors MG995.The stepper motors would provide a hundred and eighty & 360 degree of rotation so the Robotic Arm will rotate freely and work in the X, Y, Z plane. The catching gripper would handle the objects fine according the requirement of the buyer [4]. The Module may be controlled via joystick. The project would be mobile in nature and can be supported by DC Motors (4x). So supported the user commands the Robotic Arm would move around and choose of the target and griping would be done via gripper and place it at the desired location [5].

Thus, the use of Robotic Arm would lead to better efficiency and increased output of SME(s) & help them integrate with advance technology.

Objectives

The Main objectives of this paper is to design & Implement a low cost Robotic Arm which is mobile in nature and is capable of performing tasks which are

- Repetitive in nature.
- Hazardous to Human Life.
- Need high precision and accuracy.

Thus this would enable Small Medium Enterprise SME(s) to increase their efficiency & integrate technology with their main stream work, leading to better quality of end-products & reduction of overall cost.

Proposed System

We have designed a mobile robotic arm which is divided into two portions independent of each other. The upper Portion is the Robotic Arm which is responsible for picking, grabbing and placing the object, whereas the lower potion i.e. Mobility Structure is responsible for the movement of the entire structure.

We would first discuss regarding the upper portion, i.e. The Robotic Arm. It consists of 4 servo motors (MG995) which is a metal servo motor providing a torque of 10kg/cm and has 4 joints, thus 1 servo for each joint. These are controlled via Aurdino Uno microcontroller and powered by a 5V DC supply. The base servo motor (1) is responsible for base movement, it gives overall 360 movement for the entire Arm to rotate. The Servo motor (2) is responsible for the movement in the vertical axis, i.e. the Y axis to reach the precise point. The Servo Motor(3) is responsible for the movement in the Horizontal Axis i.e. the X axis to reach the object. The (2) & (3) servo motors help to reach the exact location of the object in the X&Y Co-Ordinate System. The Servo Motor(4) is responsible for the working of the Gripper. Its main objective is to catch the object & release it on the completion of task . The user controls the full movement of the entire task with the help of a Joystick (PS2). The Press movement is responsible for the Catching & dropping of the object.
The lower portion i.e. The Robotic Car consist of 4 DC motors of 200 RPM producing a torque of 2kg/cm. The DC motors are fitted into a metal frame board and are in contact with wheels. They are powered by a 12V DC Battery for the overall movement of the structure. They are controlled by 2 simple DPDT switches. When DPDT switch (1) & DPDT switch (2) are pressed forward, than the Motors are supplied with forward current leading to motion in forward direction. When the same is pressed in reverse direction, reverse current leads to reverse direction movement. For the left turn the DPDT switch (1) gives reverse current to DC Motor (1) & (3) and DC Motor (2) & (4) is given Forward current for forward Motion. For the right turn, vice versa is done

Hardware Required

A. Arduino Uno

The Arduino UNO is associate open-source microcontroller board supported the semiconductor device ATmega328P microcontroller and developed by Arduino. The board is supplied with sets of digital and analog input/output (I/O) pins which will be interfaced to varied enlargement boards (shields) and alternative circuits. The board has fourteen Digital pins, half dozen Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a kind B USB cable. It may be power-driven by a USB cable or by an external 9-volt battery, although it accepts voltages between seven and twenty volts. It is also similar to the Arduino boards like Leonardo& Nano. The hardware redesign is distributed under Creative Commons 2.5 license and is made available on the Arduino website. (Figure 1)

B. Stepper Motor (MG995)

A servomotor is a mechanism for the positional actuator or linear actuator that permits for precise management of angular or linear position, rate, and acceleration. It consists of an acceptable motor coupled to a detector for position feedback. It additionally needs a comparatively refined controller, usually an avid module designed specifically to be used with servomotors. Servomotors don't seem to be a particular category of the motor though the term servomotor is usually accustomed with a motor appropriate to be used in an exceedingly closed-loop system.
The TowerPro MG995 Metal Gear Servo Motor Weights around 55 gm with an operating voltage in the range of 4.8V to 7.2V. It has a Stall torque at 4.8V per 10 kg-cm, It increases to 12kg-cm for 6.6V.
The inbuilt gears are made of metal thus giving extra torque and better than other models. (Figure 2)

C. Joystick (PS2)

This is JoyStick Module PS2 sensor very the same as the ‘analog’ joysticks on PS2 (PlayStation 2) controllers. Directional movements are merely 2 potentiometers – one for every axis. Pots are ~10k each. This joystick additionally encompasses a choose button that's actuated once the joystick is depressed.
The X and Y axes unit are two 10k potentiometers that control 2nd movement by generating analog signals. once the module is in operating mode, it'll output 2 analog values, representing 2 directions. This module uses the 5V power provide, and value, once reading through analog input, would be regarding a pair of.5V, a value can increase with joystick movement go up until most 5V; the value will decrease once the joystick is enraptured in a different direction until 0V. (Figure 3)

D. 200 RPM Geared Motor

A DC motor a category of rotary electrical machines that converts electricity (direct current) current into energy. the foremost common varieties accept the forces made by magnetic fields. Nearly all sorts of DC motors have some internal mechanism, either mechanical device or electronic, to periodically amendment the direction of current flow partially of the motor.DC motors were the primary type wide used, since they might be power-driven from existing direct-current lighting power distribution systems
The 200 RPM motor used here, has a 2kgcm torque, which is used to move the entire body to make it mobile. (Figure 4)

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E. DPDT Switch

A switch is an electrical part that may "make" or "break" an circuit, interrupting the current or diverting it from one conductor to a different. The mechanism of a switch removes or restores the conducting path during a circuit once it's operated. It's going to be operated manually, or could also be operated by some sensor for pressure, temperature or flow. A switch can have one or a lot of sets of contacts, which can operate at the same time, consecutive, or alternately. Switches in high-powered circuits should operate quickly to stop harmful arcing and will embrace special features to help in rapidly interrupting a heavy current.

DPDT Switch is comparable to 2 SPDT switches controlled by one mechanism. (Figure 5)

F. Breadboard

A breadboard is a solder less device for a temporary model with electronics and checks circuit designs. Most electronic elements in electronic circuits are often interconnected by inserting their leads or terminals into the holes then creating connections through wires wherever applicable. The breadboard has strips of metal beneath the board and connects the holes on the top of the board. The top and bottom rows of holes are connected horizontally and split within the middle whereas the remaining holes are connected vertically. (Figure 6)

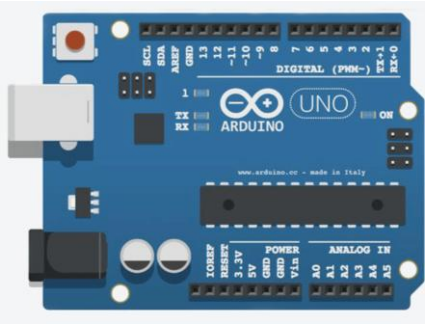

Figure 1. Arduino Uno Board

Figure 2. Stepper Motor

Figure 3. Joy Stick

Figure 4. 200 RPM Geared Motor

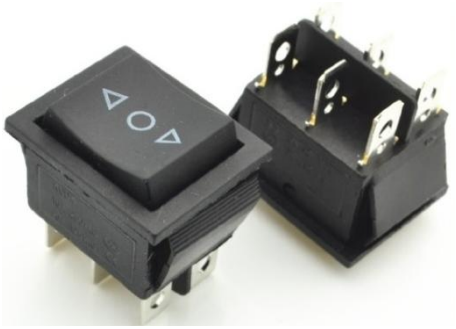

Figure 5. DPDT Switch

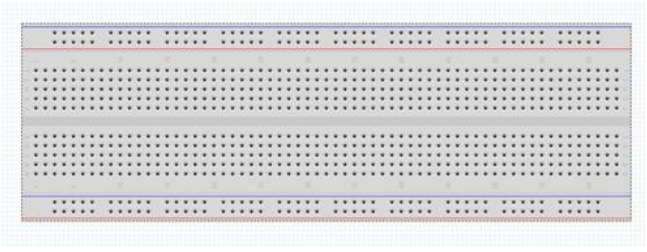

Figure 6. Bread Board

Actual Implementation

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According to block diagram, the different portions along with their respective connections are shown in figure 7. The upper portion represents the robotic arm. The components used are Arduino uno board, jumpers (MM,MF,FF), joystick(PS2) & external supply of 5V . Now talking about servo motors they are excessively used when there is a need for a accurate shaft movement or position. These are not proposed for a high speed applications. Servo motors are proposed for low speed, medium torque and accurate position application. So they are best for designing robotic arm.. We are going to use metal servo motors (four). A servo motor will have mainly three wires positive voltage another is for ground and the last one is for position setting. The RED wire is connected to power, the brown wire is grounded and the orange wire is for signal.

The steps taken are –

1. The arm has been designed with wood and also the individual components are bolted to servo motors. Arduino Uno is programmed to regulate servo motors. Servos motors are acting as joints of Robotic arm here. This setup appearance a sort of a Robotic Crane or we will convert it into a Crane by simple ways.
2. This Robotic Arm is controlled Joystick(PS2) .We can move these servos by rotating the joystick to choose some object, with some apply we will simply decide and move the item from one place to a different. Here we have a tendency to use low force servos here however we will use a lot of powerful servos to choose significant object.
3. Program done using Arduino 1.6.10.
4. We connect the circuit according to circuit diagram. (Figure 7)
5. With the help of joystick different Servo Motors are controlled accordingly.
   - The Base(1) , The mediator-Y axis(2) & angle setter X-Axis(3) is set by X & Y coordinates of the joystick.
   - The last servo motor (4) is controlled with the help of pressing the joystick.
6. The Mobility Structure is also shown in the block diagram. (Figure 8)
7. The Lower portion is controlled by DPDT switch and the 200 RPM motors are powered by 12V battery.
8. The DPDT Switch (1) Controls 1 & 3 DC Motor & DPDT Switch (2) controls 2 & 4 DC Motors.
9. The forward current is responsible for forward movement & reverse current is responsible for backward Movement of the DC motors.
10. For the left turn the DPDT switch (1) gives reverse current to DC Motor (1) & (3) and DC Motor (2) & (4) is given Forward current for forward Motion. For the right turn, vice versa is done.

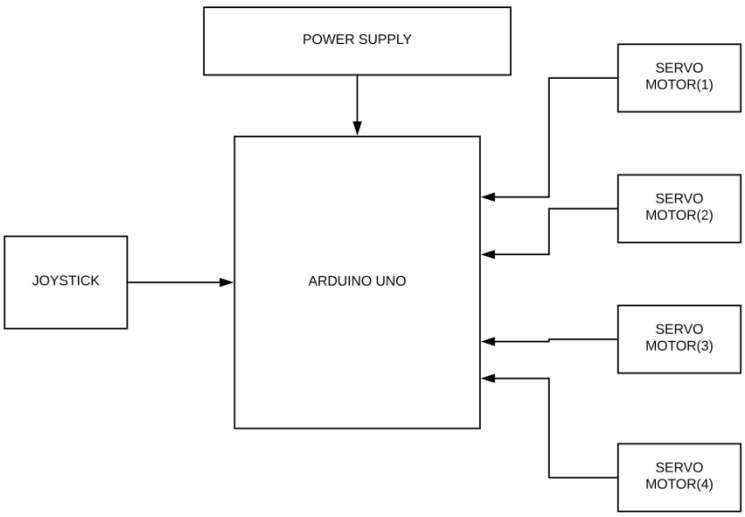

Figure 7. System Block Diagram

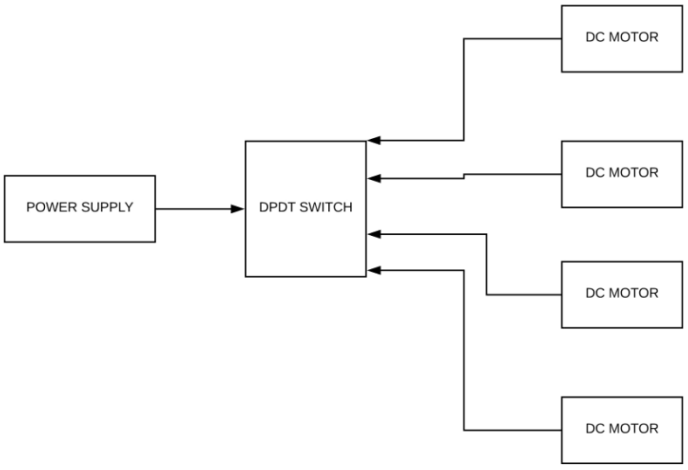

Figure 8. Mobility Structure

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Software Simulation

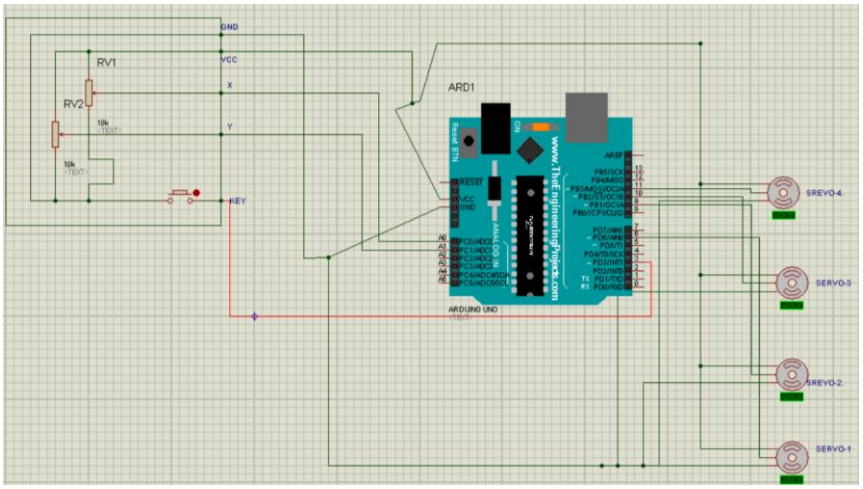


Figure 9. Actual Circuit Diagram

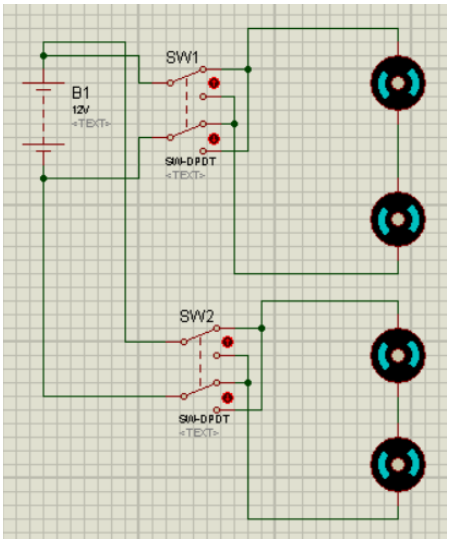


Figure 10. Stepper Motor Section

Calculation of Torque

Torque means measurement of the amount of force that is acting on an object reasons that object to rotate.

Torque T=Force*Len …… …….. (1)

Where "T" is torque&"force" and "Len" is denoted the length from a join endt. The force is accelerating on an object due to gravity (g = 9.81m/s2) multiplied by its mass.

Force=M*g ……..…….. (2)

Mass (M) and gravity (g) The force (F) is also considered of an object's weight of the overall structure (W)

W = M*g……..……..…… (3)

The torque required to hold a mass at a given distance from a joint end is shown therefore

T = (M*g)*L…….…..... (4)

The length L is the perpendicular length from a joint end to the force. This equation can found by similar doing a torque balance about a joint end point.

∑T = 0 = F*L – T……... (5)

Therefore, changing the force (F) into mass and gravity (m*g) we find out the similar equation above. This is the more accurate & best possible way to find out the torque by using the torque balance technique. This is needed to satisfy and make the robotic arm stable.

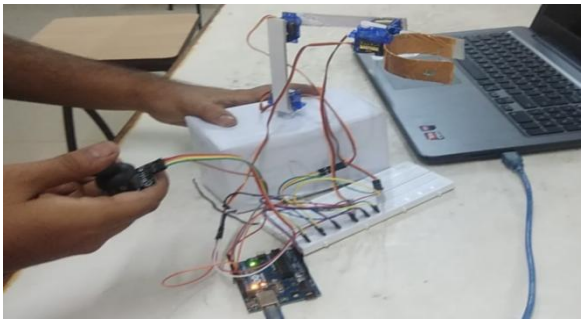
M*g*Len = TA ……..... (6)

The torque required at the first joint end is therefore.

T1 = (Len)1*A1+(Len)1*W1 ("A" is weight of the actuator or the load.) …….……..... (7)

Conclusion

Automation has reached to every corner of the world, but due to high cost it still hasn't reached to the ground level, thus leading lack of exposure to the SME(s) and wastage of man hours performing in repetitive work. The paper illustrates on designing and implementation of an inexpensive mobile robotic arm which would allow the SME(s) to adopt the technology and help in turning repetitive and life threatening work into automated process. This would also increase the speed of manufacturing and eliminate error percentage in the overall process. Thus with usage of Aurdino Uno Microcontroller with MG995 stepper motors along with 200 RPM DC motors controlled Via Joystick(PS2) & DPDT switches the Small industries will be equipped with cutting – edge technology.



Future Enhancement

Future enhancement can include further improvement that is by adding 360 degree rotary servo motor and making it more stable. Setup can be modified that will pick more weight compared to present model. Ultrasonic sensor can even be placed on the arm so that it can detect and simultaneously pick the object and keep it on other place.

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