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Design and Development of a Cost Effective Robot for Academics and Small Industries

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Abstract:The current trends in technology development are indicating that robotics, automation and internet of things are going to take central place in our society, workplace and households. Still, a large section of population is not conversant with the usage, design and development of robotic system for various activities. The high cost of such devices is the major hindrance in making the robots and robotics technology available to larger section of society, industry and academics. In order to address the above issue of availability of cheap robotic system for them, we had initiated the effort to design cost effective open source robotic system. The main focus of this work to design, development and fabrication of intelligent robotic arm can accomplish predefined task accurately. The robot is designed to work in Arduino platform and actuated by servo drives. The motivation behind designing of this robot is to provide school, colleges and small industries of Chhattisgarh to adopt robotics and automation for education and production. The robot was designed with 4-degree of freedom and well tested, further modification and improvements are being implemented to perform more complicated and precise task in all condition. Testing and validation of the robot was carried out and results shows that it work properly.

Keywords: *Low-Cost, Design, PWM Signal, Four Degrees of Freedom, Servo Motors, Arduino.*

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I. Introduction

A Robot is a programmable agent capable of performing predefined tasks. Practically, a robot is basically an electromechanical machine which can perform task as instructed by computer or electronic coding. There is wide variety of robot are available according to design and applications like manual, autonomous, semi autonomous and remotely controlled [1]. The Robotic arm (also referred as robotic manipulator) is the part of robot mainly used to carry out highly precise repetitive, defence surveillance and material handling etc. Now a days robot are designed to work in all unfavourable condition where human involvement in dangerous and risky. The robots interact with their environment, which is an important objective in the development of robot [2]. The interaction is done by means by arm; the arm has joints, similar to a human arm, in addition to shoulder, elbow and wrist, coupled with the finger joints [3]. In this work a prototype of an Arduino controlled robotic arm is designed and fabricated. A self sufficient prototype robot is fabricated using many cheap materials like scrap wooden pieces; controller and servo drives. The brain of this design is Arduino Uno controller.

System Design

The mechanical design of the robot is designed in Solidworks; solidworks is a solid modeling computer-aided design and computer-aided engineering computer program. The robotic arm is designed using the Microcontroller atmega328p using Arduino programming. The block diagram of major controlling system is depicted in figure1. It indicates the various PWM signal and power supply connections of different electronics and actuating components. This system basically consist of four servo drives to provide necessary precise control to different links by which arms can in required direction. The main reason behind selecting the servo drives in this work is to give high torque while starting and running, also servo drives have feedback system which gives more precision and accuracy to movement of links. The servo drive is a three terminal device in which two terminals are dedicated for DC power supply as it is a DC servo and one terminal for PWM Signal. The speed and degree of rotation of servo is totally depends of the PWM pulse given by Arduino board. It means that by controlling the PWM signal given Arduino board we can control the motion of servo drives as per the requirement. The Arduino board is also needs DC power supply for its own operation but power consumption is very less. The controlling of PWM signals are one by Arduino programming. Here four servo PWM signal terminals are attached to four different pins of Arduino board which are controlled individually through programming. The technical specifications of microcontroller board and servo drives are given in table-1 and table-2.

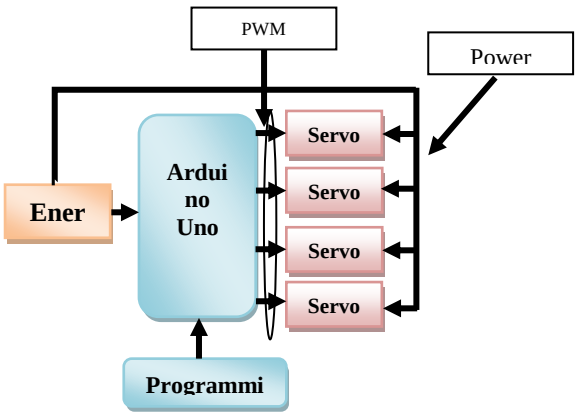

Fig 1: Block diagram of Robot

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All the links are made of scrap wooden blocks as it is our prototype model. Here exploded view of prototype model is shown in figure-4.

Weight	55 g
Dimension	40.7 x 19.7 x 42.9 mm approx.
Stall torque	8.5 kgf·cm (4.8 V), 10 kgf·cm (6 V)
Operating speed	0.2 s/60º (4.8 V), 0.16 s/60º (6 V)
Operating voltage	4.8 V a 7.2 V
Dead band width	5 µs
Temperature range	0°C – 55°C

The kinematic diagram of the design is shown in figure-2, which indicates simplest movable linkage. The flow chart of Arduino programming shown in figure-3, which indicates various loop functions to control the servo drives for a specific task. Currently it is showing for pick and place operation of robot.

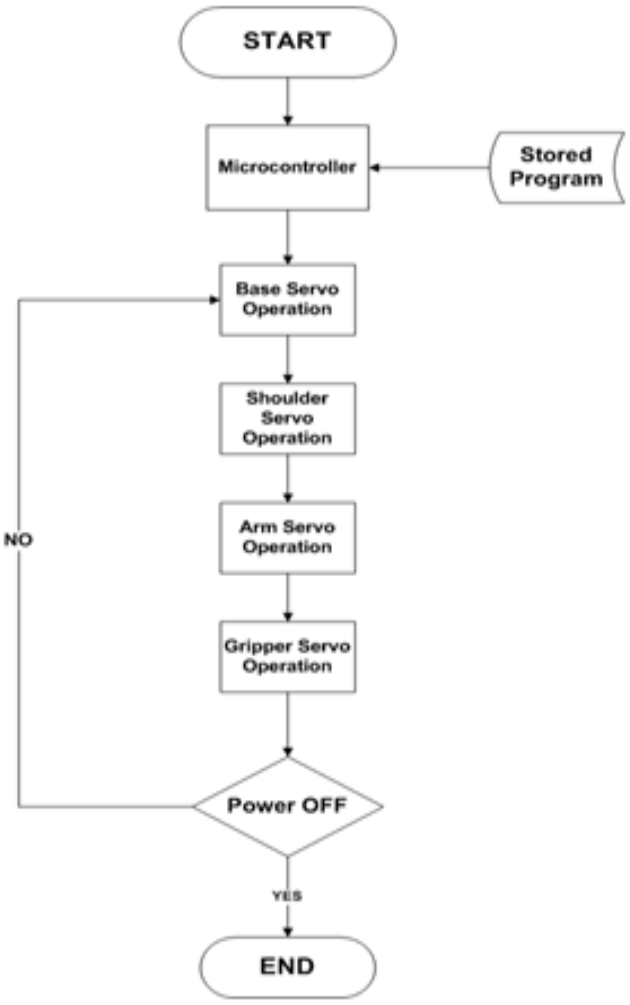
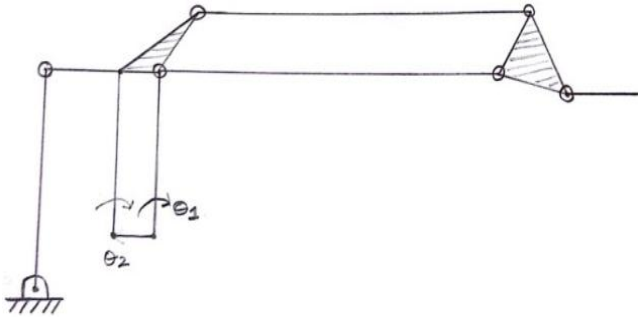


Fig 3: Flow Chart of Arduino Programme

Double four bar

The mechanical modelling of prototype is designed in Solidworks. As in exploded view all the links, bearings, servo motors and base are shown. This robot works on four bar mechanism. The end effecter (gripper in our case) also driven by micro servo drive (tower pro SG92R). Here total mechanical load rest on bearings which reduces the stress on base servo drive.



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Microcontroller	Atmega328p
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 ma
Flash Memory	32 KB (atmega328p) of which 0.5 KB used by bootloader
SRAM	2 KB (atmega328p)
EEPROM	1 KB (atmega328p)
Clock Speed	16 mhz

II. Observations And Results

The full view of robot is illustrated in figure-5 which was developed with the help of Solidworks. A servo driven gripper was attached to the wrist of the robot which plays the role of end effecter. The gripper can move up to 90°. It is a four-axis robot as three servo drives provide angular motion to links. The end effecter can also be replaced by suction cup, cleaning wipers, spinner and welding torch etc. The payload capacity of this robot is 300 gm. The maximum horizontal reach is 300mm from centre of robot and maximum vertical reach is 55mm. It can cover 942mm to about periphery of robot axis.

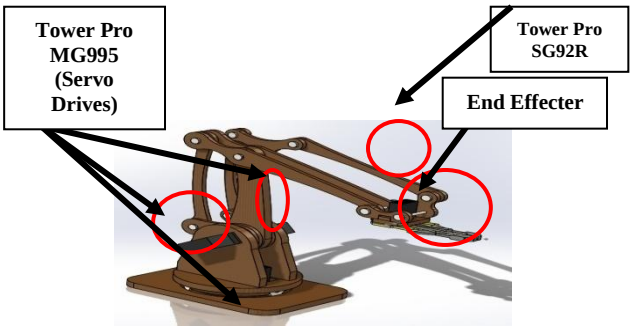

Fig 5: Solidworks View of Robot

Fig 6: Fabricated model of Robot

III. Discussion

This paper presents the design, development of implementation of Arduino controller robotic arm, which has capability to handle repetitive tasks, such as material handling from one place to another. The robotic arm was designed and built from wooden blocks where servo drives links between arms and execute arm movement in accordance with Arduino programming. Here all servos have rotation limitation of less than 180° span, which decrease the arm expansion and movement. It was limited three degrees of freedom since design allows most of the necessary motion and keeps cost and complexity of robot competitively.

Several tests were carried out to validate the performance of robotic arm where the test covers both the particular link and servo drive to overall system. All test results indicate that it is suitable for small scale industries of Chhattisgarh.

IV. Conclusion

The cost effective design of robot works satisfactorily. It is tested in various operating conditions and found that 3mm to 4mm positional error while motion, which needs further attention. As it is made of scrap wooden block, can also be made by perspex acrylic sheet that will provide precision upto greater extend and visual appearance will also be improved. The block language programming is also need to develop for this robot to achieve simplest working environment.

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