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DESIGN OF ROBOTIC ARM WITH MECHANICAL SENSING TECHNIQUE

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Abstract

The main objective of this project is to construct a robotic arm based on the design made on the software (Solidworks) and program it in such a way that it could work on its own by searching the material on the table and then revert the response to its microcontroller which would than give the commands to the respective servo motors as per the demand based on program made by the programmers via arduinos. Other than the above objectives it could further be used as to demonstrate how the robotic arm is working in factories and industries to carry out different work and processes, therefore making it very useful for educational purposes. Robots are combinations of manipulators, actuators and shafts. To reduce the human effort in industries and to function in critical areas robots\robot arm is used. It is designed to work in programmable mode in accurate time for different works like gripping, welding, pick and place etc., in major industries in order to reduce the human effort. The present work here is to design of robotic arm along with manipulators (for rotational and translation) byusing SOLIDWORKS 2014.

Keywords: *Robotic arm, Controller, gripper.*

I. INTRODUCTION

Evolution of Robot in word 'robot' is derived from the Czechoslovakian term robot which is generally translated as forced labour. This means that the original conception of a robot, as far the etymology of the word is concerned, was to be a capable servant. It was first used in the play by theet.al [1] Czechoslovakian author Karel Capek entitled R.U.R. (Rossum's Universal Robots). In the play, robots were portrayed as small, artificial and anthropomorphic creatures strictly obeying their master's orders. From this humble conception, many authors began getting inspirations from the concept of a robot. A robot may not injure humanity, or through inaction, allow humanity to come to harm.A robot may not injure or harm a human being, or through inaction, allow a human being to come to harm.A robot must obey orders given to it by human beings, except where such orders would conflict the 0th or 1st law.

- A robot must protect its own existence as long as such protection does not conflict with the previous laws. As time passed, people began formulating an encompassing definition of a robot. As currently defined, robots exhibit three key elements:
- Programmability, implying computational or symbolic manipulative capabilities that a designer can combine as desired (a robot is a computer)
- Mechanical capability, enabling it to act on its environment rather than merely function as a data processing or a computational device (a robot is a machine).
- Flexibility in that it can operate using a range of programs and manipulates transport materials in a variety of ways. This kind of description does not sway too far from what really most robots in the world are doing. Most robots used nowadays are designed for heavy, repetitive manufacturing work. They are specifically designed to handle certain tasks that are difficult, dangerous, or to boring to human beings. Robots can do more work more efficiently than humans can since robots are precise. They always do the same task with such precision over and over no matter how long they have worked. Robots nowadays are becoming more and more important in most industries of the world.

Mohd Ashiq Kamaril Yusoffa, Reza Ezuan Saminb [2] the most common of all these manufacturing robots is the robot arm. A typical robot arm is made up of seven segments joined by six joints. Usually a servo motor is used in

order to track the movement of the robot arm. The reason for this is quite obvious since servo motors are designed to move in exact increments unlike DC motors. With such configurations, a computer may be able to control or manoeuvre the robot very precisely, repeating exactly the same environment over and over again.

Six degrees of freedom (6DoF) refers toFirst Degree: Shoulder Pitch Point your entire arm straight out in front of you. Move your shoulder up and down. The up and down movement of the shoulder is called the shoulder pitch. Second Degree: Arm Yaw Point your entire arm straight out in front of you. Move your entire arm from side to side. This side to side movement is called the arm yaw. Third Degree: Shoulder roll Point your entire arm straight out in front of you. Now, roll your entire arm from the shoulder, as if you were screwing in a light bulb. This rotating movement is called a shoulder roll. Fourth Degree: Elbow Pitch Point your entire arm straight out in front of you. Hold your arm still, and then bend only your elbow. Your elbow can move up and down. This up and down movement of the shoulder is called the shoulder pitch. Fifth Degree: Wrist Pitch Point your entire arm straight out in front of you. Without moving your shoulder or elbow, flex your wrist up and down. This up and down movement of the wrist is called the wrist pitch. Sixth Degree: Wrist Yaw Point your entire arm straight out in front of you. Without moving your shoulder or elbow, flex your wrist from side to side. The side to side movement is called the wrist yaw. Six degrees of freedom: Six degrees of freedom (6DoF) refers to the freedom of movement of a rigid body inthree-dimensional space. Specifically, the body is free tomove forward/backward, up/down, left/right (translationin three perpendicular axes) combined with rotationabout three perpendicular axes, often termed pitch androll.

Moving up and down (heaving);Moving left and right (swaying);Moving forward and backward (surging);
Rotation:Tilting forward and backward(pitching)Turning left and right (yawing)Tilting side to side (rolling)
Rotation:Tilting forward and backward(pitching)Turning left and right (yawing)Tilting side to side (rolling)

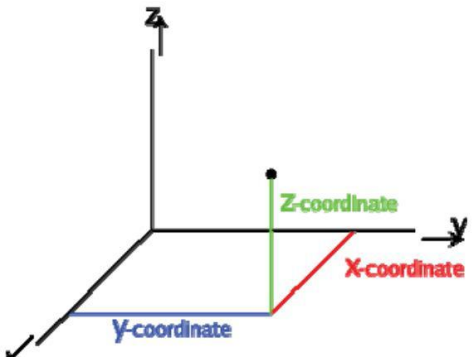

Fig 1.1: Coordinates

The axes of machines are always defined by what isknown as the right-hand rule. If we take the thumb aspointing in the direction of the positive X-Axis then thesecond finger is pointing towards the positive Y-Axis andthe middle finger towards the positive Z-Axis. The Z axis isalways in the direction of the spindle or grab arm asshown in the 'Cartesian Robot' below.

There are:
1. Cortisone robots2.Cylindrical robots 3. Spherical or polar robots
1**. Cartesian robots**: Cartesian robots are used for pick andplace work, application of sealant, assembly operations,handling machine tools and arc welding. It's a robotwhose arm has three prismatic joints, whose axes arecoincidental with the Cartesian coordinators.

2. Cylindrical robots: Cylinder robots are used in assemblyoperations, handling of machine tools, spot welding andhandling at die cast machines. They also have many usesin medical testing. The example below has two prismatic\ joints and one rotary joint. A Cylindrical robot is able torotate along its main axes forming a cylindrical shape.

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3.Spherical orPolar Robots:
Spherical or Polar Robots combine rotational movementswith single linear movements of the arm. The polar robotis sometimes referred to as the gun turret configuration. They are generally used in many welding applicationsmainly spot, gas and arc. Polar robots are extremelysuitable for reaching into horizontal or inclined tunnels.

Introduction to Solidworks
Solid works mechanical design automation software is afeature-based, parametric solid modeling design toolwhich advantage of the easy to learn windows TMgraphical user interface. We can create fully associate 3-Dsolid models with or without while utilizing automatic oruserdefined relations to capture design intent.Parameters refer to constraints whose values determinethe shape or geometry of the model or assembly.Parameters can be either numeric parameters, such asline lengths or circle diameters, or geometric parameters,such as tangent, parallel, concentric, horizontal or vertical,etc. Numeric parameters can be associated with each other through the use of relations, which allow them tocapture design intent.

II. STUDY OF EXPERIMENTS

2.1 Electrical Components
Ref by [3]Arduino UNO R3- Arduino Uno R3 is an open source microcontroller board based on theATmega328 chip. This Board has 14 digital input/output pins, 6 analog inputpins, Onboard 16 MHz ceramic resonator, Port for USB connection, Onboard DC powerjack, An ICSP header and a microcontroller reset button. It contains everything needed tosupport the microcontroller. Using the board is also very easy, simply connect it to acomputer with a USB cable or power it with DC adapter or battery to get started.

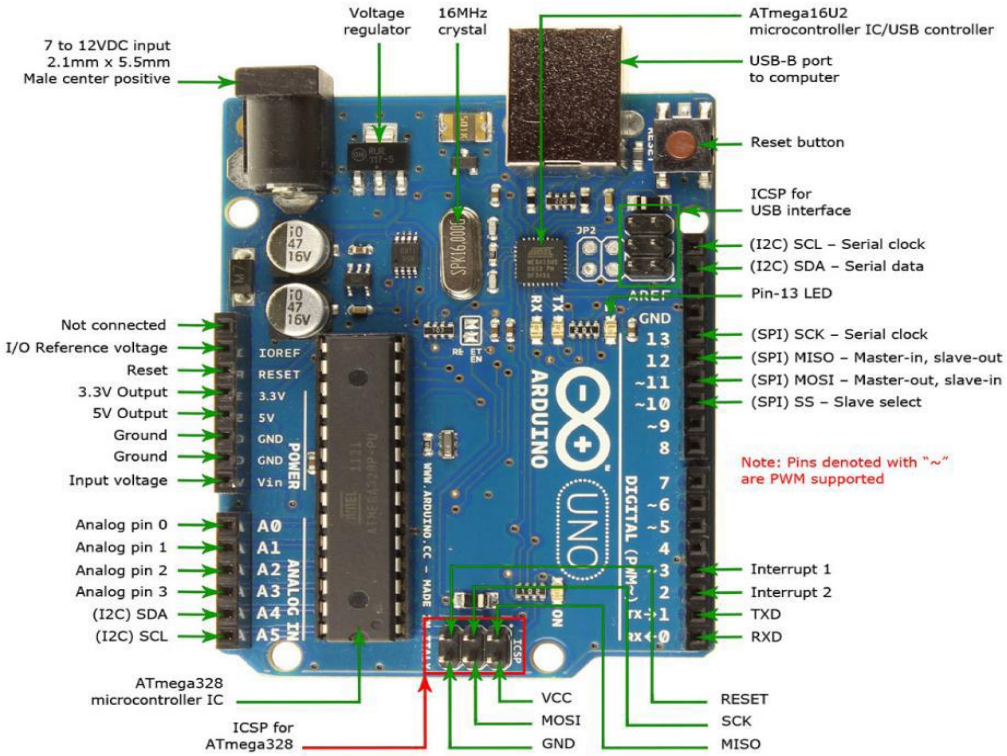

Fig 2.1: Arduino Uno r3 Board

Avinash Jain [4]*ATMEGA 328 MICROCONTROLLER*- the ATmega328 is a singlechipmicrocontroller created by Atmel in the megaAVR family.

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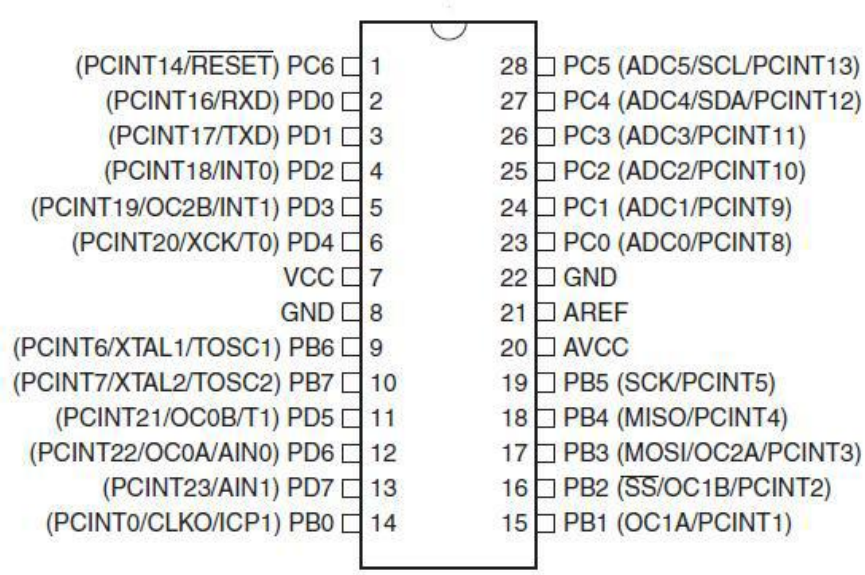

Fig 2.2: ATMEGA 328 microcontroller pin layout

Pin Descriptions:VCCDigital supply voltage and GND Ground.

Ref by[5] & [6]**Port B PB[7:0])** XTAL1/XTAL2/TOSC1/TOSC2Port B is an 8-bit bi-directional I/Oport with internal pull-up resistors (selected for each bit). The Port B output buffers havesymmetrical drive characteristics with both high sink and source capability. As inputs, PortB pins that are externally pulled low will source current if the pull-up resistors are activated.The Port B pins are tri-stated when a reset condition becomes active, even if the clock isnot running. Depending on the clock selection fuse settings, PB6 can be used as input tothe inverting Oscillator amplifier and input to the internal clock operating circuit. Atmel ATmega328/P [DATASHEET] Atmel 42735B-328/P Datasheet Summary-11/2016 12Depending on the clock selection fuse settings; PB7 can be used as output from theinverting Oscillator amplifier. If the Internal Calibrated RC Oscillator is used as chip clocksource, PB[7:6] is used as TOSC[2:1] input for the Asynchronous Timer/Counter2 if theAS2 bit in ASSR is set. Port C (PC [5:0]) Port C is a 7-bit bi-directional I/O port with internal pull-up resistors(selected for each bit). The PC[5:0] output buffers have symmetrical drive characteristicswith both high sink and source capability. As inputs, Port C pins that are externally pulledlow will source current if the pull-up resistors are activated. The Port C pins are tri-statedwhen a reset condition becomes active, even if the clock is not running.

PC6/RESET If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note thatthe electrical characteristics of PC6 differ from those of the other pins of Port C. If theRSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pinfor longer than the minimum pulse length will generate a Reset, even if the clock is notrunning. Shorter pulses are not guaranteed to generate a Reset. The various special featuresof Port C are elaborated in the Alternate Functions of Port C section.

Port D (PD [7:0]) Port D is an 8-bit bi-directional I/O port with internal pull-up resistors(selected for each bit). The Port D output buffers have symmetrical drive characteristicswith both high sink and source capability. As inputs, Port D pins thatare externally pulledlow will source current if the pull-up resistors are activated. The Port D pins are tri-statedwhen a reset condition becomes active, even if the clock is not running.

AVCC AVCC is the supply voltage pin for the A/D Converter, PC [3:0], and PE [3:2]. Itshould be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC [6:4] use digital supply voltage, VCC. 5.2.8. AREF AREF is the analog reference pin for the A/D Converter.

ADC [7:6] (TQFP and VFQFN Package Only) In the TQFP and VFQFN package,
ADC [7:6]serves as analog inputs to the A/D converter. These pins are powered from theanalog supply and serve as 10-bit ADC channels

Specifications

TABLE 1.1: Specifications of Microcontroller

Parameter	Value
CPU type	8-bit architecture
Performance	20 MIPS* at 20 MHz
*Flash memory	32 Kb
SRAM	2 Kb
*EEPROM	1 Kb
Pin count	28-pin
Maximum operating frequency	20 MHz
Number of touch channels	16
Maximum I/O pins	26
External interrupts	2

Ref by[7] **MIPS-**It stands for millions of Instruction per second. It means how much actual instruction can be performed at a defined frequency.

EEPROM - a read-only memory whose contents can be erased andreprogrammed using a pulsed voltage

FLASH MEMORY- a kind of memory that retains data in the absence of apower supply

SERVO MOTOR-A servomotor is a closed-loop servomechanism that uses positionfeedback to control its motion and final position. The input to its control is a signal (eitheranalogue or digital) representing the position commanded for the output shaft.The motor is paired with some type of encoder to provide position and speed feedback. Inthe simplest case, only the position is measured. The measured position of the output iscompared to the command position. If the output position differs from that required,an error signal is generated which then causes the motor to rotate in either direction, asneeded to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.The very simplest servomotors use position-only sensing via a potentiometer and bangbangcontrol of their motor.We are using TowerPro MGS995 for the respective project.Specifications of Towerpro MGS995

TABLE 1.2: Towerpro MGS995 Specification

Modulation:	Digital
Torque:	**4.8V**: 9.40 kg-cm **6.0V**: 11.00 kg-cm
Speed:	**4.8V**: 0.20 sec/60° **6.0V**: 0.16 sec/60°
Weight:	55.0 g
Dimensions:	**Length:**1.60 in (40.7 mm) **Width:**0.78 in (19.7 mm) **Height:**1.69 in (42.9 mm)
Gear Type:	Metal
Pulse Cycle:	1 ms
Connector Type:	JR

LED-It is a light emitting diode which glows when the input is high.

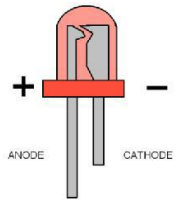

Fig 2.3: Led

Resistance-It is a device that when connected to the circuit resists the flow of currentin the circuit.

Connecting wires-It used to connect the poles of different pins.

Ultra sonic sensor- Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording theelapsed time between the sound wave being generated and the sound wave bouncing back,it is possible to calculate the distance between the sonar sensor and the object.

Fig 2.4: Ultrasonic Sensor

Gripper-There is 4 types of gripper hydraulic, pneumatic, magnetic, electronic-servoout of these options we are going to make the electronic-servo gripper.SHEET USED- We Are Using Acrylic Sheet For Fabricating The

Structure.The ReasonBehind Using This Sheet Was Its Light Weight,Higer Strength Bearing Capacity, AndEasy Workability.

Expansion and Contraction: Cast acrylic sheet responds to temperature changes by expanding or contracting at a fargreater rate than glass.

Flexibility:Cast acrylic sheet is much more flexible than glass or many other building materials.When using large sheets for windows, it is important that rabbets or channels be deepenough to provide support against high winds.

Chemical Resistance: Cast acrylic sheet has excellent resistance to attack by many chemicals. It is affected, invarying degrees, by benzene, toluene, carbon tetrachloride, ethyl and methyl alcohol,lacquer thinners, ethers, ketones and esters.

Electrical Properties: Cast acrylic sheet is an excellent insulator. Its surface resistivity is higher than that ofmost plastics.

Light Transmission: Colorless Cast acrylic sheet has a light transmittance of 92%. It is clearer than windowglass and will not turn yellow. Cast acrylic sheet is also available in a large variety oftransparent and translucent colors.
UV Light Resistance: Clear acrylic sheet resists ultraviolet light degradation. Each acrylic sheet has a ten-yearlimitedwarranty against yellowing and loss of light transmission.

Optical Clarity: Acrylic sheets have excellent light transmission. Clearer than glass Will not yellow afterprolonged sun exposure

Weather Resistance: Despite heat, cold, sunlight, and humidity acrylic sheet maintains its original appearanceand color.

Safety: Shatter-resistant, earthquake safe, and burglar-resistant. Increase safety with windowsglazed of acrylic.

Light Weight: Even with its strength and durability, acrylic sheet is only half the weight of glass

2.2 Design Components

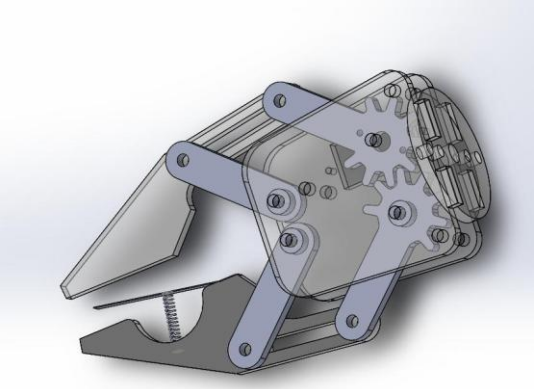

Fig 2.5: Gripper Assembly

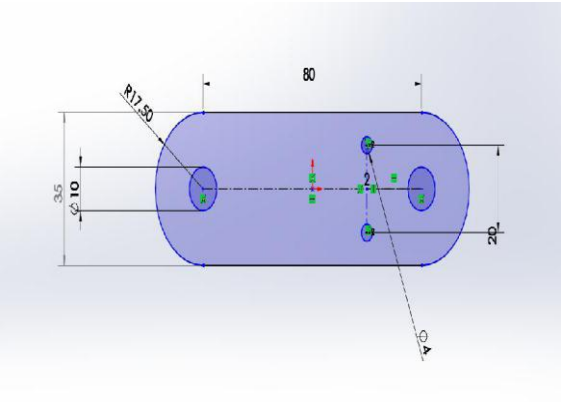

Fig 2.6: Elbows

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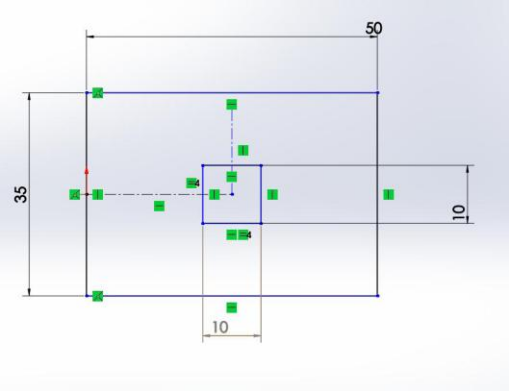

Fig2.7: Wrist Front

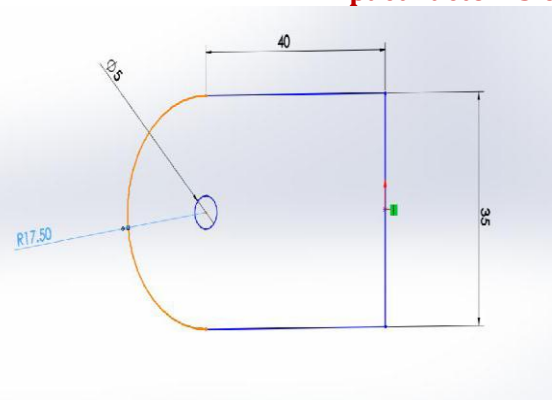

Fig 2.8: Wrist Left View

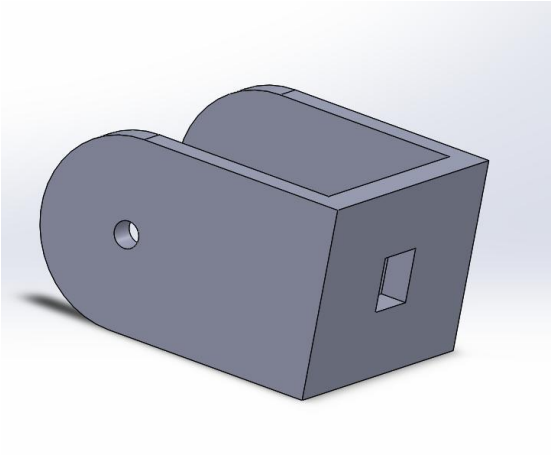

Fig 2.9: Wrist

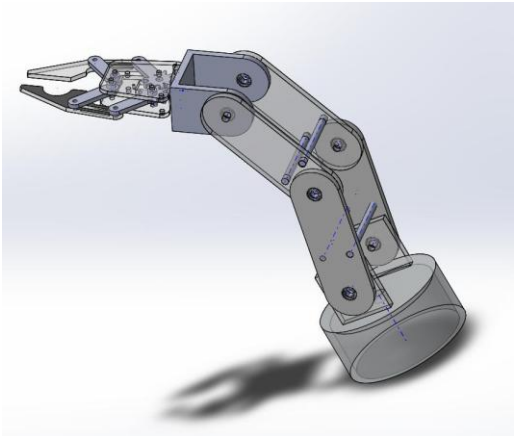

Fig 2.10: Final assembly of Arm

III. DESIGN CALCULATION AND COMMUNICATION WITH COLLABORATION TOOLS

3.1 Calculation - Maximum weight lifting capacity of the arm

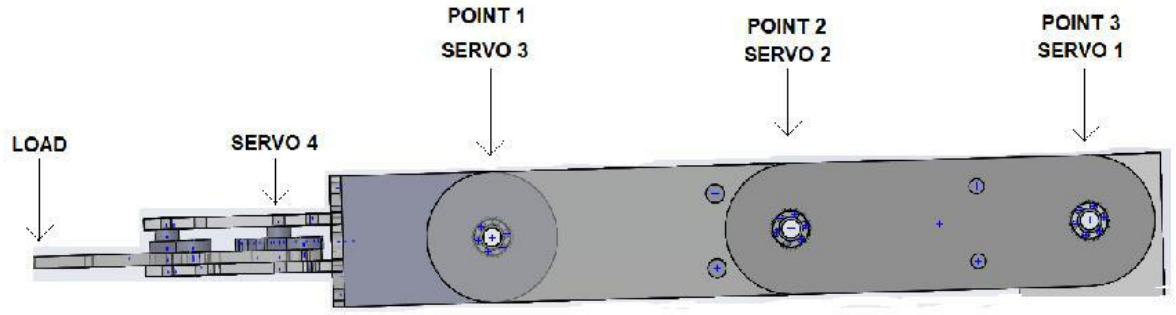

Fig 3.1: Weight Distribution Diagram

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Provided the torque of servo motor = 9.4 kg cmWeight of servo motor = 0.05 kg
Let the load picked up by the gripper be = X
At point 1
12.33x + 0.05 (4) = 9.40
x1 = 746gm
At point 2
20.33x + 0.05(8+12) = 9.40
x2 = 413gm
At point 3
28.33 + 0.05(8+16+4) = 9.40
x3= 282gm
On comparing the three values of x1, x2 and x3 we can conclude that the maximum valueof X is 282gm.

3.2 Working of Gripper Sensor

The gripper consists of two moving jaws with motion produce by servo motor transmitted to jaws via links and gears. The one jaw consists of a simple sensor to identify how muchgrabbing is required to grab the object. This sensor works on a simple open and closecircuit. It consists of a spring and two metal strips arranged/fixed as shown in fig. Initiallythe circuit is set open that is no current flows through it as shown below.

Fig 3.2: Gripper with open Circuit

Fig 3.3: Gripper with close Circuit

When the gripper starts to grab the object the metal strip startscoming closer, at a pointwhen the metal strip comes into contact the circuit closes sending high/current tothe main board. This message makes the board to stop rotating the servo motor which is controlling the gripper's jaw movement. This results in grabbing the object without unnecessary force application which would result in grabbing the object perfectly.

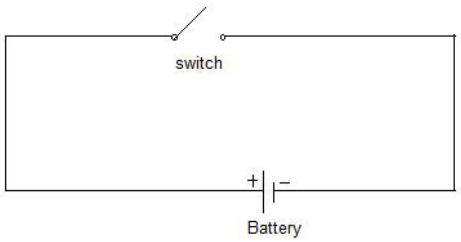

Fig 3.4

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Spring Stiffness
K(x) = f
For the give structure
x = 29.61mm
f=2.80 N
k(29.61) = 2.80
k = 94.59 N/m
Total Weight of Arm
Weight of Servo = 55 gm
Weight of structure = 50 gm
Arduino Nano = 10 gm
Bearing = 10 gm
Sensor = 5gm
Misc = 10 gm
Total weight of arm = 275+50+10+60+5+10 = 410 gm

3.3 Bill of Material

Table 3.1: BOM

S.NO	PARTICULAR	QUANTITY	COST
1	Towerpro MGS995	5	1750
2	Acrylic sheet	1	300
3	Bearing(OD-10,ID-4)	6	250
4	Arduino UNO	1	500
5	Arduino NANO	1	250
6	UltraSonic Sensor	1	95
7	Wires	1-roll	50
8	Resistator,Led And Buzzer	1 each	10
9	Adapter(5V-5Amp)	1	250
10	Battery(9V)	1	20
11	Wodden Board(17" X 10")	1	300
12	MISC		500

Drawings Professional:A communication tool for reviewing 2D and 3D productdesign data across the extended product development team. Drawings generates accurate representations ofDWG gateway is a free data translation tool that enablesany AutoCAD software user to open and edit any DWGfile, regardless of the version of AutoCAD it was made in.Mobile e DrawingsSolid Works Viewer: is a free plug-in for viewing SolidWorks parts, assemblies, and drawings.'3DVIA Composer', now known as 'Solid Works Composer',is a technical communications software that allows 3Dviews of models to be integrated into documents such aswork instructions, internal or external manuals, marketingmaterials, or web applications. The 3D views can beupdated automatically when the design updates, reducingthe workload of the employee creating the technicaldocument, as editing for changes is not as severe.

IV. CAD PRODUCTIVITY TOOLS

Solid Works Toolbox is a library of parts that uses "SmartPart" Technology to automatically select fasteners andassemble them in the desired sequence.Solid Works Utilities is software that lets designers finddifferences between two versions of the same part, orlocate, modify, and suppress features within a model.Feature Works is

feature recognition software that letsdesigners make changes to static geometric data,increasing the value of translated files. With FeatureWorks, designers can preserve or introduce new design intent when bringing 3D models created in other softwareinto the Solid Works environment.

V. RESULT

Pick items and changes place ofitems in six degrees freedom arm MOTOMEN ES 165D-100 robots are designed by usingSOLID WORKS PREMIUM 2014.

The concept of design is to say the robotic armmechanism to load and unload the object, withthe entire design concept, continue change the nextlevel that is analysis based on the designconcepts.Material consideration and size considerationand analysis included weight consideration. The analysis is to get result withslightly affected the performance of the roboticarm.

REFERENCES

1. *Low cost Sensor usability with Arduino UNOreference/Sayan Mukhopadhaya.2016*
2. *Mohd Ashiq Kamaril Yusoffa, Reza Ezuan Saminb, Babul Salam Kader Ibrahimc, "Wireless Mobile Robotic Arm", (IRIS 2012), July 2012*
3. *Farhan A. Salem, Modeling controller selectionand design of electric DC motor for Mechatronicsapplications, using different control strategies andverification using MATLAB/Simulink, Submitted toEuropean Scientific Journal, 2013*
4. *Avinash Jain, "Servo Motor Control by Using AVR ATmega32 Microcontroller",servo-motor-control-by-using-avr-atmega32-microcontroller/, June 2010*
5. *Ahmad A. Mahfouz ,Mohammed M. K., Farhan A.Salem, Modeling, Simulation and Dynamics AnalysisIssues of Electric Motor, for MechatronicsApplications2013,*
6. *Farhan A. Salem, Modeling controller selectionand design of electric DC motor for Mechatronicsapplications, Submitted toEuropean Scientific Journal, 2013*
7. *M.P.Kazmierkowski, H.Tunia "Automatic Controlof Converter-Fed Drives", Warszawa1994.*
8. *R.D. Doncker, D.W.J. Pulle, and A.Veltman.Advanced Electrical Drives: Analysis, Modeling, Control. Springer, 2011*
9. *https://www.societyofrobots.com*