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STRENGTH DETECTING ROBOT ARM MECHANISM

ADITYA.V
STUDENT, MECHATRONICS, MGIT, HYDERABAD, INDIA

Abstract:

A robot is a device with many subsystems that interact among themselves as well as with the environment in which the robot works. The human hand design forms the basis of this project in developing a robotic gripper and is the source of inspiration to achieve the sufficient level of dexterity in the domain of grasping and manipulation if coupled with wrist and arm.

This project explains the development of robotic arm with installation of Force Sensing Resistor (FSR). The main objective of this project is to design and implement a gripper and a Force Sensing Resistor (FSR) with robot arm. This project can be self-operational in controlling, performing simple tasks such as gripping, lift, rotating, out gripping and sensing the force applied on an object by gripper. An Arduino Uno board is used in the working of the prototype. It is the brain of the robot arm since it controls the robot arm and also gives information about the amount of force to be applied on a particular object. Three DC motors are used to control the motion of the robot arm.

This project describes various stages of design and development of a low cost sensor-based robotic gripper that would facilitate the task of applying appropriate forces to different objects without causing damage. It is a fully functional semi-automated pick and place gripper which can be used in many industrial applications and it can also be altered or further developed in order to suit a larger number of industrial activities. The current design of robotic gripper could be further developed to design fully automated robot grippers which have wide range of applications in many fields.

Key Words: *Robot,Gripper,Aurduino,Resistor,etc…*

1. INTRODUCTION

1.1 ROBOT:

A robot can be defined as a programmable, self-controlled device consisting of electronic, electrical, or mechanical units. More generally, it is a machine that functions in place of a living agent. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand.
The concept of robots is a very old one yet the actual word robot was invented in the 20th century from the Czechoslovakian word robota or robotnik meaning slave, servant, or forced labour. Robots don't have to look or act like humans but they do need to be flexible so they can perform different tasks.

Early industrial robots handled radioactive material in atomic labs and were called master/slave manipulators. They were connected together with mechanical linkages and steel cables. Remote arm manipulators can now be moved by push buttons, switches or joysticks.

Fig 1.1 ASIMO robot

Current robots have advanced sensory systems that process information and appear to function as if they have brains. Their "brain" is actually a form of computerized artificial intelligence (AI). AI allows a robot to perceive conditions and decide upon a course of action based on those conditions.

1.1.1 Components of a Robot:

effectors - "arms", "legs", "hands", "feet" sensors - parts that act like senses and can detect objects or things like heat and light and convert the object information into symbols that computers understand computer - the brain that contains instructions called algorithms to control the robot equipment - this includes tools and mechanical fixtures. Characteristics that make robots different from regular machinery are that robots usually function by themselves, are sensitive to their environment, adapt to variations in the environment or to errors in prior performance, are task oriented and often have the ability to try different methods to accomplish a task.

Common industrial robots are generally heavy rigid devices limited to manufacturing. They operate in precisely structured environments and perform single highly repetitive tasks under pre-programmed control. There were an estimated 720,000 industrial robots in 1998. Tele-operated robots are used in semi-structured environments such as undersea and nuclear facilities. They perform non-repetitive tasks and have limited real-time control.

1.2 Robotic Arm:

The most common manufacturing robot is the robotic arm. A typical robotic arm is made up of seven metal segments, joined by six joints. Generally, the computer controls the robot by rotating individual step motors connected to each joint (some larger arms use hydraulics or pneumatics). Unlike ordinary motors, step motors move in exact increments.

This allows the computer to move the arm very precisely, repeating exactly the same movement over and over again. Highly sophisticated robot uses motion sensors to make sure it moves just the right amount.

Fig 1.2 Robotic arm

An industrial robot with six joints closely resembles a human arm -- it has the equivalent of a shoulder, an elbow and a wrist. Typically, the shoulder is mounted to a stationary base structure rather than to a movable body. This type of robot has six degrees of freedom, meaning it can pivot in six different ways. A human arm, by comparison, has seven degrees of freedom.

Your arm's job is to move your hand from place to place. Similarly, the robotic arm's job is to move an end effector from place to place. An end effector is the device at the end of a robotic arm, designed to interact with the environment. You can outfit robotic arms with all sorts of end effectors, which are suited to a particular application. For example, the end effector of an assembly line robot would typically be a welding head, or a paint spray gun. A surgical robot's end effector could be a scalpel or others tools used in surgery. Other possible end effectors are machine tools, like a drill or milling cutters. The end effector on the space shuttle's robotic arm uses a pattern of wires which close like the aperture of a camera around a handle or other grasping point.

Industrial robots are designed to do exactly the same thing, in a controlled environment, over and over again. For example, a robot might twist the caps onto peanut butter jars coming down an assembly line. To teach a robot how to do its job, the programmer guides the arm through the motions using a handheld controller. The robot stores the exact sequence of movements in its memory, and does it again and again every time a new unit comes down the assembly line.

Most industrial robots work in auto assembly lines, putting cars together. Robots can do a lot of this work more efficiently than human beings because they are so precise. They always drill in the exactly the same place, and they always tighten bolts with the same amount of force, no matter how many hours they've been working. Manufacturing robots are also very important in the computer industry. It takes an incredibly precise hand to put together a tiny microchip.

The major categories of industrial robots by mechanical structure are:

Cartesian robot /Gantry robot: Used for pick and place work, application of sealant, assembly operations, handling machine tools and arc welding. It's a robot whose arm has three prismatic joints, whose axes are coincident with a Cartesian coordinator.

Cylindrical robot: Used for assembly operations, handling at machine tools, spot welding, and handling at diecasting machines. It's a robot whose axes form a cylindrical coordinate system.

Spherical/Polar robot: Used for handling at machine tools, spot welding, diecasting, fettling machines, gas welding and arc welding. It's a robot whose axes form a polar coordinate system.

SCARA robot: Used for pick and place work, application

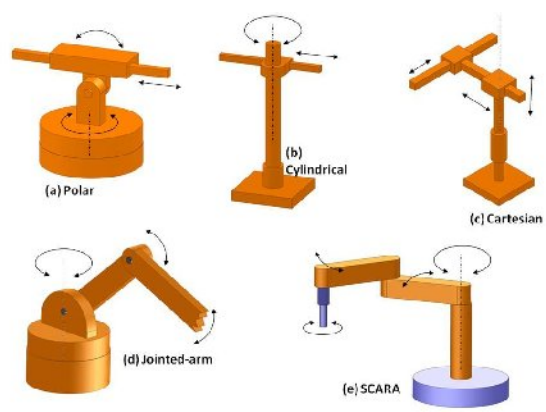


Fig 1.3 Types of Robotic Arms

2. DESIGN

2.1 Functional Block Diagram

of sealant, assembly operations and handling machine tools. It's a robot which has two parallel rotary joints to provide compliance in a plane.

Articulated robot: Used for assembly operations, die-casting, fettling machines, gas welding, arc welding and spray painting. It's a robot whose arm has at least three rotary joints.

Parallel robot: One use is a mobile platform handling cockpit flight simulators. It's a robot whose arms have concurrent prismatic or rotary joints.

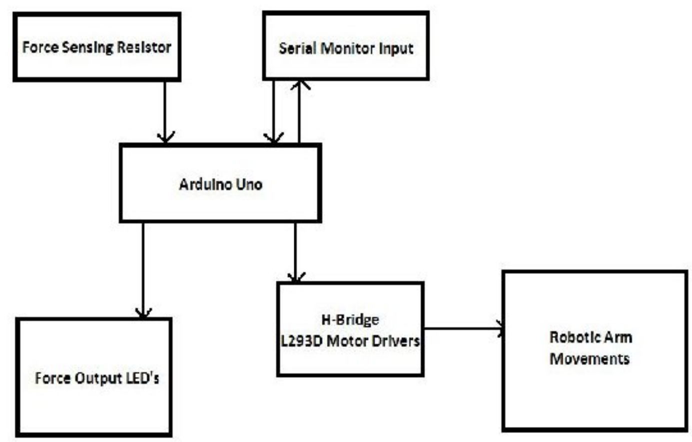


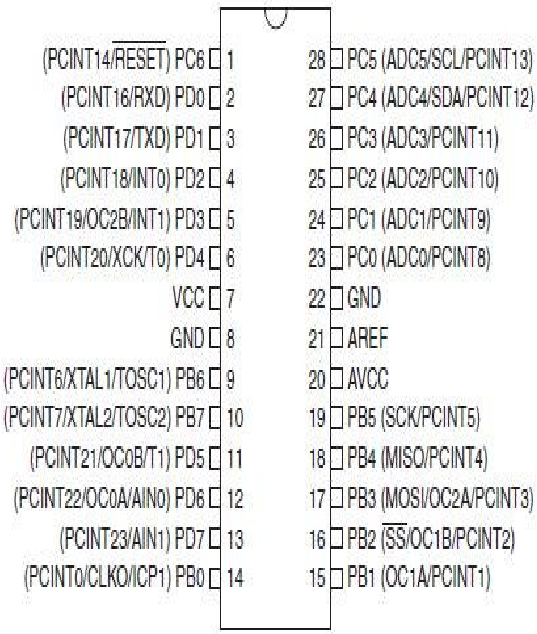
Fig 2.1 Block Diagram

2.2 Arduino Uno Introduction:

Arduino is a tool for making computers that can sense and control more of the physical world than a desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can communicate with software running on your computer (e.g. Flash, Processing, MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.

PIN Diagram



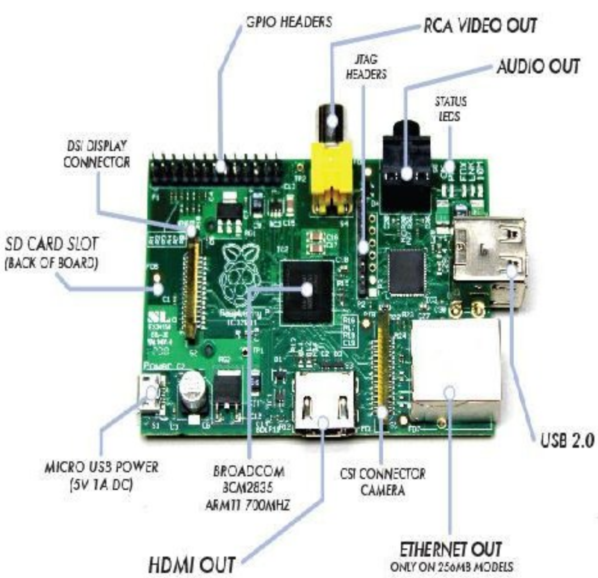


Fig 2.3 FORCE RESISTOR

- Operating Voltage 5V
- Input Voltage (recommended) 7-12V
- Digital I/O Pins ▪ 14 (of which 6 provide PWM output)
- Analog Input Pins ▪ 6
- DC Current per I/O Pin ▪ 40 mA
- DC Current for 3.3V Pin ▪ 50 mA
- Flash Memory 3 ATmega328
- SRAM 2 KB
- EEPROM 1 KB
- Clock Speed 16 MHz
- Length 68.6 mm
- Width 53.4 mm
- Weight 25 g
- Microcontroller ATMega(328)

2.3 Force Sensor Resistor

The FORCE-SENSING-RESISTOR (FSR) is made of a proprietary polymer thick film ink, typically screen printed on Mylar (PET) film, depending on the requirements of the application. As force is applied to the device, the electrical resistance decreases. The ink formulation can be customized for application-specific requirements, such as minimizing saturation with greater force, as well as for very low force needs. Temperature, humidity, and shear are some of the considerations.

The Force-Sensing Resistor can be used for such applications as computer input devices, musical instruments, interactive toys, robotics fingertips, automotive, sports, or medical applications.

Overview

A force-sensing resistor is a material whose resistance changes when a force or pressure is applied. They are also known as "force-sensitive resistor" and are sometimes referred to by the initialism "FSR". Force-sensing resistors consist of a conductive polymer, which changes resistance in a predictable manner following application of force to its surface. They are normally supplied as a polymer sheet or ink that can be applied by screen printing. The sensing film consists of both electrically conducting and non-conducting particles suspended in matrix. The particles are sub-micrometre sizes, and are formulated to reduce the temperature dependence, improve mechanical properties and increase surface durability. Applying a force to the surface of the sensing film causes particles to touch the conducting electrodes, changing the resistance of the film. As with all resistive based sensors, force-sensing resistors require a relatively simple interface and can operate satisfactorily in moderately hostile environments. Compared to other force sensors, the advantages of FSRs are their size (thickness typically less than 0.5 mm), low cost and good shock resistance. A disadvantage is their low precision: measurement results may differ 10% and more.

Description

This is a force sensitive resistor with a round, 0.5" diameter, sensing area. This FSR will vary its resistance depending on how much pressure is being applied to the sensing area. The harder the force, the lower the resistance. When no pressure is being applied to the FSR its resistance will be larger than 1MΩ. This FSR can sense applied force anywhere in the range of 100g-10kg.

Two pins extend from the bottom of the sensor with 0.1" pitch making it bread board friendly. There is a peel-and-stick rubber backing on the other side of the sensing area to mount the FSR. These sensors are simple to set up and great for sensing pressure, but they aren't incredibly accurate.

Mechanical Components

The components of a robot manipulator system often consists of links, joints, actuators, and controllers.

2.4 Joints

The rotary joints and the sliding of prismatic joints allow the links to move in the robot work space. In robot system, the number of degrees-of-freedom is determined by the number of independent joint variables. "CRS Robotics," the automation laboratory robot has 3 DOF. It's inexpensive, easy to program and limited load capacity. "IVAX SCARA" robotic arm produced by FEEDBACK has 4 DOF, it is primarily used in industrial areas such as pick & place and automated. Our Robotic arm has 3 DOF and the concept is similar to the industrial robotic arm in the factory. It is suitable for pick and place object with limited load capacity.

2.5 Actuators

Actuators are devices that cause rotary joints to rotate or drive prismatic joints to slide along their motion axes. The most used robot drivers are stepper motor and DC servo motor. We are using Reduction gear mechanism DC motors for precise movement of the Joints.

2.6 Controllers

Controllers are the most important components in a robot system. If a robot has n joints, n controllers are needed to control all joint actuators. Robot controllers used to solve the problem how robot actuators are driven to achieve a desired performance. A robot control system is actually the integration of electronic hardware and software. The task of software is to use some control algorithms to compute the control signals while the control hardware can then provide the control signals to the Robotic Arm. The Arduino Uno is programmed to listen for any incoming serial communication from the host computer then set the motors to the positions received and update the motors with their positional information so that the motors will hold their positions.

2.7 Robot Geometry

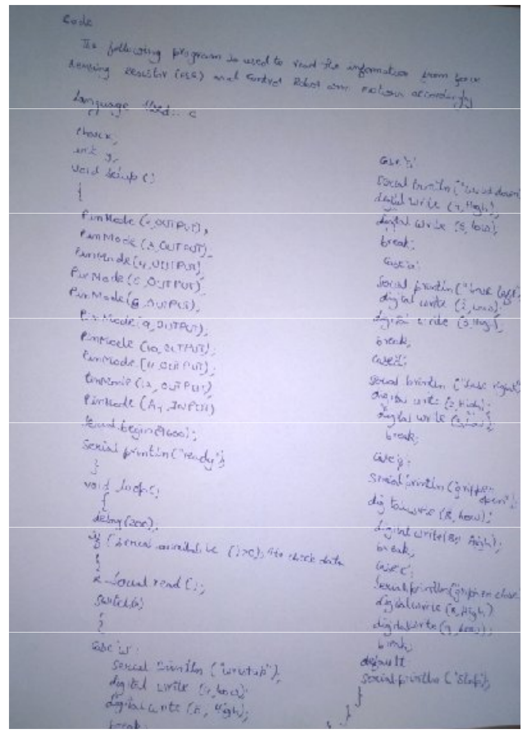
In the field of robotics, there are five types of commonly used robot arm configurations, each named according to the combination of shoulder, elbow and wrist joints. Each of the commonly used types employs simple revolute or prismatic joints. The five types are the rectangular coordinate (this includes both floor and gantry mounts), spherical coordinate (polar), cylindrical coordinate, revolute coordinate and the Self Compliance Automatic Robot Assembly (SCARA). Cartesian coordinate system. "Gantry robots (GCA Corporation)" are widely used for handling tasks such as palletizing, warehousing, and order picking or special machining task such as water jet or laser cutting where robot motions cover large surfaces. A cylindrical robot's arm forms a cylindrical coordinate. This kind of robotic arm preferably used for palletizing, loading, and unloading of machines. "Optimal Design for Laparoscopic Positioning Stands" applied spherical configuration because it is use for endoscopic surgery that is perform on the abdomen. The abdominal wall as a kinematic constraint acts as a pivoting point that the surgeon has to move tools in a spherical configuration. A SCAM robotic arm allows for 4 degrees of freedom. Freedom in the X-Y plane via two parallel, rotational joints; freedom in the Z plane via one vertical, linear joint, and the freedom to rotate the end effectors about the Z axis. One example of the SCAM configuration is "IVAX SCARA" robotic arm manufactured by FEEDBACK is specifically use for educational use. Revolute configuration actually work like a human arm the base rotate in a way similar to a twisting human torso. The shoulder and elbow on most articulating robot pivot on one axis each, perpendicular on the axis of the arm and parallel to the plane upon which the based mounted. The wrist assembly on articulating robots almost always has pitch but may or may not have yaw and roll.

Cartesian robots have three prismatic joints, whose axes are coincident with a Cartesian coordinate system. "Gantry robots (GCA Corporation)" are widely used for handling tasks such as palletizing, warehousing, and order picking or special machining task such as water jet or laser cutting where robot motions cover large surfaces. A cylindrical robot's arm forms a cylindrical coordinate. This kind of robotic arm preferably used for palletizing, loading, and unloading of machines. "Optimal Design for Laparoscopic Positioning Stands" applied spherical configuration because it is use for endoscopic surgery that is perform on the abdomen. The abdominal wall as a kinematic constraint acts as a pivoting point that the surgeon has to move tools in a spherical configuration. A SCAM robotic arm allows for 4 degrees of freedom. Freedom in the X-Y plane via two parallel, rotational joints; freedom in the Z plane via one vertical, linear joint, and the freedom to rotate the end effectors about the Z axis. One example of the SCAM configuration is "IVAX SCARA" robotic arm manufactured by FEEDBACK is specifically use for educational use. Revolute configuration actually work like a human arm the base rotate in a way similar to a twisting human torso. The shoulder and elbow on most articulating robot pivot on one axis each, perpendicular on the axis of the arm and parallel to the plane upon which the based mounted. The wrist assembly on articulating robots almost always has pitch but may or may not have yaw and roll.

3. SOFTWARE & CODE

The Arduino Uno can be programmed with the Arduino software. Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board).
The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

CODE



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Code
The following program is used to read the information from force
sensing resistor (FSR) and control Robot arm motion accordingly
Language used:- C

char x;
int y;
void setup()
{
pinMode(2,OUTPUT);
pinMode(3,OUTPUT);
pinMode(4,OUTPUT);
pinMode(5,OUTPUT);
pinMode(6,OUTPUT);
pinMode(9,OUTPUT);
pinMode(10,OUTPUT);
pinMode(11,OUTPUT);
pinMode(12,OUTPUT);
pinMode(A1,INPUT);
Serial.begin(9600);
Serial.println("ready");
}
void loop()
{
delay(200);
if (Serial.available()>0) //to check data
{
x=Serial.read();
switch(x)
{
case 'w':
Serial.println("wristup");
digitalWrite(7,Low);
digitalWrite(6,High);
break;
case 's':
Serial.println("wrist down");
digitalWrite(7,High);
digitalWrite(6,Low);
break;
case 'a':
Serial.println("base left");
digitalWrite(2,Low);
digitalWrite(3,High);
break;
case 'd':
Serial.println("base right");
digitalWrite(2,High);
digitalWrite(3,Low);
break;
case 'q':
Serial.println("gripper open");
digitalWrite(8,Low);
digitalWrite(9,High);
break;
case 'e':
Serial.println("gripper close");
digitalWrite(8,High);
digitalWrite(9,Low);
break;
default
Serial.println("Stop");
}
}
}
```

4. RESULTS AND DISCUSSION

The robotic arm embedded with Force Sensor Resistor (FSR) is constructed and tested. The completed structure is shown in figure 4.1

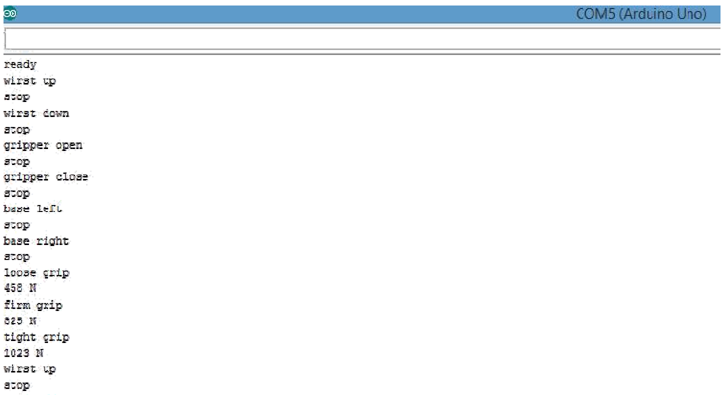

Fig 4.1 Robotic arm attached with force sensing resistor

The final robot arm is tested over various materials and its operation is found to be satisfactory. When Force Sensing Resistor is connected across a 10Kohm resistor, as expected, it gives the output.

We have tested the robot arm by choosing a sensitive material like egg, the robot arm held the egg by its gripper and when the gripping force was varied we observed the following result as shown in figure 4.2

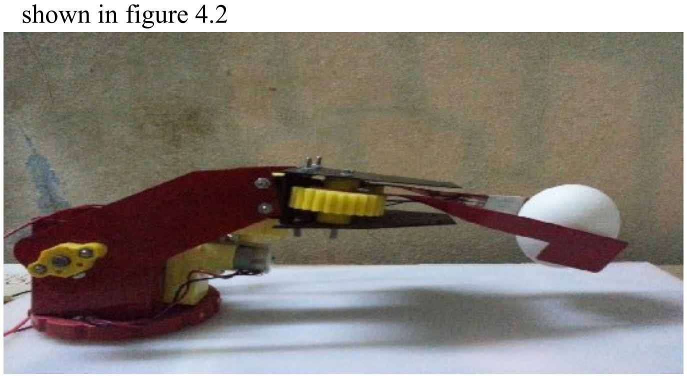

Fig 4.2 Robot arm holding an egg

When the robot arm held the egg, the Force sensor measured the amount of force applied on the egg and the Arduino Uno read the values from FSR and gave the output, and also shown the respective robotic arm movements, as shown in below figure 4.3

5. APPLICATIONS AND FUTURE SCOPE

Force sensing in robot arm is used in areas where the robot arm is required to handle delicate materials. It can be applied in industries of medicine, jewellery, poultry, etc. where handling of materials with utmost care is required and where too much pressure should not be exerted on the material by the end effector.

It is used in flexible manufacturing industries when the materials picked up are to be separated and stored according to their weight into various flexible manufacturing cells. This eliminates the need for human intelligence.

Force sensing in robot arms in used military applications such as bomb/ land-mine disposal.

The force sensing feature is in use in various manufacturing and assembling plants where workloads require a particular amount of force to be applied in various operations such as welding, screwing, binding, etc. Here, the type of end effector is adjusted based on the requirement of the operation.

Force sensing in robot arms can be deployed in humanoid robots where the feedback from the sensor can be used simulate human operation to handle various objects.

Force sensing robot arms can be deployed in military zones where it can be used in loading/unloading, retrieval, and storage of various military equipment which differ in size and weight, and which require careful handling.

6. CONCLUSION

The Force Sensing robot arm is designed and developed successfully and its operation is tested and found to be working satisfactorily. The robotic arm has many wide range of industrial applications like material handling, manufacturing and assembling operations, loading/unloading, retrieval, and storage etc. The main objective of the project is to control the amount of force applied by the robot arm on light/sensitive materials and avoid damage to the material. The machine requires minimal human involvement and at the same time improves efficiency and productivity.

7. ACKNOWLEDGEMENT

During this project we have had support from a large number of people to whom we owe great amount of gratitude. There is however one person, our mentor Dr.P.Venkata Ramana who made this report work possible and who supported and pushed

us throughout the whole process. Therefore a special recognition goes out to him, Thank You!

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9. BIOGRAPHY

Aditya Vangara is a student from Mahatma Gandhi Institute of Technology (MGIT) pursuing Bachelors in the field of Mechatronics.