Design and Implementation of Voice Controlled Robotic Arm

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Abstract

The aim of this project is to make a Voice controlled Robotic ARM which is work with the instruction of anybody Voice recognition module. In this system there have 6 servo motor is used to control the arm. Each servo have their personal duty at his position. We used here Arduino Nano to control this arm using arduino program. Arduino program are designed by arduino IDE software. The Robotic arms are mechanical products that are manufactured and marketed the world at a very high rate. There are thousands of types of arms are available on the market developed by different companies. Industrial use robot arm cannot be used at this time even more than the domestic robot can do the job. It is always use specific objectives and some conditions in the industry where humans cannot work at high temperature, polluted air region, weightlifting and so on. Robot arms are also used for high accurate places where local error are allowed. Robot arm set one tasks, and accurate implementation in a variety of environments. A robotic arm means a group of rigidly connected bodies that can be taken different configurations, and move between these configurations with speed and speed restrictions. Industrial robot arms vary in size and some are fixed body, type of joint, joint sequence. Accuracy of the results position on up 40%, down 60%, right side 80%, left side 80%, gripper open 60% and gripper close 40%.

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ABBREVIATIONS

SMPS	Switched Mode Power Supply
DOF	Degree of Freedom
IDE	Integrated Development Environment

Chapter 1
Introduction

1.1 Introduction

The Robotic arms are mechanical products that are manufactured and marketed the world at a very high rate. There are thousands of types of arms are available on the market developed by different companies. Industrial use robot arm cannot be used at this time even more than the domestic robot can do the job. It is always use specific objectives and some conditions in the industry where humans cannot work at high temperature, polluted air region, weightlifting and so on. Robot arms are also used for high accurate places where local error are allowed. Robot arm set one tasks, and accurate implementation in a variety of environments. A robotic arm means a group of rigidly connected bodies that can be taken different configurations, and move between these configurations with speed and speed restrictions. Industrial robot arms vary in size and some are fixed body, type of joint, joint sequence. The range of motion to be connected and acceptable at each joint and individual fixture are called links. Robot arm is made using different parameters such as quantity axis, degrees of freedom, working area and working space that arm cover, kinematics, payload, speed and acceleration, accuracy and repeatability, motion control and arm drive this survey summarizes a developing issue robot arm. People like to shop online rather than buy things and getting them online manually is now everywhere, comparing the last few decades into the Internet only wired, as well as people need to be in front of the computer to access the Internet. Now, the internet is just at your fingertips. We can bring the advantages of robotics into the homework's. The mechanical and electrical construction are the components used to build the robot arm. Internet controlled robots will connect these wired robot some space limitations. So in order to avoid this restriction robot control is wirelessly controlled through online. Wireless also means using Bluetooth, however the advancements used here are the most extensive so the WI-FI comes in to picture. The term robot comes from the Czech word robota, generally translated as "forced labour", this describes the majority of robots fairly well. Most robots in the world are designed for heavy, difficult to manufacture in work. They handle tasks that are difficulty, dangerous or boring to human beings. The most common robot is the robotic arm. This robotic arm is type of mechanical model arm, it is usually programmed, like of a human arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or linear displacement. An industrial arm with six joints similar to a human arm it has equivalent of a shoulder, an elbow and a wrist.

Typically, the shoulder is mounted on a stationary base structure rather than to a movable body. This type of robot has six degree of freedom, meaning it can pivot in six different ways. A human arm by comparison have seven degrees of freedom. Like as we have our arm whose job is to move your hand from place to place. Similarly job of robotic arm's is to move an object from one place to other that is what is a pick and place robotic arm. Industrial robots are designed to do exactly in an controlled environment, over and over again. For example, a robot might twist the caps of peanut butter jars coming down an assembly line. To each 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 of robots are very important in the computer industry. It takes precise hand to put together in tiny microstrip.

1.2 The History of Robotic Arms

The Beginning

In 1961, Unimate introduced the very first industrial robotic arm. Joseph Engelberger and George Devol are to thank for this. Devol developed the patent that was granted in 1961. Engelberger functioned as the entrepreneurial half of the duo who founded Unimation. Thus, while Devol was the one who conceived the idea for the arm, Engelberger was thought to be the “father of the robot”.

Characteristics of the First Robotic Arm

This revolutionary invention featured a 3-axis arm that could handle parts up to 226 kg. Equipped with hydraulic actuators, the Unimate was able to hold force constant due to the incompressibility of fluids (Inst Tools, 2019). The robot promised the ability to execute multiple tasks from material handling to welding. However, the invention proved to be a double-edged

sword. While it alleviated the work hazards for humans, it created another problem of mass unemployment if adopted. Thus, companies hesitated to move forward with the technology.



Figure 1.1: First Unimate Robotic Arm (1961) Image by IEEE

Early Adoption of Robotic Arms

Despite the fear of displacing workers, companies recognised the importance of keeping up to speed with automation. The industrial robotic arm became the perfect solution for companies in growing industries. Ultimately, companies are profit-driven and the fear of mass displacement waned over time. Many of the early adopters came from the west and Japan. The very first industrial robotic arm was installed in the General Motors factory in Trenton, USA [18]

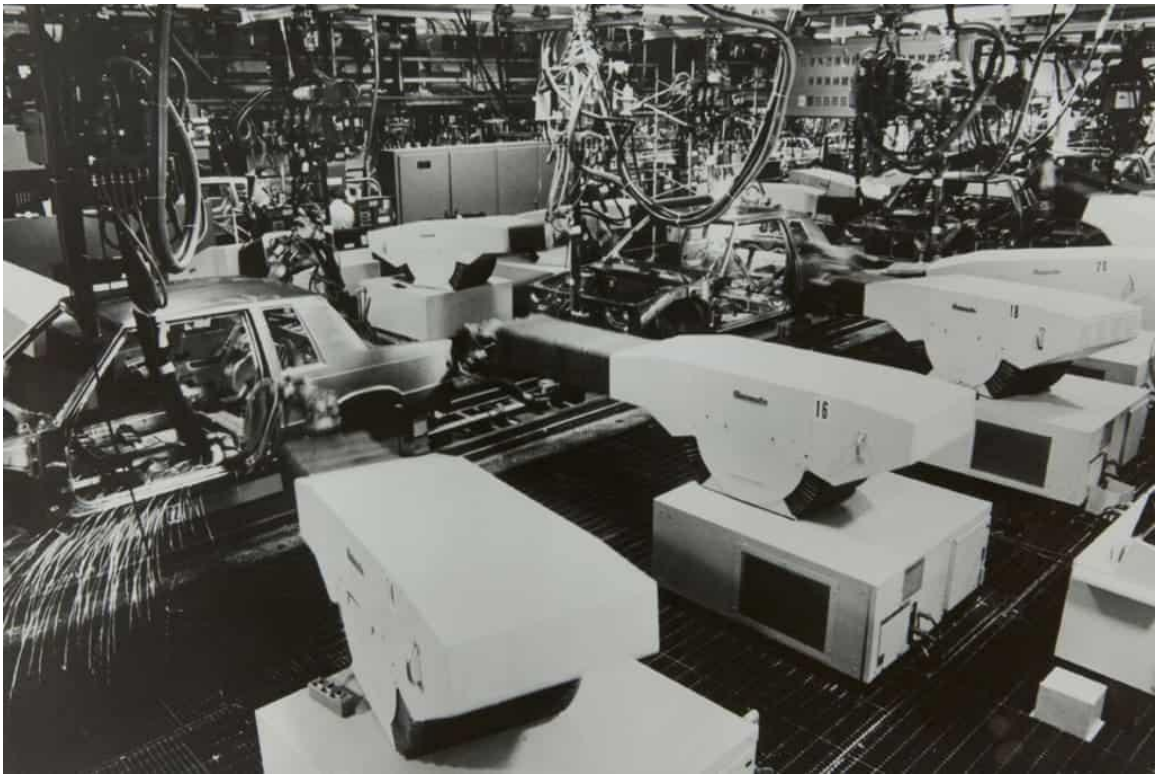


Figure 1.2: Unimate in General Motors Factory from Journal

Further Developments

However, robotics arms as we know it did not stop at just 3-axis. Robots underwent constant refinement and improvements to stay relevant.

The History of Robotic Arm Innovation: Wave 2

This wave lasted approximately 9 years from 1968 to 1977. It was characterised by having servo-controllers enabling point-to-point motion. The robot was also programmable with a teach box. However, each robot had a specific software and could only perform a specific task. Therefore, reducing the versatility of these robots.the fact that the arm was easy to control and compatible with computer systems in that era (InfoLab Stanford, n.d.)



Figure 1.3: Stanford Arm Image by Stanford InfoLab

The History of Robotic Arm Innovation: Wave 3

From 1978 to 1999, the "third-generation" industrial robots were commonly classified by their ability to perform complex tasks. Many additional features were included to enhance the overall functionality of the robot.

Firstly, robot movements could account for environmental changes. This was especially crucial in a factory setting where the arms might require relocation. Secondly, robot arms were now able to run diagnostics and provide indications of where and what type of failure has occurred. The ability to run diagnostics significantly reduces the time needed to locate errors. Lastly, robot arms were now able to perform complex tasks. For instance, data used from vision or perception systems (from the sensors or cameras) allowed the robot to perform tactile inspection and assembly operations.

Robotics Today

Presently, robotic arms have up to 7-axis and companies are spearheading change through the simplifying of programming processes. Such innovations address the pain points of many manufacturing companies and carve a way for people with no programming background to adopt such technology. Additionally, the mistakes in the work cell can be predicted beforehand and avoided with the introduction of offline programming. Accordingly, the reduction in programming downtime increases the overall efficiency of companies.

Increase in Efficiency with Cobots

Collaborative robots or cobots, have become increasingly popular as they can be safely used alongside human workers without the need for caging or safety equipment. Companies pioneering the production of cobots include Universal Robots and Rethink Robotics. With the demand for cobots expanding, manufacturers can reap economies of scale and lower the costs to access such. A prominent alteration was the change from hydraulic to electronic actuators. Electronic actuators allow greater control over position and velocity. Additionally, simultaneous adjustments can be made with accuracy and repeatability exceeding that of hydraulic actuators (Tolomatic, 2017). Scheinman pioneered the electronically powered robotic arm. He was a mechanical engineer at Stanford who built the Stanford arm. The arm boasted 6-axes and sensors to ascertain the position and velocity of the joints. Furthermore, what was groundbreaking was cobots. Therefore, the barrier to entry for using robotic arms or cobots in manufacturing processes is the ease of use rather than cost.

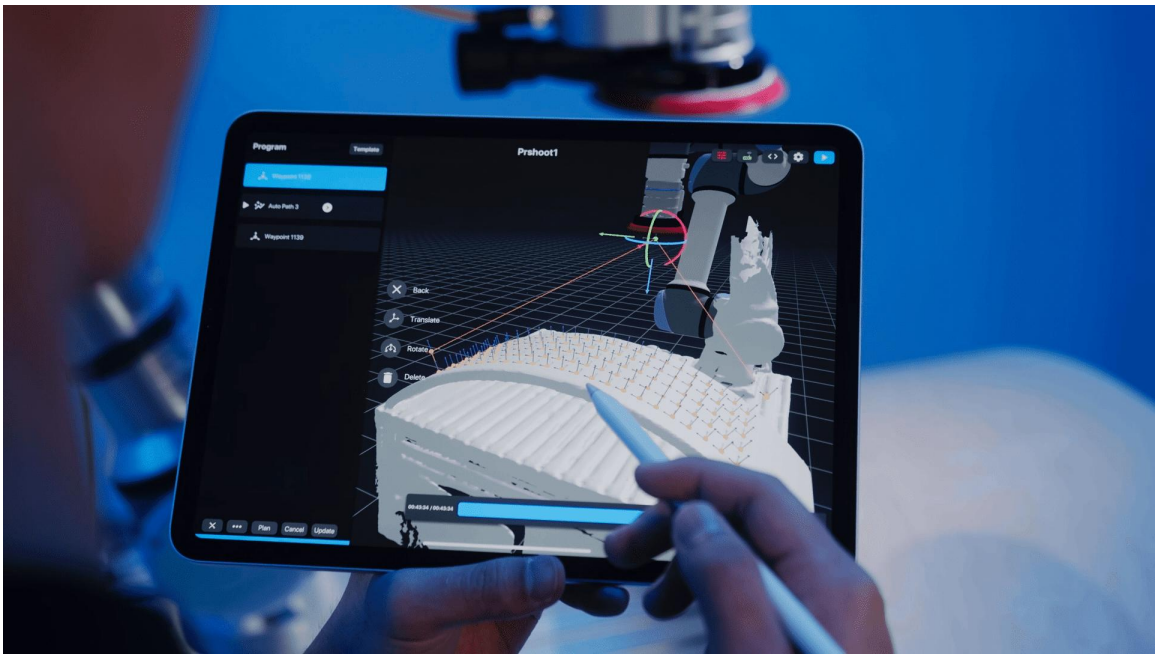


Figure 1.4: No Code Programming Technology by Augmentus

According to CNBC, we are currently in the golden era of robotics adoption (Gurdus et al., 2019). Rising labour costs coupled with the need to meet rising demands have propelled the adoption of robotic arms.

About Augmentus:

Augmentus pioneers industry-leading robotic technologies that enable easy and rapid robotic automation, enabling anyone, even those with no robotic experience, to program dynamic industrial robots in minutes. Our proprietary technology incorporates algorithms to enable fully automated robot path generation and an intuitive graphical interface that eliminates the need for coding and CAD files in robot teaching. Companies using Augmentus have experienced up to 70% cost reduction and 17 times faster deployments across a wide variety of applications, such as spraying, palletizing, welding, and inspections. Augmentus ushers in a new era of human-machine interface, democratizing robotic automation.

1.3 Objectives

The objective of controlling a 6 Degree of Freedom (6 DOF) robotic arm using Voice Recognition Module can vary based on specific project goals and requirements. However, here are some common objectives are given bellows;

- To design and control 6 DOF robotic arm.
- To check the performance test of 6 DOF robotic arm.
- To make the 6 DOF robotic arm in a cost-effective way.
- To develop a human machine interface used for control robot arm.

1.4 Classification of robotic arm;

- **Cartesian robot :** Used for pick and place work, , handling machine tools and arc welding application in various purposes like in assembly operations
- **Cylindrical robot:** It is mostly used for assembly purpose operations, handling of machine tools, spot welding. It is a robot which has axes form of a cylindrical coordinate system.
- **Spherical robot:** Used for handling machine tools, spot welding, fettling machines, gas welding and arc welding. It is a robot which has axes as form a polar coordinate system.
- **Articulated robot:** An articulated robot is a robot with rotary joints (e.g. a legged robot or an industrial robot). Articulated robots can range from simple two-jointed structures to systems with 10 or more interacting joints and materials.

- **Parallel robot :** A parallel robot is composed of a mobile platform connected to a fixed base by a set of identical parallel kinematic chains, which are called legs. The end-effector is fixed to the mobile platform. A parallel robot is said to be fully parallel when the number of legs is greater or equal to the number of degrees of freedom of the mobile platform, each parallel chain having a single actuator
- **SCARA robot:** SCARA Robots are a popular option for small robotic assembly applications. SCARA is an acronym for Selective Compliance Articulated Robot Arm, meaning it is compliant in the X-Y axis, and rigid in the Z-axis. The SCARA configuration is unique and designed to handle a variety of material handling operations.
- **Anthropomorphic robot:** It is shaped in a way that resembles a human hand, i.e. with independent fingers and thumbs.

1.5 Advantages

- Grasping and holding objects and then move them to a new location, or mixing with other fluids. (used in laboratories that trust such arms to work within a toxic environment and so do not endanger the researcher. Building cars.
- Retrieving suspicious objects without endangering humans.
- Dig trenches.
- A source of entertainment and education.
- An appendage of an anthropocentric robot.
- Used in surgery.
- Used in farming

1.6 Disadvantages

- This project is a small scale production it can pick up only small and lighter objects.
- On large scale this project may become costly and its circuit complexity increases.
- On large scale may become hazardous due to uncontrollable robotic arm it can harm physically.

1.7 Applications

- The characteristics of a robotic arm are:
  - ❖ its extension: how far from its base it can operate
  - ❖ its positioning: can it control its wrist position, orientation, with what precision, what speed
  - ❖ the tools and objects it can carry

Chapter 2
Literature Review
& Methodology

2.1 Literature Review

A survey on Arduino Controlled Robotic Arm by Ankur Bhargava. In this paper a 6 Degree of Freedom (DOF) robotic arm have been developed. It is controlled by an Arduino Nano microcontroller which accepts input signals from a user by means of a set of potentiometers. The arm is made from four rotary joints and end effectors also, where rotary motion is provided by a servomotor. Each link has been first designed using Solid works Sheet Metal Working Toolbox and then fabricated using a 2mm thick Aluminum sheet. The servomotors and links thus produced assembled with fasteners produced the final shape of the arm. The Arduino has been programmed to provide rotation to each servo motor corresponding to the amount of rotation of the potentiometer shaft. A robot can be defined according to the nature of the relative movements between the links that constitute it.

Review on development of industrial robotic arm by Rahul Gautam This selective operation robotic control method is need to be overcome the problem such as placing or picking object that at distant from the worker.[3] The robotic arm has been developed successfully as the movement of the robot can be controls precisely. It is expensive to change the cable and therefore the designing to reduce the friction on table, is crucial to increase time between maintenance.

Survey on Design and Development of competitive low cost Robot Arm With Four Degrees of Freedom by Ashraf Elfasahany In this paper the representation of the design, development and implementation of robot arm is done, which has the ability to perform simple tasks, such as light material handling. The robotic arm is designed and made from acrylic material where servo motors are used to perform links between arms. The servo motors consist of encoder so that no need to use controller. However, the rotation range of the motor is less than 180^{o} span, which greatly decreases the region reached by the arm and the possible positions. The design of the robot arm was for four degrees of freedom. The end effectors is not considered while designing because a readily available gripper is used as it is much easier and economical to use a commercial.[19]

2.2 Methodology

The components here used are arduino Nano board, Buck Converter, servo Motor, SMPS Aluminum Frame. Now talking about servo motors they are excessively used when there is a need for an accurate shaft movement or position. These are not proposed for a high speed application. Servo motors are proposed for low speed, medium torque and accurate position application. So they are best for designing robotic arm. Servo motor are available at different shapes and sizes. We are going to use small 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 wine is connected to power, the brown wire is grounded and the orange wire is for signal.

1. The arm has been built with cardboards and the individual parts have been locked to servo motors. Arduino Nano is programmed to control servo motors. Servos motors are acting as joints of Robotic arm here. This setup looks a like degrees (90 in each direction), these are excessively used when there is a need for accurate shaft movement or position. These are not proposed for high speed applications. They are proposed for low speed, medium torque and accurate position application. The voltage across variable resistors is not linear; it will be bit noisy one. So to filter out this noise, capacitors of micro are placed across each resistor a Robotic Crane or we can convert it into a Crane by easy ways.

2. This Robotic Arm is controlled by four Potentiometer with which we attach each with potentiometer that is used to control each servo. We can move these servos by rotating the potentiometer to pick some object, with some practice we can easily pick and move the object from one place to another. Here we use low torque servos here but we can use more powerful servos to pick heavy object.

3. Program done using Arduino 1.6.10.

4. We connect the circuit according to circuit diagram.

5. Now the voltage provided by these SMPS which represents position control into ADC channels of Arduino.

6. We will get data from voice recognition module by using Tx and Rx wire. as per our voice command arduino will get different signal from our voice recognition module and servo will get rotating command for every single voice command.

7. We will take this value and match it with servo position.

8. The robotic arms takes a perfect scaling that is cardboard, foam board is cut using measuring a servo are fitted according so that position of one servo motor does not affect the position of other servo motor. [19]

Chapter 3

Design And Construction

3.1 Introduction

The Voice-Controlled 6 DOF Robotic Arm presented in this project represents a significant advancement in human-robot interaction, offering a seamless and intuitive control mechanism. By harnessing the power of voice recognition technology and Arduino microcontrollers, this system exemplifies the potential for innovation in robotics and automation. Whether deployed in educational settings, research laboratories, or industrial environments, this voice-controlled robotic arm showcases the intersection of technology and user-centric design, paving the way for a future where human-robot collaboration is more accessible and efficient than ever before.

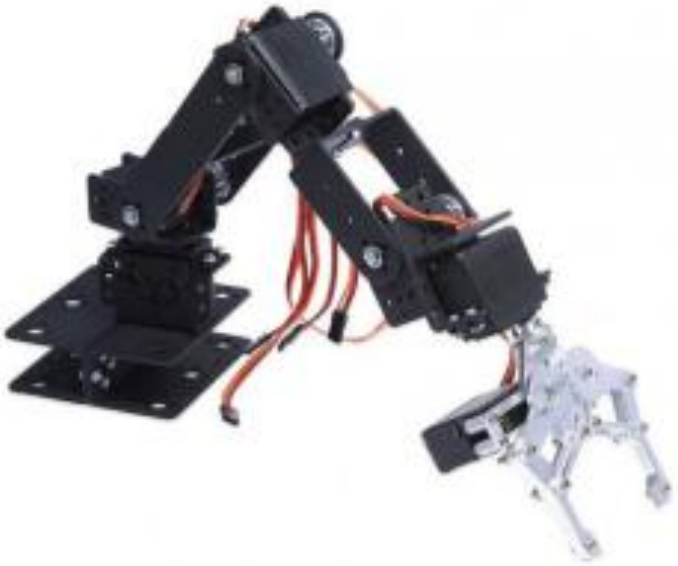


Figure 3.1: Robotic Arm

3.2 Materials and Instruments:

Instruments used in this projects can be classified into two categories which are;

a. Hardware and materials

b.Control tools and software

3.3 Hardware:

Table: 3. 1: Hardware Components

S/L	Components Name	Quantity
01	Arduino Nano	1 Nos
02	5V SMPS	1 Nos
03	Servo Motor	6 Nos
04	Mechanical Frame with Gripper	1 Set
05	Voice Recognition Module	1 Nos
06	Buck Converter	2 Nos
07	Wire	1 Mtr
08	Jumper Wire	7 Nos

3.3.1 Mechanical Gripper

A mechanical gripper is used to grip the objects and hold it while transferring it from its location to the destination the gripper has its inbuilt mini servo in it so it can open or close its jaws to grip the objects. The gripper is made from the acrylic by the LASER cutting operation. the shaft of the servo is fixed to the end of first jaw which meshes with the gear on the second jaw. as the motor rotates the gear rotates and this in turn rotates the gear in mesh and the jaws open or close to release or hold the objects.



Figure 3.2: Mechanical gripper

A gear link is attached to a servo motor which is meshes with another geared link to provide a smooth action of gripping of different objects according to their sizes the movement of both of figures of the grippers is synchronize well to hold the object.

3.3.2 Servo Motor

The three major servo motors are used in the robotic arm, one for the base movements and two on the side of the base plate two transmit the motion through the various links to the arm. The servo motor is bolted to the base plate it keeps it fixed and it avoids vibrations during the actual operations. A rotary actuator is consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.



Figure 3.3: Servo Motor

3.3.3 Arduino Nano

The Arduino Nano is a compact and versatile microcontroller board that is based on the ATmega328P microcontroller chip. It is essentially a smaller version of the popular Arduino Uno board, featuring similar functionalities but in a more compact form factor. The Nano is designed for projects where space is limited, making it suitable for use in various applications including prototyping, robotics, and embedded systems.

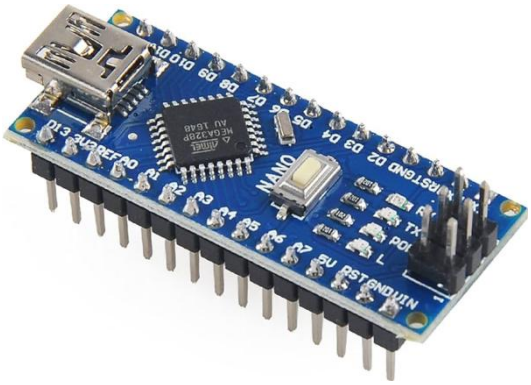


Figure 3.4: Arduino Nano

3.3.4 Jumper Wires

Jumper wires are simple electrical wires used to create connections between various components on a breadboard, circuit board, or between different electronic modules. They are commonly used in electronics projects, prototyping, and experimentation.



Figure 3.5: Jumper Wires

3.3.5 Voice Recognition Module

The "Voice Recognition Module V3" is a specific model of a voice recognition module designed to enable voice control functionality in electronic projects. Here's an overview of its features and functionality. It's worth noting that specific features and capabilities may vary slightly between different versions or manufacturers of voice recognition modules. Therefore, it's advisable to refer to the datasheet or documentation provided by the manufacturer for detailed specifications and usage instructions for the Voice Recognition Module V3.



Figure 3.6: Voice Recognition Module V3

3.3.6 Buck Converter

A buck converter, also known as a step-down converter, is a type of DC-DC converter that efficiently reduces a higher input voltage to a lower output voltage. It is widely used in various electronic devices and power supply systems to provide stable voltage output, regardless of input voltage variations. Buck converters find widespread use in various applications, including power supplies for electronics, battery charging systems, LED drivers, and renewable energy systems. [20]



Figure 3.7: Buck Converter

3.3.7 SMPS

A SMPS stands for Switched-Mode Power Supply. It is a type of power supply that converts electrical power efficiently from one form to another using switching devices such as MOSFETs or transistors, rather than using traditional linear regulators. SMPSs are commonly used in various electronic devices such as computers, televisions, mobile phone chargers, and industrial power supplies, where efficiency, size, and weight are critical factors.[19]



Figure 3.8: SMPS

3.4 Software Design:

Arduino IDE: The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.



Figure 3.9: Arduino IDE

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor .[19]

Proteus Professional: The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards. Proteus is a software tool primarily used for electronic design automation (EDA), specifically for designing, simulating, and testing electronic circuits. It is widely used by engineers, educators, and hobbyists for various purposes, including schematic capture, PCB (printed circuit board) layout, and microcontroller simulation. [19]



Figure 3.10: Proteus Professional

3.5 System Design:

3.5.1 Robotic Arm Parameters

Enlisting the industrial robotic arms parameter:

1. Number of axes
2. Degree of freedom
3. Working Freedom: The region of space a robot can reach
4. Carrying capacity or pay load: How much weight a robot can lift.
5. Speed: How fast the robot can position the end of its arm, angular linear speed of each axis or as a compound speed.
6. Acceleration: How quickly an axis can accelerate.
7. Accuracy: How closely a robot can reach a commanded position.
8. Repeatability: How well the robot will return to a programmed position.
9. Power source
10. Drive: Some robots connect electric motors to the joints via gears, others connect to the motor to joint directly.
11. Compliance

3.5.2 Robotic Arm Design

The main benefits of teleportation are that homo-sapiens are versatile and thus compliant with unstructured conditions. This project went through a range of design stages from the very first design which mainly focused on the necessary DOF, to the point that the design achieved its optimum stage and fulfilled all the criteria of the project based on complex assessments. In particular, we started by deciding the lengths of the arms connections to establish a practical configuration of six DOF and the ability to reach distances of 2 meters and the ability to fold the arm within the UGV surface dimension. The template of three connections was chosen because in conjunction with the revolving base and gripper it results in six DOF. The original lengths of the ties have been calculated from the 2 meter extension requirement. The first conceptual design was designed using computerized drawing software (CATIA) to ensure that the links are foldable over and above the UGV, and that their borders do not exceed. The following was the stage of

determining the form of each link. The subsequent approach concentrated more on the usability of trying to maximize each joint with the available rotating angle. In addition, the length and stroke were chosen in order to meet the loading criterion for each linear actuator. This stage of development led to a change of the proportions of relations, which involved a compromise to achieve the best movement. Eventually, the gripper was applied to the design, and the connecting dimensions improved, which reduced the connecting measurements in particular to a smaller arm.

3.5.3 Block Diagram

The robotic arm works on the principle of electrical input energy to perform some mechanical works effectively with the help of some automation and program based operations. The pick and place robotic arm consist of major hardware components such as strips & motors and arm gripper, Voice Recognition Module, SMPS, Metal Frame, Buck Converter and other discrete mechanical and electrical components. This project is designed for developing a pick and place robotic arm with a soft catching gripper.

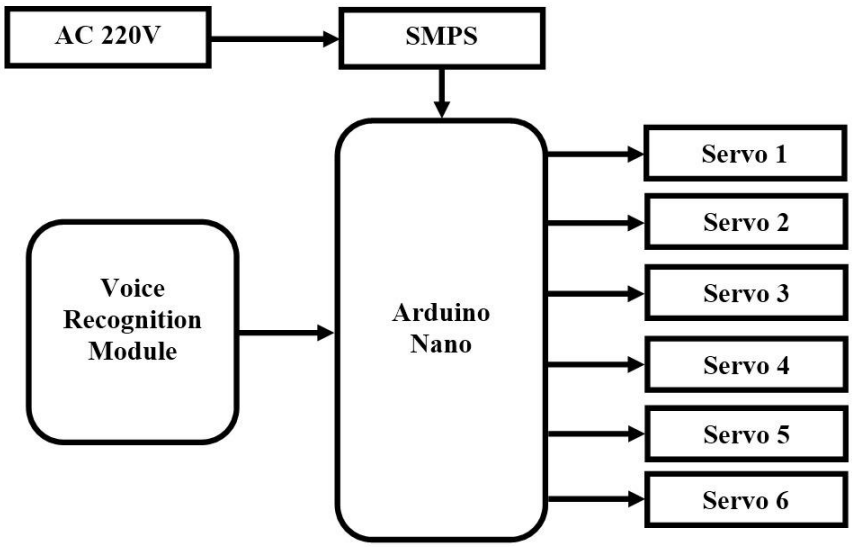


Figure 3.11: Block Diagram

This soft catching gripper is used for safely handling an object carefully while Catching and placing. The robotic arm consists of servo motor which is used for angular rotations of the arm for catching items (to hold items, to release, to rotate, to place). This servomotor used is works on the principle of Fleming's left-hand rule and is controlled using Arduino circuit board. In this system we try to make a Voice controlled robotic arm and show the system control using Voice Recognition Module V3. Arduino will get command from voice recognition module and it will rotate servo motors as per commands.

3.5.4 Circuit Diagram

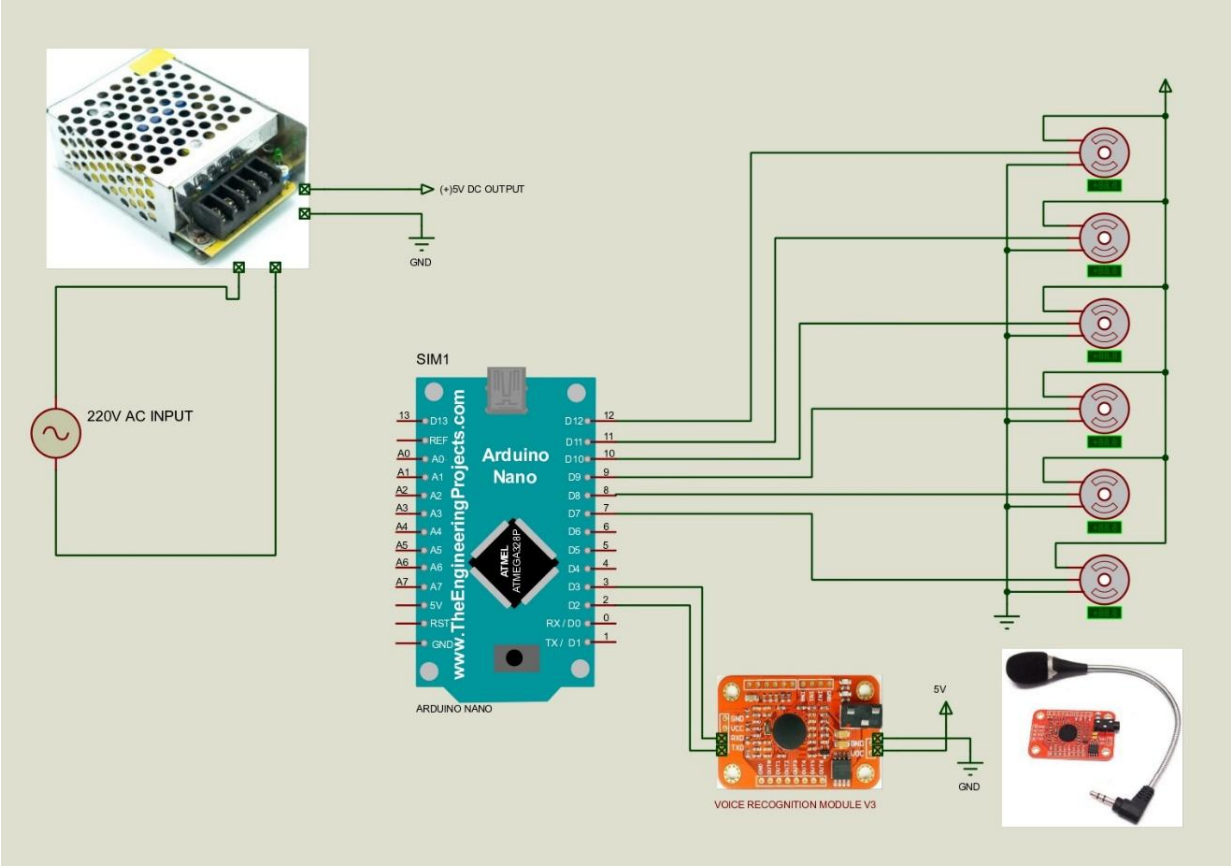


Figure 3.12: Circuit Diagram

As shown above we will need a total of 6 servo motor to operate our **robotic arm**, since these motors do not consume much power they are being driven directly by the 5V dc supply from a SMPS. I have used the veroboard to make the above connections. We use here a Arduino Nano

and Voice Recognition module to control this robotic Arm using Voice Command. once the connections are done my set-up looks something like this.

3.5.5 Drive Circuit

After the design of the robotic arm is complete, a moving circuit must be applied. The linear actuators are the robotic arm components to be operated. Essentially such actuators are DC motors which are operated by adjusting the polarity on the terminals in the direction of rotation. The linear actuators were powered by H-bridges consisting of relays. In particular, for practicality, pre-welded relay modules have been used since they enable the control of engines using a microcontroller directly.

3.6 Remote Controller

The Arduino Mega microcontroller has been chosen because its own C-based programming language is easy to program. The code includes the library which enables the Arduino Mega to be interfaced with a Bluetooth dongle that can then be linked to a PlayStation wireless controller to wirelessly monitor relays with the PS3 controller. The relays control the current direction in which the DC motors of the linear actuators flow, which controls the extension and retraction of each connection of the robotic arm. The servo motors mounted on a base rotation and a gripper were controlled by analog buttons on the PS3 controller. [19]

3.7 Mechanical Analysis

The efficiency of the robotic arm has to be evaluated, so the measurements below are carried out to insure that the mechanical configuration satisfies the standard specifications.

3.8 Torque Calculation

Newton's second rule was changed to calculate the base rotational torque and the gripper engines. The law states that an object must be rotated in torque relative to its angular acceleration

($\tau = I\alpha$), i.e., that it must be torque equivalent to the moment of inertia of the body. In order to give the arm a smooth and steady motion, the angular acceleration of its robot arm and its gripper will be preferred for the most important parameter for torque control. The motors used have produced very high torques, as the rotary arm has a ratio of 7:1 that guarantees good torque and sluggish rotational speed.

3.9 Force Analysis

A force study was carried out for the mechanical design in order to evaluate the appropriate proportions of the robotic arm connections. If the outcome of static analyzes and dynamic tests is negligible and because the arm is moving very slowly, static force analysis has been used. In addition, all the weight of the robotic arm components have been applied to the tip of the arm's gripper as a vertical force in the Y axis, including the strength weights and weights of the aluminum layer of the contact beams.[16] The robotic arm foundation had to be set, and the laws of Newton were used to perform a simple static force study. The measurement of static forces was carried out in different positions of the arm; the arm was slightly stretched, fully extended and bent down to take the target from a relatively close point in front of the UGV. The highest forces in the case of a full forward extension of the arm were the three positions. The analysis of the static force led to the reaction forces due to load and link weight. The pressures acting on the points of contact between the ties and pins linking the connected plates can be used to examine tension on each side of the head. The intensity measurement started from the gripper to the foundation joint. At each pin, weights of the previous parts were increased by the built-in charge.[12]

3.10 Stress Analysis

CATIA has been used to perform stress analysis on robotic arm components; CATIA provides stress and simulation methods that are specific to portions of different CAD drawing formats. The material to be checked must first be provided to the component to be tested; all the mechanical properties of the item must then be allocated the material using CATIA. Once the aluminum content has been allocated, forces can be positioned at various points of the component, which are dependent on the effects of the static force study. The component can be meshed and the algorithm will measure the tension. We have used the CATIA criterion for tension yield von mises. Depending on the actual stresses arising from von mises, we adjusted the measurements of the components to reduce stress, where a stress analysis protection factor was added.[14]

3.11 Tipping

Since safe operation of the arm during dangerous items is important, a tipping study has been performed for knowledge on load limitations in order to provide stabilization. The tipping equation was solved by MATLAB and the lifting load limiting graph was obtained. The study concluded that the pivot point is the car's bottom, and that the UGV runs on a flat surface. The arm will have a limited load range at each arm location (extension) that the user will learn in order to avoid device instability. The resulting time during load handling on different angels and extensions was calculated using MATLAB code, and was compared with the resulting time from the weight of the UGV. The point between equivalence of the two periods is the volatility to be prevented. The vehicle's weight is 200 Kg; 150 Kg in tipping calculations were taken into account for safety purposes. At full extension and half end, the capacity of the arm to fall over was measured. The UGV mass core is known as the UGV center 0.47 m away from the pivot. At the middle point of the component, the center of mass for every element was known.[9]

3.12 : 2D Drawing of 6 DOF robotic arm:

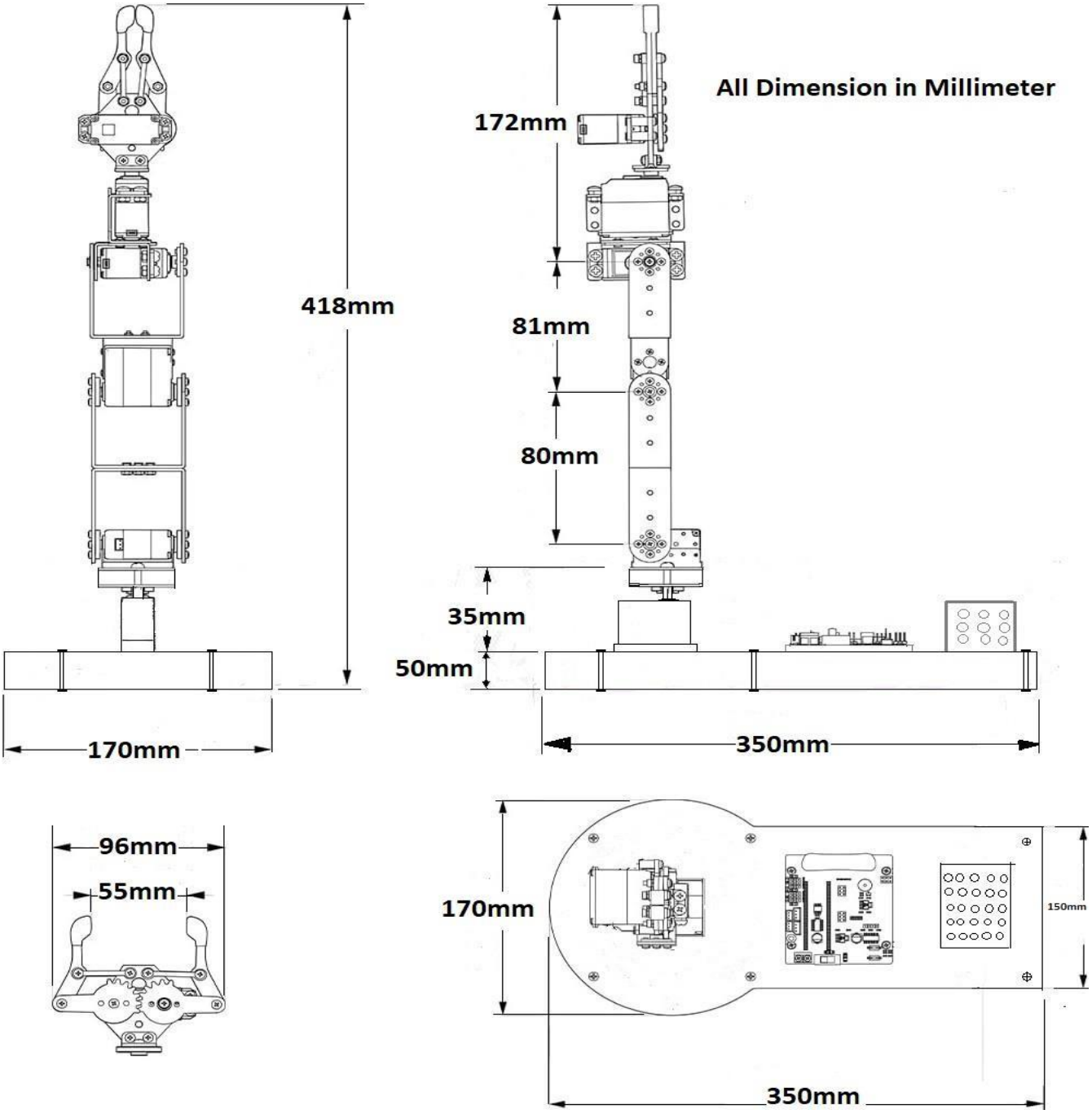


Figure 3.13: 2D Drawing of 6 dof Robotic Arm

3.13 Finally Constructed Robot:

3.13.1 Full Over View of Robotic Arm

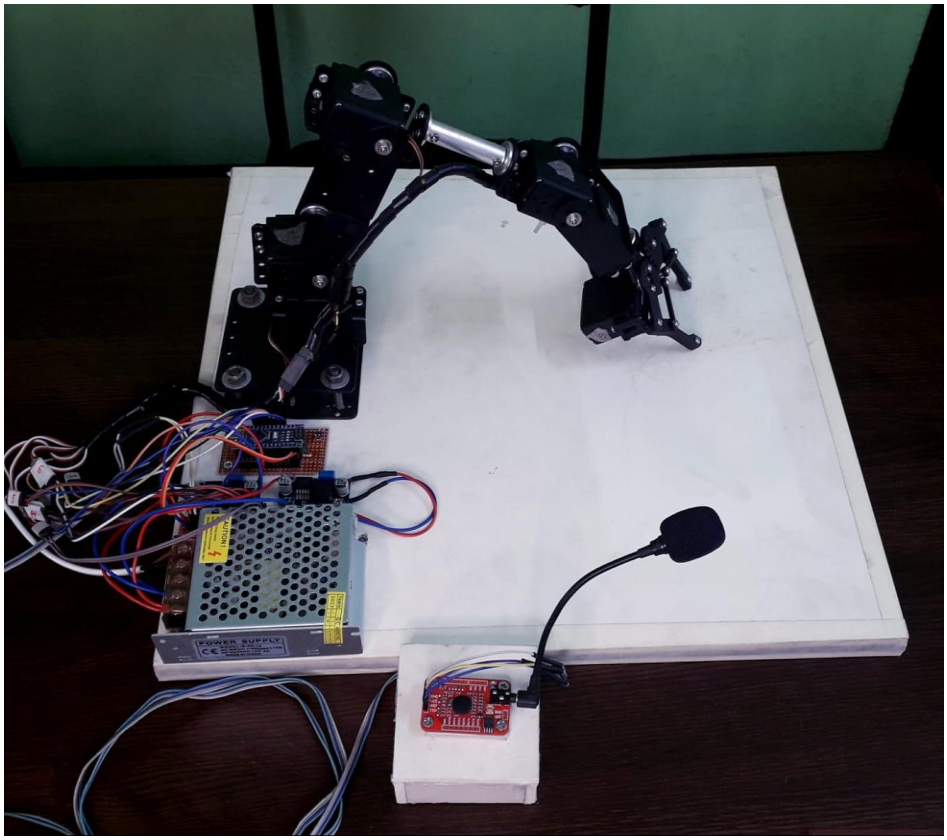


Figure 3.14: Full Over View of our Project

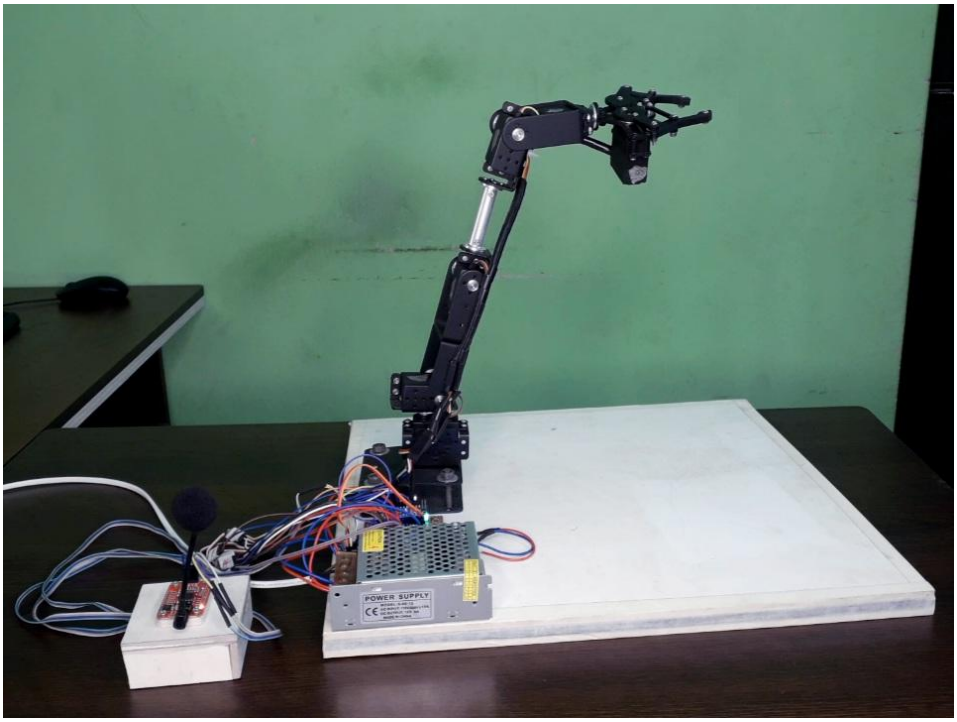


Figure 3.15: Up Position of our Robot

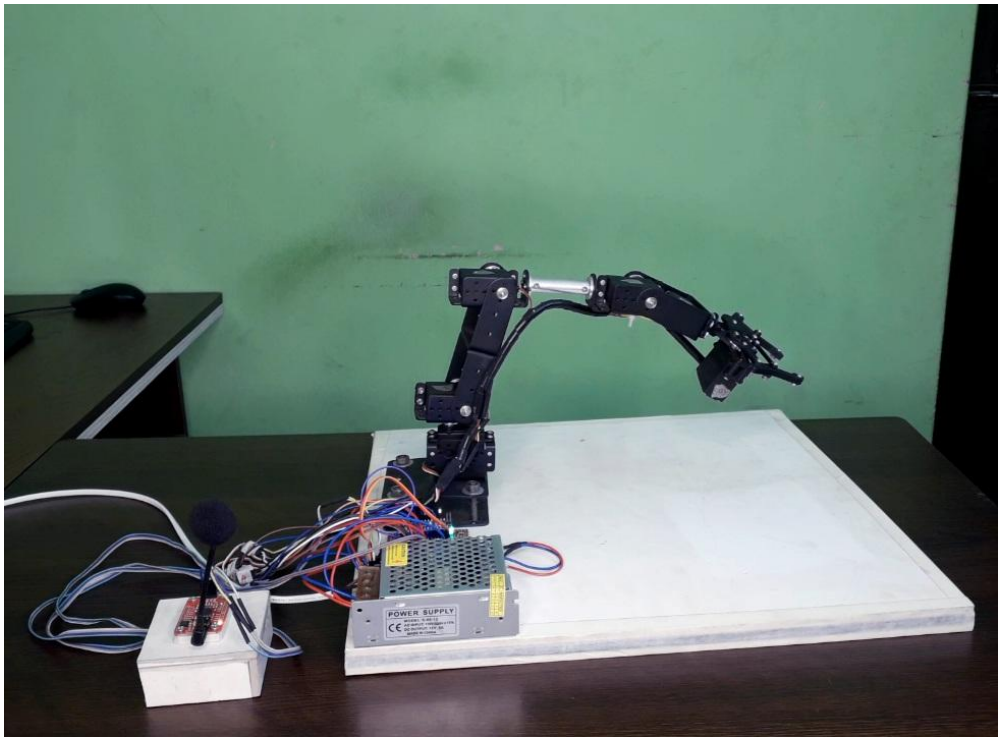


Figure 3.16: Down Position of our Robot

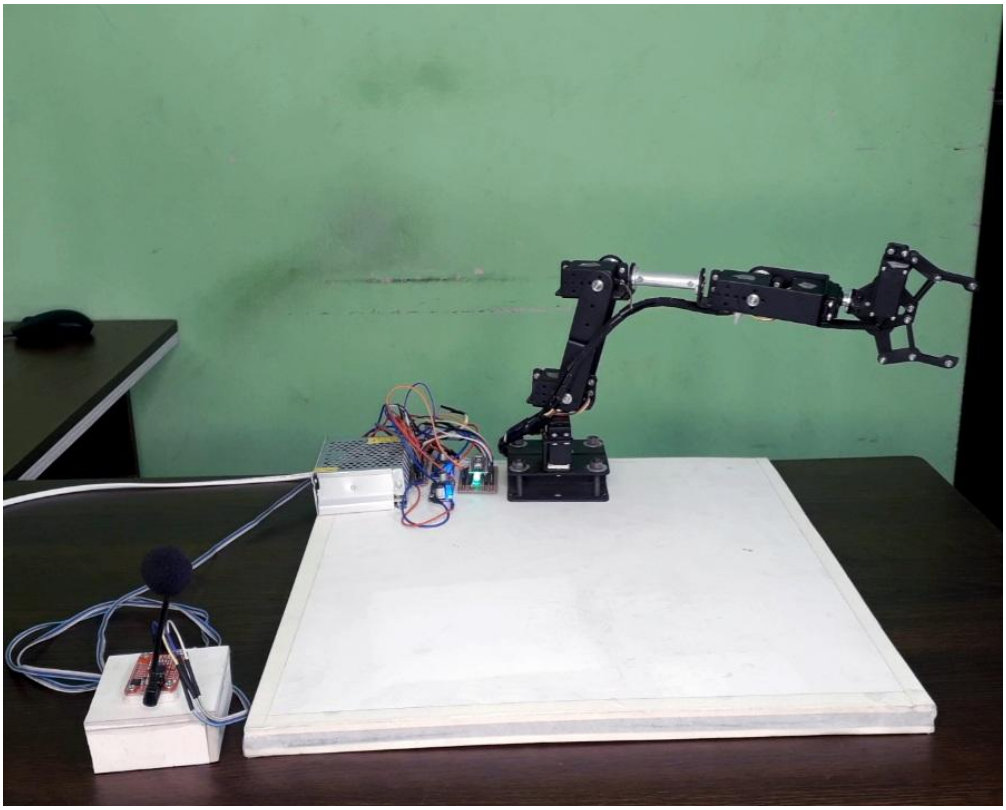


Figure 3.17: Left Position of our Robot

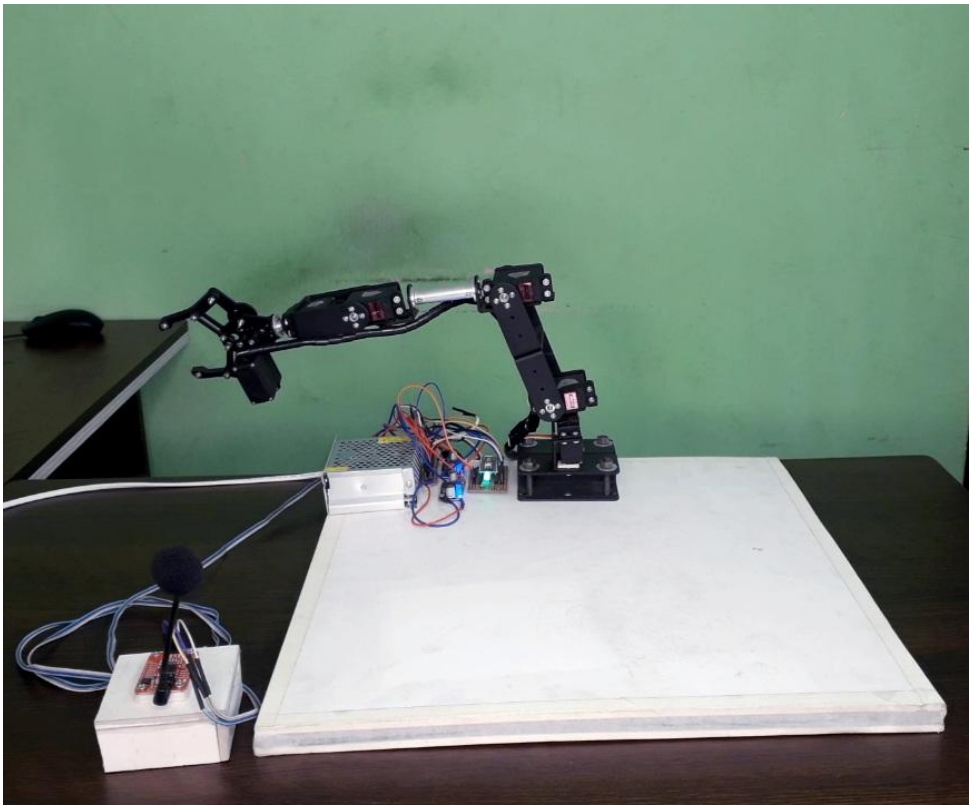


Figure 3.18: Right Position of our Robot

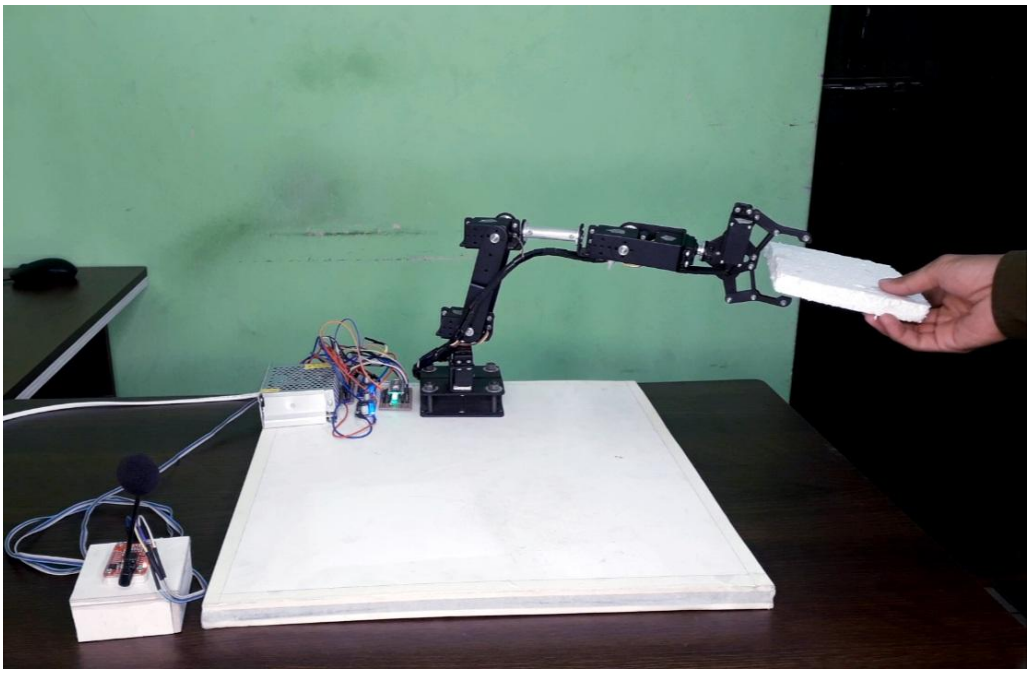


Figure 3.19: Grip Position of our Robot

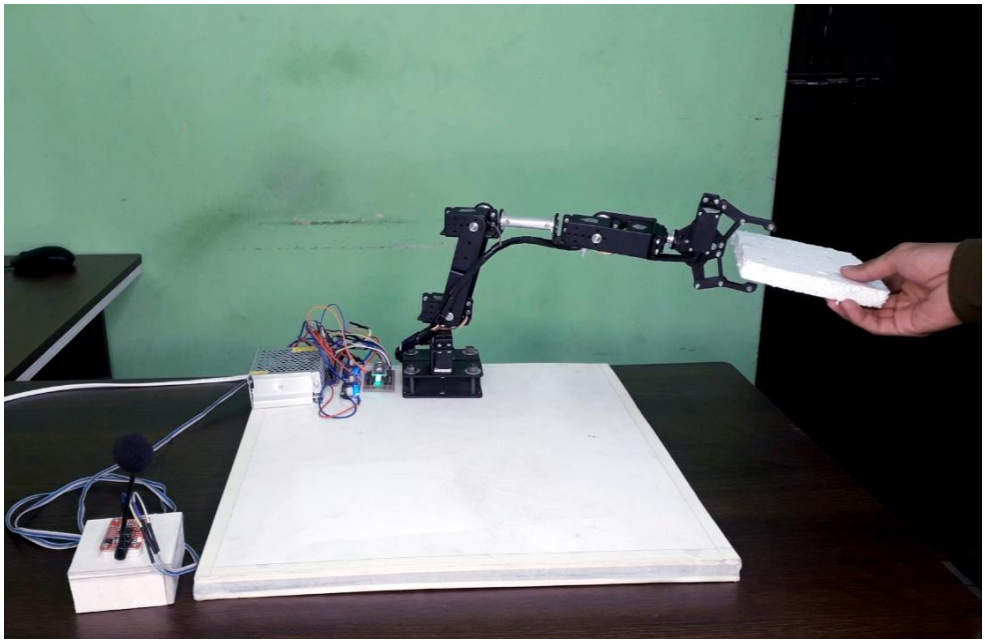


Figure 3.20: Un-grip Position of our Robot

3.14:Cost of the Project:

Table 3.2: Cost of the project

S/L	Components Name	Quantity	Price
01	Arduino Nano	1 Nos	570
02	5V SMPS	1 Nos	270
03	Servo Motor	6 Nos	3500
04	Mechanical Frame with Gripper	1 Set	5000
05	Voice Recognition Module	1 Nos	3000
06	Buck Converter	2 Nos	1200
07	Wire	1 Mtr	50
08	Jumper Wire	7 Nos	200
Total			13790

Chapter 4
Experiment And Result

Experiment:

Table: 4.1:For Up Position;

No. of Command	Result or Taken Command	Accuracy
1st	No	40%
2nd	Yes	
3rd	No	
4th	No	
5th	Yes	

Accuracy: [Number of Command/ Total Command]*100%
= [2/5]*100%
=40%

Table: 4.2:For Down Position;

No. of Command	Result or Taken Command	Accuracy
1st	Yes	60%
2nd	No	
3rd	Yes	
4th	Yes	
5th	No	

Accuracy: [Number of Command/Total Command]*100%
=[3/5]*100%

=60%

Table: 4.3:For right Position;

No. of Command	Result or Taken Command	Accuracy
1st	No	80%
2nd	Yes	
3rd	Yes	
4th	Yes	
5th	Yes	

Accuracy: [Number of Command/Total Command]*100%
==[4/5]*100%

=80%

Table: 4.4:For left Position;

No. of Command	Result or Taken Command	Accuracy
1st	Yes	80%
2nd	No	
3rd	Yes	
4th	Yes	
5th	Yes	

Accuracy: [Number of Command/Total Command]*100%
==[4/5]*100%
=80%

Table: 4.5:Gripper open position

No. of Command	Result or Taken Command	Accuracy
1st	No	60%
2nd	Yes	
3rd	Yes	
4th	No	
5th	Yes	

Accuracy: [Number of Command/Total Command]*100%

=[3/5]*100%

=60%

Table: 4.6:Gripper close Position;

No. of Command	Result or Taken Command	Accuracy
1st	Yes	40%
2nd	No	
3rd	Yes	
4th	No	
5th	No	

Accuracy: [Number of Command/ Total Command]*100%

= [2/5]*100%

=40%

Result:

Table:4.7 Final results:

Position	Accuracy
UP	40%
DOWN	60%
RIGHT	80%
LEFT	80%
OPEN (Gripper)	60%
CLOSE (Gripper)	40%

Chapter 5
Conclusion & Discussion

5.1 Conclusion & Discussion

We can do many things from this project and based on our work we discussed some things and discussed about what we can do more about this project in future.

Robotic arms are incredibly versatile tools with applications ranging from manufacturing and assembly to healthcare and even space exploration. They are designed to mimic the movement and function of a human arm, but with added precision, strength, and endurance.

One key aspect of robotic arms is their ability to automate repetitive tasks, which can increase efficiency and productivity in various industries. For example, in manufacturing, robotic arms can perform tasks like welding, painting, and packaging with high speed and accuracy, reducing the need for human labor and minimizing errors.

In healthcare, robotic arms are used in surgical procedures to enhance precision and control, leading to better patient outcomes and shorter recovery times. They can also assist individuals with disabilities by providing them with greater independence and mobility.

Moreover, robotic arms play a crucial role in exploration missions in environments where it's dangerous or impossible for humans to go, such as deep sea exploration or space exploration. They can be equipped with various tools and sensors to perform tasks like collecting samples or repairing equipment.

In conclusion, robotic arms have revolutionized many industries by providing efficiency, precision, and versatility. As technology continues to advance, we can expect to see even more innovative applications for robotic arms in the future.

5.2 Future Scope

- Future enhancement can include further improvement that is by adding 360 degree s 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

Future Prospects

The future of the robotic arms market looks promising, with continued growth expected across various sectors. As technology continues to evolve, we can anticipate the following developments:

1.Expansion into New Industries: Robotic arms will find applications in new industries, such as agriculture, construction, and hospitality, as they become more versatile and cost-effective.

2.Enhanced Mobility: The development of mobile robotic arms and drones with robotic arms will open up opportunities in logistics, search and rescue, and surveillance.

3.Continued Miniaturization: Smaller, more compact robotic arms will enable intricate tasks in confined spaces, further expanding their utility.

4.Human Augmentation: Robotic arms may be integrated with human limbs to enhance physical capabilities, benefiting both healthcare and industrial applications.

Sustainability Focus: Robotic arms will play a pivotal role in increasing efficiency and reducing waste in manufacturing, contributing to sustainability goals.

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[19] Wikipedia, https://www.wikipedia.org

[20] https://www.monolithicpower.com/en/power-elecrtonics/dc-dc-converters/buck-converters

Appendix:

Programe:

```
#include <Servo.h>
#include <SoftwareSerial.h>
#include "VoiceRecognitionV3.h"

Servo myServo;

/**
  Connection
  Arduino    VoiceRecognitionModule
   2   ------->     TX
   3   ------->     RX
*/

VR myVR(2,3);    // 2:RX 3:TX, you can choose your favourite pins.

uint8_t records[7]; // save record
uint8_t buf[64];

Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;
Servo servo5;
Servo servo6;

float mot1 = 90;
float mot2 = 90;
float mot3 = 90;
```

```
float mot4 = 180;
float mot5 = 90;
float mot6 = 90;

#define upRecord    (0)
#define downRecord   (1)
#define leftRecord    (2)
#define rightRecord   (3)
#define normalRecord    (4)
#define openRecord   (5)
#define closeRecord   (6)
/**
  @brief   Print signature, if the character is invisible,
           print hexible value instead.
  @param   buf     --> command length
           len     --> number of parameters
*/
void printSignature(uint8_t *buf, int len)
{
  int i;
  for(i=0; i<len; i++){
    if(buf[i]>0x19 && buf[i]<0x7F){
      Serial.write(buf[i]);
    }
    else{
      Serial.print("[");
      Serial.print(buf[i], HEX);
      Serial.print("]");
    }
  }
}
```

```
/**
  @brief   Print signature, if the character is invisible,
           print hexible value instead.
  @param   buf  -->  VR module return value when voice is recognized.
             buf[0]  -->  Group mode(FF: None Group, 0x8n: User, 0x0n:System
             buf[1]  -->  number of record which is recognized.
             buf[2]  -->  Recognizer index(position) value of the recognized record.
             buf[3]  -->  Signature length
             buf[4]~buf[n] --> Signature
*/
void printVR(uint8_t *buf)
{
  Serial.println("VR Index\tGroup\tRecordNum\tSignature");

  Serial.print(buf[2], DEC);
  Serial.print("\t\t");

  if(buf[0] == 0xFF){
    Serial.print("NONE");
  }
  else if(buf[0]&0x80){
    Serial.print("UG ");
    Serial.print(buf[0]&(~0x80), DEC);
  }
  else{
    Serial.print("SG ");
    Serial.print(buf[0], DEC);
  }
  Serial.print("\t");
```

```
  Serial.print(buf[1], DEC);
  Serial.print("\t\t");
  if(buf[3]>0){
    printSignature(buf+4, buf[3]);
  }
  else{
    Serial.print("NONE");
  }
  Serial.println("\r\n");
}

void setup()
{
  /** initialize */
  myVR.begin(9600);

  Serial.begin(115200);
  Serial.println("Elechouse Voice Recognition V3 Module\r\nControl LED sample");

servo1.attach(4);     //Attach the servo 1 to pin 3, servo 2 to 5 and so on...
servo2.attach(5);
servo3.attach(6);
servo4.attach(7);
servo5.attach(8);
servo6.attach(9);

// Primary Position of servos
        servo1.write(110);
        servo2.write(80);
        servo3.write(180);
        servo4.write(80);
```

```
        servo5.write(120);
        servo6.write(10);


if(myVR.clear() == 0){
  Serial.println("Recognizer cleared.");
}else{
  Serial.println("Not find VoiceRecognitionModule.");
  Serial.println("Please check connection and restart Arduino.");
  while(1);
}

if(myVR.load((uint8_t)upRecord) >= 0){
  Serial.println("upRecord loaded");
}

if(myVR.load((uint8_t)downRecord) >= 0){
  Serial.println("downRecord loaded");
}

  if(myVR.load((uint8_t)leftRecord) >= 0){
  Serial.println("leftRecord loaded");
}

  if(myVR.load((uint8_t)rightRecord) >= 0){
  Serial.println("rightRecord loaded");
}

  if(myVR.load((uint8_t)normalRecord) >= 0){
  Serial.println("normalRecord loaded");
}
```

```
  if(myVR.load((uint8_t)openRecord) >= 0){
  Serial.println("openRecord loaded");
 }

  if(myVR.load((uint8_t)closeRecord) >= 0){
  Serial.println("closeRecord loaded");
 }
}

void loop()
{
 int ret;
 ret = myVR.recognize(buf, 50);
 if(ret>0)
 {
  switch(buf[1]){

    case upRecord:
       servo1.write(110);
       servo2.write(80);
       servo3.write(180);
       servo4.write(80);
       servo5.write(120);
       delay(100);
      break;

    case downRecord:
       servo1.write(110);
       servo2.write(80);
       servo3.write(100);
```

```
    servo4.write(30);
    servo5.write(120);
    delay(100);
  break;

case leftRecord:
    servo1.write(180);
    servo2.write(80);
    servo3.write(100);
    servo4.write(10);
    servo5.write(10);
    delay(100);
  break;

case rightRecord:
    servo1.write(10);
    servo2.write(80);
    servo3.write(100);
    servo4.write(10);
    servo5.write(180);
    delay(100);
  break;

case normalRecord:
    servo1.write(120);
    servo2.write(80);
    servo3.write(180);
    servo4.write(80);
    servo5.write(120);
    servo6.write(10);
    delay(100);
```

```
      break;

    case openRecord:
        servo6.write(10);
        delay(100);
      break;

    case closeRecord:
        servo6.write(100);
        delay(100);
      break;


     default:
      Serial.println("Record function undefined");
      break;
   }
   /** voice recognized */
   printVR(buf);
  }
}
```