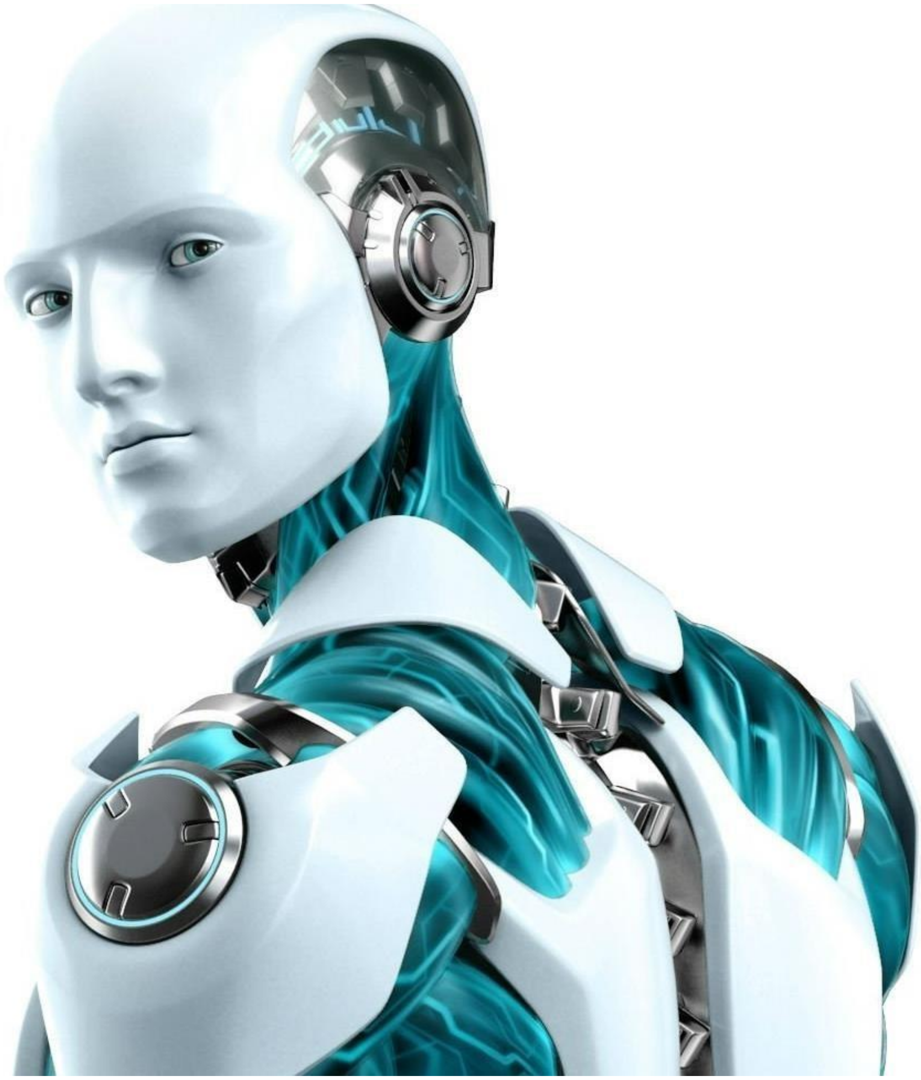


ROBOTIC ARM CONTROL SYSTEM

PROJECT: IMPLEMENTING A ROBOTIC ARM CONTROL SYSTEM (REPORT)

Submitted by AKASH DEBNATH

ABSTRACT

Today, technology is developing in the same direction in line with rapidly increasing of human needs. The work done to meet these needs makes life easier every day, and these studies are concentrated in robotics studies. Actually in recent year's scientists use the word "**Robot**" to mean any man-made machine that can perform work or other action normally performed by humans, either automatically or by remote control because of this robot pervasive machine because of it is accuracy of work and doing thing that people can't do in addition robot can work in dangerous regions that human can't work in it because of all these reason robot became one of the most popular thing that scientists still persevere to make it better by finding new controllers and designs that make robot more efficient and more reliable.

In the very **first part** of our project we have built an very basic robotic arm with four servo motors and four corresponding potentiometers for controlling the degrees for rotation for each motor.

Following this, in the **second part** of our project we have made a modification in the first part by removing all the poetentiometer,instead we have used serial communication between the user and the Arduino UNO microcontroller board,which will let the user to set the degrees of rotation (for each motor as input) in the serial monitor.We have used **Serial.parseInt()** function in our code.(no switch statement is used)

In the whole project we have used a **Arduino UNO** microcontroller board,a power supply,4 servo motors and four potentiometer.

OBJECTIVES

The industrial sector has been quickly moving toward automated processes in recent years. Industrial robots today either augment manual labour or take its place totally. This has generally been motivated by the desire to raise manufacturing quality and increase efficiency, among other value-adding goals.

The unsung heroes of this industrial automation movement are industrial robot arms. They remain a mystery to many yet have a big impact on how well industry robots function. Understanding how your operations operate may be useful if you want to automate them.

The main objective behind this work is to construct a robotic arm capable of movement and which will help in carrying objects from one place to another(if possible the higher version of this could be used in industries later).We have done this in two different ways.

So our project mainly consists of two distinct parts as follows:

- **Part 1: To implement a robotic arms control system using potententiometer.Here the motor control is brought about by changing the parameters of the potentiometer**.

- **Part 2: To implement an advance robotics arms control system using serial communication between the user and the Arduino UNO microcontroller board.Here we will not use any potentiometer unlike the first part.Part 2 is a slight modification of part 1.**

INTRODUCTION

Overview:

A robot is a machine designed to execute one or more tasks automatically with speed and precision. We need robots because robots are often cheaper to use over humans, in addition it is easier to do some jobs using robots and sometimes the only possible way to accomplish some tasks! Robots can explore inside gas tanks, inside volcanoes, travel the surface of Mars or other places too dangerous for humans to go where extreme temperatures or contaminated environments exist. Robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. Robotic system has been widely used in manufacturing, military and surgery since the robot can perform many advantages and used as the countermeasure for some job that cannot be conduct by the human excellently.

Robots are used in different fields such as industrial, military, space exploration, and medical applications. These robots could be classified as manipulator robots and cooperate with other parts of automated or semi-automated equipment to achieve tasks such as loading, unloading, spray painting, welding, and assembling. Generally robots are designed, built and controlled via a computer or a controlling device which uses a specific program or algorithm. Programs and robots are designed in a way that when the program changes, the behavior of the robot changes accordingly resulting in a very flexible task achieving robot. Robots are categorized by their generation, intelligence, structural, capabilities, application and operational capabilities.

Types of robots:

In this study robots are reviewed according to their structural properties:

(1) Linear Robots

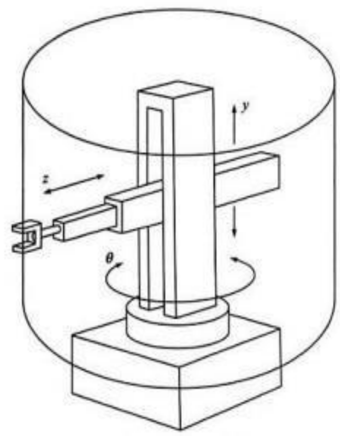
A robot which has linear actuators cooperating with linear motors linked to a linear axis is known as a linear robot (also known as gantry or Cartesian) as shown in figure 1.1. This link can be fixed or flexible connections between the actuators and the robot. The linear motor is attached directly to the linear axis. Robots which use two motors in controlling a linear axis defined gantry robots. Each motor has a limited distance orthogonal to the linear axis. Ball screws follow the same principles which either use linear motors or rotary motors. This kind of robots usually achieve tasks such as palletizing, unitizing, and stacking, order grasping, loading, and coordinate measuring. The manipulator (also known as end-effector) of the linear robots is connected in an overhead way that allows the robot to move along the horizontal plane easily, where each of these movements are perpendicular to each other.

Linear Robots

This type of robot has many advantages like high speed and stiffness, good performance, Good for multiple machines and lines, good handling with large loads. However, it has large structural frame, complex mechanical properties for linear sliding movements, Energy inefficiency, large floor space requirement, Limited workspace, Common workspace restriction.

(2)<u>Cylindrical Robots</u>

Cylindrical robots have two prismatic joints: one rotary joint for positioning task and the end-effector of the robot forms a cylindrical workspace. The main idea of the cylindrical robots is to mount a horizontal arm which moves in forward and backward directions. The horizontal arm is linked to a carriage which goes up and down and is connected to the rotary base. When the arm of the robot has a revolute and two prismatic joints, it can operate in z-axis and each point that can be reached by this robot can be represented by the cylindrical coordinates. As shown in figure, the robot can move in and out in z direction, can elevate in y direction and can rotate in θ direction. The arm can move in directions between the specific upper and lower boundaries.



Cylindrical Robots

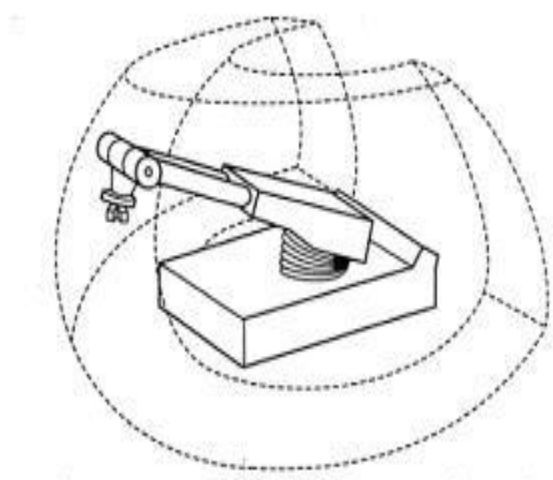
(3)Parallel Robot

A parallel robot has an end-effector with n DOF which is connected to a fixed base. The connection is done by at least two independent kinematic chains which provide the movements of the robot as shown in figure. A generalized parallel manipulator has a closed-loop kinematic chain mechanism where the manipulator is linked to the base.

Parallel Robot

(4)Spherical Robots

The spherical robot (also known as polar robot) is huge in terms of size and has a telescopic arm. Spherical robot basic movements are rotation at the base and angularly up and down at the arm. 15 Spherical robots have at least two movable joints and one fixed joint. The schematic diagram and the motion of the spherical robot consists of the following three movement steps; the first movement defines the rotation of the base along vertical axis. The second movement defines the rotation of the arm and finally the third movement defines the in and out motion. The workspace of the spherical robot depends on the volume of globe of the sphere. The workspace of the robot is the space between two concentric hemispheres. When the arm is fully retracted, the reach of the arm is the inner hemisphere and when the arm is fully straightened, the reach is the outer hemisphere.



Spherical Robots

This type of robot has many advantages like light weight, simple kinematics, compatible with other robots especially with ones in a common workspace, sharp joints level, good resolution due to perpendicularity of the end-effector’s errors. However, it need of variable torque due to the large size, challenging counter balancing, chance of having collision with obstacles due to bounded ability to avoid collisions and large position errors due to the rotation and proportional radius.

(5)SCARA Robot

Selective Compliance Assembly Robot Arm (SCARA) was first designed and invented in early 1960s in Japan. SCARA robots are perfect for the applications which require high speed and repetitive point to point movements. This is why SCARA is used widely in assembly operation. Special end-effector movement makes SCARA ideal for the tasks which require uniform motion and accelerations in a circular form. SCARA consists of two parallel rotary joints and a prismatic joint. The rotary joints can move along the horizontal plane and the prismatic joint moves along the vertical plane. One of the special characteristic of SCARA is that the robot is smooth while operating on x and y-axis but very strong versus the z-axis.

SCARA arm is able to pick up a part vertically from a horizontally placed table and move along the horizontal plane to a desired point and accomplish the assembly task by lowering the arm and placing the part at its proper location as shown in the following figure.

SCARA Robot

(6)Articulated Robots

Articulated robots (also known as revolute robots) have three fixed axis connected to two revolute base as shown in figure. All joints of an articulated arm are revolute and most likely represent the human arm.

A **robotic arm** can be said to be a typical example for articulated robot. An important matter which should be considered is that the dimension of the configuration space increases with the number of joints however the operation speed is limited due to the different payloads at the manipulator and nonlinear environment.

Articulated Robots

This type of robot has many advantages like super structural flexibility, compatible with other robots operating in common workspace, high rotation speed. However, it has low accuracy and resolution because of rotary joints and positional errors, counter balancing difficulties due to the large and variable torque, high chance of collision and dynamic instability due to higher moment of inertia and gravity.

Robot arm

Robotic manipulators resembling the human arm are known as **robotic arms**. They are constituted by a structure consisting of structurally robust links coupled by either rotational joints (also referred to as revolute joints) or translating joints (also referred to as prismatic joints) a **robotic arm** is thus a type of mechanical arm, usually programmable, with similar functions to a human arm. A typical robotic arm has the following components:

• Links and joints

• Actuators

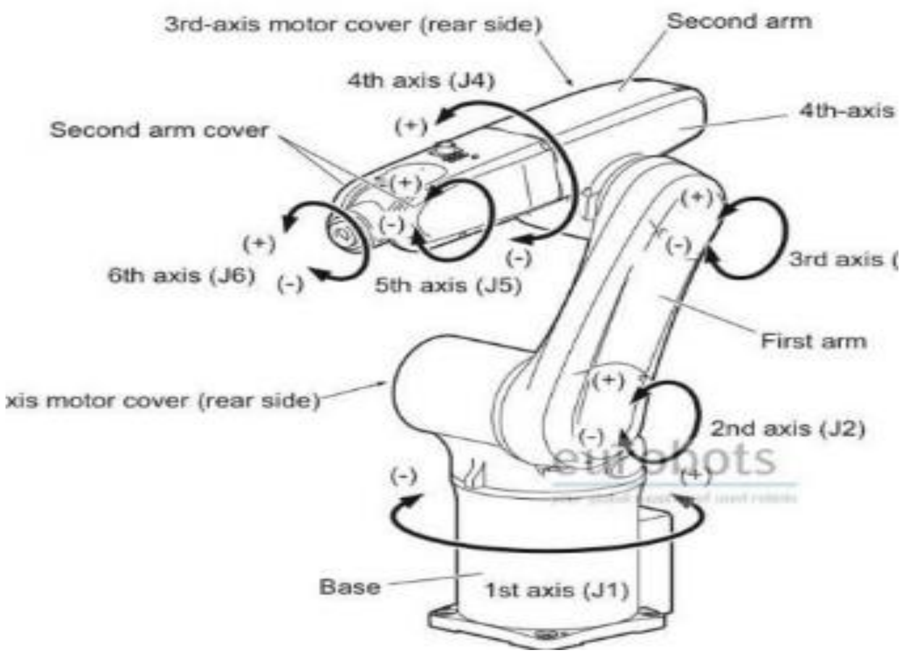
• Controller

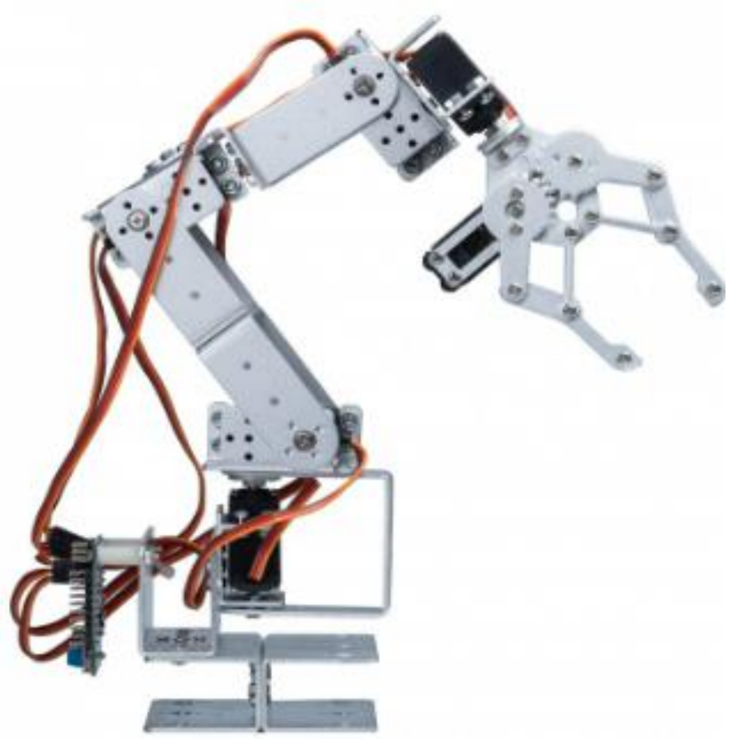
• End-effector

• Sensor

A robotic arm is a mechanical device designed to replicate the structure and functionality of a human arm. Comprising a series of rigid links connected by joints, these arms are capable of performing tasks with a range of motion similar to that of a human limb. These joints can be of two main types: rotational joints, allowing for bending and rotation akin to a hinge, and translating joints, facilitating linear movement along a specific axis, much like a piston. Actuators, such as electric motors or hydraulic cylinders, power these movements. At the end of the arm, there's typically an end effector, which can be a gripper, welding torch, camera, or other tool suited to the task at hand. These arms are programmable, allowing for manual or automatic control through sophisticated control systems, often incorporating sensors and feedback mechanisms for precise operation. Robotic arms are widely used across industries for tasks such as assembly, welding, surgery, and inspection, owing to their versatility, precision, and repeatability in various applications.

A robotic arm represents a sophisticated mechanical system engineered to emulate the dexterity and versatility of the human arm. Constructed from robust segments linked by joints, these arms exhibit a remarkable range of motion akin to their biological counterparts. The joints, which can either rotate or translate, facilitate bending, twisting, and extending movements essential for performing diverse tasks. Actuators, the powerhouses of motion, drive these joints, converting energy into mechanical action. Positioned at the arm's terminus, the end effector assumes various forms tailored to specific applications, whether it be gripping objects, wielding welding torches, or capturing images. Programmability lies at the heart of these systems, enabling precise control through intricate algorithms and feedback mechanisms.


3rd-axis motor cover (rear side)
Second arm
4th axis (J4)
(+)
4th-axis
Second arm cover
(+)
(-)
(+)
(-)
(+)
(-)
6th axis (J6)
(-)
5th axis (J5)
(-)
3rd axis (
First arm
xis motor cover (rear side)
(+)
2nd axis (J2)
(-)
(-)
(+)
Base
1st axis (J1)



1- **Links and joints:** A link is considered as a rigid body that defines the relationship between two neighboring joint axes of a manipulator. Manipulators consist of rigid links, which are connected by joints that allow relative motion of neighboring links. The links move to position the end-effector.

2- **Actuators:** Actuators play the same role the muscles play in the human arm - they convert stored energy into movement. Actuators are used to move a robot’s manipulator joints, the actuator can be pneumatic, hydraulic and electrical actuator but in the project we used electrical actuators (servo motors).

3- **The controller:** is the main device that processes information and carries out instructions in a robot. It is the robot's 'brain' and controls the robot's movements. It is usually a computer of some type which is used to store information about the robot and the work environment and to store and execute programs which operate the robot. It contains programs, data algorithms, logic analysis and various other processing activities which enable the robot to perform its intended function, most robots incorporate computer or microprocessor-based controllers. These controllers perform computational functions and interface with and control sensors, grippers, tooling, and other peripheral equipment , so the controller that we used in this project is Arduino mega microcontroller.

4- **End-effector:** In robotics, an end-effector is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application of the robot. Typical functions of the end-effector include grasping, pushing and pulling, twisting, using tools, performing insertions, welding and various types of assembly activities. Thus, the major types of robot endeffectors are Grippers , material removal tools, welding torches, tool changers, and there is a surgical robots have end-effectors that are specifically manufactured for performing surgeries.

5- **Degree of Freedom(DOF):**When the parts of a robotic arm move, the **degree of freedom—an independent motion number**—occurs in three dimensions.

Typically, we consider delivery mechanism movement to be a measure of freedom.

Humans have 27 degrees of flexibility from their fingers to their shoulders, but creating a robot arm with that many degrees of movement would be more difficult and useless. According to mechanical analysis, an object only has six degrees of freedom in space. Therefore, the delivery mechanism must likewise have six degrees of freedom in order to capture and move objects that are in diverse positions in space. Commonly used robot arms often have less than six degrees of freedom (DOF), while universal robot arms typically have between four and six DOF.

Robot arm movement flexibility can be characterised by joint and DOF since each DOF is achieved by a separate driving joint. We also refer to the joint as the axis since it is an axis that completes the actural framework and allows the joint to move.

ARDUINO CODE

PART 1:In the first part of the project we are focused on the implementation of a robotic arm control system using potentiometer. The code for achieving this is shown below:

```
#include<Servo.h>
Servo servo[4];
const byte servoPin[4]={2,3,4,5};
void setup(){
Serial.begin(9600);   for(int
i=0;i<4;i++){
servo[i].attach(servoPin[i]);
servo[i].write(90);   delay(1000);
     }
    }
 void loop(){
  int angle1=map(analogRead(A0),0,1023,0,180);
int angle2=map(analogRead(A1),0,1023,0,180);    int
angle3=map(analogRead(A2),0,1023,0,180);    int
angle4=map(analogRead(A3),0,1023,0,180);

  servo[0].write(angle1);
servo[1].write(angle2);
servo[2].write(angle3);
servo[3].write(angle4);}
```

<u>PART 2</u>:In the second part of the project we are focused on the implementation of an advance robotic arm control system without using any potentiometer rather we will use serial communication-the user will be able to give the input in the serial monitor itself. The code for achieving this is shown below:

```
#include<Servo.h>
int angle1; int
angle2; int angle3;
int angle4; Servo
servo[4];
const byte servoPin[4]={2,3,4,5};
void setup(){
Serial.begin(9600);   for(int
i=0;i<4;i++){
servo[i].attach(servoPin[i]);
servo[i].write(90);   delay(1000);
  }
}          void
loop(){
  Serial.println("Set the degree of motion for 1st motor:");
while (Serial.available() == 0){ }       angle1 =
Serial.parseInt();
  Serial.println("Set the degree of motion for 2nd motor:");
while (Serial.available() == 0){ }

    angle2 = Serial.parseInt();
```

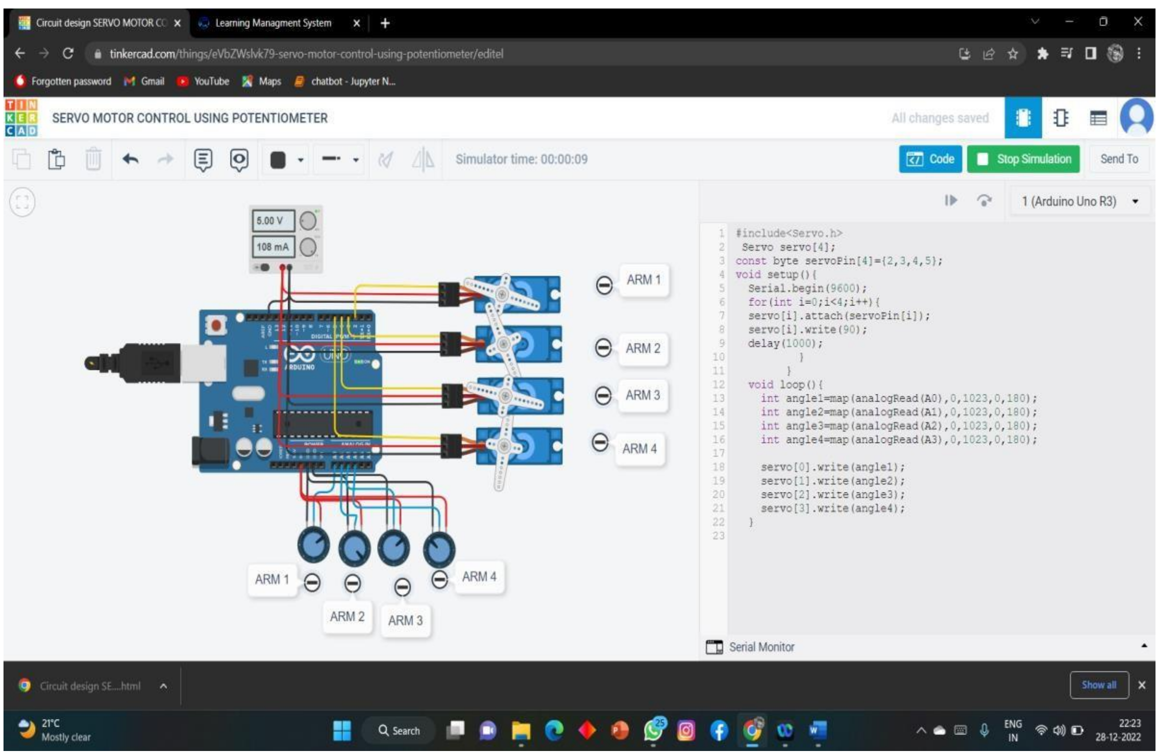
```
    Serial.println("Set the degree of motion for 3rd motor:");
while (Serial.available() == 0){ }        angle3 =
Serial.parseInt();
    Serial.println("Set the degree of motion for 4th motor:");
while (Serial.available() == 0){ }        angle4 =
Serial.parseInt();

    servo[0].write(angle1);
servo[1].write(angle2);
servo[2].write(angle3);
servo[3].write(angle4);     while
(Serial.available() == 0){ }
 }
```

METHODOLOGY

In the **methodology** section we will go through the implementation of both part1 and part 2 of our project-starting from the hardware connections to the final output so as to achieve our desired objectives.

PART 1:

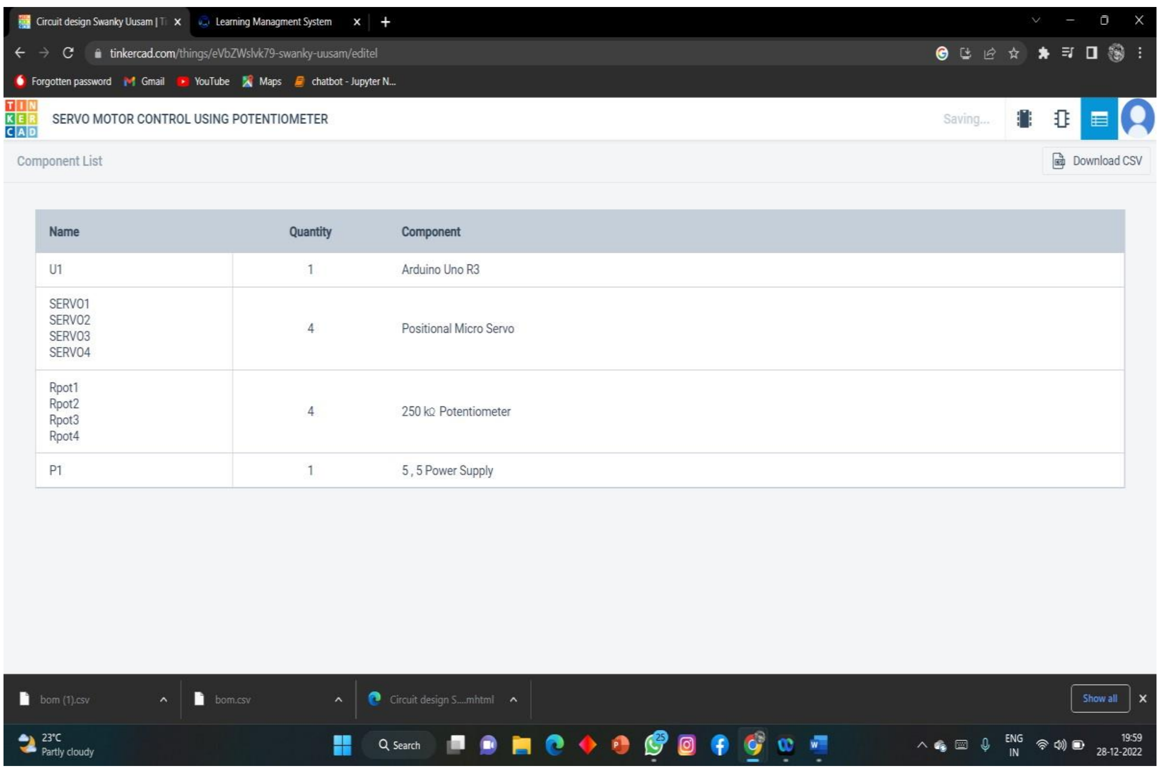
STEP 1: We have joined the hardware components and constructed the required circuit as shown in the figure below.We have used the tinkercad as a platform for simulation. For this,we have used four servo motors and four corresponding potentiometers for each motor,and a power supply all connected through a Arduino UNO board.



STEP 2: Wrtite the code for the controlling the degree of rotation of the servo motors using potentiometer.After doing so,click on the start simulation button to run the code.

STEP 3: Once the simulation has started it is observes that at first all the servo motors will set them into 90 degrees rotation as we have metioned this value in our code inside the **void setup(){}** section.After that we can change the values of the potentiometer to rotate each motor by different degrees of rotation.

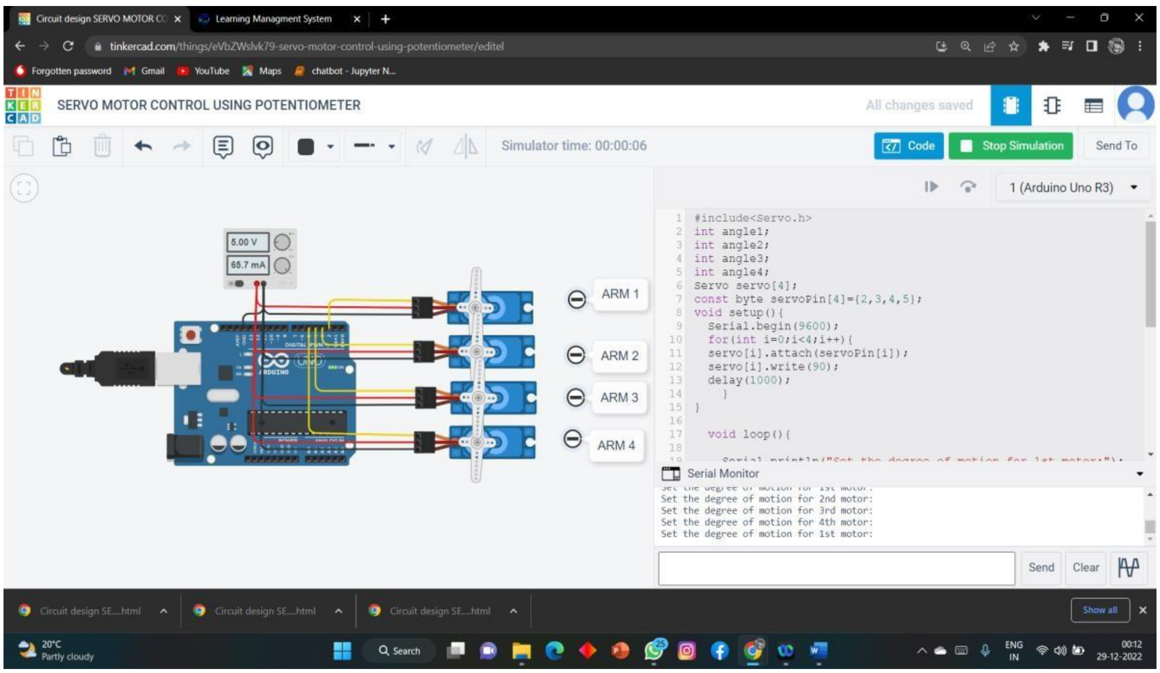
Here is a list of all the hardware components used in the very first part of our project.



Name	Quantity	Component
U1	1	Arduino Uno R3
SERVO1 SERVO2 SERVO3 SERVO4	4	Positional Micro Servo
Rpot1 Rpot2 Rpot3 Rpot4	4	250 kΩ Potentiometer
P1	1	5 , 5 Power Supply

PART 2:

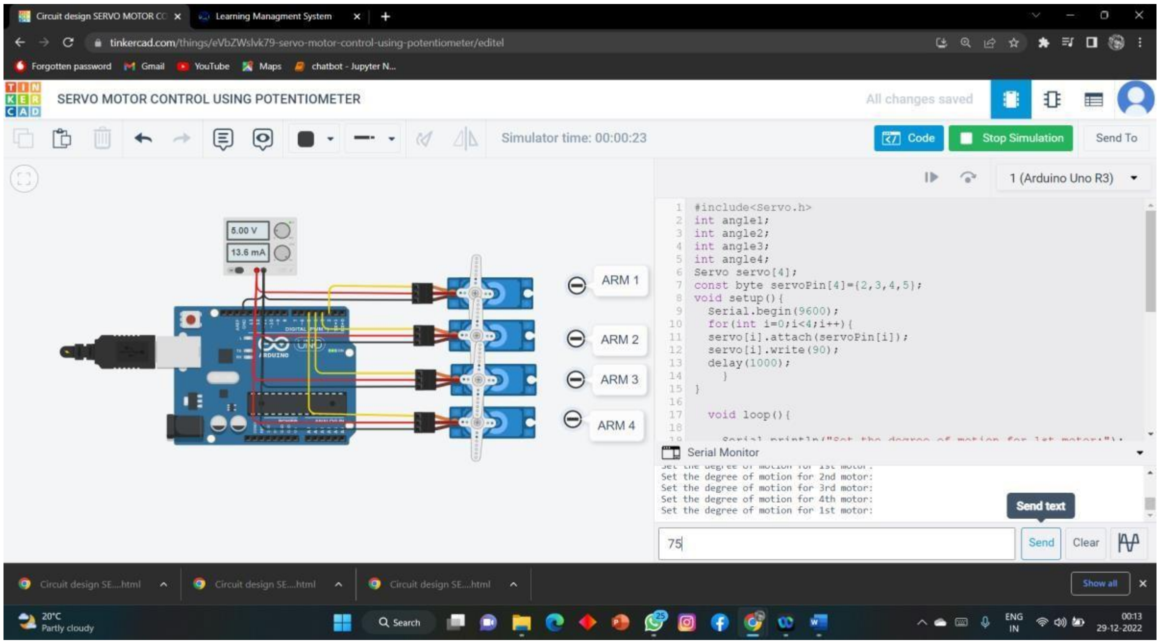
STEP 1: Wrtite the code for the controlling the degree of rotation of the servo motors without using potentiometer instead we are using serial communication between the system and the user .After doing so,click on the start simulation button to run the code,as shown below.



Initially we observe that all motors set them into 90 degrees

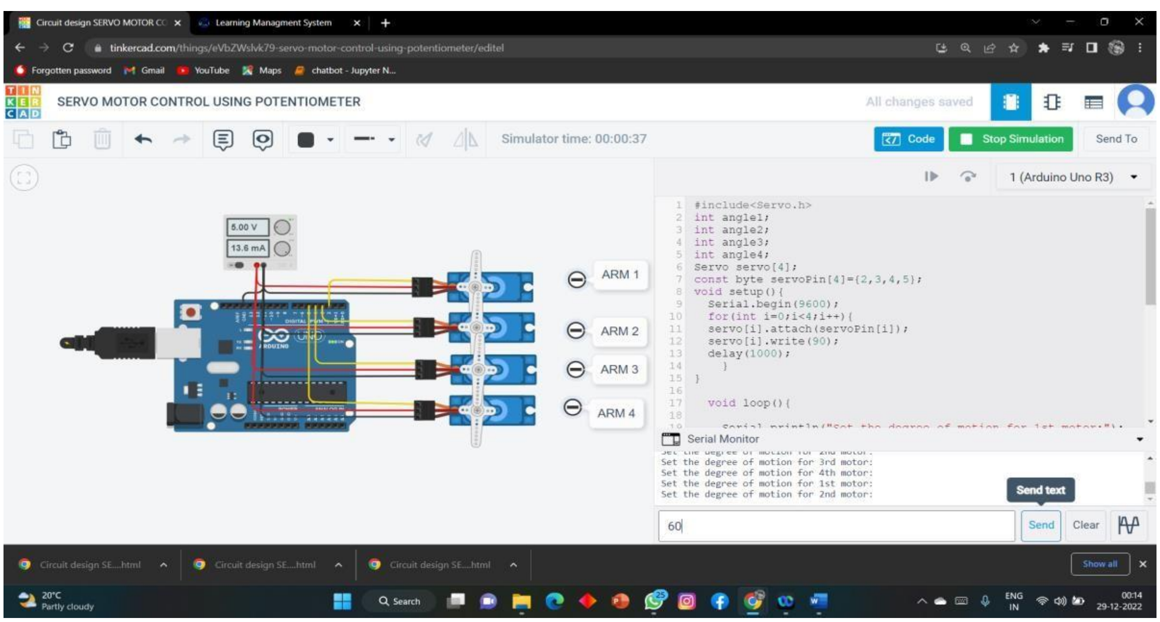
STEP 2: Wrtite the code for the controlling the degree of rotation of the servo motors using serial communication.After doing so,click on the start simulation button to run the code.

STEP 3: As soon as step 2 is performed ,the user will be asked in the serial monitor to give the degree of rotation for first motor as input as shown on the next page.

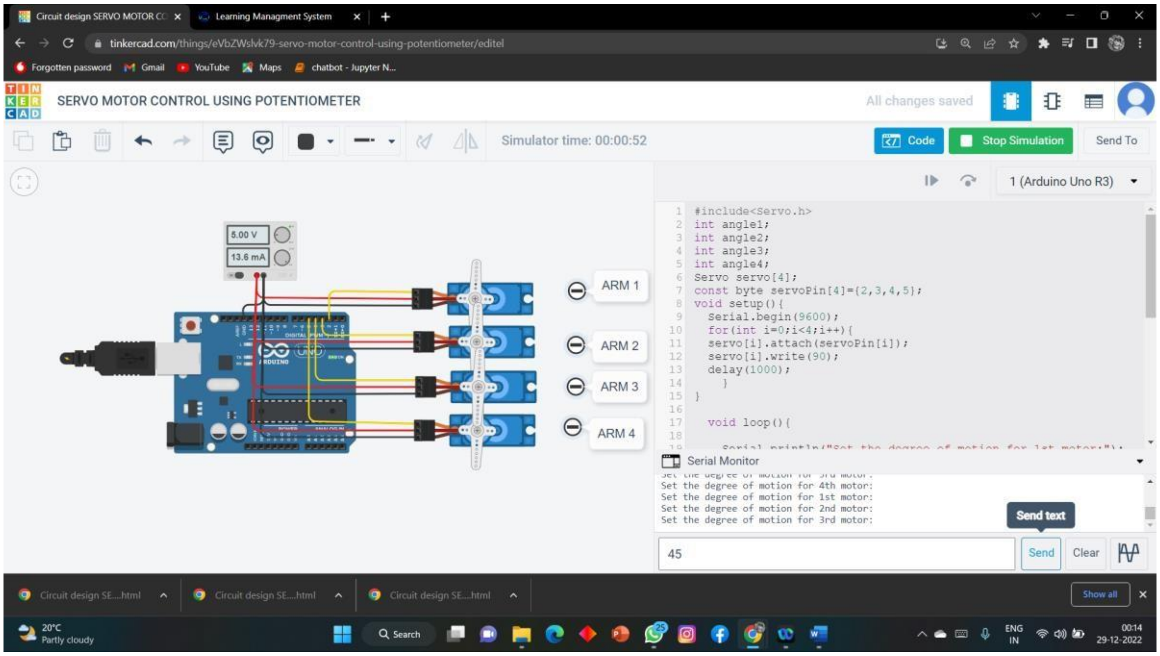


Setting 75 degrees for the first motor

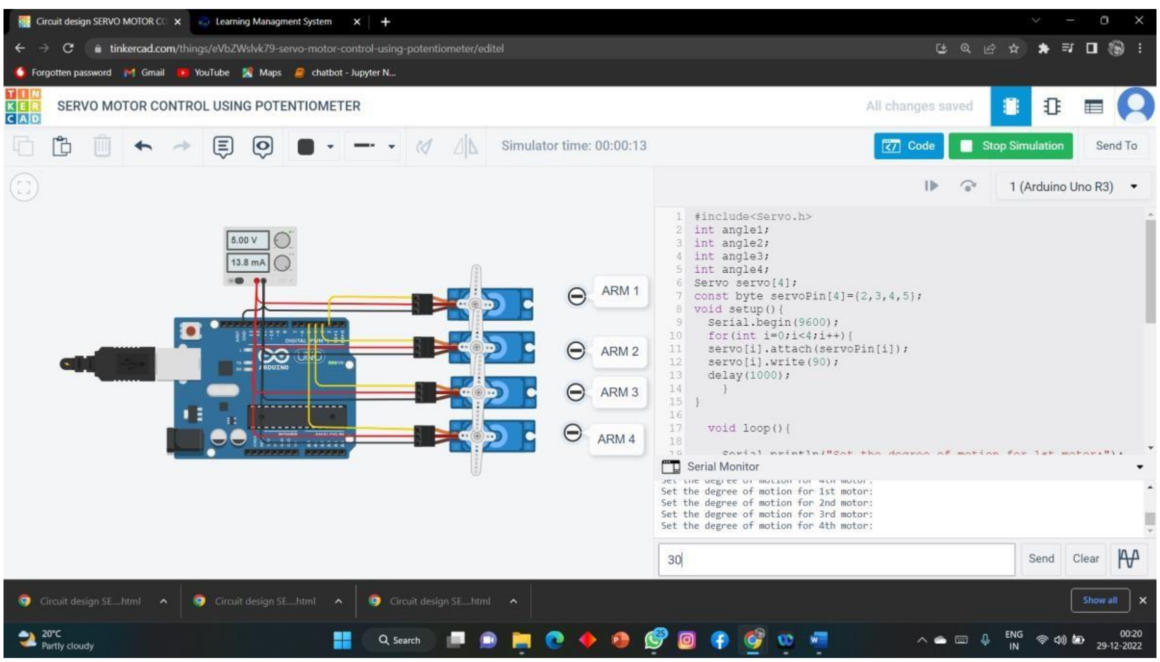
STEP 4: As soon as step 3 is performed ,the user will be asked again in the serial monitor to give the degrees of rotation for second,third and finally fourth motor in a succession as input as shown in the corresponding figures below.



Setting 60 degrees for the second motor

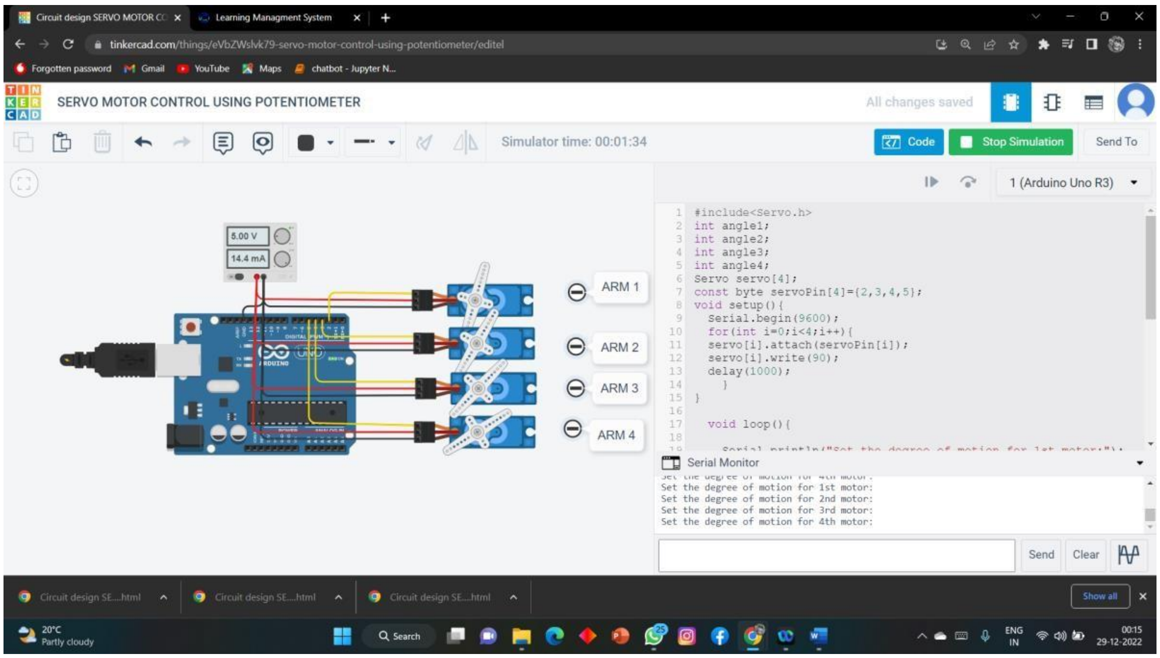


Setting 45 degrees for the third motor



Setting 30 degrees for the fourth motor

STEP 5: Here this is the observation step,in which following all the previous steps, we we observe that that user can give degree of motion for first Motor then second then third then fourth etc. once all the input are given, all the motors has set them into that degree which is specified by the user.This completes the second part of our project.The final output is shown in figure shown just below.



Final state of all the motors

CONCLUSION

Today we find most robots working for people in industries, factories, warehouses, and laboratories. Robots are useful in many ways. For instance, it boosts economy because businesses need to be efficient to keep up with the industry competition. Therefore, having robots helps business owners to be competitive, because robots can do jobs better and faster than humans can, e.g. robot can built, assemble a car. Yet robots cannot perform every job; today robots roles include assisting research and industry. Finally, as the technology improves, there will be new ways to use robots which will bring new hopes and new potentials.

Industrial robot development is characterised by the multidisciplinary fusion of a wide range of technologies. Many of these technologies can be created from solutions in other, far broader product categories and are not just for robotics. One of the most crucial essential competencies for the advancement of industrial robotics is robot control, and more specifically robot motion control, which is particularly specific to the robot product. In order to maximise performance and reduce the cost of industrial robot automation, advanced control must be applied and developed in order to continually improve robot performance.

THANK YOU