IE 410 – Introduction to robotics

Prof. Tapas Kumar Maiti

Project 1:- Inverse Kinematics using Arduino

Group : 6 (Gearsgurus)

202201142 – Dip Baldha

202201154 – Rishi Godhasara

202201203 - Ajay Chovatiya

202201206 – Vatsal Patoliya

1. Aim of the Project:

- The aim of this Project is to move the robot arm to the given coordinates of the end-effector using inverse Kinematics.

2. Material Used in the experiment :

➔ Robot arm
➔ Arduino Uno
➔ Arduino Cable
➔ Arduino compatible Shield
➔ Power Adapter

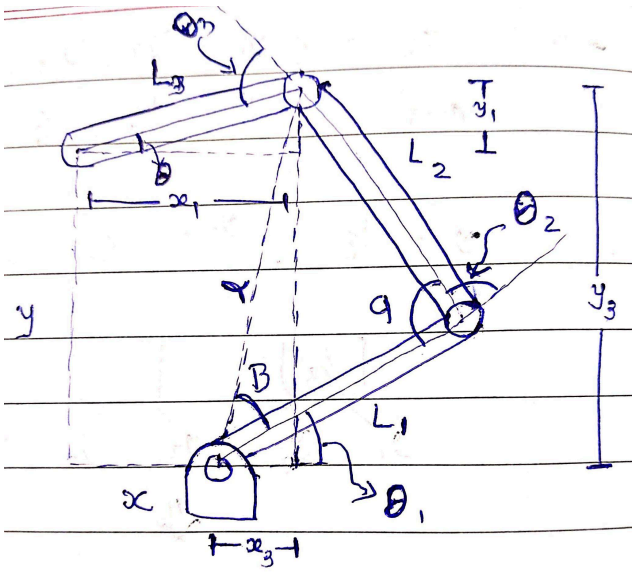
3. Code:

```
#include <Braccio.h>
#include<Servo.h>

Servo base;
Servo shoulder;
Servo elbow;
Servo wrist_rot;
Servo wrist_ver;
Servo gripper;

const float L1 = 12.5;
const float L2 = 12.5;
const float L3 = 7.15;

void setup() {
  Serial.begin(5000);
  Braccio.begin();
  delay(1000);
}

void loop() {
  float x = -32.15, y =0 , theta=180;
  inversekinematics(x, y, theta);
  delay(1000);
}
```

```
void inversekinematics(float x, float y, float theta) {

  float x1=L3 * cos(radians(theta));
  float y1=L3 * sin(radians(theta));
  float x3 = x - x1;
  float y3 = y + y1;
  float l = sqrt(pow(x3, 2) + pow(y3, 2));

  if ((L1 + L2) > l) {
    float thetaa=acos((pow(L1, 2) + pow(L2, 2)-pow(l, 2))/(2*L1*L2));
    float thetab=acos((pow(L1, 2) + pow(l, 2)-pow(L2, 2))/(2*L1*l));
    float a = degrees(thetaa);
    float B = degrees(thetab);

    float theta1 = degrees(atan2(y3, x3)) - B;
    float theta2 = 180 - a;
    float theta3 = degrees(atan2(y, x)) - theta1 - theta2;

    Braccio.ServoMovement(20 ,0,int(theta1),90+int(theta2),90+int(theta3),0,73);

    Serial.println(theta1);
    Serial.println(theta2);
    Serial.println(theta3);
  }
}
```

➔ **Explanation :**

-



- The code includes the necessary libraries: <Braccio.h> and <Servo.h>.
- Constants L_1, L_2, and L_3 represent the lengths of links as shown in the figure.
- In the setup() function, the robotic arm will be set in its initial position.
- In the main loop, we will give coordinates (x,y) of the end-effector and the value of theta. Then we will call inversekinematics() function to calculate θ_1, θ_2, θ_3.

- From the values of θ and L_3, we will calculate values of x_1 and y_1.
  - x_1 = L_3*$cos\ \theta$, y_1 =$L_3 sin(\theta)$

- From the value of x, y, x_1, y_1 calculate x_3 and y_3.
  - $x_3 = x - x_1$, $y_3 = y + y_1$
- From the value of x_3 *and* y_3, we calculate l which is the reachable distance.
  - $l = \sqrt{(x_3^2 + y_3^2)}$
- Using the cosine method we have calculated angle a and b.
  - $a = \cos^{-1}((L_1^2 + L_2^2 - l^2)/ (2 * L_1 * L_2))$
  - $B = \cos^{-1}((L_1^2 + l^2 - L_2^2)/ (2 * L_1 * l))$
- As shown figure
  - $\theta_1 = tan^{-1}(y_3 / x_3) - B$
  - $\theta_2 = 180 - a$
  - $\theta_3 = tan^{-1}(y / x) - \theta_1 - \theta_2$
- And then we will give θ_1 , θ_2 , θ_3 to servo motors M2(shoulder) , M3(elbow) , M4(wrist_rot) throught servomovement function.

4. Procedure:

i)Turn on the system and start up the microcontroller.

ii) Connect the Arduino Uno to the computer using a cable.

iii) In the computer's Arduino software, write code for inverse kinematics.

iv) In code we will give different end effector coordinates and the value of θ.

v) For each coordinate we will upload code and observe robot arm movement.

vi) Here are the different coordinates and values of the θ that we have given to obtain specific positions.

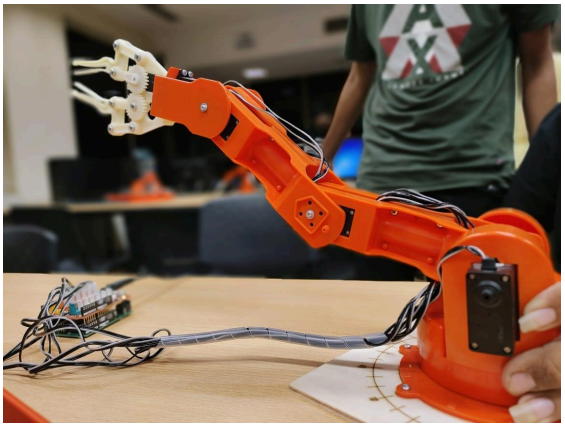
Sr.no.	x(cm)	y(cm)	θ (in degrees)
1.	32.15	0	0°
2.	-32.15	0	180°
3.	22.5	22.5	45°

4.	-22.5	22.5	135°
5.	0	32.15	90°

5. Observation :

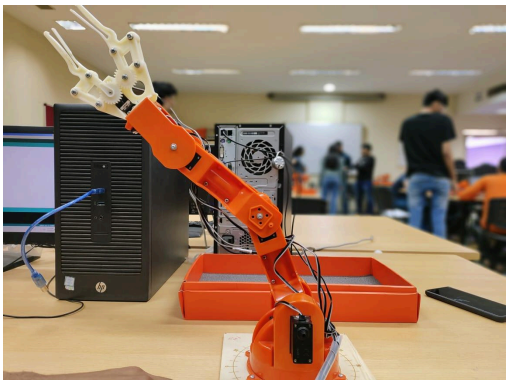
- Here are images of the robotic arm for each coordinate

1. x=32.15 , y=0, θ=0°

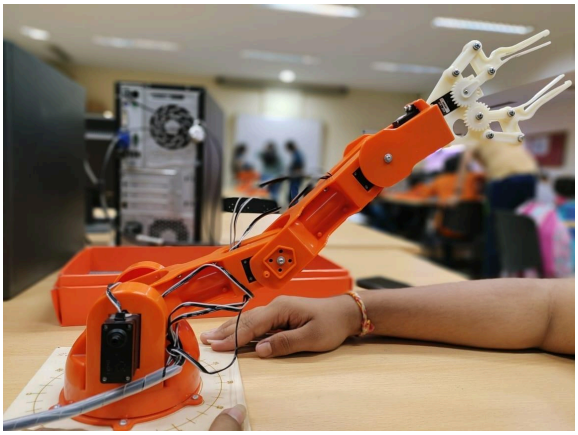


2. x=-32.15 , y=0, θ=180°

3. x=22.5 , y=22.5, θ=45°



4. x=-22.5 , y=22.5, θ=135°



5. x= 0 , y=32.15, θ=90°

- We observed that the robot arm was moving according to end-effector coordinates.
- When x coordinate is positive robot arm will move to the left side and when x coordinate is negative robot arm will move to the right side.
- Link: video link
- Github : Github

6. Result :

- In this Project, we learned how to calculate the angle of the joint using inverse kinematics with given coordinates of the end-effector how to write code in Arduino IDE, and how to move the robotic arm's end-effector to the given coordinates.