4-Servo Humanoid Robot with Walking Algorithm

Electronics Engineering

[Task 2]

Mohamad Abdulmoula,R. Rama

ramamohameed9@gmail.com

Department of Software Engineer

Under the Supervision Of:

Eng Asmaa Duramae

July 11, 2025

Contents

Glossary of Terms

Term	Definition
Servo Motor	A type of motor that can be controlled to move to a specific angular position.
Arduino	An open-source electronics platform used for building digital devices and interactive objects.
PWM (Pulse Width Modulation)	A method used to control servo motors by sending pulse signals.

Project Overview

In this project, we developed a simple servo-based walking robot using an Arduino Uno and four micro servo motors. The goal was to simulate a bipedal walking motion using basic servo control and step-by-step movement planning. The robot performs an initial sweep to test motor responsiveness, then enters a basic walking cycle by sequentially moving its legs. The project serves as an introductory exercise in humanoid robotics and motion control programming.

1. Planning

The project began by outlining the required motion and identifying the servo assignments for each joint (left hip, left knee, right hip, right knee). We planned to break the walking motion into several repeatable steps and implement them via Arduino code. Time constraints, hardware limitations, and servo angles were taken into consideration to ensure smooth and safe motion.

2. Requirements Analysis

Hardware Components

We used the following components:

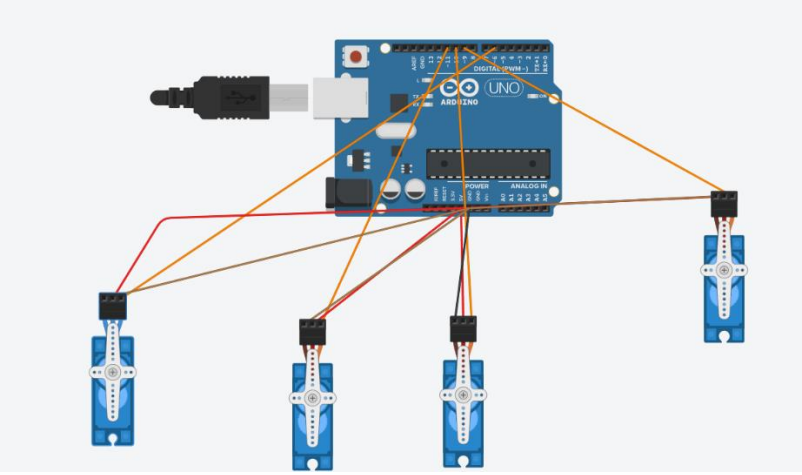
1) Arduino Uno R3 ×1
2) Micro Servo Motors ×4
3) Jumper wires

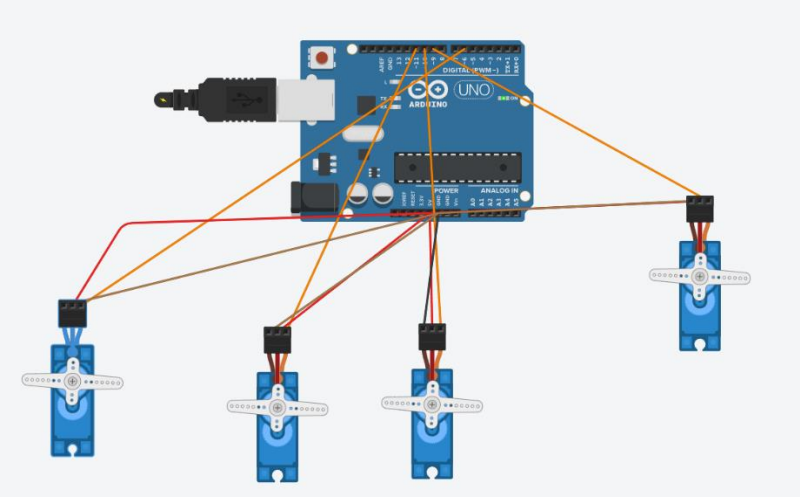
Software:

1) Arduino IDE or TinkerCAD Circuits
2) Servo library Servo.h

3. Design

The system is designed to control four servo motors corresponding to the hip and knee joints of both legs. Each servo is connected to a dedicated digital pin on the Arduino:





The robot starts by sweeping all servos from 0° to 180° for 2 seconds, then stabilizes in the neutral 90° position. A step-by-step walking cycle is planned afterward.

4. Coding

The Arduino code below initializes the servos, performs a sweep test, and sets the robot into a neutral pose

```
#include <Servo.h>

// Declare servo objects
Servo servo1;
Servo servo2;
Servo servo3;
Servo servo4;

unsigned long startTime;
bool sweepCompleted = false;

void setup() {
  // Attach servos to pins
  servo1.attach(9);
  servo2.attach(10);
  servo3.attach(11);
  servo4.attach(6);

  // Initialize timer
  startTime = millis();
}

void loop() {
  unsigned long currentTime = millis();

  // Perform sweep for 2 seconds
  if (currentTime - startTime < 2000) {
    for (int pos = 0; pos <= 180; pos += 5) {
      moveAllServos(pos);
      delay(15);
    }
    for (int pos = 180; pos >= 0; pos -= 5) {
      moveAllServos(pos);
      delay(15);
    }
  } else if (!sweepCompleted) {
    // After sweep, lock all servos to 90°
    moveAllServos(90);
    sweepCompleted = true;
  }

  // Optionally add walking code here
}

// Function to set all servo angles
void moveAllServos(int angle) {
  servo1.write(angle);
  servo2.write(angle);
  servo3.write(angle);
  servo4.write(angle);
}
```

5. Testing

Testing was carried out using the TinkerCAD Circuits simulator. The servos were visually observed to perform the sweep motion correctly and then stabilize at 90°. The output angles were verified using simulation logs. Additional testing with walking motion can be integrated using delay-timed step sequences.

6.Walking Motion Algorithm

Initial Pose:

All joints are set to 90° to simulate a neutral upright stance.

Step-by-step Walking Cycle:

1) Lift right leg
    a) Right Knee: 60°
    b) Right Hip: 70°
2) Move right leg forward
    a) Right Hip: 110°
3) Lower right leg
    a) Right Knee: 90°
    b) Right Hip: 90°
4) Shift weight to right leg
5) Repeat steps for the left leg
    a) Left Knee: 60° → forward via hip → return to 90°

Conclusion

This project successfully demonstrated a basic implementation of robotic walking using Arduino-controlled servo motors. Through structured planning, design, and testing, we were able to simulate a simple yet effective walking behavior using four degrees of freedom. The project introduced foundational robotics principles, and sets the stage for more complex movements, balance control, and sensor integration in future iterations.

References

1. Arduino Servo Library Documentation: https://www.arduino.cc/en/Reference/Servo

2. TinkerCAD Circuits: https://www.tinkercad.com