Ghulam Ishaq Khan Institute of Engineering Sciences and Technology (GIKI)
EE212-Electrical Network Analysis

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Faculty	Department	Area of Specialization
FEE	EE	Electrical Network Analysis

Title: Intelligent Robotic Servo Arm

Project Overview

This project aims to guide enthusiasts through the process of building a functional servo-controlled robotic arm using an Arduino microcontroller. The initiative focuses on hands-on learning, integrating mechanical design with electronic control systems to foster a comprehensive understanding of robotics.

Objectives

Educational Engagement: Introduce learners to the fundamentals of robotics, including servo motor control and Arduino programming.

Skill Development: Enhance practical skills in electronics, coding, and mechanical assembly.

Teleoperation: Mimicking movement remotely for hazardous environments.

Innovation Encouragement: Stimulate creativity by allowing customization and experimentation with the robotic arm's design and functionality.

Scope

- Servo-based actuation for shoulder, elbow, wrist, and base rotation.
- Control of the robotic arm using a microcontroller and PWM signals.
- User interface using potentiometers or buttons for manual control.
- Programmed sequences to perform repetitive or automated tasks.
- Basic end effector (gripper) control for object manipulation.
- Demonstration of potential applications in sensitive tasks such as:
  Surgical assistance (simulating delicate motion control in minimally invasive operations).
  Bomb diffusion simulations (remotely handling objects in hazardous zones to demonstrate safety-enhancing designs).

System Description

The robotic arm consists of four joints driven by servo motors, each responsible for specific motion: base rotation, shoulder lift, elbow movement, and wrist tilt or gripper control. An Arduino microcontroller will control these servos by sending precise PWM signals.

Hardware Components

- **Servo Motors (4x SG90/MG996R)**

  Controlled via PWM signals for joint actuation.

- **Arduino Uno**
  Generates PWM signals and runs the control logic.

- **Power Supply (6V–9V external battery or adapter)**
  Required to power servo motors independently.

- **Potentiometers (optional)**
  Used for manual control of servo angles.

- **Push Buttons / Switches**
  Trigger pre-programmed sequences or reset positions.

- **Jumper Wires and Breadboard**
  For prototyping and making electrical connections.

- **Mechanical Arm Chassis (acrylic, wood, or aluminum)**
  Laser-cut or manually constructed links for the arm.

- **Screws, Nuts, and Servo Horns**
  To assemble the structure securely.

Simulation Tools

1. **Proteus**
   Simulate PWM output and servo behavior.

2. **Arduino IDE**
   For writing and uploading control code to the microcontroller.

3. **Fritzing / SolidWorks**
   To design circuit layouts or 3D model the arm structure.

Methodology

Design Stages:

1. Mechanical and Circuit Design:

- Design and cut arm links using acrylic/aluminum.
- Connect servo motors to joints.
- Interface servos with Arduino using PWM and external power.

2. Programming and Control:

- Write Embedded C++ code to control servo positions.
- Implement manual control via potentiometers.
- Develop automated sequences for predefined tasks.

3. Testing and Debugging:

- Test each joint individually.
- Debug servo positioning and stability under load.
- Calibrate angles and refine code logic.

Target Audience

- Students and hobbyists interested in robotics and electronics.
- Makers and DIY enthusiasts looking to expand their skill set.
- Medical Professionals
- Law Enforcement Agencies

- Rescue Workers

Timeline

Week 1 – First Half:
Plan project, gather components, and begin assembling the robotic arm structure.

Week 1 – Second Half:
Finish mechanical assembly, mount servo motors, and complete wiring to Arduino.

Week 2 – First Half:
Write and test Arduino code for servo control and arm movement coordination.

Week 2 – Second Half:
Finalize testing, document the build, and prepare demo materials or presentation.

Summary

The servo robotic arm project combines mechanical design, servo motor control, and embedded systems programming to create a functional robotic manipulator. With four degrees of freedom and a gripper, the arm is capable of executing precise movements, controlled manually or through programmed sequences. The project not only emphasizes core engineering principles such as PWM-based actuation and real-time control but also highlights the arm's potential in critical fields like surgical assistance and bomb diffusion. Through simulation, testing, and hardware implementation, this project offers a practical understanding of robotics and its role in enhancing automation and safety.