4-Link Robot Arm

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ME 537

Project Overview

- Objective: build and control a robotic manipulator
- Main components:
  - 3D printed parts
  - 5 x MG996R Servos
  - Microcontroller - ESP32 dev board
  - 11.1V LiPo battery (typical drone battery)
  - Voltage converter
- Metrics for success
  - Implementation of mechanical and electrical design
  - Software control and forward kinematics
  - Inverse kinematics
  - Object avoidance

Mechanical Design

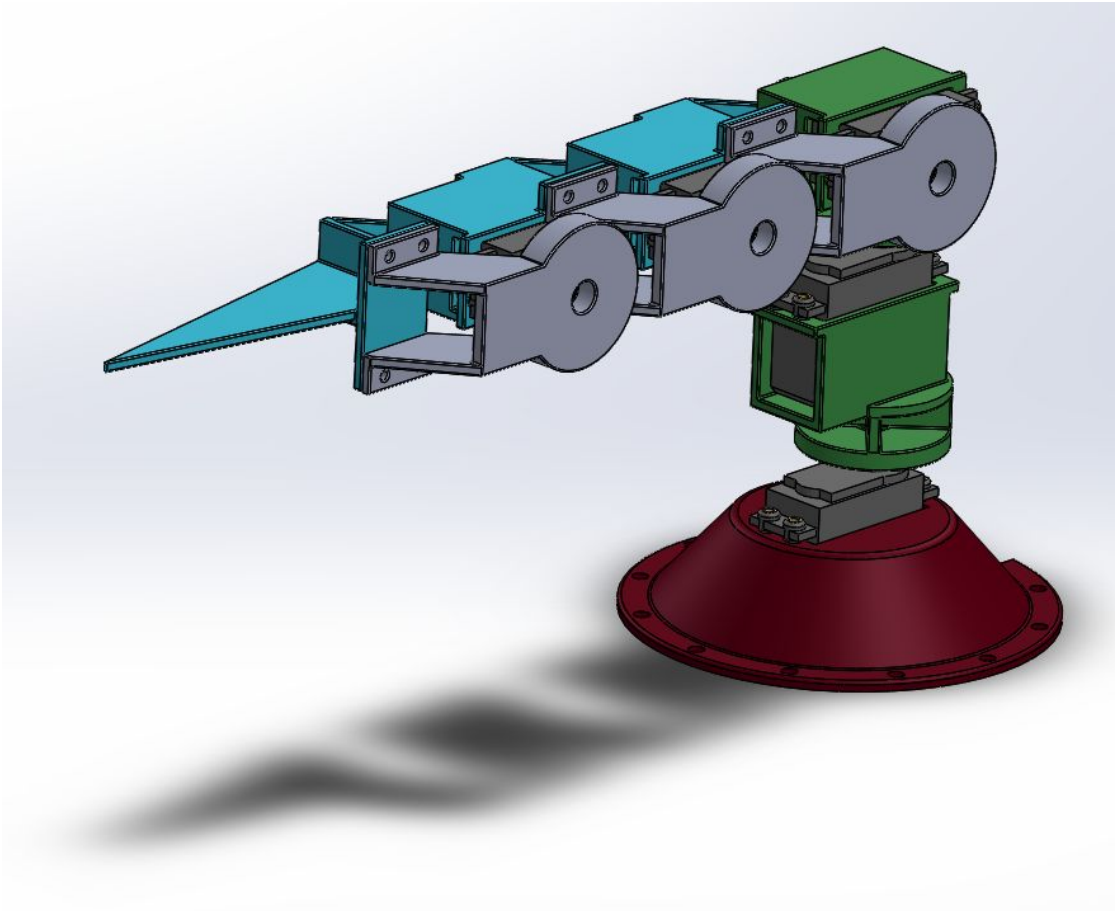
Standardized connectors so adding links is easy.

Strength capabilities were verified:

- Torque=14 kg*cm
- Very long arm (>50cm) is possible with servos

DH parameters were retrieved from CAD model and modeled as a 4-joint arm in ArmPlayer

- First two links (trunk) are modeled as one joint, but split into 2 180-degree joints for control



Electrical Design

Requirements:

- Servos
  - 4.8-6V operating voltage
  - 2.2 A stall current x 5 servos = 11A peak current

Power Supply

- LiPo Battery (regular drone)
  - Voltage output: 11.1 V - needs conversion
  - Current output: 180A (discharge), 360A (burst)
- Voltage converter
  - Input: 6-40V
  - Output: 1.2-36V, 20A (enough for servos), 300W max

Software Design and Functionality Development

Software Design

- ESP32 firmware (serial communication and servo signals)
- Serial interface using Python: PC and ESP32
- Modified libraries: SerialArm and ArmPlayer

Functionalities

- Servo calibration of PWM signal
  - 500-2500 us spec, 550-2350 experimentally more accurate for 0-180 degree range
- Basic forward kinematics
- Inverse Kinematics

Object Avoidance

Objective:

- Reach target location with end effector
- Avoid 1 object (sphere)
- Avoid self

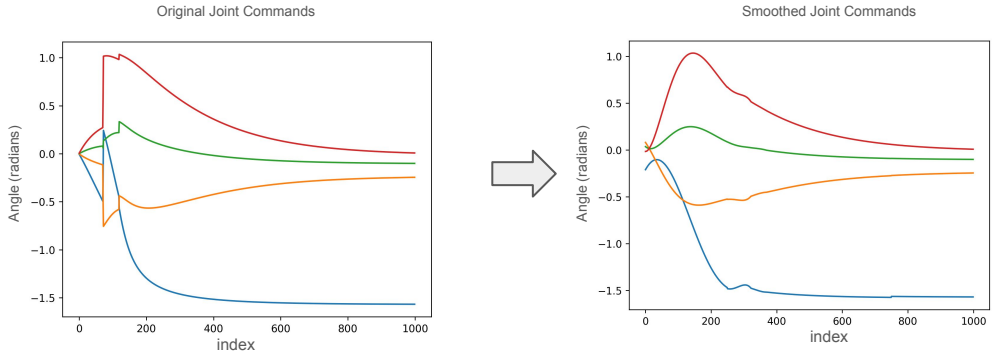
Additional limitations:

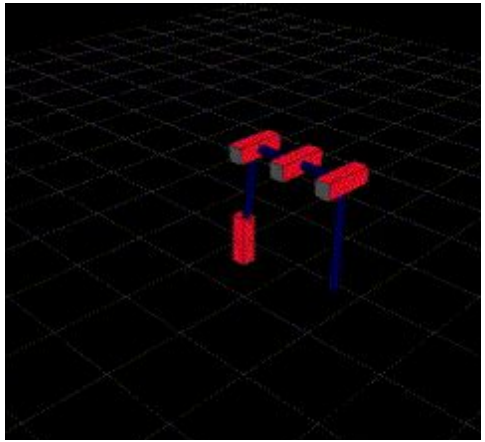
- Joint limits
- Floor limit

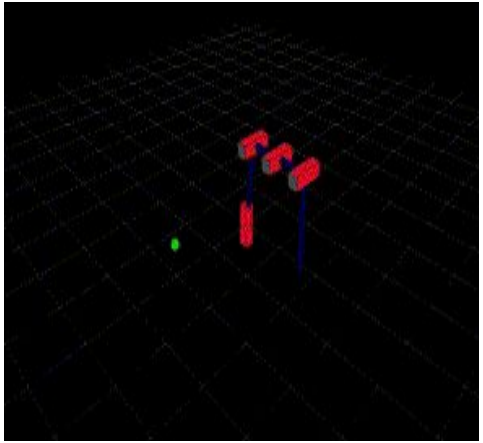
Method: Repulsive & Attractive Fields with limits

Post-processing: Savitzky-Golay Filtering

- 6th order polynomial
- window_size = 501
- Smooth out sequential joint commands for a more naturally moving robot







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