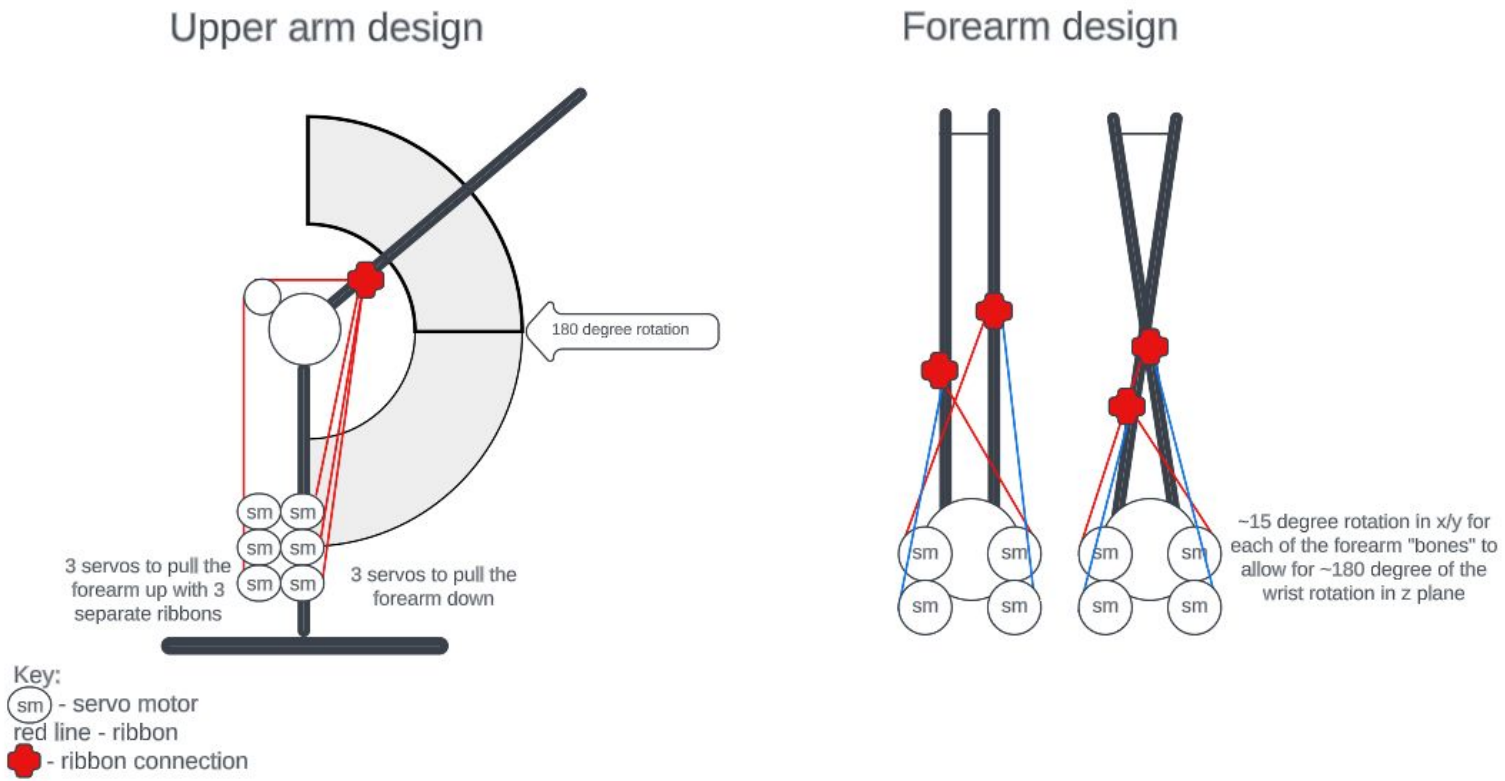
Robotic arm simulating human arm muscle movement

ECE 478
Dmitrii Fotin

Concept


Upper arm design
180 degree rotation
sm
3 servos to pull the forearm up with 3 separate ribbons
3 servos to pull the forearm down
Key:
sm - servo motor
red line - ribbon
- ribbon connection
Forearm design
~15 degree rotation in x/y for each of the forearm "bones" to allow for ~180 degree of the wrist rotation in z plane

Specifications

- 1 ft elbow length, 1 ft forearm length
- Load of up to 1 lb
- 180 degree movement in elbow, 180 degree movement in wrist

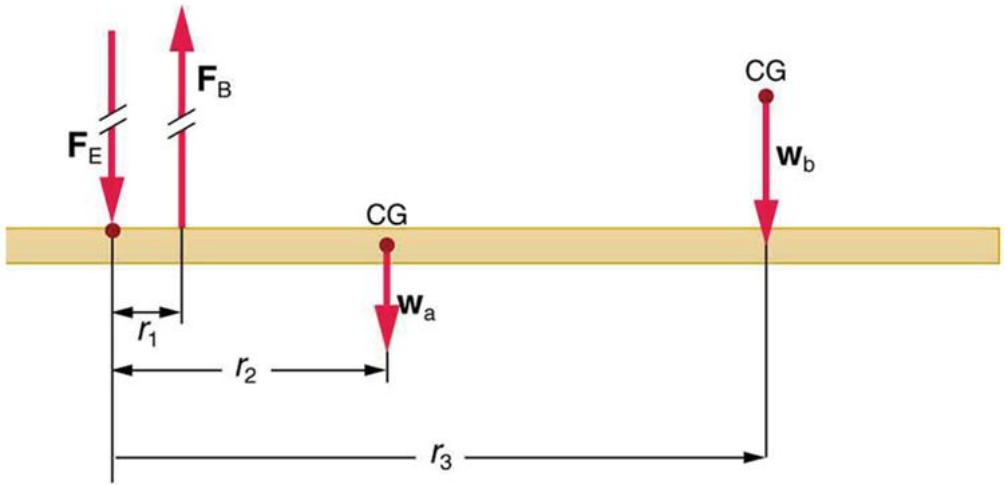
Calculations

Elbow:

0.15 m × 0.5 kg × 9.8 m/s + 0.3 m × 0.5 kg × 9.8 m/s = **2.21 Nm**

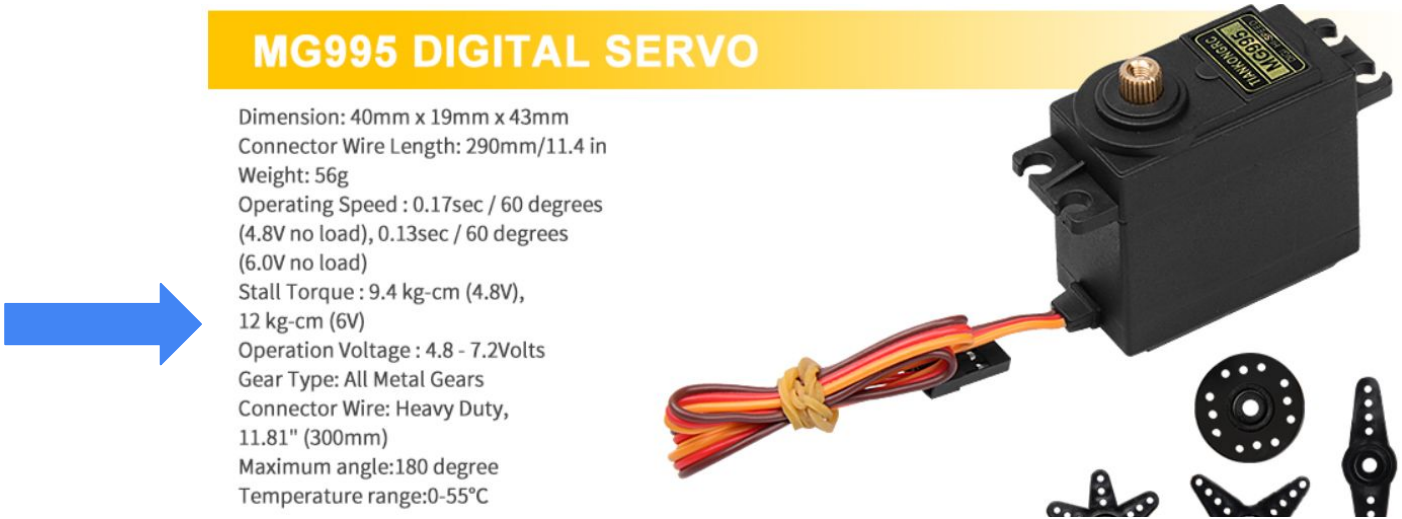
Wrist:

0.15 m × 0.25 kg × 9.8 m/s = **0.37 Nm**

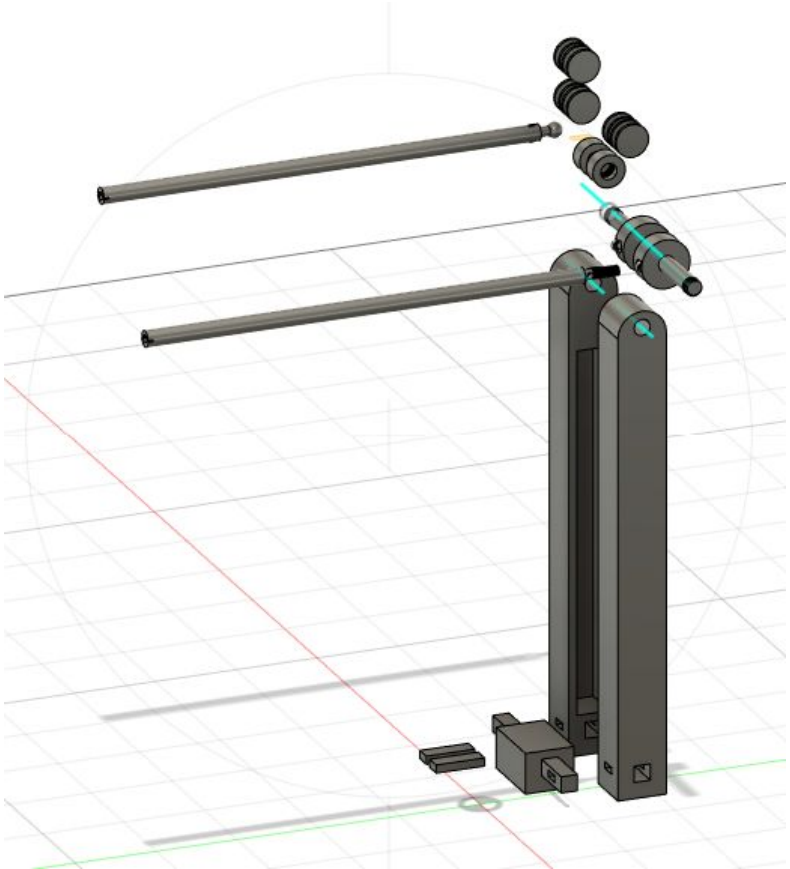


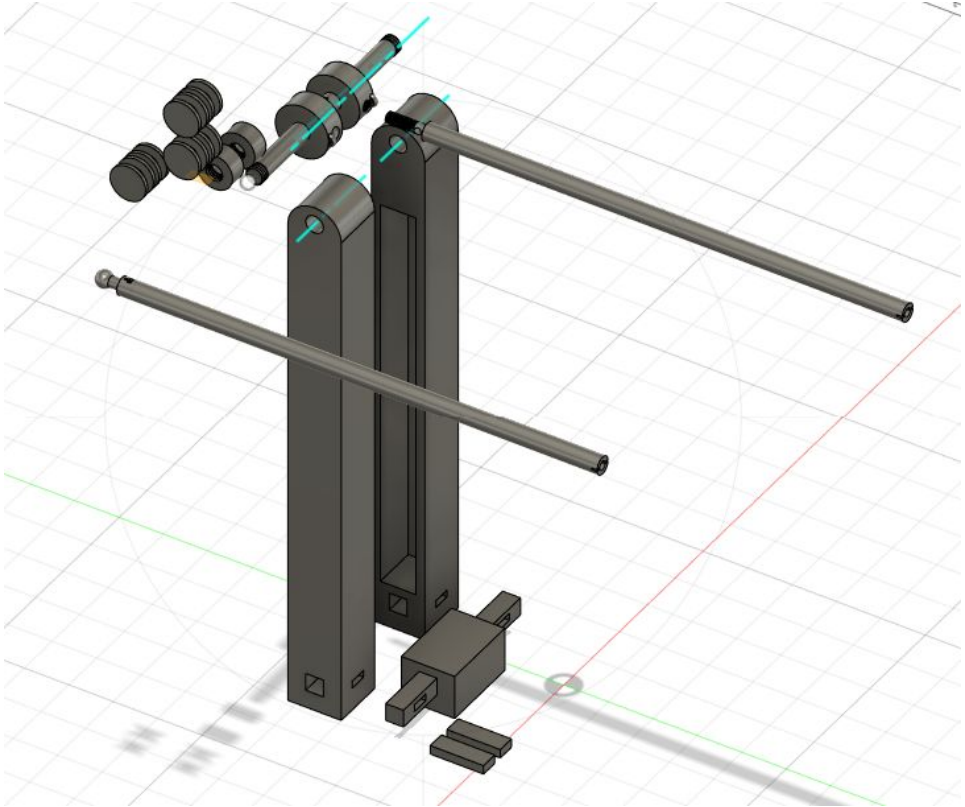
Servos

The 12 kg×cm torque at 6V can be converted to 1.17 Nm. Given the the 2.21 Nm, two servos are required to rotate the forearm up and down.

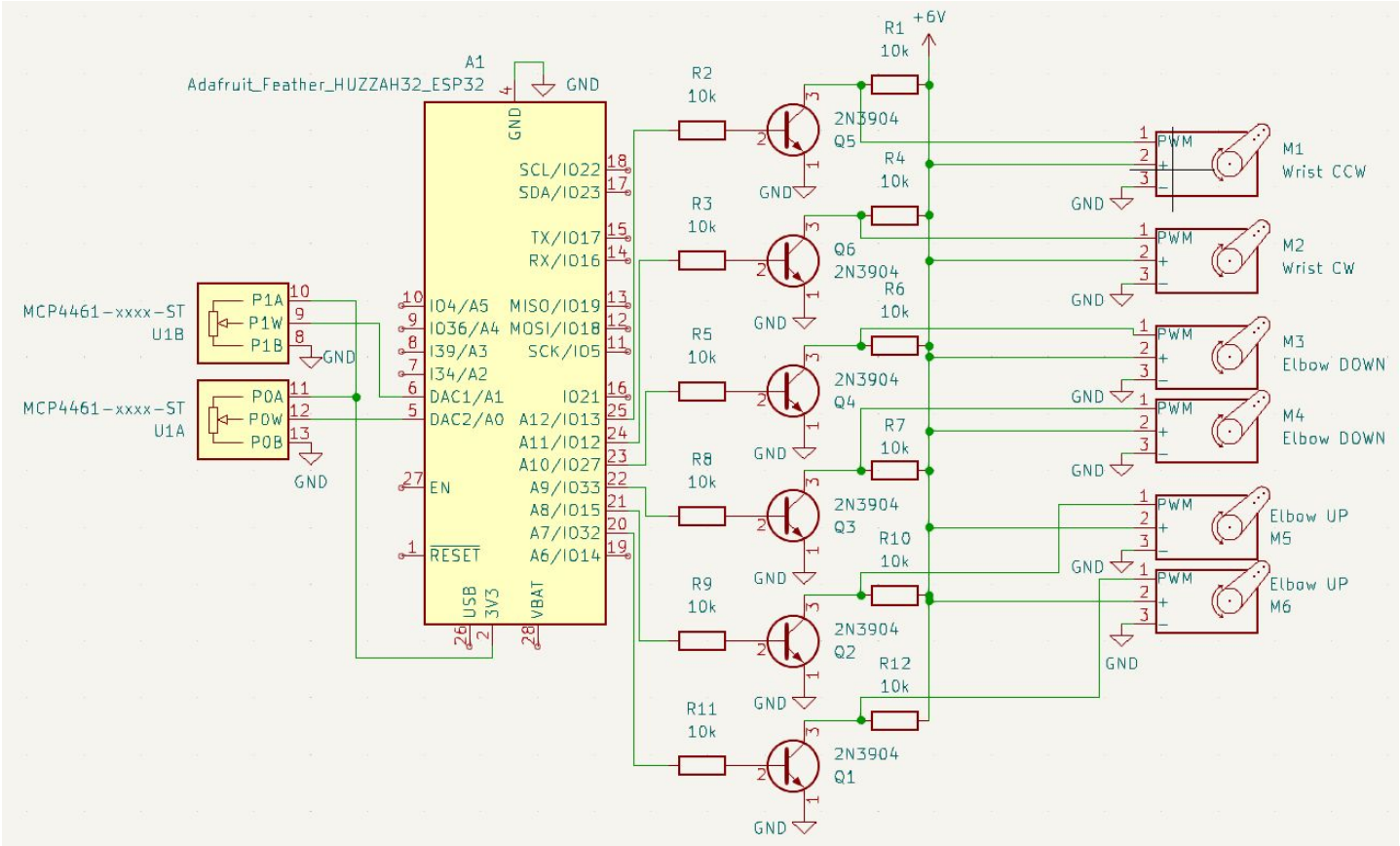


3D Model





Circuit


A1
Adafruit_Feather_HUZZAH32_ESP32
GND
SCL/IO22
SDA/IO23
TX/IO17
RX/IO16
IO4/A5
IO36/A4
I39/A3
I34/A2
DAC1/A1
DAC2/A0
EN
RESET
MISO/IO19
MOSI/IO18
SCK/IO5
IO21
A12/IO13
A11/IO12
A10/IO27
A9/IO33
A8/IO15
A7/IO32
A6/IO14
USB
3V3
VBAT
MCP4461-xxxx-ST
U1B
P1A
P1W
P1B
MCP4461-xxxx-ST
U1A
P0A
P0W
P0B
+6V
R1
10k
R2
10k
R3
10k
R4
10k
R5
10k
R6
10k
R7
10k
R8
10k
R9
10k
R10
10k
R11
10k
R12
10k
2N3904
Q5
Q6
Q4
Q3
Q2
Q1
PWM
M1
Wrist CCW
M2
Wrist CW
M3
Elbow DOWN
M4
Elbow DOWN
Elbow UP
M5
Elbow UP
M6

Results

- 3D model improvements:
  - Unobstructed elbow movement
  - Constraints for the wrist to follow the expected path
  - Adjustments to prevent wrist strings from pulling the forearm up/down
  - Fanned out ribbon/string attachment for more surface area pull/less stress on critical points
- Code improvements
  - Smoother movement (ease in/out)
  - More granular control
- Circuit improvements
  - Remove servo jitter
  - Increase and stabilize power supply and ensure sufficient current for required torque