UNIVERSITY OF ILLINOIS
URBANA-CHAMPAIGN

Bench Press Smart Helper
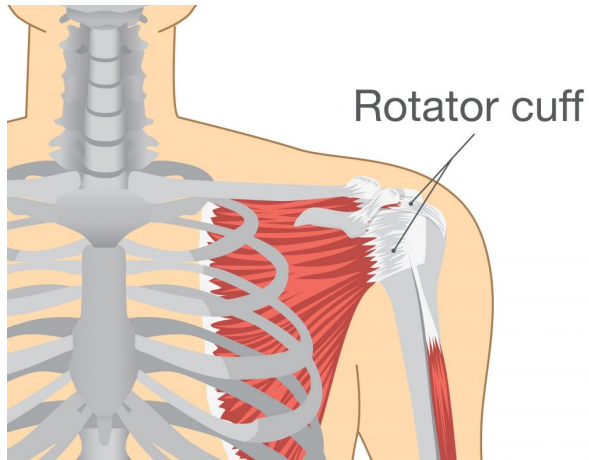
ECE 445 Team 35

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Introduction

Rotator cuff

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Injury-related concerns

- According to a recent study by BMJ Open Sport & Exercise Medicine conducted over sub-elite to elite powerlifters, up to 46 % of injuries in powerlifting are caused by the bench press

- According to St. John and St. Elizabeth hospital, the two most common bench press-related injuries are the *subacromial bursitis* and the *torn rotator cuff*

- Recovery from a torn rotator cuff might take 4 to 6 months or even longer in severe cases
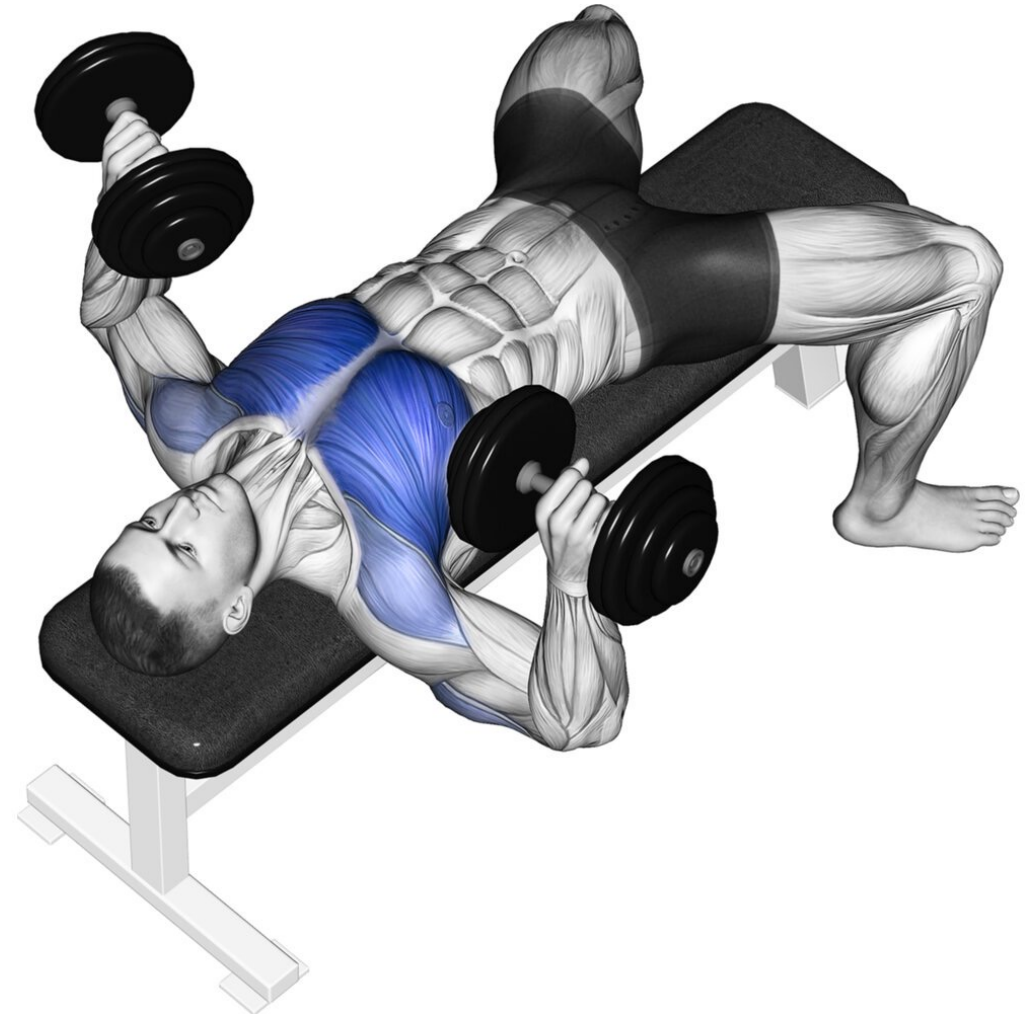
Performance-related concerns

To avoid those injuries, one tends to:

- Not perform the exercise at maximum intensity

- Perform at maximum intensity, but not to failure
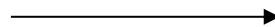
- Choose alternative exercises

Performance-related concerns

NOT Ideal, because:

- The best exercise according to the two largest EMG studies conducted for chest activation is the **BARBELL BENCH PRESS**
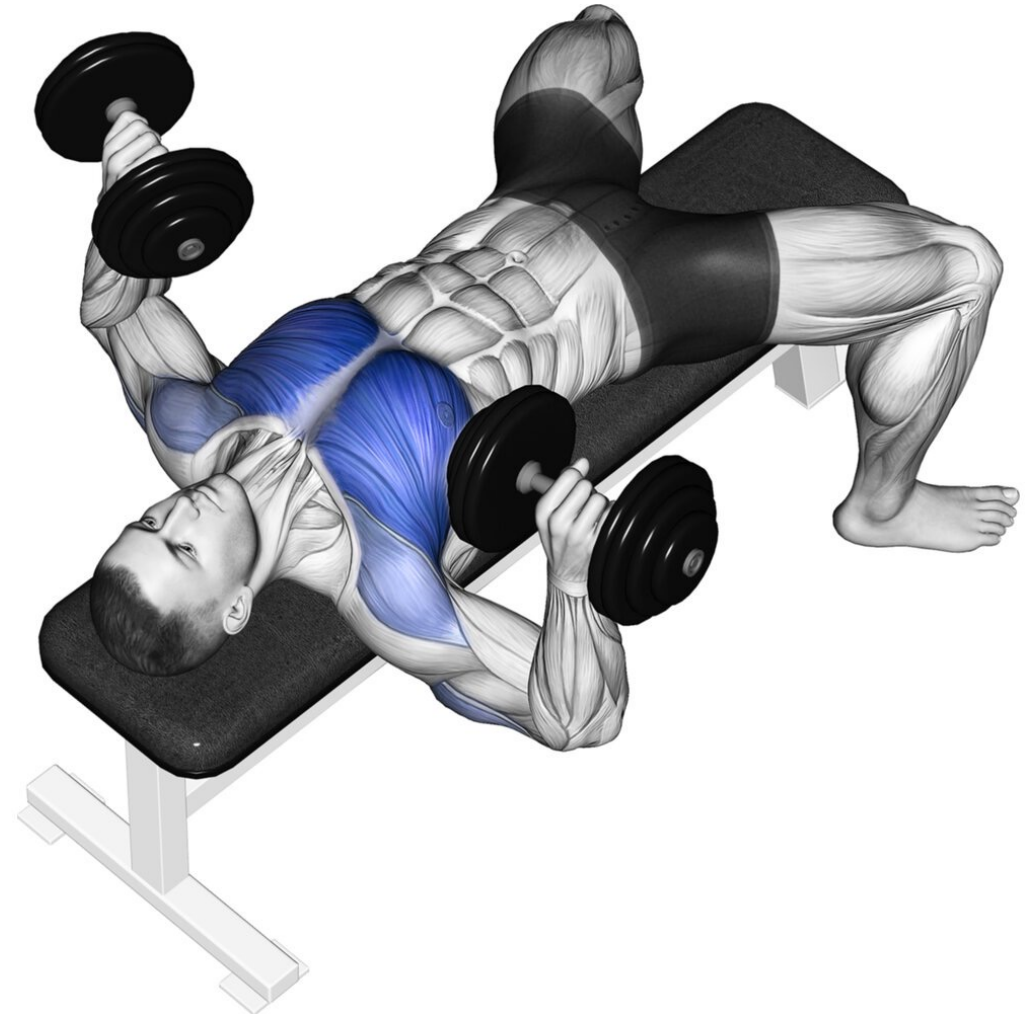

EMG Results in relation to Barbell Bench Press (100%)
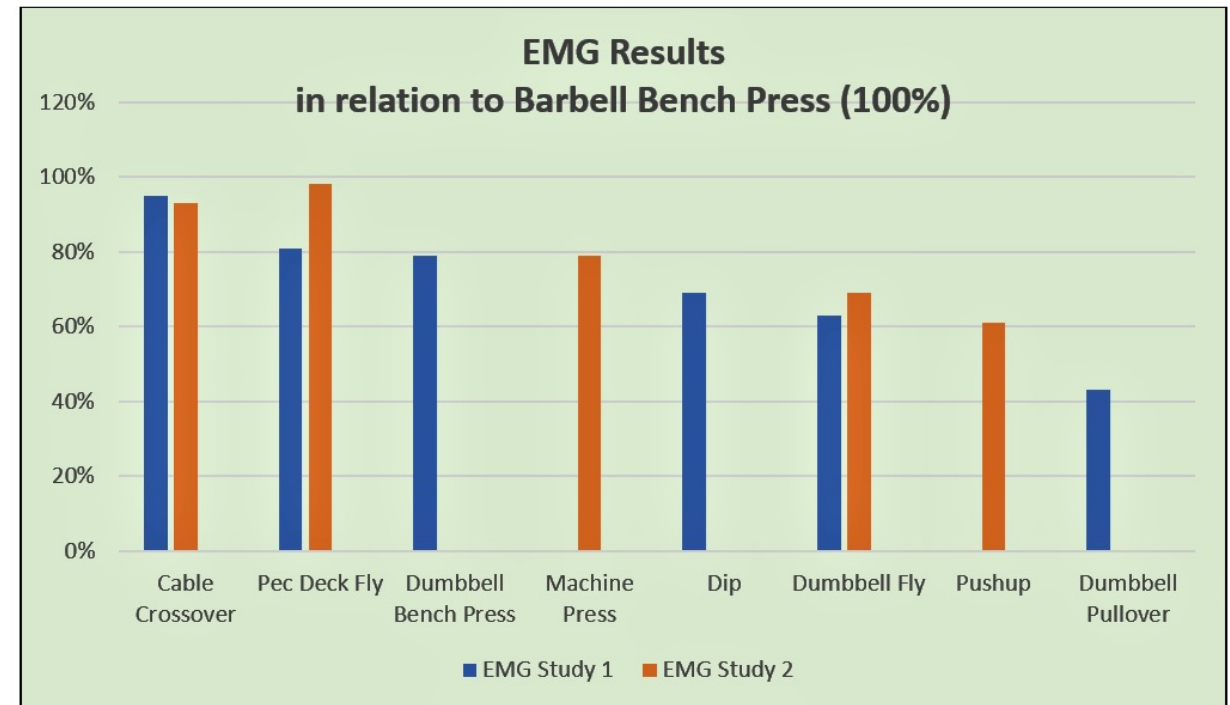
THE SPOTTER $\longrightarrow$

Our solution

We:

- Eliminate the need for a spotter

- Allow you to always perform the exercise at maximum intensity

- Guarantee that you get the best result out of the bench press

Objectives

Motivation

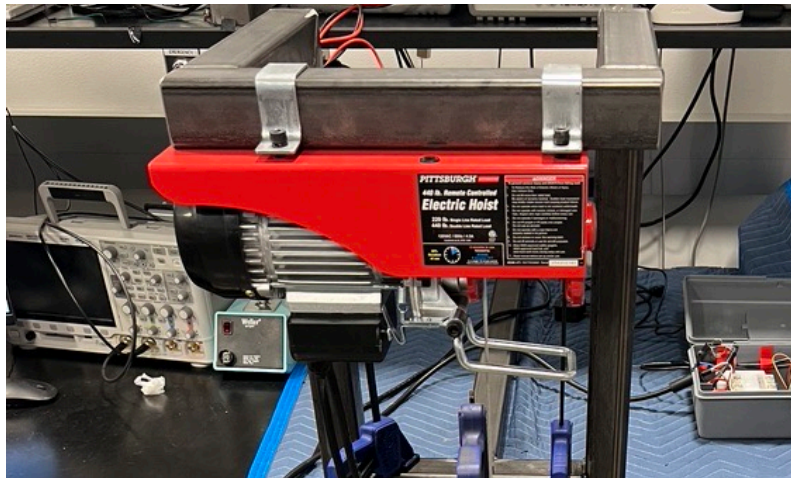### Bench Press Leg Self Spotting

Smith Machine for Bench Press

High Level Requirements

1. Repetition Tracking & Failure Detection
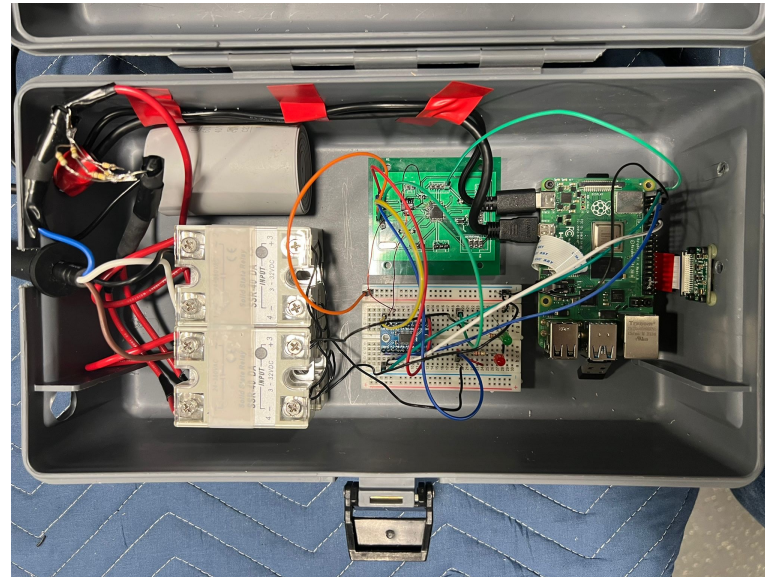2. Hoist Activation
3. User Control

Repetition Tracking & Failure Detection

- Python computer vision program

- Real-time coordinates tracking and time measurements

- Provide useful help and prevent injuries

Hoist Activation

- Protection relays

- 3.3V from Raspberry Pi to 5V in microcontroller
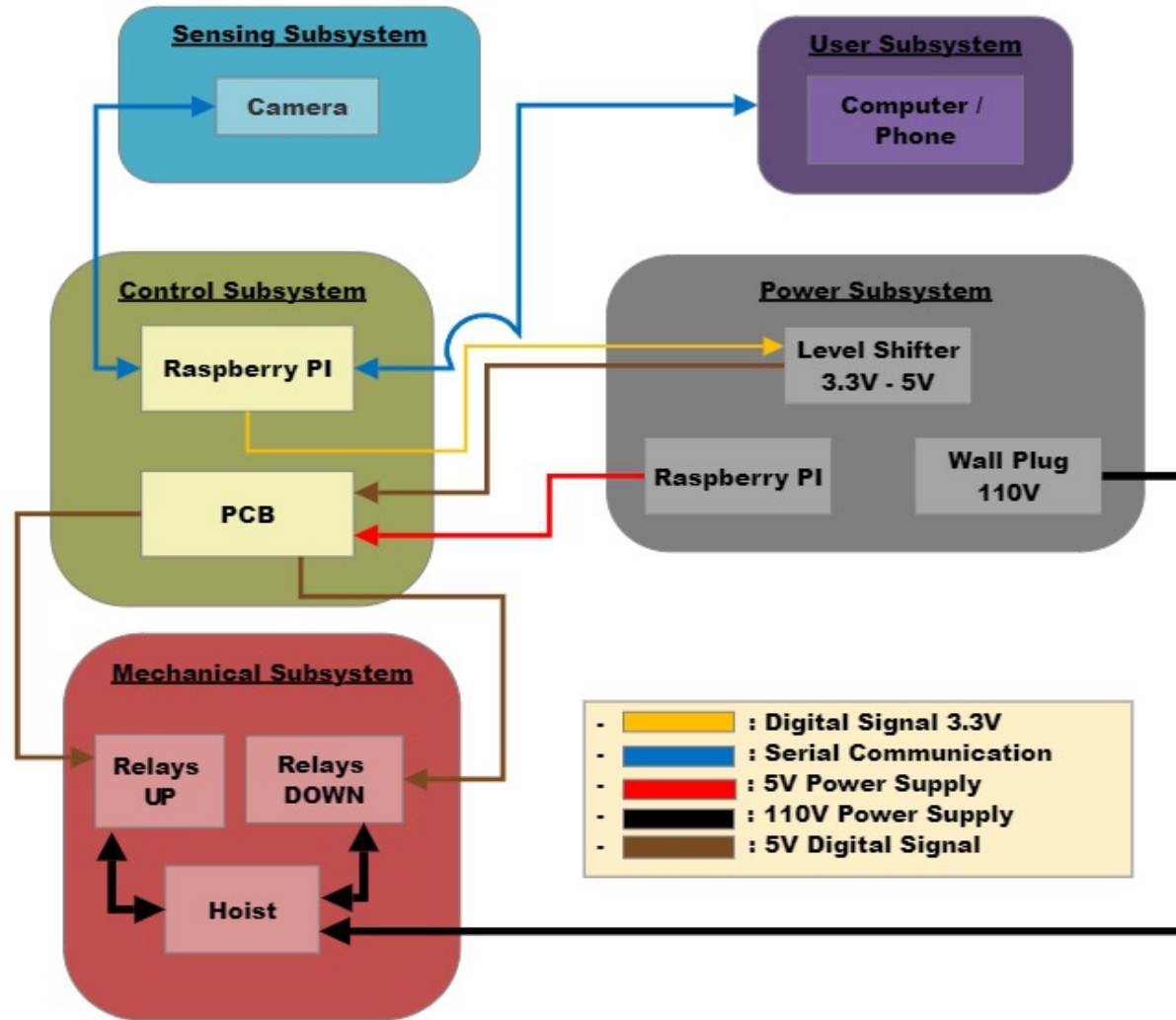
- Physical integration

User Control

- User input (repetitions to be performed without and with help)

- Adjust position of hoist
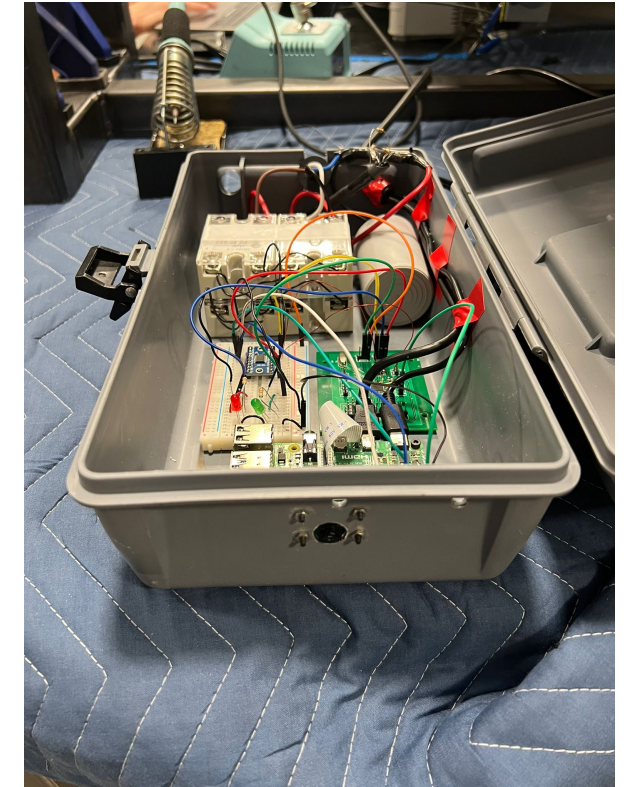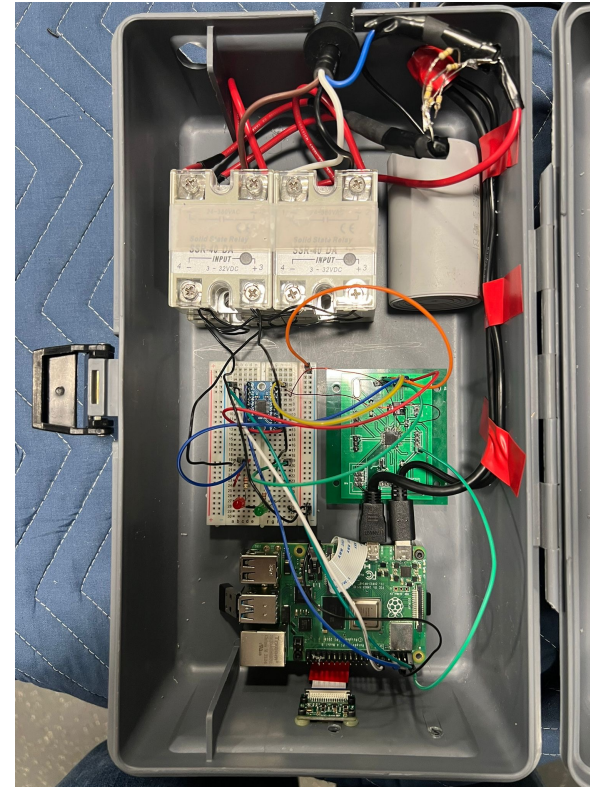
- Mobile control

Design

Design

Control Subsystem

Key Requirements:

- **Hardware:** establish communication protocol
  Raspberry Pi ⟶ PCB ⟶ Hoist

- **Software:** track the motion of the barbell
  accurately and develop the hoist activation logic

Major Challenges:

- PCB implementation

- Barbell coordinate tracking

- System integration

PCB Design

Sensing Subsystem

Key Requirements:

- The webcam should be able to capture the barbell from end to end horizontally and follow along the vertical motion

Major Challenges:

- Different camera resolutions

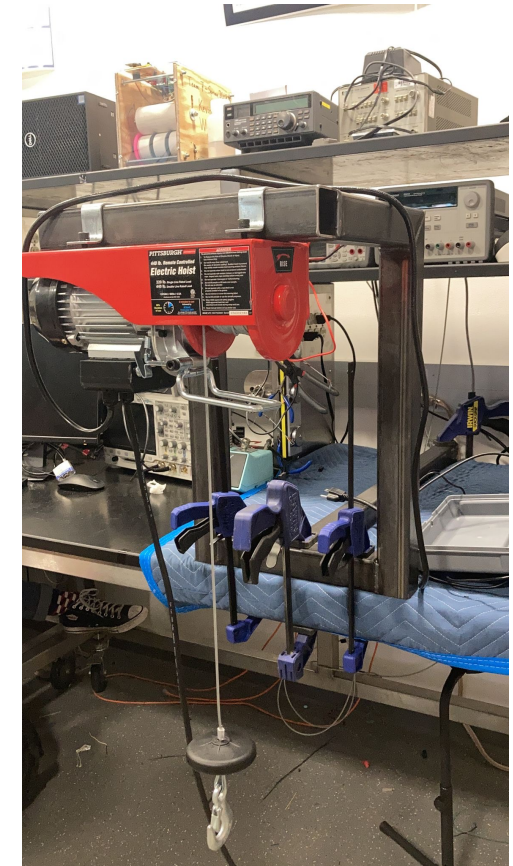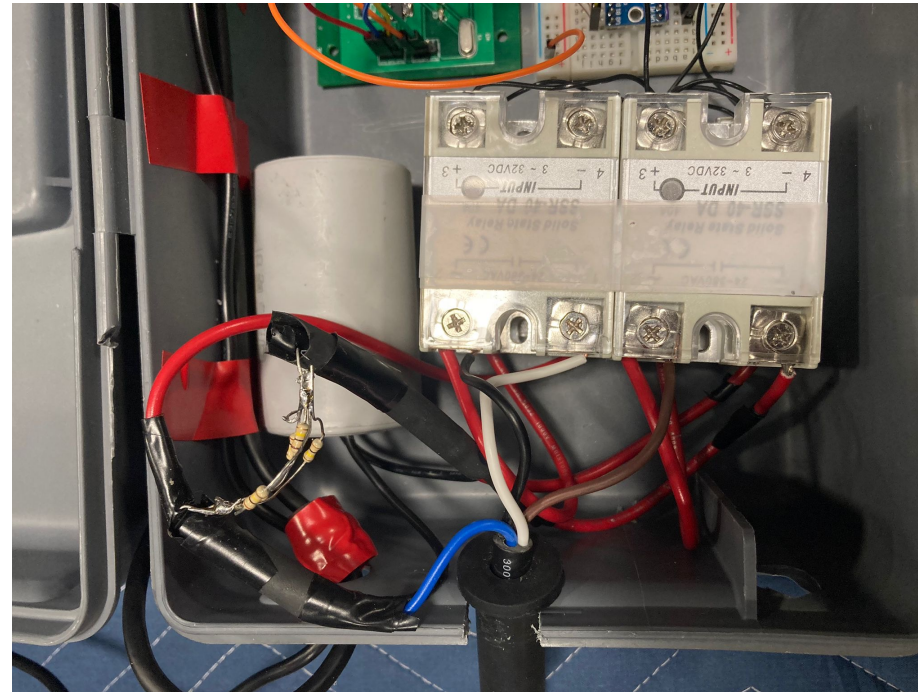- Varying lighting conditions

- Background noise

Mechanical Subsystem

Key Requirements:

- Remove the manual switch of the hoist

- Control the hoist with our PCB

- Mounting frame

Challenges:

- Hoist control with ATMEGA328
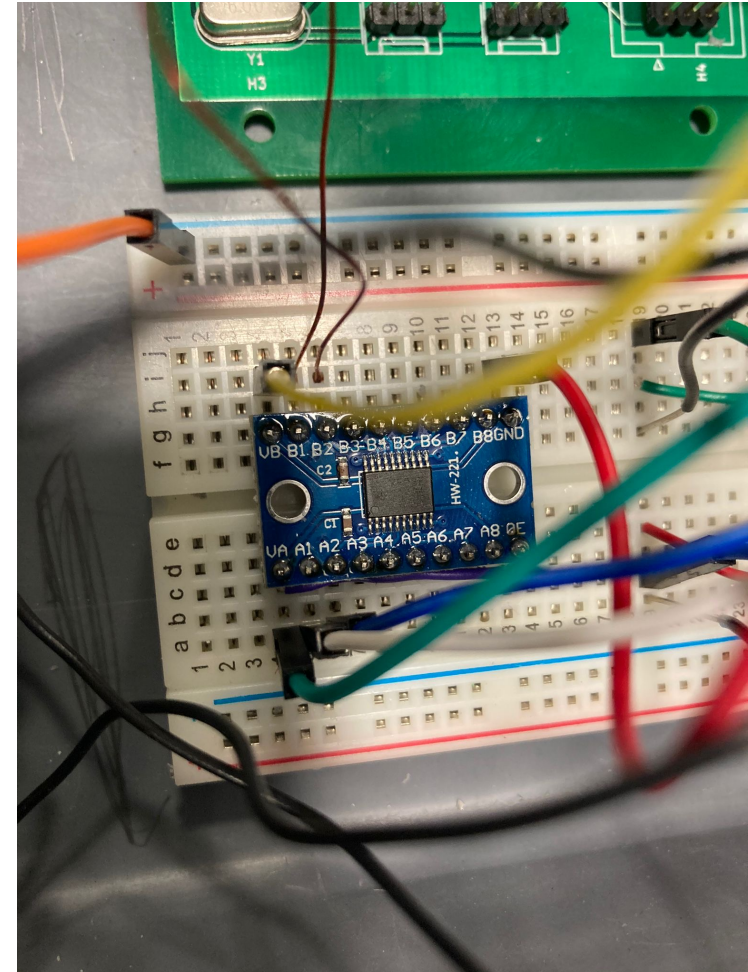
- Capacitor discharge

Power Subsystem

Key Requirements:

- Level shifter must perform the 3.3 V → 5 V conversion correctly (within a desired range)

Major Challenges:

- Malfunctioning components

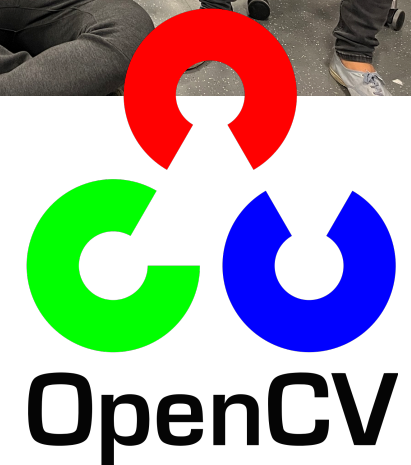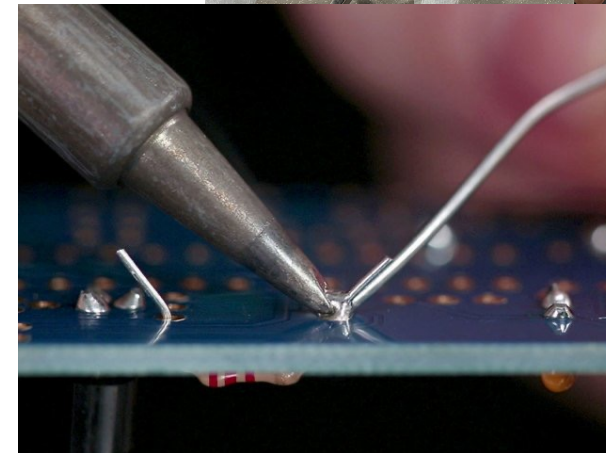- Late component arrival / tight deadlines

Conclusions

What we learned

Personal:

- Value engineering skills in solving real life problems
- Teamwork and consistency are key to success
- Almost nothing works on the first try.

Technical:

- PCB design and optimization.
- Component interconnection and communication.
- Soldering
- System Integration
- OpenCV

Future direction

- Optimize the structure

- Modify design for commercial and gym compatibility purposes

- Adjust for other exercises

THANK YOU!

Questions?

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