X-Chair:
Autonomous Wheelchair Restraint Adaptations

Client: Mr. Keith Wanta

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Advisor: Mitchell Tyler

Overview of Presentation

- Problem Statement
- Background Material
- Product Design Specifications
- Final Design
- Code Flowchart
- Discussion
- Future Work
- Acknowledgments & References

Client Information

- Mr. Keith Wanta
  - Works as a Senior Programmer Analyst in the Biostatistics and Medical Informatics Department at the UW-Madison School of Medicine and Public Health
  - Diagnosed with Spinal Muscular Atrophy (SMA) Type 2

Problem Statement

- Client is unable to safely enter and operate standing wheelchair
- Movement has many benefits - blood flow, digestion, bone health, which are less obtainable when mobility is restricted
- Existing standing wheelchair supports enable mobility but lack autonomous accessibility
- CNA and licenced physical therapists can facilitate productive device usage but are too costly

Background

What is Spinal Muscular Atrophy (SMA) [1]

- Impacts voluntary movement of muscles

Benefits of being in upright position vs sitting [1]

- Increased blood flow
- Stretching and exercising muscles

Current Problems in standing wheelchair supports

- Difficult to secure in place
- Requires help during entry and exit

Product Design Specifications

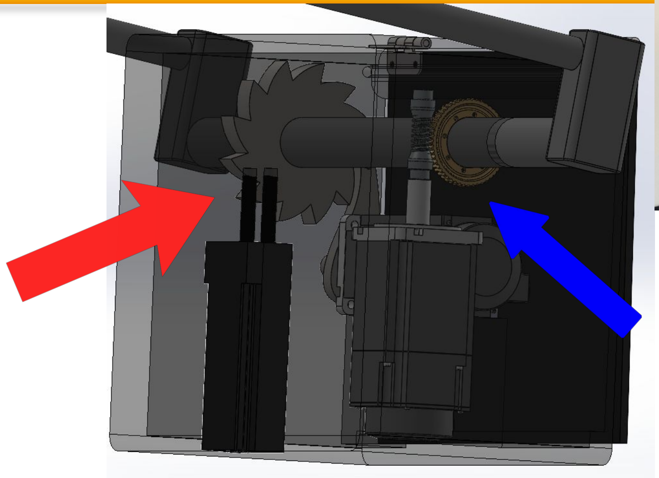
Client requirements:

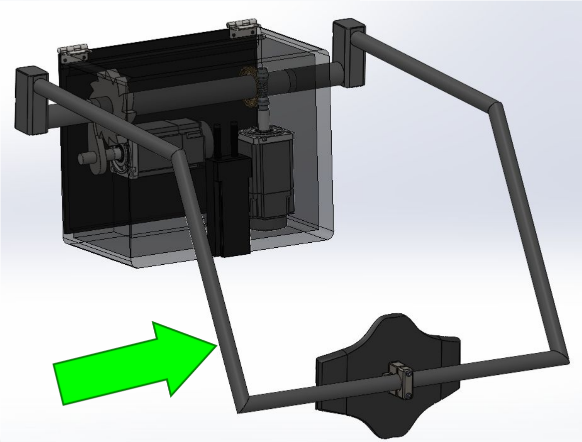
- Motorized, accessible controls for individual device operation
- Secure user in the standing position
- Cannot impede entry to wheelchair via ceiling lift
- Must be removable from wheelchair

Design requirements:

- Chest support obtains position with 100% accuracy
- Leg support obtains position with 100% accuracy
- Functionally effective over duration of 8 hours
- Supports must enter position within 30 second period

Final Design - Chest Support





- Overhead bar
  - Moved via worm gear
  - Locked via ratchet system
- Worm gear
  - Driven by 360° servo motor
  - Provides torque increase and prevents backdrive
- Ratchet system
  - Lock controlled with 180° servo motor
  - Ensures dynamic system stability

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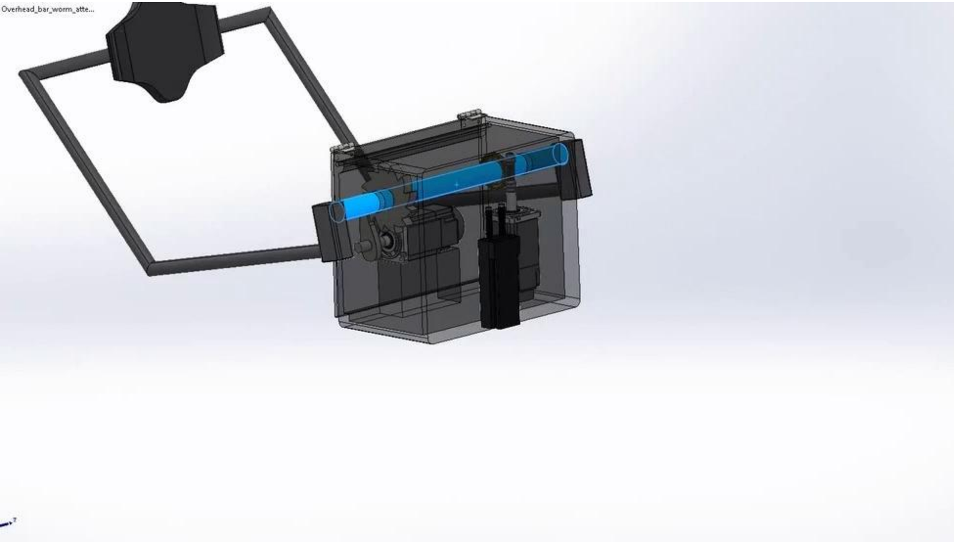
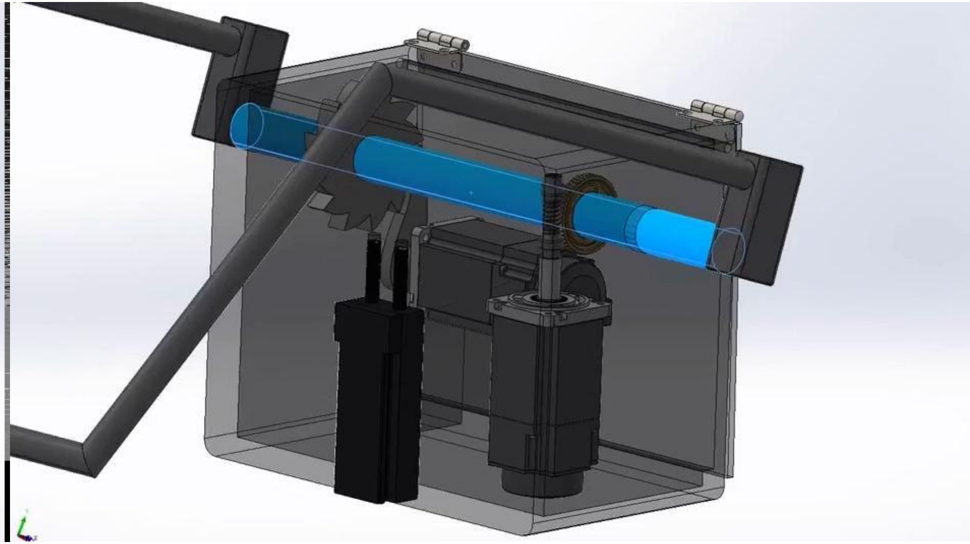
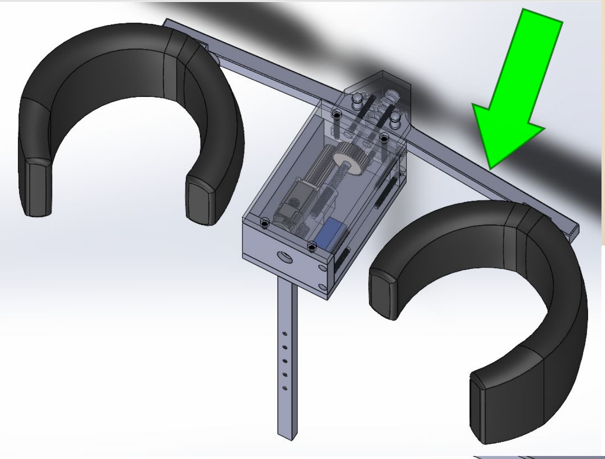
Final Design - Chest Support Videos

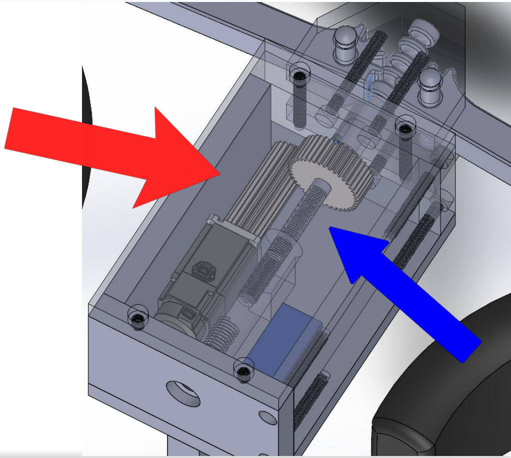




Final Design - Leg Support

- Support arm (pinion)
  - Adjustable pad positioning
- Threaded bolt (rack)
  - Threading/unthreading of bolt changes support arm positioning
  - Secures support arm during operation
- Gear system
  - Driven by 360° servo motor (0.3 N·m)
  - Threaded bolt turned by gear stock





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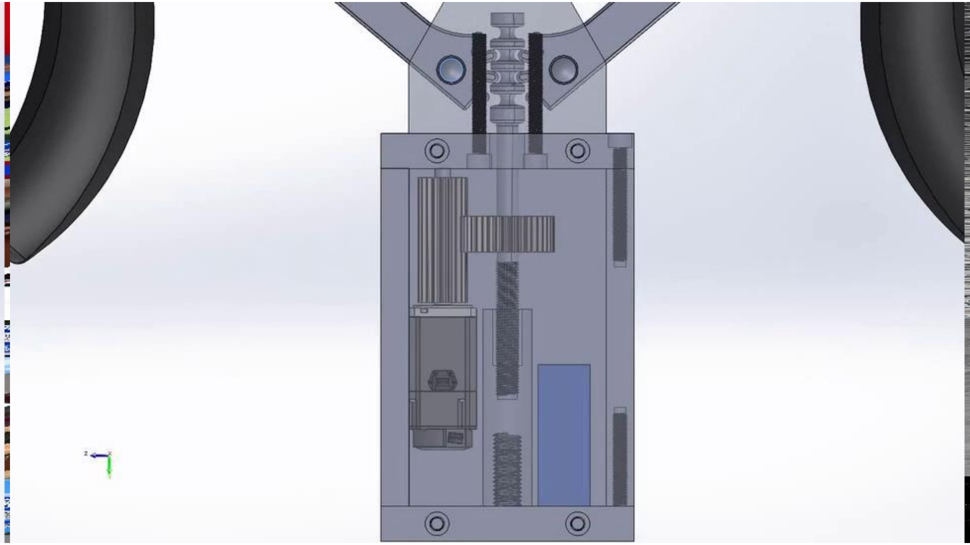
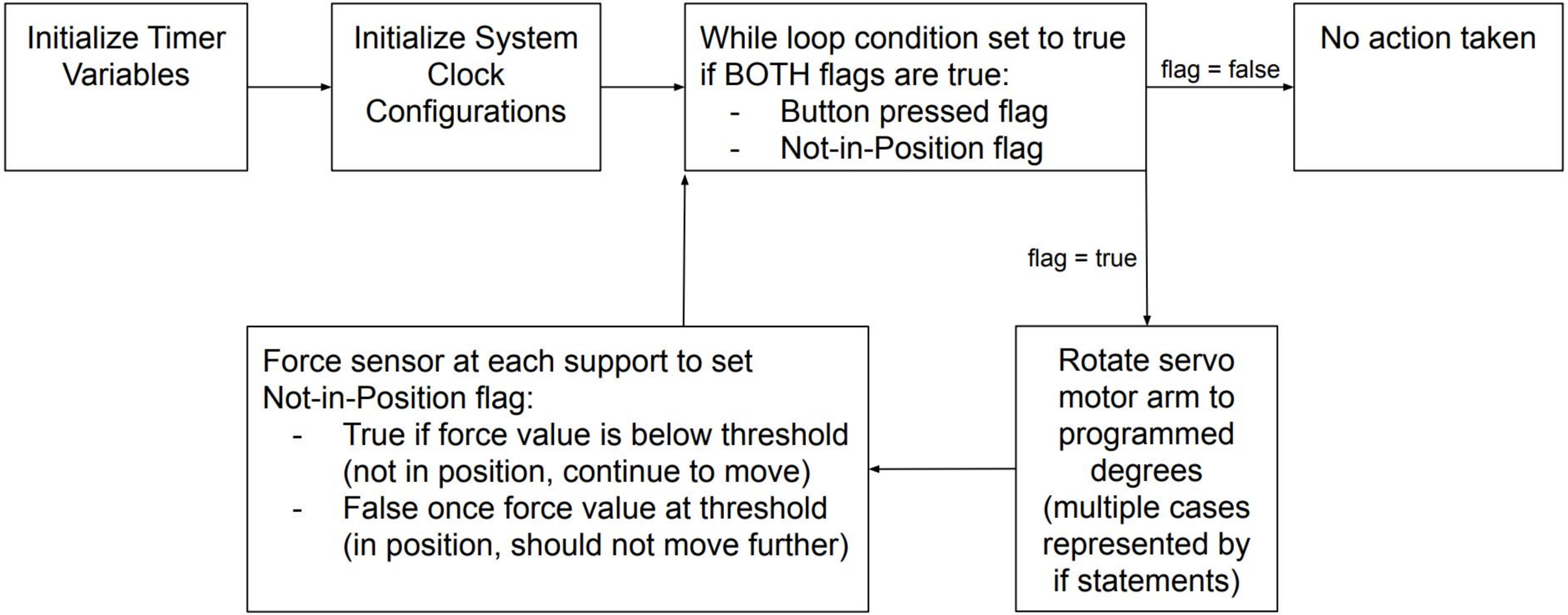
Final Design - Leg Support Videos



Code Flowchart



Discussion

- Potential problematic areas
  - Friction at the pin in the leg support
  - Shearing of pinion teeth in rack and pinion system
  - Potential backdrive of chest support bar
- Calculations
  - Calculate torque needed for the motors
  - Mechanical stress at specific points
  - Factor of safety of 2 accounted for mechanical stresses
- Testing various metrics to determine functionality

Testing Plan

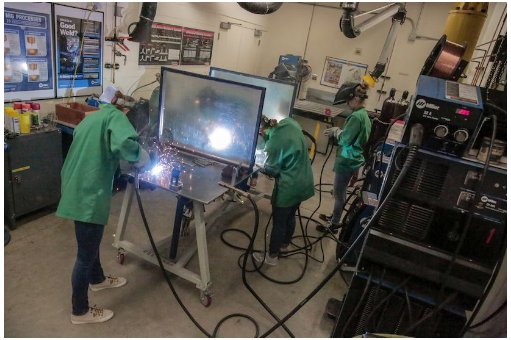
- Nucleo Code - Functionality Testing
  - Tests proper execution of movement code
  - 100% Accuracy
- Nucleo Code - Execution Time Testing
  - Tests the execution duration of code
  - Measures if the movement time is within parameters
  - 95% Accuracy
- Limit Switch - Failsafe Test
  - Tests limit switch performance as mechanical failsafe
  - 100% Accuracy

[2]

[3]

Future Work

- Fabrication
  - Component outsourcing
  - TeamLabs Welding Pass
  - Device assembly
- Conduct mechanical stress testing to determine possible points of failure
- Install a secondary safety measure to ensure no accidental usage of the device
- Foot plate design and fabrication



[4]

Acknowledgments

A special thanks to…..

- Our Client: Mr. Keith Wanta
- Our Advisor: Mr. Mitch Tyler
- BME Director: Dr. John Puccinelli
- BME Department

Questions???

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