Design and Control of a Continuum Wire Manipulator (CWM) for Minimally-Invasive Surgery *(Project 2)*

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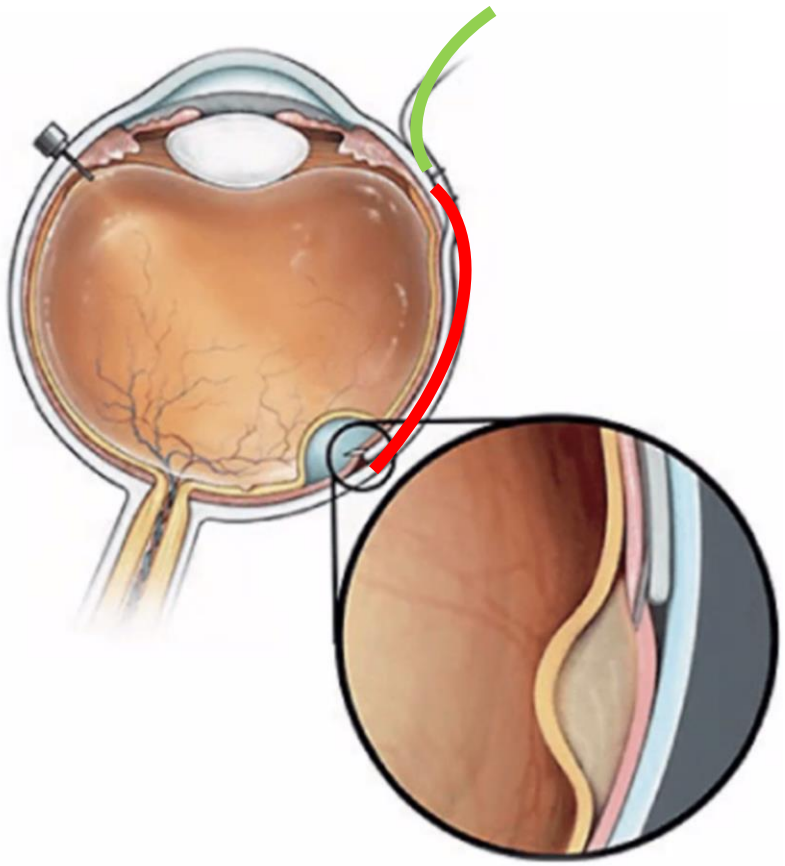
Recap



- Problem
  - Retinal Degenerative Diseases affect **200M** people.
  - The **straightforward** needle would do harm on the eyeball and retinal.
- Solution
  - The continuum robot can find **minimal access** for safe subretinal delivery of gene therapy.
- CIS Goal
  - Design a mechanical **prototype** for the retinal robot.
  - Realize low-level **motor control**.
  - Integrate with the Steady Hand Eye Robot (**SHER**).
  - Test **C- and S-shape** in agar-gel.

Project Status

- MINIMAL:
  - ✓ Design CAD Model for new robust CWM actuator
  - ➢ Select appropriate parts and make wiring plan including housing and motor controller

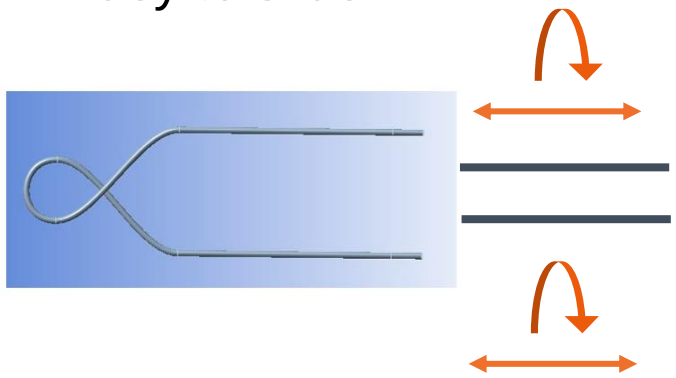
- EXPECTED:
  - ✓ Construct new robust prototype iteration
  - ➢ Build basic ROS package for actuator control of all actuators with nitinol end effector attached

- IDEAL:
  - ➢ Develop removable mount hardware for SHER
  - Incorporate the continuum robot in with SHER control system, demonstrate motion with SHER
  - Show motion of system inside of agar gel with integrated control, characterizing C-curve and S-curve ability.

Accomplished: Mechanical Design

Novel-designed end effector

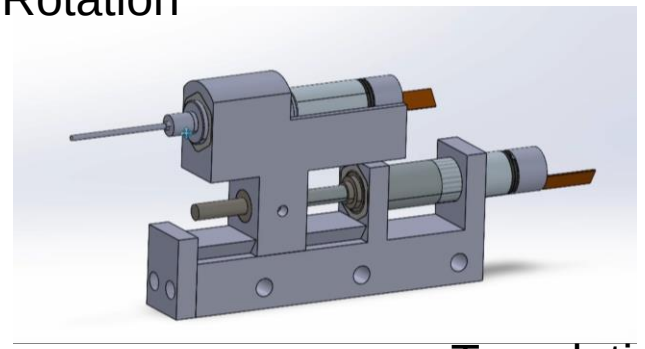
- Nitinol
- 4 DoF
- Easy to curve
- Easy to slide



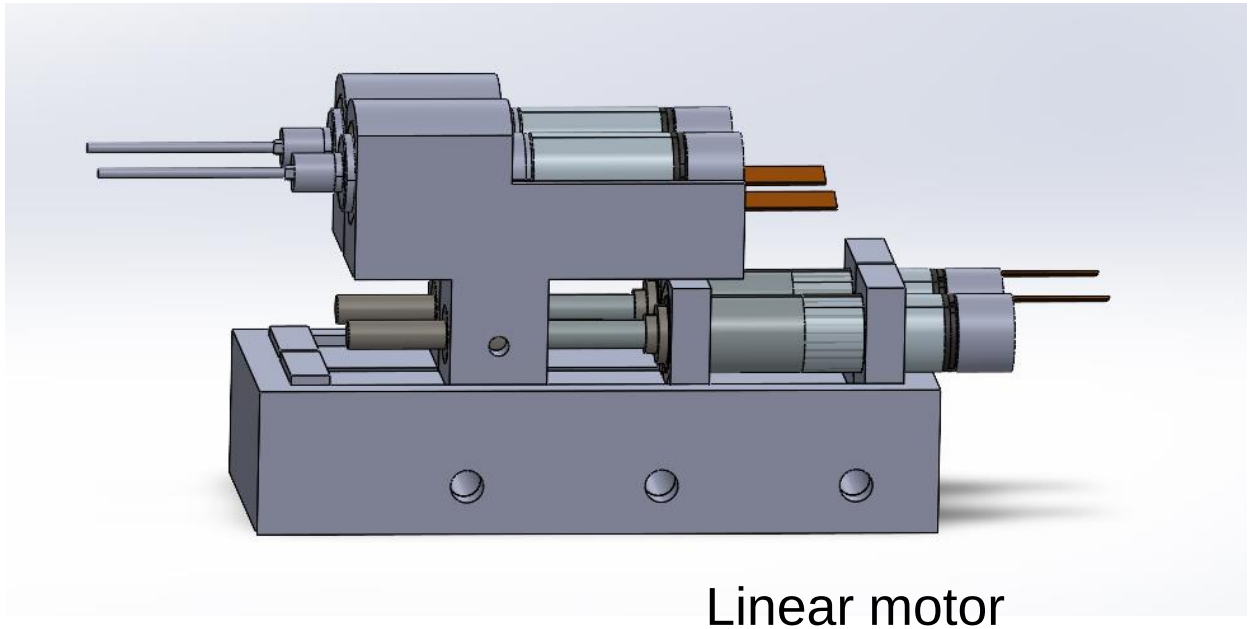
Rotation motor

- Maxon Motor DCX 8 M
- Gear box and encoders

Rotation



Translation



Linear motor

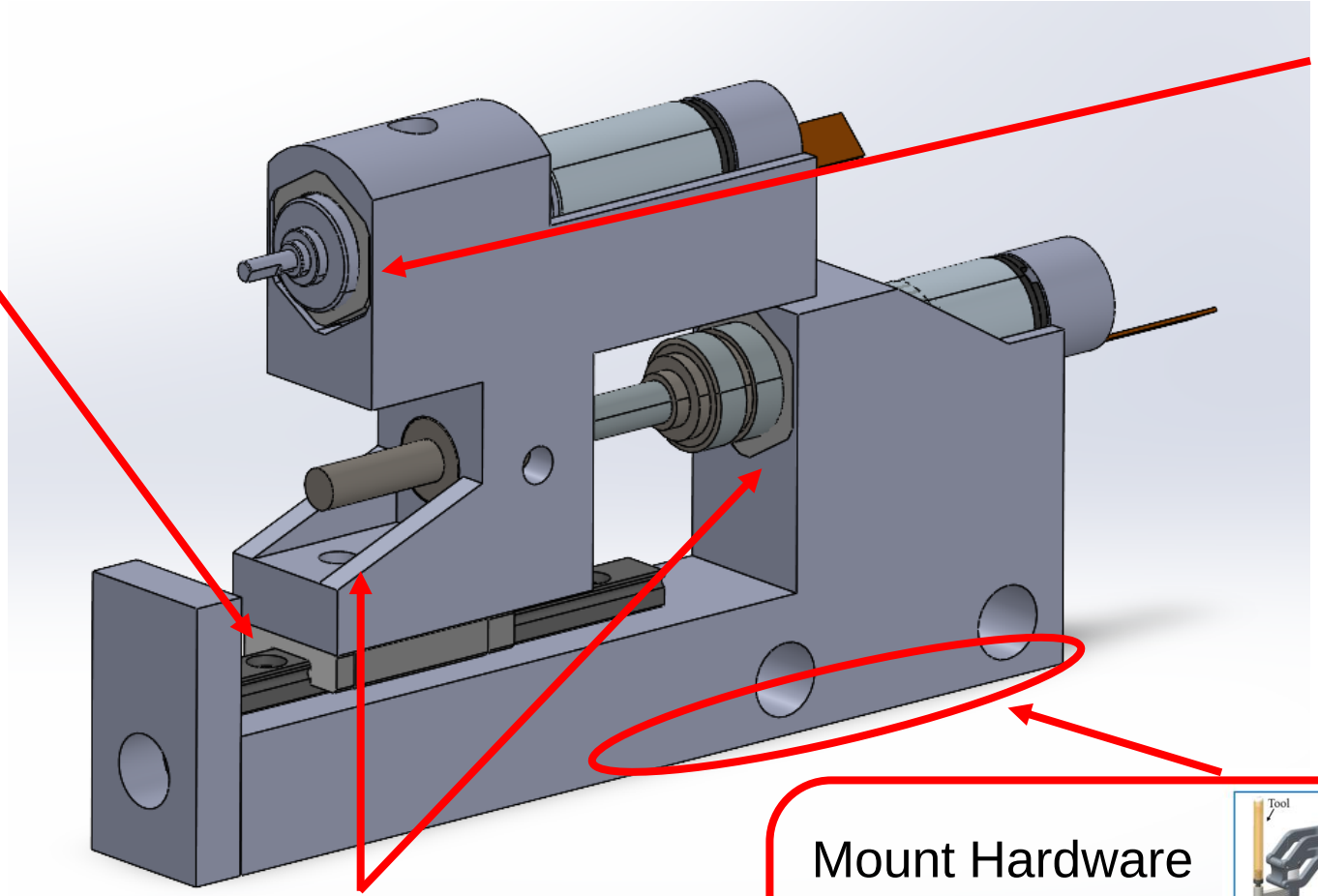
- Maxon Motor RE 8
- Lead thread

Galil Motion Controller

Accomplished: Prototype Iteration

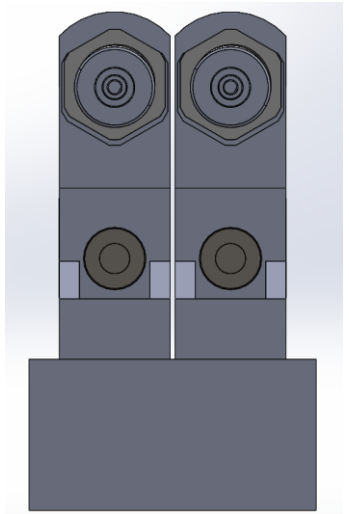
IKO Linear Guide

- Steel ball inside
- Easy to slide
- Avoid pitch torque
- Precise control



Tune housing thinner

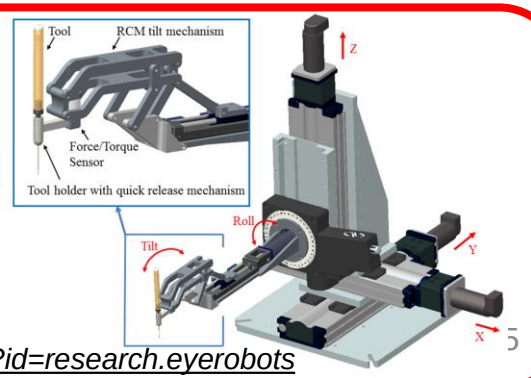
- 2 parallel control wires
- Small spacing
- Precise shape control



Nuts and Threaded Inserts

- Fixed and stable
- Protect motors

Mount Hardware for SHER (in progress)



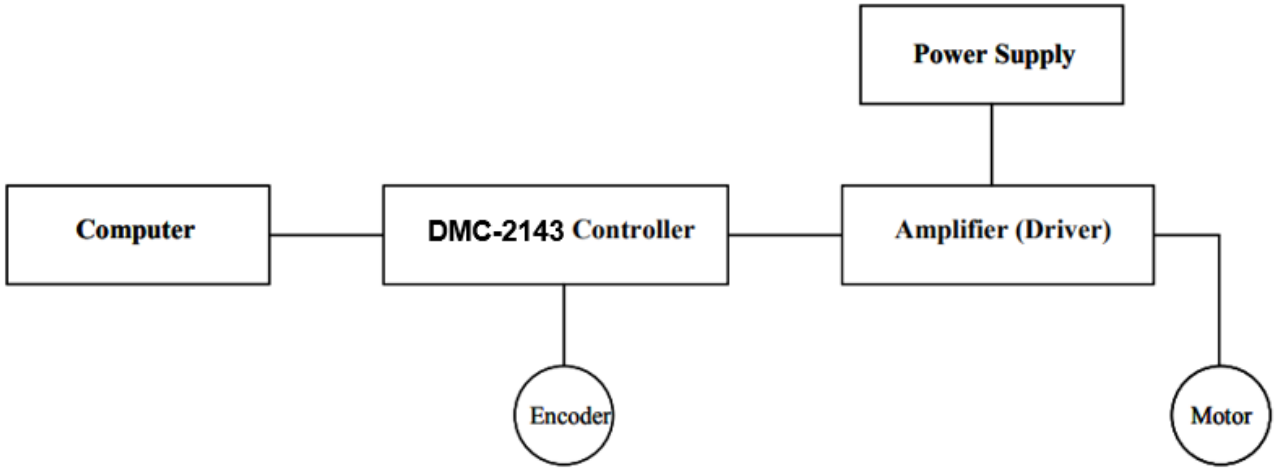
https://ciis.lcsr.jhu.edu/doku.php?id=research.eyerobots

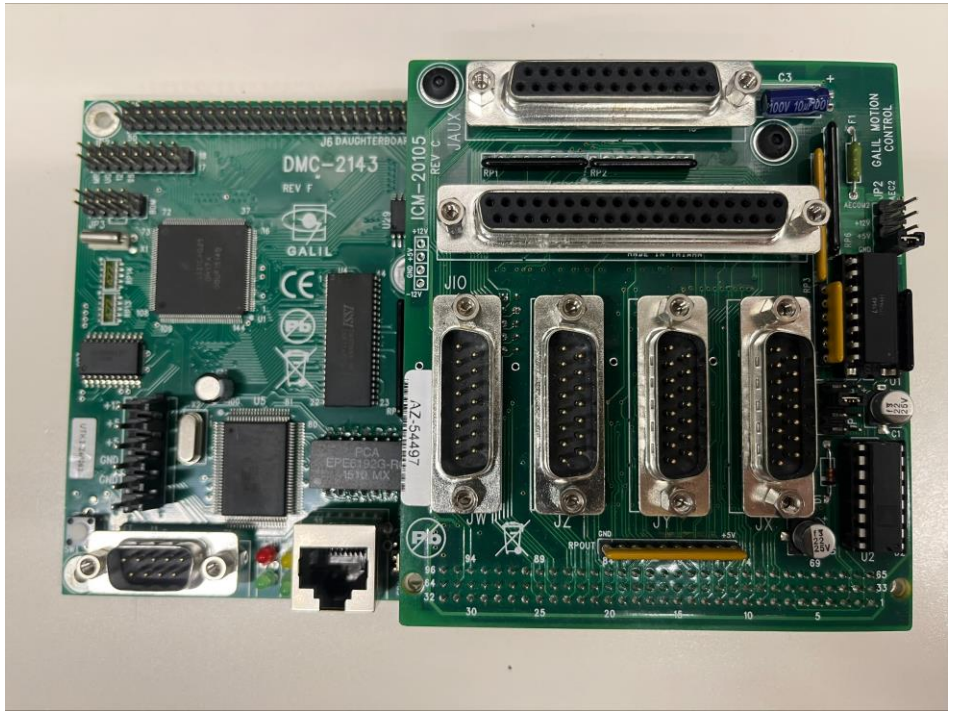
In Progress: Control

Low-level control

- Interact with the physical process
- PID for individual motor control
- Galil controller Library (**DMC-2143**, ICM-20105)

- 4 axes control simultaneously
- High speed motor/encoder interface
- Plenty of motor control functions and API
- Keep consistent with SHER





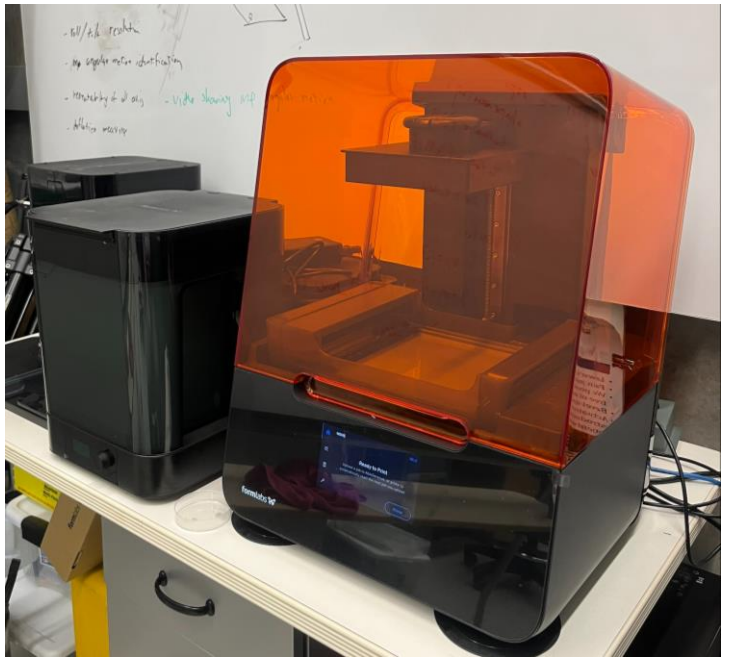
Issues

Problem

- Shared printer in Robotorium
- Tune the tolerance
- Example: 8.5 mm hole

Solution

- SLA printer
- Micrometer-level resolution
- Thread inserts



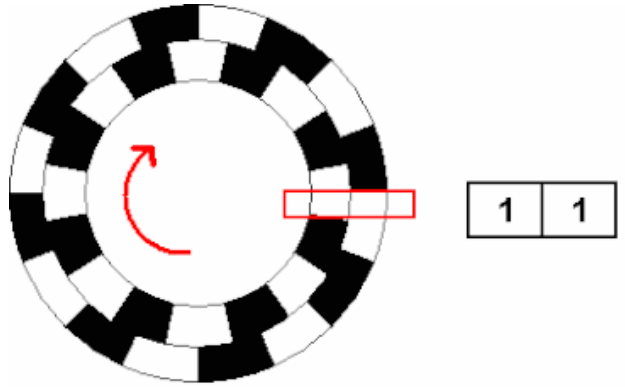
Issues

Problem

- Relative encoder
- No absolute positions
- Tricky for precise control

Solution

- Mapping from motor positions to robot shapes (kinematics)
- Define homing point
- Reinitialize every time

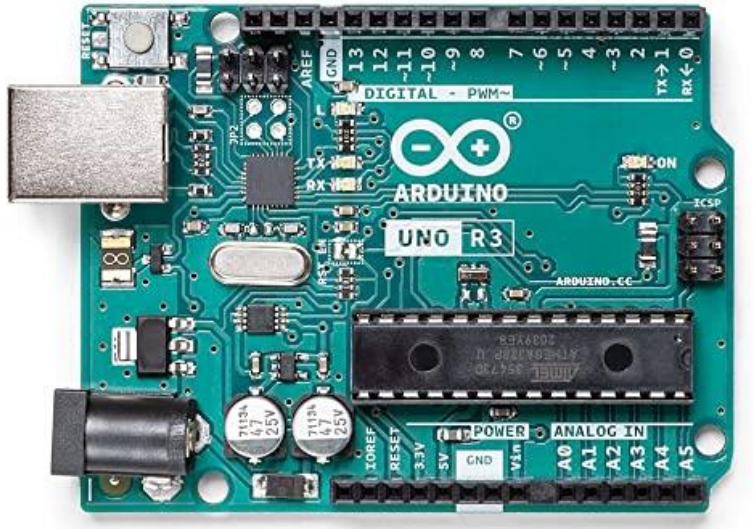


Problem

- Galil controller
- Few documentations (hardware setting ups)
- Hard to learn

Solution

- Arduino, Raspberry Pi
- Online resources
- Use ROS to integrate with SHER



Timeline

	12-Feb	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr
✓ Design CAD Model for motors' combo structure												
✓ Print and purchase different parts and test the design details												
Make wiring plan												
✓ Iterate the mechanical design for better performance												
✓ Set up python and ROS environment												
Learn, apply and test the ROS and GALIL control library												
Test C- and S- curve in agar gel												
Estimate constant curvature model with design for forward kinematics												
Design mechanical interface with the SHER system												
Integrate the low-level control with the SHER system												

original

updated

Dependencies

Dependency	Need	Status & Deadline	Contingency	Effect
Manufacture	need access to SLA printer and laser cutting machine	Done	order online & use shared printer	help to make the mechanical design into real world
Motor Controller Selection	basic parts to set up the surgey system	Done	detach parts from other robots	help to actuate and control the robot
Environment Acquired	set up python and ROS environment for robot control	Done	configurate shared computer in the lab	basic step to realize robot control
Access to SHER system	integrate the continuum robot with the SHER platform	Done	alternate with other surgey robot system, such as Da Vinci	improve the user experience and surgey applications
Agar Gel for Testing	test C- and S- curve in agar gel	not start; 4/15	None	realize the kinematic of the continuum robot

Documentation

- Done
  - CAD models and notes (DevLog) of different iterations on OneDrive
  - Datasheet and manuals of the motors and controllers on OneDrive
- In Progress
  - Hardware and software requirements and interface
- Coming Soon
  - Control codes on GitHub
  - Testing plan and records on OneDrive

Management

- Meetings
  - Weekly meetings with mentor to discuss progress (Tue 3 pm)
  - Frequent discussions about technical details
  - Coordination with a closely related team on the motor control and ROS
- Platform
  - Communication: e-mail, Microsoft Team, and Zoom meetings
  - Code: a private repository on GitHub
  - Data: Hopkins OneDrive (secure and encrypted)
  - Report Writing & Filesharing: LaTeX (Overleaf), OneDrive, CIS II wiki page

Reference

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Thank you!

Q & A