Design and Control of a Continuum Wire Manipulator for Minimally-Invasive Surgery

Computer Integrated Surgery II
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Introduction

- Over **200 million** people worldwide suffer from retinal degenerative diseases.
- This project proposes a novel approach for retinal gene therapy delivery using a continuum robot.
- The **deformable and steerable** robot allows surgeons safely access the subretinal space without puncturing key visual structures.

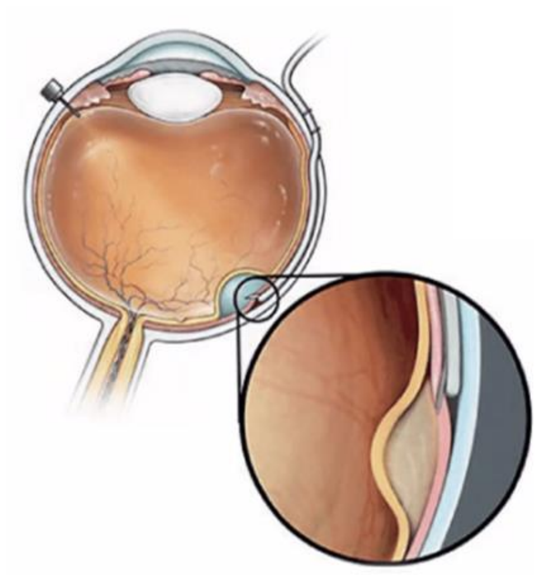

Fig 1. Example route of the CWM for subretinal injection.

The Problem

- The cutting-edge research uses trans-vitreal (go-through) approaches, **making a hole** through the retina to inject drugs.
- Piercing through the retina is traumatic and does not readily heal.
- The trans-scleral (go-over) robot requires **smooth** and **precise** motion.
- Both surgeons and patients would benefit due to the reduced risk of potential retinal damages.

The Solution

- Design and iterate a robotic platform to support the motors and guarantee smooth robot motion.
- Develop an EPOS package to conduct precise and simultaneous control.
- Realize three motion modes to showcase the **tortuosity** of the robot.

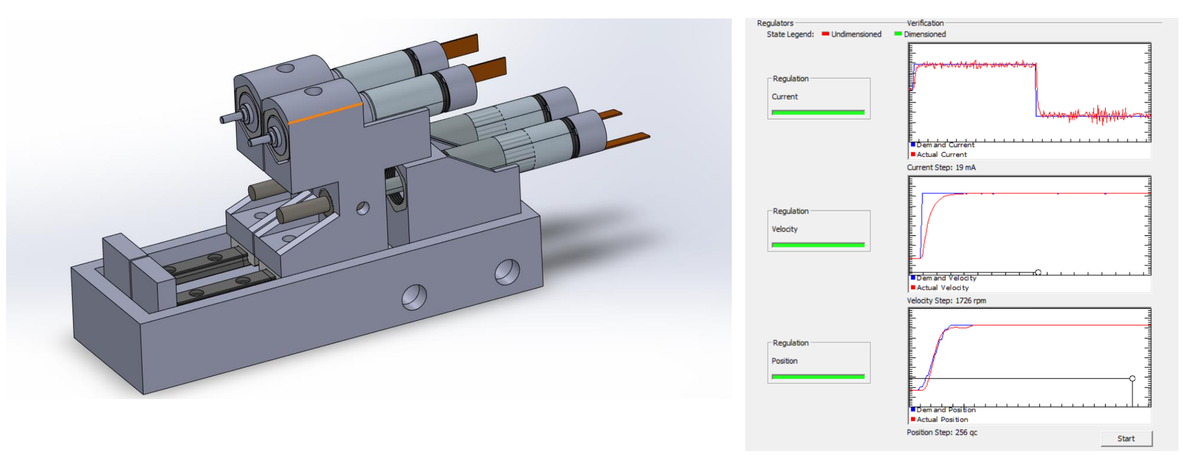

Fig 2. Robotic platform and fine-tuned control process.

Outcomes and Results

- The wire loop can twist, curl, yaw, feed and retract by the elaborate control of position and velocity. (4 DoF)
  - **Twist** in roll direction to generate a node which allows the wire slide and curve in desired shape.
  - **Curl** in pitch direction to simulate the C- and S- curve of trans-scleral motion.
  - **Yaw** combines with **Feed and Retract** to arrive the designated location.

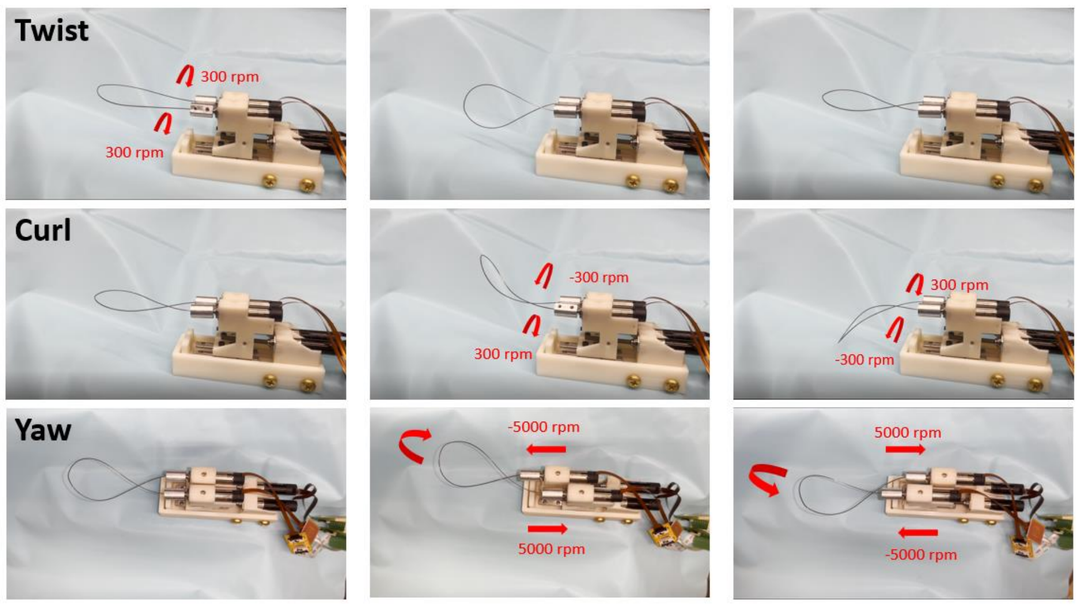

Fig 3. Robot motion modes.

Future Work

- Integrate with the Steady Hand Eye Robot.
- Derive the kinematic model by neural networks and finite element analysis.
- Safe subretinal delivery into a phantom pig eye.

Lessons Learned

- Mechanical iteration strategies based on user study.
- Wiring methods to connect multiple signal channels.
- Fine documentation custom to record research details.

Publications

- We plan to build up the kinematic model and submit our results to ICRA 2024.

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