CIS II Project Proposal

Project 17: Actuation Design for Loop Snare Operation in Eye Surgery

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Significance

This snare loop robot will be advance the process in retinal drug delivery. The retinal drug delivery is a challenging area in the field, and an ideal drug delivery system has not yet been found. If this project is succeeded, this robot will provide a perfect solution for solving this drug delivery problem. In order to have advance the project, the team will make sure the actuation system will hold a reasonable result for the further development of the project.

Introduction and Project Goals

The title of this project is Actuation Design for Loop Snare Operation in Eye Surgery. As mentioned in this title, there are two key factors involve in this project. The first factor is the eye surgery, and the second factor is the snare loop robot. The snare loop robot is widely used in medical field, and there exists different modes of snare loop for different categories of medical. For the snare loop robot made for eye surgery, the snare loop must be accurate and safe to operate in a limited workspace, since the eye is a fragile organ. The robot needs to make sure there should present no damage to the retina, which this part is unrecoverable. The following picture is a set of pictures that demonstrates the motions that a snare loop can present by applying forces (in this case, the driven force is torque).

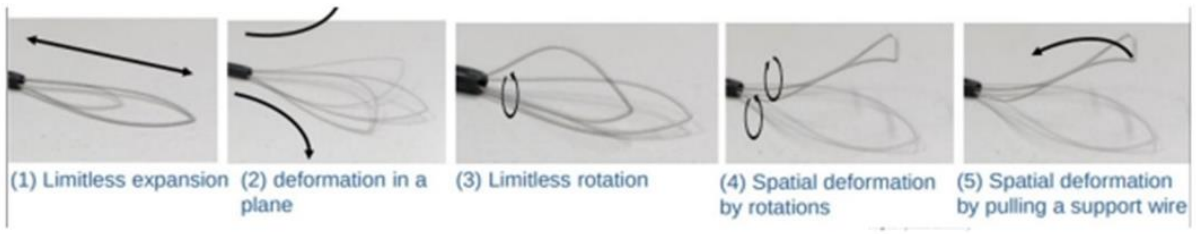
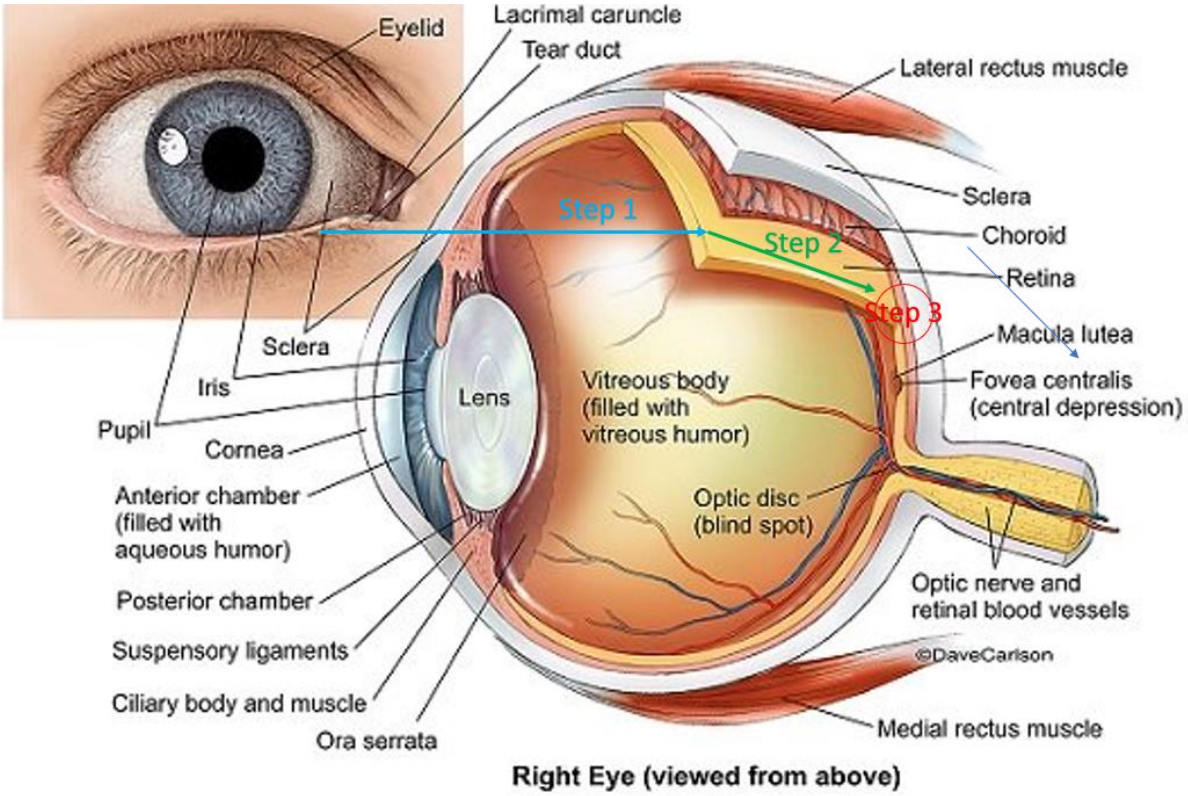


Figure 1. Examples of loop motion

In the picture 3, 4, and 5 above, the loop is presenting a curved shape by the torque applied to the wire. The curvature of the loop will be determined by the amount of torque applied to the wire. The mathematical relationship between torque and curvature have not been determined

yet, but it will be determined later for a better controlling effort.

In this portion of project direction, the team will briefly talk about the overall direction of this



project. Notice that the actuation is only a small portion of the entire project, but this is enough for the course of CIS II. The CIS project is aiming for design an actuation system that can help move the loop through the eye with no damage to the critical structure inside the eye, while the big project will combine control and vision to navigate the loop to the backside of retina and to deliver the medicine at the backside of retina. The following picture is for demonstrating the entire process.

Figure 2. Robot Procedure

The step 1 will cut through the sclera and choroid at front side of the eyeball, where the sclera will be thinner than backside of the eyeball, where the cutting should be located here. After cutting through the sclera and the choroid, the robot (snare loop) needs to move between the choroid and retina. The robot should not touch either side, for choroid, it is rich with vessels and will cause a mess with blood if damaged, and for retina, it is the critical part of patient's vision, which should not be damaged during the operation. The way to navigate to the location

of step 3 will be moving actively by injecting fluid between the choroid and retina to expand a safe space for the snare loop. As the robot reach the location for step 3, the robot will leave the medicine there for curing the patient. After all these above steps, the robot the leave the patient's eye by the exact path, which will make sure there is no further damage to the patient.

As mentioned in the detailed steps above, the actuation will participate a lot during the step 2, which it needs to bend itself into a suitable curvature to make sure the loop will not hit choroid and retina of the patient.

Technical Approach

Parts for Actuation

The actuators will be used for bending the wire are 2 motors from Maxon group. The controller of those motors will be EPOS4 motion controller. The team have already controlled the motor by using a EPOS2 controller, but there is still some issue with the setup of EPOS4.

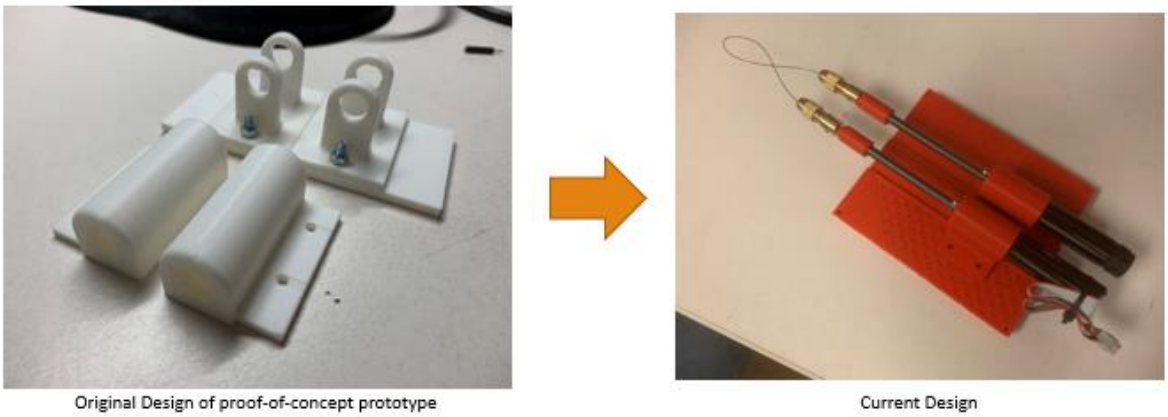


Figure 3. Actuators in housing

Control Package

The control of EPOS motion controller will be in the software of EPOS studio. To be controlled using buttons or other interface, the team will first develop a python package that can read the

user input and deliver it to the control interface (C/C++ package will be considered later if needed). This package will be used to set a bridge between user input and the EPOS studio. This step is the further step since the demonstration of controlling inside the EPOS studio.

Deliverables

The deliverables will contain basically three levels, which are minimum, expected, and maximum. The minimum deliverable is the main task that the team working on, which is to build a proof-of-concept prototype and to get it tested.

The next level of deliverable is to add a linear actuator to the system that will handle the bending of the loop to the direction left and right. And lastly, the maximum is to combine the finding and functions obtained into a prototyped tool that can bend itself into the desired shape based on the user input.

Dependencies

Table 1. Project Dependencies

	Current Status	Alternate Plan	Needed by	Effect
EPOS4	Ordered	Use a second EPOS2 motion controller	03/15/2022	Delay in using the actual controller to shrink the design
EPOS2	Obtained	N/A		
Second EPOS2	Not started	Depends on the arrival of EPOS4	03/15/2022	Depends on the arrival of EPOS4
POC* prototype	Obtained	N/A		
Linear actuator	Not started	N/A	03/31/2022	Delay in building the second prototype with left/right controlling logic
Wire for loop	Obtained	N/A	looped wire for POC by 02/28/2022	No preshaped wire: limited bending in up/down
Metal parts	Obtained for POC*	N/A	EP** by 03/31/2022	Delay in finishing prototype of Expected deliverable
Maxon motor	Obtained	N/A		
EPOS Studio	Obtained	N/A		
Linux	Obtained	N/A		
ROS	Obtained	N/A		
9-24V Power Supply	Obtained	N/A		
3D Printer	Obtained	N/A		
Solidworks	Obtained	N/A		

Here is the table for the entire project dependencies. The team have just obtained the ordered EPOS4 controller. But the team is facing a fatal issue in connecting the controller to the EPOS studio. The issue itself is that EPOS studio can’t detect the presence of EPOS4, but the team

could add it manually with a fatal error presented of hall sensor value error. The team is contacting with the technical support of Maxon motors and trying to get this fixed by the end of this week. Unfortunately, the key data might need to be pushed back a week to accommodate this issue if needed.

Key dates & Responsibilities

Since this project only contains one student from the CIS II course, I will take responsibility in related CIS II course works and the controlling aspect of the actuation system, which is mainly consisting of using the EPOS controller and developing the package to control. There is also an undergraduate student participate in this project, who will mainly focusing on modeling CAD files.

Table 2. Key Dates

Milestones	Expected Date
POC prototype	03/15/2022
Expected prototype	04/15/2022
Maximum prototype	05/01/2022

Management Plan

Project meeting with mentors will be hold on Friday 4 pm. The meeting with Dr. Mandeep Singh is a bi-weekly meeting, which the next meeting with him will be held on the next week and depending on his availability.

The related project files will be shared and monitored on OneDrive, including CAD, FEA, etc.

Reading List

Cehajic-Kapetanovic J, Singh MS, Zrenner E, MacLaren RE. Bioengineering strategies for restoring vision. *Nature biomedical engineering*. January 2022. doi:10.1038/s41551-021-00836-4

Duvvuri S, Majumdar S, Mitra AK. Drug delivery to the retina: challenges and opportunities. *Expert opinion on biological therapy*. 2003;3(1):45-56. doi:10.1517/14712598.3.1.45