Force feedback of dual force sensing instrument for retinal microsurgery

Overview

Retinal surgery is a very delicate procedure requiring small and accurate movements. This procedure can benefit largely from the use of robot, which can reduce error and invasiveness as well as speed up the operation and recovery time. One existing problem with retinal surgery is the maximum acceptable magnitude of force by the tip of the instrument on the eye tissue is below the perceptible threshold. In addition, although the force exerted by the instrument on the sclera is above the sensing threshold, excess force may also be deleterious. It is our goal to test various methods of alerting the surgeon when the force applied to the eye tissue or the sclera is near or past the acceptable range using a novel retinal surgery instrument that is able to sense both the tip and sclera force. From the results, we will be able to conclude which combination of force feedback method provides for optimal operation proceedings.

Goal: To develop and assess different force feedback methods (auditory, haptic, etc.) for a dual force sensing instrument for retinal microsurgery

Team members and mentor

Students: Can Wang, Sally Hong, Will Yang

Mentors: Xingchi He, Dr. Iulian Iordachita, Dr. Russell Taylor

Relevance/Importance

One major challenge in the field of surgical robots which has yet to be overcome is the lack of haptic feedback. The lack of such a feedback system leaves the control of the robotic arms solely on the vision field provided to the surgeon. Most agree that the addition of force feedback is generally expected have significant benefits for the surgeon’s “feel of the operation”, which would further result in increased patient safety.

Retinal microsurgery requires extremely delicate manipulation of retinal tissue where tool-to-tissue interaction forces are usually below the threshold of human perception. Creating a force-sensing surgical instrument that measures the forces directly at the tool tip poses great challenges due to the interactions between the tool shaft and the sclerotomy opening. Auditory feedback at the tip of the tool will alarm the surgeons when the force exerted is beyond a certain threshold and reduce the chance of retinal damage while haptic feedback at the sclera will exert an opposing force to the surgeon’s hand to increase the safety of the operation.

Technical Approach

l Design and build phantoms for eye experiments. (Use rubber bands to simulate forces on the sclera and retina)

l Get acquainted with the eye robot, program and auditory feedback tools

l Develop force feedback methods.

l Carry out assessment experiments. Use Eye Robot to provide haptic feedback and produce sounds

l Evaluate experiment results.

Deliverables

Various investigations have been carried out to develop force sensors for microsurgery, micromanipulation and minimally invasive surgery. Previous studies have demonstrated that auditory and haptic feedback based on force sensing can effectively improve the consistency of the applied forces and regulate the applied forces under a desired threshold. A phantom will be developed for a planar membrane peeling task with a simulated sclera constraint that approximates the sclera stiffness. The new dual force sensing instrument with different force feedback methods is supposed to further improve the performance of the cooperative robotic assistant for vitreoretinal surgery.

Minimum

Minimum five person test to analyze the effectiveness of:

- auditory feedback on auditory tip force feedback, haptic sclera force feedback

- auditory feedback on the sclera, haptic feedback on the tip force

- auditory feedback on both the sclera and tip force

Expected

IRB approval of use of outside volunteers for the study

Virtual phantom simulation of the retina to produce estimated axial force, which would allow us to produce haptic feedback on both the tip and the scleral force

Maximum

Force sensing retina phantom to measure axial force

Vibrotectile feedback mechanism to substitute the auditory feedback.

Dates and Responsibilities

02/19 Planning and proposal finalization

03/15 IRB approval for use of human subjects.

03/30 Testing haptic vs. auditory testing

4/12 New set of tests on improved phantom

4/26 Presentation/final analysis preparation

Management Plan

~Group meeting at 3PM every Tuesday and Thursday

~Meeting with mentor at 4:30 every Tuesday

~Weekly update of the wiki page

Reading List

1. M. Balicki et al. Micro-force Sensing in Robot Assisted Membrane Peeling for Vitreoretinal Surgery. MICCAI 2010, Part III, LNCS 6363, pp. 303–310, 2010

2. I. Iordachita et al. A sub-millimetric, 0.25 mN resolution fully integrated fiber-optic force-sensing tool for retinal microsurgery. Int J CARS (2009) 4:383–390

3. X. He et al. A Novel Dual Force Sensing Instrument with Cooperative Robotic Assistant for Vitreoretinal Surgery

4. R. Kumar et al. Preliminary Experiments in Cooperative Human-Robot Force Control for Robot Assisted Microsurgical Manipulation. IEEE(2000) 610

5. M. Kitagawa et al. Effect of sensory substitution on suture-manipulation forces for robotic surgical systems. The Journal of Thoracic and Cardiovascular Surgery 129:1,151