THE PROBLEM

Retinal disease, among them epiretinal membranes (ERMs) formation, is a leading cause of blindness. Surgical removal of ERMs is confounded by:
- small size
- transparency
- sparse location

Intra-operative OCT imaging can:
- greatly facilitate ERM localization
- provide up-to-date information during surgery

Incorporation of OCT imaging with an assistive robot can address issues like accuracy, hand tremor and safety.

This project addresses the need for:
- a quantitative assessment of surgical performance improvements achieved with the intraoperative OCT imaging system
- conversion of depth vs time Ms cans to more useful depth vs space images

THE SOLUTION

In order to test the efficacy of the OCT imaging system we designed a subject experiment that would directly compare performance on the same task with and without the aid of the system, while resembling most closely a real surgical scenario. This required us to:
- obtain IRB approval
- develop a retina and ERM phantom that would mimic a real ERM in its small dimension and difficulty in visualization

To address the time-space distortions inherent to the OCT Mscan we wrote two scripts based on two methods:
- similarity coefficient
- time-interval scaling

THE PHANTOM

- Retina: ~9 layers of latex paint on which vessels and a macula are drawn.
- ERMs: thin layers of household adhesive sealant (silicone) applied with a razor.
- Eye: hardening silicone mix made using eyeball-shaped mold.

EXPERIMENTAL DESIGN

The experimental set-up is the following:

- The experiment consists of two segments, preceded by a demo and practice:
  - Unassisted (control): locate ERM edge by closely inspecting microscope/stereo image.
  - Intraoperative OCT imaging assisted: additional overlays display data from the OCT probe, scan path, ability to select landmark in OCT image and have it highlighted in scan path.

There are 3-5 phantoms per segment, and 2-5 mins per phantom to demarcate as much of the ERM edge as possible, using at least 5 points. When an edge is found a circle is drawn around it, inside which no more points can be selected. For both segments pre-operative OCT images are available.

For each point the shortest distance to the true location of the membrane edge is computed. To obtain the true location of the membrane edge the EyeRobot is scans area containing membrane to obtain 3D image of tissue.

The 2D projection of this image is registered with the image containing subject guesses. The absolute shortest distance is then the numerical quantifier that allows us to gauge the extent to which the system facilitates ERM localization.

The statistical analysis should explore two sets of hypothesis, one for accuracy and one for time:

\[ H_0: \text{The imaging system does improve accuracy, } \mu_{\text{assisted}} > \mu_{\text{unassisted}} \]
\[ H_A: \text{The imaging system does improve accuracy, } \mu_{\text{assisted}} > \mu_{\text{unassisted}} \]

\[ H_0: \text{The imaging system does not improve find time, } \mu_{\text{assisted}} = \mu_{\text{unassisted}} \]
\[ H_A: \text{The imaging system does improve find time, } \mu_{\text{assisted}} > \mu_{\text{unassisted}} \]

THE REFERENCES


Acknowledgements

- Many, many thanks to Marcin for his kind help with everything.
- Thanks to Dr. Taylor and Elisa for their help and guidance with the IRB.