Assessment of Intra-operative OCT Imaging in a Simulated Micro-surgical task

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Assessment of Intra-operative OCT Imaging in a Simulated Micro-surgical task
We aim to assess the efficacy of Intra-Operative OCT imaging as an aid in vitreoretinal surgery, in particular for peeling epiretinal membranes (ERMs). We intend to investigate this using a simulated micro-surgical task.
Background

- **Retinal Disease & Vitreoretinal Surgery**
  - Retinal disease is one of the leading causes of blindness
  - Inherent difficulties of vitreoretinal surgery
    - Manipulation of delicate 1-100 $\mu$m structures
    - Risk of retinal damage due to tremor and lack of force feedback
    - **Visualization difficulties**

Figure: www.eyemdlink.com
Background

- **Epiretinal Membranes**
  - Pathology of the eye in which a membrane of scar tissue grows on the macula. As the membrane tightens it deforms and progressively contracts the macula, affecting vision.
  - Are usually surgically removed

Figure: http://www.retinaeye.com/epiretinalmembrane.html
Motivation

- Intra-Operative imaging greatly facilitates location of ERMs, and allows for obtaining updated images of tissue operated upon

Figure: M Balicki et al
What is Optical Coherence Tomography Imaging?
OCT provides micron-scale images of anatomical structures within a given tissue. It can display the depth of different tissue layers (A-mode), as well as cross-sectional images (B-mode).

Fiber Integrated Surgical Pick
OCT fiber is incorporated directly into ophthalmic instrument, allowing for imaging of structures ahead of the instrument.

Figure: M Balicki et al
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Visual Tracking and Annotation
Registration of the position of intraoperative retinal imaging with stereo video microscope, and annotation on the video feed.

Figure: M Balicki et al

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• **Areas for improvement**

  • User interfacing/GUI
  • OCT image quality
    - Color enhancement
  • Smart OCT processing
    - Correct for time-space differences
    - Automatic Scanning
Technical Approach

- Experimental Validation of Intra-Operative OCT for locating ERMs
  - Phantom Design
    - Thin
    - Transparent
    - Non-reflective
  - Experimental Task Design
  - Data Analysis

Figure: M Balicki et al

- GUI and OCT processing
## Dependencies

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Solution</th>
<th>Status</th>
<th>Fallback Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to Robotorium</td>
<td>Apply</td>
<td>Resolved</td>
<td></td>
</tr>
<tr>
<td>Functional OCT System, probes and software</td>
<td>Schedule time for use</td>
<td>Resolve by 03/19</td>
<td>Re-schedule \ Simulate</td>
</tr>
<tr>
<td>Visualization system &amp; software</td>
<td>Schedule time for use</td>
<td>Resolved</td>
<td>Back-up at med campus</td>
</tr>
<tr>
<td>Marcin</td>
<td>Schedule weekly meetings</td>
<td>Resolved</td>
<td></td>
</tr>
<tr>
<td>Materials and resources for phantom</td>
<td>Get access and funding</td>
<td>Resolve by 02/27</td>
<td>Fundraise</td>
</tr>
<tr>
<td>IRB approval</td>
<td>Submit application</td>
<td>Resolve by 03/14</td>
<td>Re-apply with necessary changes</td>
</tr>
<tr>
<td>Attend Vitreoretinal surgery</td>
<td>Ask Marcin for help scheduling</td>
<td>Unresolved</td>
<td>Discuss VR surgery with surgeons</td>
</tr>
<tr>
<td>Subject Recruitment</td>
<td>Fliers, Today’s announcements, etc.</td>
<td>Resolve by 03/21</td>
<td>Increase incentives, try different forms of advertisement</td>
</tr>
<tr>
<td>Subject Incentive Funding</td>
<td>Apply for funding for T-shirts, gift cards, etc.</td>
<td>Resolve by 03/21</td>
<td>Fundraise</td>
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Deliverables

**Minimum**
- Phantom
- IRB approval
- Subject experiment
- Refined mScan user interface

**Expected**
- Functional demo of GUI
- Results from executed experiments
- Statistical analysis of results
- OCT image enhancement

**Maximum**
- Automatic scanning
- Time-space differences correction
- Publication
- Robot integration
Milestones

- Design of micro-surgical task that simulates ERM peeling
- Working phantom
- IRB approval
- Completion of advertisement and incentive for subject recruitment
- Completion subject trials
- Statistical analysis of data from subject trials
- OCT enhancements
  - Color enhancement
  - Annotation of anatomical landmark
  - GUI improvement
  - Time-Space correction
### Timeline

#### Assessment of Intra-operative OCT Imaging in a Simulated Micro-surgical task

<table>
<thead>
<tr>
<th>Week</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Read Relevant Literature</td>
</tr>
<tr>
<td>2</td>
<td>Plan Project</td>
</tr>
<tr>
<td>3</td>
<td>Evaluate Success of mScan for Finding ERM Edges</td>
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<tr>
<td>4</td>
<td>IRB Application</td>
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<tr>
<td>5</td>
<td>IRB Training</td>
</tr>
<tr>
<td>6</td>
<td>Attend Vitreoretinal Surgery</td>
</tr>
<tr>
<td>7</td>
<td>Design Phantom</td>
</tr>
<tr>
<td>8</td>
<td>Design Experimental Task</td>
</tr>
<tr>
<td>9</td>
<td>IRB Approval</td>
</tr>
<tr>
<td>10</td>
<td>Make Subject Incentives</td>
</tr>
<tr>
<td>11</td>
<td>Recruit Subjects</td>
</tr>
<tr>
<td>12</td>
<td>Perform Subject Experiments</td>
</tr>
<tr>
<td>13</td>
<td>Analyze Data</td>
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<tr>
<td>14</td>
<td>Develop GUI with OCT Path Overlay and mScan Display</td>
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<tr>
<td>15</td>
<td>Improve User Interface</td>
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<tr>
<td>16</td>
<td>mScan and OCT Path Correspondence</td>
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<tr>
<td>17</td>
<td>Automatic Scanning</td>
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<tr>
<td>18</td>
<td>Project Conclusion</td>
</tr>
<tr>
<td>19</td>
<td>Poster Design</td>
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<tr>
<td>20</td>
<td>Final Report</td>
</tr>
<tr>
<td>21</td>
<td>Presentation</td>
</tr>
</tbody>
</table>
Management Plan

- Weekly meetings with mentor
- Assessment of progress and timeline update
- Wiki maintenance
- We will collaborate on each task and share responsibility equally
- Possible use of Redmine
“Intraoperative Visualization of Anatomical Targets in Retinal Surgery” Ioana N. Fleming, Sandrine Voros, Balazs Vagvolgyi, Zach Pezzementi, Dr. Jim Handa, Russell Taylor, Gregory D. Hager


“Common-path Fourier-domain Optical Coherence Tomography with a Fiber Optic Probe Integrated Into a Surgical Needle” Jae-Ho Han, Marcin Balicki, Kang Zhang, Jae-Ho Han, Marcin Balicki, Kang Zhang, Xuan Liu, James Handa, Russell Taylor, and Jin U. Kang; Proceedings of CLEO Conference, May 2009


“Biopsy site re-localisation based on the computation of epipolar lines from two previous endoscopic images.” Allain B, Hu M, Lovat LB, Cook R, Ourselin S, Hawkes D. Centre for Medical Image Computing, University College London

Thank You!

Questions?