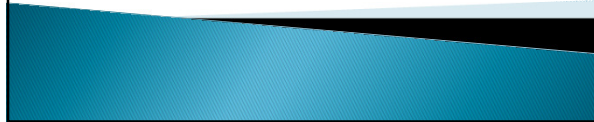


Visual Annotation of Clinically Important Anatomical Landmarks for VitreoRetinal Surgery

Vincent Ng
Xin Yuan Wang




Outline

- ▶ Background
- ▶ Relevance
- ▶ Project Goals
- ▶ Technical Approach
- ▶ Timeline
- ▶ Deliverables
- ▶ Assigned Responsibilities
- ▶ Dependencies
- ▶ Management Plan



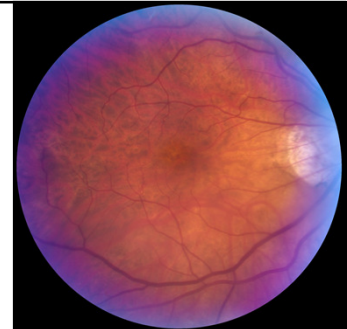
Team Members

- ▶ Student:
 - Xin Yuan Wang
 - Vincent Ng
- ▶ Mentors:
 - Prof. Russ Taylor
 - Rogerio Richa
 - Marcin Balicki
 - Prof. Gregory Hager (Computer Vision)




Background

- ▶ Fundus
 - Interior surface of the eye
- ▶ OCT
- ▶ Surgical Tools
- ▶ Macular Hole Surgery
 - Internal Limiting Membrane (ILM)

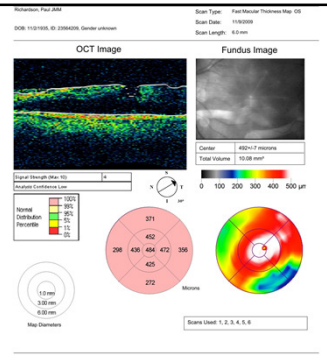


Images courtesy of Rogerio Richa




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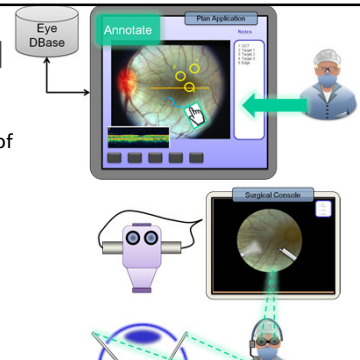


Images courtesy of Rogerio Richa




Background

- ▶ Fundus
 - Interior surface of the eye
- ▶ OCT
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Images courtesy of Rogerio Richa



Relevance

Surgeon annotates preoperative image

Problem:
Mentally track notes & locations during surgery, adding significant load to the already challenging surgical task.

Solution:
Annotations overlay on video

Slide taken from Rogério Richa's presentation

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Project Goals

- ▶ Registration
 - Preoperative images to intraoperative images
 - Overlay of landmarks on live microscopic feed
- ▶ Integration
 - GUI for surgeons
 - Frameworks - CISST, OpenCV
- ▶ Modern Hardware
 - Parallel
 - GPU
 - Multi-core

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Technical Approach

- ▶ Registration
 - Intra-intra feature registration
 - Preop-intra registration
 - OpenCV, SURF/SIFT
 - Image processing
 - OpenCV
- ▶ Modern Computing Power
 - Multi-core
 - GPU

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Technical Approach(SIFT)

- ▶ Scale-space extrema detection
- ▶ Keypoint localization
- ▶ Orientation assignment
- ▶ Keypoint descriptor

Courtesy of David Lowe

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Technical Approach(SIFT)

(a) 233x189 image
 (b) 832 DOG extrema
 (c) 729 left after peak value threshold
 (d) 536 left after testing ratio of principle curvatures

Courtesy of David Lowe

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Technical Approach(RANSAC)

RANdom SAmple
ConsenSUS


Courtesy of wiki

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Technical Approach

- ▶ Registration
 - Intra-intra feature registration
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 - OpenCV, SURF/SIFT
 - Image processing
 - OpenCV
- ▶ Modern Computing Power
 - Multi-core
 - GPU
- Image Processing
 - Aperture
 - Light cone
 - Focus
 - Exposure issues
 - Interference with floaters
 - Tool interference



Technical Approach


- ▶ Registration
 - Intra-intra feature registration
 - Preop-intra registration
 - OpenCV, SURF/SIFT
 - Image processing
 - OpenCV
- ▶ Modern Computing Power
 - Multi-core
 - GPU






Deliverables

- ▶ Minimum
 - Utilize, understand and implement SURF
 - Test/Validate program using manually picked annotations as ground truth
 - Data: Surgical and non-surgical
- ▶ Expected
 - Multicore processor speedup
 - Simple GUI that marks annotation for surgeon
 - Initial Image processing for real surgery data
- ▶ Maximum
 - Deploy solution into OR.
 - Integrate fundus/OCT data to surgeon's screen
 - Real-time image processing with GPU acceleration




Timeline

Task	14-Feb	21-Feb	28-Feb	7-Mar	14-Mar	21-Mar	28-Mar	4-Apr	11-Apr	18-Apr	25-Apr	2-May
Presentation and Proposal												
Feature detection and Matching												
Pre-op image processing												
Annotation registration												
GUI												
Speed-up with multicore												
Advanced Image Processing												
Refinement Final report and Poster												




Assigned Responsibilities

- ▶ Cycle 1 (Checkpoint: Feb. 17-28)
 - Paired Programming
 - Understanding CISST, OpenCV
 - Shared Reading List
- ▶ Cycle 2 (Checkpoint: Feb 29-March 19)
 - Xin: Identify areas of image processing to tackle for real images
 - Vincent: Plan GUI/GPU strategy
- ▶ Cycle 3 (Checkpoint: March 19)
 - Xin: More image processing, GUI
 - Vincent: GPU/Parallelization



Dependencies

- Cycle 1: (Checkpoint: Feb. 17-28)
 - Fundus image of the phantom model
- Cycle 2: (Checkpoint: Feb 29-March 19)
 - Pre-op/intra-op phantom data
 - Pre-op/intra-op rabbit retina data
- Cycle 3: (Checkpoint: March 19)
 - Feedback from surgeons about our test GUIs (HIPPA training, observe an actual procedure to see what the surgeon might want from our project)
 - Access to actual hardware (CPU/GPU).



Management Plan

- Weekly Meetings with Richa and Dr.Taylor on Friday
- Weekly FAQ session with Richa on Monday or Wednesday
- Weekly programming for 20 hrs, paper-reading and algorithm discussion for 5 hours
- Weekly Documentation Update
- Assess the viability of cycle 2-3 when cycle 1 is completed

Reading List

- [1] I. Fleming S. Voros, B. Vágvölgyi, Z.A. Pezzementi, J. Handa, R.H. Taylor,G.D. Hager. "Intraoperative Visualization of Anatomical Targets in Retinal Surgery," 2008. WACV. <http://www.cs.jhu.edu/~rht/RHT%20Papers/2008/wacv2008_Fleming.pdf>.
- [2] Hong Shen Stewart, C.V.; Roysam, B.; Gang Lin; Tanenbaum, H.L. "Frame-rate Spatial Referencing Based on Invariant Indexing and Alignment with Application to Online Retinal Image Registration." Mar. 2003. Web. <http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1182101>.
- [3] V. Mester, F. Kuhn. "Internal Limiting Membrane Removal in the Management of Full-Thickness Macular Holes." *Macular Surgery*, June 1999. Web. 14 Feb. 2011. <<http://www.ncbi.nlm.nih.gov/pubmed/10926987>>.
- [4] Johannes P.W. Grimm, Clemens Wagner and Reinhard Männer. "Interactive RealTime Simulation of ILM." 2004. Web. <<http://www.springerlink.com/content/64grw7h72f716t75/>>.
- [5] Paul M. Novotny, Jeff A. Stoll, Nikolay V. Vasilyev, Pedro J. Del Nido, Pierre E. Dupont, Todd E. Zickler, Robert D. Howe. "GPU Based Real-time Instrument Tracking with Three-dimensional Ultrasound." July 2007. Web. <<http://www.cs.jhu.edu/~rht/RHT%20Papers/2010/SPIE%20Ophthalmology%202010%20-%20LIU.pdf>>.
- [6] Herbert Bay , Andreas Ess , Tinne Tuytelaars, and Luc Van Gool. "Speeded-Up Robust Features(SURF)." 2008. Web. <<http://www.vision.ee.ethz.ch/~surf/papers.html>>.

Questions?

- ▶ Thank you