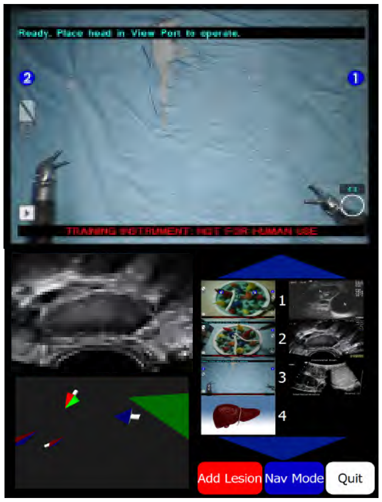
Advanced Computer-Integrated Surgery (600.446)
Possible Projects

Russell H. Taylor

NOTE

- These are just some possible projects
- You are free to choose one, modify one of these, or propose something different on your own
- You do need to get your mentor (and me) to agree to your proposal

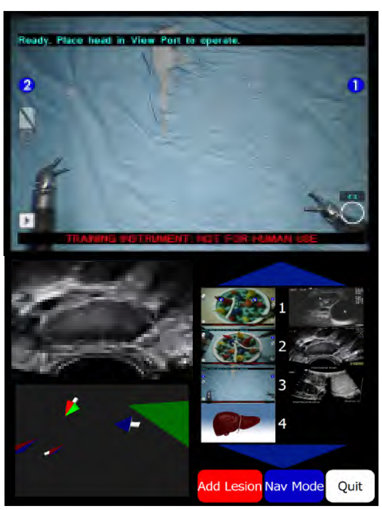
A User Interface for Data Integration during Robotic Ultrasound guided Surgery



Background: Robotic LapUS is starting to be used to guide the removal of cancerous lesions. The current process for doing ultrasound is cumbersome and requires help from additional technicians to manipulate the ultrasound images, undermining ergonomy and efficiency.

Goal: Further develope the current TilePro interface for working with real time ultrasound images from within the DaVinci console. Add additional tools to aid the doctor. Help with clinical testing and experiments.

A User Interface for Data Integration during Robotic Ultrasound guided Surgery



Minimum:
- Engineering support of clinical study
- Create a measurement tool for the Ultrasound images
- Assist in testing and deployment of the software

Expected (Some subset of):
- Create a measurement tool for the Ultrasound images
- Incorporate DICOM reader with Masters as Mice into the interface
- Use 3D fiducials with other imagery to show previously viewed areas
- Integrate segmentation software

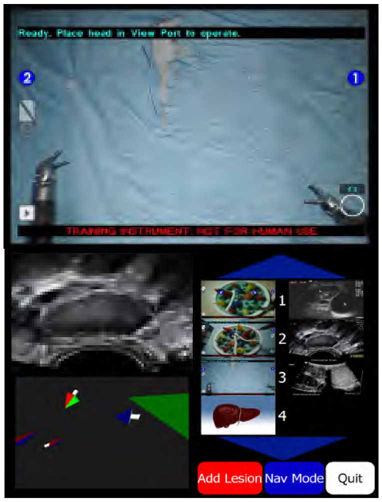
Maximum deliverables:
- Improved and ergonomically optimized software

Group size: 1-3

Skills: C++ (Qt and CISST are a plus)

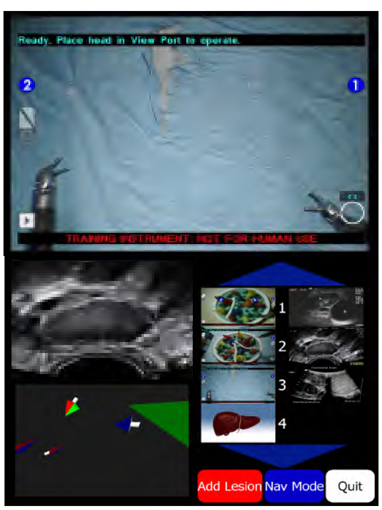
Mentors: Clinical: Dr. Michael Choti, Theodore Katsichtis
Engineering: Prof Taylor, Anton Deguet, Colin Lea
Email: colincsl@gmail.com, theokatsichtis@gmail.com

3D Visualization of Ultrasound Guidance Cues in the da Vinci Console (may combine with previous)



- **Goals**
  - This project involves converting an existing 2D image guidance interface to a 3D interface for use in a human trial of robotic ultrasound imaging using the da Vinci Surgical System
- **What Students Will Do:**
  - Implement a two-channel video pipeline for injecting stereo into the da Vinci Si console via the TilePro feature.
  - Modify image guidance widgets and features for stereo.
  - Explore new image guidance features that leverage stereo visualization.
  - Demonstrate and test the system at the medical school in preparation for a human study.
  - Participate in the IRB amendment to incorporate stereo visualization.

3D Visualization of Ultrasound Guidance Cues in the da Vinci Console (may combine with previous)

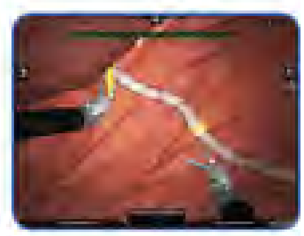


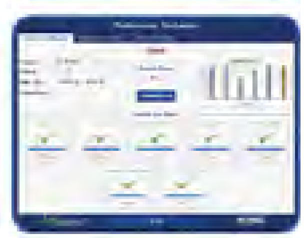
- **Deliverables:**
  - An ultrasound image guidance application that provides stereo visualization.
  - A test protocol and test results showing that the system is ready for experimental deployment.
  - An IRB amendment that incorporates changes to the existing 2D protocol.
- **Size group:** 1-3
- **Skills:** video and image processing, robot kinematics and linear algebra; graphics and GUIs.
- **Mentors:** Clinical: Dr. Michael Choti, Theodore Katsichtis, Engineering: Prof Taylor, Colin Lea, Anton Deguet

Simulated Anatomical Models for Interactive Storyboarding in the da Vinci Console

- This project involves implementing simulated models of surgical instruments, organs, and image guidance cues that can be manipulated and visualized within the da Vinci console. This will be useful for developing procedure storyboards, such as for exploring optimal port placement and the use of image guidance cues.
- **What Students Will Do:**
  - Bring up the H3D framework and Intuitive's Simulation Sandbox on a PC.
  - Integrate with either the "spare parts da Vinci" or da Vinci S system.
  - Import surface models that describe key human anatomy.
  - Implement mechanisms to inject different port placements, instruments, and ultrasound imaging planes.
- **Deliverables:**
  - Interactive control of da Vinci instruments within a virtual patient model.
  - Demonstrated ability to explore instrument reach and workspace, based on user defined port locations, with ability to record and play back motions.
  - Demonstrated ability to visualize an ultrasound imaging plane in the surgical field, with the imaging probe location interactively specified by the user.
- **Size group:** 1-3
- **Skills:** C++, some robot kinematics & linear algebra; graphics and GUIs.
- **Mentors:** Prof. Taylor, A. Deguet, [Simon DiMaio (ISI)]

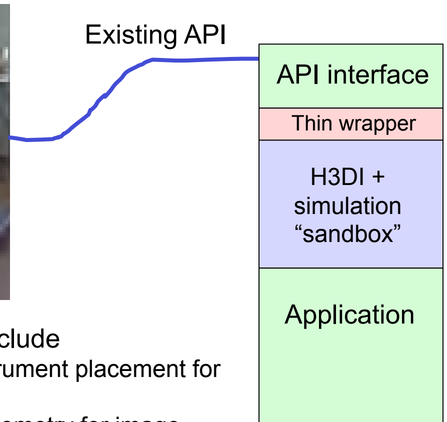
ISI Simulator





ISI Exploratory Research

What students would do



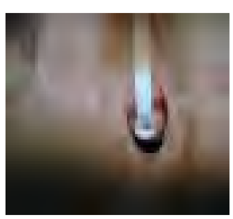
Interesting Applications Include

- Simulation of port and instrument placement for surgical planning
- Optimization of imaging geometry for image-guided surgery
- Development of new procedures
- Haptic interfaces for training

TRACHEOESOPHAGEAL PROSTHESIS INSUFFLATOR

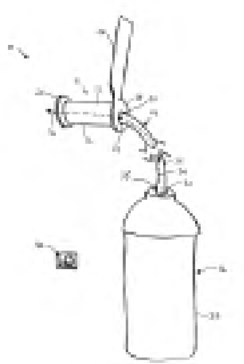
- Goal: To develop an insufflator for tracheoesophageal prosthesis to allow laryngectomy patients to speak hands-free.
- Laryngectomy is a common procedure for advanced and recurrent laryngeal cancer and involves removal of the larynx (voice box) and bringing the trachea directly to the skin in the lower neck.
- Various forms of vocal rehabilitation exist, including esophageal speech, external vibratory devices (electro-larynx), assistive speech devices, and tracheoesophageal (TE) speech.

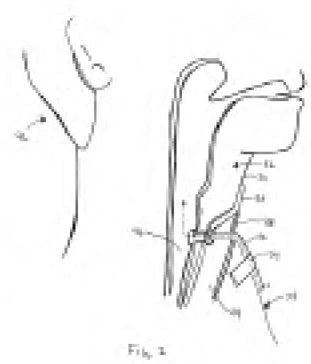
- TE speech relies on the placement of a small prosthesis with a one-way valve that spans the trachea and esophagus and allows for the shunting of air from the trachea into the esophagus when the stoma, or opening of the prosthesis is occluded. The shunted air creates vibration and sound within the pharynx that can be articulated into understandable speech.



- Problem: In order to occlude the stoma the patient has to manually close it with a finger. Not only is this cumbersome for a patient and potentially awkward when interacting with those not familiar with TE speech, but many patients don't have the coordination and dexterity necessary to properly occlude their stoma to produce fluent speech.

- Solution: Development of a controlled air insufflator that attaches to the TE prosthesis and allows for hands free TE speech.



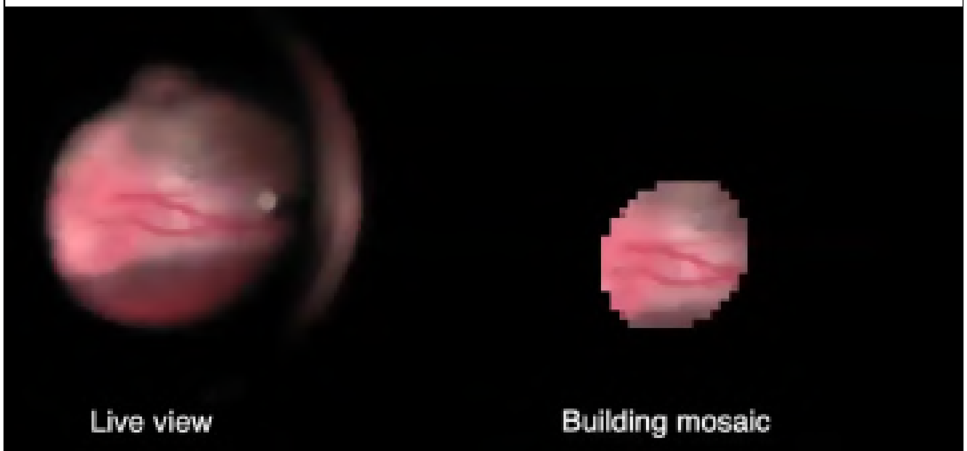


- To do: develop an air insufflator to deliver air through a small tube into the TE prosthesis and allow for speech production. The flow of air will be controlled by a finger activated remote device. Appropriate safety checks to avoid excessive pressure must be included.
- Group size: 1-2 students
- Skills:
- Mentors:
    - Jeremy Richmon, MD, Head and Neck Surgeon, Johns Hopkins Hospital
        - Russell Taylor, PhD

Design of Image Feature Descriptor for Retinal Surgery

- Common image feature descriptors are not well suited for characterizing retinal image features due to their generalized nature. A feature descriptor designed specifically to locate and characterize the vasculature and nervous system details of the retina may lead to the development of more robust registration and tracking algorithms.
- **What Students Will Do:** Understand common feature descriptors; record and study retinal images; develop specialized feature descriptor and extractor algorithm.
- **Deliverables:**
    - Record human vireo-retinal surgeries in JHH Wilmer
    - Select suitable segments from recorded videos
    - Establish baseline performance by using SURF, SIFT and ORB features for pre-operative-fundus to intra-operative-video registration
    - Identify suitable image features on recordings
    - Implement specialized feature extractors and descriptors
    - Compare registration performance to baseline

Design of Image Feature Descriptor for Retinal Surgery



Design of Image Feature Descriptor for Retinal Surgery

- **Size group:** 2
- **Skills:**
  - *Required:* image processing, C++
  - *Ideally:* computer vision, OpenCV
- **Mentors:**
  - Balazs Vagvolgyi (balazs.vagvolgyi@jhu.edu)
  - Rogerio Richa (ask Balazs for contact info)

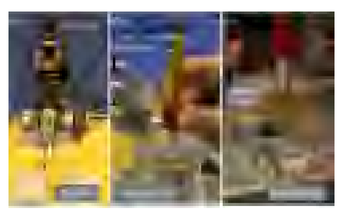
Force feedback of dual force sensing instrument for retinal microsurgery

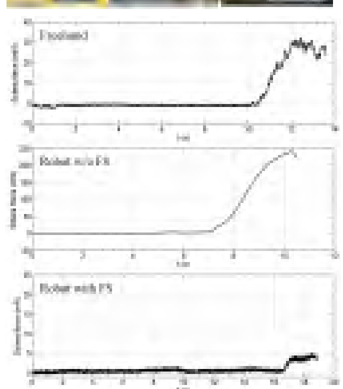
- Develop and assess different force feedback methods (auditory, haptic, etc.) for a dual force sensing instrument for retinal microsurgery
- **What Students Will Do:**
  - Develop force feedback methods
  - Use Eye Robot to provide haptic feedback
  - Design and carry out assessment experiments
  - Design and build phantom for the experiments
  - Evaluate experiment results
- **Deliverables:**
  - Report, data, code, and experiment results
- **Size group:** 1-3
- **Skills:** Programming (matlab, C/C++), prototyping
- **Mentors:** Xingchi He, Dr. Iulian Iordachita, Dr. Russell Taylor

Force feedback of dual force sensing instrument for retinal microsurgery (cont'd)

- 2×2 degree-of-freedom force sensor based on fiber Bragg grating
  - Instrument tip: interaction force between tool tip and tissue
  - Sclera section: interaction force between tool shaft and sclera
- Preliminary results with
  - auditory feedback based on tool tip force
  - haptic feedback with Eye Robot based on sclera force

  demonstrate significant reduction of forces at the tool tip and on the sclera.

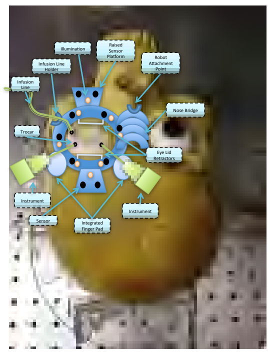


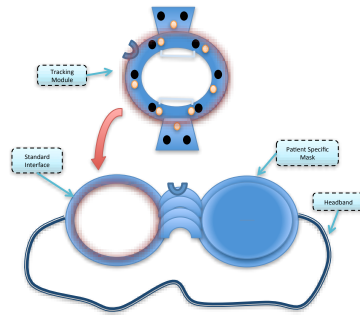


Prototype of a Micro-Surgical Tool Tracker

Need a way to track surgical instruments relative to the human anatomy.

Uses: Robot Assisted microsurgery and Surgical Skill Assessment.



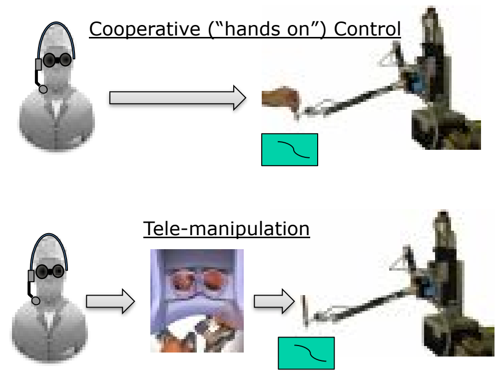


Teleoperation vs Cooperative Control - a comparative study in robot assisted microsurgery

- **What Students Will Do:**
  - Research computer tracking methods and technology
  - Design a scaled up version of the tracking system using existing off—the—shelf parts.
  - Demonstrate its function on a simulated scaled up environment.
- **Deliverables:**
  - Tracking System design and Computer Vision methodology
  - Scaled up phantom
  - Scaled up prototype
  - Report
- **Size group:** 2 or 3
- **Skills:** Computer Vision, Electro-Mechanical fabrication.
- **Mentors:**
  - Russell Taylor (rht@jhu.edu)
  - Marcin Balicki (marcin@jhu.edu)

Tele-manipulation vs Cooperative Control
A comparative study in robot assisted microsurgery

Which robotic paradigm provides more effective assistance in microsurgical manipulation?



References:

- M. Balicki, T. Xia, M. Y. Jung, A. Deguet, B. Vagvolgyi, P. Kazanzides, and R. Taylor, "**Prototyping a Hybrid Cooperative and Tele-robotic Surgical System for Retinal Microsurgery**," Insight Journal, pp. 1–10, 2011.
- Y. Noda, Y. Ida, S. Tanaka, T. Toyama, M. F. Roggia, Y. Tamaki, N. Sugita, M. Mitsuishi, and T. Ueta, "**Impact of Robotic Assistance on Precision of Vitreoretinal Surgical Procedures**," PloS one, vol. 8, no. 1, p. e54116, Jan. 2013.

Teleoperation vs Cooperative Control - a comparative study in robot assisted microsurgery

- **What Students Will Do:**
  - Design a human subjects experiment comparing the two robotic approaches. This will require fabrication of phantoms, IRB approval, video processing, and possibly development of robot control algorithms.
- **Deliverables:**
  - Design experimental protocol
  - Design and build Phantom
  - Human Subjects IRB
  - Run Experiments and write a paper.
- **Size group:** 1 or 2
- **Skills:** Mechanical fabrication, statistics. Optional: computer vision, robot control methods, c++.
- **Mentors:**
  - Marcin Balicki (marcin@jhu.edu)
  - Russell Taylor (rht@jhu.edu)
  - Iulian Iordachita (iordachita@jhu.edu)

CIS-2 Projects
Siewerdsen (jhu.edu/istar)

Siewerdsen et al.

Siemens Healthcare

Fahrig et al.

C-Arms for Intraoperative 3D Imaging ("Cone-Beam CT")

CIS-2 Projects
Siewerdsen (jhu.edu/istar)

C-Arms for Intraoperative 3D Imaging ("Cone-Beam CT")

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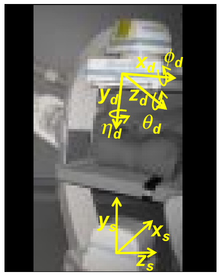
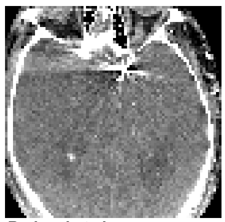


PROJECT #1:
Automatic Determination of System Geometry for 3D C-Arm Imaging



Radvani et al.

PROJECT #2:
Metal Artifact Removal in C-Arm Cone-Beam CT

Automatic Determination of System Geometry for Advanced 3D C-Arm Imaging

3D Imaging in the Operating Room
C-arm cone-beam CT provides 3D images in the OR for guidance / visualization during surgery.

Conventional C-arms are limited to a circular orbit about the patient.

New **robotic C-arms enable non-circular trajectories** that could improve image quality and reduce dose.

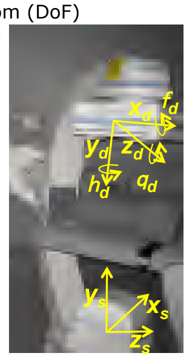
The Challenge
High-quality 3D image reconstruction requires that **the geometry ("pose") of the x-ray source and detector be known for each projection**.

It is difficult to calibrate the C-arm such that the geometry is known and reproducible for every possible pose of the robot.

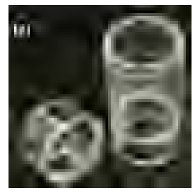
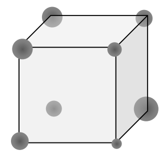
Project Proposal
Develop and test a method by which the imaging **geometry can be automatically determined** from each projection acquired in dynamically controlled, non-circular C-arm trajectories.

Automatic Determination of System Geometry for Advanced 3D C-Arm Imaging

System Geometry
9 degrees of freedom (DoF)
Detector Location
(x_d, y_d, z_d)
Detector Rotation
(h_d, q_d, f_d)
Source Location
(x_s, y_s, z_s)



Possible Phantom Designs
Exactly-known arrangement of radiographic markers


Cho et al. Med Phys (2005) Jain et al. Med Phys (2005)

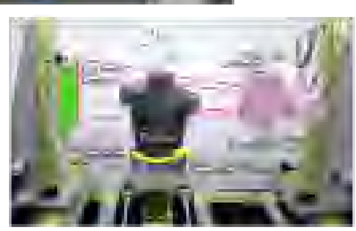
Algorithm for 3D-2D Registration
Solves for the relationship between
an object in the 3D (world) domain
and the 2D (projection) domain
Image–based or Feature-based
Forward-projector on GPU
Similarity function: GI
Optimizer: CMA-ES

Otake et al. Phys Med Biol (2012)

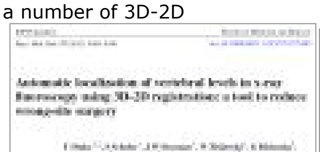
Automatic Determination of System Geometry for Advanced 3D C-Arm Imaging

Project Resources:
3D Imaging Systems
Zeego (JHH– Int. Radiology)

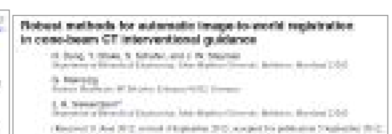
Cone-Beam CT Imaging Bench
I-STAR Lab (Traylor Building)



3D-2D Registration Software
Previously developed for a number of 3D-2D registration applications:



Automatic localization of vertebral levels in x-ray fluoroscopy using 3D-2D registration: a tool to reduce wrong-site surgery



Robust methods for automatic image-to-world registration in cone-beam CT interventional guidance

Building towards an Intelligent ICU: *Fine-grained event detection*

There are many fine-grained patient-centered events in an ICU.

(Eg. Suctioning, accessing central line tubes, Monitoring ventilation tube)

Task: Develop a vision system that can detect when events are occurring around these areas of interest.

Group size: 1-3

Programming Skills: Python+NumPy, Matlab, or C++ (w/ OpenCV)

Knowledge: Vision required, Machine learning recommended

Mentors: Dr. Suchi Saria, Colin Lea

Building towards an Intelligent ICU: *Mobility Assessment*

There is limited data quantifying patient movement. This is important for evaluating the condition of one's health and for testing new sedation methods.

Task: Develop a vision system that can quantify when and how much patients are moving.

Group size: 1-3

Programming Skills: Python+NumPy, Matlab, or C++ (w/ OpenCV)

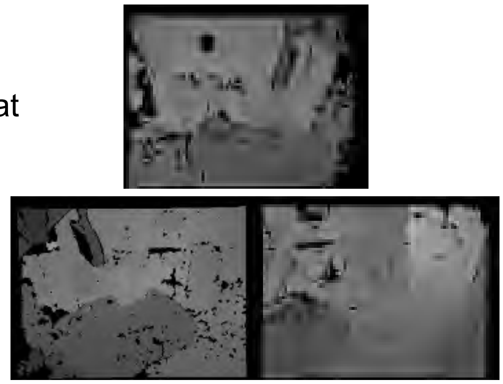
Knowledge: Vision required, Machine learning recommended

Mentors: Dr. Suchi Saria, Colin Lea

Building towards an Intelligent ICU:
Multi-User Tracking

Knowing the position and orientation of users in the ICU is important for classifying what actions are taking place.

Task: Develop a set of algorithms that tracks multiple users over time using multiple 3D sensors.



Group size: 1-3

Programming Skills: Python+NumPy, Matlab, or C++ (w/ OpenCV)

Knowledge: Vision required; CIS1, Robotics, or ML recommended

Mentors: Dr. Suchi Saria, Colin Lea

Building towards an Intelligent ICU:
Scene Analysis

Performing situational awareness requires knowledge of objects in the room like medicine cabinets, computers, monitors, and the patients bed.

Task: Develop a set of algorithms that recognizes medium-scale objects in a room.

Group size: 1-3

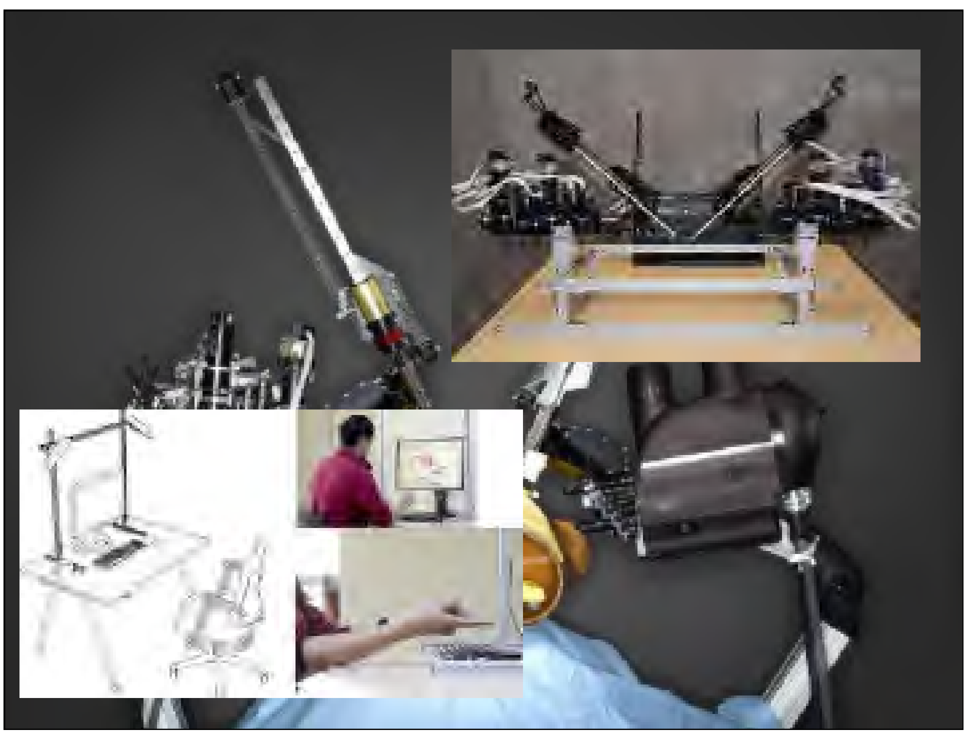
Programming Skills: Python+NumPy, Matlab, or C++ (w/ OpenCV)

Knowledge: Vision required, Machine learning recommended

Mentors: Dr. Suchi Saria, Colin Lea

Hand Gesture Interface for the Raven Robot

- ***Use a hand gesture interface to control the Raven Surgical Robotic System***
- **Students will:**
  - Develop or use a hand tracking system to provide Cartesian control frames to the raven robot
  - Develop software which can communicate with the Raven. This software will probably use CISST and ROS
  - Write control software to command the Raven robot position and orientation
  - Develop a simple, accessible user interface for using the robot with gestures.
- **Deliverables:**
  - Software for hand tracking, either using existing libraries, or new code
  - Software for interfacing with the Raven robot, using either CISST or ROS frameworks. (or both)
  - Control software for commanding the Raven robot
- **Size group:** 2-3
- **Skills:** Programming in C++ !!!, user interface design
- **Mentors:** Kelleher Guerin, Anton Deguet



Evaluation of Dynamic Tracking Accuracy of Surgical Tracking Systems

- **Goal:** To investigate the dynamic tracking performance of commercial surgical trackers, such as optical trackers and electromagnetic trackers.
- **What Students Will Do:**
  - Devise experiments to evaluate dynamic tracking accuracy (3-axis Cartesian robot is available)
  - Develop test software and integrate with different tracking systems
  - Perform experiments with different velocities and accelerations
  - Analyze the collected data to evaluate tracking performance
- **Deliverables:** : Code, experiments, results and analyses
- **Size group:** 2-3 students
- **Skills:** C++, MATLAB or some other math tool
- **Mentors:** Peter Kazanzides, Tutkun Sen

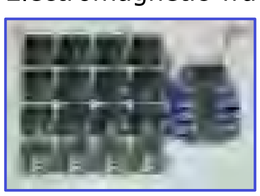
Evaluation of Dynamic Tracking Accuracy of Surgical Tracking Systems

- **Some systems that can be evaluated:**

- NDI Aurora:
  - Electromagnetic Tracker

- Claron Micron:
  - Optical Tracker

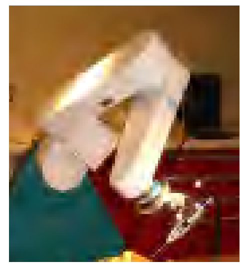
- Coil Array:
  - Electromagnetic Tracker



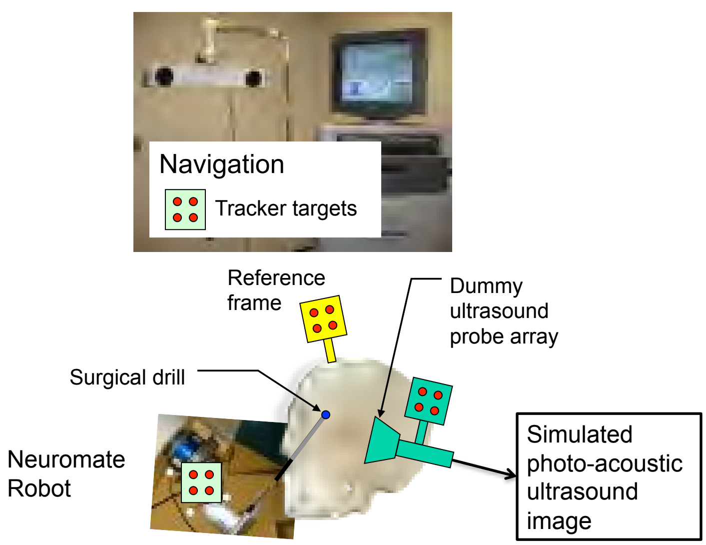
- Polaris:
  - Optical Tracker

Guidance for Skullbase Surgery

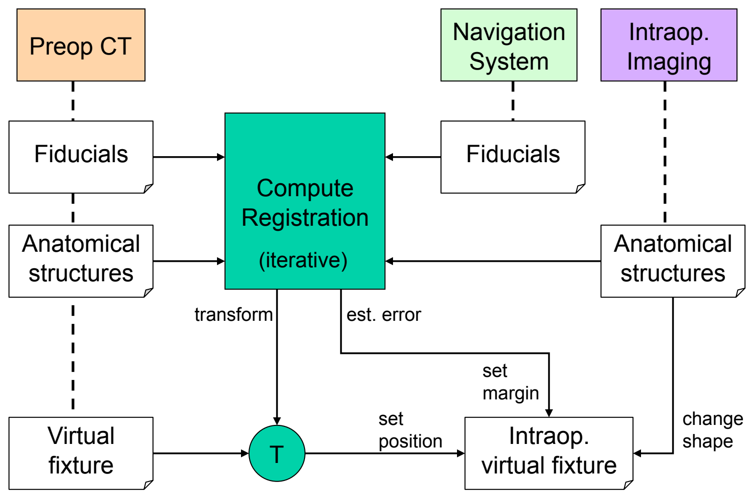
- Develop framework to incorporate real-time image guidance during skull base surgery.
- **What Students Will Do:**
  - Create phantom of skull with carotid artery
  - Create simulated photo-acoustic image based on tracked location of tool wrt. anatomy
  - Use anatomical features to iteratively improve registration between CT and robot
- **Deliverables:**
  - Phantom
  - Software
  - Documentation: design, validation results
- **Size group:** 2-3
- **Skills:** C++, experimentation skills
- **Mentors:** Peter Kazanzides, Muyinatu Bell



System Diagram



Iterative Registration Framework



Augmented Reality Goggles for Surgery

- Enhance augmented reality goggles for surgical navigation
- **What Students Will Do (some of):**
  - Better hardware integration and calibration
  - Integrate inertial sensing (sensor fusion)
  - Add zoom capability (LCD shutter glass)
  - Improved registration procedure:
    - Automatic or semi-automatic recognition of fiducials
    - Voice interface and/or gesture recognition
- **Deliverables:**
  - Software
  - Hardware, including calibration targets
  - Documentation: design, validation results
- **Size group:** 1-3
- **Skills:** C++, mechanical design, hardware integration, computer vision
- **Mentors:** Peter Kazanzides, Jayfus Doswell (Juxtopia)

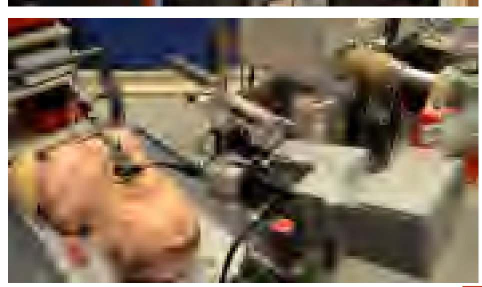
Project Ideas Carried Over from 2012

- Some of these may still be worth perusing

A Robotic Assistant for Trans-Oral Surgery: The Robotic Endo-Laryngeal Flexible (Robo-ELF) Scope

K. Olds, A. Hillel, E. Cha, J. Kriss, A. Nair, L. Akst, J. Richmon, R. Taylor

- **Goals**
  - Develop clinically usable robot for manipulating flexible endoscope in throat and airways
  - Permit bimanual surgery
  - Manipulation of ablation catheter
- **Approach**
  - Simple hardware for manipulating unmodified flexible scope
  - Simple joystick control
  - Platform for image guidance
- **Status**
  - In process of obtaining IRB approval for clinical use



Robo-ELF Vision Guidance/GUI(Summary)

This project involves designing and building a new Graphical User Interface for the Robotic EndoLarygneal Flexible Scope (Robo-ELF Scope) system, and integrating existing vision-based guidance software into the system.

- **Goals:** to create a new graphical user interface for the Robo-ELF using vision-based, point-and-click guidance, possibly utilizing an Apple iPad
- **Significance:** the current GUI is not useful to the surgeon, and the joystick control method is not intuitive or optimal
- **Background:** The Robo-ELF system manipulates a standard flexible endoscope for use in laryngeal surgery. The system lacks a useful GUI, and surgeons have expressed interest in a vision-based, point-and-click, guidance method. Some code exists for implementing vision-based guidance, but it is not fully tested or integrated with the robot

Mentors: Kevin Olds, John Kriss, Dr.Jeremy Richmon, Prof. Taylor

65 600.446; Spring 2013

Engineering Research Center for Computer Integrated Surgical Systems and Technology

Robo-ELF Vision Guidance/GUI(Key technical idea)

The Robo-ELF system controls three degrees of freedom of a flexible endoscope: insertion-extraction, rotation about its axis, and tip manipulation. The current joystick system maps these movements to two standard joysticks. The optimal control method, as expressed by surgeons, would be point-and-click control on the video feed from the endoscope. This can be implemented on an iPad, providing one-touch control to the surgeon. A GUI could give the surgeon quick access to pre-operative images, or other useful features.

Existing control levers

Video feed with marked target position

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Robo-ELF Vision Guidance/GUI (Aims & Significance)

- **Specific Aims**

  Create a useful GUI for the Robo-ELF that:

  1. Provides point-and-click, one touch, control of the system
  2. Provides useful information and features to the surgeon
  3. Can operate the robot from an iPad or a desktop PC

- **Significance**
  - The current GUI provides no useful information to the surgeon, and the current joystick control method is unintuitive and disliked by surgeons. A useful GUI and simple control method would greatly benefit users of the system, which is currently undergoing FDA approval for clinical trials

Robo-ELF Vision Guidance/GUI (Background)

- **Background**
  - The Robo-ELF system is quickly approaching real clinical use, but lacks a satisfying user input device and a useful GUI. The system is capable of much more than it currently provides.
- **Preliminary Results**
  - Previous user interface devices
    - 3D space navigator mouse/Custom joystick
      - Overly simplistic control
      - Unintuitive for surgeons
    - Development/Debugging GUI
      - Provides limited information about robot status
      - Not useful to the surgeon
  - Existing code for point-and-click navigation
    - Written by Hongho Kim during summer 2011
    - Computes required robot position from mouse clicks in video window
    - Not tested or integrated with overall system

Robo-ELF Vision Guidance/GUI(Approach)

- Skills needed
  - Strong programming background in C++/Qt/cisst
  - Basic understanding of computer vision techniques
- Deliverables
  - Working point-and-click navigation of the Robo-ELF system
  - Robust GUI that provides functions requested by surgeons
- The Robo-ELF system is fully functioning in the Hackerman Hall lab, and the project is ready to begin immediately

Robo-ELF Joystick (Summary)

Mentors: Kevin Olds, John Kriss

This project involves designing and building a new user interface system for the Robotic EndoLarygneal Flexible Scope (Robo-ELF Scope) system.

- **Goals:** to build a new user interface system for the Robo-ELF
- **Significance:** the current joystick system is an overly simplified prototype and is not optimal for mainstream surgical use
- **Background:** The Robo-ELF system manipulates a standard flexible endoscope for use in laryngeal surgery. The system is currently controlled by a simple joystick system, but surgeons have found it unintuitive and difficult to use.
- **Project Scope:**
  - Project duration: 1 term
  - number of people: 1-3
  - budget requirements, $100-$500
  - **Possible Funding Sources:** covered by Otolaryngology budget

Robo-ELF Joystick (Key technical idea)

The Robo-ELF system controls three degrees of freedom of a flexible endoscope: insertion-extraction, rotation about its axis, and tip manipulation. The current joystick system maps these movements to two standard joysticks. Surgeons would prefer a system which is easily controlled by one had, is very easy to clean, and has safety features to prevent unintended movements.

Robo-ELF Joystick (Aims & Significance)

- **Specific Aims**

  Build a joystick system for the Robo-ELF that:
  1. Can be intuitively and easily controlled by one hand
  2. Can be easily cleaned/sterilized
  3. Intuitively maps to the degrees of freedom of the endoscope itself
  4. Has safety features to prevent unintended movements
- **Significance**
  – The Robo-ELF system is currently going through FDA and JHMI clinical engineering review, so it is likely that a mainstream clinically usable controller will be needed in the near future. The current joystick, though meeting basic requirements, is clearly not adequate for the final version of the system.

Robo-ELF Joystick (Background)

- **Background**
  - The Robo-ELF system is quickly approaching real clinical use, but lacks a satisfying user input device. The input devices used so far have been simplistic prototypes and lack the design optimization needed.
- **Preliminary Results**
  - Previous user input devices
    - 3D space navigator mouse
      - Difficult to control
      - Not designed for medical uses
    - Custom joystick system
      - Usable in medical applications
      - Overly simplistic control
      - Unintuitive for surgeons
  - Some data gathered about surgeon preferences for user interfaces with this system

Robo-ELF Joystick (Approach)

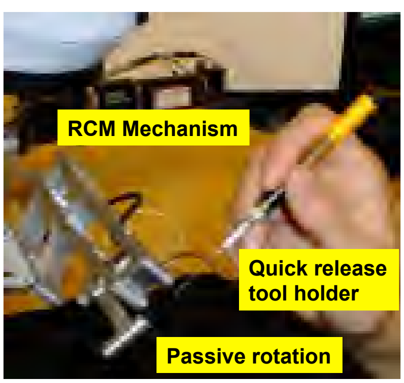
- Skills needed
  - Basic electronics design and build skills
  - Mechanical design and fabrication skills
  - A group with one member specializing in electronics and the other in mechanics would be ideal
- Deliverables
  - By the end of the term, a functioning user input device should be designed, built, documented, integrated, and tested with the Robo-ELF
- The Robo-ELF system is fully functioning in the Hackerman Hall lab, and the project is ready to begin immediately

Voice Control for RoboELF Laryngology Snake Robot

- Implement a voice control interface to an existing teleoperated robot for manipulating a laryngosocpe
- **What Students Will Do:**
  - Define a suite of voice commands
  - Develop C++ code to control the robot using voice commands (will use CISST libraries and voice command framework developed by CIS lab)
  - May help with further development of voice command framework
- **Deliverables**
  - Documentation of voice command protocol
  - C++ code and documentation of software application for voice control
- **Size group:** (1-2)
- **Skills:** programming in C++, user-oriented product development
- **Mentors:** Kevin Olds, Dr Taylor

JHU Steady Hand "Eye Robot"

Russell Taylor, Iulian Iordachita, D. Gierlach, D. Roppenocker, *et al.*



- Highly precise robot
- Hands-on cooperative control or teleoperation
- Several generations in lab

- Precise, stable platform for developing "smart" surgical instruments and sensors
- Virtual fixtures and advanced control

Visual Servoing for Robot Assisted Cannulation

- **Goal:** Develop a cooperative robot control algorithm to assist in inserting a pipette in a retinal vain for drug delivery
- **What Students Will Do:** Combine computer vision with already developed tools to create robot behaviors that help cannulation and also assist in maintain the cannulation for a few minutes.
- **Deliverables:**
  - **Minimum:** Phantom; Vision processing; Design of behaviors
  - **Expected:** Working system to achieve alignment with simulated cannula and phantom
  - **Maximum:** Demonstration on chicken embryo
  - **Beyond:** Subject experiments to compare the system with conventional freehand cannulation (over summer).
- **Dependencies:** Access to microscope & robot, access to real cannulas, insertion tool & chick embryo phantom
- **Size group:** 1 or 2
- **Skills:** Robotics, Computer Vision, Matlab, C++ Programming, Python programming, Some fabrication skills
- **Mentors:** Marcin Balicki, Dr. Iordachita, Prof. Taylor

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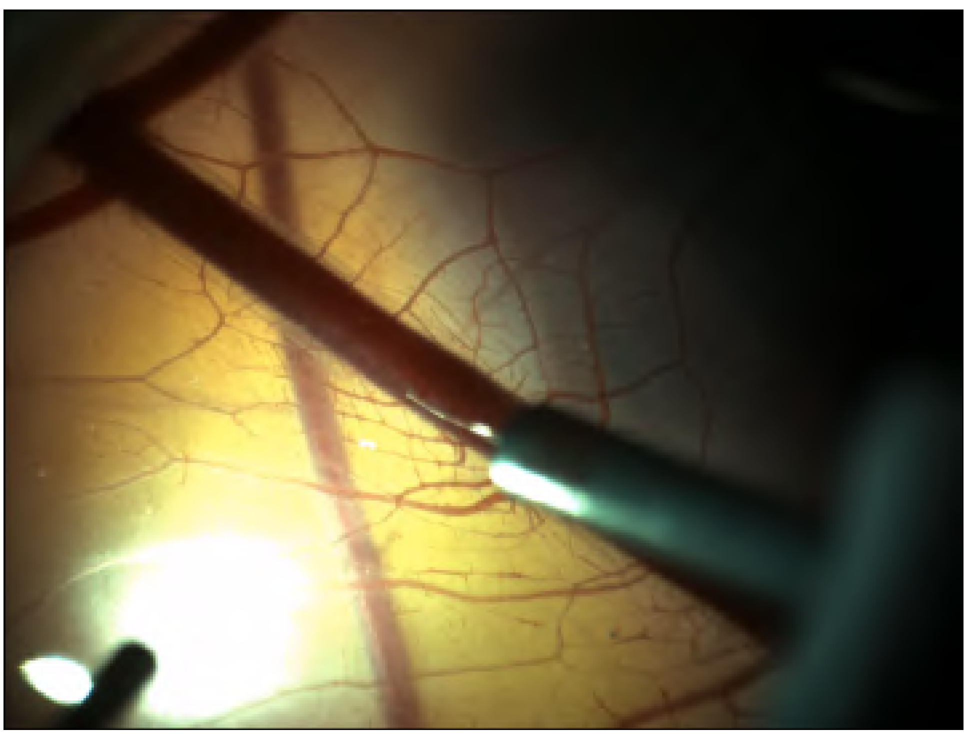


Assessment of Intra-operative OCT Imaging in a Simulated Microsurgical Task

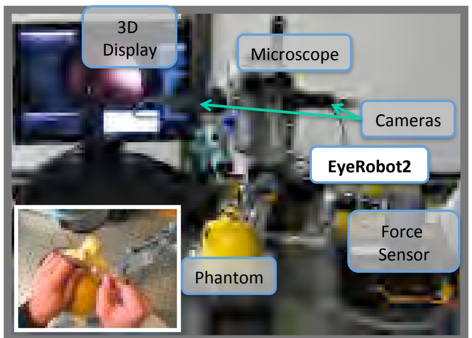
- **Goal:** Assess the efficacy of intra-ocular OCT imaging in simulated epiretinal membrane peeling task.
- **What Students Will Do:** Experiment design, phantom development, IRB approval for subject experiments, conducting the subject experiments, data analysis.
- **Deliverables:**
  - **Minimum:** Phantoms, experimental protocol, Approved protocol
  - **Expected:** Completed study, report
  - **Maximum:** Paper
- **Dependencies:** OCT, Access to surgical workstation
- **Size group:** 1 or 2
- **Skills:** Statistics, Mechanical Fabrication
- **Mentors:** Marcin Balicki, Prof. Taylor, Prof. Kang

Miniature rotary encoder for Microsurgical Robot

- **Goal:** Create a very small rotary encoder that is integrated into the tool holder of our "Eye Robot".
- **What Students Will Do:**
  - Engineering design and build
  - Extend work of a visiting MS student from last summer
- **Deliverables:** short description or bullets
  - Minimum: complete design
  - Expected: fabricated prototype with bench verification
  - Maximum: integrated demo on robot
- **Size group:** 1-2
- **Skills:** Electromechanical Design and Prototyping, C++ Programming.
- **Mentors:** Marcin Balicki, Dr. Iulian Iordachita

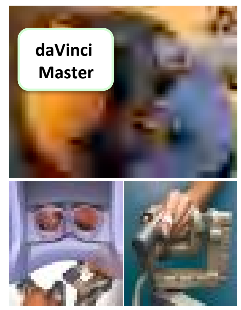
Cooperative Teleoperation with DaVinci / EyeRobots

- **Goal**: To create a bimanual surgical system that integrates cooperative control **and** teleoperation for micro-manipulation using existing EyeRobots and DaVinci surgical console.
- **Significance**
  - Combines the benefits of both control methods.
  - Teleoperation allows motion scaling
  - Virtual Fixtures with smart surgical instruments
  - Hand-over-hand training

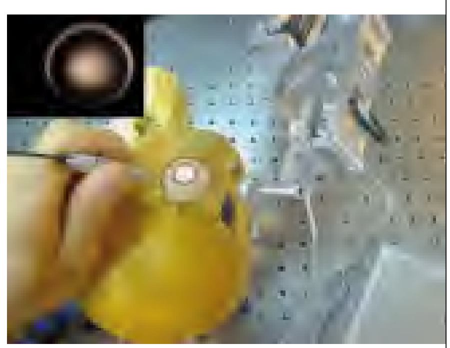


Video/
Sensor
Data

Position
Exchange

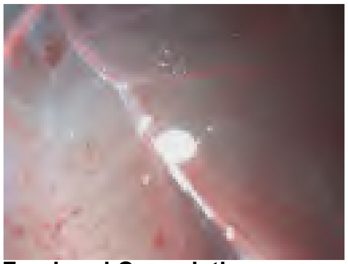


Cooperative Teleoperation with DaVinci / EyeRobots

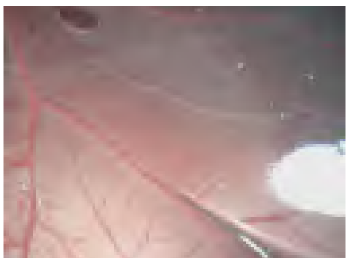


- **Background**
  - Basic proof-of-concept done.
- **Project Scope**
  - 1 - 2 Semesters (1-2 people)
  - Minimal budget requirements.
- **Funding**
  - NIH/NSF?
- **Details**
  - Work with eyeBRP team to update the slave manipulators
  - Improve user experience (visualization and system controls, pedal inputs, voice, etc?)
  - Explore classic and sensor based Virtual Fixtures
  - Run subject experiments to compare interaction modes
- **Deliverables:** code, demos, experimental results
- **Skills:** C++, CISST, Robot Control & Design

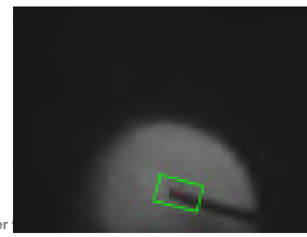
Visual Servoing for Robot Assisted Cannulation



Freehand Cannulation



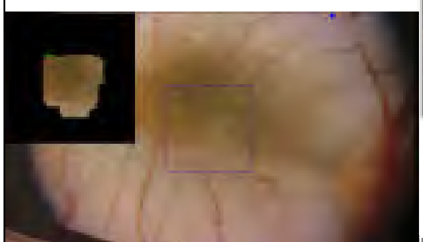
Robot Assisted Cannulation

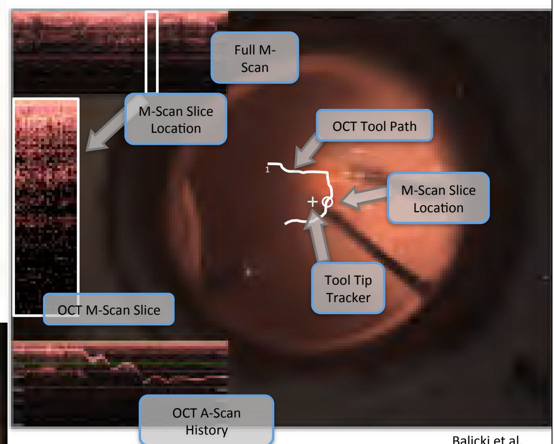


Assessment of Intra-operative OCT Imaging in a Simulated Micro-surgical task

- **Goal:** Assess the efficacy of intra-ocular OCT imaging in simulated epiretinal membrane peeling task. Tasks involve experiment design, phantom development, IRB approval for subject experiments, conducting the subject experiments, data analysis.
- **Motivation:** We have developed a diagnostics and visualization system for Vitreoretinal surgery. It allows a high-resolution, intra-ocular imaging of retinal, and sub-retinal structures simultaneously annotating the location of such scans on the stereo-video stream. The hypothesis is that such technology can assist surgeons in locating ideal areas for initiating membrane peeling. Currently, this is done by visual inspection, trial and error, and/or by interpreting preoperative images. We would like to determine if our intraocular imaging system is effective in aiding surgeons in locating an edge of a membrane.
- **Mentor(s):** Marcin Balicki
- **Skill/Background Assumed:** Stats, Mechanical Fabrication, C++ helpful
- **Related CiiS Research:** https://ciis.lcsr.jhu.edu/dokuwiki/doku.php?id=research.optical_sensing_instruments

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





Balicki et al.