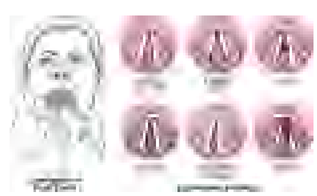
Human Subjects Study for the Robo-ELF Scope Robotic Endoscope Manipulation System

- Work closely with clinical collaborator to evaluate robotic endoscope manipulation system in 20 human subjects.
- **What Students Will Do:**
  - Get training for human subjects studies
  - Get training for work in OR
  - Train in how to use the Robo-ELF Scope system
  - Work with clinical collaborator in the OR to run the system
  - Assist in collecting and analyzing data about system performance
  - Get feedback from clinicians and OR staff about the system
- **Deliverables:**
  - Report detailing system performance and feedback
- **Size group:** 1-2
- **Skills:**
  - Basic mechanical and computer skills
  - Strong organizational and planning skills
- **Mentors:** Kevin Olds kolds1@jhu.edu

Development of a Phantom for Surgical Training and Evaluation in the Vocal Cords

- Work closely with clinical collaborators to develop a realistic training phantom to simulate vocal cord pathology.
- **What Students Will Do:**
  - Work closely with clinical collaborator to determine specifications
  - Develop phantom
  - Evaluate phantom with clinical collaborator
  - Document phantom and results
- **Deliverables:**
  - Functional vocal cord pathology phantom
  - Documentation of how to make phantom and its evaluation
- **Size group:** 1-2
- **Skills:**
  - Basic wet lab experience
  - Basic mechanical experience
- **Mentors:** Kevin Olds kolds1@jhu.edu



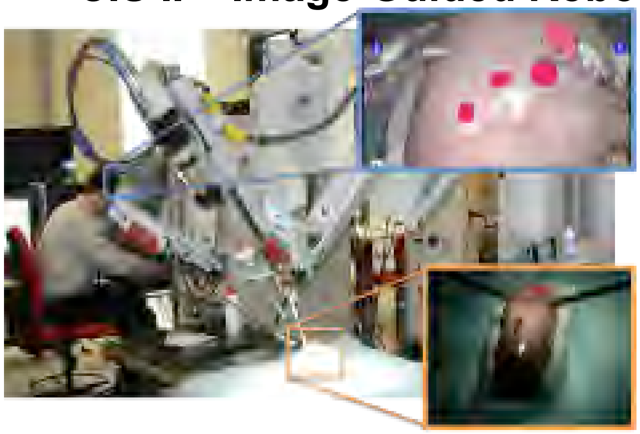
Mobile Device Camera Connector for Flexible Laryngoscopy

- Work closely with clinical collaborator to develop mobile interface for diagnostic flexible endoscopes.
- **What Students Will Do:**
  - Discuss requirements with clinical collaborator
  - Design solution
  - Program Android interface
  - Purchase and fabricate parts
  - Test in phantom
- **Deliverables:**
  - Completed system with documentation
- **Size group:** 2-3
- **Skills:**
  - Android/Java programming
  - Basic mechanical design and fabrication
  - Knowledge of cameras and video processing
- **Mentors:** Kevin Olds kolds1@jhu.edu

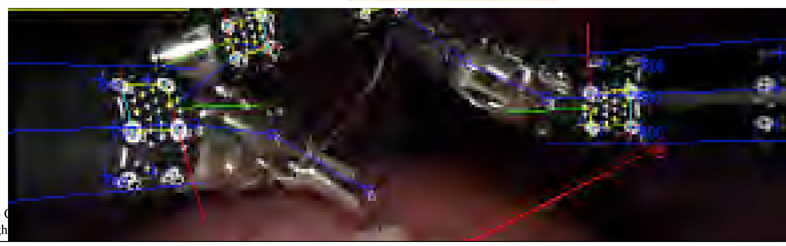
Surgical Instrument for Robotic Open Microsurgery

- Work closely with clinical collaborator to develop novel surgical instruments for robotic vein suturing.
- **What Students Will Do:**
  - Discuss requirements with clinical collaborator
  - Design solution
  - Fabricate solution
  - Test solution in simple model
  - Iterate design until satisfactory
  - Test in phantom
- **Deliverables:**
  - Completed instrument
  - Documentation
- **Size group:** 1-2
- **Skills:**
  - CAD/CAM
  - Machine shop experience
  - Design experience
- **Mentors:** Kevin Olds kolds1@jhu.edu

CIS II – Image-Guided Robotic Surgery



Q: How do we achieve reliable intraoperative tissue & relative tool tracking?



CIS II – Image-Guided Robotic Surgery

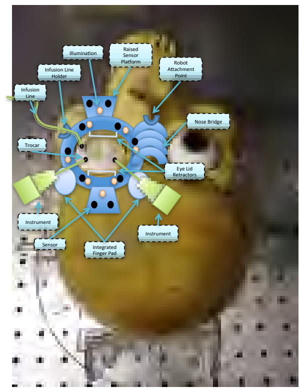
- What Students Will do:
  – Improve vision-based intraoperative tracking of a rigid fiducial
  – Improve vision-based marker tracking for daVinci tools

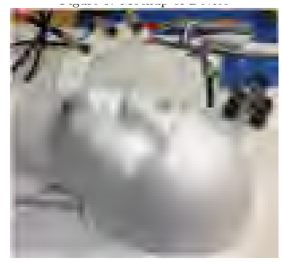
- Deliverables:
  – Design new fiducial & markers
  – Updated tracking software
  – da Vinci demo
  – Quantitative analysis of improvement
- Group size: 1-2
- Skills: Programming (C++), computer vision
- Mentors: Wen P. Liu, wen.p.liu@jhu.edu, Anton Deguet

Prototype of a Micro-Surgical Tool Tracker

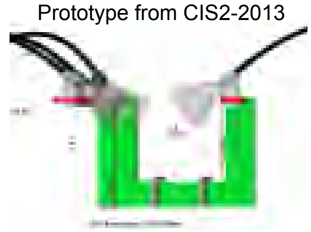
Need a way to track surgical instruments relative to the human anatomy.

Uses: Robot Assisted microsurgery and Surgical Skill Assessment.





Prototype from CIS2-2013

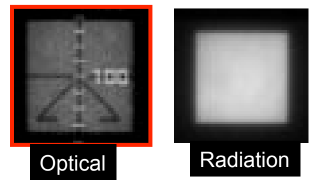


Teleoperation vs Cooperative Control - a comparative study in robot assisted microsurgery

- **What Students Will Do:**
  - Research computer tracking methods and miniature camera technology
  - Refine an existing prototype of a 4-camera tracking system
  - Demonstrate its function on a simulated environment
- **Deliverables:**
  - Computer Vision methodology for calibration and tracking of instruments
  - Miniaturization of the existing 4-camera tracking system
  - Implement the tool tracking algorithm for real-time execution
  - Validation of tracking accuracy
  - Report
- **Size group:** 2 or 3
- **Skills:** Computer Vision, Electro-Mechanical fabrication.
- **Mentors:**
  - Russell Taylor (rht@jhu.edu)
  - Marcin Balicki (marcin@jhu.edu)

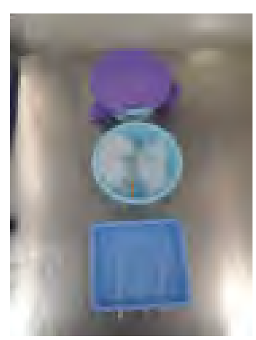
Robotic Controlled Radiation Therapy QA System for unified optical and radiation measurements

- Work closely with clinical collaborator to develop novel quality assurance system.
- **What Students Will Do:**
  - Discuss requirements with clinical collaborator
  - Design solution for motorized stage
  - Test solution in the existing QA system
  - Iterate design until satisfactory
  - In field test
- **Deliverables:**
  - Completed instrument
  - Documentation
- **Size group:** 1-3
- **Skills:**
  - Design experience
  - Data analysis (R, Matlab)
  - Programming experience (C++)
- **Mentors:** John Wong jwong35@jhmi.edu



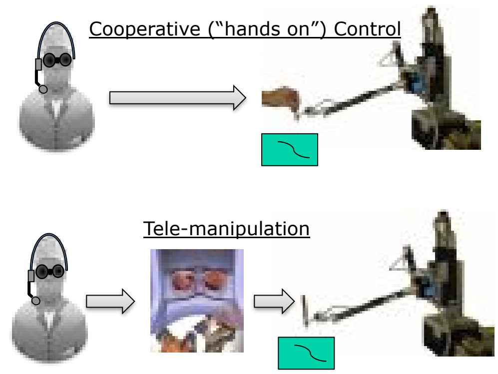
Development of a comprehensive dissection and energy-cutting model for robotic surgery training

- To create an inanimate surgical training model for sharp and blunt dissection and blood vessel energy-cutting
- **What Students Will Do:**
  - Work closely with robotic surgery educators in Surgery
  - Search for phantom material for realistic recreation of human tissue
  - Search for tubing material for blood vessel which can be coagulated and cut
  - Create a dissection and energy model
  - Test the model during actual training
  - Document the results and user feedback
- **Deliverables:**
  - A comprehensive dissection and energy-cutting training model
- **Size group:** 1-2
- **Skills:** basic lab experience
- **Mentors:** Drs. Gyusung and Mija Lee (glee49@jhmi.edu, mlee204@jhmi.edu)



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

Which robotic paradigm provides more effective assistance in microsurgical manipulation?



References:

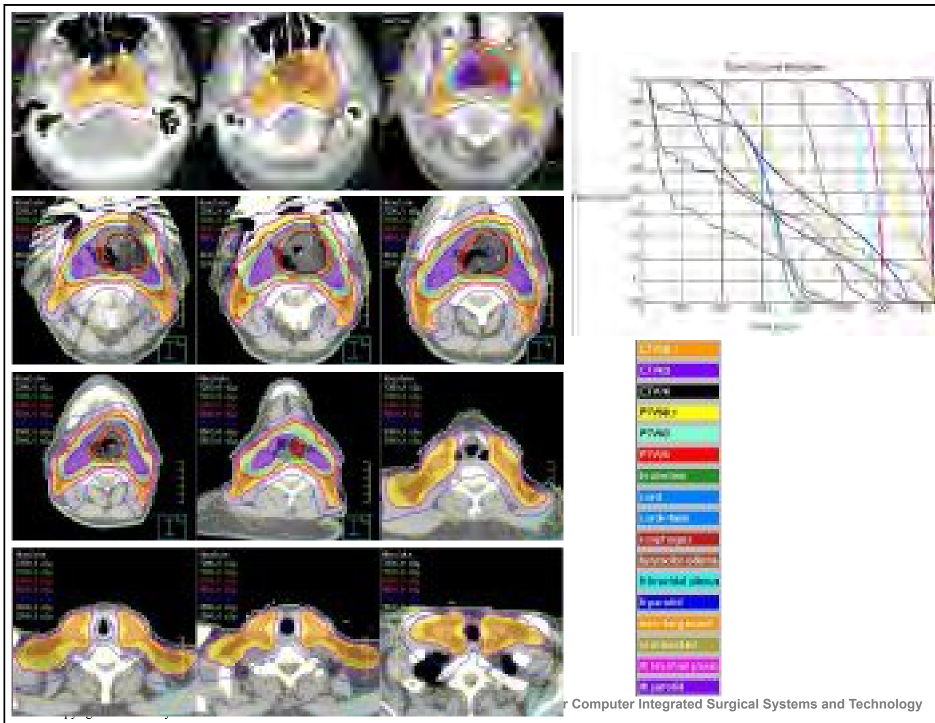
- M. Balicki, T. Xia, M. Y. Jung, A. Deguet, B. Vagvolgyi, P. Kazanzides, and R. Taylor, "**Prototyping a Hybrid Cooperative and Tele-robotic Surgical System for Retinal Microsurgery**," Insight Journal, pp. 1–10, 2011.
- Y. Noda, Y. Ida, S. Tanaka, T. Toyama, M. F. Roggia, Y. Tamaki, N. Sugita, M. Mitsuishi, 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)
  - Iulian Iordachita (iordachita@jhu.edu)
  - Xingchi He (xingchi.he@jhu.edu)
  - Russell Taylor (rht@jhu.edu)

Automatic Identification of Critical Organ Subregions for Refined Dose-Toxicity Analysis in Radiotherapy

- Design, implement, and evaluate an algorithm that advances the analysis of dose-toxicity relationships at the sub-organ level to identify specific portions of the organs that are more or less critical and sensitive to radiation damage.
- **What Students Will Do:**
  - Work with an existing database of over 500 oncology patients
  - Assist in algorithm development to search for subregion clusters to identify more specific locations of radiation induced toxicities
  - Evaluate the algorithm for xerostomia and dysphagia toxicities
  - Generalize the model to support any number or type of subregions for analysis of multiple disease sites and toxicities.
- **Deliverables:**
  - An algorithm and software platform for toxicity analysis in organ subregions
  - Toxicity models for xerostomia and dysphagia
- **Size group:** 1-3
- **Skills:**
  - Algorithm design
  - Programming experience (SQL, C, C#, python, or MATLAB preferred)
- **Mentors:** Todd McNutt (tmcnutt1@jhmi.edu), Scott Robertson (srober52@jhmi.edu)



Question?

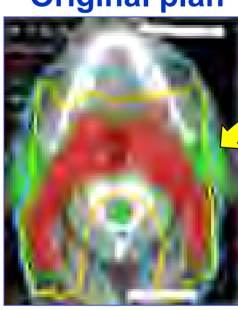
We currently assess our plan quality by evaluating the dose to the critical structures through dose volume histograms which fail to consider where the higher doses are within the critical structure. This project seeks to refine the analysis to help us understand what parts of the critical structures are more or less important.

Are there regions of a given structure that are more sensitive than others? Or are there combinations of regions that make a difference to overall function? Xerostomia may involve a combination of regions of submandibular and parotid and dysphagia involves several muscle groups that may compensate for one another.

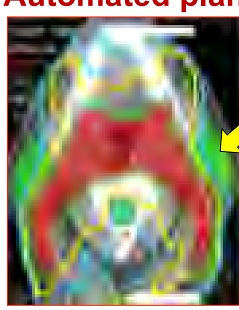
The project seeks to solve this with algorithms to explore the data to find region clusters that are associated with the toxicities.

Sample automated radiation planning result

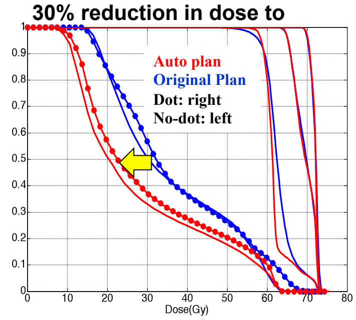
Original plan



Automated plan



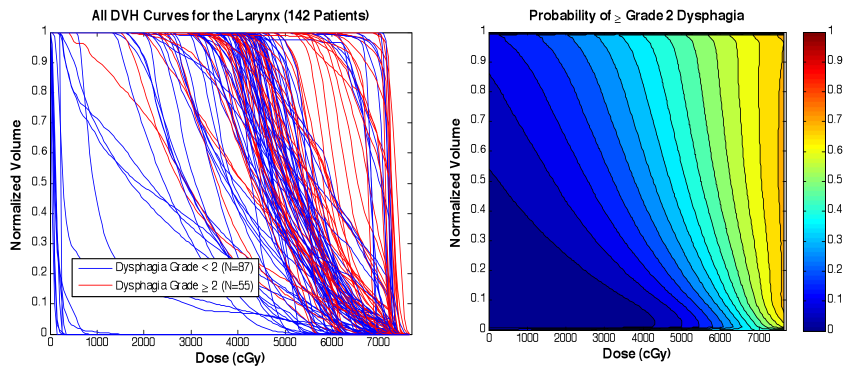
30% reduction in dose to



	brain (Gy) (max)	Brainstem (Gy) (max)	Cord4mm (Gy) (max)	L inner ear (Gy)(mean)
original	61.25	54.58	41.75	57.18
re-plan	56.33	46.48	37.89	43.72
	R inner ear (Gy) (mean)	**mandible (Gy) (max)**	**larynx for edema (V50)**	**esophagus (Gy)(max)**
original	40.57	66.58	61%	63.74
re-plan	38.38	63.78	59%	61

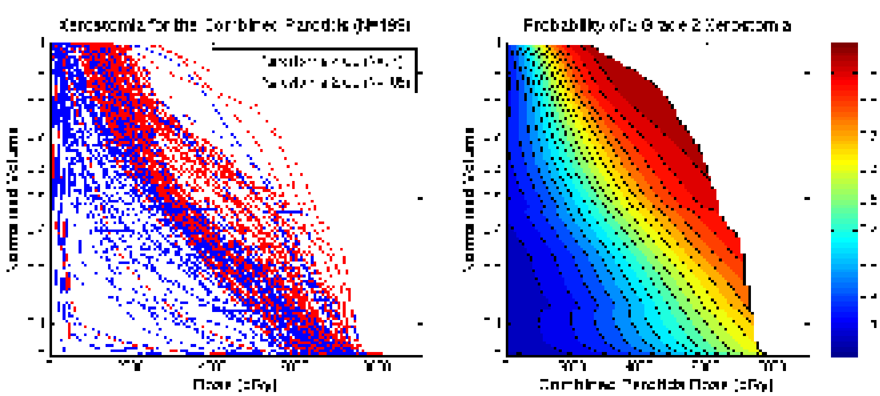
Probability of Toxicity with DVH

Larynx DVH vs Grade ≥ 2 Dysphagia



Probability of Toxicity with DVH

Parotids DVH vs Grade ≥ 2 Xerostomia



Evaluation of Dynamic Tracking Accuracy of Surgical Tracking Systems

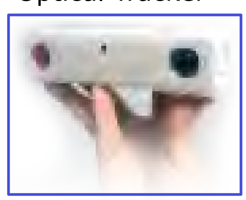
- **Goal:** To investigate the dynamic tracking performance of commercial surgical trackers, such as optical trackers and electromagnetic trackers.
- **What Students Will Do:**
  - Devise experiments to evaluate dynamic tracking accuracy (3-axis Cartesian robot is available)
  - Develop test software 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

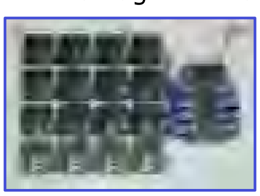
- **Some systems that can be evaluated:**

  - NDI Aurora:
    - Electromagnetic Tracker

  - Claron Micron:
    - Optical Tracker



  - Coil Array:
    - Electromagnetic Tracker



  - Polaris:
    - Optical Tracker

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Engineering Research Center for Computer Integrated Surgical Systems and Technology

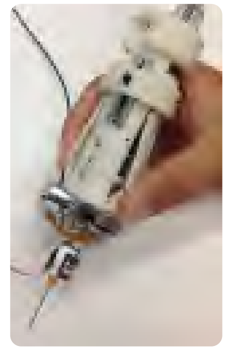
Evaluation of an Assistive Robotic System for Epiretinal Membrane Peeling

Challenges

- Non-uniform tissue properties
- Poor visualization
- Physiological hand tremor
- Fatigue
- Lack of force feedback

Goals

- Atraumatic membrane removal
- Minimized surgeon effort
- Maximized surgeon comfort
- Maximized patient safety



The Micron robotic system with integrated force-sensing tools aims to make retinal microsurgery safer and less invasive by actively cancelling out surgeons' hand tremor and limiting the applied forces to the retina to avoid complications.

In this project, we seek to **a)** design and conduct membrane peeling experiments with several subjects on chicken embryos **b)** develop software to evaluate the robotic system's performance with force feedback vs. the free-hand performance.

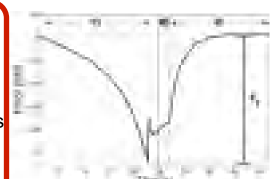
Skills: MATLAB, LabVIEW (Not required, but preferred), patience and good dexterity (The experiments involve very slow hand motion in a constrained and fragile environment. The current setup is good for right-handed subjects.)

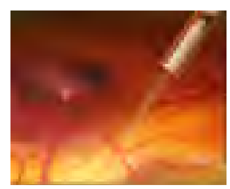
Need: 1-2 students **Mentors:** Berk Gonenc, Iulian Iordachita – bgonenc1@jhu.edu

Evaluation of an Assistive Robotic System for Retinal Vein Cannulation

Challenges

- Very small and fragile vessels
- Hard to see the thin glass pipette tip
- Fragile glass pipette tip
- Large incision required due to large glass pipette diameter.
- Physiological hand tremor



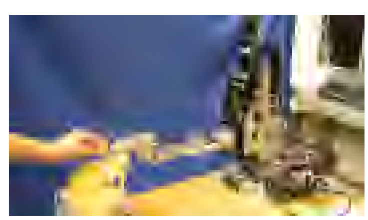


Source: Ergeneman, 201

Goals

- Use flexible titanium alloy needles – easier to see, do not easily break, and can fit through a small incision
- Use the Steady-Hand Robot – eliminate hand tremor
- Integrate force sensors to 1. measure typical cannulation forces with this robotic system.
  2. inform the operator when the cannula tip enters into the vessel.

In this project, we seek to
a) design and conduct vein cannulation experiments with several subjects on chicken embryos
b) evaluate the robotic system's performance with force feedback vs. the free-hand performance.



Skills: MATLAB, , C++ (Not required, but preferred), patience and good dexterity (The experiments involve very slow hand motion in a constrained and fragile environment.)

Need: 1-2 students **Mentors:** Berk Gonenc, Iulian Iordachita – bgonenc1@jhu.edu

Ultrasound Elastography with DaVinci

(Boctor, Billings, Taylor)

Human-robotic collaboration for in-vivo detection of tumors and monitoring of therapy

(Research DaVinci Application – Not for Human Use)

Ultrasound Elastography on DaVinci Robot

- **Goal:** Enhance ultrasound elastography capabilities on DaVinci robot, using either ISI DaVinci tool or drop-in probe
- **What Students Will Do:**
- **Deliverables:** short description or bullets
  -
- **Size group:** 1-2
- **Skills:** Computer Science, programming, image processing expertise
- **Mentors:** Names & contact info here

Apparatus and method for colon full biopsy

- Develop a device and a method for collecting tissue samples inside the colon. The biopsy sites should be uniformly distributed on the colon full surface.
- **What Students Will Do:**
  - Define the requirements for colon biopsy
  - Propose solutions for possible scenarios, analyze and classify them
  - Define and build a colon biopsy device (proof of concept)
  - Design and carry out assessment experiments
  - Evaluate experiment results
- **Deliverables:** prototype for colon biopsy device (manually actuated/motorized?) and method for colon full biopsy. Patent disclosures.
- **Size group:** 2 students
- **Skills:** mechatronics, mechanical design, prototyping
- **Mentors:** Dr. Florin Selaru, Dr. Iulian Iordachita, Dr. Peter Kazanzides, Dr. Russell Taylor

Project Title

- Summary phrase or short description (can follow with another 1-2 slides with more technical detail, if desire)
- **What Students Will Do:** short description or bullets
- **Deliverables:** short description or bullets
  -
- **Size group:** (no more than 3, if more split into sub projects)
- **Skills:** (short description or key phrases)
- **Mentors:** Names & <u>contact info </u>here

NOTE: You can follow with 1-3 additional slides for more info if desired or split this into 2 slides. Main point is that this is the info the students need