Robotic Endoscopic Tumor Ablation System

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Mentors: Kevin Olds, Dr. Russell Taylor
Sponsor: Dr. Jeremy Richmond
Motivation

• There are approximately 25,000 new cases of throat cancer every year in the US, resulting in approximately 6,000 deaths per year

• Radiation and chemotherapy have many undesirable side effects, especially in a sensitive and critical area like the throat

• Surgical approaches are often used to treat throat cancer
Surgical Techniques

- Types of surgical techniques in throat surgery:
  - Through incisions in the patient’s neck
  - Inside the airway using an endoscope and specialized surgical tools including a cutting laser
Pros and Cons of Intra-Airway

• Advantages of Intra-Airway
  – Less risk of infection
  – Less scarring
  – Smaller risk of complications (damaged vocal cord nerves, etc.)
  – Faster recovery time

• Disadvantages of Intra-Airway
  – Limited visibility
  – Limited working room
Current Intra-Airway Surgery at JHMI

• Minimum of 4 hands needed:
  – Laser and endoscope are separate instruments
  – Endoscope needs two hands to operate
  – 3rd grabbing instrument is needed
• Laser is rigid and cannot bend around corners
• Scope does not remain stationary when hands removed and is difficult to control accurately
• Result: working environment is crowded and awkward and visibility is poor
Problem

- Current methods for throat tumor removal require multiple surgeons, risky/expensive surgeries with general anesthesia, and unnecessarily long hospital stays
- Other devices are not specialized, too expensive or don’t have the functionality for a full system.
Goal

Design, build, and test a clinical quality prototype robotic throat tumor ablation system to aid in performing minimally invasive intra-airway surgery done potentially as an outpatient procedure under local or weak general anesthesia.

- Reduce number of hands needed
- Control all motion of endoscope
- Allow for use of one hand to control system leaving surgeon free to hold tool in other
- Have scope remain stationary with no hands
Solution

• Use a robotized endoscope with:
  – Single hand operation for laser/scope, leaving the other hand to use tissue manipulators
  – Built-in working channel for cutting laser
  – Precision movement
  – Laser and scope remain stationary when hands removed
  – Use pre-existing clinical endoscope and laser to minimize cost
Our Approach

• Design and build a 3 axis robotic assistance device
• Uses a laptop for surgeon to control system
Constraints and Design Issues

- Resistant to long term exposure to hospital grade cleaning agents
- Cannot contain any allergens or toxic materials
- Submersion proof
- Well grounded
- Should not have a lot of mass over the patient
- As few visible moving parts as possible
- Corrosion resistant seals
- All exposed metal parts must be stainless steel, aluminum, or plastic
- Robot must be able to resist bumps and minor abrasions
Prototype I
Hardware

• 3 servo brushed, coreless motors
• Integrated magnetic encoders
• Linear potentiometers for redundant sensing
• Galil Motion Controller (DMC-4030)
  – C++ Wrapper
  – Analog and Digital Inputs
  – Auto-tuning Control Loop
Software

• Utilizes CISST libraries
• Controls each axis of motion separately
• Contains software safety features and limits
• GUI
  – alternative way to move robot
  – adjust speed and other variables
  – visualization/debug feature
GUI
Prototype 2
Deliverables

• Minimum
  – Functioning system capable of performing mock operations with phantoms

• Expected
  – System capable of performing extensive cadaver experiments demonstrating functionality of system
  – User interface able to control and adjust system

• Maximum
  – Design and construction of a new input device
  – System able to pass clinical engineering standards
Testing Plan

• Clinical Engineering Standards (waterproof, grounded, chemical resistant, etc.)
• Phantom Evaluation
• Initial Cadaver Study
• Final Cadaver Study
# Dependencies

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Plan to Resolve</th>
<th>Resolve By</th>
<th>Affects</th>
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<tbody>
<tr>
<td>Cadavers Required</td>
<td>Have Surgeons Order</td>
<td>Resolved</td>
<td>Expected</td>
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<tr>
<td>Surgeon Feedback</td>
<td>Schedule Meeting</td>
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<td>Minimum</td>
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<td>New Space Mouse</td>
<td>Order new mouse</td>
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<td>Mechanical Work</td>
<td>Have Kevin finish</td>
<td>February 16</td>
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<tr>
<td>Funding</td>
<td>Submit budget proposal</td>
<td>Resolved</td>
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<tr>
<td>New Input Device</td>
<td>Find an alternative or build alternative</td>
<td>April 1</td>
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<tr>
<td>Electronics Equipment</td>
<td>Ask Dr. Taylor</td>
<td>March 9</td>
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<tr>
<td>QT toolkit/RobotGUI task</td>
<td>Talk to students in Lab</td>
<td>March 1</td>
<td>Maximum</td>
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Previous Work

### Milestones

**2009**
- Phase I: Feasibility Prototype
- Phase IIa: Clinical Prototype
- Requirements and Planning
- High Level Design
- Choose Parts
- CAD Drawings
- Order Parts and Materials
- Endoscope Adaptor
- Z-Stage
- Theta-Stage
- Electronics
- Software and Control
- Integration and Testing
- Phase IIb: Enhancements
- Phase IIc: Phantom Evaluation
- Phase IIIa: Clinical Engineering
- Phase IIIb: Cadaver Study
- Phase IIIc: IRB Approval
- Phase IIId: Further Evaluation
- Phase IV: Clinical trials
- Phase V: FDA Approval/Commercialization

**2010**
- ... (continue with details as per the diagram)
## Timeline and Milestones

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<th>Milestones</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
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<td>01 08 15 22 29</td>
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<td>Project Plan</td>
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<td>Project Plan Presentation</td>
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<tr>
<td>Install Rotation Motor (B)</td>
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<td>Tune Motors/Control Loop</td>
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<td>Redundant Sensor Integration</td>
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<td>GUI</td>
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<td>Design New Input Device</td>
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<td>Build New Input Device</td>
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<td>Create Interface For New Input Device</td>
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<td>Phantom Test</td>
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<td>Initial Cadaver Trials</td>
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<td>Project Final Presentation</td>
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**Legend:**
- **Planning**
- **Hardware**
- **Safety**
- **GUI**
- **Input Device**
- **Testing**
- **Wrap Up**
Management Plan

• 25 hours per week on project
• Reassess deliverables at each milestone
• Meeting Schedule
  – Daily meeting with Kevin Olds
  – Weekly meeting with Dr. Taylor
  – Monthly meeting with Dr. Richmon
## Budget

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<th>Budget Allocation</th>
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<td>Scope</td>
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<td><strong>Hardware</strong></td>
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<td>• Theta-stage</td>
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<td>• Z-stage</td>
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<td>• Misc. Shop Materials</td>
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<td>• Computer/accessories</td>
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<td><strong>Total</strong></td>
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References


Questions?