Tremor Reduction Assessment in Microlaryngeal Surgery

CIS II Spring 2020
Project Written Plan Proposal
Jasmine (Sue Min) Cho

1. Mentors

Professor Taylor, Balazs Vagvolgyi, Dr. Francis Creighton, Dr. Deepa Galaiya, Dr. Ioan Lina

2. Goal

Perform user study to assess the degree of tremor reduction in robotic microlaryngeal surgical procedures on cadaveric phantoms

3. Background, Specific Aims, and Significance

Previous studies using JHU REMS robot and Galen Robot for "Operation Game" on phantom, Microsurgical anastomosis, and Laryngeal surgery have shown that the effects of hand tremor are eliminated when these robotic systems were used. However, quantitative assessment of tremor reduction is necessary in order to objectively compare the performance in free-hand surgery and robot-assisted surgery. With recently improved surgical microscope and video capture capability, we will be able to collect higher quality videos which will allow more accurate tremor reduction assessment.

- Aim 1: Develop/adapt surgical tool tracking software using microscope video (with colored instruments)
  - Significance:
    - Facilitate automatic acquisition of instrument tracking data
- Aim 2: Conduct user study & reduce data
  - Significance:
    - Provide meaningful data for analysis
- Aim3: Write paper with surgeons
  - Significance:
    - Share quantitative assessment results of tremor reduction in robotic microsurgical procedures with the medical and engineering community
    - Provide assessment for usefulness for tremor-eliminating robots (e.g. Galen) and may provide additional input for future design

4. Deliverables

- Minimum
  - Experimental apparatus
    - Expected by: 03/15/2020
  - Documented code for surgical tool tracking software
    - Expected by: 03/25/2020
- Expected
  - Experimental data
    - Expected by: 04/07/2020
  - Documented code for tremor reduction assessment
    - Expected by: 04/07/2020
  - Report
    - Expected by: 04/30/2020
- Maximum
  - Academic paper
    - Expected by: 05/13/2020

5. Technical Approach

a. Experimental apparatus
   i. Paint instruments with easily distinguishable colored nail polish + matte topcoat
   ii. Paint laryngoscope with darker color or paint stationary marker
   iii. Use stereo camera

b. Surgical tool tracking software
    i. Stabilize background using line registration or stationary marker
    ii. Track instrument using modified template matching-based tracker algorithm
c. Data Analysis
    i. Perform economy of motion analysis
    ii. Perform frequency analysis

6. Milestones

- Project Proposal Presentation (02/11/2020)
- Project approval (02/16/2020)
- Project Plan Proposal Submission (02/26/2020)
- Seminar Presentation (03/03/2020)
- **Completion of Surgical Tool Tracking Software Development/Adaptation (03/15/2020)**
- **Completion of Surgical Tool Tracking Software Documentation (03/25/2020)**
- **Completion of User Study and Data Collection (03/31/2020)**
- Project Checkpoint (03/31/2020)
- **Completion of Tremor Reduction Assessment Pipeline Development and Documentation (04/07/2020)**
- **Completion of Data Analysis (04/19/2020)**
- Project Poster Session (05/05/2020)
- Project Final Report Submission (05/05/2020)
- Completion of Academic Paper (05/13/2020)

7. Detailed Weekly Schedule

Week 1 (02/12 – 02/18)

- Consult with Balazs about surgical tool tracking software, microscope video acquisition software, and second camera for microscope
- Coordinate with Prof. Taylor to order second camera and adapter from Haag-Streit
- Order colored nail polish and matte topcoat
- Follow up with surgeons (Deepa, John, Pete) regarding user study scheduling
- Work on surgical tool tracking software

Week 2 (02/19 – 02/25)

- Follow up with Balazs about microscope video acquisition software, and second camera for microscope
- Follow up with surgeons (Deepa, John, Pete) regarding user study scheduling
- Work on surgical tool tracking software (rewrite general tracker algorithm from C++ to Python)
- Finish project written proposal and update CiiS wiki page
- Finish creating reading list (ask Prof. Taylor about Chris' paper)
- Read and review half of reading list

Week 3 (02/26 – 03/03)

- Read and review remaining half of reading list
- Submit project written plan proposal
- Prepare for seminar presentation
- Follow up with Prof. Taylor about microscope video acquisition software, and second camera for microscope
- Follow up with surgeons (Deepa, John, Pete) regarding user study scheduling and equipment preparation (laryngoscopes, stands, pig larynxes, laryngeal tools)
- Add features to tracker algorithm

Week 4 (03/04 – 03/10)

- Follow up with Prof. Taylor about microscope video acquisition software, and second camera for microscope, and follow alternative plans if necessary

- Follow up with surgeons (Deepa, John, Pete) regarding user study scheduling and equipment preparation (laryngoscopes, stands, pig larynxes, laryngeal tools)
- Work on surgical tool tracking software and documentation
- Update CiiS wiki page

Week 5 (03/11 – 03/17)
- Work on surgical tool tracking software and documentation
- Prepare and conduct user study
- Reduce video data

* Must have experimental apparatus ready by start of this week

Week 6 (03/18 – 03/24)
- Conduct user study
- Reduce video data
- Finalize surgical tool tracking software and documentation
- Begin acquiring tracking data
- Update CiiS wiki page

* Must have documented code for surgical tool tracking software ready by end of this week

Week 7 (03/25 – 03/31)
- Conduct user study
- Reduce video data
- Acquire tracking data
- Prepare for project checkpoint presentation update CiiS wiki page

* Must have reduced experimental data by end of this week

Week 8 (04/01 – 04/07)
- Finish acquiring tracking data
- Develop pipeline for tremor reduction assessment
- Update CiiS wiki page

* Must have tracking data for all videos by end of this week

Week 9 (04/08 – 04/14)
- Finalize pipeline for tremor reduction assessment and documentation
- Analyze data
- Begin writing report

* Must have documented code for tremor reduction assessment ready by end of this week

Week 10 (04/15 – 04/21)
- Analyze data
- Write project report
- Update CiiS wiki page

* Must have results for tremor reduction assessment ready by end of this week

Week 11 (04/22 – 04/28)
- Write project report
- Work on project poster

Week 12 (04/29 – 05/05)

- Finish project report
- Finish project poster
- Write academic paper with surgeons
- Prepare for project poster session

* Must have finished project report by end of this week

Week 13 (05/06 – 05/12)

- Write academic paper with surgeons

* Would like to have finished academic paper by end of this week, but planning to continue this in summer or next semester if not finished

8. Dependencies & Plan for Resolving

a. Access to computer
   - Proposed solution: Use personal laptop and back up on external hard drive
   - Alternative solution: Use spare personal laptop
   - Effect on milestone/deliverable: Needed for entire project
   - Needed by: Immediately
   - Status: Resolved

b. Access to OpenCV
   - Proposed solution: Use OpenCV that is already installed on my computer
   - Alternative solution: Use different opensource computer vision packages/libraries
   - Effect on milestone/deliverable: Needed for surgical tool tracking software
   - Needed by: Immediately
   - Status: Resolved

c. Video acquisition software (e.g. frame grabber)
   - Proposed solution: Coordinate with Balazs and Prof. Taylor to acquire necessary software
   - Alternative solution: Use existing data
   - Effect on milestone/deliverable: Needed for microscope video acquisition
   - Needed by: 03/15/2020 but as soon as possible for trial videos
   - Status: In progress

d. Second Camera for stereo and adapter
   - Proposed solution: Coordinate with Balazs and Prof. Taylor to buy camera and adapter from Haag-Streit
   - Alternative solution: A) Use IR camera for 2nd view (need cable & acquisition software) B) Do analysis using monocular stereo
   - Effect on milestone/deliverable: Needed for stereo image processing
   - Needed by: 03/15/2020 but as soon as possible for trial videos
   - Status: In progress

e. Experimental protocol
   - Proposed solution: Coordinate with Prof. Taylor
   - Alternative solution: Use existing data
   - Effect on milestone/deliverable: Needed for user study
   - Needed by: 03/15/2020
   - Status: Resolved

f. Equipment (laryngeal tools, pig larynxes, nail polish, laryngoscopes, microscope, camera, Galen Robot)
   - Proposed solution: Coordinate with Prof. Taylor and surgeons, and order/gain access in advance
   - Alternative solution: Use existing data
   - Effect on milestone/deliverable: Needed for user study
   - Needed by: 03/15/2020
   - Status: In progress (laryngeal tools, pig larynxes, laryngoscopes, Galen Robot), Resolved (nail polish, microscope, first camera)

g. Surgical tool tracking software
   - Proposed solution: Consult with Balazs and develop software in time

- Alternative solution: Focus more on adaptation than new development
- Effect on milestone/deliverable: Needed to acquire instrument tracking data from videos
- Needed by: 03/25/2020
- Status: In progress

h. Data – videos
- Proposed solution: Make sure everything is ready on time
- Alternative solution: Use existing data
- Effect on milestone/deliverable: Needed as a new dataset to analyze for this project
- Needed by: 03/31/2020
- Status: In progress

i. Availability of surgeons
- Proposed solution: Follow up with surgeons regularly for use study scheduling
- Alternative solution: A) Use old data B) Enlist graduate students
- Effect on milestone/deliverable: Needed for user study
- Needed by: 03/15/2020
- Status: In progress

j. Tremor reduction assessment pipeline
- Proposed solution: Develop pipeline before beginning analysis
- Alternative solution: Focus more on adaptation than new development
- Effect on milestone/deliverable: Needed for assessing tremor reduction
- Needed by: 04/07/2020
- Status: In progress

9. Management Plan

- Attend weekly meetings (Galen meeting with Professor Taylor and surgeons)
- Meetings with Balazs as needed
- Additional meetings as needed

10. Reading List

- Feng, Allen L., et al. "The Robotic ENT Microsurgery System: A Novel Robotic Platform for Microvascular Surgery." *The Laryngoscope*, vol. 127, no. 11, 2017, pp. 2495–2500., doi:10.1002/lary.26667.
- Akst, Lee M., et al. "Robotic Microlaryngeal Phonosurgery: Testing of a 'Steady-Hand' Microsurgery Platform." *The Laryngoscope*, vol. 128, no. 1, 2017, pp. 126–132., doi:10.1002/lary.26621.
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- Maguire, Sharon K., et al. "Three-Dimensional Printing of a Low-Cost, High-Fidelity Laryngeal Dissection Station." The Laryngoscope, vol. 128, no. 4, 2017, pp. 944–947., doi:10.1002/lary.26905.
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- Sznitman, R., Richa, R., Taylor, R. H., Jedynak, B., & Hager, G. D. (2013). Unified detection and tracking of instruments during retinal microsurgery. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 35, 1263–1273.