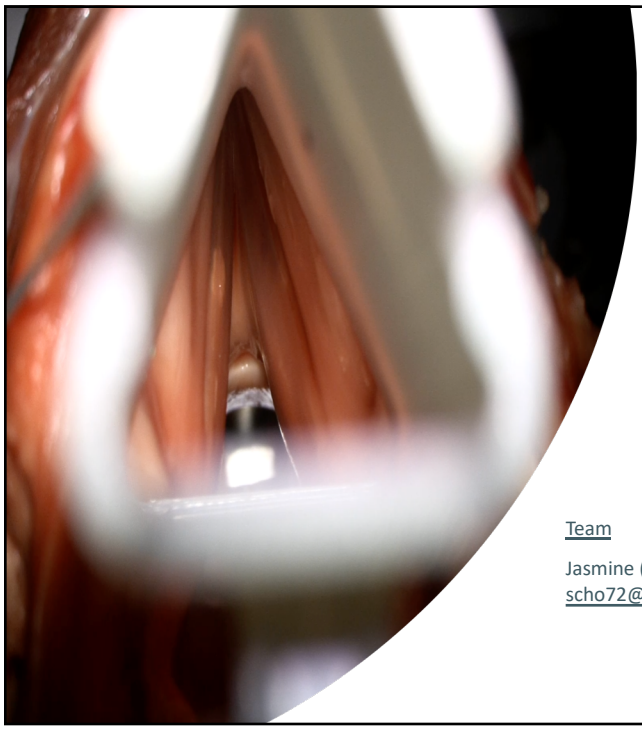

Checkpoint Presentation:
Tremor Reduction Assessment in Microlaryngeal Surgery

Team

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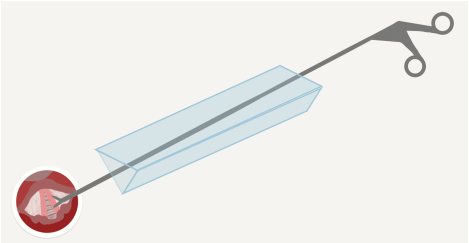
Project Overview

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

- **Aim 1:** Develop/adapt surgical tool tracking software using microscope video (with colored instruments)
- **Aim 2:** Conduct user study & reduce data
- **Aim 3:** Write paper with surgeons



Product rendering of Galen Mark 2 from Galen Robotics Inc.
Retrieved from https://www.artstation.com/artwork/W286BX

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Project Overview (cont.)

Experimental Apparatus

- Paint instruments with nail polish
- Use stereo camera

Surgical Tool Tracking Software

- Develop/adapt surgical tool tracking software to facilitate automatic acquisition of instrument tracking data

User Study

- Collect video data from surgeons of different levels of expertise performing microlaryngeal procedures on pig larynxes with and without robotic assistance

Data Analysis (Tremor Reduction Assessment)

- Perform economy of motion analysis
- Perform frequency analysis

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Minor Changes and Update

Experimental Apparatus

- Paint instruments with nail polish
- ~~Use stereo camera~~

→ Monocular videos were taken

Surgical Tool Tracking Software

- Develop/adapt surgical tool tracking software to facilitate automatic acquisition of instrument tracking data

User Study

- Collect video data from surgeons of different levels of expertise performing microlaryngeal procedures on pig larynxes with and without robotic assistance

→ A shortened version of the user study was conducted by my mentors

Data Analysis (Tremor Reduction Assessment)

- Perform economy of motion analysis
- Perform frequency analysis

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Deliverables Status Update

Deliverables		Date	Status
Minimum	Experimental apparatus	03/15/2020	Met
	Documented code for surgical tool tracking software	03/25/2020	Met
Expected	Experimental data	04/07/2020	On schedule
	Documented code for tremor reduction assessment	04/07/2020	On schedule
	Report	04/30/2020	On schedule
Maximum	Academic paper	05/13/2020	On schedule

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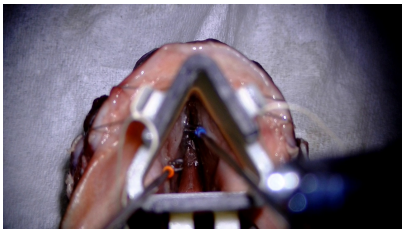
Video Data

	A	B	C	D	E	F	G	H
1	path	filename	pig cadaver (o/x)	**left** (R/FH)	color	**right** (R/FH)	color	length (s)
2	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest01A.mov	x	FH	green	FH	blue	62
3	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest01B.mov	x	FH	green	FH	purple	19
4	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest02.mov	x	FH	blue	R	green	102
5	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest03A.mov	x	FH	purple	R	blue	53
6	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest03B.mov	x	FH	green	R	blue	35
7	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest04.mov	o	FH	orange	R	blue	170
8	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest05.mov	o	FH	orange	FH	green	61
9	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest06.mov	o	FH	green	R	blue	189
10	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest07.mov	o	FH	red	R	green	68
11	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	DeepaTest08.mov	o	FH	orange	R	blue	72
12	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	IoanTest01.mov	o	FH	green	R	blue	113
13	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	IoanTest02.mov	o	FH	green	R	green	62
14	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	IoanTest03.mov	o	FH	green	FH	green	28
15	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	Microscope_A.mov	x	FH	purple	FH	green	41
16	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	Microscope_B_1.mov	x	FH	purple	FH	green	35
17	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	Microscope_B_2.mov	x	FH	blue	FH	green	21
18	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	Microscope_B_3.mov	x	FH	purple	FH	blue	12
19	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	Microscope_B_4.mov	x	FH	green	FH	blue	7
20	/Users/sueminchо/Research/Laryngeal_Tremor_Analysis/Spring2020/CIS2/Microscope_Videos	PeteTest02.mov	o	FH	red	FH	green	83

- Total 19 videos = 10 videos (x pig cadaver) + 9 videos (o pig cadaver)
- Robot used in 9 out of 19 videos



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Tracking using OpenCV

Tracking Algorithm	**CSRT** (Discriminative Correlation Filter (with Channel and Spatial Reliability))	**KCF** (Kernelized Correlation Filters)	**BOOSTING**	**MIL** (Multiple Instance Learning)	**TLD** (Tracking, learning and detection)	**MEDIANFLOW**	**MOSSE** (Minimum Output Sum of Squared Error)
Pros	- higher object tracking accuracy	- Decent accuracy and speed	none	- better than BOOSTING - reasonable job under partial occlusion	- works the best under occlusion over multiple frames - tracks best over scale changes	- excellent tracking failure reporting - works well when motion is predictable and there is no occlusion	- very very fast
Cons	- slower fps throughput	- does not recover from full occlusion	- mediocre tracking performance - does not reliably know when tracking has failed	- does not report tracking failure reliably - does not recover from full occlusion	- too many false positives	- fails under large motion	- not as accurate - Reports failures well - model fails when there is too large of a jump in motion
Performance in Microscope Video	Best	Tracking fails for more than half of video	Not too bad	Slow and inaccurate	Very slow and very inaccurate	Only good when there is no light change or fast movement	Fast but loses tracking for about half of video

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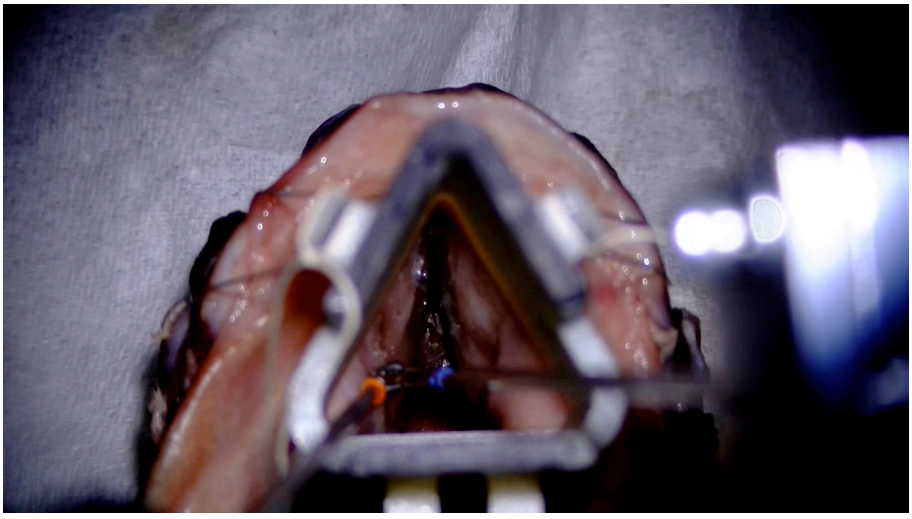
CSRT Tracker Demo



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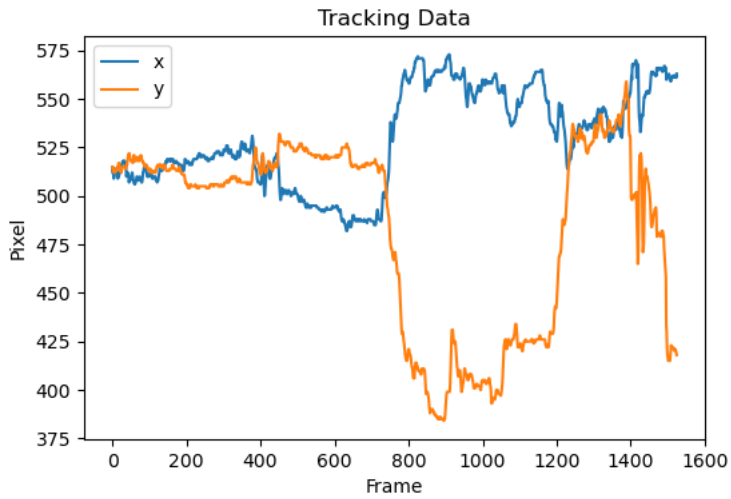
Tracking Data Visualization



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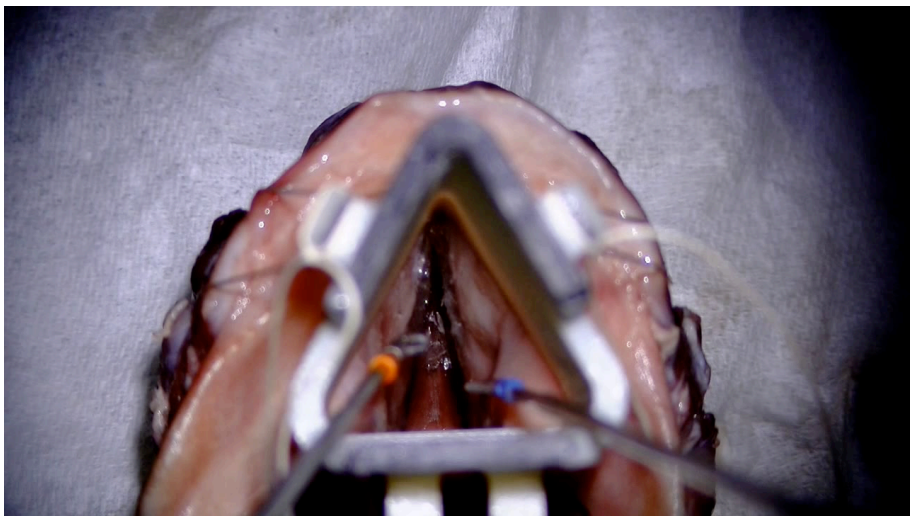
Tracking with Increased Delay Time



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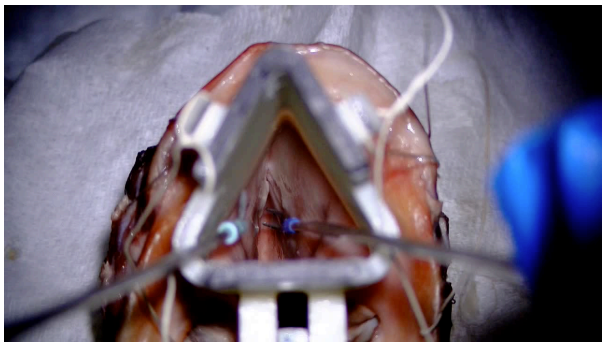
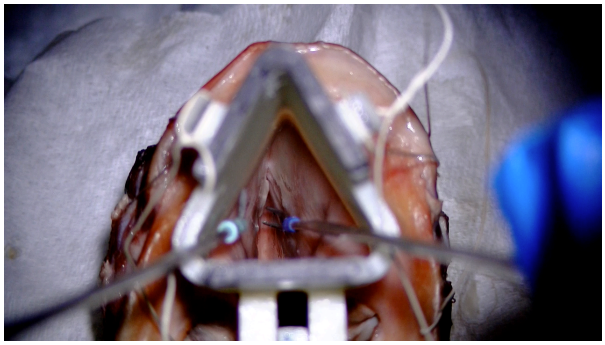
Problem

→ For some colors (e.g. blue), tracker shows evident tremor without actual tremor present

Possible Solutions

- Perform image pre-processing to increase contrast between colored instrument foreground and background
- Compute local optical flow within a window and find frame-to-frame correlation





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Dependency Status

Dependency	Proposed Solution	Alternative Plan	Effect on Milestone/Deliverable	Needed By (*Status*)
Access to Computer	Use personal laptop and back up on external hard drive	A) Use spare personal laptop	Needed for entire project	Immediately (*Resolved*)
Access to OpenCV	Use OpenCV that is already installed on my computer	A) Use different opensource computer vision packages/libraries	Needed for surgical tool tracking software	Immediately (*Resolved*)
Video acquisition software (e.g. frame grabber)	Coordinate with Balazs and Prof. Taylor to acquire necessary software	A) Use existing data	Needed for microscope video acquisition	03/16/2020 *(Resolved)*
Second camera for stereo and adapter → Use in follow-up study	Buy camera and adapter from Haag-Streit (Coordinate with Dr. Taylor)	A) Use IR camera for 2nd view (need cable & acquisition software) B) Do analysis using monocular stereo	Needed for stereo image processing	03/16/2020 (*Resolved*)
Experimental protocol	Coordinate with Prof. Taylor	A) Use existing data	Needed for user study	03/16/2020 (*Resolved*)
Equipment (laryngeal tools, pig larynxes, laryngoscopes, microscope, camera, Galen robot)	Coordinate with Dr. Taylor and surgeons, and order/gain access in advance	A) Modify user study schedule accordingly	Needed for user study	03/16/2020 (*Resolved*)
Data - videos	Contact surgeons regularly	A) Use old data	Needed as a new dataset to analyze for this project	03/27/2020 (*Resolved*)
Availability of surgeons → Schedule user study with more surgeons in follow-up study	Work through Ioan and Deepa	A) Use old data B) Enlist graduate students	Needed for user study	03/16/2020 (*Resolved*)

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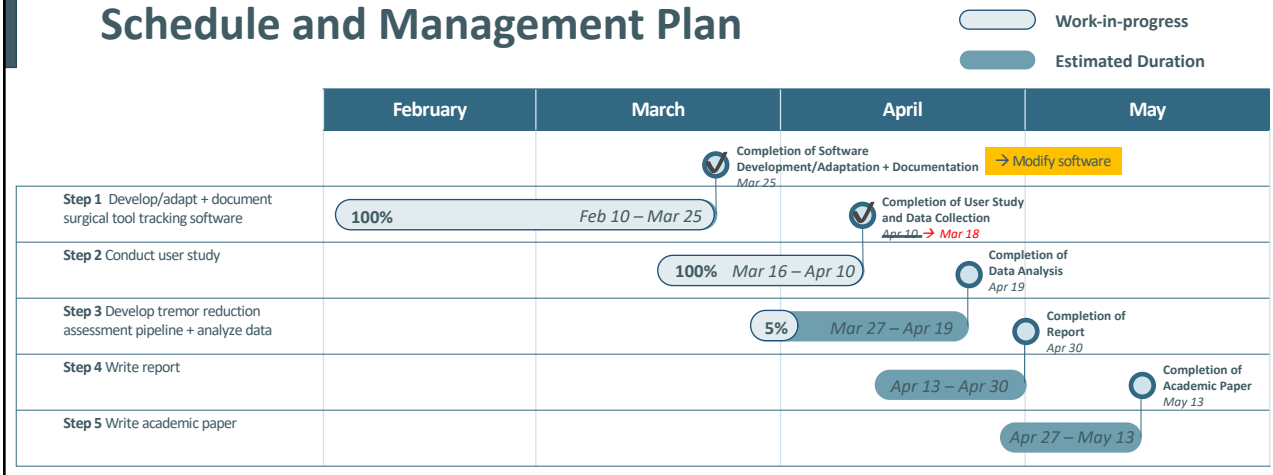
Schedule and Management Plan



Management Plan

1) Weekly meetings (Galen meeting with Professor Taylor and surgeons)
2) Meetings with Balazs as needed
3) Additional meetings as needed

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Thank you

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