# Group 21: Robotic Soft Tissue Assessment

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## Goal

The goal of this project to design and conduct a study that quantifiably assess robotically-assisted soft tissue manipulation. We will be doing a specific case of otolaryngology in which the patient has a vocal cyst treated with surgery. The further aim of this project is to develop an algorithm to create virtual fixtures in 3D to improve robotically-assisted surgical accuracy.

## Statement of Relevance/Importance

The current surgical treatment techniques of vocal cords do not involve robotic assistance. This results in unintended damage to benign tissue during the surgery caused by hand tremor, or incomplete removal of the cyst due to limited movement ability whilst phonosurgery. Robotic assistance can minimize hand tremor as well as provide virtual fixtures to maximize movement ability within safe boundaries. Designing a method to quantifiably assess robotically-assisted soft tissue manipulation can help increase the use of robots during surgeries. Additionally, the analysis can be used to improve accuracy of robotically-assisted surgery techniques for various robot algorithms.

# List of Deliverables

## Minimum

I. Study design for surgery, data collection and analysis
II. CAD design of a phantom to conduct surgical experiments on
III. Collected data and results of surgical experiments on 3D printed phantom conducted by experts & med students with and without robotic assistance
IV. Computer vision based analysis algorithm using Matlab/Python to quantify success of vocal cyst removal surgery

## Expected

I. Study design for conducting surgery on an non-living animal vocal cord
II. Collected data and results of surgical experiments on animal vocal cord conducted by experts & med students with and without robotic assistance
III. Improved computer vision based analysis algorithm to quantify success of vocal cyst removal surgery

## Maximum

I. 3D virtual fixture algorithm developed for the robot using C++
II. Study design for conducting robotically-assisted surgery with virtual fixtures
III. Collected data and results of robotically-assisted surgical experiments with virtual fixtures on the phantom conducted by experts
IV. Comparison of quantified success results of non-assisted, robotically-assisted with no virtual fixtures, and robotically-assisted with virtual fixtures surgeries on the phantom

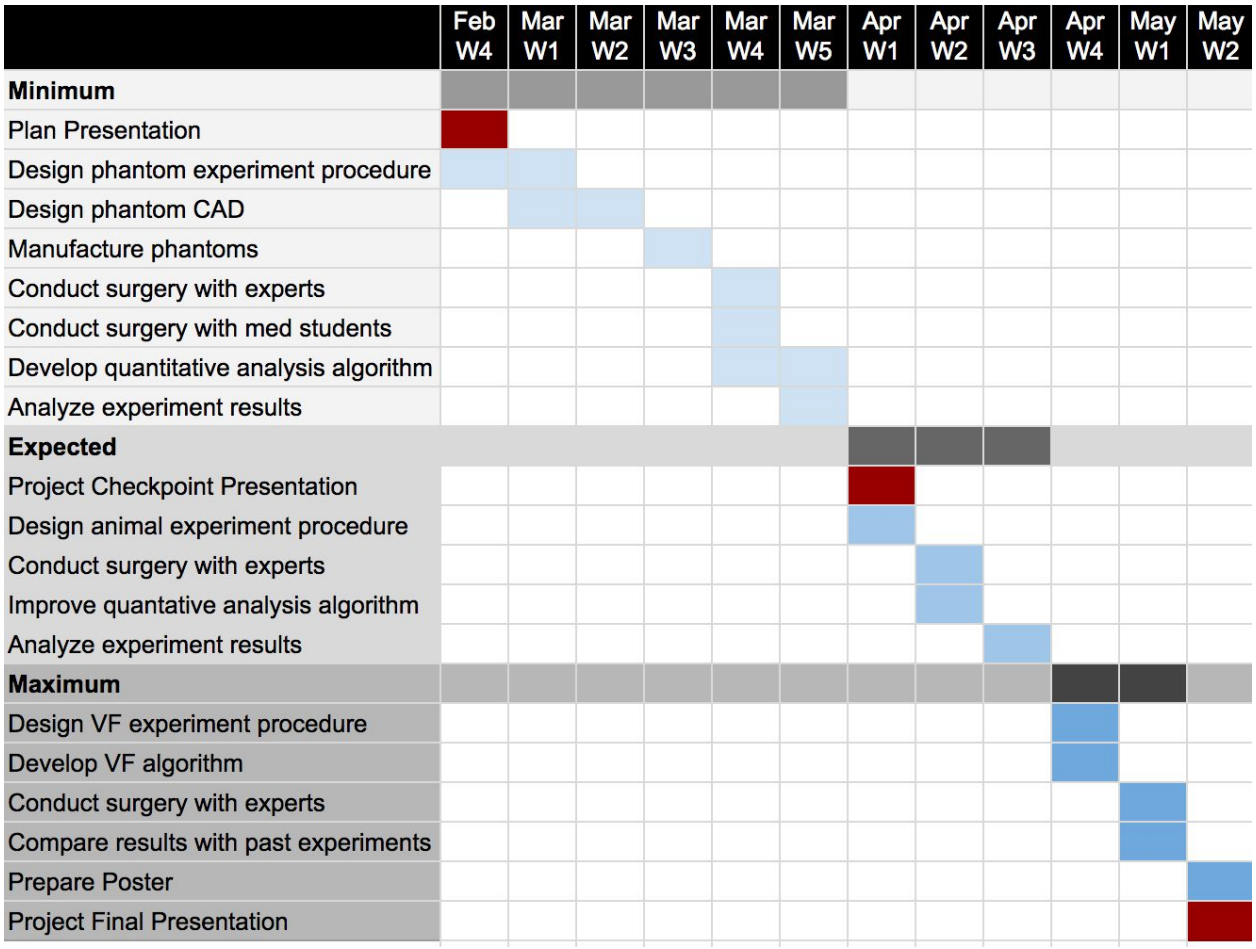
## Technical Summary of Approach

*For the minimum deliverables,* we will be modifying readily available human CAD models to extract the relevant regions for the surgery of vocal cyst. We will create the cyst using a colored silicon liquid and a syringe, injecting the liquid into the white healthy human phantom. As the surgery is conducted in a Mock OR setting by the experts, med students with and without robotic assistance, we will be collecting the extracted phantom cysts. Images of extracted regions from different angles will be recorded. Developed Python algorithm will compute the red region volume (the cyst) and the white region volume (benign tissue.) of the extracted region from the recorded images.

*For the expected deliverables,* we will inject a colored silicon into animal vocal cord area. Repeat the experimental procedure, and record images of extracted regions. Using an upgraded algorithm we will compute the volume of cyst and benign tissue.

*For the maximum deliverable,* we will design an advanced virtual fixture algorithm that creates a 3D boundary for the surgeon preventing damage to the benign regions. This will be accomplished by improving upon the pre-packaged 2D virtual fixture algorithm to develop a 3D virtual fixture by locating the boundaries of the cyst using a pointer to show the boundaries before surgery. The same analysis procedure as the phantom will be used for quantitative analysis of success.

# Key Dates & Assigned Responsibilities



## List of Dependencies & Plan for Resolving

| Dependency | Resolution |
|---|---|
| Computer Vision library decision and tutorial | Meet with Paul Wilkening |
| 3D CAD software decision and tutorial | Meet with Yunuscan Sevimli |
| Mock OR access | Access granted |
| 3D printer access for phantom manufacturing | Access granted |
| Get experts to conduct experiment Mar W4 | Confirmation received |
| Get experts to conduct experiment Apr W2 | Meet with Yunuscan Sevimli |
| Get experts to conduct experiment May W1 | Meet with Yunuscan Sevimli |
| Get med students to conduct experiment Mar W4 | Confirmation received |
| Get permission to experiment with animals | Meet with Yunuscan Sevimli |
| ROS background for virtual fixture algorithm | Meet with Paul Wilkening |

## Management Plan

Syed Hossain is a BME with CAD design, wet lab and Mock OR experience. He will be mainly responsible for designing study & procedure, building the phantom from CAD models, assisting the surgery, making sure the procedure is correctly followed by the experts & med students, and collecting data.

Bugrahan Cigdemoglu is a BME & CS double major with experience in computer vision, Python, Python data science libraries, ROS, and C++ for virtual fixture development.

We will be in constant contact with our mentors. Bugrahan will consult Paul Wilkening for programming related questions, and Syed will consult Yunuscan Sevimli for surgery and phantom related concerns.

# Reading List

Jensen JB, Rasmussen N. Phonosurgery of vocal fold polyps, cysts and nodules is beneficial. *Dan Med J*. 2013 Feb. 60(2):A4577. [Medline].

Stanković P, Vasić M, Djukić V, Janosević Lj, Vukasinović M. Vocal fold masses removal--the sub epithelial micro flap technique. Acta Chir Iugosl. 2008;55(4):43-7.

Schweinfurth, J., MD. (2016, March 21). Vocal Fold Cysts Treatment & Management (A. D. Meyers MD, Ed.). Retrieved February 21, 2017, from http://emedicine.medscape.com/article/866019-treatment#d13

D. Aarno, S. Ekvall, and D. Kragic. Adaptive virtual fixtures for machine-assisted teleoperation tasks. In Proc. *IEEE Intl. Conf. on Robotics and Automation*, pages 1151-1156, 2005.