VIOLINS: Visualizing Intra-Operative Line-of-cut In Nasal Surgery

Computer Integrated Surgery II

Spring, 2016

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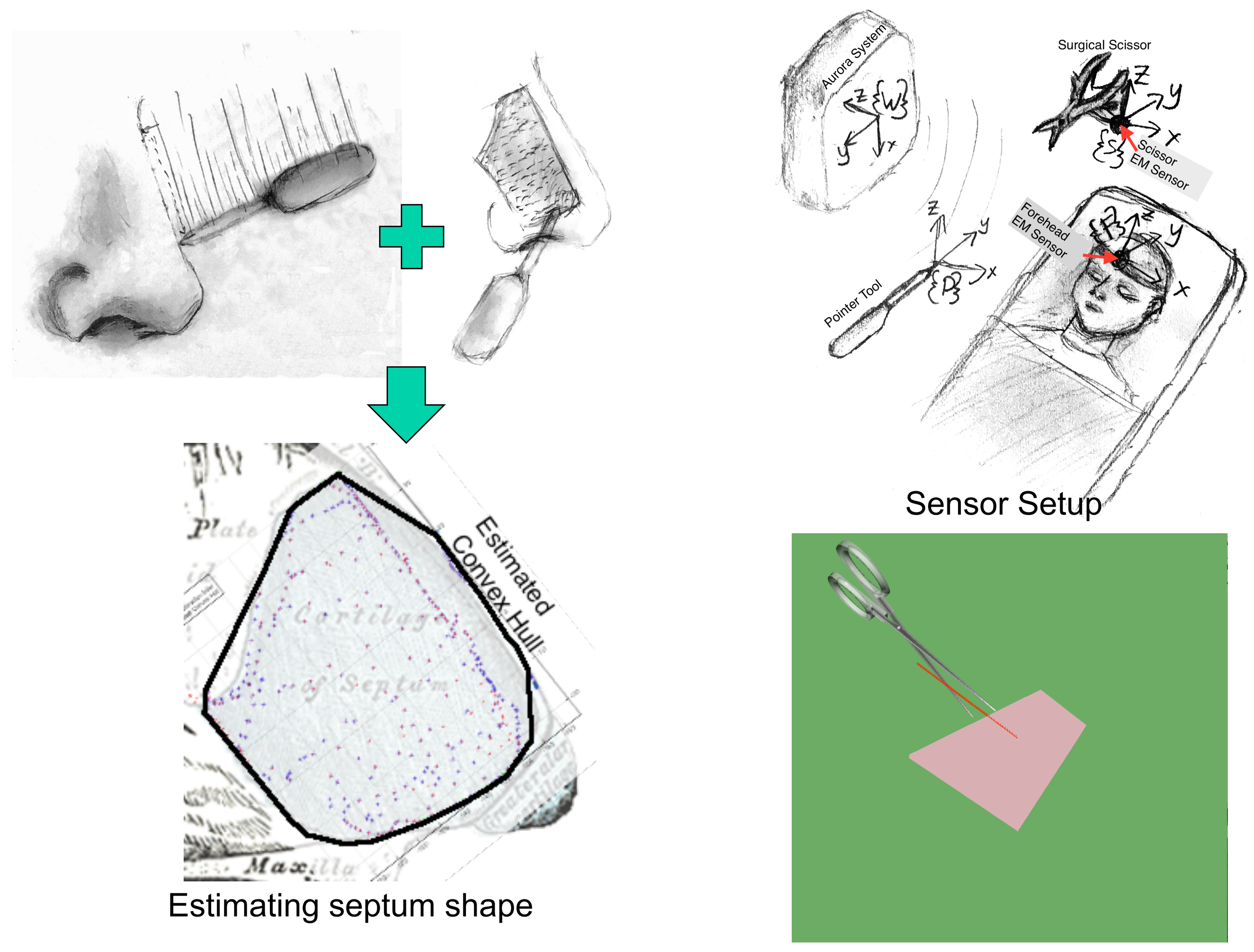


Estimating septum shape

Sensor Setup

Line Of Cut Visualization

Project Overview

Introduction

- Surgical residents learn by watching and performing surgery.
- Septoplasty is a nasal surgery that aims to improve breathing by correcting a deviated septum.
- Septoplasty is performed inside the nose, which makes it difficult for surgical residents to observe proper technique demonstration.
- One of the steps in septoplasty is cutting the septal nasal cartilage, which needs to be performed with extreme precision to minimize post-surgery complications.

The Problem

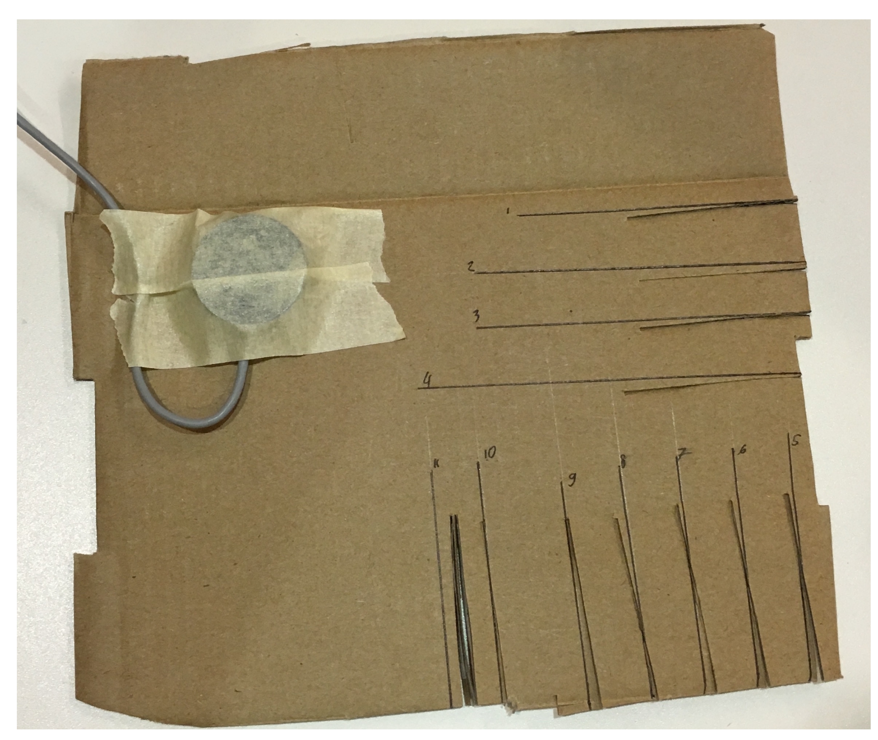
- A surgical cut of the septal nasal cartilage needs to sufficiently preserve a critical region called L-strut region in the cartilage.
  - Removing more cartilage than necessary may cause collapse of the nose bridge and other complications.
  - Removing less cartilage than necessary can potentially leave behind defected parts of the cartilage which may require a second surgery.
- Poor visual input for surgeons causes difficulty in learning the tool movement in the confined space, which leads to clinical problems.
- Although endoscopic septoplasty tools have been around since 1991, but they only show tool movement if it is in the line of sight of the endoscope.
- Septoplasty is one of the most common types of nasal surgery
  - It is very important that surgical residents have the best tools that can minimize complications while they are learning to perform septoplasty.

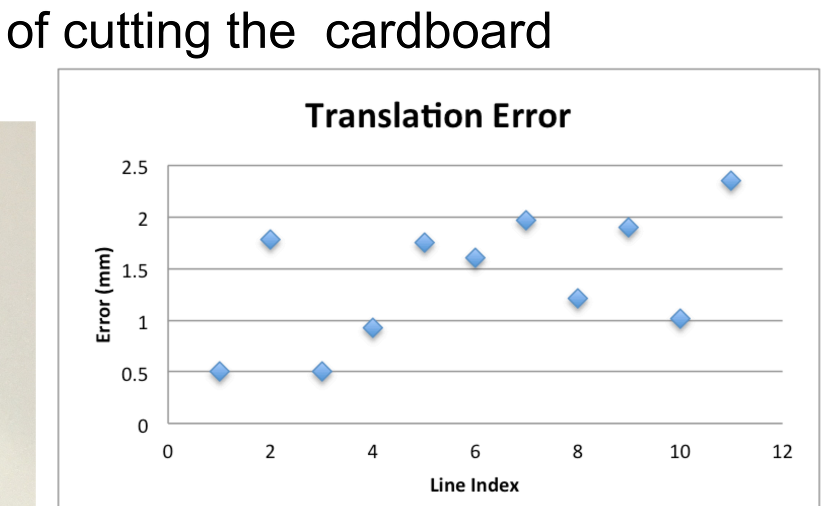
The Solution

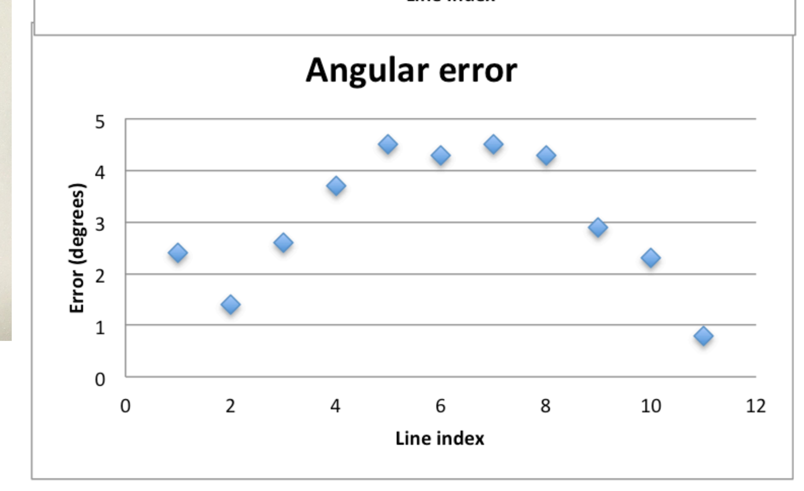
- We developed an application that visualizes nasal cartilage, scissor movement inside the nose, and predicts the line-of-cut of surgical scissors with no line-of-sight dependency.
- We achieve this by using an EM sensor that has no line-of-sight dependency.
  - We place one sensor on the patient's forehead, one on the surgical scissors, and use an EM pointer to trace the patient's anatomy.
  - The sensor on patient's forehead removes the effect of patient movement during the surgery.
  - The pointer tool is used to estimate patient's cartilage shape with a planar convex hull.
  - The EM sensor on the scissors estimates the scissor blade position relative to the cartilage, which isused to predict the line of cut on the cartilage.
- Additionally, we also developed a tool to calibrate the EM sensor position and orientation relative to the scissor blade.

Outcomes and Results

- We attached a sensor to the cardboard, and traced lines to cut
  - We then used our system to validate the line-of-cut prediction by cutting without looking at the cardboard.
  - Below is an image of the result of cutting the cardboard







Future Work

- Using mesh for better approximation of deviated septum surface.
- Develop septum surface reconstruction with randomized surface touching.
- Recommend the location of the next surgical cut using an atlas collected from many surgeries

Lessons Learned

- Treat the process of validating data collection like any algorithm

Credits

- Felix developed the septum reconstruction concept, scissor training procedure and algorithm, and line of cut prediction algorithm.
- Michael developed the septum reconstruction algorithm, GUI, data processing pipeline, EM sensor data parser, and visualization platform.

Publications

- We plan to submit a paper to medical journal this summer

Support by and Acknowledgements

- Thanks to Narges Ahmidi, Dr. Masaru Ishii, Satyanarayana Vedula, Dr. Gregory Hager.