Surgeon Septum Surface Generation Procedure

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This document describes the steps that a surgeon must perform to generate the septum surface model that is used in the septum line of cut prediction. It also contains a mathematical model describing how this data is used.

In this document we use "world coordinate system," and frame transformations superscripted with "w," to mean the coordinate system of the NDI Aurora system.

In the algorithm below, we refer to the three following steps as "Collection Step 1, 2, 3, and 4"

1 Before We Begin

An EM Sensor for the face, an EM Sensor attached to the surgical scissors, and the EM Pointer should be connected to the Aurora system. The Septoplasty Feedback Project needs to be started before we can begin the septum surface generation process.

2 Secure EM Sensor on Patient's Face

The EM sensor needs to be secured on the patient's face so that it does not move during the procedure. During the Septum Surface Generation Process, the Face EM Sensor will collect points p_F^w at times $i : t$.

When the patient's head moves, this sensor will move so that we can perform a frame transformation between the EM Pointer and the patient's septum.

3 Trace a line with the EM pointer from the nasal bridge to the tip of the nose

Tracing a line with the EM pointer from the nasal bridge to the tip of the nose will establish a boundary outside of where we want to cut. This limits the septum plane dimension.

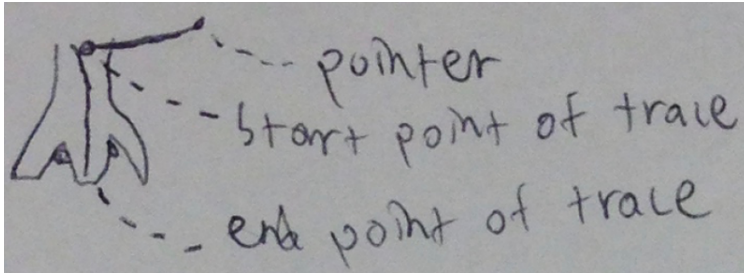At time i, $(T_F^W)^{-1} p_{N_B}^W$ is the nasal brige trace in Face Coordinates.

Image 1. Pointer tracing along outside of nose from nasal bridge to the tip of the nose.

4 Trace Along the Septum

Tracing a zig-zag pattern inside the nasal septum (NS) will generate an array of points that we can use to construct a surface model of the Septum. Denote the points collected in the reference point of the septum by $P_{N_S}^W$, and they can be transformed to the reference frame of the patient's face at time i (by doing a frame transformation from the data in the sensor from 2 at time i) with the transformation: $(T_F^W)^{-1} P_{N_S}^W = P_{N_S}^F$.
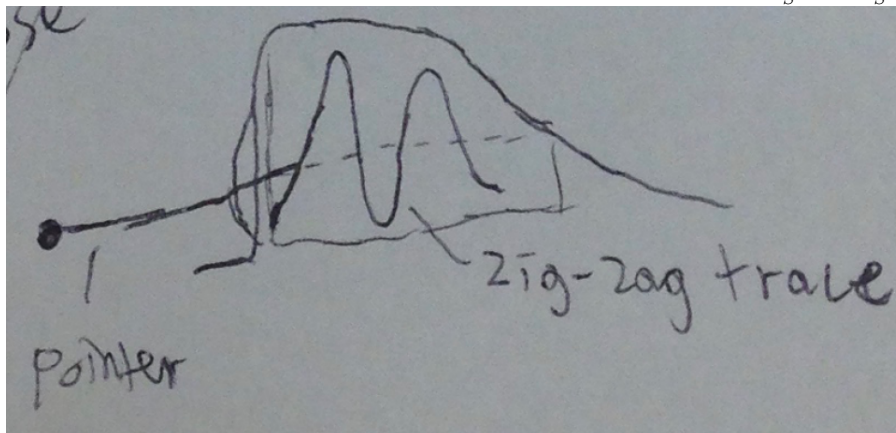

Image 2. Pointer tracing inside the nose along the septum plane.

Generating The Septum Plane and Septum Mesh

The first iteration of our project will generate a simplified version of the septum, which will treat the septum as a plane. The second iteration of our project will generate a septum mesh. Following are the psuedocode for the algorithms to generate the plane and mesh which specify the input and output data, and the PCL methods that will be used to generate the data format.

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1 **Function** *Septum Plane Generation*
2 | Septum Plane Generation
  input : an array of points $p_{N_B}^{W}$, collected with the EM Pointer by tracing the
             nasal bridge at times $1 : t$ [from collection step 3]
             an array of points $p_{N_S}^{W}$, collected with the EM Pointer by tracing the
  nasal septum at times $1 : t$ [from collection step 4]
             an array of points p_{F}^{W}, collected with the EM Sensor positioned on the
  patient's face at times $1 : t$ [from collection step 2]
  output: A Septum Plane in the form $ax + by + cz + d = 0$

3 Run Point Cloud Library's function
  pcl::SACSegmentation¡pcl::PointXYZ¿::segment

Algorithm 1: Septum Plane Generation From Data Collected By Surgeon

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1 **Function** *Septum Mesh Generation*
2 | Septum Mesh Generation
  input : an array of points $p_{N_B}^{W}$, collected with the EM Pointer by tracing the nasal
             bridge at times $1 : t$ [from collection step 3]
             an array of points $p_{N_S}^{W}$, collected with the EM Pointer by tracing the nasal
  septum at times $1 : t$ [from collection step 4]
             an array of points p_{F}^{W}, collected with the EM Sensor positioned on the
  patient's face at times $1 : t$ [from collection step 2]
  output: A Septum Plane in the form $ax + by + cz + d = 0$

3 Run Point Cloud Library's function
  pcl::GreedyProjectionTriangulation¡pcl::PointNormal¿::reconstruct

Algorithm 2: Septum Mesh Generation From Data Collected By Surgeon