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Research In-Progress

Statistical Shape Modeling and Simulation for Reconstructive Breast Surgery

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Introduction: Simulation and visualization tools for communicating postoperative breast shape changes and for elicitation of patient preferences following reconstructive surgery are limited. We propose a shape simulation method on 3D surface images that allows data-driven deformable, non-rigid localized changes to breast shape.

Methods: Active Shape Models (ASM) is a statistical approach, that leverages specificity (common features) and variability (features of significant variations in the given dataset) for shape modeling. We previously developed a spherical harmonics-based breast shape model (SPHARM), which utilizes orthogonal basis functions defined on the surface of unit sphere to obtain descriptors of breast shape. In this work we utilize the descriptors from SPHARM modeling with ASM to achieve breast shape simulations. For a training set with 321 breast images (168 preoperative and 153 postoperative (30 tissue expander, 81 implant-based, and 42 autologous) reconstructed breasts), we computed the covariance matrix with SPHARM-based shape descriptors. Eigen value decomposition on the covariance matrix determines the eigen vectors and corresponding eigen values. Weight parameters (shape controls) assigned to these eigen vectors can be adjusted to allow shape simulations.

Preliminary Results: Our preliminary result showed that the first 24 eigen vectors capture 98% of the variability in the dataset. We adjusted the weights of the eigen vectors on the preoperative breast image shape to obtain a postoperative shape simulation (Figure 1).

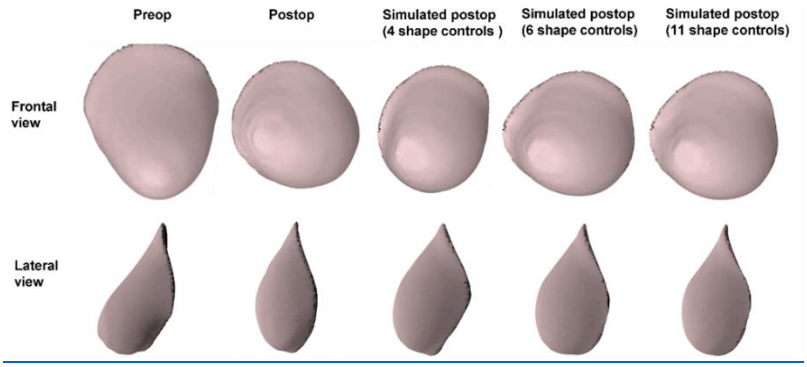

Figure 1: Simulation of postoperative results. We adjusted the shape controls on the preoperative breast image to achieve the desired postoperative shape outcome. Closest simulation to postoperative shape was obtained using 11 shape controls.

Next Steps: Mapping of shape controls to intuitive and anatomically relevant features is required for clinical implementation. For example, a specific shape control parameter would map to an anatomic feature, e.g., upper pole fullness. We will utilize synthetic breast images with known dimensions to determine the association between controls and anatomical features using regression models. This will facilitate visualization of postoperative shape simulation on the preoperative torso for clinical consultations.