Visual predictive model for breast appearance following breast-conserving surgery

Project Description:

Breast-conserving therapy (BCT), which includes minimal surgical intervention such as lumpectomy, has become a preferred treatment for early-stage breast cancer due to its ability to preserve breast tissue and reduce recovery time. However, patients often face uncertainty regarding the aesthetic outcome of such procedures, which can impact their decision-making and psychological well-being.

Objective:

The aim of this MSc project is to develop a **visual predictive model** that, given pre-operative and historical post-operative data, can forecast the likely appearance of a patient's breast following BCT. The model will assist clinicians in counseling patients and setting realistic expectations, ultimately contributing to more informed and personalized care. Additionally, the model could be useful for making a better pre-operative assessment of whether plastic surgery is desirable.

Methods:

1. **Data Acquisition and Geometric Modeling:**
    - Process pre-operative breast imaging data (e.g., photos and/or MRI 3D scans) to reconstruct patient-specific breast geometry.
    - Segment breast tissues and tumor locations to define regions that will be affected by surgery.
2. **Material Modeling and Simulation Framework:**
    - Implement or adapt soft tissue models (e.g., finite element or position-based dynamics) to simulate breast biomechanics.
    - Define elastic and visco-elastic material properties.
    - Simulate tissue deformation under gravitational forces and constraints from the chest wall and skin.
3. **Surgical Modeling:**
    - Integrate the effects of tissue removal (lumpectomy) through surgery into the breast model simulation.
    - Explore how different excision volumes and locations affect post-operative shape.
4. **Visualization and Evaluation:**
    - Visualize the predicted post-operative breast shape using 3D rendering.

- Compare simulation outcomes with historical patient data (when available) to adjust the simulation pipeline and ultimately validate accuracy.

Expected Outcomes:

- A pipeline that predicts post-surgical breast appearance based on patient-specific anatomical and surgical input.
- Visual comparison tools for clinicians and patients.

Required Skills:

- Basic knowledge of soft body simulation techniques.
- Proficiency in C++ or Python.
- Familiarity with 3D geometry processing and visualization.