

**Name:** Michael Pérez

**Research Advisor:** Dr. Jörg Peters

**Research Site:** Department of Computer & Information Science & Engineering, University of Florida, Gainesville

### Creating a 3D Model of the Stomach for use with Haptic Interfaces

A three-dimensional model of a stomach and a spleen was created for Laparoscopic Nissen Fundoplication surgery simulation. The model needed to be both visually accurate for the surgeon and digitally accurate for computations. To support both needs, the model was created using only quadrilaterals. This allows B-spline surface evaluation to be performed, and results in a smoother surface when using the subdivision operator function of Blender. A surgeon in training will interact with the stomach model using haptic interfaces and the simulation program, Simulation Open Framework Architecture (SOFA); however, SOFA is only capable of representing objects using straight lines, and represents curves as series of line segments. This inherently limits the accuracy of 3D models. SOFA cannot represent curved surfaces because it cannot calculate the energy and force of curved surfaces as is necessary to apply forces during surgery simulations. Expressing the formula for the energy in terms of curved surfaces will solve this problem. The formula was found by differentiating the parametric equations of a Bézier curve with three control points, substituting them for  $\frac{dx}{du}$  and  $\frac{dy}{du}$  in the arc length equation, differentiating, substituting the results for  $\frac{dl}{du}$  and  $\frac{dl'}{du}$  in the equation for the energy of a spring, and then integrating. The final formula was found to be  $E = \frac{YA}{2} \int \frac{(\sqrt{A'u^2+2B'u+C'} - \sqrt{Au^2+2Bu+C})^2}{\sqrt{Au^2+2Bu+C}} du$ , where A, A', B, B', C, and C' are expressions containing the initial control points and the displaced control points.

**Keywords:** Bézier Curve, Blender, Elastic Energy of Spring, Laparoscopic Nissen Fundoplication, SOFA, Surgery Simulation, and CGAL Tetrahedralize.

### References

- [1] M.S. Subramanya; M.B. Hossain; S. Khan; B. Memon; M.A. Memon, "Meta-analysis of laparoscopic posterior and anterior fundoplication for gastro-oesophageal reflux disease," *Complex Medical Engineering (CME), 2010 IEEE/ICME International Conference on*, vol., no., pp.270-276, July 13-15, 2010 [Online] Available: IEEE Xplore, [http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5558829&queryText=laparoscopic+nissen+fundoplication&newsearch=true&searchField=Search\\_All](http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5558829&queryText=laparoscopic+nissen+fundoplication&newsearch=true&searchField=Search_All). [Accessed July 1, 2015]
- [2] S.F. Queiros, J.L. Vilaca, N.F. Rodrigues, S.C. Neves, P.M. Teixeira and J. Correia-Pinto, "A laparoscopic surgery training interface," *Serious Games and Applications for Health (SeGAH), 2011 IEEE 1st International Conference on*, pp. 1-7, 16-18, Nov. 2011. [Online] Available: IEEE Xplore, <http://ieeexplore.ieee.org/xpl/abstractAuthors.jsp?arnumber=6165446>. [Accessed July 1, 2015]