An Efficient Simulation Approach for Virtual Interactive Colorectal Anastomosis

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Introduction

- The Colorectal Objective Structured Assessment of Technical Skills (COSATS) developed by the Operative Competency Committee of the American Society of Colon and Rectal Surgeons and has been introduced into the American Board of Colon and Rectal Surgeons certification, including five open surgical tasks: Handsewn anastomosis, Stapled Anastomosis, Coloanal Anastomosis, Ileal pouch anal anastomosis, and Rectal prolapse. [1]
- While VR simulation technologies have been developed for coloscopy and laparoscopic surgical procedures, no focus has been made to simulate open surgeries such as those in the COASTS.
- For the first time, this work aims to simulate one of the most essential but challenging surgical procedures in the COASTS - colorectal anastomosis.

Methods and Preliminary Results

- We proposed a novel skeleton-driven approach, ***Skeletal-Colon***, for simulating colon anatomy and its physics behavior in virtual reality, based on a new sphere-joint representation (i.e., a grid-structure comprising layers of evenly distributed spheres connected by 6-DOF spring-damping *joints*); a polygonal mesh is used to render the skin of the colon, see **Fig.1(A)**.
- To deform the mesh, each vertex is mapped to four neighboring spheres, and its position is updated by interpolating all the adjacent spheres' positions. **Fig.1(B-C)** illustrates the deformation of the simulated colons.
- To simulate side-by-side colon anastomosis using a linear stapler, we devised **two unique operators** to simulate anastomosis: ***split*** - remove the joints between the spheres of each sphere-joint model based on the input splitting plane determined by the linear stapler held by the user and ***join*** - add new joints to connect the corresponding spheres of the two colon models to form a new connection.
- To split the mesh, each triangle is split along the same splitting plane (see **Fig.1(D)**); the mapping between the vertices of those triangles to the spheres of the new connection is then updated to join the meshes of the two colons together, see **Fig.1(E-F)**.

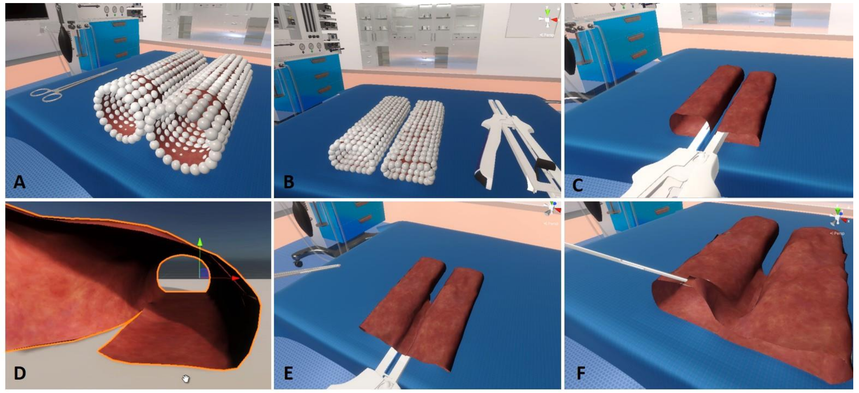


Fig.1: Preliminary results of the proposed skeleton-driven approach - *Skeletal-Colon*, for virtual colorectal anastomosis simulation using linear stapler.

Conclusions

- We proposed a novel skeleton-driven approach for simulating the colorectal anastomosis procedure in virtual reality. The sphere-joint represented *Skeletal-Colon* can effectively mimic colon anatomy's physics behavior and ease the anastomosis procedure by using two operators: *split* and *join*.
- The preliminary results have demonstrated the potential of using this technique to simulate the COASTS's five open surgical tasks. We will work with colorectal surgical experts on validating this technique in the next step.

References & Acknowledgements

[1] S. L. De Montbrun *et al.*, "A novel approach to assessing technical competence of colorectal surgery residents: The development and evaluation of the colorectal objective structured assessment of technical skill (COSATS)," *Ann. Surg.*, vol. 258, no. 6, pp. 1001–1006, 2013, doi: 10.1097/SLA.0b013e31829b32b8.

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