Autonomous Suture Management for STAR Robot

Testing Procedure

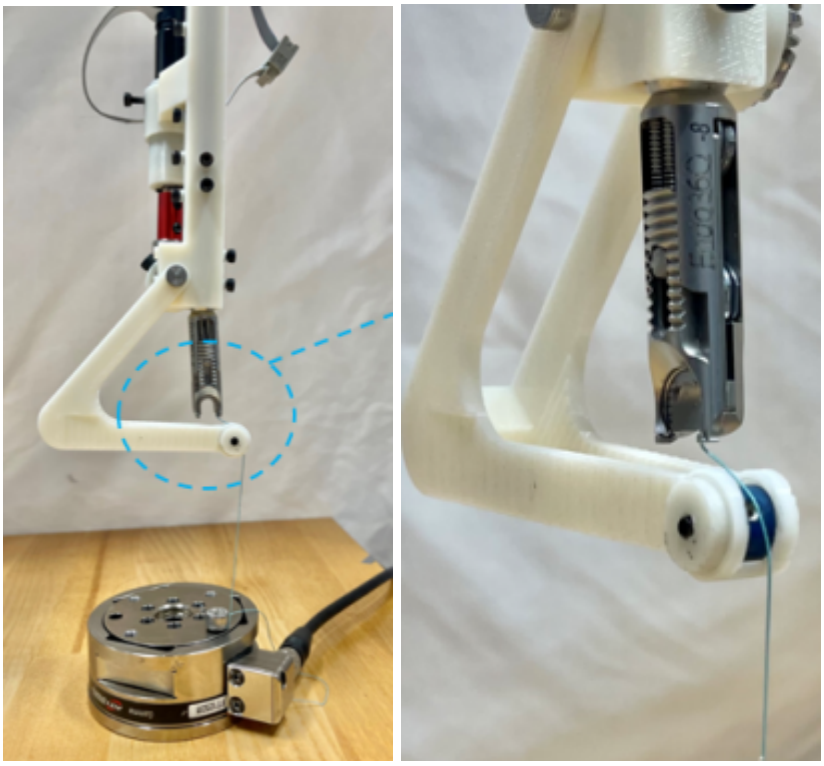

Figure 1a (Left) Force sensor setup below the STAR arm so that the thread is orthogonal to the table. 1b (right) the prototype pulling on the thread as it completes its motion.

Tension Force Testing

1. Set up the ATI industrial automation multi-axis force sensor on the table directly below the arm of the STAR robot as shown in Figure 1a.
2. Position the swing mechanism in front of the thread so that when it swings through it will catch and tension the thread (Fig. 1b).
3. Tie the suture to a screw on the faceplate of the force sensor.
4. Send a current to the motor using CANbus control and record the output of the force sensor as the thread is pulled by the swing mechanism. Send currents ranging from 20-50 mA in increments of 5mA to the motor.

5. Plot the relationship of current vs. force. This will allow us to determine the appropriate amount of current to send to the motor to result in a 1N tensioning force which has been shown to be sufficient in [1].

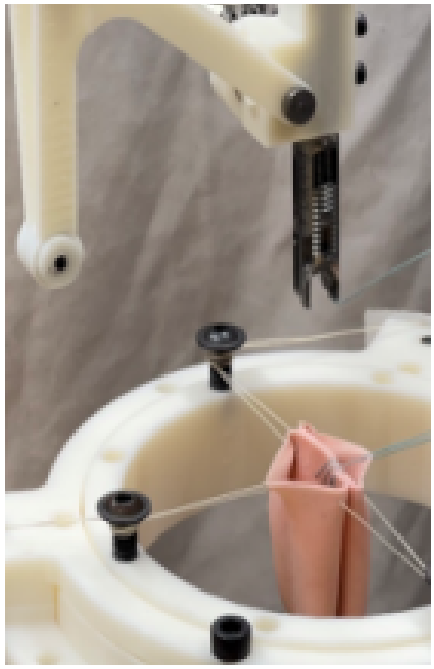

Figure 2. Synthetic Bowel full testing setup

Synthetic Skin Bowel Anastomosis testing

1. Set up the synthetic bowel tissue (3-Dmed, Franklin, Ohio, USA) into a 3D printed ring setup as shown in Figure 2.
2. Star will place 27 running stitches with 3mm suture spacing.
3. Record the time per stitch, suture spacing, and bite depth for each sample. Take photos of the synthetic bowel tissue and record any other findings. Compare these results to previous results from [2] to evaluate the performance of the STAR with single-arm suture management to STAR with second arm tension assistant, STAR with human assistant, human laparoscopic surgery, and teleoperated robot-assisted laparoscopic surgery.

References:

[1] A. Shademan et al., “Supervised autonomous robotic soft tissue surgery,” Science Translational Medicine, vol. 8, no. 337, pp. 337-345, 2016, doi: https://doi.org/10.1126/scitranslmed.aad9398

[2]S. Leonard et al., "Vaginal Cuff Closure With Dual-Arm Robot and Near-Infrared Fluorescent Sutures," in IEEE Transactions on Medical Robotics and Bionics, vol. 3, no. 3, pp. 762-772, Aug. 2021, doi: https://doi.org/10.1109/TMRB.2021.3097415