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Research In-Progress

Automated Surgical Knot-Tying Skill Assessment Tool using Computer Vision

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Introduction: A surgeon's ability to securely and efficiently tie surgical knots is critical to procedural safety, recovery times, and patient satisfaction. Despite this, the current method of evaluating knot-tying skill is a manual process involving human resources, introducing error into outcomes. To address this need for automated tools that evaluate the knot-tying process, this research introduces an experimental design that uses computer vision to track and characterize participant hand movements during an open knot-tying task.

Methods: Two Intel® RealSense™ D415 RGB-D cameras were mounted onto a 3D-printed assessment rig for monitoring hand movements during four square knot-tying tasks: (1) two-handed right, (2) two-handed left, (3) one-handed right, (4) one-handed left. Tasks were replicated with 2-0 Vicryl and 2-0 Prolene. MediaPipe software was used to collect hand data (IRB Protocol Number: Pro00062197), providing positional information throughout the tasks on 21 hand landmarks. Videos were uploaded to a repository and scored using a binary checklist adapted from Huang et al. (2015), then used to correlate task performance and surgeon skill level.

Preliminary Results: Preliminary trials were conducted with 30 general surgery residents and 9 attending surgeons from the Duke University School of Medicine. System calibration during the first assessment day revealed the camera setup was able to reliably track objects with a calibration error of ± 1.45mm. Mean registration error across the initial 13 trials was ± 45.42mm, indicating the MediaPipe live-tracking method might improve in post-processing for the remaining trials.

Next Steps: Future work on this project will require using MediaPipe in post-processing to improve mean registration error. Additionally, the kinematic data from each of the hand landmarks will be assessed and compared across skill levels to provide feedback to participants on: a) their position on a novice to expert distribution curve, b) any specific aspects of knot-tying that require improvement.

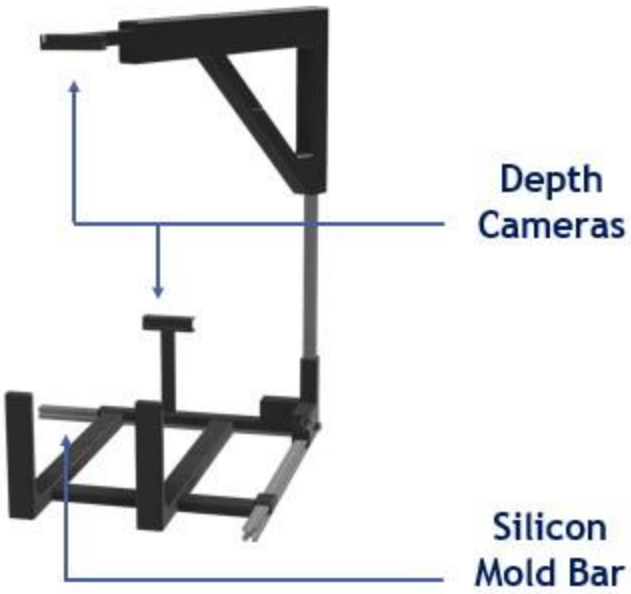

Figure 1. CAD model of physical design.