A Surgical Simulator for Intra-corporeal Suturing Utilizing the SPRING Platform

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Background

Training with surgical simulators requires accurate, realistic computer representation of the conditions unique to minimally invasive surgery. The approximation of tissues is a surgical manipulation that requires hand-eye coordination and practice to assure effective and efficient closure.[1] Open suturing, the conventional method, is practiced mostly in open surgery and in the emergency department; laparoscopic suturing is not routinely practiced unless skills labs are available. Proficiency standards for suturing have not been established by experienced surgeons for most commercially available simulators. For example, box trainers lack consistent scoring metrics, as they require users to manually report their errors, which results in only rudimentary evaluations. Other media that attempt to replicate intra-corporeal suturing include computer-based surgical simulators, which often compromise the realism of suture interactions and lack haptic interfaces. Even with more sophisticated metrics and assessment methods, current simulators neglect to provide real-time feedback beyond traditional text-based reports.

Tools and Methods

Our suturing trainer is built on SPRING[2], an open-source, real-time, cross-platform surgical simulator with haptic capability. SPRING's immersive realism is augmented by its compatibility with multiple haptic devices, including bimanual interfaces.

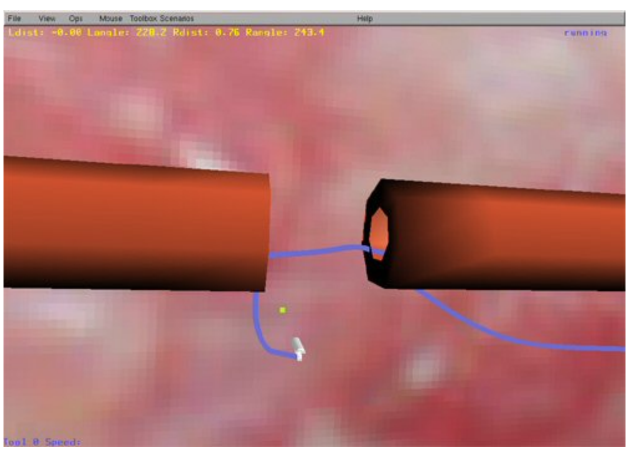

Figure 1. Snapshot of a suturing procedure in SPRING.

We have implemented several novel features, such as advanced visco-elastic tissue properties, realistic object models, and standardized metrics. The instruments were modeled using Autodesk Inventor and utilize techniques such as smooth shading and reduced polygonal counts for streamlined computation. We also provide relevant feedback options, including workflow diagrams, haptic force, audio feedback, and video capture and editing methods, designed to accelerate learning. Brief background demographics collected upon initial

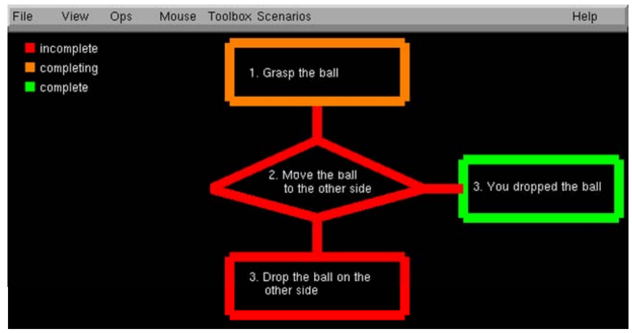

Figure 2. Sample workflow diagrams in SPRING.

login and sporadic terminal surveys are stored in MySQL databases and used to facilitate the interpretation of relevant user data. All of these features are unique to computer-based simulators and contribute to the efficacy of the SPRING suturing trainer.

Results

Performance assessment and improvement among resident and attending physicians is used to evaluate our trainer. Proficiency scoring[3] is based on an implementation of *R*, an open-source statistical modeling application[4], and several metrics, including error recognition and correction, navigation of instrument routes, frequency and severity of tissue damage, and number of attempts required to complete various tasks and manipulations. The trainer's efficacy is determined through quantitative comparisons of performance between novice and experienced surgeons. We also assess the potential benefits of individual and combined feedback options on suturing proficiency. Administrators are able to track user performance and make comparisons among user groups based on survey demographics acquired upon login.

Conclusions/Discussion

The SPRING suturing trainer possesses learning advantages as a consequence of its extensive incorporation of dynamic feedback and detailed metrics. We believe that the SPRING trainer has potential as a valuable tool for learning and maintaining skills through practice and in enabling users to gauge and compare their proficiency over time with intra-corporeal suturing, which is one of the most difficult videoendoscopic manipulations.

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