ACS 2026 Surgeons and Engineers: A Dialogue on Surgical Simulation

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Challenges in Surgical Education

Enhancing Fundamentals of Laparoscopic Surgery (FLS) Training with Vision and Infrared Camera-Based 3D Tracking

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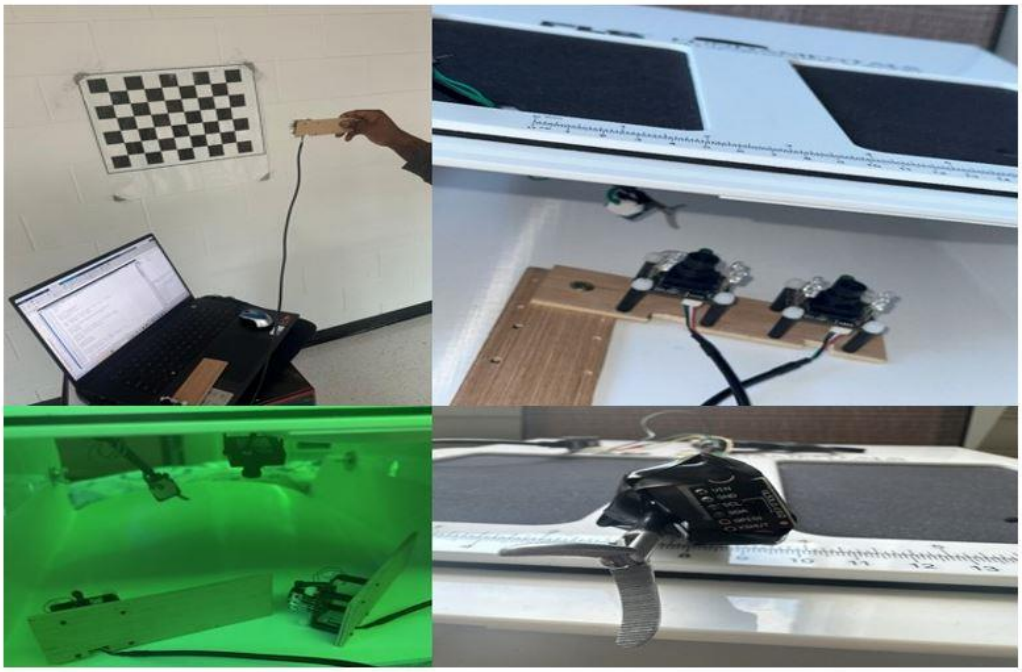
Background: The Fundamentals of Laparoscopic Surgery (FLS) program is a standardized, proficiency-based curriculum designed to develop and assess core laparoscopic skills through task trainers and validated performance metrics. While these trainers provide essential psychomotor skill development, current evaluation methods often rely on subjective observation or limited scoring systems, which can lack spatial precision. There is a growing need for supplemental technologies that can deliver objective, high-resolution performance feedback to enhance skill acquisition and retention.

Current Challenges: Existing FLS training systems do not typically capture fine-grained spatial performance data such as instrument tip trajectories, path lengths, and motion smoothness in real time. Without detailed motion analysis, it can be difficult for trainees to pinpoint inefficiencies or errors in their technique, and instructors may have limited data for targeted coaching.

Need of Innovation: We have developed a low-cost, vision and infrared camera-based 3D tracking system to integrate with FLS task trainers. The system uses laser ranging, stereo vision, and probe-based tracking to precisely map instrument movement within the trainer workspace. MATLAB-based processing enables depth mapping, 3D reconstruction, and map matching to generate quantitative performance metrics such as motion path accuracy, efficiency, and precision. By providing objective, spatially accurate feedback, this technology can augment FLS training by identifying subtle errors, quantifying performance improvements, and enabling data-driven instruction. This approach supports modular and accessible enhancements to surgical task training without altering the core FLS curriculum, making it suitable for both high-resource and resource-limited training environments.



Top Left: Checkerboard Collaboration with One Stereovision Camera

Top Right: Modified Laparoscopic Surgery Training System with Stereovision Cameras

Bottom Left: Laparoscopic Surgery Training System with Disposable Graspers, Sensor, and Stereovision Cameras

Bottom Right: Disposable Graspers with Mechanical Design for the Infrared Laser Ranging Sensor (VL53L0X) Attached