Virtual ACS 2021 Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting

Research In-Progress

Machine Learning and Mixed Reality Surgical Simulator for Autonomous Instructional Guidance and Performance Assessment

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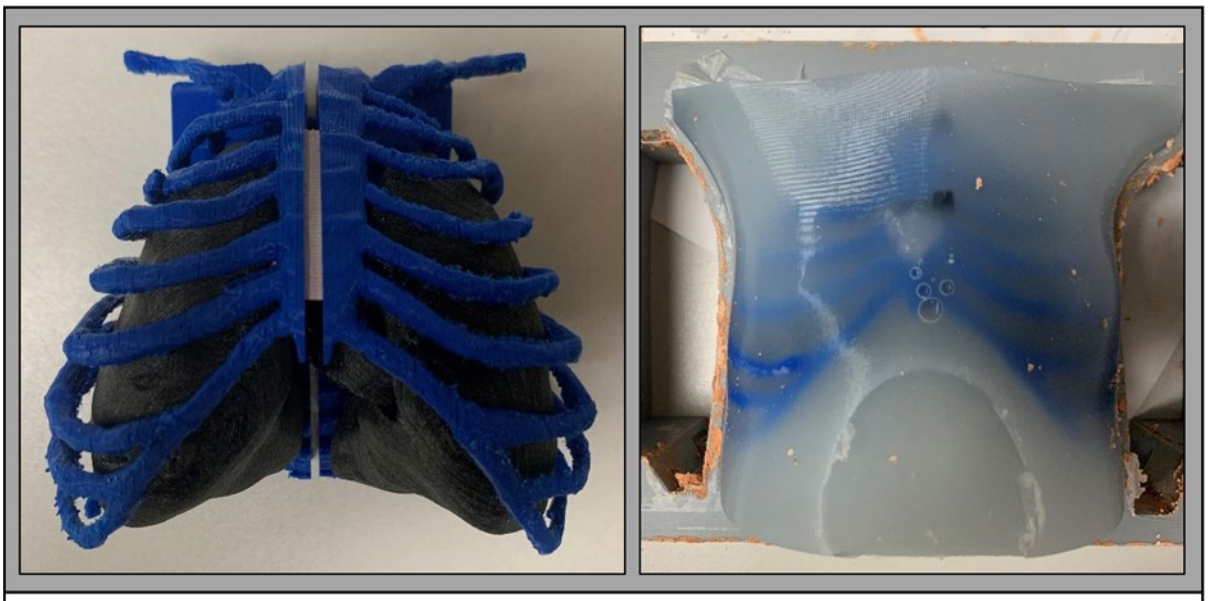
Introduction: Interactive instructional feedback and performance assessment of learners during surgical simulation and training are effective to increase patient safety, but they are long, subjective, difficult, expensive, and instructor-heavy tasks. The goal of this project is to develop a fully-autonomous training system that will be able to provide precise, accurate, and real-time instructional coaching, as well as objectively measure learners' skill performance using a combination of machine learning (ML) and mixed reality (MR) technologies. As a proof of concept, the simulator will be applied for teaching neonate thoracentesis and pericardiocentesis, which are rare but complex life-threatening procedures.

Methods: Based on MRI and CT scans of real patients, a virtual 3D anatomical model has been designed and used to create a manikin using 3D printing technology. The flexible organs (pleura, collapsed lung, and heart) and rigid bony structures (ribcage and spine), have been encased in flexible silicone to simulate the skin and underlying soft tissue. A software application is currently being developed for combing real and virtual 3D patient anatomy and surgical instruments in a mixed reality environment. Trainees' actions during surgical training are determined by tracking and storing the 3D positions and orientations of multiple surgical instruments with an NDI DriveBay electromagnetic system.

Preliminary Results: The flexible 3D printed organs allow for realistic ultrasound-assisted needle insertion. A preliminary evaluation and content validation about anatomical details, realism of ultrasound guidance, and tactile feedback have been provided by Pediatrics surgeons, experts in performing and teaching these surgical procedures.

Next Steps: The captured tracking motion data will be used to train a recursive neural network to detect and classify the execution of the different surgical steps being performed by experts and novices during the simulated surgical procedures, and in-turn provide relevant instructional guidance and valuable feedback about the trainees' surgical skills.



Left image: 3D-printed models of flexible lungs and pleura, and rigid ribcage.
Right image: Flexible silicone enclosing the 3D printed neonate anatomy.