

Scientific Keynote

Digital convergence: multi-material phantoms for the validation of surgical micro-robotics

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As the field of minimally invasive surgery shifts toward the micro-scale, the gap between digital robotic design and clinical validation has become a primary bottleneck. Traditional benchtop testing often relies on simplified synthetic models or inconsistent porcine tissue, neither of which fully captures the nuanced haptic and structural complexities of human anatomy. This keynote explores the frontier of Bio-Digital Convergence, focusing on the development of high-fidelity, 3D-printed multi-material phantoms as a definitive validation platform for surgical micro-robotics. We present a collaborative framework for translating patient-specific imaging data into sophisticated physical models that mimic the heterogeneous mechanical properties of biological tissue. By utilizing advanced multi-material additive manufacturing, we have engineered phantoms that simulate varying physical properties—ranging from rigid bone structures to compliant vascular networks—within a single integrated print. By converging additive manufacturing with robotic engineering, we can create a "digital twin" of the surgical theater, providing a repeatable, ethical, and highly accurate environment for the next generation of precision medicine.



Prof. Jack Stubbs studied Physics and Electro-Optics at the Miami University of Ohio and the University of Dayton (Ohio). In the 1980's he worked with the Department of Defense at Wright Patterson Airforce Base, the Naval Weapons Center and Kirtland Airforce Base. This work included development of customized Optical Metrology system to characterize High Energy lasers for application to the Airborne Laser Lab and the Star Wars SDI Laser system. Additionally, he became involved in pilot protection, advanced cockpit control and materials characterization. In the 1990's, Jack lead a Technology development team for Ethicon Endo Surgery in the scale up of Laparoscopic surgery, implementing imaging, visualization, robotics and sensors to Surgical Operating. This led to the appointment of Principal Investigator for the Surgical Operating Room of the Future with the Defense Advanced Research Projects Agency, developing telepresence surgical robotics and computer-based simulation systems for training and education. Jack founded and directed a research and development company in 1996, operating through 2010 that resulted in over 50 patents including the Airseal trocar for laparoscopic surgery. This is now the trocar of choice for robotic surgery having been used in over 1,00,000 surgeries globally. The last 9 years have been at the University of Minnesota Medical School and most recently the University of Central Florida Institute for Simulation and Training where he leads a team developing new approaches and technology for simulating and teaching healthcare interactions and procedures. He has used rapid prototyping, 3D printing and additive manufacturing since the mid 1990's to improve designs, prototype and test devices and systems and to implement into a cost-effective development model. Jack Co-founded (2020) and is President/Ceo of Digital Anatomy Simulations for Healthcare LLC. (DASH). Working with hospitals, Simulation labs and medical device companies, we are helping to push the applications of 3D printing in the medical field.