Training Simulation Models

New Virtual Tissue Modeling for Use in Military Medical Training Simulators

Combat surgeons deal with horrific injuries rarely seen in civilian trauma centers. Major barriers to controlling intra-abdominal hemorrhage in solid organs, mainly the liver, lead to serious mortality and morbidity from combat injuries. Researchers at the University of California, Los Angeles (UCLA: Los Angeles, California) are developing and evaluating a new virtual tissue modeling methodology for use in military medical training simulators for forward surgical and interventional care of combat injuries. Researchers at the Massachusetts General Hospital (Boston, Massachusetts) developed a mathematical framework that allows model parameter determination in soft tissues with fluid-filled vessels (*Kerdok et al. 2003, Kerdok, Ottensmeyer, and Howe 2006, Konofagou et al. 2004, Ottensmeyer 2002*). This prior work relative to models of the cardiovascular system, organ models for heart and lung, numerical methods for real-time interaction, constitutive tissue modeling, tissue property measurement, and full body anatomic models will be leveraged to create a virtual tissue framework for use in surgical training simulators.

During FY17, the research at UCLA has focused on the development of the constitutive model of the liver as a porous multi-species medium. This model consists of an elastic surface membrane, a hyperelastic bulk interior, embedded elastic vascular, as well as a porous fluid matrix. Furthermore, this model can be simulated with considerable flexibility to topological change and extreme deformation. In response to simulated traumatic injuries, an excision tool was developed which allows for simulated surgical manipulation. To improve the accuracy of a virtual liver model, additional research is scheduled to build up the perfusion system and collect data from ex vivo perfused liver and sectioned liver samples. Real-time deformations will be computed via a machine learning platform.

In conclusion, high fidelity training simulators will enable more pre-deployment opportunities for training under more realistic conditions and cases.

This research was funded by Defense Medical Research and Development Program, and is strategically aligned with Medical Simulation and Information Systems Research Program (MSISRP). This award (W81XWH-15-1-0147) is managed by Congressionally Directed Medical Research Programs.

REFERENCES:

Kerdok, A. E., Cotin, S. M., Ottensmeyer, M. P., Galea, A. M., Howe, R. D., and Dawson, S. L. 2003. "Truth Cube: Establishing Physical Standards for Soft Tissue Simulation." Med Image Anal 7 (3):283-91.

Kerdok, A. E., Ottensmeyer, M. P., and Howe, R. D. 2006. "Effects of Perfusion on the Viscoelastic Characteristics of Liver." J Biomech 39 (12):2221-31. doi: 10.1016/j.jbiomech.2005.07.005.

Konofagou, E. E., Ottensmeyer, M., Agabian, S., Dawson, S. L., and Hynynen, K. 2004. "Estimating Localized Oscillatory Tissue Motion for Assessment of the Underlying Mechanical Modulus." Ultrasonics 42 (1-9):951-6. doi: 10.1016/j.ultras.2003.12.001.

Ottensmeyer, M. 2002. "TeMPeST I-D: An Instrument for Measuring Solid Organ Soft Tissue Properties." Experimental Techniques 26 (3):48-50.