Surgical Tool Development

Load Transducer Engineering Solutions for Ultrasound and Surgical Tool Integration and a Functional Web-based Data Management and Querying System to Support Reference Models for Musculoskeletal Tissue Layers

Engineers at the Cleveland Clinic (Cleveland, OH) developed an instrumentation strategy to integrate a load transducer into any ultrasound system for freehand measurement of probe forces during imaging (*Schimmoeller et al., 2019*). An ultrasound system instrumented with a load transducer provides the capability to measure internal deformations of organs as a function of external loading. This tool helps quantify anatomical and mechanical variations of multi-layer tissues of musculoskeletal extremities, which are used for development of models for surgical simulations and can be leveraged to design protective gear for musculoskeletal extremities.

In demonstration of this functionality, an ultrasound system with an integrated load transducer was used to characterize the skin, fat, and muscle thickness of 100 human volunteers at multiple sites along the legs and arms (*Neumann et al., 2018*). Tissue thicknesses were measured under two conditions: unloaded (minimal force applied) and loaded (at a rate greater than 1 N/second). The data were used to create a database of anthropomorphic measurements, toward a broader goal of establishing a reference set of finite element representations of the non-linear mechanics for multi-layer tissue structures.

To organize and publicly disseminate the data, the researchers developed a web-based data management and querying system (https://multisbeta.stanford.edu/).

The instrumentation strategy designed for the ultrasound system has been extended to surgical tools to quantify forces of fundamental surgical acts (*Schimmoeller et al., 2018*). Ongoing experimentation and model development efforts, and additional data and models can be accessed through the public project site at https://simtk.org/projects/multis.

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