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Computation-Enhanced Surgery and Intervention: An Engineering Exemplar in Translation

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While modern medical imaging coupled to contemporary image processing and informatics has allowed for dramatic expansions of diagnostic information, similar advances in procedural medicine have lagged due to systematic barriers associated with conventional practice and clinical translational research. The work in this presentation paints a different picture where surgery and intervention advancements no longer represent fragmented injections of technology to advance focal capabilities. Rather, the assertion in this talk is that technology treatment platforms of the future will be intentionally designed for the dual purpose of treatment and discovery. As an exemplar, a platform technology is presented that translates complex biophysical models represented by large systems of equations from predictive roles to ones that are integrated to guide therapeutic applications such as tissue resection and locoregional intervention. The work then goes on to suggest the use of quantitative, biomarker image-data driven forecasting as a means to harness phenotypic presentation of disease for improving therapy application and potentially outcome. Throughout the work, the common thread that ties the approaches together is the concept of biophysical models serving as a constraining scaffold for sparse therapeutic & surgical/interventional data which when of sufficient strength enables a functional purpose greater than the sum of contributing data. This blend of model, therapy mechanism, phenotypic presentation, and therapeutic control as described typifies one realization of these intraprocedural technology platforms designed for treatment and discovery. Finally, the talk will conclude by looking at the impact on the field of biomedical engineering as well as paradigms being investigated to codify training.

Michael I. Miga, Ph.D. received his B.S. and M.S. from the University of Rhode Island in Mechanical Engineering and Applied Mechanics, respectively. He received his Ph.D. from Dartmouth College specializing in biomedical engineering. He joined the faculty in the Department of Biomedical Engineering at Vanderbilt University in 2001 and is currently the Harvie Branscomb Professor at Vanderbilt. He is a Professor of Biomedical Engineering, Radiology and Radiological Sciences, Neurological Surgery, and Otolaryngology. He is director of the Biomedical Modeling Laboratory, and co-founder of the Vanderbilt Institute for Surgery and Engineering (VISE, www.vanderbilt.edu/vise). He has been PI on several NIH grants concerned with image-guided brain, liver, kidney, and breast surgery. He is also PI and Director of a novel NIH T32 training program entitled, 'Training Program for Innovative Engineering Research in Surgery and Intervention' that is focused on the creation of translational technologies for treatment and discovery in surgery and intervention. He also was a co-inventor of the first FDA cleared image guided liver surgery system. Dr. Miga is an AIMBE and SPIE Fellow and has served as a charter member of the Biomedical Imaging Technology (BMIT-B) and the Bioengineering, Technology, and Surgical Sciences (BTSS) Study Sections at the National Institutes of Health from 2010-2014, and 2017-2021, respectively. His research interests are in the fields of computational modeling, inverse problems/computational imaging, soft-tissue biomechanics/biotransport, technology-guided therapy, image/imaging-guided surgery and intervention, and data-driven procedural medicine.

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