INDUSTRIAL & SYSTEMS ENGINEERING
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MECHANICAL ENGINEERING
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ME/ISE SEMINAR: Luigi Perotti, Ph.D.

Modeling Cardiac Mechanics and Electrophysiology

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Heart failure (HF) is a leading cause of death in developed countries, yet its underlying mechanisms are not well understood. This lack of understanding limits our ability to diagnose the onset of HF and to identify effective therapies. In this context, computational models are able to interpret patient specific experimental data, expose the causal factors of HF, and provide insights into interventional and pharmacological therapies.

First we present a new framework to identify changes in the material properties of passive myocardium, which underlie several forms of heart disease. This novel approach is based on clinical data that can be acquired routinely for HF patients, is formulated in finite kinematics, and results in unique material properties that, as a result, can be used as diagnostic markers. We validate our approach using in silico generated data and present a new strategy to formulate material laws that optimally describe available experiments and can be applied to future in vivo data.

Cardiac dysfunction is related not only to changes in the myocardium mechanical response but also to compromised cardiac electrical activity. In the second part of my talk I will discuss our validated electrophysiology model of a rabbit heart to study the risk of ventricular fibrillation (VF) in patients affected by congestive HF. Our multiscale model is based on an anatomically accurate heart geometry obtained from MRI, fiber directions obtained from DTMRI, a Purkinje activation network, and experimentally based ionic cellular models. This computational model led to the discovery of a new mechanism for the onset of VF and can be employed for studying interventional and pharmacological therapies.

Luigi Perotti received his Laurea (B.S./M.S.) degree in Civil Engineering from Politecnico di Milano, Italy, in 2004. Subsequently he continued his studies in Mechanical Engineering at the California Institute of Technology where he received his M.S. in 2006 and his Ph.D. with a minor in Applied and Computational Mathematics in 2011. During his Ph.D. research he worked in Dr. Ortiz's group on developing new finite elements and mesh-free methods for plates and shells and on modeling the response of fiber composite sandwich structures to underwater explosions. At the end of 2011, he joined Dr. Klug’s group in the Mechanical and Aerospace Engineering department at UCLA to pursue his research interests in biomechanics. Since then he has worked on several multidisciplinary projects involving collaborations across the Departments of Physics, Bioengineering, Radiology, and the School of Medicine to study both the assembly and maturation of viral capsids, and cardiac mechanics and electrophysiology using computational and continuum mechanics models. In 2014 he received the American Heart Association postdoctoral fellowship and joined Dr. Ennis' group in the Bioengineering and Radiological Sciences departments at UCLA to develop advanced methods for evaluating cardiac mechanics of the failing heart.