15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Plenary Lecture

MULTI-RESOLUTION GEOMETRIC MODELS OF THE MITRAL HEART VALVE

Michael Sacks

Center for Cardiovascular Simulation, Department of Biomedical Engineering
The University of Texas at Austin, United States
mssacks@icloud.com

Keywords: Heart Function, Mitral Valve, Computational Simulations

Summary: An essential element of the heart function, the mitral valve (MV) ensures proper directional blood flow between the left heart chambers. Over the past two decades, computational simulations have made marked advancements towards providing powerful predictive tools to better understand valvular function and improve treatments for MV disease. However, challenges remain in the development of robust means for the quantification and representation of MV leaflet geometry. In this study, we present a novel modeling pipeline to quantitatively characterize and represent MV leaflet surface geometry. Our methodology utilized a two-part additive decomposition of the MV geometric features to decouple the macro-level general leaflet shape descriptors from the leaflet fine-scale features. First, the general shapes of five ovine MV leaflets were modeled using superquadric surfaces. Second, the finer-scale geometric details were captured, quantified, and reconstructed via a 2D Fourier analysis with an additional sparsity constraint. This spectral approach allowed us to easily control the level of geometric details in the reconstructed geometry. The results revealed that our methodology provided a robust and accurate approach to develop MV-specific models with an adjustable level of spatial resolution and geometric detail. Such fully customizable models provide the necessary means to perform computational simulations of the MV in a range of geometric detail, allowing identification of the complexity required to achieve predictive MV simulations to a desired accuracy level. We then extend these approaches to develop novel in-vivo methods for patient specific model development.