Department of Structural Engineering
University of California, San Diego
Computational Mechanics Seminar Series

Professor Ming-Chen Hsu
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Iowa State University

"An Immersogeometric Framework for Patient - Specific Heart Valve Design and Analysis"

Tuesday, January 17, 2017
Seminar, 1:30 pm - 2:30 pm, SME Building, Room 248
Reception, 1:00pm - 1:30pm, SME Building, 2nd Floor Patio

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Abstract

In this work, we present a framework for designing patient-specific bioprosthetic heart valves using recently proposed isogeometric analysis based parametric design platform and immersogeometric fluid–structure interaction (FSI) analysis. The patient-specific aortic root geometry is reconstructed from the medical image data and is represented using non-uniform rational B-splines. We then parametrically design prosthetic heart valves based on the aortic root, using a Rhino/Grasshopper-based interactive geometric design platform. Due to the complex motion of the heart valve leaflets, the blood flow domain undergoes large deformations, including changes of topology. The FSI simulations are carried out using our hybrid immersogeometric/arbitrary Lagrangian–Eulerian methodology, which allows us to efficiently perform a computation that combines a boundary-fitted, deforming-mesh treatment of the artery with a non-boundary-fitted treatment of the leaflets. We simulate the coupling of the deforming, patient-specific aortic root and parametrically designed heart valves, and the surrounding blood flow under physiological conditions through several cardiac cycles. The attachment edge of the leaflet is coupled with the arterial wall motion using a penalty formulation. The results demonstrate the effectiveness of the proposed framework in practical computations with greater levels of physical realism. A parametric study is carried out to investigate the influence of the geometry on heart valve performance, indicated by the effective orifice area during the opening and the coaptation area during the closing. Finally, the simulation

result for the best-performed heart valve is compared with the phase-contrast MRI data to demonstrate the qualitative similarity of the flow patterns in the ascending aorta.

Biography

Dr. Ming-Chen Hsu is an Assistant Professor of Mechanical Engineering at Iowa State University, where his work focuses on computational mechanics and fluid–structure interaction with an emphasis on contemporary engineering problems, such as wind turbine analysis and biomedical application. He received his B.S. (2003) and M.S. (2005) degrees in Engineering Science and Ocean Engineering from National Taiwan University, and his M.S.E. (2008) degree in Engineering Mechanics from the University of Texas at Austin. He earned his Ph.D. Degree in Structural Engineering from University of California, San Diego in 2012. He was a postdoctoral fellow at the Institute for Computational Engineering and Sciences (ICES) before he joined Iowa State University in Fall 2013. He was recently identified as Highly Cited Researchers 2016 by Thomson Reuters for the period 2004 through 2014.

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Sponsored by Professor Yuri Bazilevs
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