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Information Mining and Design Through Physics-Based Models

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Abstract: Inverse and design problems arise in many applications in science and engineering. Inverse problems arise when we need to infer hidden characteristics of a system from partial/imperfect observation. Design problems are similar to inverse problems in the sense that we want to determine the characteristics of a system that would achieve a desired performance. Inverse and design problems share many common elements and can be addressed through a common PDE- constrained optimization framework. I will discuss our ongoing work on computational techniques for inverse and design problems. I will present general formulations based on optimization with PDE-constraints (e.g. boundary-value problems) as well as general software development strategies amenable to general, large-scale inverse and design problems. We will discuss applications related to medical diagnosis using ultrasound vibrometry, design of neutrally-buoyant acoustic cloaks, and materials design in elastodynamics.

Biographical Sketch: Dr. Aquino is a professor in the Department of Civil and Environmental Engineering at Duke University. Before joining Duke in January 2012, he spent 8 years at Cornell University as an Assistant and Associate Professor in the School of Civil and Environmental Engineering. At Cornell, he was also a member of the fields of Applied Mathematics, Theoretical and Applied Mechanics, and Computational Science and Engineering. His research interests encompass computational mechanics (in general), inverse problems in engineering and biomedicine, numerical optimization, and scientific computing, among others. His current research projects include the development of inverse problem techniques for noninvasively characterizing the mechanical properties of arterial vessels and the heart wall from ultrasound imaging methods; the development of stochastic reduced-order models in the context of stochastic inverse problems; and the development of fast algorithms for near-real time source identification, among others.

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