IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Engineering Robotic Biological Systems

Amor A. Menezes
University of California, Berkeley
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Abstract
Biological processes engineered for autonomous, on-line decision-making and control will transform medicine, science, and industry. For instance, optimizing and regulating biological system behavior can counteract pathological conditions such as tumor genesis, while providing personalized, targeted approaches to treatment. Similarly, cell-based genetic control systems can overcome the detrimental effects of host physiology variability and mutation-induced genetic circuit instability to ensure production-level constancy of a desired output like isobutanol, a next-generation biofuel. In this talk, I will discuss my efforts to achieve this vision of SYBORGS, which are SYnthetic/SYstems Biological Optimization, Regulation or Generation Systems, by: 1) applying systems engineering approaches to various biological processes to yield novel mechanistic insights and accomplish new capabilities, and 2) moving away from a paradigm of “biology-in-the-loop” control, where electro-mechanical components externally regulate biological signals, towards one of biologically-integrated controllers. First, I demonstrate how a control-oriented dynamical system can answer four outstanding challenges in the clinical care of trauma coagulation, which are mechanism characterization, treatment personalization, rapid data provision, and dimension reduction. Next, I describe how cell-based genetic modules capable of performing regulation and optimization for synthetic biology can be developed. Thereafter, I highlight how my work capturing evolution in dynamic environments as a tunable stochastic optimization process suggests a rationale of efficient search, with controllable responsiveness trade-offs that impact the synthetic biology technique of directed evolution. Finally, I showcase future venues and development directions for robotic biological systems, including in emerging markets such as space synthetic biology, which I recently characterized.

Biography
Amor Menezes is a Postdoctoral Scholar in the California Institute for Quantitative Biosciences at the University of California, Berkeley. He previously was a Research Fellow between 2010 and 2011 in the Department of Aerospace Engineering at the University of Michigan, where he received a Ph.D. degree as an NSERC Post-Graduate Scholar and Michigan Teaching Fellow in 2010, and a Master of Science in Engineering degree as a Milo E. Oliphant Fellow in 2006. He graduated from the University of Waterloo in 2005 with a Bachelor of Applied Science degree in Mechanical Engineering with Distinction, Dean's Honors (i.e., top 10%), and the Sandford Fleming Co-op Medal. Dr. Menezes' research interests include the theory and application of control systems principles in synthetic and systems biology, and also stochastic optimization, evolutionary computation and the feedback control of novel dynamical systems. He was a guest editor for *Robotica* in 2011. He is a 2015 fellow of the Synthetic Biology Leadership Excellence Accelerator Program in recognition of his efforts to enable the practical application of synthetic biology to space.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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