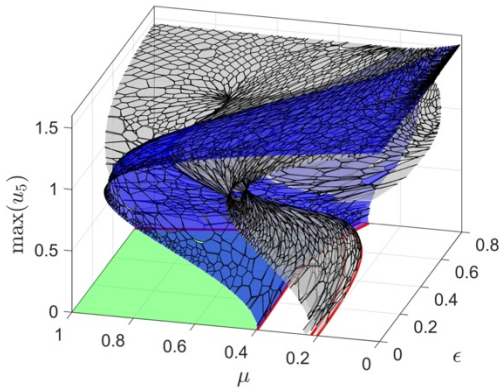
Design of Self-Excited Oscillator Networks as Nonlinear Dynamic Sensors

Harry Dankowicz
The Grainger College of Engineering
University of Illinois at Urbana-Champaign
E-mail: danko@illinois.edu

This keynote discusses sensor design ideas developed in the context of networks of coupled linear and nonlinear oscillators of arbitrary topology. As an example, it presents a hysteretic sensor design, in which short bursts of exogenous excitation result in sustained endogenous network activity that returns to a quiescent state only after a characteristic time and along a different path than when originally excited. The desired behavior is obtained through the coupling of self-excited oscillations with purposely designed rate laws for slowly varying nodal parameters, governed only by local interactions in the network. The proposed architecture and the sought dynamics take inspiration from complex biological systems that combine endogenous energy sources with a paradigm for distributed sensing and information processing. As a second example, a hybrid realization of a mass sensor is presented, in which the dynamics of a physical cantilever are coupled asynchronously with a nonlinear oscillator realized in a simulation model. An iterative algorithm ensures that the dynamics in the asymptotic limit mimics self-excited oscillations of a nonlinear oscillator network, while eliminating any effects of distortion from actuator latency. The use of parameter continuation techniques in the associated bifurcation analysis and design validation is illustrated using the open-source package COCO.



Bio-sketch of H. Dankowicz

Harry Dankowicz is Professor of Mechanical Science and Engineering in The Grainger College of Engineering at the University of Illinois at Urbana-Champaign. He graduated from KTH Royal Institute of Technology in Stockholm, Sweden, with an M.Sc. in Engineering Physics in 1991 and from Cornell University with a Ph.D. in Theoretical and Applied Mechanics in 1995. Following postdoctoral and research associate appointments at KTH between 1995 and 1999, he joined the Department of Engineering Science and Mechanics at Virginia Polytechnic Institute and State University, where he remained until 2005. Since May 2021, he is Program Director for the Dynamics, Control and Systems Diagnostics Program in the Division of Civil, Mechanical and Manufacturing Innovation at the National Science Foundation. Prof. Dankowicz is a recipient of a Junior Investigator Grant from the Swedish Foundation for Strategic Research and CAREER and PECASE awards from the US National Science Foundation, a Fellow of the ASME, and a recipient of the Fred Merryfield Design Award and Archie Higdon Distinguished Educator Award from the ASEE. In fall 2022, he concluded a ten-year term as Editor-in-Chief of ASME Applied Mechanics Reviews.