MECHANICAL ENGINEERING
PH.D. DISSERTATION DEFENSE SEMINAR

Digital Twin Enabled Collective Sensing and Steering for Source Determination Problems

Derek Hollenbeck
Mechanical Engineering
University of California, Merced

ABSTRACT

Motivated by climate change and the global warming potential of methane (86 times more potent than CO2), this dissertation focuses on the source determination problem using collective sensing and Digital Twins. Recently, Digital Twins have been developed to provide better performance assessment, fault prognosis and predict future behavior of complex systems. The term `collective', refers to the group of mobile sensors that, as a whole, provide more information than a single mobile sensor can. The mitigation of methane emissions into the atmosphere is important to focus on in reducing the effects of global warming in the near term. In order to mitigate emissions, the leaks have to first be detected and assessed before they can be repaired. Many of these emissions can be modeled as a point source governed by partial differential equations (PDE), which, solutions are typically time-stepped into the future (i.e. the forward problem). In many cases, the emission plume is subject to turbulence which requires the use of turbulence models, such as large eddy simulations (LES), to compute. In both cases, the computational requirements and run-time can prevent real-time or near real-time analysis. Considering hybrid modeling approaches (e.g. deterministic and stochastic), the forward behavior matched Digital Twin model can be computed in near-real time and used for improving emission quantification methodologies as well as perform optimization (e.g. sensor placement and sensing / actuation policy). The dissertation is broken into four main parts: the first part is on source seeking based optimization using random search, collective foraging, Fluxotaxis, and Extremum Seeking Control; the second part is on the application of leak detection and quantification with sUAS (including: sensors, platforms, and methods) as well as controlled release and real world field campaigns; the third part is on Digital Twins (POSIM and MOABS/DT) and how to use them for environmental sensing, method development, and performance evaluation case studies; the last part is on the sensor placement problem and how the observability Gramian combined with Digital Twins, can be used for collective sensing and steering.

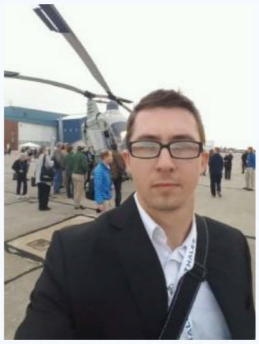
Schedule

Date: 4/27/2023
Time: 10:00 am- 11:00 am
Location: COB1 320
Zoom Link:
https://ucmerced.zoom.us/j/81212850366

More Information:

Derek Hollenbeck
dhollenbeck@ucmerced.edu

Faculty Advisor:
Prof. YangQuan Chen
ychen53@ucmerced.edu



BIOGRAPHY

Derek Hollenbeck is a Ph.D. candidate studying Mechanical Engineering at the University of California, Merced. He joined the Mechatronics Embedded Systems and Automation (MESA) Lab in 2016 as a graduate student after completing his B.S. in Mechanical Engineering at UC Merced. Derek has research interests in fluid mechanics, controls, and dynamics with applications in: small unmanned aerial systems (sUAS); methane leak detection/localization and quantification; fractional calculus; and cyber physical systems.

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