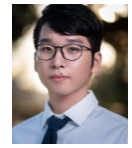
Texas Tech University
Department of Chemical Engineering
Seminar Series



Zhe Wu
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Machine Learning in Model Predictive Control, Operational Safety and Cybersecurity

Abstract
Machine learning is creating new paradigms and opportunities in the design of advanced process control systems for chemical processes. Traditionally, model predictive control (MPC), a constrained optimization-based control problem formulation that is the gold standard employed in advanced control of chemical processes, is formulated with linear data-based empirical models and is used to compute control actions to maintain optimal process operation while accounting for process and control actuator constraints. However, chemical processes are inherently nonlinear and often require nonlinear models in order to be controlled efficiently. Nonlinear first-principles process modeling provides a direct way for accounting for nonlinear process behavior in the control system design but it is cumbersome and difficult to implement in complex industrial processes which are not well-understood. Machine learning tools like recurrent neural networks and ensemble learning provide an efficient way to build nonlinear dynamic models from data that can be used in the model predictive control system, thereby improving control system performance and process operational safety. In addition to revealing nonlinear process relationships from data, machine learning tools can address classification problems such that the ones arising in diagnosing process faults and cyber-attacks, thus providing a broad array of topics where machine learning can make an impact.

In this talk, we will present our research work on the use of machine-learning tools in developing nonlinear model predictive control methods that ensure optimal control system performance and process operational safety, as well as establishing cybersecurity for nonlinear processes. Specifically, we will present: a) a machine-learning-based predictive control framework that integrates recurrent neural networks within MPC and utilizes ensemble learning and parallel computing for enhanced prediction accuracy and computational efficiency, b) machine-learning-based MPC structures for nonlinear processes, which address simultaneously closed-loop stability and performance, and ensure process operational safety in the sense of guaranteed avoidance of unsafe operating conditions, and c) a two-tier control architecture that uses a machine learning-based classification detector to ensure process robustness with respect to a broad set of cyber-attacks. Throughout the talk, we will present applications of our methods to chemical processes of industrial interest to demonstrate their applicability and performance in meeting next-generation industrial goals related to improving process economics, safety and cyber-security.

Bio
Zhe Wu received his B.S. in Control Science and Engineering from Zhejiang University, China in 2016 and he is currently a doctoral candidate in Chemical Engineering at the University of California, Los Angeles. His research interests are in the general area of process systems engineering with a focus on process dynamics, optimization and control as well as on data science and machine learning and their application to chemical engineering. His graduate research focuses on machine-learning-based model predictive control methods as well as the development of novel methods addressing process operational safety and cyber-security for nonlinear processes using machine-learning tools.

Mon. Jan 27th
3:00 pm
Livermore 101