Enhancing Cybersecurity of Chemical Process Control Systems

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Introduction

- Control system cybersecurity breaches have the potential to impact safety and economic performance
- Despite greater recognition of cyber threats to chemical processes, relatively few results have appeared regarding cyberattack-resilient control for chemical processes described by nonlinear dynamic models

Project Goals:

- Focusing on optimization-based control, seek to develop control-theoretic results which characterize the conditions required to guarantee cyberattack-resilience of nonlinear systems and next-generation manufacturing systems

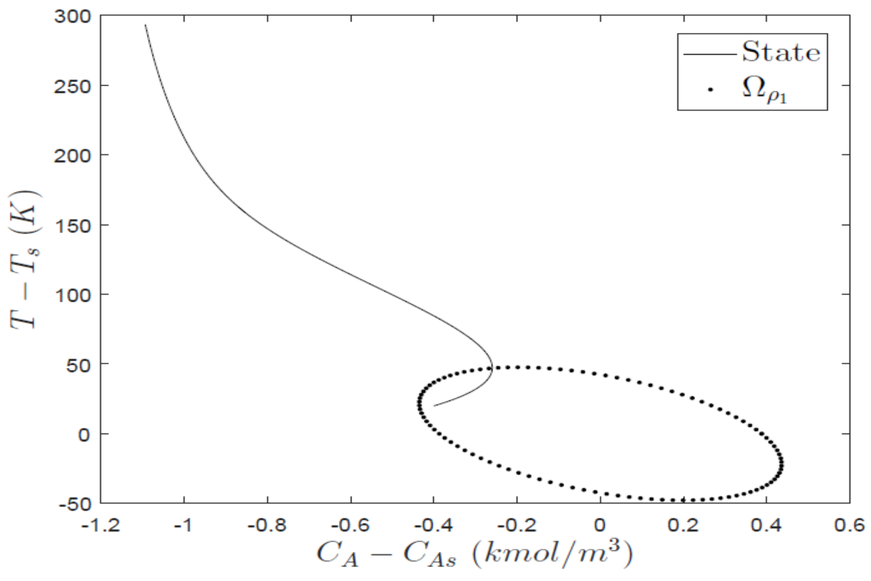

Figure 1. State-space plot for a continuous stirred tank reactor showing the closed-loop state driven out of a bounded region of operation by a cyberattack providing false state measurements to a model predictive controller [1].

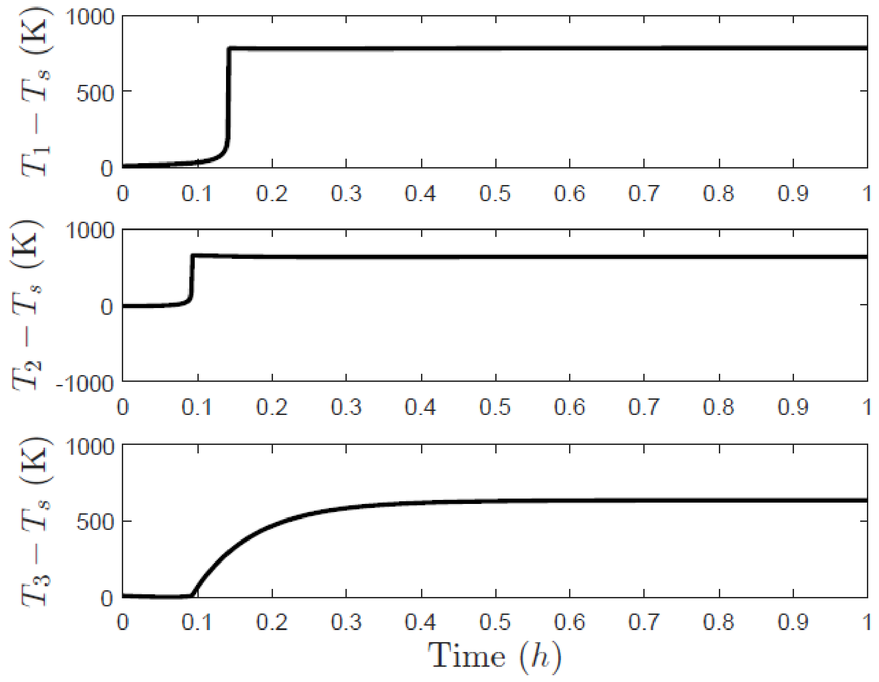

Figure 2. Temperature profiles in two continuous stirred tank reactors and a flash drum [2] (in deviation from the unstable steady-state value) when a cyberattack is performed providing the unstable steady-state as the state measurement at each sampling time to a model predictive controller [3].

Scientific Impact:

- Results will be developed for broad classes of nonlinear systems, allowing them to cross application domains

Solution:

- Combining control-theoretic results with detection and state estimation theory to develop cyberattack-resilient strategies for various attack types under sufficient conditions
- Develop novel strategies for enhancing intelligence of automated systems for advanced manufacturing, along with cyberattack protection methodologies
- Simulation-based demonstration and evaluation of proposed techniques in the context of chemical processes of various types

Societal Impacts:

- Enhanced production safety and production reliability
- Prevention of cyberattacks from harming US industries economically

Education and Outreach:

- Outreach to middle school students via participation in Wayne State's STEM Day
- Outreach via animated shorts teaching aspects of the research fundamentals

References:
[1] H. Durand. A nonlinear systems framework for cyberattack prevention for chemical process control systems. *Mathematics*, 6:44 pages, 2018.
[2] L. Lao, M. Ellis and P. D. Christofides. Proactive fault-tolerant model predictive control. *AIChE Journal*, 59:2810-2820, 2013.
[3] H. Durand. Process/equipment design implications for control system cybersecurity. *Proceedings of the Foundations of Computer-Aided Process Design Conference*, 263-268, Copper Mountain Resort, Colorado, 2019.

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