**Economic Model Predictive Control: Tracing a Path from Theory to Industrial Productization**

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**Abstract:**  Traditionally within process control, economic optimization of chemical processes has been addressed in a two-layer hierarchical architecture. In the upper layer, real-time optimization carries out economic optimization by computing optimal set-points using detailed nonlinear steady-state process models. These set-points are used by the lower layer feedback control systems to force the process to operate on these set-points. While this paradigm has been successful, we are witnessing an increasing need for dynamic market and demand-driven operations for more efficient operation, increasing response capability to changing customer demand (demand-response), and achieving real-time energy management. To enable next-generation market-driven operation, economic model predictive control (EMPC), which is an advanced predictive control technique formulated with an economically-oriented cost function, has ignited widespread interest within the control community. Owing to the unique ability of EMPC to integrate dynamic economic optimization of processes with feedback control, several application areas have been considered including the chemical process industries and energy systems, such as building HVAC systems.

In this talk, we share and discuss the last seven years of our work on EMPC that has spanned the full technology development process from early theoretical research to advanced development and industrial productization. Our work has covered theoretical analysis and computational methods and the development and deployment of an industrial EMPC system to various energy system applications. Specifically, we have developed: a) EMPC structures for nonlinear systems, which address infinite-time and finite-time closed-loop economic performance and time-varying economic considerations such as changing energy pricing; b) two-layer (hierarchical) dynamic economic process optimization and feedback control frameworks that incorporate EMPC with other control strategies allowing for computational efficiency; and c) EMPC schemes that account for real-time computation requirements. Our chemical process application studies, where we have applied our EMPC schemes and methodologies, have demonstrated the effectiveness of the EMPC schemes to maintain closed-loop stability and improve economic performance. Finally, we give a summary of key design concepts employed during our development of an industrial EMPC system for application on energy systems and share some of our success stories of deploying the EMPC system to several applications.

**Biography:**

Matthew Ellis received his B.S. degree in Chemical and Biological Engineering from the University of Wisconsin—Madison in 2010 and his Ph.D. degree in Chemical and Biomolecular Engineering from the University of California, Los Angeles in 2015. His graduate research focused on economic nonlinear model predictive control (EMPC) addressing the development of novel theory establishing closed-loop properties of nonlinear systems under EMPC, designing EMPC algorithms that are computationally efficient, and applying EMPC to numerous chemical process examples. Dr. Ellis’s graduate research resulted in numerous refereed publications and presentations including a co-authored monograph entitled Economic Model Predictive Control: Theory, Algorithms and Chemical Process Applications. Dr. Ellis was the recipient of the UCLA 2016 Outstanding Ph.D. Award in Chemical Engineering.

Dr. Ellis joined the advanced development team at Johnson Controls (JCI) after graduating from UCLA in 2015 where he co-designed and developed the core patent-pending EMPC algorithm used within JCI’s Central Plant Optimization product. Currently, he serves as the technical lead in extending this optimization-based control strategy to building-side HVAC systems. Dr. Ellis has also served as a technical reviewer for many major international control and chemical engineering journals such as AIChE Journal, Automatica, IEEE Transactions on Automatic Control, Journal of Process Control, and Journal of the Franklin Institute. His interests include model predictive control (MPC) and other advanced control algorithms, practical computational methods for real-time implementation of MPC, system/parameter identification, and cost/profit-driven control and automation algorithms for real-time applications.

**When: Thursday, January 17, 2019 at 4:00 pm**

**Where: CBEC 2228**