Dr. Qing Chang Manufacturing Research Focus

Dr. Chang's research has focused on improving sustainability and efficiency of smart manufacturing systems. She specializes in dynamic manufacturing system modeling and simulation, data-driven analysis, real-time production control and real-time energy management of manufacturing systems, and intelligent maintenance of manufacturing systems.

The industrial sector is entering its fourth revolution, characterized by a *merging of the internet and factories*. Dr. Chang's research group actively works to enhance the basic understandings of real-time performance of manufacturing processes and systems, and advance mathematical theory and computational algorithms that are sufficiently flexible and robust to deal with the complex nature of manufacturing processes and systems.

Event-Based Data-Driven Mathematical Modeling: this research develops an innovative data-driven stochastic manufacturing system model to describe production dynamics. The material/part flow in the manufacturing process is modeled as a continuous time networked dynamical system with stochastic disruptions (e.g., machine failures) and control input. The model addresses the interactions of robots loading/unloading and multi-stage processes, and the integration of the individual process and the system.

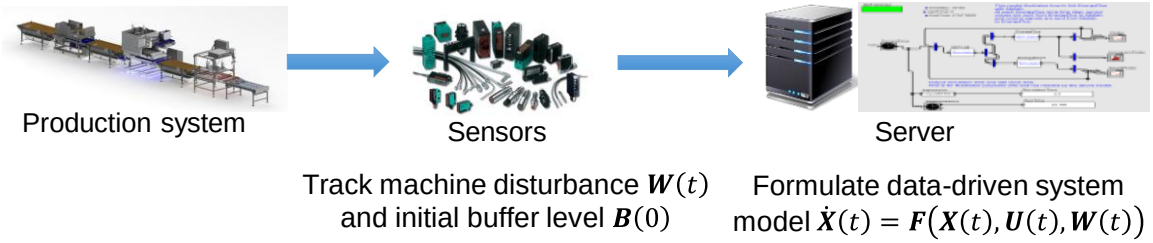

Figure 1: Event-Based Data-Driven Modeling

System Performance Diagnosis and Prognosis: the research has focused on developing data-driven diagnostic and prognostic methods to identify the causes of permanent production loss in both deterministic and stochastic scenarios. The methods integrate available sensor data with the knowledge of production system physical properties. Such methods can be transferred to a computer for system self-diagnosis/prognosis to enable a better understanding of the underlying relationships between system status and performance, and to facilitate real-time production control and decision making.

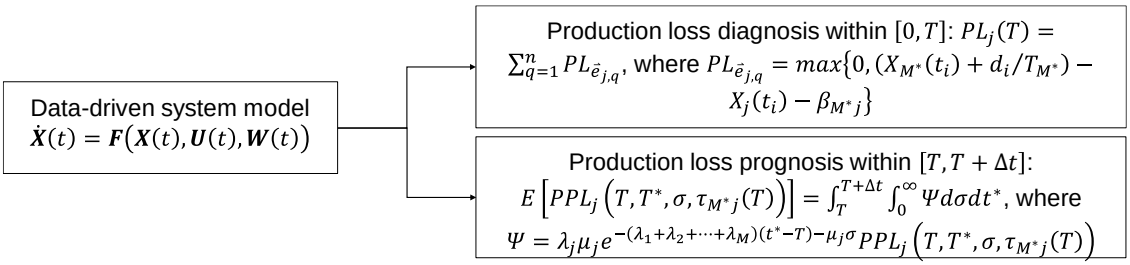

Figure 2: Real-time System Diagnosis and Prognosis

Theory and Algorithms for Real-time Control and Collaborative Decision Making: the group is working on establishing theory and developing automated real-time distributed control schemes to cope with the complex nature of manufacturing processes and systems. The problem is formalized as an online decision-making problem under uncertainty. A supervisory control architecture with partial decentralization is adopted.

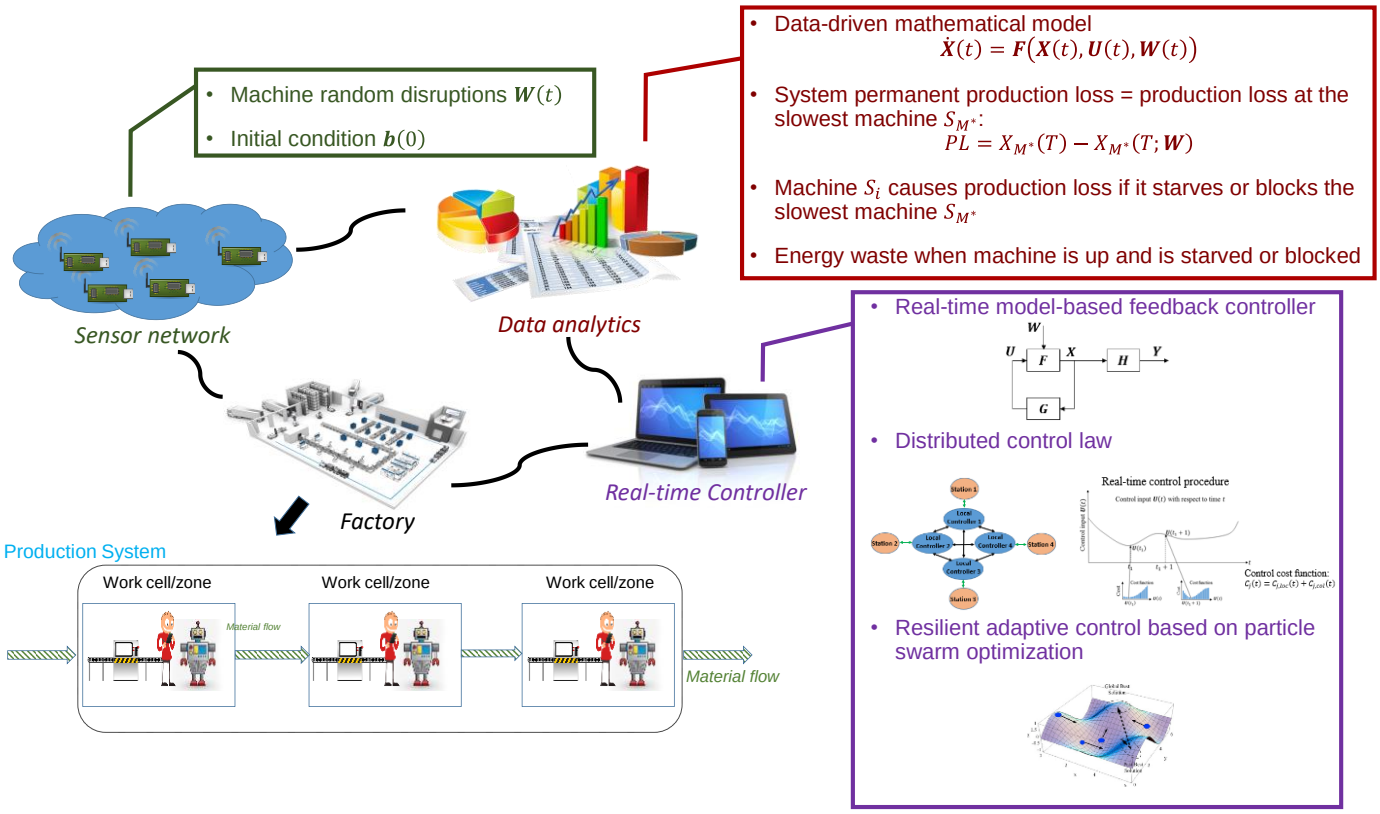

Figure 3: Smart Manufacturing System Real-time Control

Integrated Modeling & Control for Energy Efficient Manufacturing: real-time energy management of manufacturing systems is another line of the research efforts. The objective of this research is to combine sensor information processing and intelligent real-time control to coordinate production operations and HVAC systems to significantly improve energy efficiency in manufacturing facilities while maintaining desired production throughput and occupant comfort. The two largest energy consumers in a manufacturing facility: the production line and the HVAC system, are holistically considered and modeled. By joining these two systems, an integrated control scheme is developed to coordinate shut offs of certain machines without any throughput loss on the production line. These timed shut offs are called energy saving opportunity (ESO). The ESO for the production line are synced with the peak periods of energy demand for the HVAC system to optimize the energy cost savings.

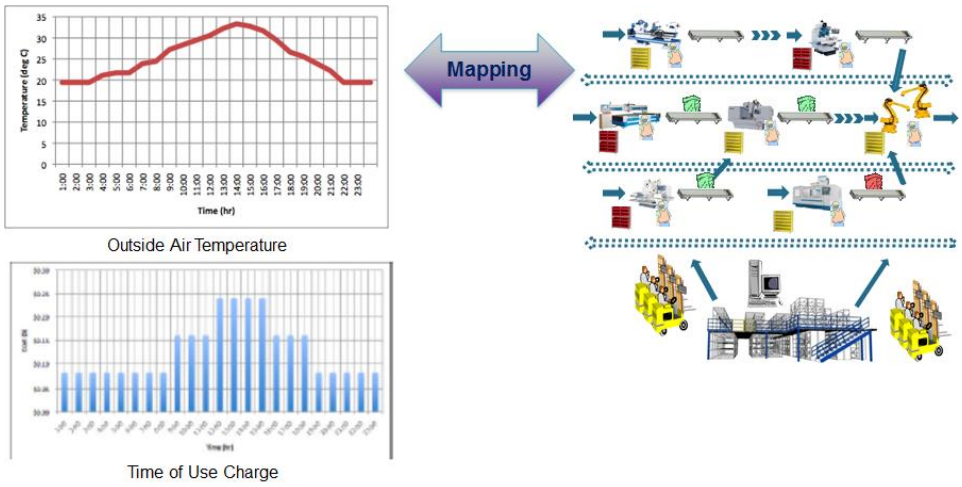

Figure 4: Integrated Modeling & Control for Energy Efficient Manufacturing