Smart Control - Learning for Safe and High Performance Control Systems

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Manufacturing, like many other domains, is transformed by the opportunity of increasing automation, sensing and coordination with the goal of achieving new levels of efficiency. Production units will become “smart” and flexible components that can be easily configured and which can automatically react to their environment and to changes in tasks and materials. These developments are driving the need for advanced control techniques that can leverage this opportunity while ensuring reliable automatic operation, and which can integrate themselves in a human-operated environment.

In this talk, I will present a class of control methods that leverages learning to automatically improve closed-loop performance. Most importantly, I will discuss the challenge of integrating safety requirements in a learning-based control approach. Today, two main paradigms are predominant: optimization-based control and reinforcement learning. While optimization-based control allows to explicitly provide safety guarantees, it suffers from the need of a mathematical problem representation, i.e. a model, constraints and objective. Reinforcement learning has demonstrated its success for complex problems where such a representation is not available, by directly interacting with the system, however, at the cost of safety guarantees. I will discuss techniques that aim at bridging these two paradigms. We will begin with methods integrating learning in optimization-based control, i.e. for inferring the cost, objective or constraints, and then discuss a modular approach augmenting reinforcement learning to introduce safety properties. While the methods will be motivated by problems arising in smart manufacturing, I will show examples of using these techniques in a number of robotics applications.