Master Project

On complexity of data-driven controls in stochastic environments

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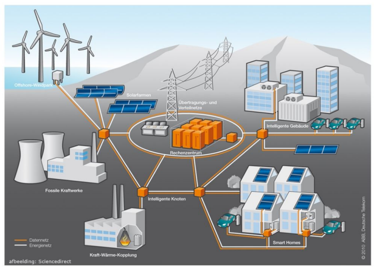
Context

(a) In autonomous vehicles uncertainty comes from both the sensors and the dynamic nature of the agent's environment

(b) In multi-agent robotics, the agents not only have to avoid each other, but also have to coordinate with them and optimally interact with their environment.

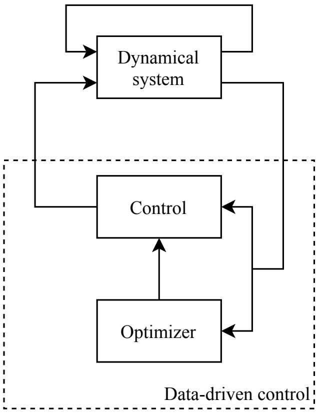


(c) Smart electrical grids have to deal with distributed power generation while at the same time being robust against any spurious demand or loss of power.

Figure 1: Notable applications where decisions under uncertainty have to be made include, but are not limited to, autonomous driving, robotics, and smart grids.

In recent years, due to the advent of increased computing power, Machine Learning has seen a resurgence in popularity amongst the scientific community. Data-driven methods have fueled the development of new innovative technologies, such as those pictured in Figure 1. Despite Machine Learning being excellent at non-parametric tasks, it does not offer much insight and/or guarantees. Control on the other hand, excels at finding solutions to problems where analytic models are available. The goal of this project is to leverage tools from these fields, and, through the common lens of Optimization, attempt to derive optimal (or near optimal) decisions from stochastic data.

Specifically, this thesis project aims to develop a novel data-driven control approach that works under uncertain conditions. We will derive suboptimality bounds, and also bounds on the necessary amount of data required to achieve sufficient performance. Additionally, since we are dealing with potentially lots of data in an online fashion, we have to be computationally efficient. Therefore, computational complexity will not be left as an afterthought – instead, a thorough analysis will attempt to estimate the complexity aspects of our solution. We will primarily work with linear dynamics, since tools developed for such systems are very expressive and powerful.



Project tasks

This master thesis project is aimed to accomplish the following tasks:

- Survey the current state of the art methods (both direct and indirect) and classify them in terms of complexity
- Develop a novel data-driven control algorithm, along with a mathematical analysis of its properties and computational cost
- Compare in a simulation environment how well our algorithm fares against the state of the art