Master Project

Learning Parametric Mixed Integer Quadratic Programming via Inverse Optimization

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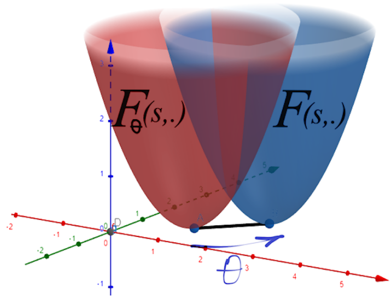
Context



Model-free controllers (such as the ones achieved through Reinforcement Learning) have been gaining increasing attention from the Control community, as that approach allows to control dynamical systems through a direct mapping between a state space (s) and a control input space (u). Additionally, in several control applications it may be useful to learn such a control policy directly from expert demonstrations. Alternatively, assuming that the Expert acts minimizing a cost function $F(s, u)$, it is possible for the Learner to approximate that unknown cost through a parametric function $F_\theta(s, u)$, acting on the parameter θ. The result of this learning process is a simpler controller, which regulates the dynamical system minimizing the approximated cost function used by the Expert Agent (usually much heavier from a computational perspective). That is the Inverse Optimization Problem: learn the cost through which the data was generated, having the availability of the data only.

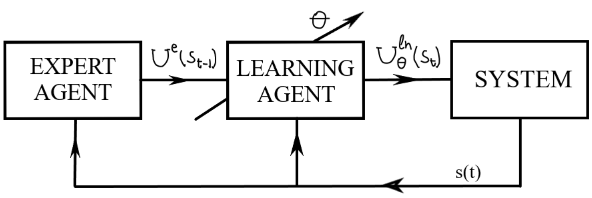


Figure 1: Control scheme with Learning Agent

This project aims at learning the cost $F_\theta(s,u)$ online, while controlling the system. In fact, at every time-step, the Learner chooses the best control input according to what it learned until that moment. Subsequently, with one step delay, the Expert reveals the optimal input, providing the Learner with information that it can use to improve the value of the parameter θ. At time instant T_{cut} the Expert is shut off and the Learner keeps controlling the system.
In the considered scenario, the Expert is an MPC controller and the Learner aims at achieving the same performance but with a cost function that is computationally much more tractable.

Project tasks

1. Achieve an algorithm capable of solving the Inverse Optimization Problem online and achieving a cost function $F_\theta(s,u)$ that allows a performance comparable to the one achieved by the Expert Agent (MPC).

2. Explore the problem with mix-integer/binary variables and provide a theoretical analysis. Possibly extend theoretical results in Supervised Learning to Inverse Learning.

3. Test the algorithms on actual data provided by a company, trying to achieve a simpler and better controller than the used one. Alternatively, perform lab-testing on physical set-ups.