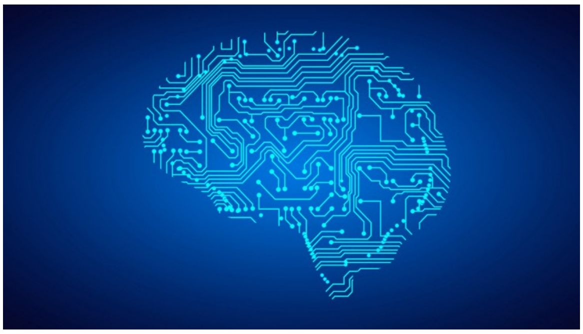
PG SS2019: Reinforcement Learning for Model Predictive Control of Electric Motors

1 Introduction

Reinforcement Learning (RL) is increasingly investigated on various domains and applied successfully while being widely appreciated for its explorative behavior in environments with delayed numerical reward. Models trained with reinforcement learning are able to map situations onto optimal actions, even when past decisions affect current ones. Typical application areas comprise solving games by achieving super-human performance, resource management e.g. in a computing cluster, traffic light control, robot control, web system configuration, optimizing chemical reactions etc. However, applications in engineering remain rare, not to mention the development of workflows from the conceptual idea to real-time software.

Model Predictive Control (MPC), on the other hand, is gaining more and more importance in research and industrial applications due to its beneficial properties such as simplicity (although computationally heavier than rule-based approaches), intuitiveness and the capability to incorporate arbitrary cost functions with nonlinearities and edge constraints. The ever increasing computational power of microprocessors makes a large number of calculations at low cost feasible today, such that model based controls begin to enter the embedded software market albeit the theory has been tackled for decades already. A heavy downside of MPC is the necessity to parametrize it on each motor individually, requiring special engineering expertise. RL denotes a chance to overcome this shortcoming by learning different motor types adaptively and autonomously.

The project group shall investigate the current state of the art, identify similar applications in the same or in a foreign domain, evaluate different approaches first in a simulative manner and then go over to implement auspicious algorithms on a physical test bench. Different validation schemes need to be worked out as well as the design of a real-time capable software framework that is going to be applied on the test bench. While simulation is often realized in higher programming languages (Python, Matlab), embedded software is bound to C/C++, requiring a suitable conversion of identified algorithms whose implementation constitutes an additional project phase.



The goal of the project is the development and implementation of RL strategies and toolchains for real-time capable software in the context of electric motor control. Hence, the project group will contribute to transfer latest proceedings in RL to electric motors in vehicles, trains, planes and power plants in order to make them more efficient, safe and cost-effective.

2 Desired Prerequisites

- Practical experience in software experiment design
- Programming and debugging in Python and/or Matlab
- Programming and debugging in C/C++ on embedded systems
- Basic idea of Reinforcement Learning and Supervised Learning
- Fundamental knowledge in statistical learning
- Willing to work in a team

3 Your Learning Outcome

- Practical experience in Machine Learning for important engineering applications (like electrical drives for vehicles)
- Expertise in evaluation of statistical models especially in the increasingly important field of Reinforcement Learning
- Hands-on experience working with industry-like laboratory test benches
- Working on complex technical systems in a team

4 Project Outline

- Coordination, task assignment
- Search for papers, reading, self-study
- Choose approporiate algorithms, evaluate available frameworks
- Implement prototypes
- Simulation: Apply selected algorithms on different electric motors (synchronous, asynchronous) in Python or Matlab
- Work out suitable benchmarks and validation strategies for different control approaches
- Implement software models for evaluating different control strategies on real test bench
- Convert promising reinforcement learning approaches from simulation to hardware-interpretable code
- Measure and validate performance on test bench
- Documentation and presentation