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Machine Learning Control Workshop

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WORKSHOP PROPOSAL

Model Predictive Control (MPC) has become increasingly prevalent when implementing control for a wide variety of engineering applications. MPC is of particular utility when the control problem contains constraints. Machine Learning (ML) can be integrated with MPC to combine the advantages of both. To implement MPC, a model of the system is needed and often physics-based models are difficult to obtain and techniques such as system identification are used. Machine learning can be used in order to provide more accurate plant models for the MPC design. This modelling can be done offline by collecting the system inputs and outputs and developing ML models for MPC. Alternatively, ML can be used in an online learning framework to adapt the model as it is running and to learn disturbances to enhance the accuracy of the system model and consequently improving MPC robustness. ML can also be integrated with predictive control in a variety of ways other than modelling. In one approach, ML is used to adjust the prediction horizon, the control horizon, and the weight factors of the cost function in an MPC framework. In another approach, ML is used to clone MPC behaviour and can be replaced with MPC online optimization. In this approach, the ML algorithm tries to imitate the MPC but has the advantage of being much less computationally intensive. As it is difficult to ensure constraints of learning controllers in general, ML and MPC can be combined so the MPC is used to make sure the hard constraints are met. In this workshop first background knowledge of both ML and MPC will be covered; then different ways to integrate MPC and ML will be explained and illustrated with examples including mechanical engineering systems. This workshop is organised into three main modules as summarised here:

Module 1: Machine Learning [2 hrs]

a. Supervised vs Unsupervised Learning
b. Artificial Neural Networks
c. Deep Learning
d. Reinforcement Learning
e. Matlab and Python Workshop

Module 2: Model Predictive Control [2 hrs]

f. Optimization and Optimal Control
g. MPC Design Methods
h. Matlab Implementation Workshop

Module 3: Integration of Machine Learning and Model Predictive Control [2 hrs]

i. Machine Learning in the MPC model
j. Machine Learning as an add-on controller
k. Machine Learning for imitative MPC
l. MPC for safe learning

In this workshop, two sessions of Matlab and Python implementation of ML and MPC will be covered by implementing on engineering application.

word count = 400