Data-Driven Auto-Tuning of Model Predictive Controllers via Transformer Architectures

TECHNISCHE UNIVERSITÄT DARMSTADT

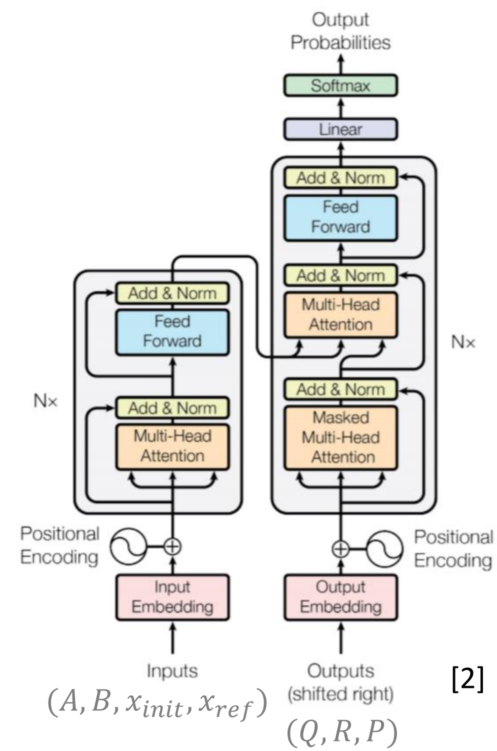
Master‘s Thesis

Modern control strategies, particularly Model Predictive Control (MPC), have proven highly effective for regulating multivariable systems with constraints. However, the practical performance of MPC depends on the tuning of its cost function weights. Manual tuning can be time-consuming and suboptimal, especially for high-dimensional systems. This thesis investigates a data-driven approach that employs transformer-based neural network architectures to automatically determine optimal weight parameters for MPC by extending results recently presented in literature for linear control algorithms [1].

Task Outline:

- Literature Review: A review of data-driven control, MPC tuning methods, and transformer architectures should be conducted.
- Develop an Auto-Tuning Framework: Design a transformer that learns the mapping from characteristics such as dynamics or input-output data, initial state conditions, and reference signals, to optimal MPC cost matrices.
- Integrate Stability Criteria: Incorporate stability conditions (e.g., Lyapunov-based penalties) into the training process to ensure closed-loop stability.
- Benchmark and Validate: Evaluate the proposed framework on both simulated benchmark systems.

A solid foundation in control engineering and a good understanding of machine learning concepts, particularly neural networks, is required. Proficiency in Python, experience with MPC, and stability analysis are advantageous.



[2]

[1] https://arxiv.org/pdf/2411.06482
[2] https://builtin.com/artificial-intelligence/transformer-neural-network

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CCPS Control and Cyber-Physical Systems