PADERBORN UNIVERSITY

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RAT

MASTER PROJECT ET/CE/ESE

Applied data-driven Model Predictive Control (DDMPC)

Background

In the era of abundant data, control techniques have evolved to incorporate the vast amounts of data acquired from systems, this has opened a research direction in *data-driven control* [4]. These new controllers infer the system behavior directly from data, bypassing explicit modeling. Instead by analyzing input-output data, they can mathematically predict the future system behavior [5], enabling a predictive control that is independent of an explicit system model.

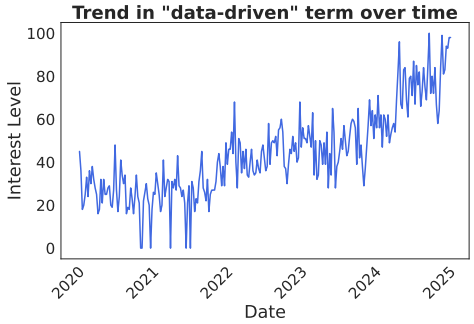

Figure 1: From *Google Trends*, interest score for *data-driven* term in the "Science" domain [2].

From the wide variety of data-driven control schemes that have been recently developed, the data-driven Model Predictive Control (DDMPC) variant offers flexibility for many robotic applications and has several research directions including Reinforcement Learning, adaptive schemes, and behavioral theory [3].

Project Goal

In this project, students will explore the development and implementation of a data-driven model predictive controller on a time-variant system, an example of such a system can be considered in Figure 2, this type of drones will change their structure while flying.

(a) H morphology. (b) O morphology. (c) T morphology.

Figure 2: A foldable drone presented in [1].

Intermediate Goals

- Study of DDMPC theory: understanding the basis of Model Predictive Control and its incorporation of a data-driven approach.
- "System identification" from data: a data acquisition phase will take place to build a black-box model of a system.
- Control development: the data-driven MPC will be implemented in simulation to collect results.
- Testing: it will be possible to incorporate the controller in a real system if requested by the students.

Possible technologies (not limited to)

- Python / C++ / Julia / MATLAB
- Robot Operating System 2 (ROS2)
- Simulation environments (Gazebo, Isaac Sim, PyBullet)
- CAD design (Solidworks, Fusion 360)
- Linux (Ubuntu)

Learning Outcomes

- Hands-on experience with modern control schemes.
- Bridge theoretical concepts to real robotic applications.
- Development of skill in technologies sought in many research/industry scenarios.

References

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[2] Google. Google trends, 2025. Accessed: 2025-02-28.

[3] M. M. Morato and M. S. Felix. Data science and model predictive control:: A survey of recent advances on data-driven mpc algorithms. *Journal of Process Control*, 144:103327, 2024.

[4] W. Tang and P. Daoutidis. Data-driven control: Overview and perspectives. In *2022 American Control Conference (ACC)*, pages 1048–1064. IEEE, 2022.

[5] J. C. Willems, P. Rapisarda, I. Markovsky, and B. L. De Moor. A note on persistency of excitation. *Systems & Control Letters*, 54(4):325–329, 2005.

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