Chair of Automatic Control
TUM School of Engineering and Design
Technical University of Munich

Semesterarbeit / Master's Thesis:
Vision-based Discrete-Time Control for the Magnetic Levitation System

Introduction: Vision sensors (cameras) are increasingly popular for position measurement in automatic control due to their low cost, convenient installation, and wide range of applicability. However, common cameras have relatively low sampling rates ($\sim$30Hz) compared to widely used laser distance sensors (>1kHz), which, by neglecting the sampling mechanism, significantly affects the controller's performance due to increasing model mismatch, up to the point of destabilization. Higher-order discrete-time control proposed in our recent works [2, 3, 1, 4] addresses this problem without needing to redesign a control law, and allows for a control implementation with minimal modifications compared to the quasi-continuous case.

Tasks: The goal of this thesis is to realize position control on the magnetic levitation test bench using a camera as position sensor, to showcase the advantage of higher order discrete-time control. The work is expected to include the following aspects:

- Integrate a camera to the current test bench.
- Implement a computer vision algorithm to realize position measurement.
- Utilize the measurement data for higher-order discrete-time control.
- Evaluate the performance of the implementation in comparison to the current setup.

Desired prerequisites:

- Strong interest in automatic control (documented by the transcript of records).
- Knowledge in computer vision, experience preferred.
- Programming skills in MATLAB and Python.
- Fluent in English or German.

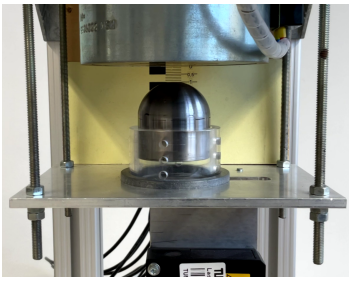

Figure 1: Magnetic Levitation System

Related works

[1] Paul Kotyczka. "Cubic Hermite Interpolation and Lobatto Collocation for Nonlinear Sampled-Data Control". In: *IFAC-PapersOnLine* 56.2 (2023), pp. 2883–2888. ISSN: 2405-8963.

[2] Paul Kotyczka, Christian J. Martens, and Laurent Lefèvre. "High Order Discrete-Time Control Based on Gauss-Legendre Collocation". In: *IFAC-PapersOnLine* 54.19 (2021), pp. 237–242. ISSN: 2405-8963.

[3] Paul Kotyczka and Tobias Thoma. "Symplectic discrete-time energy-based control for nonlinear mechanical systems". In: *Automatica* 133 (2021), p. 109842. ISSN: 0005-1098.

[4] Le Zhang and Paul Kotyczka. *Discrete-Time Passivity-Based Control using Hermite-Obreschkoff Methods*. 2025. arXiv: 2501.11495 [eess.SY].

Supervisor: Le Zhang, M.Sc.
MW0206, ☎ +49 89 289 15592
le.zhang@tum.de

PD Dr.-Ing. habil. P. Kotyczka
kotyczka@tum.de
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