

Bachelor's Thesis

Task description for Bachelor's Thesis of

Name Surname

Development of a Surrogate Model of the Hopper Propulsion System for Application in Optimal Control

Entwicklung eines Surrogatmodells des Hopper-Antriebssystems für die Anwendung mit optimaler Regelung

Topic

The space sector is currently gaining increasing attention due to the commercialization of space (e.g., OneWeb, SpaceX Starlink) and upcoming human missions, such as the return to the lunar surface and the long-term goal of landing humans on Mars. The remoteness and complexity of these missions demand a high degree of autonomy in spacecraft control systems.

Spacecraft, and particularly their propulsion systems, are complex machines composed of multiple interacting subsystems. Accurate control of these systems is essential for mission success, especially during landing manoeuvres. The current industrial standard relies on hierarchical control architectures using conventional control algorithms, mainly due to their predictable behaviour and the possibility to guarantee system stability.

However, for landing applications, optimal control algorithms have shown promising results by making use of knowledge of system dynamics and by being able to enforce boundary conditions.

A challenge in applying optimal control lies in the fidelity of the system dynamics model. The model must be simple enough to enable fast convergence of the optimal control solver, while still sufficiently accurate to represent the system's true behaviour. One solution is to employ a surrogate model — a reduced-order representation of a complex system — that maintains most of the original model's accuracy while significantly reducing computational cost.

Therefore, the goal of this thesis is to implement a surrogate model of the current simulation of the ASCNET propulsion system. In the ASCENT project a pressure fed rocket hopper for vertical take-off and vertical landing is being developed as a research platform for advanced control algorithms, including optimal control.

The goal of this thesis is therefore to develop and implement a surrogate model of the current ASCNET Hopper propulsion system simulation.

Within the ASCENT project, a pressure-fed rocket hopper for vertical take-off and vertical landing is being developed as a research platform for advanced control algorithms, including optimal control. The surrogate model developed in this thesis will serve as an efficient dynamic representation of the Hopper propulsion system, suitable for use in optimal control applications.

Tasks

1. Subdivision into work packages with sub-tasks and creation of a time plan
2. Literature research on development of surrogate models
3. Familiarization with the hopper propulsion system model
4. Development/Implementation of a surrogate model
5. Analysis and comparison of the surrogate model to the Hopper propulsion model
6. Documentation and presentation of results

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