Internship in ESA's Advanced Concepts Team

on

A 6DOF G&CNET for aggressive quadcopter racing

Topic description

With the recent advances in deep learning, there is a push to use Deep Neural Representations of the Optimal Control onboard various systems where it is infeasible to solve the Optimal Control Problem due to computational constraints [1][2][3]. Building on previous work by the ACT and TU Delft, the goal of this project is to investigate the feasibility and efficiency a Deep Neural Network trained on the optimal controls of a 6DOF quadrotor model. Although numerous possible avenues of investigation exist, some of the key questions that need to be answered are:

• How can a neural network be trained on the optimal controls of 6DOF model?

• How stable is the trained controller with regards to inertial delay from the rotors and due to delays in processing?

• How feasible is it to run this onboard hardware with limited resources?

• How robust is the network to noise in the input variables?

The purpose in answering these questions is to ultimately evaluate the feasibility of using a time-optimal Neural Network Controller for the Guidance and Control in a quadrotor race.

Candidate's tasks

- Update the current training pipeline to work with the 6DOF model.
- Create a database of optimal trajectories for a range of initial conditions.
- Find a suitable network architecture for a controller.
- Investigate the influence of delay on the robustness of the trained controller.
- Determine if it is feasible to run this controller onboard a quadrotor.

The ideal candidate

Mandatory:

- Strong programming skills in Python.
- Familiarity with optimization and neural network training.

Desirable:

- Familiarity with space engineering.
- Strong programming skills in C.

References

[1] C. Sánchez-Sánchez and D. Izzo, "Real-time optimal control via deep neural networks: study on landing problems", *Journal of Guidance, Control, and Dynamics, vol.* 41, no. 5, pp. 1122–1135, 2018. https://arxiv.org/abs/1610.08668

[2] D. Tailor and D. Izzo, "Learning the optimal state-feedback via supervised imitation learning", *Astrodynamics*, Sep 2019. https://arxiv.org/abs/1901.02369

[3] D. Izzo, D. Tailor, and T. Vasileiou, “On the stability analysis of deep neural network representations of an optimal state-feedback”, *arXiv e-prints, p. arXiv:1812.02532,* Dec 2018. https://arxiv.org/abs/1812.02532