Neural Lander: Stable Drone Landing Control Using Learned Dynamics

Precise near-ground trajectory control is difficult for multi-rotor drones, due to the complex aerodynamic effects caused by interactions between multi-rotor airflow and the environment.

The authors open with a combined general discussion (precise near-ground trajectory control) and some specific background (the cause of the challenge).

Conventional control methods often fail to properly account for these complex effects and fall short in accomplishing smooth landing.

The authors then summarize the knowledge gap, i.e., where other approaches are lacking.

In this paper, we present a novel deep-learning-based robust nonlinear controller (Neural-Lander) that improves control performance of a quadrotor during landing. Our approach combines a nominal dynamics model with a Deep Neural Network (DNN) that learns high-order interactions. We apply spectral normalization (SN) to constrain the Lipschitz constant of the DNN. Leveraging this Lipschitz property, we design a nonlinear feedback linearization controller using the learned model and prove system stability with disturbance rejection.

Next, the authors explain their methods. Notice here how they use the hourglass approach: first explaining at a high level what their algorithm does, then what specific tools they use.

To the best of our knowledge, this is the first DNN-based nonlinear feedback controller with stability guarantees that can utilize arbitrarily large neural nets.

The authors then explain the implications of their algorithm and what it contributes to the field. This corresponds to the widening section of the hourglass as the authors are again appealing to a broader audience.

Experimental results demonstrate that the proposed controller significantly outperforms a Baseline Nonlinear Tracking Controller in both landing and cross-table trajectory tracking cases. We also empirically show that the DNN generalizes well to unseen data outside the training domain.

Finally, the authors discuss their results while also explaining the greater implications of their work.

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