Adaptive Tuning of an Aircraft Pitch Controller with Reinforcement Learning

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Abstract: An aircraft controlled with a proportional-integral-derivative (PID) controller displays weak dynamic performance when subjected to wind gusts, varying aerodynamic characteristics, among others. Fixed observation-based controllers produce optimal gains only for specific flight configurations and therefore need to be retuned in stochastic environments. In this paper, we propose an adaptive tuning method that produces optimal gains with time-varying observations to control an aircraft's pitch motion. While the idea of adaptive tuning is not new, its application along with a neural net to control an aircraft's longitudinal dynamics makes this work a novelty. Our method uses reinforcement learning and deep deterministic policy gradient algorithm to produce a trained agent. The agent takes the error in pitch angle, derivative and integral of error as observations and produces a set of three PID optimal gains. The reward function, neural net architecture and hyperparameters are varied as well for better training purposes. Validation is performed by subjecting the aircraft to random pitch inputs between -90 to 90 degrees. The adaptive controller displays superior performance in terms of transient characteristics when compared to fixed observation-based controllers for every single validation case, thus establishing the robustness of the controller to varying uncertain observations.
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Keywords: Reinforcement Learning, aircraft controls, deep deterministic policy gradient.



Adyasha Mohanty is a first-year graduate student at Stanford University in the Aeronautics and Aeronautics department, supported by a three-year Stanford Graduate Fellowship. She currently works in the Navigation Lab (NAV Lab) on variety of perception, localization and navigation algorithms which utilize sensor fusion, computer vision, machine learning and GPS. She received her bachelor's degree in Aerospace Engineering from Georgia Institute of Technology, Atlanta. As an undergraduate, she primarily researched on turbulence modeling using high performance computing, parallel architectures and direct numerical simulation. Her interests