Lan-DLE: Uncertainty-Aware Autonomous Landing of Fixed-Wing Aircraft With Deep Learning Ensembles

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Accurate and robust autonomous landing of fixed-wing aircraft will revolutionize economic, industrial, and military missions that are generally dangerous or suboptimal for humans to perform. However, current semi-autonomous airport-based landing solutions are costly and unsustainable. There is a need for an aircraft-based solution that is both inexpensive and does not interfere with nearby radio frequencies. Humans pilots already perform safe landings, so imitation learning can be leveraged to produce an effective behavioral policy. An effective behavioral policy needs to be both accurate and confident. To simultaneously model behavior and uncertainty, we propose a novel solution based on Bayesian methods, the Landing Deep Learning Ensemble model (Lan-DLE), which is a combination of 10 different deep neural networks trained on different datasets. Lan-DLE learns fly-by-wire landing actions based on onboard sensor outputs, while also assessing the confidence of those predictions. Then, a policy is implemented to decide when the model is confident enough to make a safe prediction. Results demonstrate that Lan-DLE can accurately clone the throttle inputs of a human pilot during landing, with maximum confidence in the flare phase of landing. We also show Lan-DLE accurately generalizes well to unseen data disjoint from the training dataset.