Proceedings of the 1st international Symposium on AI and Fluid Mechanics
Abstract No S15 A5

Reinforcement twinning for attitude control of multirotor drones: an experimental proof of concept

Yannick Lecomte[1], Manuel Ratz[1,2], Lorenzo Schena[1, 3], Aren Vardanyan[1], and Miguel A. Mendez[1,2,4].

[1] the von Karman Institute (VKI) for Fluid Dynamics, Spain

[2] Université Libre de Bruxelles, Belgium

[3] Vrije Universiteit Brussel, Belgium

4 Universidad Carlos III de Madrid, Spain

Abstract:

Despite the growing popularity of Unmanned Aerial Vehicles (UAVs) for a wide range of applications, their control in highly turbulent conditions remains a significant challenge. The nonlinearity and high sensitivity of the control actuation make the tuning of traditional Proportional-Integral-Derivative (PID) controllers particularly challenging in the presence of gusts and turbulent flow conditions. Moreover, due to the limited reliability of models for unsteady propeller aerodynamics in turbulent flows and complex maneuvers, more advanced model-based control methods are usually not feasible. While model-free control offers greater flexibility in handling nonlinear dynamics and removes the need for detailed modeling, these methods tend to have lower sample efficiency.

To address these gaps, this work proposes the first proof of concept of Reinforcement Twining (RT) for attitude control in quadcopters. RT combines model free and model-based strategies for flow control, using adaptive models of the plant based on a combination of physics-based models and machine learning. Moreover, it introduces learning feedback between the two learning approaches. In this work, the RT was implemented using Multi-fidelity Gaussian Processes, with the different ``fidelities'' corresponding to policies derived from the current best model and from the full back box interaction with the system. The approach was implemented on a dedicated test bench featuring two propellers mounted on the ends of a beam pivoting on a central fulcrum, targeting a set point in terms of attitude, using the motor torque as control actuation and relying only on measurements of motor rpm and attitude angle. The results show that the cooperation of the two approaches outperforms their independent implementation in terms of achievable stability, robustness to disturbance and learning efficiency.