PID control systems have been extensively explored in UAV stabilisation. According to a 2023 survey, Lopez-Sanchez et al. conducted an exhaustive literature review and realized that the most common control technique for quadrotor UAVs is PID control [7]. With adaptive PID control being the most stable under unstable conditions, providing robustness against parameter uncertainty. An adaptive PID changes the gains of the controller during flight based on performance evaluation loop built into the controller. As all our testing will be conducted in laminar flow, an adaptive PID will not be implemented and a classical PID will be developed to reduce complexity of implementation.

Tuning a PID using trial-and-error is a manual, tedious process often requiring expert domain knowledge [6]. To address this, researchers are applying machine learning to the problem of finding high-performing gains for PID controllers. Support Vector Regression (SVR) is increasingly being used for PID controllers to facilitate the tuning process. Studies have shown that SVR-based controllers display enhanced stability and accuracy in variety of applications [8].

In terms of applications in bio-inspired wings, Wenfu et al. in a 2021 experiment showed the effectiveness of implementing a PID in a robotic bird. They describe that as their bird gets more complex, increasingly complex methods of control will be required.

As Okasha et al. discussed in their 2022 paper. Model Predictive Control (MPC) is a powerful controller that is more robust and stable compared to PID, though it is computationally expensive [10]. Another advantage over PID is that it bypasses the tuning phase.

The existing literature on PID, SVR tuning and MPC in the UAV space provided valuable insights for our project. By learning from these approaches, we can utilise a variety of control methods in a novel platform the Kestrel bio-inspired wing.

[7] Lopez-Sanchez I, Moreno-Valenzuela J. PID control of quadrotor UAVs: A survey. Annu Rev Control. 2023;56:100900. doi: 10.1016/j.arcontrol.2023.100900.

[8] Uçak K, Günel G Ö. Model-free MIMO self-tuning controller based on support vector regression for nonlinear systems. Neural Comput & Applic 33, 15731–15750 (2021). <https://doi.org/10.1007/s00521-021-06194-1>

[9] Wenfu XU, Erzhen PAN, Juntao LIU, Yihong LI, Han YUAN, Flight control of a large-scale flapping-wing flying robotic bird: System development and flight experiment, Chinese Journal of Aeronautics, Volume 35, Issue 2, 2022, Pages 235-249, ISSN 1000-9361, <https://doi.org/10.1016/j.cja.2021.03.009>.

[10] Okasha M, Kralev J, Islam M. Design and Experimental Comparison of PID, LQR and MPC Stabilizing Controllers for Parrot Mambo Mini-Drone. Aerospace. 2022; 9(6):298. https://doi.org/10.3390/aerospace9060298.