ENAE 743: Applied Nonlinear Control

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Project Prospectus

**Overview**: Micro aerial vehicles (MAV’s) may have novel applications in surveillance, reconnaissance and mapping by allowing a vehicle to access small or intricate spaces. Consequently, these vehicles require precise control to navigate through complex or narrow terrains [1]. Coupled with the nonlinear dynamics of the flapping mechanism, these vehicles require a nonlinear control law to guide their flight.

This project seeks to recreate some of the key results from [2]. This paper is split in two parts: 1) deriving the dynamic model from a Lagrangian formulation and 2) building a nonlinear controller for position and altitude tracking of a MAV. The governing equations are found in the appendix. In this project, key results from the second half of the paper will be reconstructed; it is assumed the nonlinear dynamic model is correctly constructed and these particular results will not be verified.

The project will closely follow the construction outlined in sections 4.1 and 4.2. Section 4.1 designs the outer-loop controller, which designs for the desired cycle-averaged forces and moments to control the system. This section uses sliding mode control as its primary mechanism. These are fed into the inner-loop controller, which take the virtual inputs and output control surface actions. The control law is designed with a Lyapunov-style argument using the state errors and a gain matrix, K, to define the Lyapunov function. A high-level outline of the control system is found below.

*Fig 1. Control Architecture with Pertinent Sections Referenced.*

A diagram of a system

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**Project Outcomes**: This project seeks to recreate the paper’s nonlinear control results; see figures 10, 11, and 12 in [2]. The dynamic model will first be constructed in MATLAB/Simulink and the controller will be built around it. While the project will follow the authors’ controller design, their approach will be commented upon, tested, and improved as the project demands. This project will take care to explicitly detail the nonlinear control mechanisms applicable to class, including integral sliding mode control and Lyapunov control laws.

**Works Cited:**

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| [1] | R. Wood, "The first takeoff of a biologically inspired at-scale robotic insect," *IEEE Transcations on Robotics, 24(2),* pp. 341-347, 2008. |
| [2] | B. Wissa, K. Elshafie and A. El-Badawy, "Lyapunov-based control and trajectory tracking of a 6-DOF Flapping Wing Micro Aerial Vehicle," *Nonlinear Dynamics,* p. 2919–2938, 2020. |

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