Project Proposal

Project Name: *Multi-Layer Modeling, Simulation and Testing Environment for Uncrewed Aerial Systems (UAS)*

Project Team Members: *Jack Lee, Jim Pamplona, Jonathan Ortiz, Mai Evans*

Problem Statement:

As UAS becomes more common in both commercial and military applications, it is critical to ensure that they can avoid collisions with other aircraft, structures, and obstacles in complex environments. Also, traditional testing methods can be time-consuming, costly, and lack the scalability required to cover a wide range of potential collision scenarios. This project aims to solve the need for more reliable and efficient testing and validation of collision avoidance systems for uncrewed aerial systems (UAS).

Stakeholders:

Primary stakeholders: *Jose Alejandro Gonzalez Nunez*

Secondary stakeholders: *Ilhan Akbas*

Proposed Solution:

The proposal covers the development of an open-source framework aimed at improving the testing and validation of collision avoidance systems for AI-controlled uncrewed aerial systems (UAS). The scope includes the creation of a two-tiered simulation environment—comprising a low-fidelity simulator for rapid, large-scale scenario testing and a high-fidelity 3D simulator for more detailed analysis.

The framework will employ a two-tiered simulation approach, starting with a low-fidelity simulator for rapid scenario testing and progressing to a high-fidelity 3D simulator for more precise validation of collision avoidance strategies. During the initial phases, simulated data will be used to develop and refine these strategies, allowing for extensive coverage of potential collision situations. By the second semester, the software will be integrated with real UAS hardware, enabling selected scenarios to be tested in real-world conditions. The framework is designed to interface with various AI-based collision avoidance systems, moving from simulated environments to live UAS tests as part of its comprehensive validation process.

Semester 1:

In the initial phase, the team will utilize Julia to create a low-fidelity simulation framework to test collision avoidance. This framework will allow for the rapid testing of numerous scenarios, providing the foundation for refining and improving collision avoidance strategies before moving to more complex, high-fidelity simulations.

The team will then concentrate on translating the low-fidelity simulation from Julia to a high-fidelity simulation environment using Gazebo, a powerful robotics simulation platform. This will allow for more detailed testing and refinement of UAS collision avoidance strategies. To support this, the team will compile a dataset to streamline and enhance testing efficiency.

Additionally, they will also document the installation process of the tools used for future reference. Throughout the course of the semester, the Julia code will be slowly converted to Rust for a more secure and optimized implementation. This will serve as a valuable reference for future users, ensuring replicability and further development of the project.

Semester 2:

Using the dataset compiled during the first semester, the team will integrate this data into real UAS hardware systems to validate and refine the collision avoidance strategies tested in the simulation environment. The transition from simulated data to real-world application will allow for a thorough evaluation of the efficiency and practicality of these methods in real flight conditions, providing a clearer understanding of the potential and limitations of the developed technology.

The team will also document the entire process, including challenges, breakthroughs, and any system modifications, to create a comprehensive progress report. This documentation will not only serve as a reference for ongoing improvements but will also act as a roadmap for future teams to further develop and expand upon the system.

Additionally, various real-life scenarios, including drone swarm operations, will be tested to push the framework's capabilities. These scenarios will provide insight into how the collision avoidance system handles complex and dynamic environments, offering valuable feedback for iterative improvements.

As a far stretch goal, the team will explore integrating advanced AI algorithms or machine learning techniques to adapt the collision avoidance strategies in real time. This would elevate the system's responsiveness and efficiency, though this goal will depend on the success and timing of earlier stages.

Proposed Project Budget:

The project's budget is currently based on the team's progression with the project and will be determined by the product owner.

References:

Gazebo-Ardupilot

https://youtu.be/AP1UC0DllrE?si=1bffBdBC8xUgcEDs

https://github.com/Intelligent-Quads/iq_tutorials

https://ardupilot.org/dev/docs/sitl-with-gazebo.html

Julia

https://www.freecodecamp.org/news/learn-julia-programming-language/

Getting Started with Julia (julialang.org)

Tutorials (julialang.org)