VERSATILE AUTONOMOUS NAVIGATION TESTING AND GUIDANCE ENVIRONMENT

VANTAGE

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Problem Statement

As uncrewed aerial systems (UAS) become increasingly prevalent in commercial and military applications, ensuring their ability to avoid collisions with other aircrafts and obstacles in complex environments is critical. 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).**

Background

- The project covers the development of an open-source framework aimed at improving **AI-controlled collision avoidance systems for uncrewed aerial vehicles (UAV).**
- The scope includes the creation of a two-tiered simulation environment—comprising a low-fidelity simulator and a high-fidelity 3D simulator.
- The framework is designed to undergo rigorous training and testing for extensive coverage of potential collision situations, with goals to **move from simulated environments to live UAS tests as part of its comprehensive validation process in terms of UAS collision avoidance.**

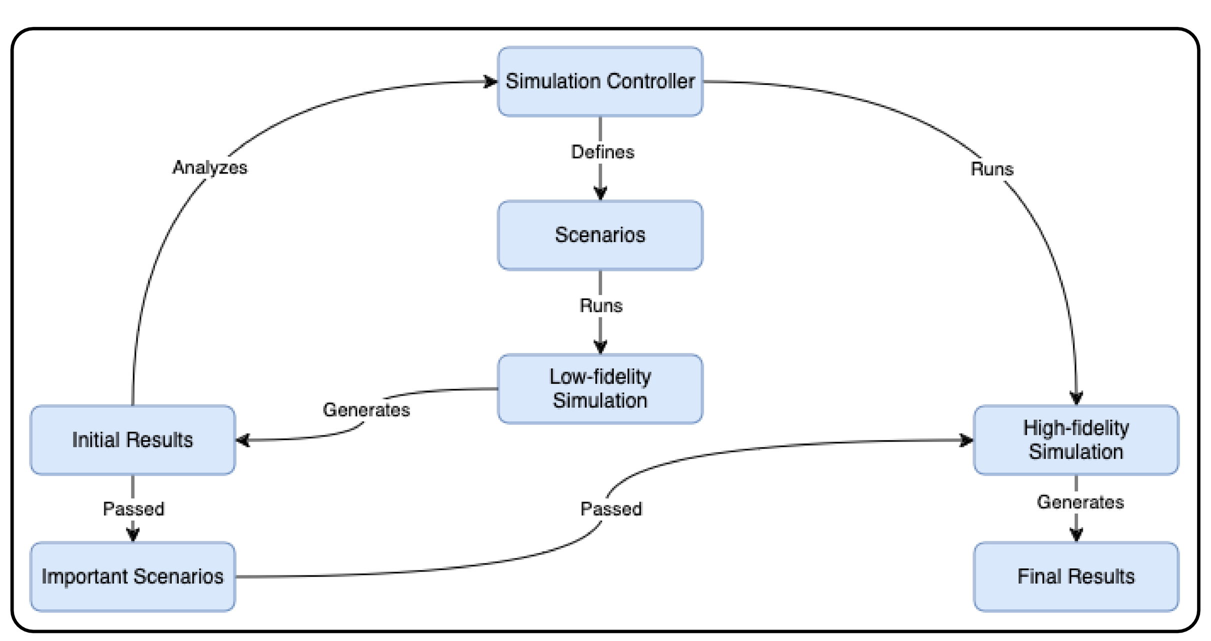

Figure 1. System flow chart

Methodology

- **Two-Tiered Simulation Framework**:
  - **Low-Fidelity Simulations**: Produce initial results through rapid testing using JuliaSim to identify key UAS collision scenarios.
  - **High-Fidelity Simulations**: Generate final results through detailed 3D analysis via Gazebo, ArduPilot, & ROS2 [1][2].
- **Simulation Manager**: Seamlessly integrates both simulation types, manages simulations, and logs necessary telemetry data.
- **Data Analysis**: Each simulation will iterate through various scenarios with different parameters. After simulations are complete, the manager will determine whether a violation, collision, or nothing occurred between the two drones.

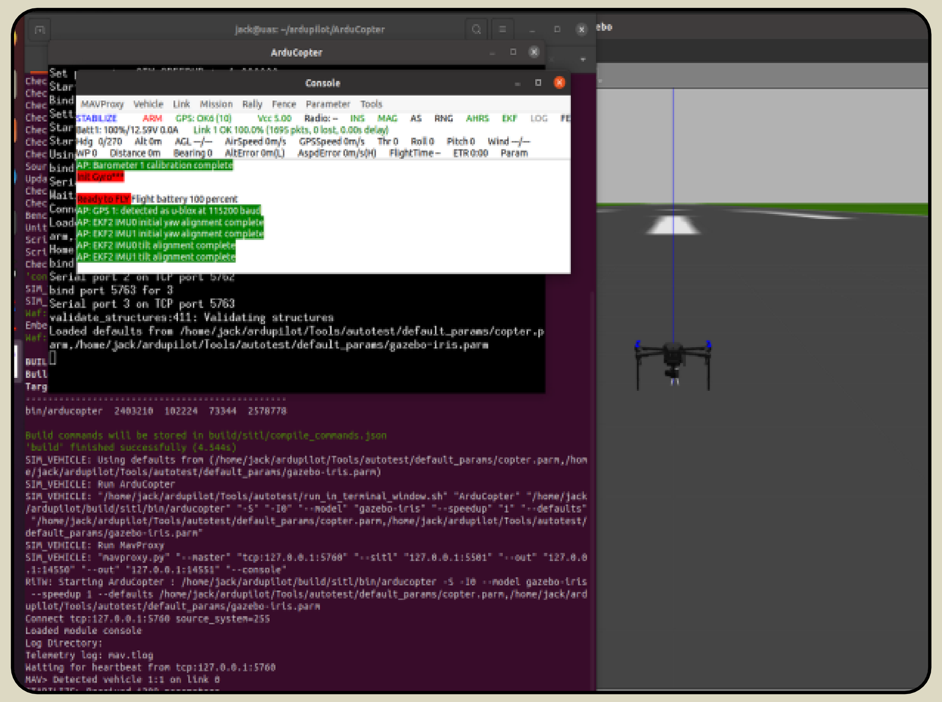

Figure 2. Gazebo, Ardupilot, ROS2 Integration

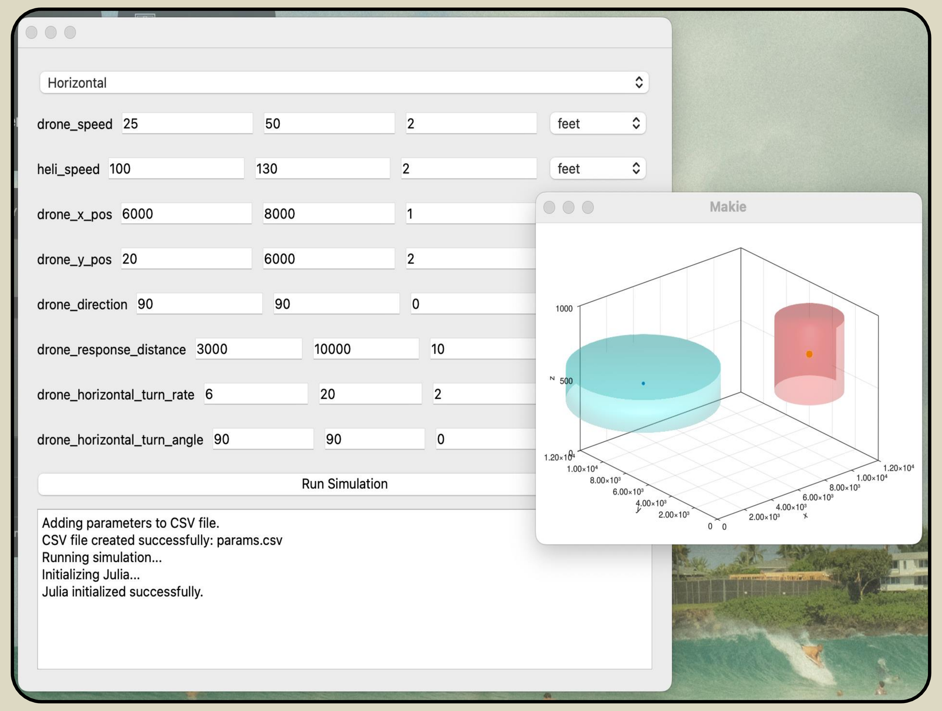

Figure 3. Julia Sim + Controller Integration

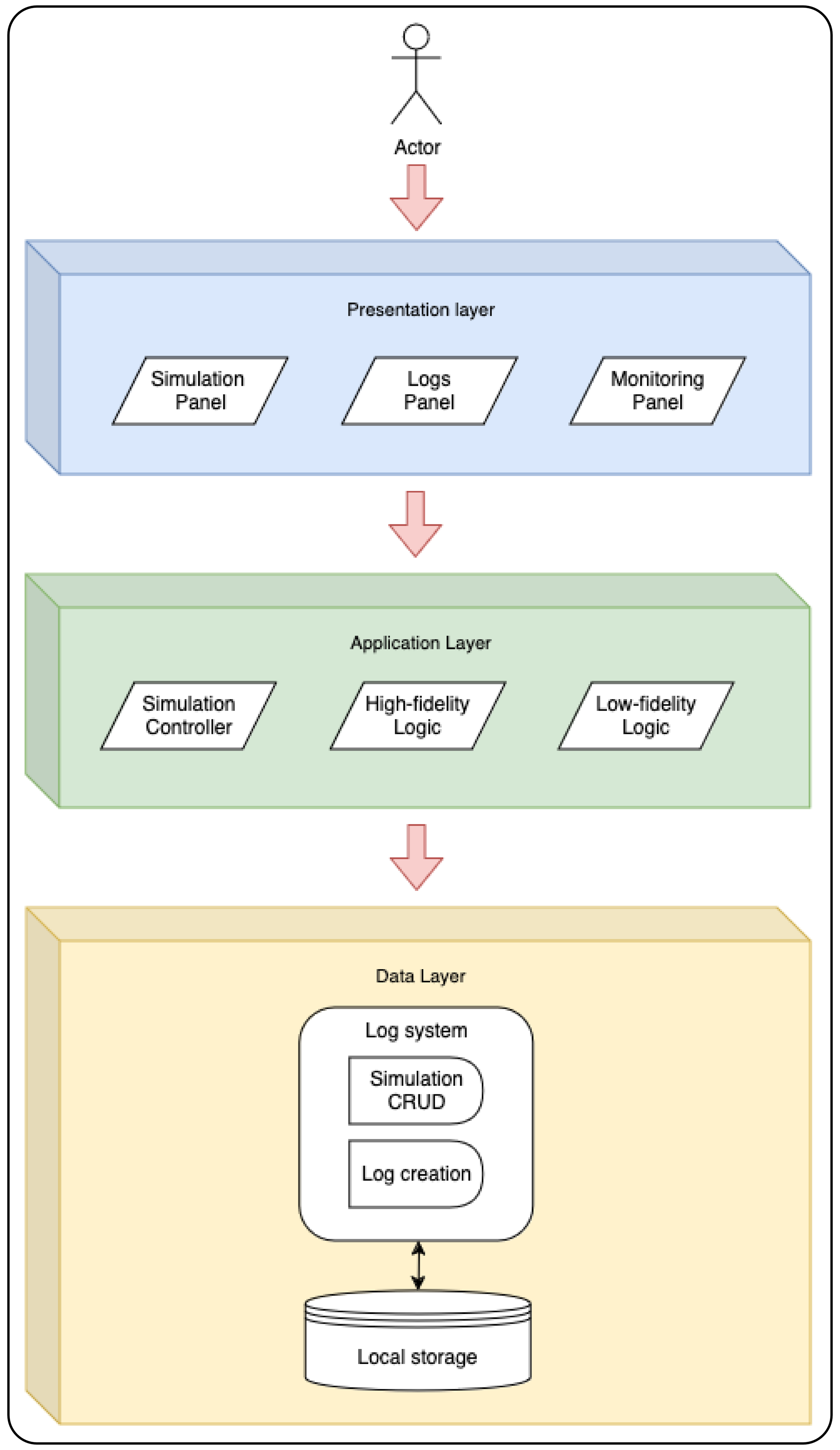

Figure 4. System Software Architecture

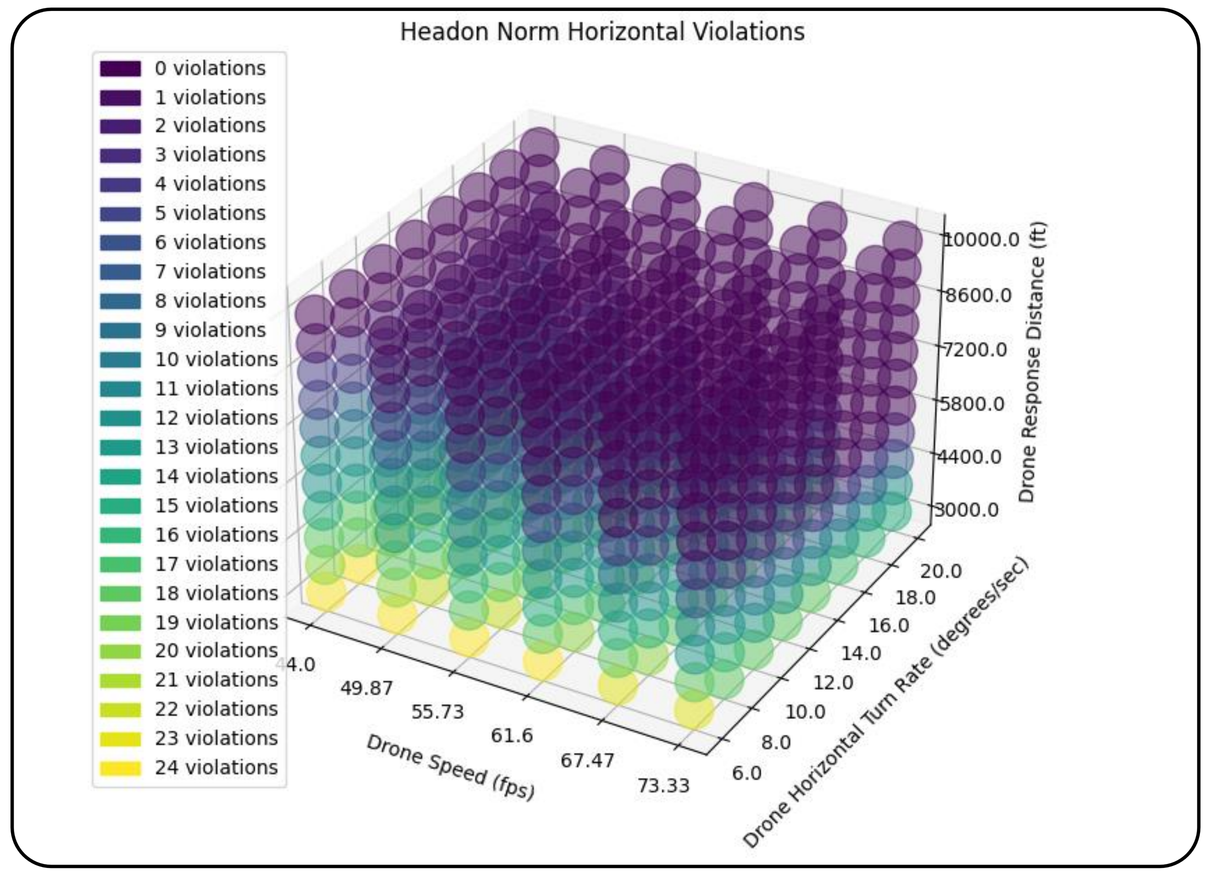

Figure 5. JuliaSim Headon Norm Horizontal Violation Graph

Results & Conclusion

- **Gazebo-Ardupilot-ROS2**: Successful integration between all softwares to establish a unified simulation environment.
- **Controller Integration**: Created controller for low-fidelity simulations for simulation management
- **Process Documentation**: Compiled detailed documentation of installation and configuration steps for each simulation tool, enabling reproducibility and ease of use for future researchers.

The project successfully established the foundation for a two-tiered simulation framework, setting up both low-fidelity and high-fidelity simulators. **By addressing configuration challenges and integrating various tools, the project ensures scalability and usability for further UAV research and testing efforts.**

Future Work

- **High-Fidelity and Utility Enhancements**: Connect the controller to high-fidelity simulator, add lidar support, and enable drone swarm simulations.
- **AI Integration**: Implement AI algorithms for advanced collision avoidance training.
- **Hardware Integration**: Transition to real-world testing with physical drones.

References

[1] ArduPilot Dev Team, "Using SITL with Gazebo," Using SITL with Gazebo - Dev documentation, https://ardupilot.org/dev/docs/sitl-with-gazebo.html (2024)

[2] Intelligent-Quads, "Intelligent-quads/iq_tutorials," GitHub, https://github.com/Intelligent-Quads/iq_tutorials (2024)

[3] "Docs/Gazebo Harmonic," Binary Installation on Ubuntu - Gazebo harmonic documentation, https://gazebosim.org/docs/harmonic/install_ubuntu/ (2024)

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