VERSATILE AUTONOMOUS NAVIGATION TESTING AND GUIDANCE ENVIRONMENT

VANTAGE

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Problem Statement

Ensuring uncrewed aerial systems (UAS) avoid collisions with other aircrafts and obstacles in complex environments is crucial. Traditional testing methods are time-consuming, costly, and lack scalability. **This project aims to develop more reliable and efficient testing and validation methods for collision avoidance systems in 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 undergoes rigorous training and testing to cover potential collision situations. **It aims to validate its effectiveness in live UAS tests, moving from simulated environments to real-world scenarios.**

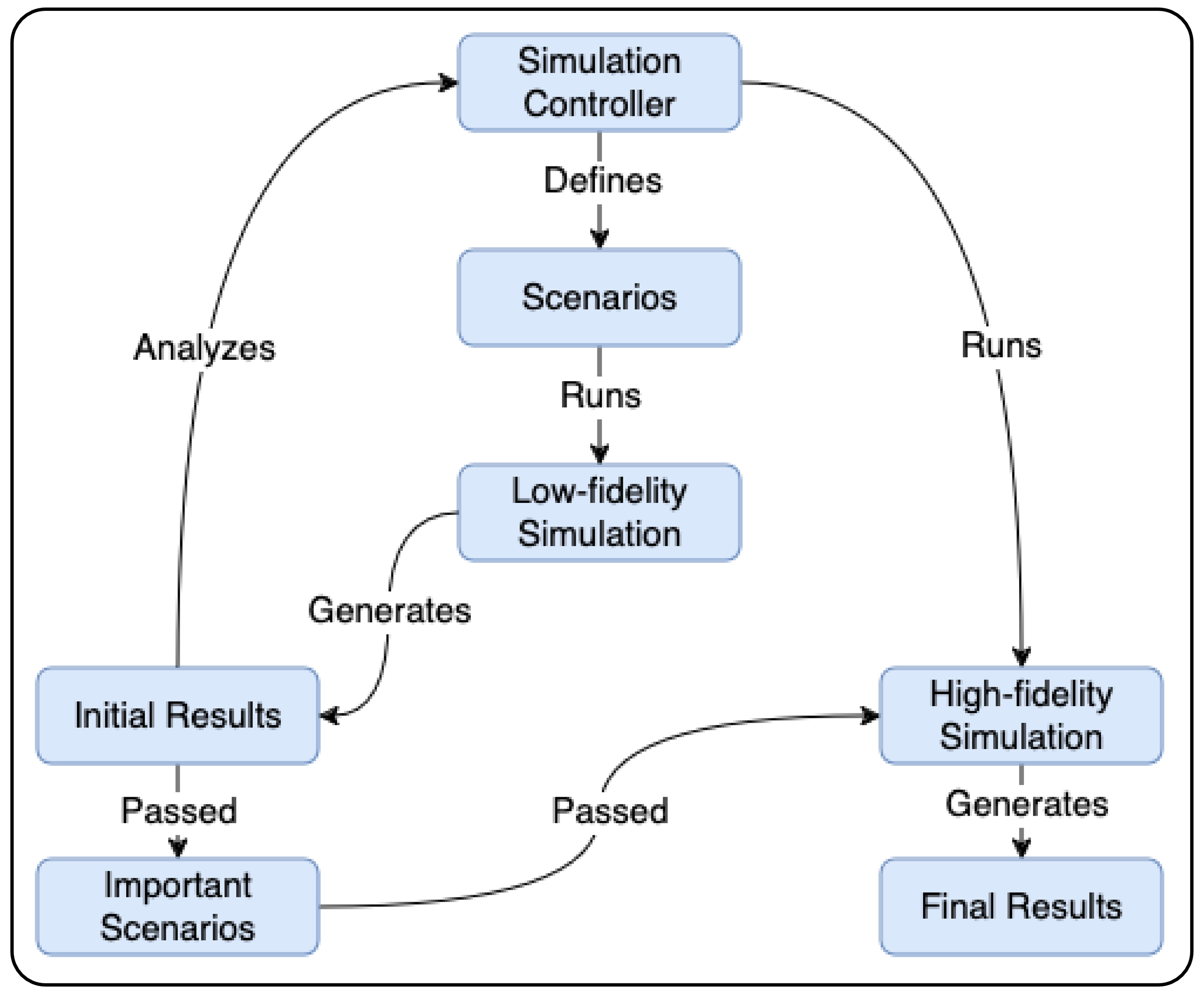

Figure 1. System flow chart

Methodology

- **Two-Tiered Simulation Framework:**
  - **Low-Fidelity Simulations:** Rapidly test key UAS collision scenarios using JuliaSim.
  - **High-Fidelity Simulations:** Generate final results through detailed 3D analysis using Gazebo, ArduPilot, and ROS2.
- **Simulation Manager:** Integrates both simulation types, manages simulations, and logs telemetry data.
- **Data Analysis:** Simulations iterate through various scenarios with different parameters. The manager determines if a violation, collision, or nothing occurred between the two drones.

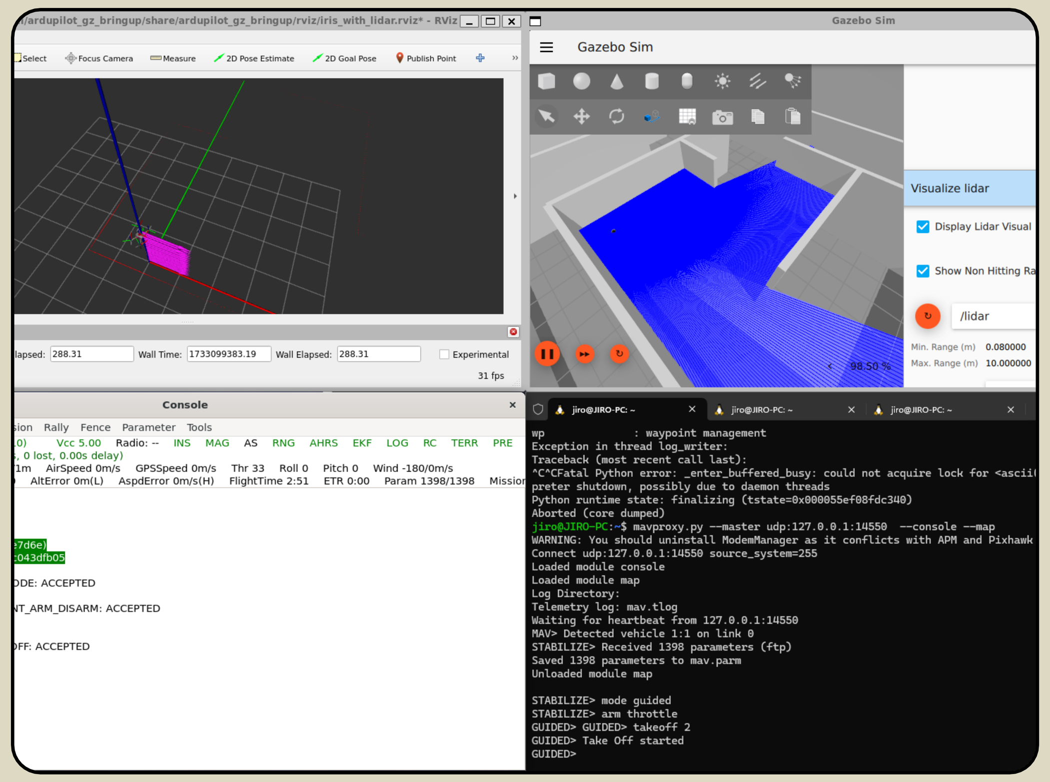

Figure 2. Gazebo, Ardupilot, ROS2 Integration

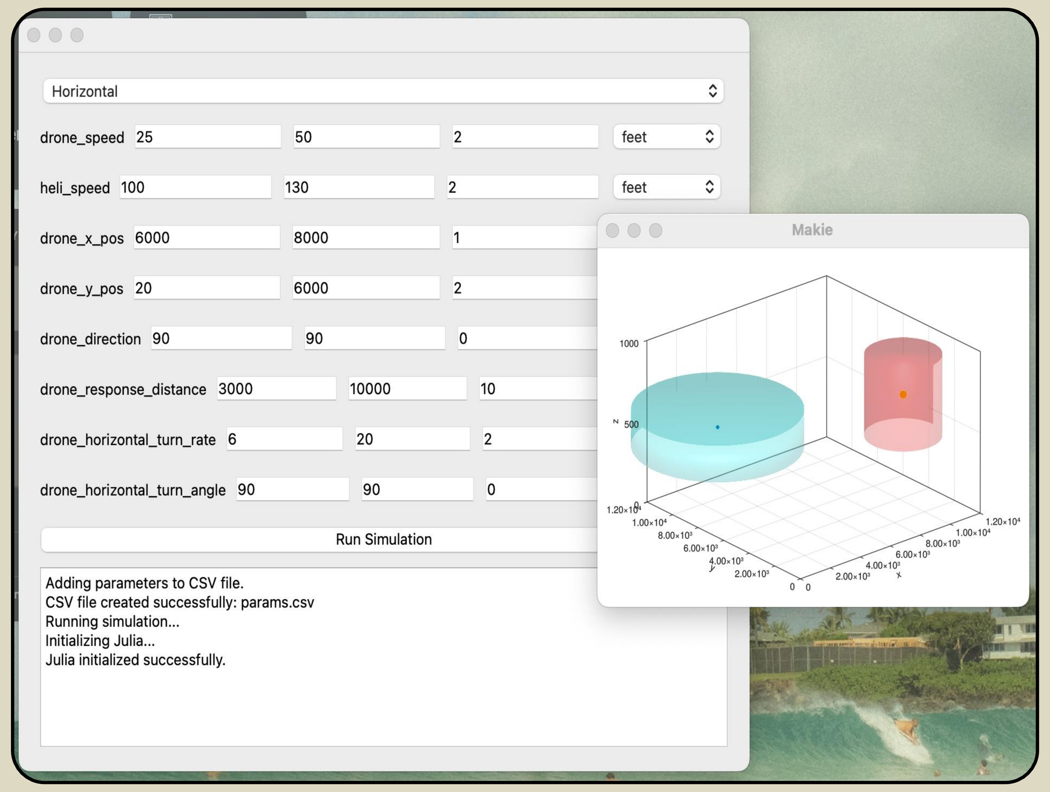

Figure 3. Julia Sim + Controller Integration

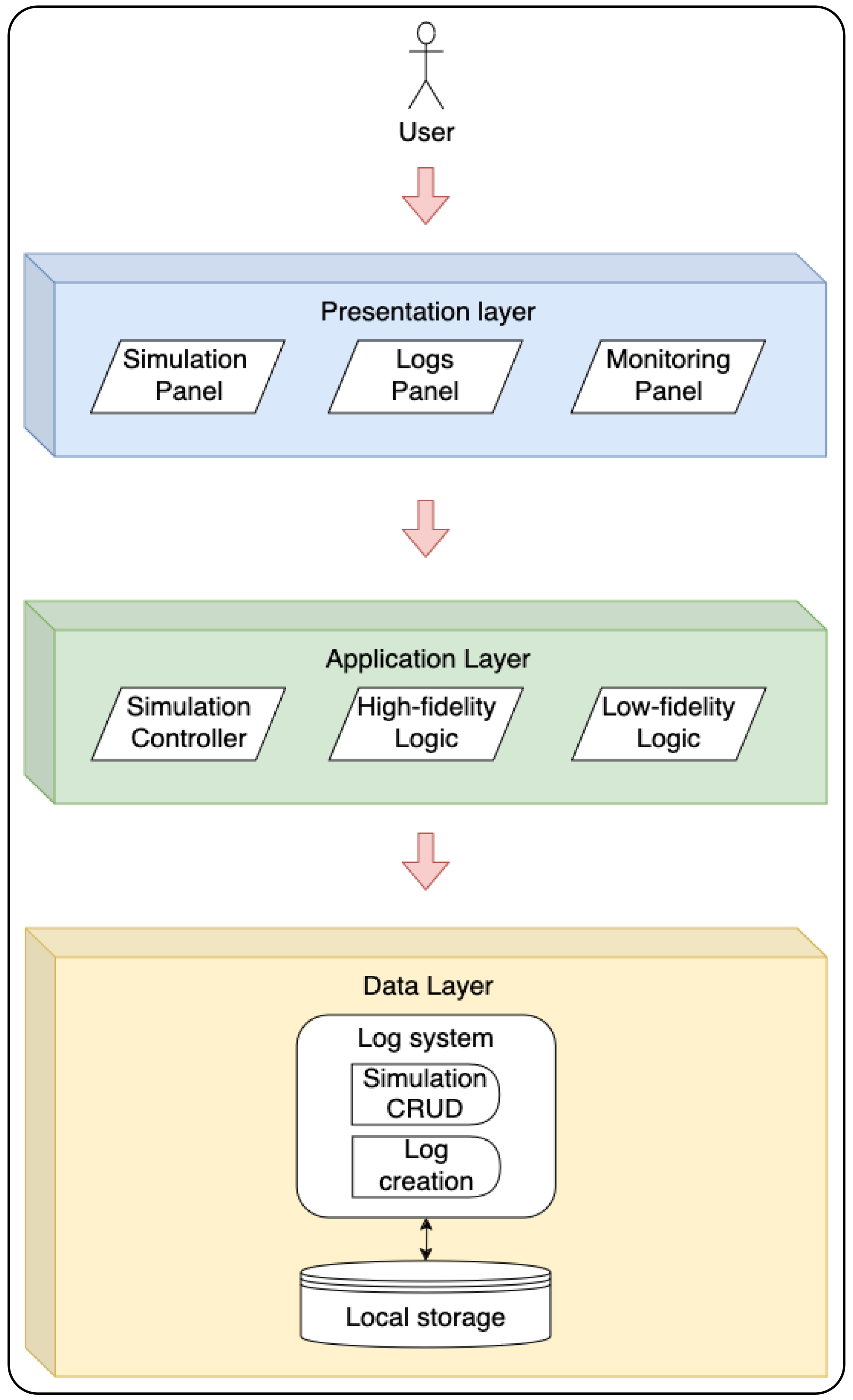

Figure 4. System Software Architecture

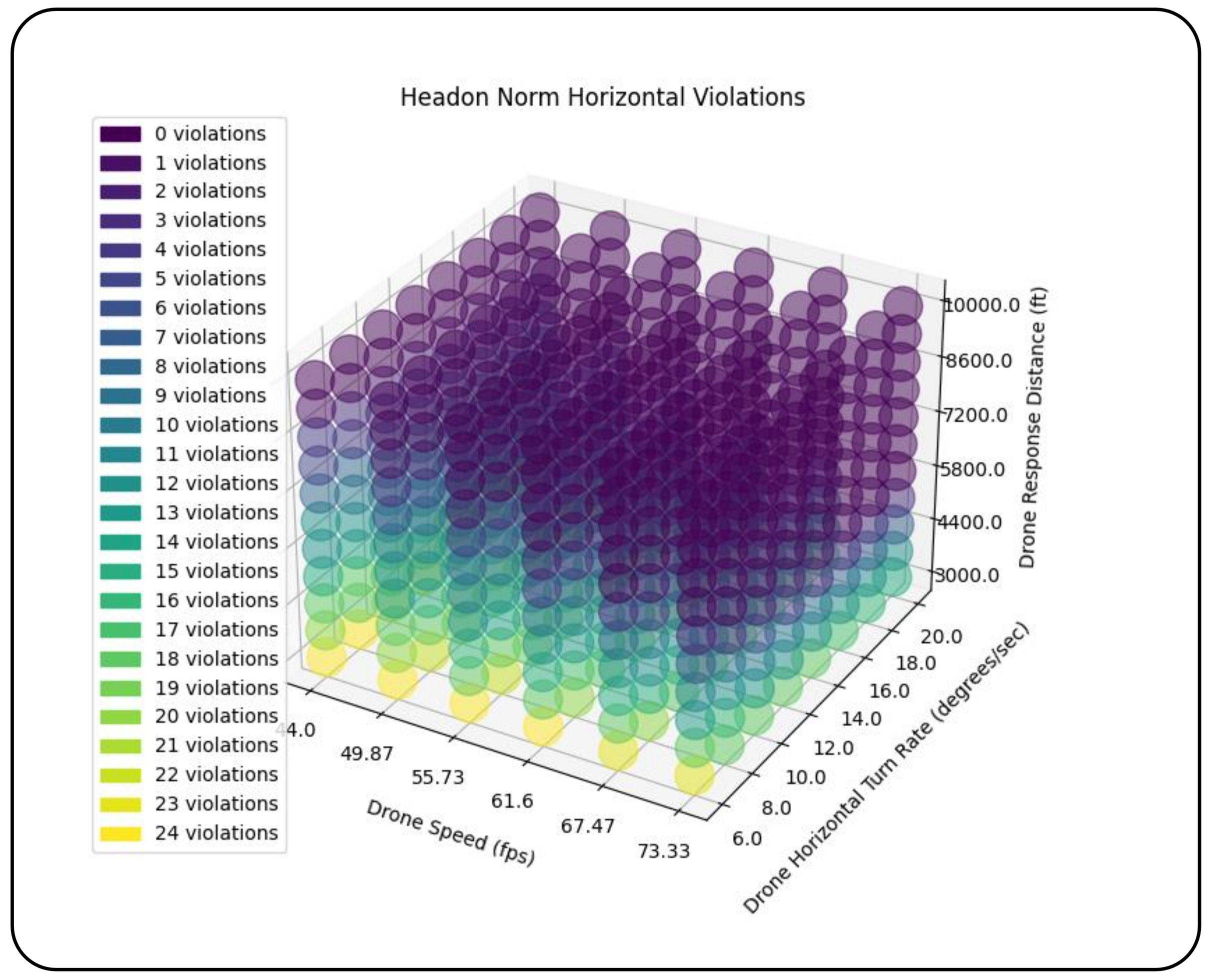

Figure 5. JuliaSim Headon Norm Horizontal Violation Graph

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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