Embry-Riddle Aeronautical University

Versatile Autonomous Navigation Testing and Guidance Environment

VANTAGE

Jack Lee, Jim Pamplona, Jonathan Ortiz, Mai Evans

Department of EECS

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 developed more reliable and efficient testing and validation methods for collision avoidance systems in UAS.**

Background

- The project covered the development of an open-source framework aimed at improving **collision avoidance systems for uncrewed aerial vehicles (UAV).**
- The scope included the creation of a two-tiered simulation environment–comprising a low-fidelity simulator and a high-fidelity 3D simulator.
- The framework underwent rigorous training and testing to cover potential collision situations. **It aimed to validate its effectiveness in live UAS tests, moving from simulated environments to real-world scenarios.**

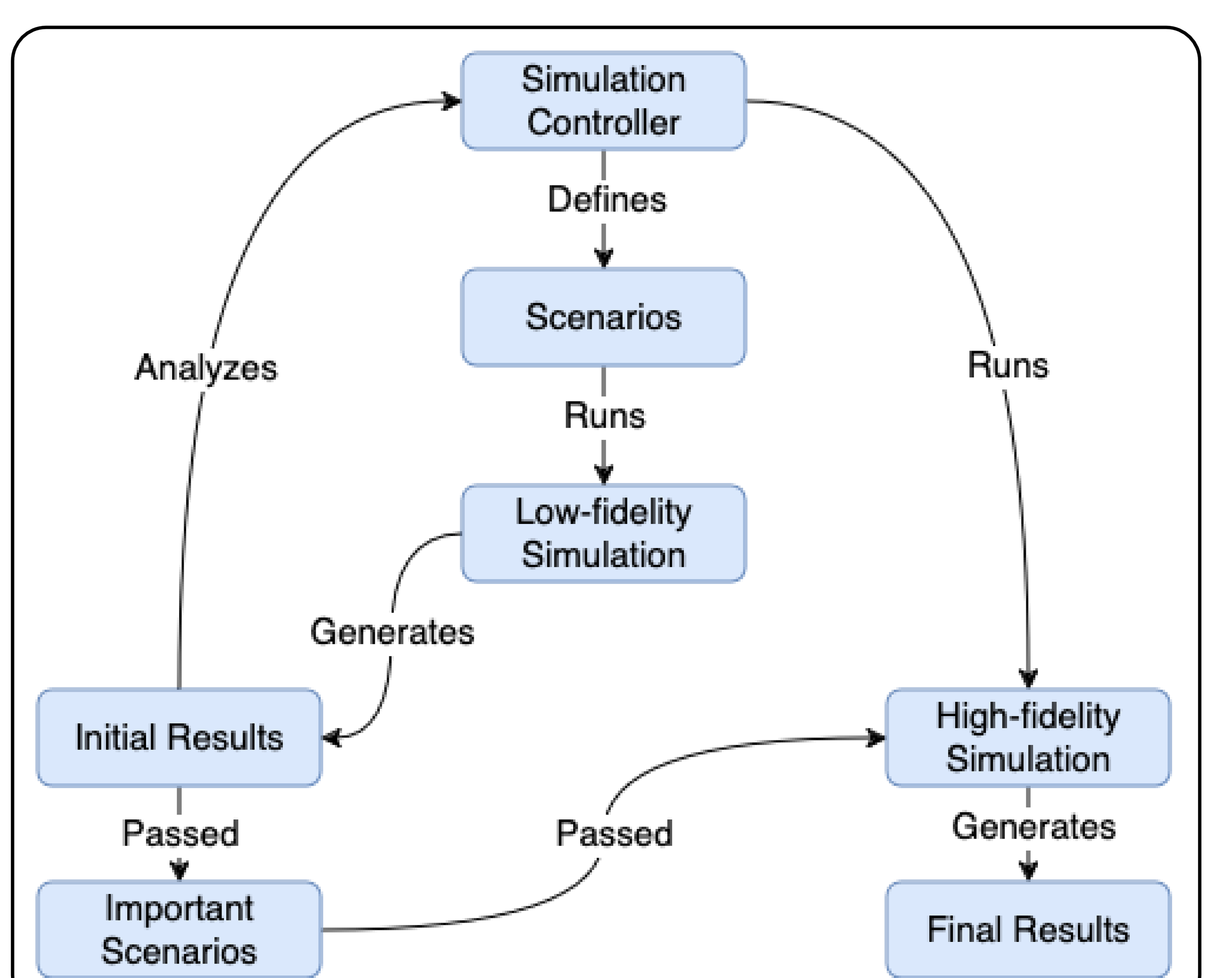

Figure 1. System flow chart

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.

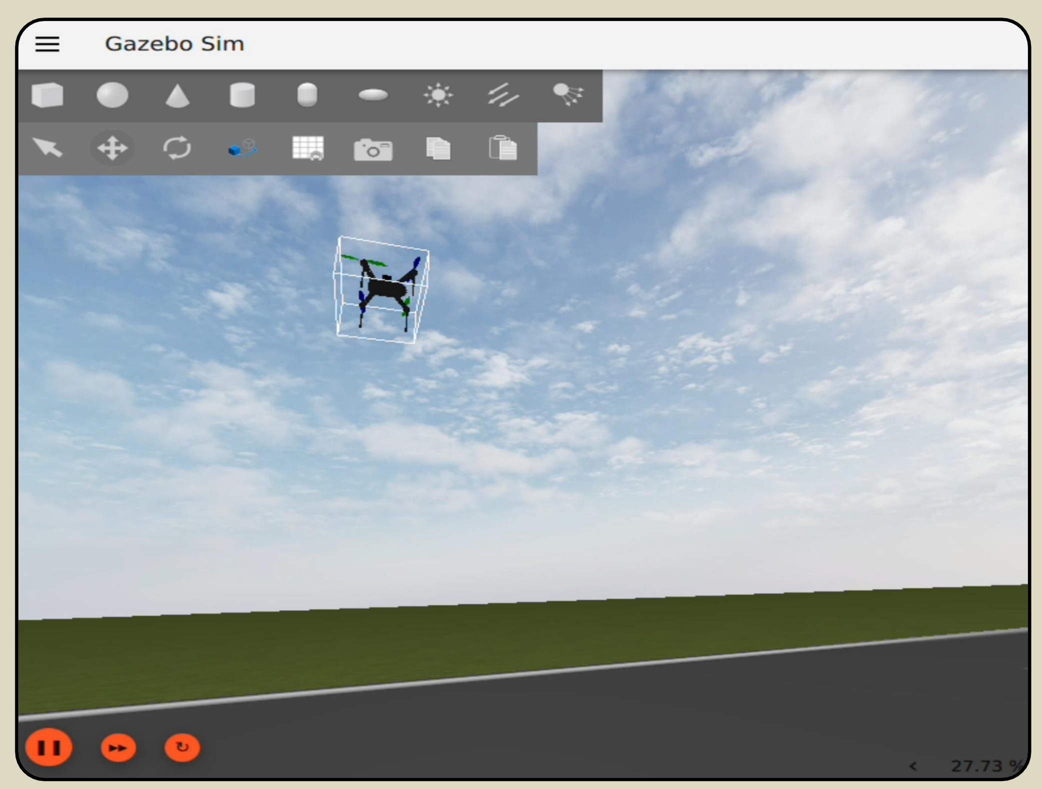

Figure 2. Gazebo, Ardupilot, ROS2 Integration

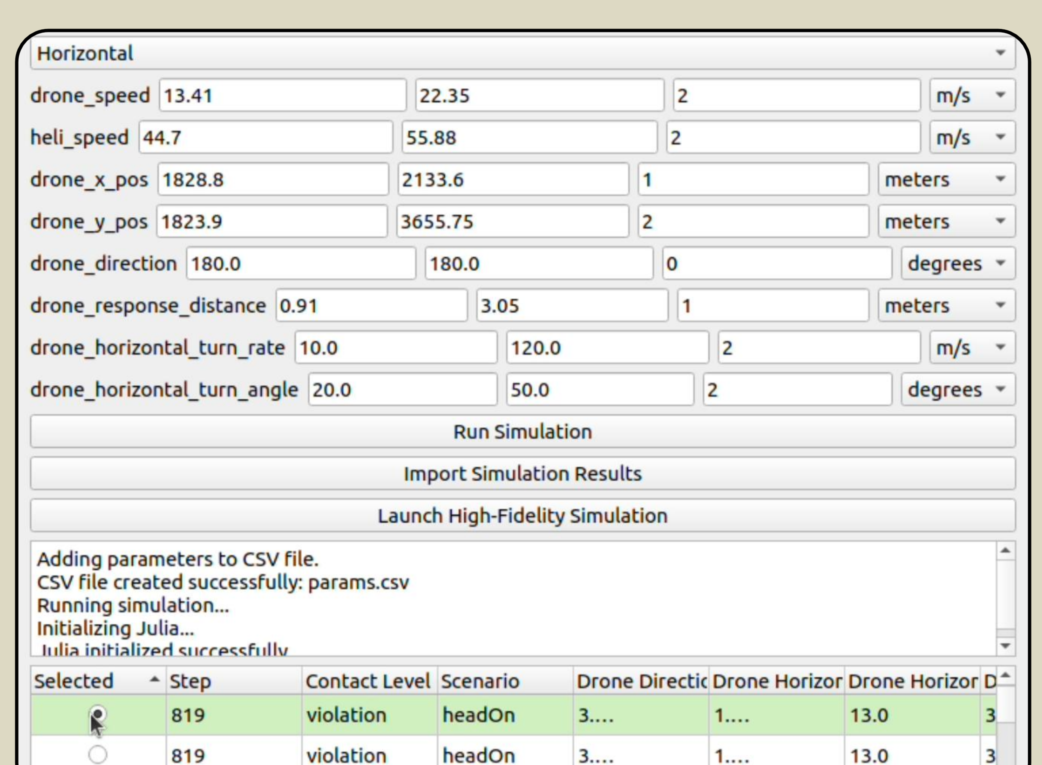

Figure 3. Julia Sim + Controller Integration

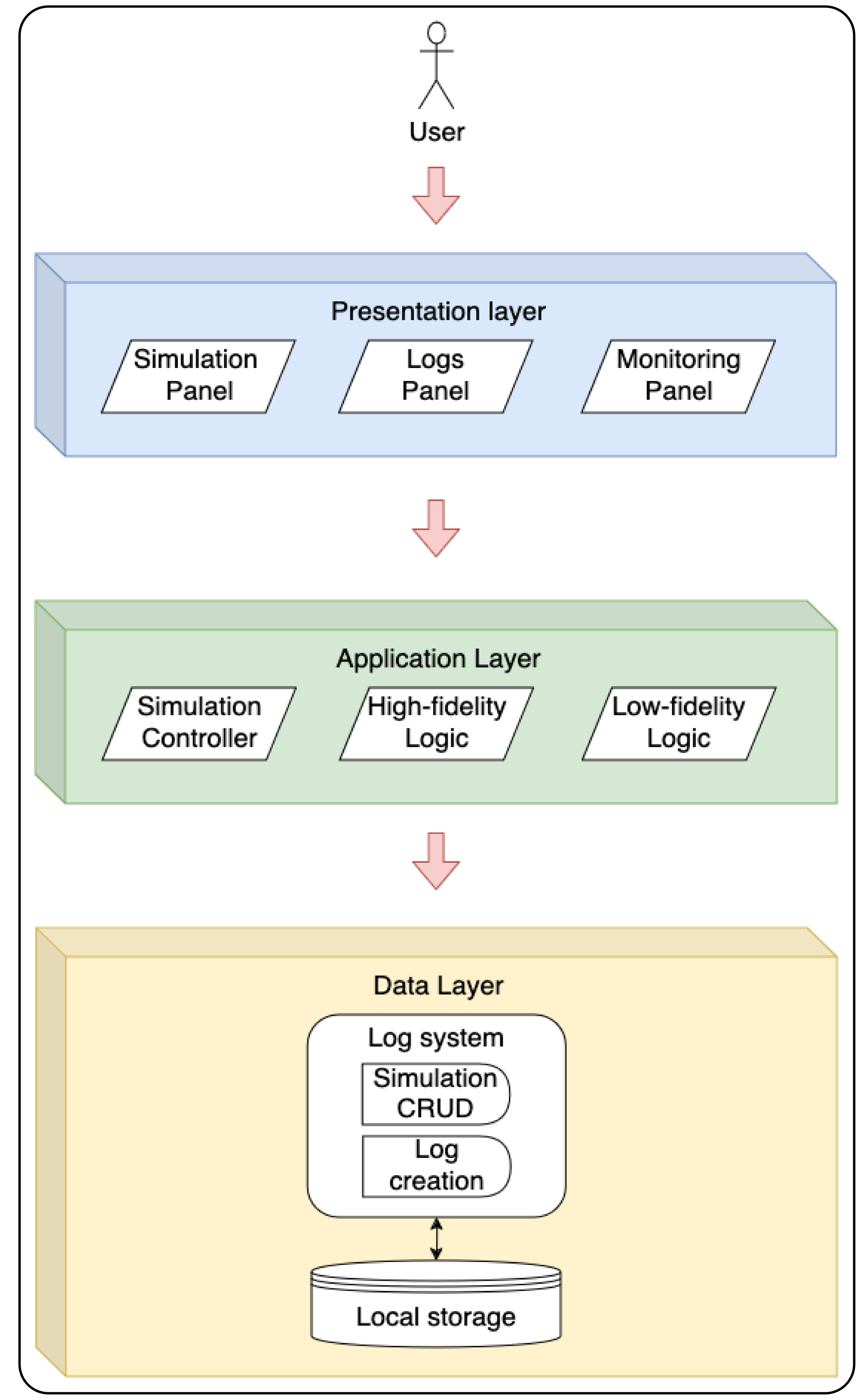

Figure 4. System Software Architecture

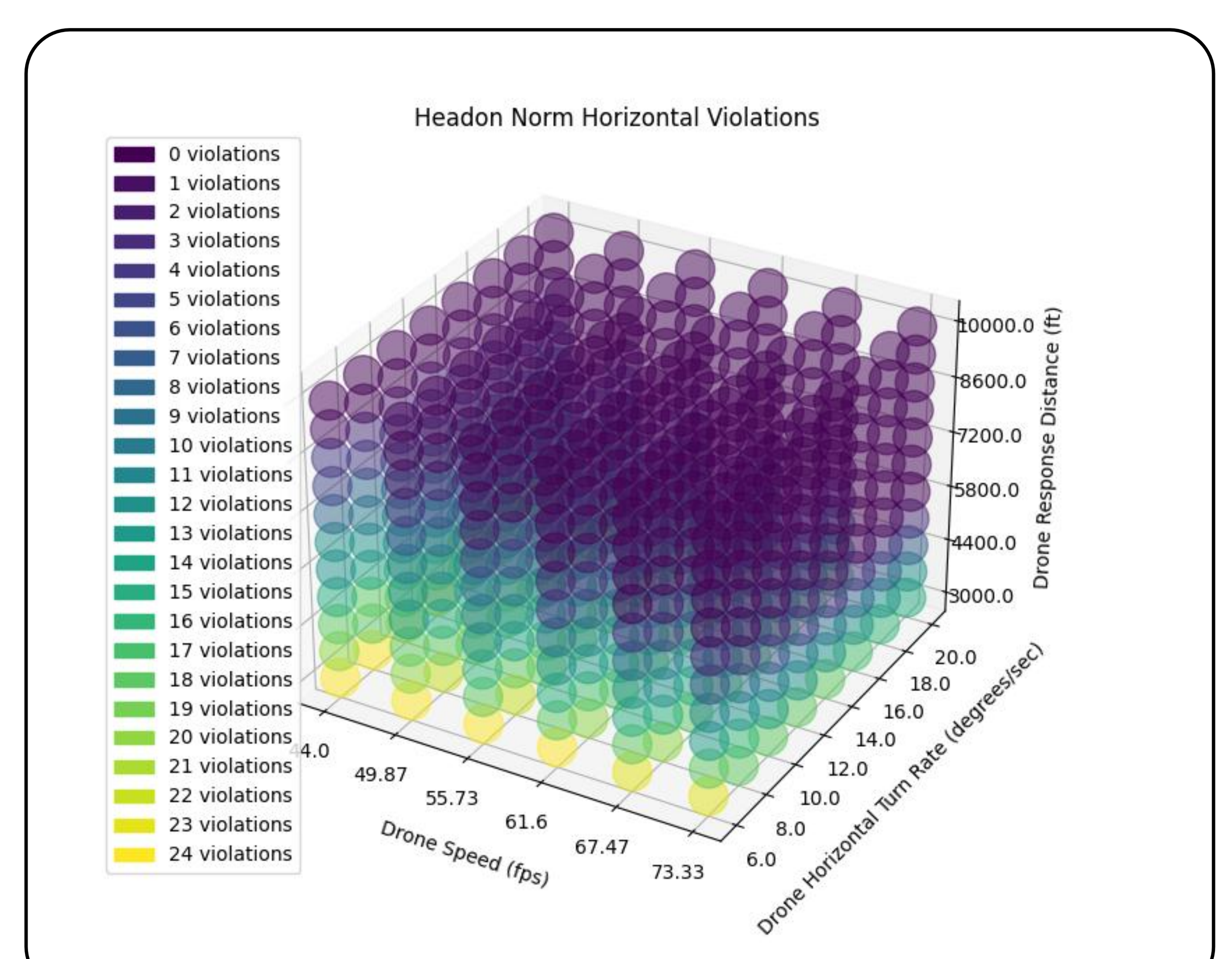

Figure 5. JuliaSim Headon Norm Horizontal Violation Graph

Results & Conclusion

- **Gazebo-Ardupilot-ROS2**: Successful integration between all software to establish a unified simulation environment.
- **Controller Integration**: Created a controller for simulation management across both low-fidelity and high-fidelity simulations.
- **Data transfer and Logging**: Implemented a reliable data flow pipeline and structured logging system between both simulation environments.

The project successfully established a two-tiered simulation framework, setting up both low-fidelity and high-fidelity simulators, for to support UAV collision avoidance research. **By addressing configuration challenges and integrating various tools, the project offers a scalable and user-friendly environment for future testing and development efforts.**

Future Work

- **AI Integration**: Implement AI algorithms for advanced collision avoidance analysis and training.
- **Hardware Integration**: Transition to real-world testing with physical drones.
- **Research Utilization**: Use VANTAGE to run research simulations and record the results and findings in papers.

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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