Simulation-Guided Testing for Autonomous Aerial Robotics Applications

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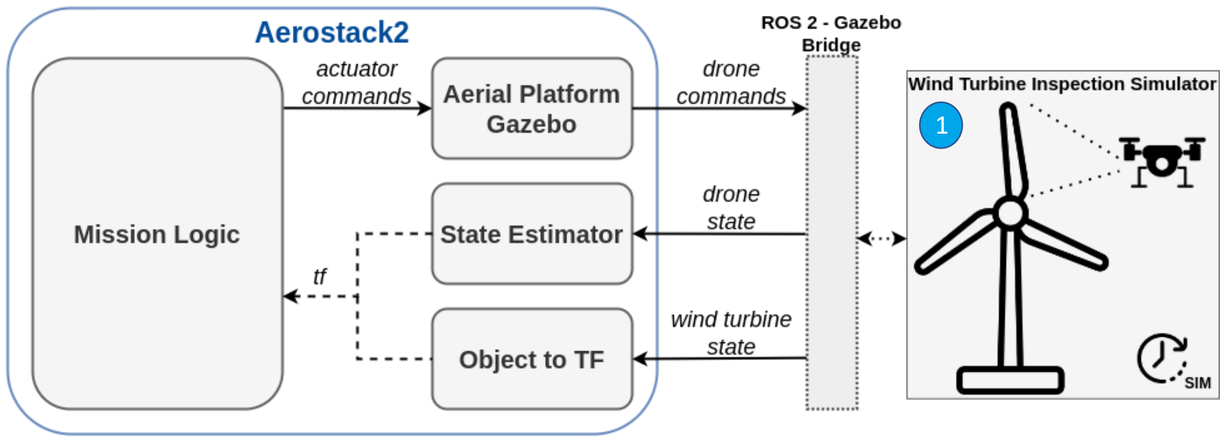
Abstract

Simulation testing is essential for the safe and efficient development of UAV applications. Simulation can help greatly in identifying and mitigating potential risks. In many applications, such as industrial inspections, conducting real flight experiments on the final installations is not only complicated but also quite risky. In such cases, being able to perform real flights using simulated data from the final application allows for more thorough testing of the robotic system without putting expensive industrial devices at risk. In this paper, we demonstrate how the **Aerostack2** framework facilitates the transition between simulation and the final application by using simulation data for real flight experiments. We achieve this through an intermediate step called "Hybrid Simulation," which allows for real flight testing without endangering the actual industrial facility.

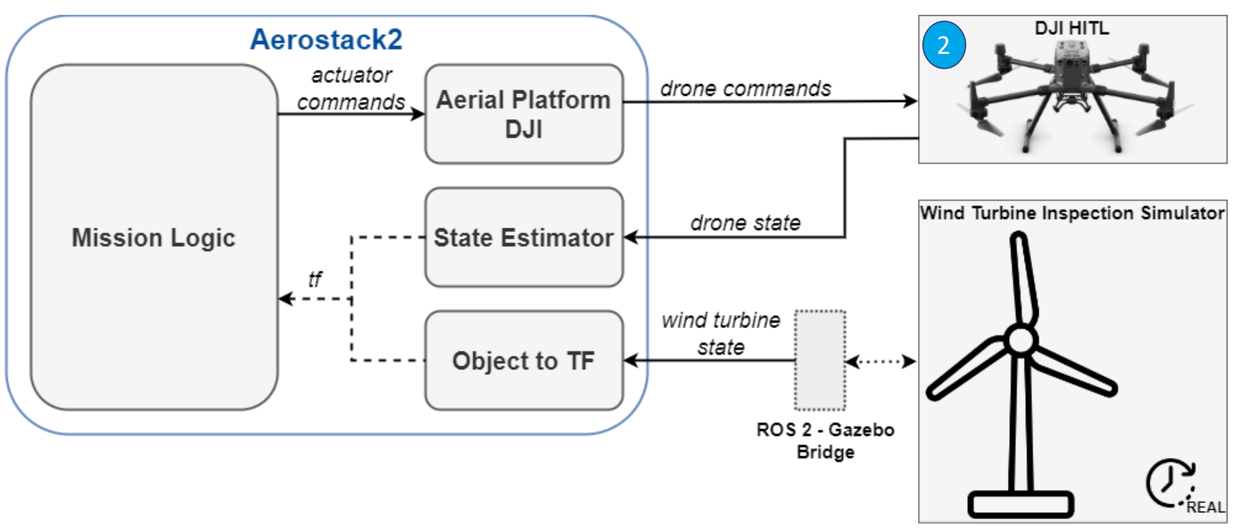
Pipeline

1. Simulation in Gazebo
   - ✓ Autonomous algorithms behavior
2. Hybrid Simulation
   - ✓ Algorithms performance
   - ✓ Hardware compatibility
3. Real Flight
   - ✓ Performance in real environment

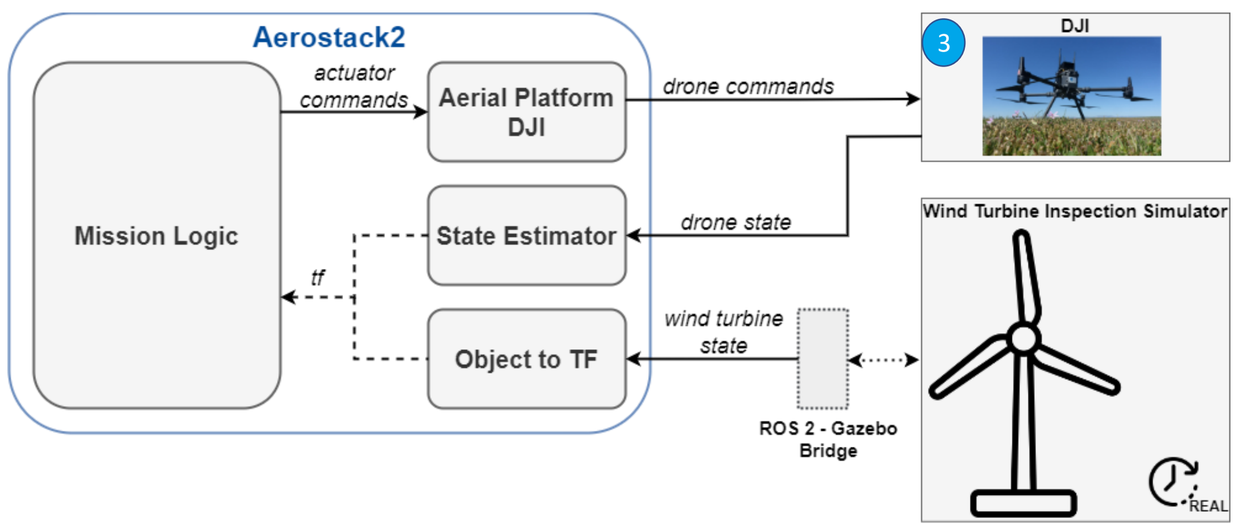
1. Simulation in Gazebo



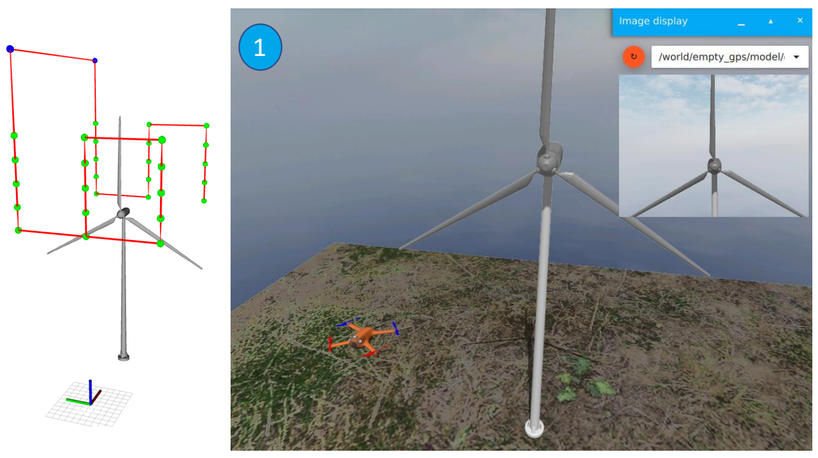
2. Hybrid Simulation



3. Real Flight

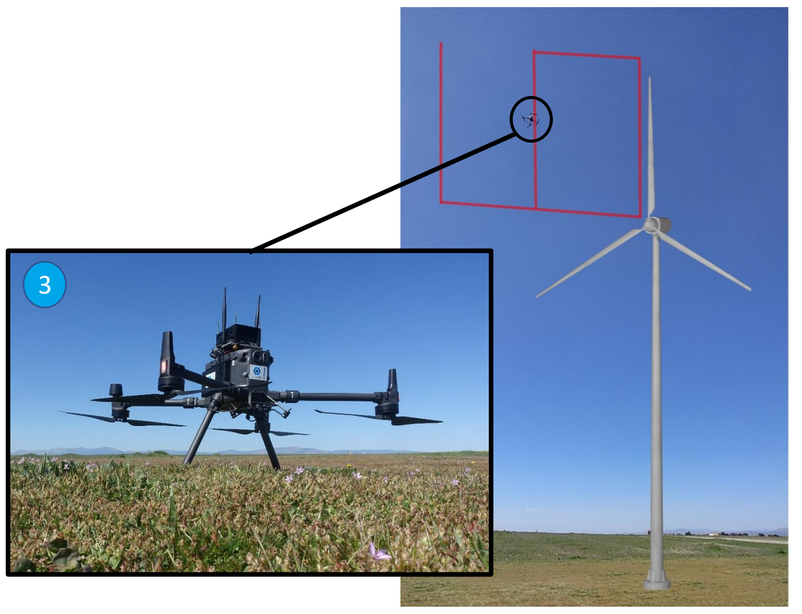


Experiments



Gazebo Simulator for Wind Turbine inspection and RViz visualization of the inspection trajectory waypoints

DJI Assistant 2 for DJI M300 aircraft Hardware In The Loop simulation



Real Flight using DJI M300, with a simulated wind turbine and inspection trajectory, both drawn in mixed reality

Conclusions

- **Proposed three stages methodology** makes much **easier and safer the development of UAV** industrial applications, such as wind turbine inspection.
- The use of **simulation data in real flight experiment** highly **improves the safety of the test process,** in the intermediate Hybrid Simulation stage, by significantly reducing the intrinsic risks when flying close to critical industrial facilities.
- **Aerostack2** framework **facilitates the development** of aerial robotic applications **by using the same software in all three development stages.**

Reference: M. Fernandez-Cortizas, M. Molina, P. Arias-Perez, R. Perez-Segui, D. Perez-Saura, and P. Campoy, 2023, "Aerostack2: A software framework for developing multi-robot aerial systems", ArXiv DOI 2303.18237.

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