Robust Fault-Tolerant Control of GPS-Denied Quadrotors using PID-TinyMPC and VIO
Real-time autonomous flight despite rotor failures

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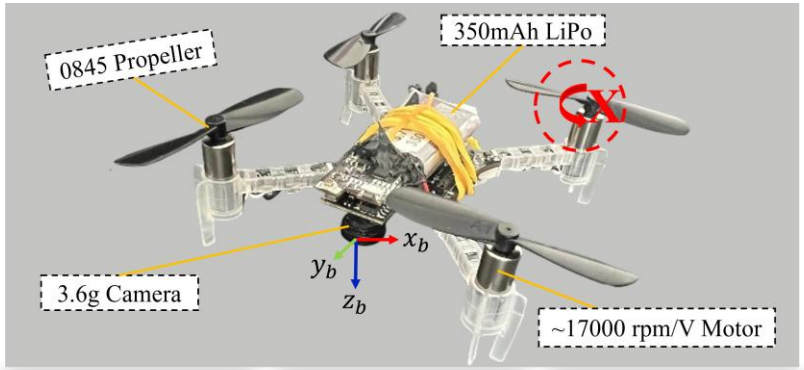
COGVILAB

Introduction:

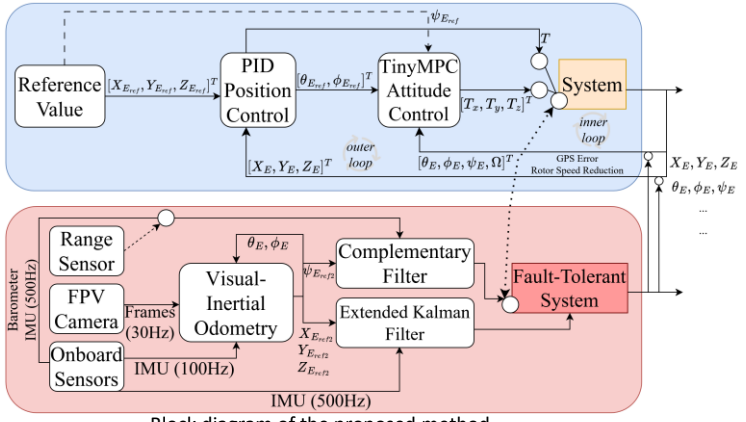
- Problem: Maintaining stable flight after rotor failure in GPS-denied environments.
- Solution: Integrating PID, TinyMPC, and ORB-SLAM3 VIO on mini quadrotor.



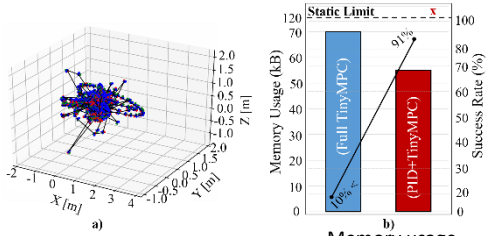
Experimental quadrotor platform equipped with a downward-facing 3.6g camera and a ~17000 rpm/V motor. The visual-inertial odometry (VIO) pipeline utilizes the captured visual features (middle), 3D point cloud and pose estimation (left), and coordinate alignment with the world frame (right). This quadrotor rotates at ~2.61 rad/s (equivalent to 150 deg/s) with one rotor slowed down.

Methodology:

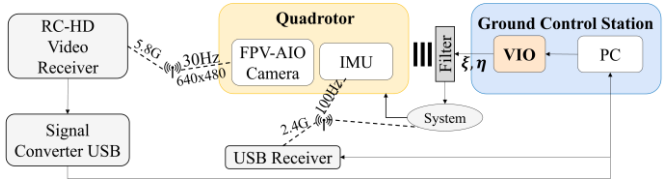
1. PID for basic stabilization.
2. TinyMPC for predictive control.
3. ORB-SLAM3 VIO for state estimation.
4. Real-time onboard execution.



Block diagram of the proposed method

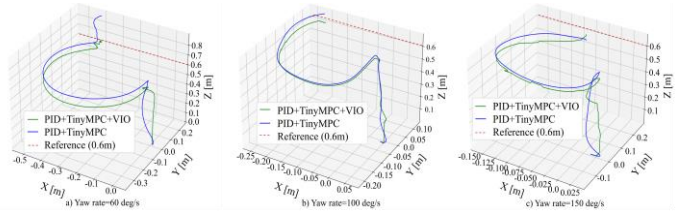


IMU estimated poses | Memory usage

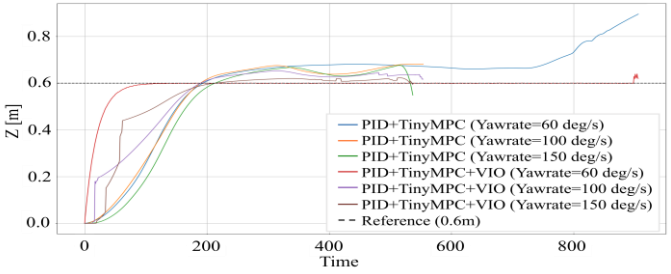


Results:

- Stable hover despite rotor failures.
- Improved tracking performance.
- Experimental validation on mini quadrotor.



Fault-tolerant control experiment with mini quadrotor. vy=-0.3



Fault-tolerant control Z-axis deviations