Project 9: Crazyflie 2.1 (STEM Ranging Bundle) — “Table-Top Altitude Guard”

Topics: ultra-light UAV, state monitoring, ranging sensors, fault detection

Objective

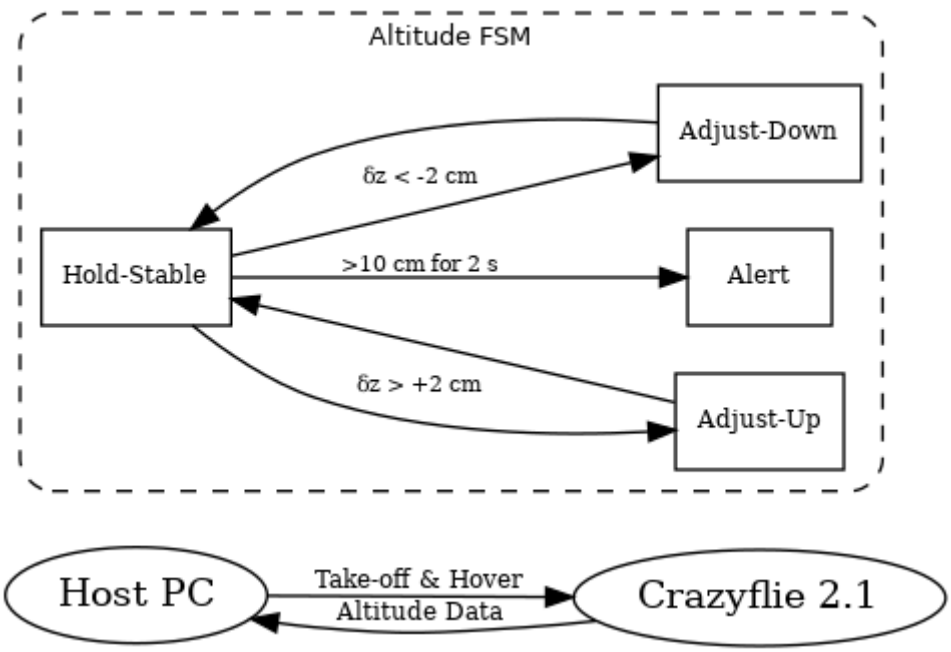
Model a small-scale drone hovering experiment, where the Crazyflie 2.1 maintains a target altitude of 0.7 meters using its downward-facing ToF sensor. The system should detect and respond to vertical oscillations and trigger an alert if the altitude deviates by more than 10 cm for over two seconds.

Description

The Crazyflie 2.1 hovers in place above a desk while its onboard ToF (Time-of-Flight) module continuously measures its distance from the surface. The target altitude is set at 0.7 meters. A host PC receives the altitude data at 50 Hz via the Crazyradio interface and visualizes it as a live strip-chart.

An FSM governs the system behavior with the following states: Hold-Stable (within ±2 cm of target), Adjust-Up, Adjust-Down, and Alert. Transitions occur based on vertical deviations: if the drone rises or drops slightly, it enters adjustment states; if a significant deviation persists for more than two seconds, it switches to Alert, flashing LEDs and sounding a tone via the host console.

A typical fault scenario involves manually placing a book or object under the drone to fool the ToF sensor into perceiving false altitude. This triggers a false-positive hover reading, which the system must detect and respond to by entering Alert.



Methods and Tools

- Bitcraze Crazyflie 2.1 with STEM Ranging Bundle
- Crazyradio + Crazyflie-lib-python for control and telemetry
- FSM logic implemented in Python
- Matplotlib for real-time altitude plotting
- CSV-based logging for post-flight analysis

Expected Outcome

- A 2-minute hover test maintaining ±2 cm precision under normal conditions
- Successful detection of a false-floor scenario and triggering of Alert state
- Strip-chart visualization of altitude data and event logging
- CSV trace of altitude vs time for evaluation

Project Phases and Workload Distribution

First phase – Industrial IoT course (logic prototyping): Implementation of the FSM and basic visualization in Python. Altitude thresholds and transitions will be defined and tested using emulated sensor data.

Deliverables:

- FSM logic script
- Simulated test run with artificial deviations
- Strip-chart demo and performance summary

Second phase – Internship (hardware testing): The drone will be deployed for real hovering experiments. Actual altitude readings will be collected and visualized. The fault scenario with a false floor will be induced to validate system response.

Deliverables:

- Configured Crazyflie STEM setup
- Real-time altitude plot and test video
- Alert logs and response time metrics
- Short evaluation report

Third phase – Thesis project (analysis and refinement): Analysis of altitude stability, adjustment behavior, and fault detection robustness. Optionally, introduce adaptive thresholds or integrate alerts into a dashboard.

Deliverables:

- Final thesis report
- CSV datasets with altitude traces
- Comparative analysis of adjustment vs alert transitions
- Optional GUI or dashboard extension