Design, Implementation and Evaluation of a Fault Detection and Emergency Control Strategy for a Quadcopter System

Popular science summary of the Master Thesis [2] at the Faculty of Engineering LTH, Lund University

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In this thesis, a sophisticated fault detection and diagnosis system for the Crazyflie 2.1, a compact and versatile unmanned aerial vehicle (UAV) was developed. The thesis investigates the various types of faults that can occur within the UAV and presents suitable methods and tests to effectively identify and address these issues. While the primary focus was on enhancing the UAV's lighthouse positioning system, the techniques and solutions proposed are versatile enough to be applied across other modules of the Crazyflie ecosystem.

Crazyflie 2.1 unmanned aerial vehicle [1]

Faults in UAVs can lead to unpredictable behavior and potential crashes, which is why detecting and responding to these faults promptly is crucial. This thesis explored different strategies for managing faults, emphasizing ways to bring the quadcopter safely to the ground in the event of an issue. To enhance user experience and customization, the developed system allows users to define specific actions for each type of fault. These actions are seamlessly integrated into the UAV's onboard state machine, ensuring that the Crazyflie can respond quickly and appropriately to the detected fault.

One of the significant achievements of the thesis is the promising performance of the newly developed control strategies. These strategies showed effective results in maintaining the UAV's stability and performance during faults. However, due to their simplicity and proven effectiveness, some pre-existing strategies were preferred in certain scenarios. The new system stands out for its simplicity, flexibility, and robustness, making it a valuable addition to the Crazyflie's operational capabilities.

In addition to the fault detection system, the thesis also revisited a propeller unbalance estimator that had been developed in previous work. This estimator is capable of identifying which propeller is damaged and estimating the extent of the unbalance with good accuracy. Despite its accuracy, the estimator was found to be highly model-dependent, limiting its utility as a general diagnostic tool across different Crazyflie configurations and setups.

Overall, the thesis represents a significant step forward in enhancing the safety and reliability of Crazyflie UAVs. By providing a flexible and robust fault detection and response system, it ensures that users can customize their UAVs to react appropriately to various faults, thereby reducing the risk of accidents and improving the overall flight experience. While some components, such as the propeller unbalance estimator, may require further refinement for broader application, the study lays a strong foundation for future advancements in UAV fault detection and management systems.

[1] Bitcraze. *Crazyflie 2.1*. 2023. URL: `https://www.bitcraze.io/products/crazyflie-2-1/`.

[2] Björn Fredlund. *Design, Implementation and Evaluation of a Fault Detection and Emergency Control Strategy for a Quadcopter System*. Master's thesis. The report is available for downloading from https://lup.lub.lu.se/student-papers/. Dept. of Automatic Control, LTH, Lund University, Lund, Sweden, July 2024.