PEPPYCARROT

ADVANCED FLIGHT CONTROL SYSTEM WITH FAULT TOLERANT ARCHITECTURE

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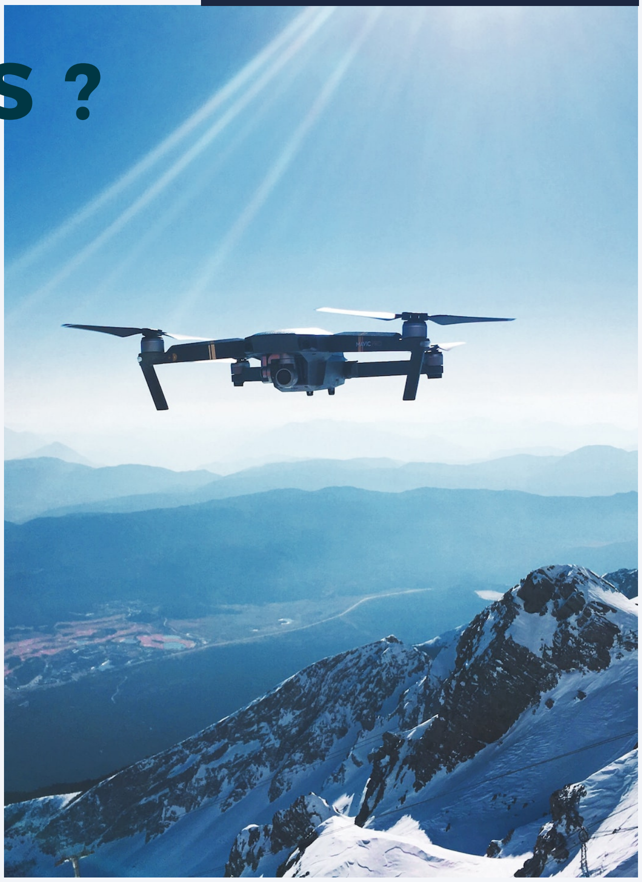
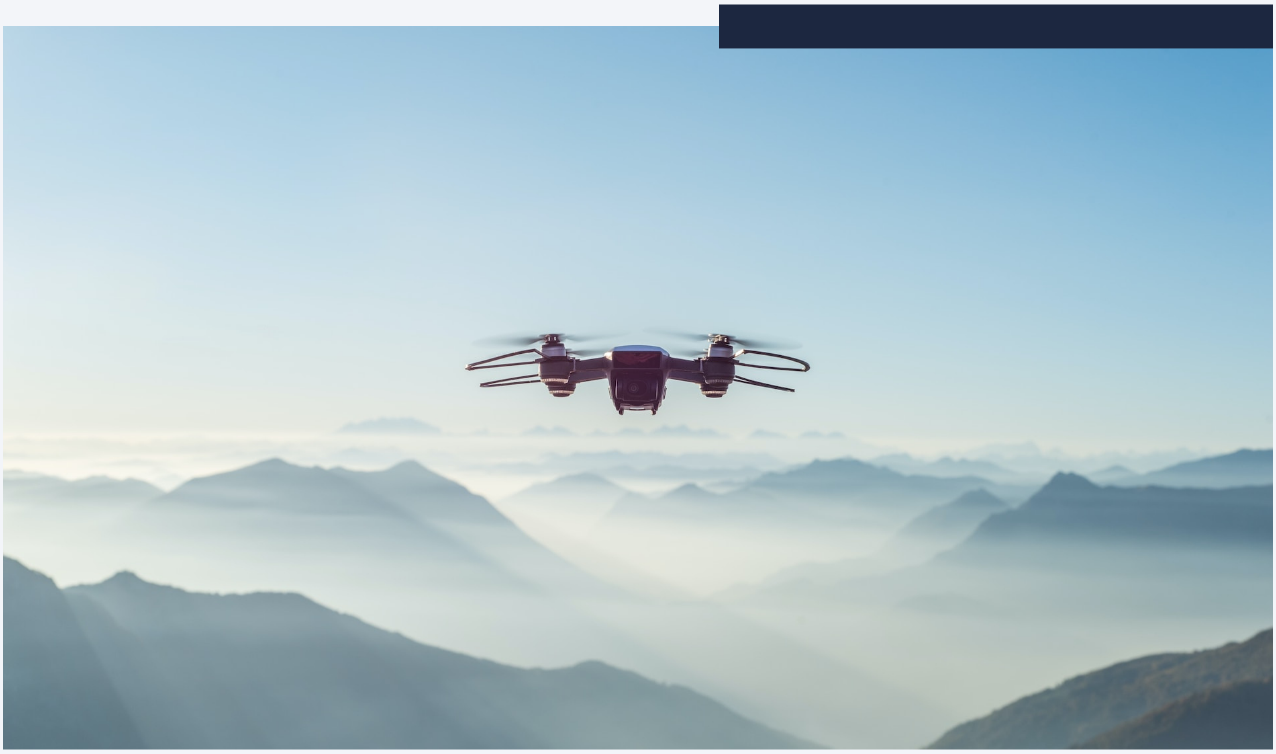
WHAT ARE FLIGHT CONTROLLERS ?



Flight controllers in drones are synonymous with the processing unit in a computer. They could be thought of as the brain of the drone. These controllers come in a variety of sizes and complexity. The operational efficiency and unique capabilities of drones are defined by the flight controller.

The flight controller is responsible for the drone's fail-safe operation at all times. The activities of a flight controller can be categorized into the following - sensing, controlling, and communicating.

INTRODUCTION



Consumer drones have flooded the market in droves. In the Indian drone market, consumers can choose between cheap drones and expensive purpose-built drones. The plethora of choices and high availability come with their own set of challenges. When buying a drone, users are usually spoilt by choice. Additionally, the spec sheets may be so extensive that it can cloud their judgement on what to buy.

A commonly overlooked factor is the operational safety and data security of these systems. In-flight system failures could bring down the drone and cause critical data loss. Such failures could be disastrous in mission-critical applications such as military surveillance, logistics, defence, fire and safety, etc. Off-the-shelf solutions on the market provide little to no control over the SoC or the firmware, making them tightly bound to some foreign manufacturer's ecosystem.

Before delving into the system-level components of a flight controller let us understand what they do. A flight controller is responsible for the following key aspects of the drone:

Perception

The flight controller is connected to a set of sensors. These sensors give the flight controller information about its height, orientation, and speed. Common sensors include an Inertial Measurement Unit (IMU) for determining angular speed and acceleration, a barometer for height, and distance sensors for detecting obstacles. Just like human perception, the drone filters a lot of this information and fuses some of it to get more efficient and precise knowledge of its surroundings. Advanced flight controllers can sense this more accurately and detect differences more quickly.

Control

A flight controller controls the movements of the drone in addition to detecting its surroundings. The drone can rotate and accelerate by creating speed differences between each of its four motors. The flight controller uses the data gathered by the sensors to calculate the desired speed for each of the four motors. The flight controller sends this desired speed to the Electronic Speed Controllers (ESCs), which translate this desired speed into a signal that the motors can understand.

An algorithm calculates the motions, fuses and filters the sensory input, and estimates the safety and durability of a flight.

The most commonly used flight control algorithm is called PID control: Proportional Integral Derivative control. There is ongoing extensive research in this field, which has resulted in INDI: Incremental Nonlinear Dynamic Inversion. This algorithm reads out and reacts to incoming information way faster, making the drone flight more stable.

Communication

Another key part of a flight controller is communication. The sensor's job is to give out information that needs to be clearly translated for a pilot to read. For example, the battery level communicates if a pilot wants to fly further or return to the charge.

However, communication is not limited to transactions between flight controllers and human pilots; with the entrance of auto-pilot programs in the drone industry, flight controllers need to communicate with other computer systems about their flight destinations and how to get there. Communication is mostly done with Wi-Fi and radio frequencies right now, but cellular solutions are also already in use. In short, the flight control system serves a very critical role in the successful operation of a drone. In addition to being the human-machine interface, these control systems are responsible for the existence of the drone ecosystem as we know it.

FAULT TOLERANT MULTI REDUNDANT FLIGHT CONTROL

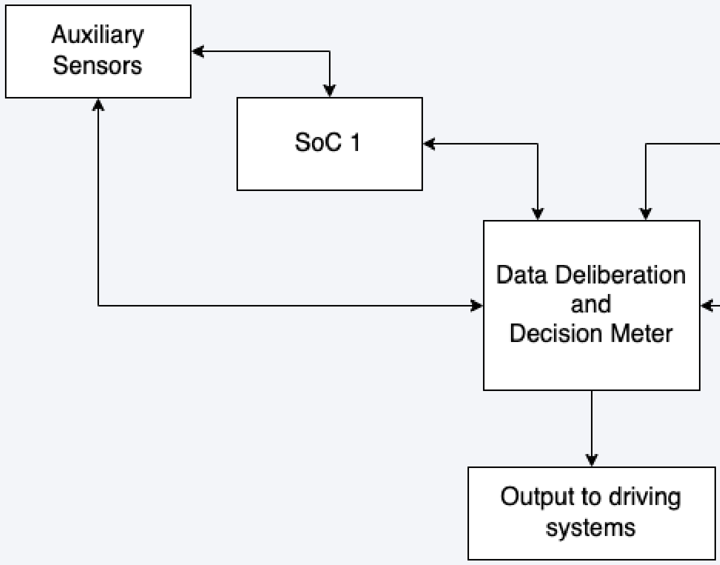
Now that we have established how big of a responsibility the flight controllers serve in a drone, it is essential that the controller never fails. Since we live in a not-so-perfect world, it is imperative that the system design of these controllers has to factor in the risks of in-flight system failures. This paper discusses our proprietary flight control system developed with the core idea of supporting safe, risk-free flight operations. The Fault-Tolerant Multi-Redundant Flight Control System is our take on an intelligent flight controller that has risk management built-in to its very design.

The Fault-Tolerant Multi-Redundant Flight Control System designed by PeppyCarrot is a leap towards verified reliability in the UAV Flight Control Systems. This is our step towards Human-Certified UAV Systems with a plethora of fault-tolerant mechanisms and multi-sensor fusion. The flight controller SoC supports interoperability with multiple SoCs currently available in the market.

Our engineers have designed this flight controller to withstand system failures by designing intelligent Decision and Management Circuits (DMC) to switch between circuit paths. This allows the backup systems to kick in and take over when a critical error happens. Fault Tolerance is achieved through multi-sensor fusion, with the option to add more than one sensor input of the same kind, along with proprietary decision circuits. Our proprietary system management circuit ensures the following:

- continuous interruption-free operation
- an auto-recovery mechanism for sensors and SoC
- automatic pairing and unpairing of sensors from one SoC to another, when possible faults are detected during operation.

Our proprietary flight control system allows the addition of sensors, auxiliary inputs, and other processing systems with the auto-scaling DMC. This makes the flight controller scale for different missions with varying reliability requirements. The DMC is designed to work without any processing delay. It has in-built fault detection and recovery circuits along with alternate circuit paths to ensure the operation is not interrupted during error detection and recovery. The image below shows a very high-level view of the major building blocks of our flight control system.



The codebase is designed to be cross-platform capable, to be run on any SoC with different processor architecture. The whole system is composed of components that are totally vendor independent and locally sourced, which ensures the supply is independent of geo-political supply problems.

In conclusion, our indigenously developed flight controller systems offer a safe choice for defense and security applications. A fully made-in-India control system ensures data security and ownership for the state's drone defense ecosystem.