Overview

The main purpose of the autopilot is to enable the unmanned aircraft to accomplish their mission autonomously, without any (or with minimal) input from the operator. An autopilot is using the aircraft state information provided by the on-board sensors to drive the control surface actuators (servos). UNMANNED DYNAMICS designs autopilot algorithms that provide autonomy to the aircraft in all phases of a typical UAV mission, including automated take-off and landing.

There are three hierarchical levels of control that can be identified in a modern UAV autopilot system:

Low-level Control (Stability & Control)

This level includes the stability and control loops. These provide the airplane with improved dynamic stability, regulation of flight parameters, as well as tracking of basic autopilot commands. Although there are many control law architectures, the classic PID control approach augmented with online gain scheduling provides the ideal mix of robustness and performance for typical aircraft dynamics. The stability loops include the Pitch, Roll, and Yaw Dampers. Typical control loops implemented on UAVs are: Airspeed Hold, Altitude Hold, Altitude Rate Hold, Turn Compensation, Turn Coordination, Turn Rate Control, Bank Angle Hold, Heading Hold.

The stability and control loops can be tuned to provide the desired performance and robustness specifications by adjusting a set of autopilot parameters or gains. This is done through linear analysis - the nonlinear aircraft model is linearized for a representative set of flight conditions that cover the operating envelope of the aircraft. The linear dynamics of the closed-loop system (aircraft + autopilot) are analyzed in terms of stability and control responses (overshoot, settling time).

Mid-level Control (Navigation)

The mid-level control provides guidance and navigation capability to the UAV - automatic take-off and landing, climb, cruise, and loiter. This includes generation of safe autopilot commands for the low-level control laws as well as specialized navigation algorithms such as a Flightplan Tracker or a Glideslope Coupler. Our nonlinear tracker design (AIAA paper 2001-0016) provides smooth, exponential convergence of the aircraft to the current flightplan segment regardless of the aircraft speed.
High-level Control (Autonomy)

The highest level of control is arguably the most complex and it provides a higher degree of autonomy to the Unmanned Air Vehicle. This involves interpreting the mission objectives and safety constraints, awareness of the current aircraft and environment conditions, online updates of the mission plan such that the mission objectives are optimally achieved. This level also provides a certain amount of fault tolerance to the UAV system by detecting sensor, actuator, or airframe faults and reconfiguring the low and mid-level control algorithms appropriately.

Piccolo Avionics Integration

PICCOLO is a highly-integrated programmable autopilot for small UAVs developed by CLOUD CAP TECHNOLOGY. UNMANNED DYNAMICS has contributed to the PICCOLO project by providing the flight control algorithms that run on-board this miniature avionics, as well as the nonlinear aircraft model used by the Piccolo Hardware-in-Loop Simulator.

We have extensive knowledge of the Piccolo system architecture and development environment, and we provide support for fast and efficient integration of this avionics in custom UAV applications.

Here are some of the integration services that UNMANNED DYNAMICS can provide to Piccolo customers:

- Development of custom aircraft models for the Piccolo HIL Simulator
- Autopilot gain tuning
- Development of custom autopilot architectures
- Flight-testing of Piccolo-equipped aircraft
- Payload integration - CAN bus or serial connection
- Satellite datalinks - Iridium
- Cellular network datalink - GSM