College of ENGINEERING
UNIVERSITY OF HAWAI'I AT MĀNOA

Aerospace Engineering Program

Seminar Series

Integrated Guidance, Navigation, and Control
for Unmanned Aerial Vehicles and Advanced Air Mobility

by

Evan Kawamura

April 13, 2022, 3:00 pm-4.00 pm Hawai'i time

Invitation link: https://hawaii.zoom.us/j/96500428733
Meeting ID: 965 0042 8733, Passcode: 082950

Abstract: ACTUAS is a NASA-funded *Established Program to Stimulate Competitive Research* (EPSCoR) project, which branched from the NASA-funded *Hawai'i's STEM Pathways* (HESTEMP) project. It has assembled a fixed-wing drone for agricultural and environmental applications and is planning to conduct flight tests with pilot training. In parallel, ACTUAS is also working on assembling a quadcopter and conducting flight tests of a DJI M100 to demonstrate the Onboard Software Development Kit (OSDK) capabilities. The goal of this research study is to demonstrate the implementation of guidance, navigation, and control functions and their integration for applications. The utility of integrated optimal control and explicit guidance functions is considered to replace current PID control laws. This approach leverages UAV flight autonomy, thereby paving the way for creating an autonomous control technology with real-time target-relative guidance and re-targeting capabilities. Three illustrative examples demonstrate the utility of extremal control and explicit guidance in quadcopters. Future work includes analyzing methods for extending explicit guidance, implementing navigation with extremal control and explicit guidance, satisfying the second-order conditions to determine optimal control with a corresponding trajectory, and testing the proposed guidance, navigation, and control functions onboard a DJI M100 using DJI's OSDK libraries and functions. Advanced Air Mobility (AAM) aircraft require perception systems for precision approach and landing systems (PALS) in urban, suburban, rural, and regional environments. The current state-of-the-art methods approved for automated approach and landing will be difficult to utilize in support of AAM operational concepts. However, there are technology and systems from other applications and lower-TRL research that use vision, IR, radar, and GPS methods to provide baseline perception and sensing requirements for AAM aircraft approach and landing. Focusing on vision-based PAL demonstrates a closed-loop baseline controller while adhering to the Federal Aviation Administration requirements and regulations. The coplanar algorithm determines pose estimation, which feeds into an Extended Kalman filter. Combining IMU with vision creates a sensor fusion navigation solution for GPS-denied environments. The state estimate leads to glideslope and localizer error computations, which will be pertinent for designing and deriving guidance laws and control laws for AAM PALS. The IMU and vision navigation solution provides promising simulation results for AAM PALS, and higher fidelity simulations will include computer graphics rendering and feature correspondence.

About the Speaker: Evan Kawamura received the B.S. and PhD degrees in Mechanical Engineering in Fall 2016 and Fall 2020, respectively. He has been part of University of Hawai'i Drone Technologies (UHDT) since Spring 2014 and currently serves as a mentor. He also led Dr. Azimov's Autonomous Control Technologies – Unmanned Aerial Systems (ACTUAS) project, where students learned about UAS kinematics, dynamics, guidance, navigation, control, and conducted simulations, assembled, integrated and flew UASs, such as fixed-wing and multi-rotor UASs for a wide range of applications. He was a NASA Pathways intern and recently converted to a full-time civil servant in 2021. Currently, he works on the Perception and Distributed Sensing project under Transformational Tools and Technologies at NASA Ames Research Center, conducting research in computer vision and navigation for distributed sensor networks and precision approach and landing.