Course number	U-LAS70 10002 SE50				
Course title (and course title in English)	ILAS Seminar-E2 :Introduction to Quadrotor Unmanned Flight Control: Principles and Applications（クアッドローター無人飛行制御入門：原理と応用） ILAS Seminar-E2 :Introduction to Quadrotor Unmanned Flight Control: Principles and Applications	**Instructor's name, job title, and department of affiliation**	Graduate School of Engineering Senior Lecturer,Tam Willy Nguyen		
Group	Seminars in Liberal Arts and Sciences	**Number of credits**	2	**Number of weekly time blocks**	1
Class style	seminar (Face-to-face course)	**Year/semesters**	2025・First semester	**Quota (Freshman)**	25 (15)
Target year	Mainly 1st year students	**Eligible students**	For all majors	**Days and periods**	Tue.5
Classroom	20, Yoshida-South Campus Bldg. No. 4			**Language of instruction**	English
Keyword	Unmanned Aerial Vehicle / Modeling / Sensor / Flight Control / Software Implementation				

[Overview and purpose of the course]

This lecture introduces the fundamentals of flight control for quadrotor unmanned aerial vehicles (UAVs), widely used in both civil and military applications. The growing prevalence of drones and their remarkable stability often inspire curiosity, particularly among engineering students, who may wonder how these devices stabilize and navigate in three dimensions. In this course, students will explore the key challenges of flight control and develop a solid understanding of quadrotor UAVs.

Throughout the course, students will be introduced to essential control systems and modeling concepts, supported by both basic and advanced mathematical tools. If time permits, students will have the opportunity to implement algorithms on real-world flight systems, providing hands-on experience to complement their theoretical learning.

[Course objectives]

By the end of this course, students will:
1. Understand system modeling, control systems, and numerical validation techniques as applied to UAVs.
2. Develop the ability to analyze UAV dynamics using mathematical models.
3. Apply control theory concepts to stabilize and navigate quadrotors in simulations.
4. (If time permits) Implement real-world flight control algorithms for quadrotor UAVs.

[Course schedule and contents)]

1. Introduction to Manned and Unmanned Aerial Vehicles (UAVs)
2. Fundamentals in Mechanics: reference frames, force, and differential equation concepts.
3. Attitude (SO(3)) dynamics: Rotation matrices and their parameterization through Euler angles and quaternions. Discussions on the gimbal lock and representation issues.
4. Simulations: How to numerically solve differential equations? Introduction to the Forward-Euler, Runge-Kutta (RK4), and ODE45 methods.
5. Numerical analysis of the UAV trajectories through simulations.
6. Introduction to control systems and closed-loop feedback theory.

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7. Cascaded control scheme for attitude and position control.
8. Real-world sensors, their issues, and sensor-fusion technology with Kalman Filters to deal with sensor noise and drifts.
9. Numerical implementation of Kalman Filters through simulations.
10. Experimental implementation of Kalman Filters for motor speed estimation.
11. Implementation of PID motor control loop in simulations.
12. Experimental implementation of PID motor control loop through PWM.
13. Implementation of PID for the inner and outer loop control with attitude reference generation in simulations.
14. Experimental implementation of the overall scheme in real-world drones.
<<Final examination>>
15. Feedback

[Course requirements]

A basic understanding of Algebra, Programming, and Mechanics is recommended to help grasp the fundamentals of the lectures. The course content will be adapted to the class level as needed.

[Evaluation methods and policy]

Evaluation Methods and Policy:
-Active participation (20%)
-Midterm report (20%)
-Final report (60%)

Important Notes:
-Students who are absent more than four times will not be able to pass.
-Submission of the final report is mandatory.
-Additional points will be awarded for reports and answers that demonstrate originality.

[Textbooks]

Randal W. Beard and Timothy W. McLain 『Small Unmanned Aircraft: Theory and Practice』 （Princeton University Press）ISBN:978（0691149219）

[References, etc.]

（References, etc.）

Brian L. Stevens, Frank L. Lewis, Eric N. Johnson 『Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems』 （Wiley-Blackwell,2015）ISBN:978（1118870983）

[Study outside of class (preparation and review)]

The students are expected to read the provided materials before each class and actively ask questions after the class about unclear points. It is also recommended that students review their class notes regularly.

[Other information (office hours, etc.)]

[Essential courses]