
Unmanned Aerial Vehicles

MEAer - Spring Semester – 2020/2021

<https://fenix.tecnico.ulisboa.pt/disciplinas/ARob46/2020-2021/2-semester>

Faculty:

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General Guidelines

- Contact hours (remotely on zoom, link to be announced)

- Lectures and Exercises (T): twice a week, 1h30

- Wednesdays: 9h00 – 10h30

- Thursdays: 14h30 – 15h00

- Laboratory (L): every 2 weeks, 3h00, total: 5

- Tuesdays: 15h00 - 18h00

- Doubt clarification (by appointment)

- Schedule to be defined.

- Course website

- <https://fenix.tecnico.ulisboa.pt/disciplinas/ARob46/2020-2021/2-semester>

General Guidelines

- Laboratory Sessions:
 - Groups of 3, organized in 2 shifts (5 groups per shift)
 - **Enrolment through fenix from March 8 to March 11, 18h00.**
 - 3 Assignments (L1, L2, L3)
 - Handouts published in the course website under ‘Laboratories’
 - 1 lab session for L1
 - 2 lab sessions for L2 and L3 (every 2 weeks)
 - 1 Report per assignment
 - Submission typically 1 week after 2nd lab session (check schedule)
 - Use cover provided in website under ‘Laboratories’

General Guidelines

- Grading

- 2 Tests or Exam (40%)

1st Test (T1): 20/04/2021, 19:00-21:00

2nd Test (T2): 31/05/2021, 19:00-21:00

Exam (E) or 1st Test or 2nd Test: 12/07/2021, 18:30-21:30

- 3 Lab assignments (L1, L2, L3) (60%)

- Final grade

$$T = \max(E, 0.5 * \max(T1, T1rep) + 0.5 * \max(T2, T2rep))$$

$$L = 0.2 * L1 + 0.4 * L2 + 0.4 * L3$$

$$F = 0.4 * T + 0.6 * L$$

Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
March	1	2	3	4	5	6	7
Week 1			T1	T2			
Week 2	8	9	10	11	12	13	14
			T3	T4			
	Lab Enrolment						
Week 3	15	16	17	18	19	20	21
		L1	T5	T6			
Week 4	22	23	24	25	26	27	28
		L1	T7	T8	Submit L1		
April	29	30	31	1	2	3	4
Week 5							
Week 6	5	6	7	8	9	10	11
		L2	T9	T10			
		Submit L1					
Week 7	12	13	14	15	16	17	18
		L2	T11	T12			
Week 8	19	20	21	22	23	24	25
		L2	T13	T14			
		Test 1					
Week 9	26	27	28	29	30	1	2
		L2	T15	T16			
		Submit L2					

Lectures	Labs Shift 1		Lab Classes		
Rita Cunha			Group enrolment		Holidays
Labs Shift2			Shift 1		
José Raul Azinheira			Shift 2		

Schedule

May		3	4	5	6	7	8	9
Week 10			L3 Submit L2	T17	T18			
Week 11		10	L3	T19	T20	14	15	16
Week 12		17	L3	T21	T22	21	22	23
Week 13		24	L3 Submit L3	T23	T24	28	29	30
Week 14		31	1	2 T25	3	4	5	6
	Test 2	Submit L3						

Lectures	Labs Shift 1		Lab Classes		
Rita Cunha			Group enrolment		Holidays
Labs Shift2			Shift 1		
José Raul Azinheira			Shift 2		

Test 1	20/04/2021	19:00-21:00
Test 2	31/05/2020	19:00-21:00
Exam	12/07/2021	18:30-21:30

Syllabus

- Introduction to UAVs
 - System Architecture, types of UAV configurations, applications.
- Modelling
 - Rigid body dynamic modelling.
 - Quadrotor dynamic modelling and design considerations.
- Control Systems Design
 - Quadrotor trajectory tracking control. Control design using root locus and loop shaping. Inner-outer loop control structure.
 - Linear systems and state space models.
 - Linear state feedback control and linear state observers. Duality and separation principle. LQR design example.

Syllabus

- Sensors for UAVs
 - Accelerometers. Rate gyros. Pressure sensors. Digital compasses. GNSS. Proximity sensors.
- State Observers and Kalman Filtering
 - Position, velocity, and attitude estimation including bias correction.
 - Use cases and connection to complementary filters
- Nonlinear Systems
 - Stability analysis and nonlinear control design.
 - Application to quadrotor trajectory tracking control.
- Path following and path planning for UAVs
 - Voronoi graphs, RRTs, Coverage algorithms
 - Dubin's paths, waypoint transitions, optimization-based methods.

Bibliography

Recommended:

- *Small Unmanned Aircraft: Theory and Practice*, Randal W. Beard & Timothy W. McLain, Princeton University Press, ISBN: 9781400840601, 2012.
- *Feedback Systems - An Introduction for Scientists and Engineers*, Karl Astrom and Richard Murray, online version at http://www.cds.caltech.edu/~murray/amwiki/index.php/Second_Edition

Additional:

- Flying Robots. In: Handbook of Robotics, B. Siciliano, O. Khatib, Eds. S. Leutenegger, C. Hürzeler, A. K. Stowers, K. Alexis, M. W. Achtelik, D. Lentink, P. Y. Oh, R. Siegwart, 2016. Springer.
- Handbook of Unmanned Aerial Vehicles, K. Valavanis, G. Vachtsevanos, Editors. 2015. Springer.
- Introduction to UAV Systems, P. Fahlstrom, T. Gleason, 2012. Wiley.

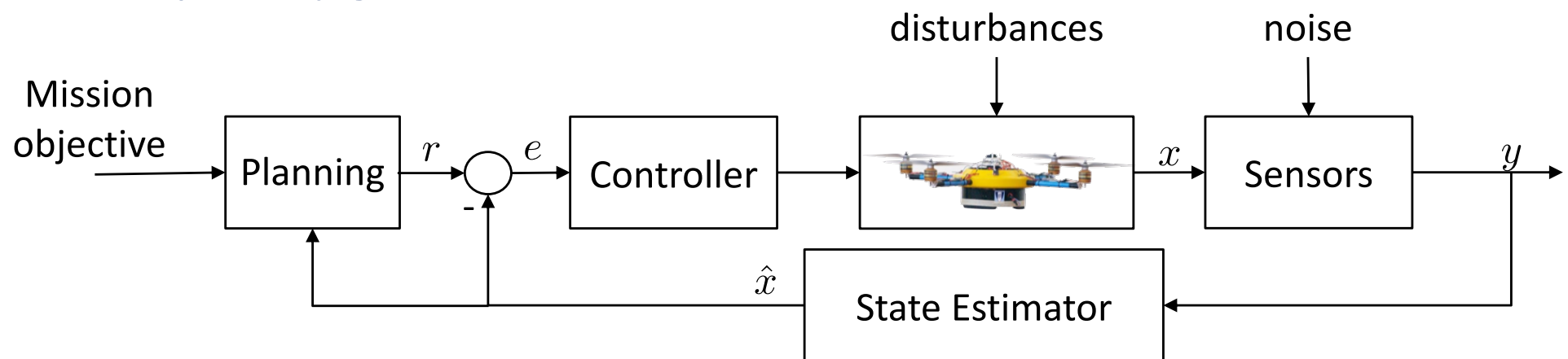
Introduction

General Topics

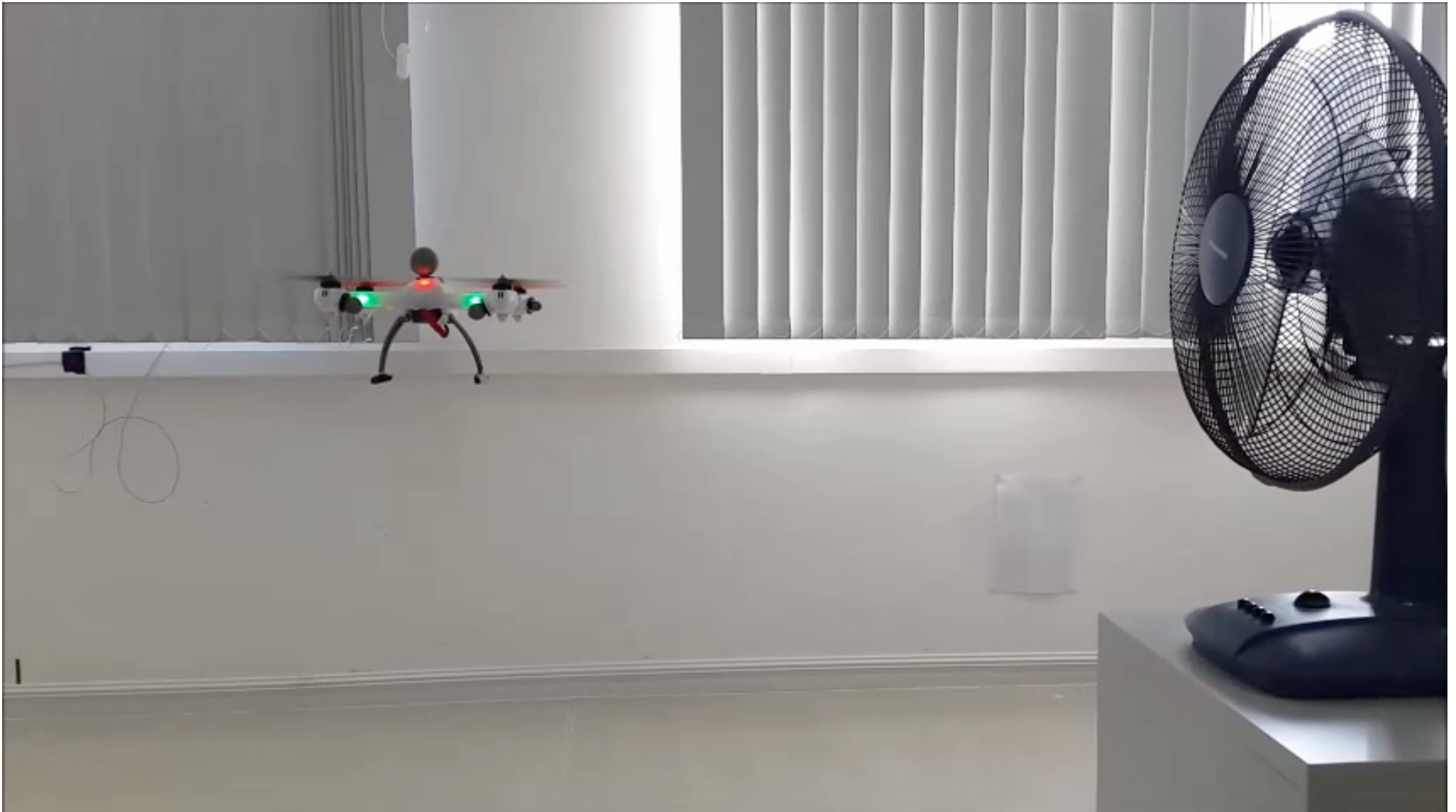
- Modeling (L1)
- Estimation (L2)
- Control (L3)
- Guidance / Path Planning / Trajectory generation

Control objective:

- Track a trajectory



Stabilization with wind disturbance rejection



Trajectory Tracking



Distributed Consensus-based Formation Control

