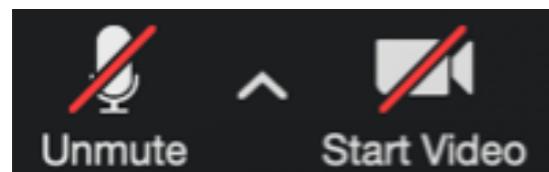




AEROSP 584 - Navigation and Guidance: From Perception to Control



Lectures start at
10:30am EST

Vasileios Tzoumas

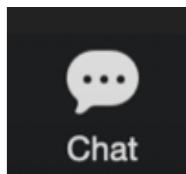
Lecture 1

To ask questions:



[Raise Hand](#)

or

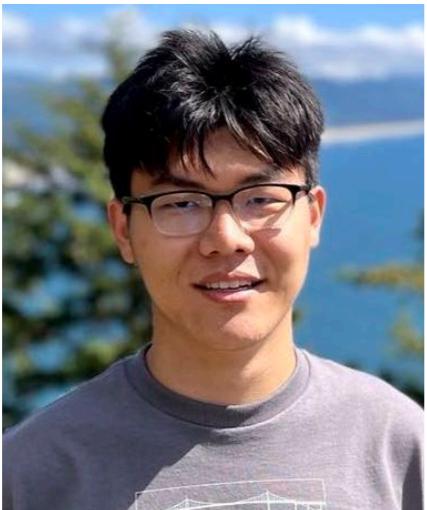


[Chat](#)

584 Staff

Teaching Assistants

GSI



Ray Zirui Xu
(he/him/his)
ziruixu@umich.edu

Grader



Jiasheng Tang



Vasileios Tzoumas
(he/him/his)
vtzoumas@umich.edu

Instructor

Lecture's Outline

Logistics

- Goals of 584
- Structure
- Assignments, Mini-Projects (Midterm and Final), and Grading
- Requirements and Pre-Requisites

Navigation and Guidance: From Perception to Control

- The robot-autonomy revolution
- The role of avionics, navigation, and guidance

1-slide Introductions of 584 Staff

Goals of 584 (1/2)

Theory

- Learn/develop/exercise **theoretical tools** necessary for control and robotics research (geometry, estimation, planning, optimization, ...)
- Learn about foundational and state-of-the-art **algorithms** for estimation, trajectory planning, and control, including special topics in pursuit and evasion
- Get an overview of **open problems** in navigation and guidance

Overarching goal:

- Gain a close-look understanding of robots' sensing & control capabilities
- Prepare you to perform state-of-the-art research in robotics

Note: If you do not like writing **math**, you may not like this class

Goals of 584 (2/2)

Practice

- Learn/practice coding in **MATLAB**
- Rigorous testing of theoretical results in practical (simulated) scenarios
- Delve into the **limitations** of state-of-the-art estimation, control, and optimization methods

Overarching goal:

- Exposure to fundamental limitations when translating theory to practice
- Develop an engineering way of thinking
- Refine your skills to perform state-of-the-art research in control/robotics

Note 1: If you do not like coding in MATLAB, you may not like this class.

Note 2: MATLAB tutorials will be given by Ray.

Structure of 584

Lectures

- Tue/Thu, 10:30am-12:00pm EST (in-person and remotely on Zoom)
- Mostly on the “board” (notepad)

Office Hours

- Both in-person and remote (**password for Gather Town: nav-f22**)

Homework assignments (optionally team assignments)

- Theory and Coding assignments
- Announced ~biweekly on either Tue or Thu, 7pm EST
- Due ~2 weeks later, 11:59pm EST

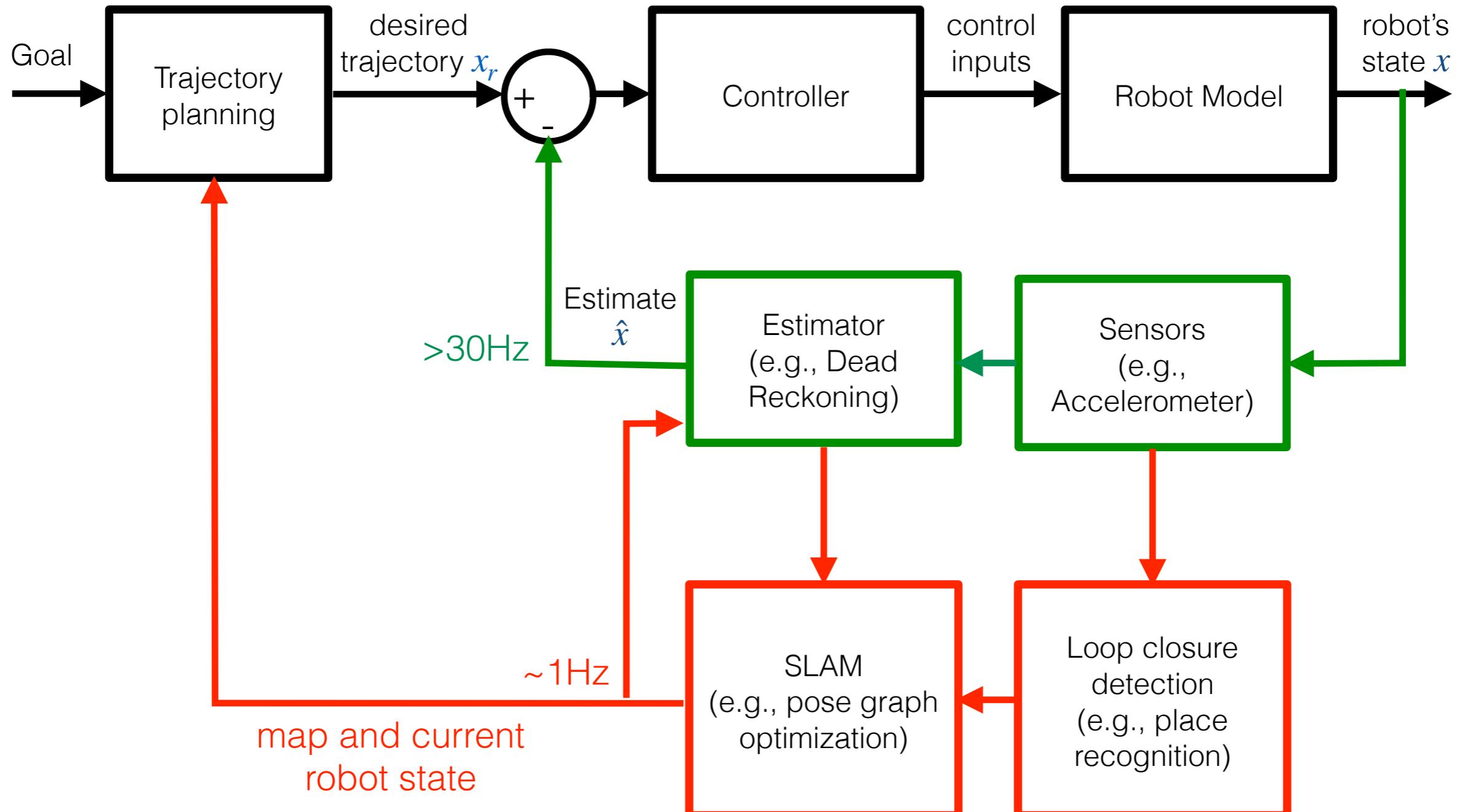
Mid-term and Final Mini-Projects (individual assignments)

- Similar to a homework set but it’s an individual assignment

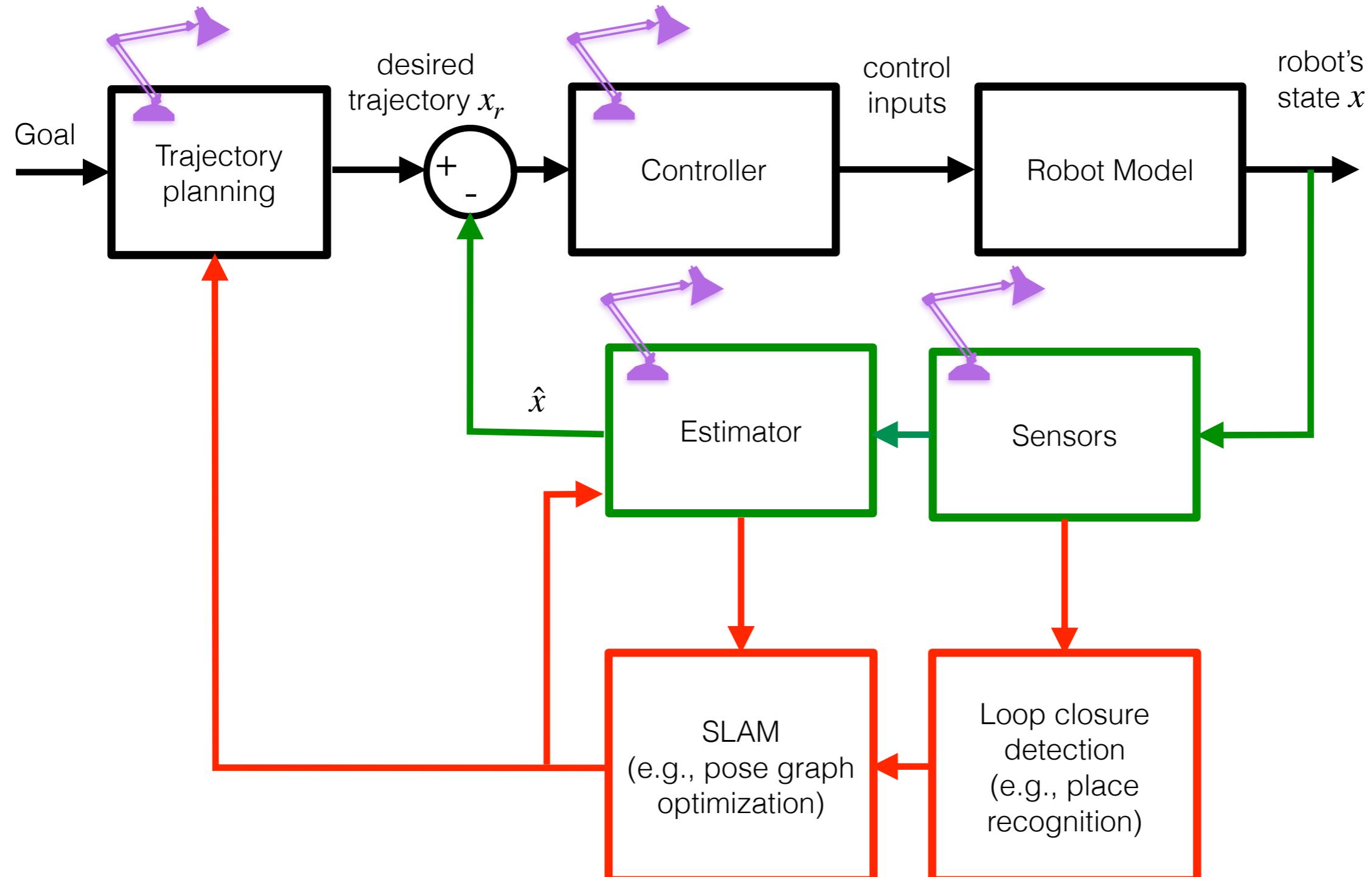
Big Picture



Big Picture: Mobile Autonomy Pipeline



Big Picture



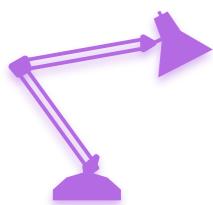
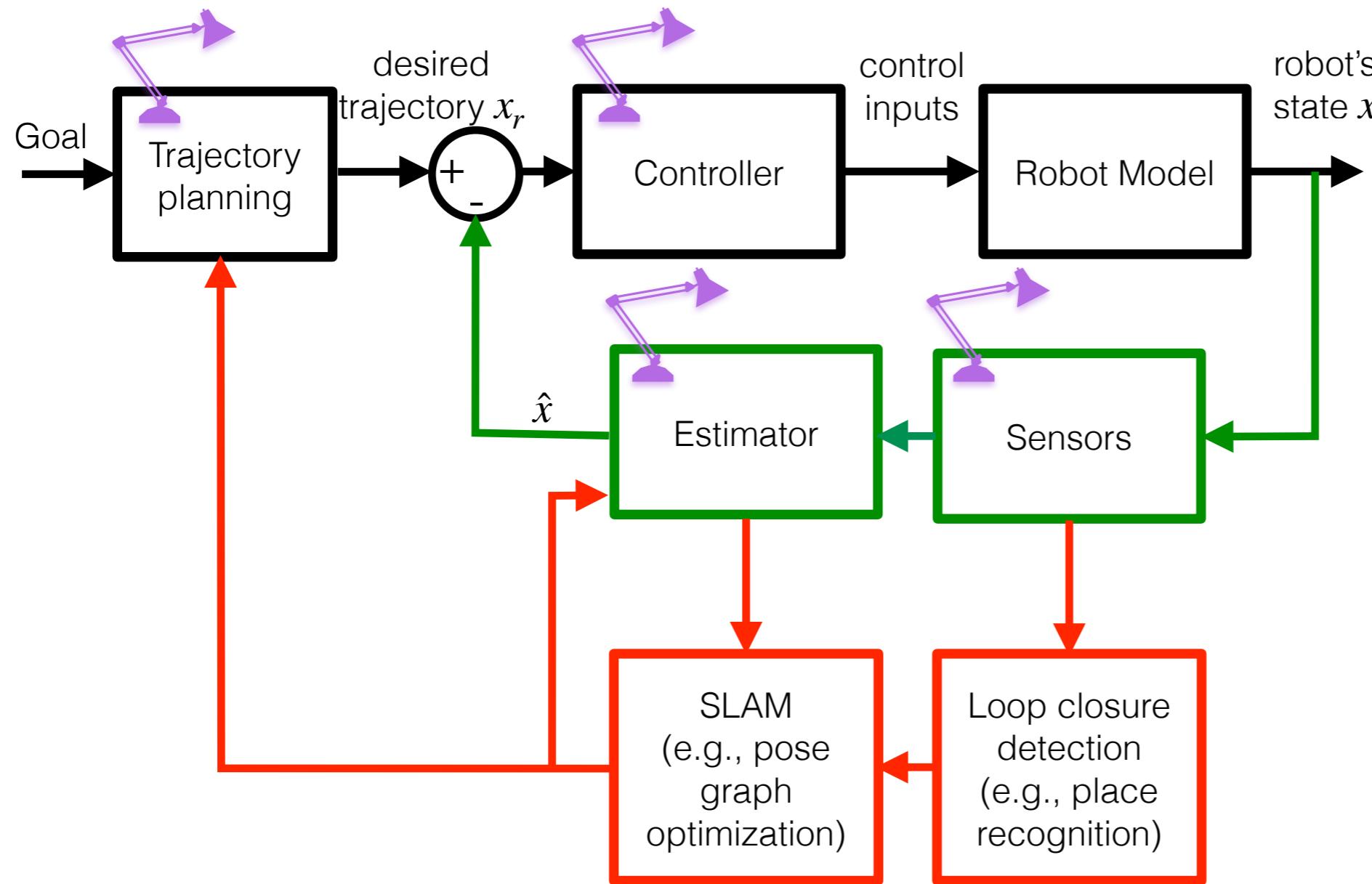
= focus of 584

Lectures' Schedule

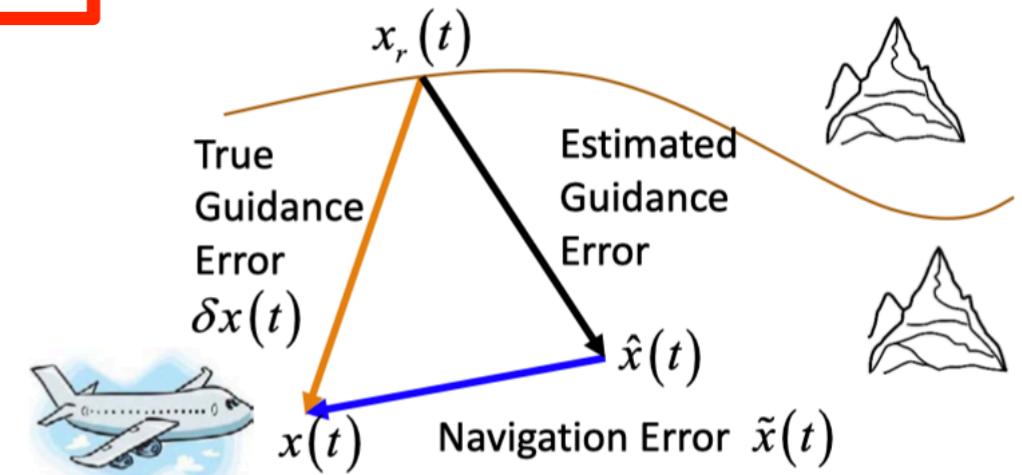
Let's take a look at the syllabus together:

<https://tinyurl.com/584-F22-syllabus>

Big Picture



= focus of 584



Poll

What departments are you affiliated with?

- A. Aerospace Engineering
- B. Robotics Institute
- C. Electrical Engineering and Computer Science
- D. Mechanical Engineering
- E. Naval Architecture and Marine Engineering
- F. Other

Assignments

Week	Assignment	Individual/ Team of 2	Announced (7pm)	Due (11:59pm)
1	Students' Introduction Slide	I	Tue, Aug 30	Thu, Sept 8
1	Homework 1 (on "At-Home" lectures)	I/Tof2	Thu, Sept 1	Tue, Sept 20
3	Homework 2 (on Lectures 5 and 6)	I/Tof2	Tue, Sept 20	Tue, Oct 4
6	Homework 3 (on Lectures 5 through 10)	I/Tof2	Tue, Oct 4	Thu, Oct 20
8	1) Midterm Mini-Project (on Lectures 2 through 13) 2) Teammate Assessment Form for HW1-3 3) Midterm Course Evaluation (bonus points)	I	Thu, Oct 20	Thu, Nov 3
10	Homework 4 (on Lectures 11 through 19)	I/Tof2	Thu, Nov 3	Thu, Nov 17
12	Homework 5 (on Lectures 20-24)	I/Tof2	Thu, Nov 17	Tue, Dec 6
15	1) Final Mini-Project (possibly on Lectures 20-24) 2) Teammate Assessment Form for HW4-5 3) Final Course Evaluation (bonus points)	I	Thu, Dec 1	Mon, Dec 19

Ray will be giving tutorials introducing each homework assignment. Please also come to our office hours to discuss questions you may have, and to facilitate your progress in mastering the course material.

**Please see the syllabus for submission specifications
(Section "Assignment Policies and Specifications")**

Grading

[30%] Homework 1-5: theory and coding exercises (Individual or team assignment)

[20%] Midterm project: theory and coding exercises (Individual assignment)

[35%] Final project: theory and coding exercises (Individual assignment)

[7.5%] Participation and GIS's evaluation

- Extra points for catching typos in assignments and lecture notes
- Extra points for helping fellow classmates in Piazza :)

[7.5%] Team members' assessment

[Bonus 4%] Midterm and Final Course Evaluation

Penalty on late submissions:

$$\text{grade_late_submission} = \text{grade} * \max(1 - 0.15 * \text{days_late}, 0)$$

if intend to submit late, please email Ray and Vasileios

For questions on graded assignments, please email Ray

Requirements and Pre-Requisites

Requirements satisfied by 584

- Counts as a *Reasoning* course for the Robotics M.Sc./Ph.D.
- Category 1 course for the AEROSP Ph.D. prelim exam
- 3 credits hours for the AEROSP M.S.E.

Prerequisites

- Undergraduate control course
- Undergraduate analysis and linear algebra course
- Familiarity with coding in MATLAB

Good to have

- Background in optimization
- Excitement to ask questions and support each other :)

Textbook

None.*

*Specific pointers to chapters in books and other resources will be provided in a regular basis. Some are already listed on syllabus

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1-slide Introductions of 584 Staff

The Robot Revolution: Drones

Introducing Skydio R1

<https://www.youtube.com/watch?v=gsfkGlSajHQ>

Agile Robotics



The DARPA **Sub**terranean Challenge



#SUBTCHALLENGE

The Loyal Wingman



https://www.youtube.com/watch?v=BiSHVI7UMRk&ab_channel=RoyalAustralianAirForce

The Robot Revolution

ground

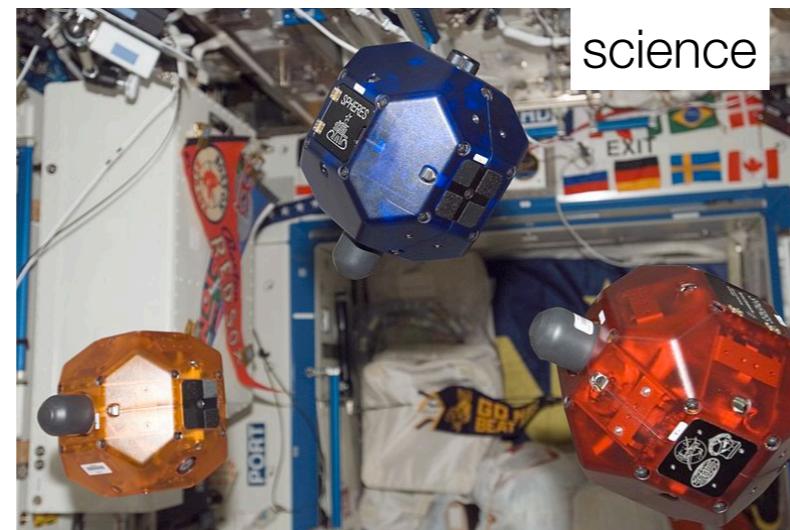
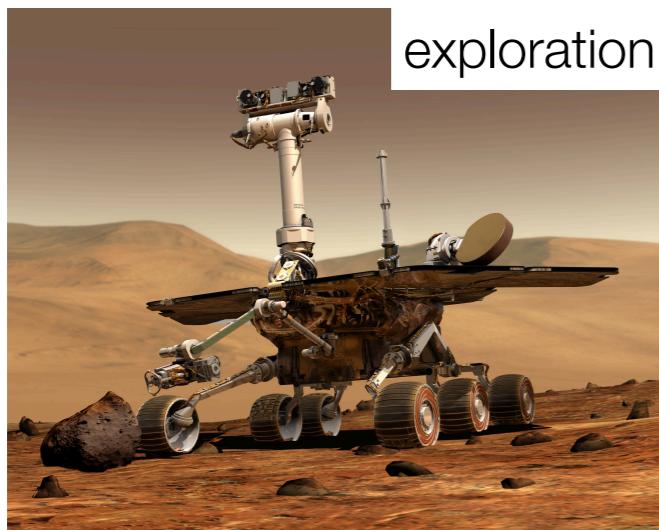


air



and more ...

space



reasons for adoption: faster, better, safer, cheaper, access

Lecture's Outline

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1-slide Introductions of 584 Staff

A few words about myself (Vasileios | he/his)

I am runner; love hiking; enjoy cooking.



My wife and I have a Vizsla



A few words about myself (Vasileios | he/his)

I am runner; love hiking; enjoy cooking.



Her name is Meli



A few words about myself (Vasileios | he/his)

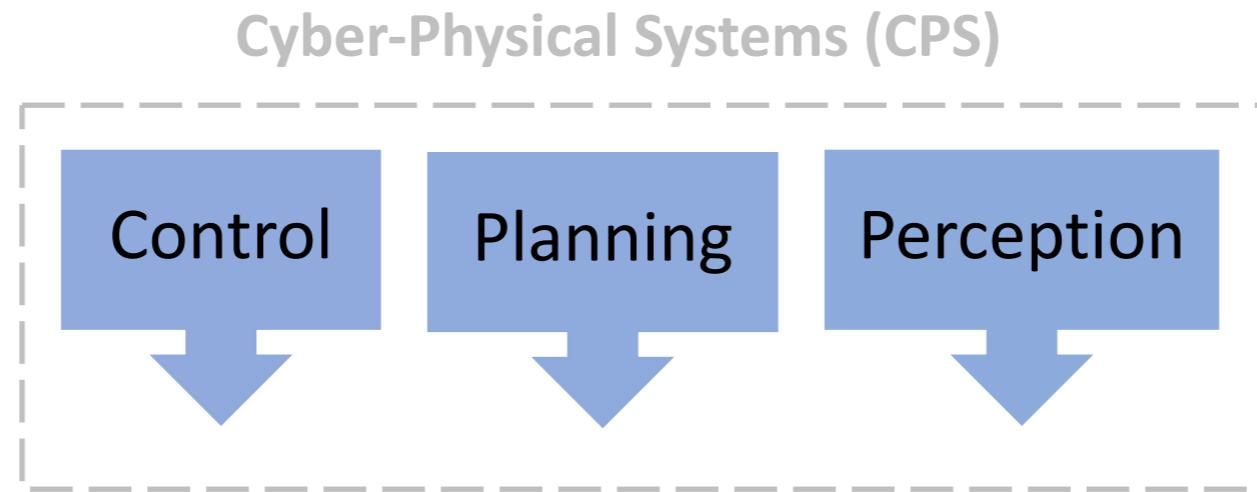
I am runner; love hiking; enjoy cooking.

Her name is Meli



A few words about myself (Vasileios)

*Resource-Aware
Control and Planning*
TAC '16, '18, '20
TCNS '18
CDC '15, '16
ACC '15, '16, '17, '18



*Inapproximability of
Outlier-Robust Perception*
IROS '19

Combinatorial
Optimization

**Algorithmic Foundations
of Trustworthy Autonomy**

Non-convex
Optimization

*Attack-Robust Combinatorial
Optimization*
TAC '20, CDC '18
CDC '17
Best Student Paper Award Finalist, CDC

DoS-Robust Multi-Robot Planning

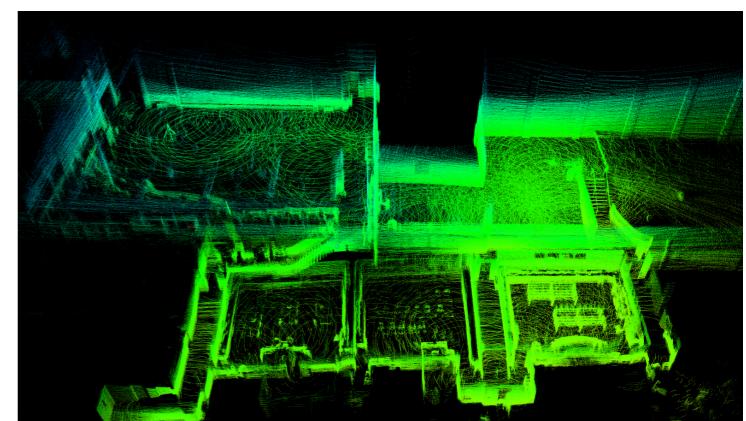
TRO '20
RAL '19, ICRA '19, '20
IROS '18



Provable
Near-Optimality

Hardness

Outlier-Robust Perception
TRO '20, RAL '20, IROS '19
ICRA '20
Best Paper Award in Robot Vision, ICRA
Honorable Mention, RA-L



Ray Zirui Xu

- GSI for AEROESP 584, Fall 2022
- From Shenyang, China
- 2nd year Aerospace Ph.D. student
- M.S. in ECE from Georgia Tech
- B.Eng. in Automation from Northeastern University (Shenyang, China)
- Research Interests
 - **Provably near-optimal approximation algorithms:** Online learning, combinatorial optimization, and optimal control
 - **Robot coordination and learning algorithms:** How robots learn provably near-optimal actions on the fly for complex tasks in unpredictable environments



1-slide Introductions, and Teams Formation

1-Slide Introductions [submit by Thu, Sept 8, 11:59pm]

Teams formation [form teams by Thu, Sept 8, 11:59pm]

- Team search and sign-up form [form teams by Thu, Sept 8, 11:59pm EST]

See you on Thursday!