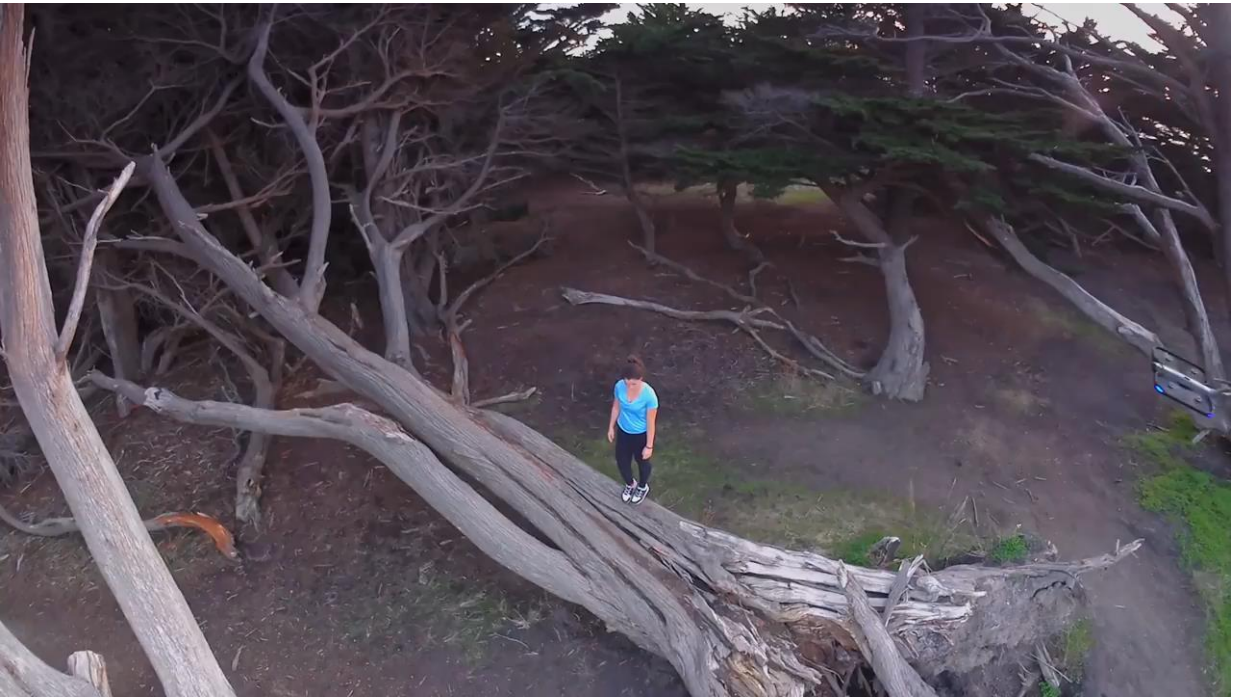
MEAM 620

INTRODUCTION

Please hold questions about the waitlist until after class.

Penn Engineering | GRASP Laboratory
General Robotics, Automation, Sensing & Perception Lab

What is MEAM 620 About?

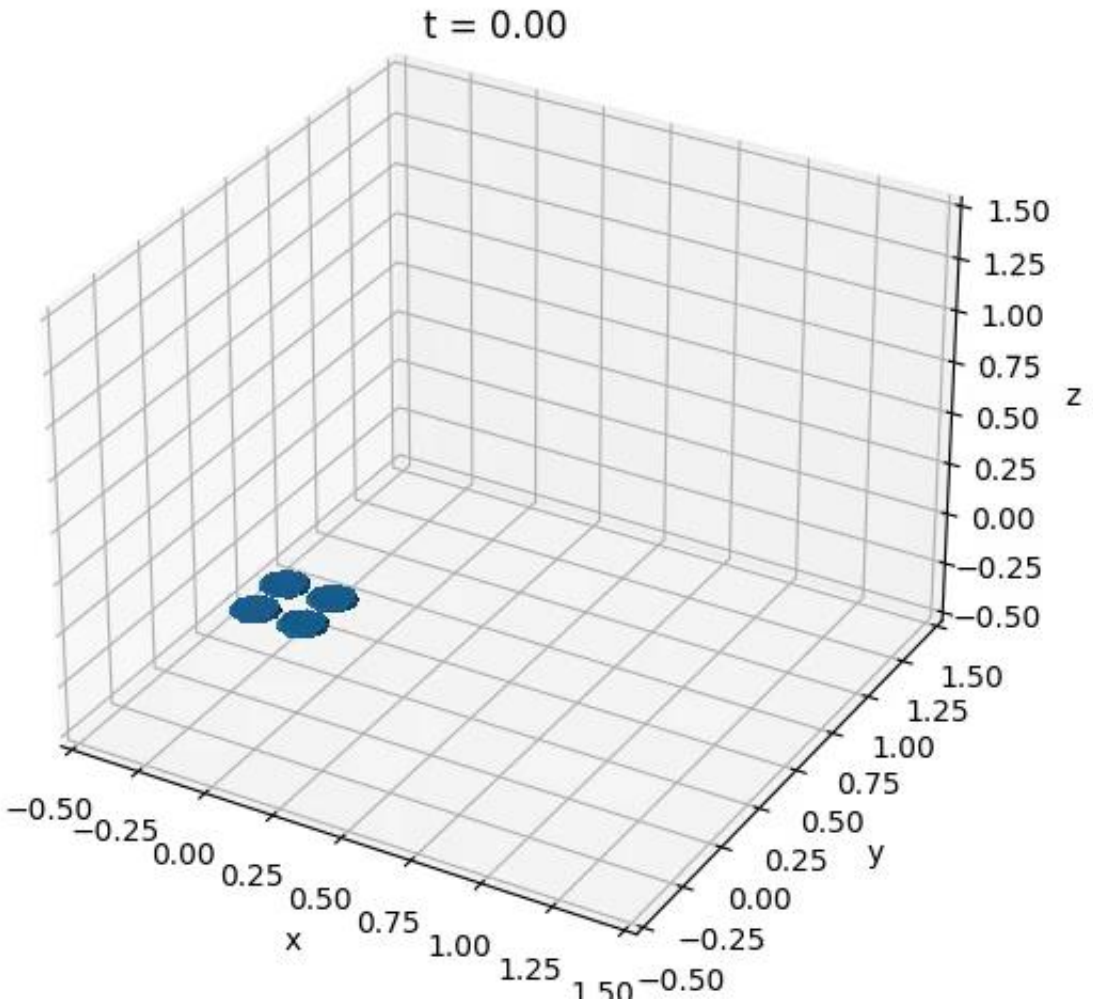


Skydio

Exyn

Truth in Advertising

Your very first project is going to look a little more like this…



What is MEAM 620 About?

Quadrotors

Kinematics

Dynamics

Control

Trajectory Planning

Pose Estimation

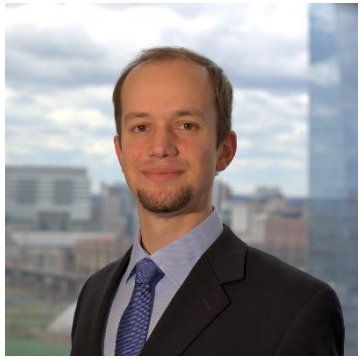
Computer Vision

Sensor Fusion

Who is Teaching?

Camillo J. Taylor
- Deputy Director of GRASP
- Professor, CIS
- cjtaylor@seas.upenn.edu
- Office: 457 Levine

Jimmy Paulos
- Postdoc, MEAM
- jpaulos@seas.upenn.edu
- Office: PERCH at Pennovation



TAs
- Austin Chen
- Laura Jarin-Lipschitz
- Rebecca Li
- Daniel Mox
- Shreyas Shivakumar

Please message 'Instructors' through Piazza for questions about assignments and deadlines.

Please privately email Jimmy and Vijay for personal questions, accommodations, emergencies, etc.

Prerequisites

This course lies at the intersection of **dynamics**, **controls**, **computer vision**, and **computer science**.

MEAM 520, Introduction to Robotics

or

Background in at least two of

- Dynamics (e.g. MEAM 535)
- Linear Controls (e.g. ESE 505, ESE 500)
- Vision (e.g. CIS 580, 581)
- Introductory Computer Science

Expect to do a lot of programming!

Course Outline

Week 1, Introduction

Week 2, Kinematics

Week 3, Dynamics and Control

Week 4, Control and Trajectories in SE(3)

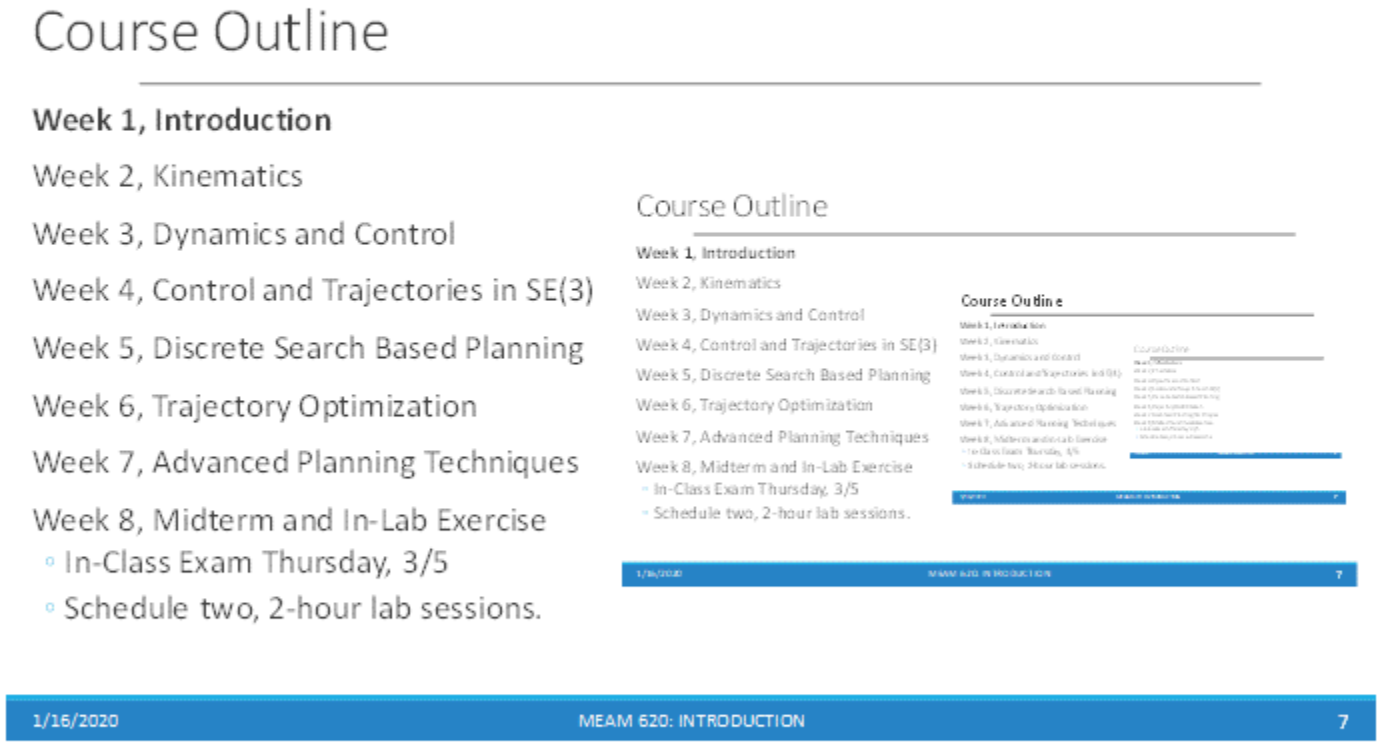
Week 5, Discrete Search Based Planning

Week 6, Trajectory Optimization

Week 7, Advanced Planning Techniques

Week 8, Midterm and In-Lab Exercise

- In-Class Exam Thursday, 3/5
- Schedule two, 2-hour lab sessions.



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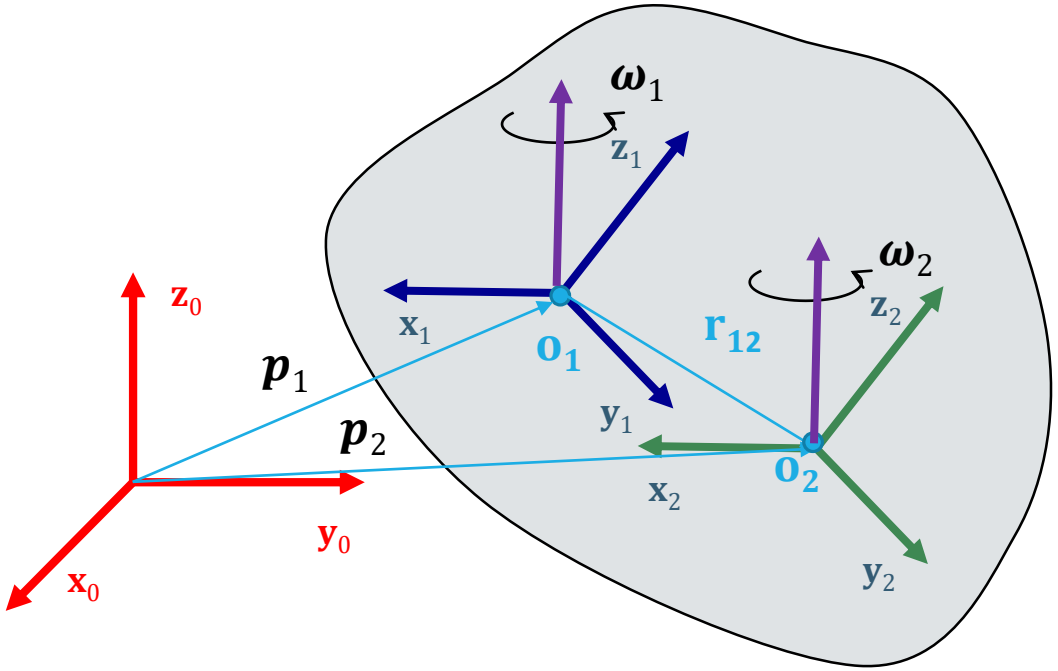

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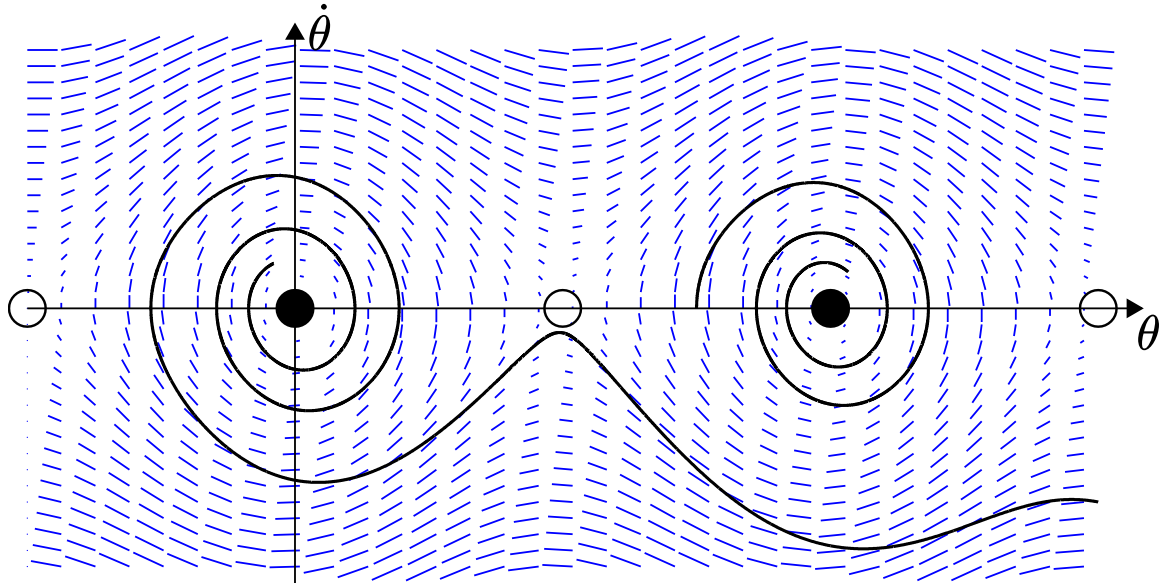

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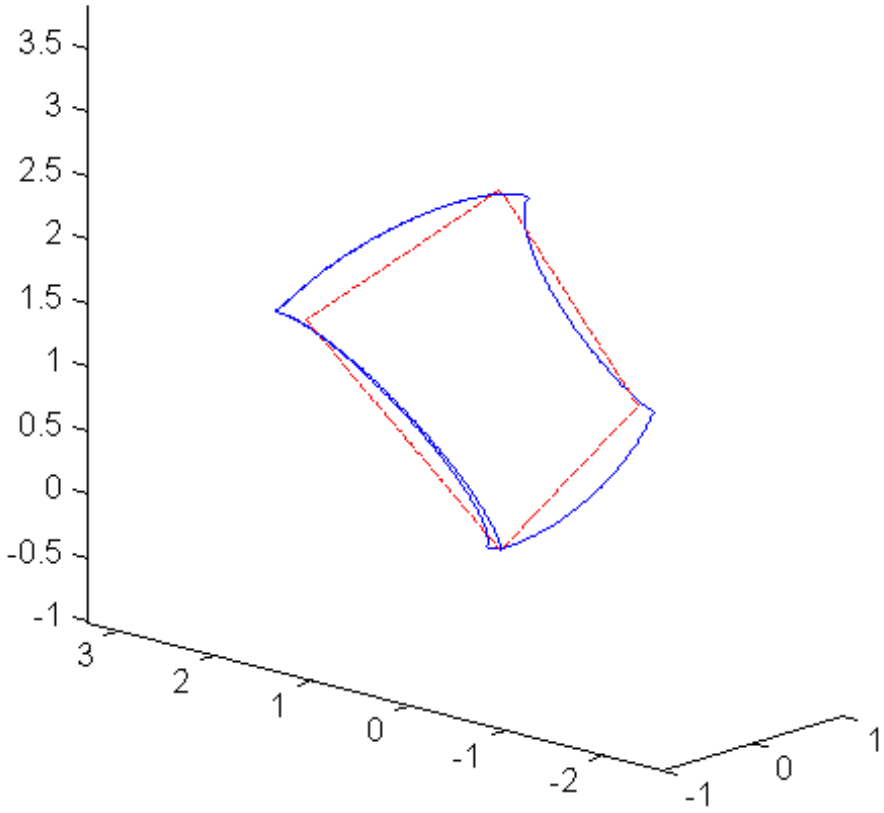

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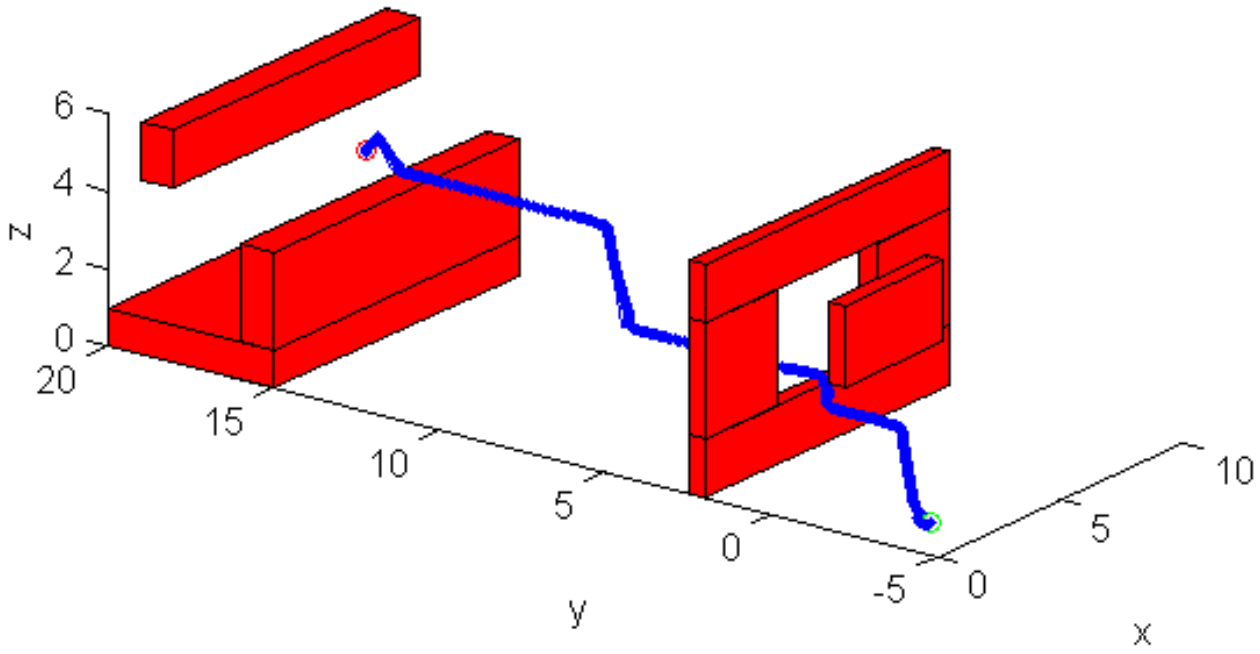

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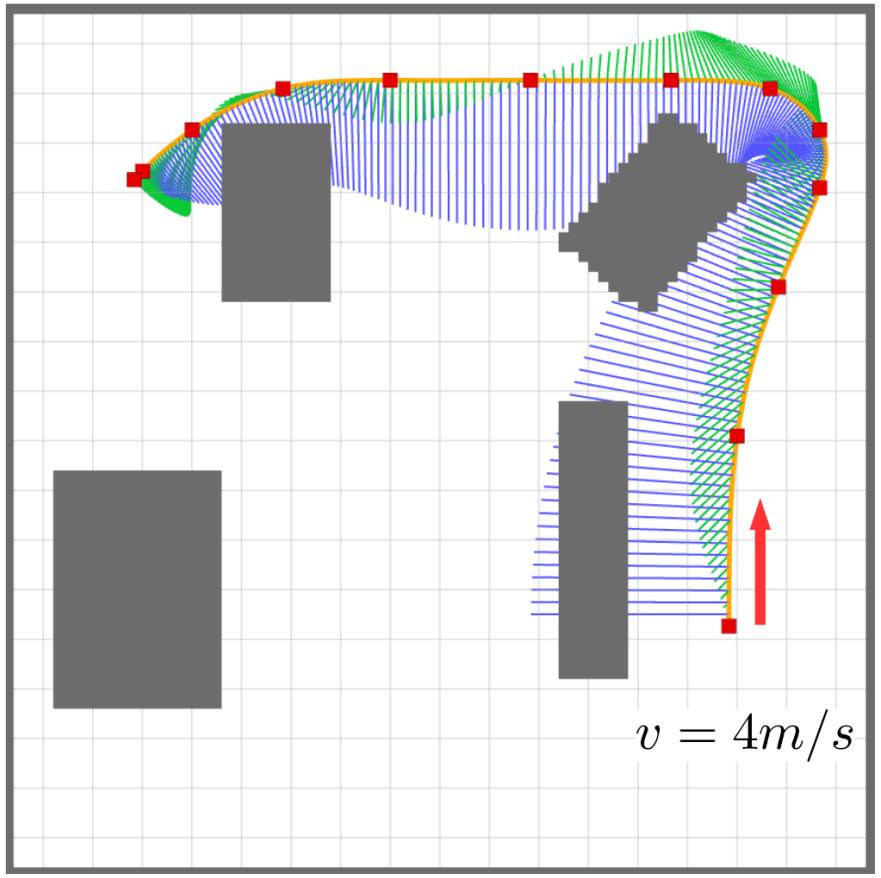

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Week 10, Projective Geometry

Week 11, Pose from Images

Week 12, Monocular Visual Inertial Odometry

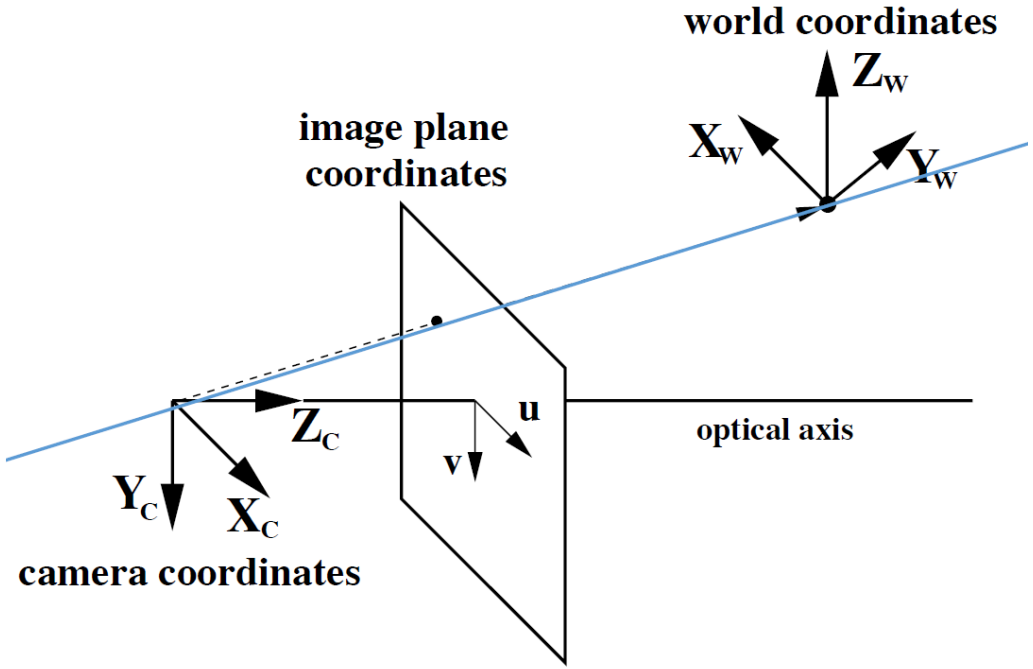
Week 13, Stereo Vision

Week 14, Mapping

Week 15, SLAM

Week 16, Review

- Exam Period Monday, May 4 (tentative)



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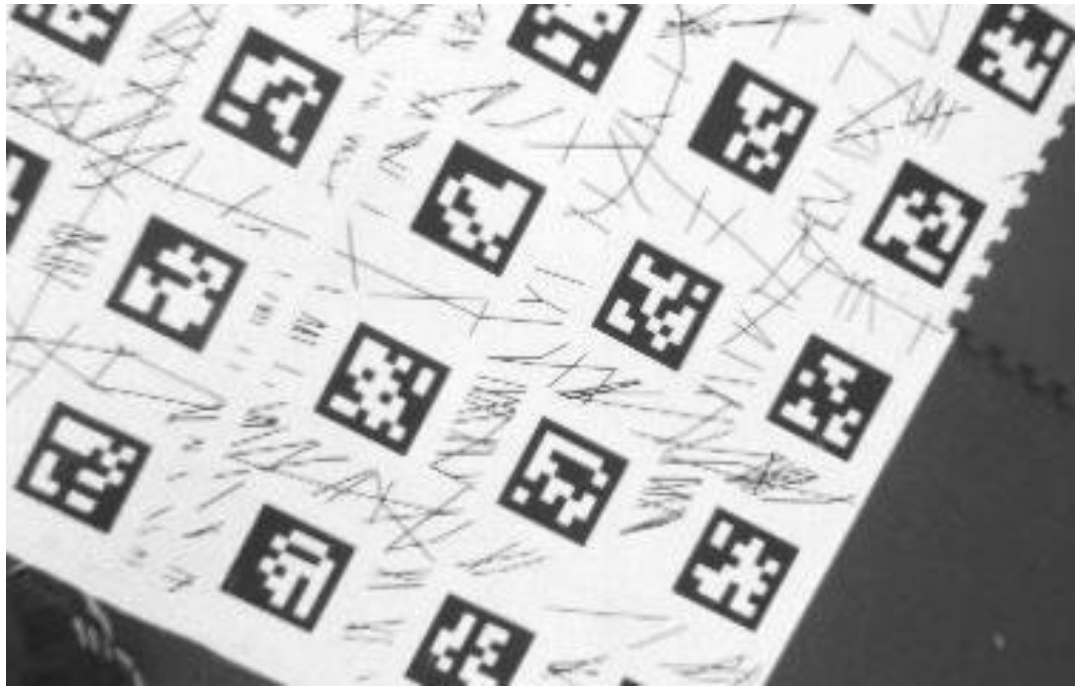

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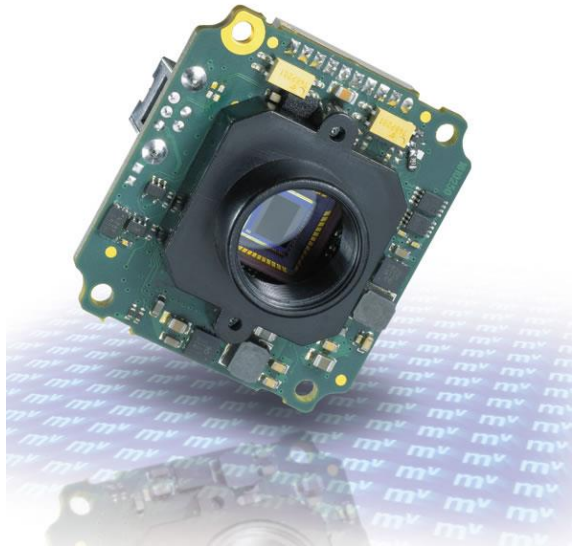

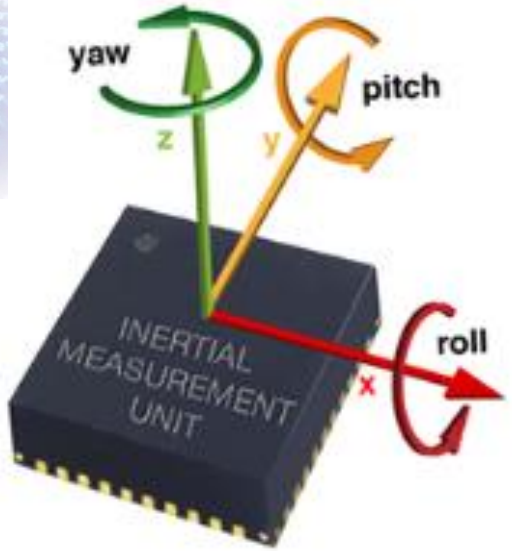

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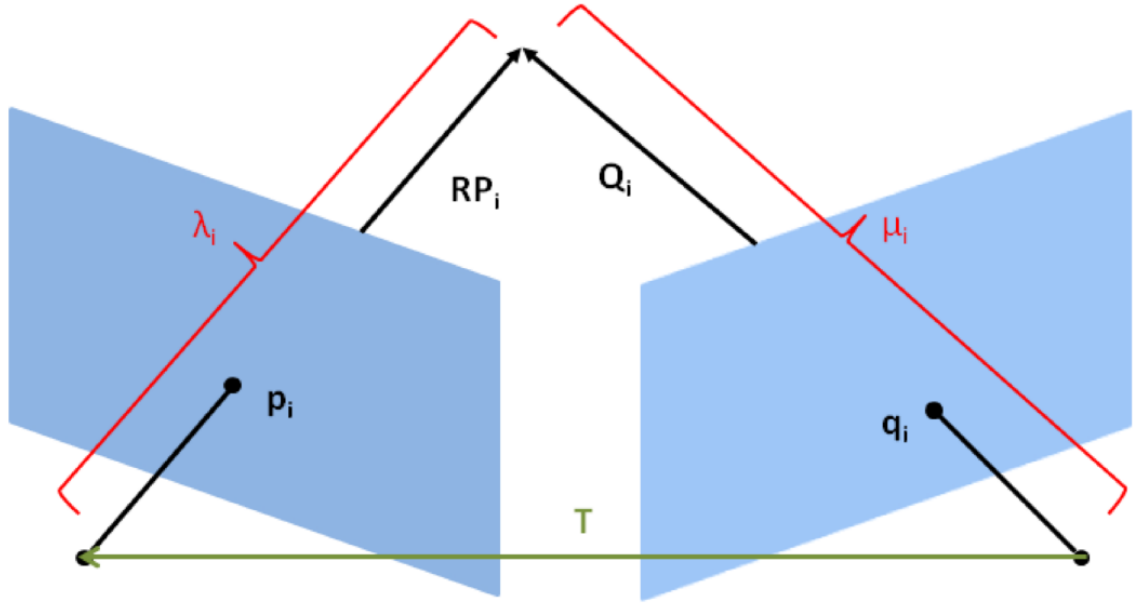

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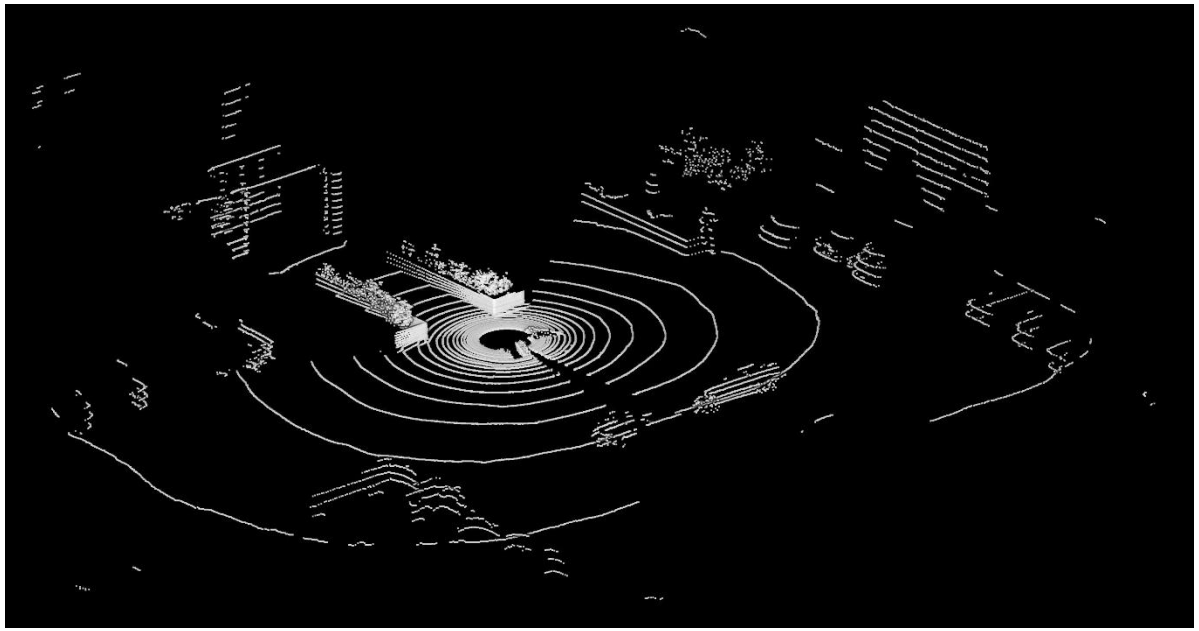

data from Velodyne HDL-32E
from PointCloudLibrary

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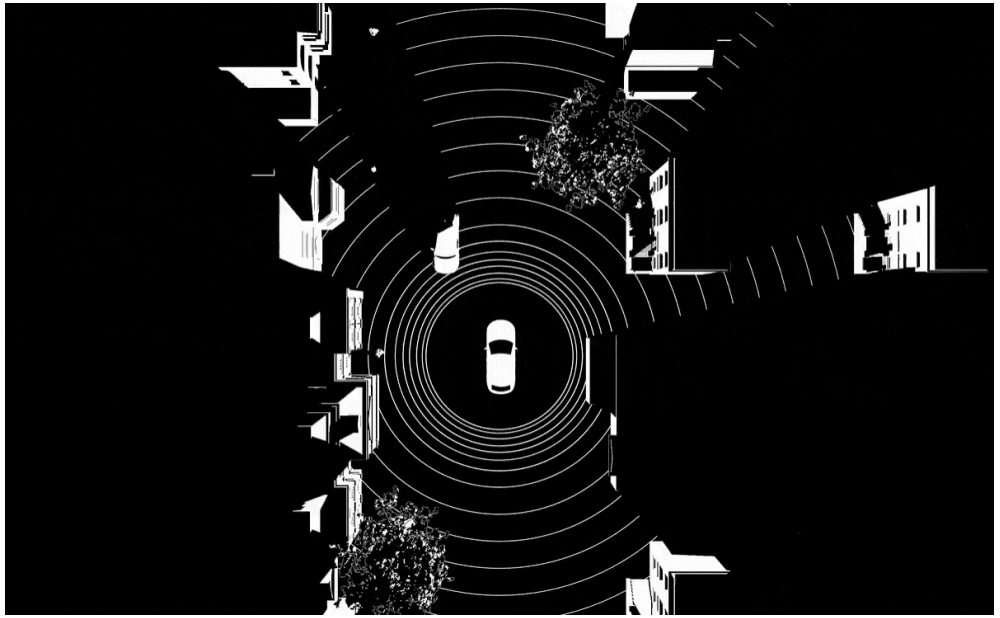

from *The Verge* interview with Velodyne

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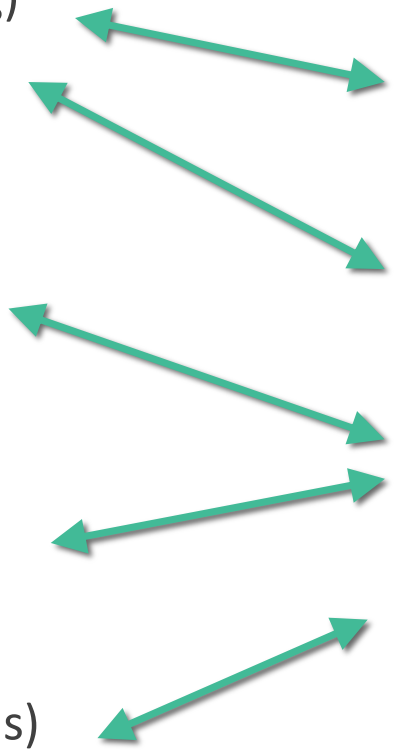
Relation to other Courses

ESE 650: Learning in Robotics
- Data driven methods (machine learning)
- Maps and SLAM

ESE 619: Model Predictive Control
- Theory of Optimization
- Hybrid Systems, Constraints, Safety

ESE 615: Autonomous Racing
- Applied, real-time laboratories.
- Hands-on sensors, hardware, and ROS.

CIS 580: Machine Perception
- Image space data (filters, features, CNNs)
- Projective geometry
- Structure from motion



This Class!

- Dynamics and model-based methods.
- Planning in maps.
- Underactuated systems, control in SE(3)
- Fusing vision with inertial sensing for state estimation.

Course Logistics

Class meets Tuesdays and Thursdays, 12-1:30 in the LRSM Auditorium.

Canvas

- Syllabus, lecture slides, assignments, homework submission.
- https://canvas.upenn.edu/

Piazza

- Course announcements.
- Discussion forum for class.
- Message TAs about assignments and office hours.
- https://piazza.com (also link through Canvas)

Deliverables

Projects (60%)
- Mixed individual and group submissions.

Homework (10%)
- Individual submissions.

Exams (30%)
- Exam 1, Thursday 3/5 (in class)
- Exam 2, Monday 5/4 (exam period)

Lots of work!
- Written assignments
- Programming assignments
- Laboratory assignments

This is a project based class; expect this class to be a lot of work.

Major project deadlines are guaranteed to overlap with ESE 650, CIS 580!

Laboratory time
- May be in evenings and weekends
- Will be in Levine 457
- Very little flexibility

Collaboration Policy

Most assignments will be submitted individually.

Your submitted work must be your own work.

You are ***encouraged*** to discuss the course, assignments, and solution methods with each other.

You must credit any collaborators in every assignment.

- At the top of your homework
- In your project submission readme.txt

Academic Integrity

We take academic integrity very seriously in this class.

Penn Code of Academic Integrity is available online:

- https://catalog.upenn.edu/pennbook/code-of-academic-integrity/

Plagiarism is presenting someone else's ideas as if they were your own.

- Never include code in your submission that is not your own.
- When in doubt, ask *before* you act.
- Credit collaborators and outside resources in your readme.
- Code plagiarism will result in a grade of zero on the entire assignment.

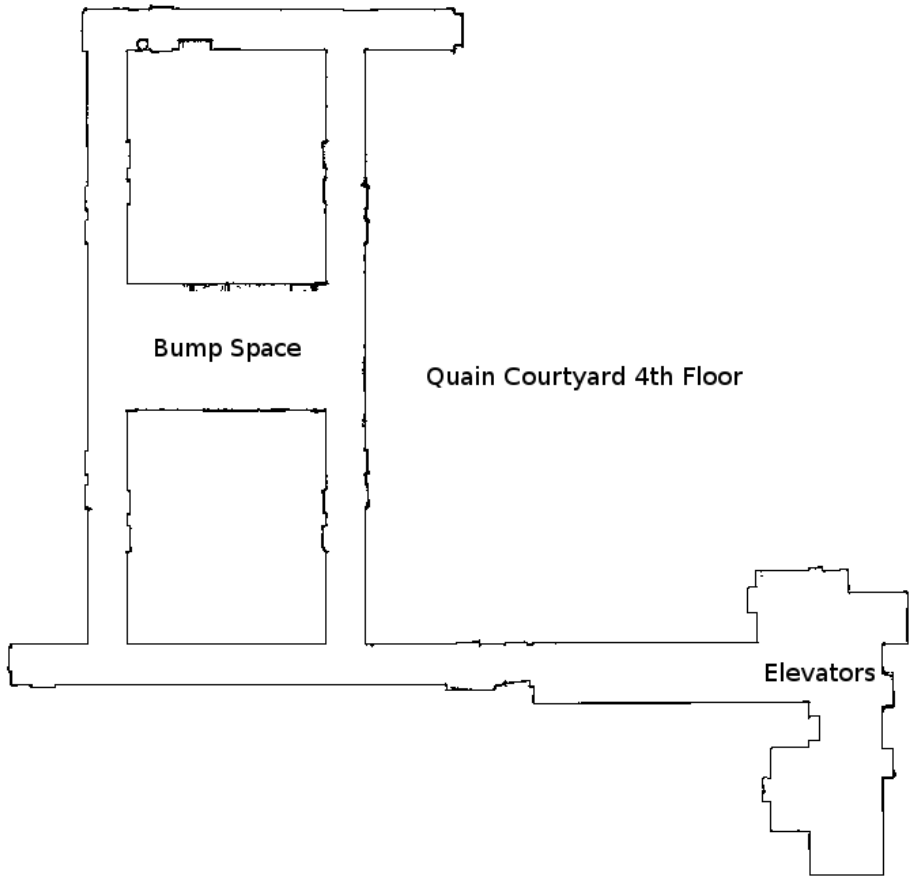
Office Hours

Location: “Bump space” on the 4th floor of Levine.

See Google Calendar in Canvas for schedule and location updates.

If you wish, you may add the calendar to your Google@SEAS account.

https://calendar.google.com/calendar/b/1?cid=c2Vhcy51cGVubi5lZHVfdjRscjBsdGVqMWN0dnN2Z25ocDZtZXJuOTRAZ3JvdXAuY2FsZW5kYXIuZ29vZ2xlLmNvbQ



Textbook

There is no required text book.

Reading excepts will come from various texts and academic papers. Some suggested reference texts are listed on Canvas.

Outside Course Material

Our website from previous years; much out of date.

- https://alliance.seas.upenn.edu/~meam620/wiki/

Our companion Coursera course (videos); also much out of date.

- https://www.coursera.org/learn/robotics-flight/

Waitlist

- The course is presently full, and there is a waitlist.
- Please let the instructors know by email if you are enrolled and intend to drop.
- If you would like to remain on the waitlist, please sign the paper list after class.
- Enrollment will be finalized on Monday.