How to be make the most out of this virtual class

- Zoom Setup
  - Comfortable and quiet space
  - Join a couple of minutes early
  - Maximize screen
    - See Presentation / Code
    - See Speaker
    - See Chat
  - Hear speaker
  - Mic off
  - Camera on

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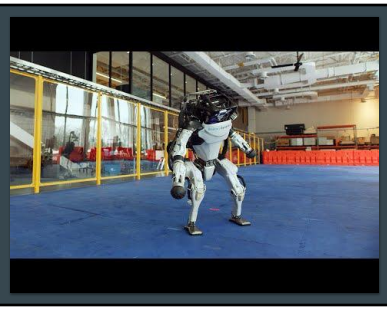
  - Hear speaker
  - Mic off
  - Camera on
- Participate
  - Keep camera on
  - Mic on to ask questions or comment
  - Questions on Chat
  - Thumbs up/down
  - Polls
- Do the labs
  - Get machine ready
  - Allocate time within and outside lab
  - Sign up for Slack



CS4501
Robotics for Soft Eng

•••

Sebastian Elbaum
Spring 2021

Is this Class for me? - Poll

- You want to learn about unique aspects of software development for robots
  - Class is not about AI, Mechanics, or Electronics
- You have not taken a Robotics class at the University level that require progr.
- You are a very competent programmer in python or C++
- You are familiar with programming with threads
- You can handle systems' issues on your own

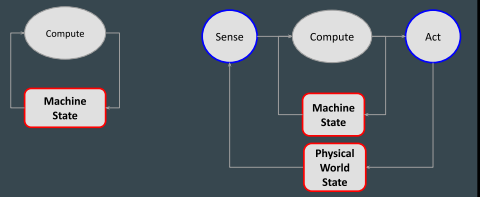
If your answer was YES to ALL questions then this class is for you

How do we build systems that can

physically operate in the world?

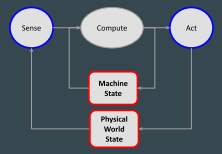
Operating in Cyber World

Operating in Cyber vs Physical World



Operating in Physical World - Exercise

- Robotics pincer
  - Command to open/close
  - Tight grip
  - Can move in X, Z
  - WB low-res camera



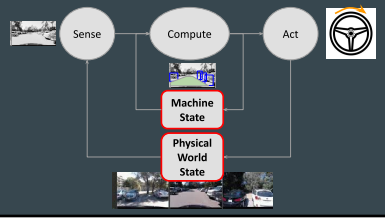
Operating in Physical World - Exercise

- Demo
- Challenges identified
  - *Poor quality / limited angle of images*
  - *Depth perception is hard with single camera*
  - *Pincer's strength/grip*
  - *Frames of reference (what is move left?)*
  - *Incomplete model of world (did not model inclined or broken plane)*
  - *...*

Operating in Physical World is Hard

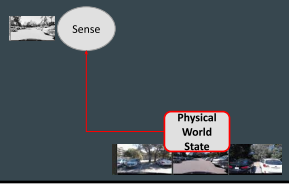
- World is messy
- Sensors are not perfect
- Interpreted world is an approximation at best
- Actuation effect is uncertain
- Timing is important
- Model of world matters

Operating in Physical World



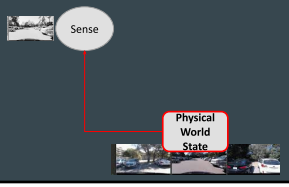
Sensing Physical World

- Physical world state is partially observable



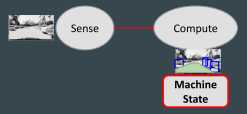
Sensing Physical World

- Physical world state is partially observable
- Sensors are noisy, inaccurate, and limited



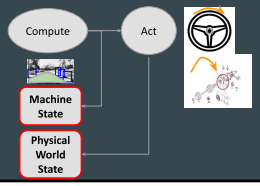
Sensing Physical World

- Physical world state is partially observable
- Sensors are noisy, inaccurate, and limited
- Inferring state from sensors' data is another approximation



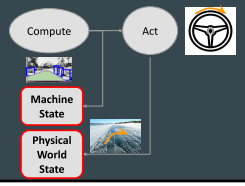
Actuating on Physical World

- Actuators inaccuracies when electro-mechanic assumptions break



Actuating on Physical World

- Actuators inaccuracies when electro-mechanic assumptions break
- Actuators inaccuracies when mismatch of physical and machine state



Compensation Strategies

- More and more powerful sensors
- Better models of the robot and the world
- More and faster feedback loops
- Exposure to more scenarios

Are we there yet?

NATIONAL TRANSPORTATION SAFETY BOARD - 2020: *"The Tesla's Autopilot lane keeping assist system steered the vehicle to the left into the neutral area of the gore, without providing an alert to the driver, due to limitations of theAutopilot vision system's processing*

How do we ~~build~~ software engineer systems that can physically operate in the world?

Software Engineer

- Architectures and design patterns
- World representation in the machine
- Algorithms and data structures
- Simulation to bridge the testing gap with physical world
- Programming the deployment in the real world

How this class came about

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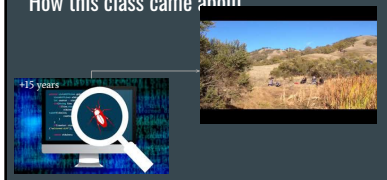

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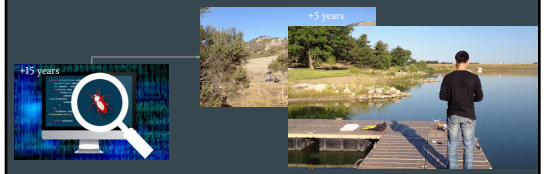

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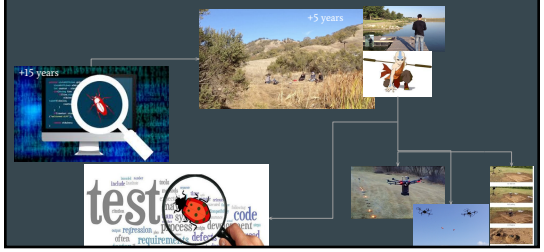

Course Structure

- Lectures on Tuesdays
  - Zoom
  - Recorded
- Labs on Thursdays (70 points)
- 4 Quizzes on covered materials (8 points)
- 2-min Robotics Video (2 points)
- Project for the last couple of weeks (20 points)

Lab Structure

- Be laptop-ready on Thursdays to complete labs
- Work in mini-groups with rotating support
- Sign-up for Slack
  - Better than zoom for asking/tracking questions
  - Call for help or to get checked
- Lab Grading
  - "Life grading" during office hours or Lab time
    - "Life" means we get to chat a bit more, dig a bit deeper, answer questions
  - Grading Timelime
    - To get full grade: graded within a week of being assigned
    - To get 50%: within 2 weeks of being assigned
    - 0 otherwise

Course Materials Walkthrough

- Website for all materials and labs
- Collab for announcements, grades, and recorded lectures
- Slack for lab support

Course Policies - Doing your own work

- Students must fully comply with all the provisions of the University's Honor Code.
- Offering and accepting solutions from others is a serious offense. All suspected violations may be forwarded to the Honor Committee, and you may, at the instructor discretion, receive an immediate zero on that assignment and fail the course regardless of any action taken by the Honor Committee.
  - All graded labs, quizzes, and project must be pledged.
  - You can discuss labs and project, but you cannot share code.
  - Do not exchange information during online quizzes.
- Labs can get full credit if returned within a week of the class when they were introduced. After a week, the labs get 50% credit. After two weeks the labs get 0 credit.

When in doubt, ask me.
When in need of a break, talk to me beforehand.

Course Policies - Accommodations

- You are responsible for all missed work. It is also the absentee responsibility to get all missing notes or materials.
- If you anticipate any issues related to the format, materials, or requirements of this course, please meet with me outside of class so we can explore potential options.
- If you are unsure if you require an accommodation, or to learn more about their services, you may contact the SDAC at the number above or by visiting their website at https://studenthealth.virginia.edu/sdac.
- If you are struggling with violence or discrimination, I am ready to provide support and guide you towards the many resources available at the University of Virginia.
- If you need academic accommodation for a religious observance, please submit an email request to me as far in advance as possible. Note that accommodations do not relieve you of the responsibility for completion of any part of the coursework missed as the result of a religious observance.

Tentative Schedule

1	Introduction		Lab-1: Set up and Basic ROS
2	Architecture and Patterns		Lab-2: Node communication and simulation environment
3	Software Machinery + Q1		Lab-3: Domain types and libraries, parameter and launch
4	Robot and world through sensors		Lab-4: Sensor filtering and fusion
5	Perception + Q2		Lab-5: Perception of images
6	UVA Break Day		Invited Speaker
8	Controlling your robot		Lab-6: Controlling and testing your robot
9	Making plans + Q3		Lab-7: Mapping and Motion Planning
10	Localization and navigation		Lab-E: Ethics
11	Transformations		Lab-8: Transformations
12	Advanced Robotics + Q4		UVA Break Day
13	Project parameters		Catch-up Lab and project questions
14	Project		Project
15	Project Presentations and Demos		Taking stock

TODO by Thursday

- Visit class website
- Sign up for Slack
- Get ready for first lab
  - Lab 1 up to Checkpoint 1 (download the VM)