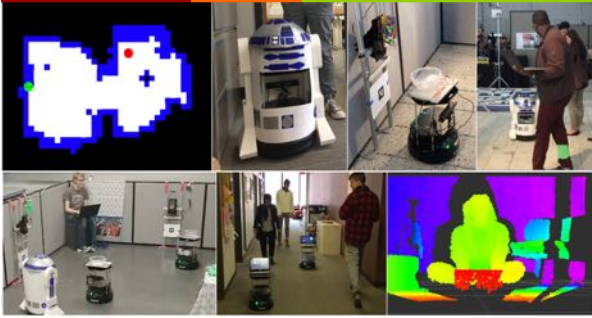


CS 189: Autonomous Robot Systems

Spring 2020, Fridays 9-11:45am, Pierce 301



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Spring 2020, Fridays 9-11:45am, Pierce 301

Lecture 1: Introduction

Lecturer: **Prof. Radhika Nagpal** nagpal@g.harvard.edu

TFs: **Billy Koech** and **Ernie Omondi**

URL: <https://canvas.harvard.edu/courses/65155>



IMPORTANT: Don't Forget....

Interested in taking this course?

- **Friday (today) before noon** (short class today)
 - Add the class to your **STUDY CARD** and make sure to **request permission of instructor**,
 - Please also fill out **Google Signup Forms!** On our canvas website
- I will resolve the lottery by **3pm** today
 - Then I will go ahead and approve all the requests before 4pm and you can submit your study card fully resolved before 5pm.
 - There will be a wait list, to be resolved before Monday evening.

Why Study Robotics?...



Yesterday's Robots

Why Study Robotics? ...



Way in the Future Robots.....

Why Study Robotics? ...



Today's Robots!

Why Study Robotics? ...



Roomba, 2002
(10 million units)

Darpa Urban Challenge, 2007

Today's Revolution: Sensing and Vision!

Today's Robots!

Why Study Robotics? ...



Robots that can **perform many tasks** and **navigate** in many environments

Today's Robots!

IROBOT | AMAZON | TESLA | CYPHYworks | JIBO | FETCH ROBOTICS | BUDGEE | GOOGLE

Why Study Robotics?...



Today's Robots!

IROBOT | AMAZON | TESLA | CYPHYworks | JIBO | FETCH ROBOTICS | BUDGEE | GOOGLE

Why Study Robotics?...



Today's Robots!

Why Study Robotics?...

Key Point:
 Robots are quickly moving out of the
 "factory" and into the "real-world"
 Soon there will be robots for the masses
 But we aren't there yet.....

Technical Ideas:
 Complex decisions in a complex world,
 Sensing, Thinking, Acting,
 i.e.
AUTONOMY

What is this Class About?



.....That Do Your Bidding

What is this Class About?

- **Best way to study Robotics is to do it yourself**
 - In this class, we will learn about robot systems by implementing *autonomous problem-solving*
- **Focus is on Autonomy**
 - Your robot must do all its *sensing-thinking-acting* on its own.



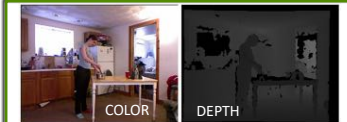
What is this Class About?

Meet the TURTLEBOT!



ROS & Python

Robot operating system (industry standard, used by modern robots, from PR2 to cars).



RGB-D Camera (ASUS xtion pro) which we will use for applications like object recognition, map building, people tracking, etc (OpenCV Library, Point Cloud Library).

Kobuki driving base works in all indoor environments!

And we can add many attachments/devices to change robot structure

What is this Class About?

- **Focus is on Autonomy**
 - Your robot must do all its *sensing-thinking-acting* on its own.
- **Low-level control: Programming the lowest-level of robot "reflexes"**
 - **Motion control** (kinematics for wheeled robots, feedback control).
 - **Vision** (RGB, Depth, and Motion Video based reasoning).
 - **Behavior Programming** (Finite State Machines)
- **Higher-level reasoning: Task Plans and Navigation.**
 - **Navigating** the world: algorithms for localization, building maps, path planning.
 - **Application:** Following a plan, using structured memory, and dealing with errors.
- **"Applied" Skills:**
 - **Programming and debugging hardware** for autonomous control
 - Using software systems and libraries e.g. ROS (industry standard, distributed OS), computer vision (e.g. OpenCV and ARTags, etc).

How this Class will Work

This is a Hands-on Robotics class, which means.....

- **Studio Class Format (Every Friday 9-11:45am, in Pierce 301)**
 - **First half of each class:** Lecture on technical topic
 - **Second half of each class:** Lab or Pset demonstration
- **Logistics**
 - Attendance: expected (Psets due Fridays during class)
 - No extra lab hours, just office hours (Wed evening 7:30pm)
 - Robot Lab: Pierce 301 and nearby hallways! Test and run robots right here, any time during the week; later B127.

How this Class will Work

This is a Robotics class, which means.....

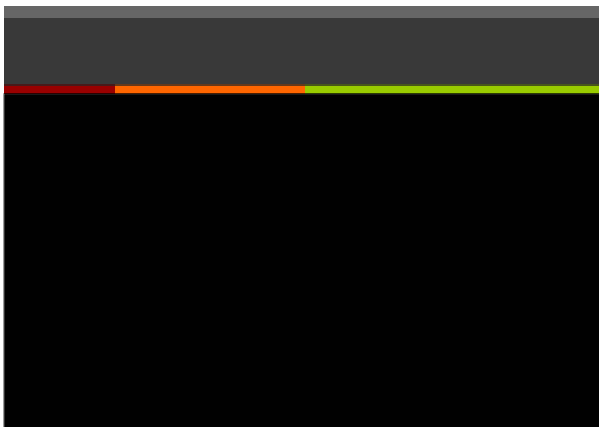
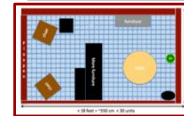
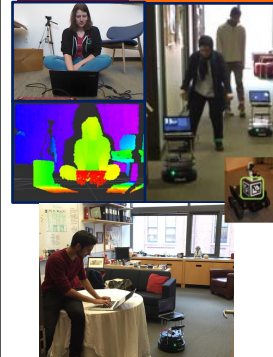
- **Weekly Psets [Feb 7 through Apr 10]**
 - Will be done with partners (pairs), all on Turtlebot robots
 - All psets include a graded in-class "demo" component.
 - **4 psets** (grade distribution 5,10,20,25 = 60%), no exams
- **Final project [Apr 10 through May 8]**
 - **Automated Robot Candy Store!**
 - See website for detailed schedule and information.
 - Also show off the work at **SEAS Design Fair!**

Labs & Problem Sets

ASSIGNMENTS

Pset1: Roomba (behaviors)
Pset 2: Wanderer (depth + collision avoidance)
Pset 3: Follower (RGB and feedback control)
Pset 4: Mapping (Occupancy Grid)
Final Project: Candy Store! (Navigation)
(each assignment builds on the previous)

Lab 1&2: Motion and Vision (depth/color)
Lab 3&4: Navigation (Kalman Filters, ARTags)



Who can take this class?

- **Enthusiasm for robotics essential**
 - Learn many general topics (e.g. vision, sensors, control)
 - Also learn debugging, patience, and reading APIs....
- **Programming experience**
 - CS51 or CS61 (or other programming experience)
 - We will make heavy use of **python**, **git**, **ssh**, & **patience**.
- **No background in Robotics or AI is assumed**
 - You do not need cs181 or cs182.
- **Appropriate for CS or ES concentrators**
 - Robotics is naturally multi-disciplinary

FAQ

- **What language do we program in?**
 - Python, pair programming, we will teach you ROS
 - You will end up learning many software packages on your own
- **How many hours do the Psets take per week?**
 - Our aim is ~10 hours.
 - Harder assignments are broken over 2 week periods
 - Because robots are shared by 2 teams, also some natural limits (and scheduling constraints).
- **Is there a required textbook?**
 - No. We will assign chapters from online books

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 - On the course canvas website
- I will resolve the enrollment by **3pm** today
 - Then I will go ahead and approve all the requests, and notify you if you got in or if you are waitlisted. Waitlist will be resolved by wed evening.

Questions?

DON'T FORGET TO SIGN UP ASAP!

Study Card, Google form

nagpal@g.harvard.edu if you have questions

