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Introduction to Intelligent Systems

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INTRODUCTION

What is Intelligence?

Merriam-Webster

(1) : the ability to **learn** or **understand** or to deal with new or trying situations : **reason**; *also* : the skilled use of reason (2) : the ability to apply **knowledge** to **manipulate** one's environment or to think **abstractly** as measured by objective criteria (as tests)

Wikipedia

A very general mental capability that, among other things, involves the ability to **reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly** and **learn from experience**.

It is not merely book learning, a narrow academic skill, or test-taking smarts.

Rather, it reflects a broader and deeper capability for comprehending our surroundings—"catching on," "making sense" of things, or "figuring out" what to do. [Gottfredson, Linda S. (1997). "Mainstream Science on Intelligence (editorial)". *Intelligence* **24**: 13–23.]

Intelligent Systems



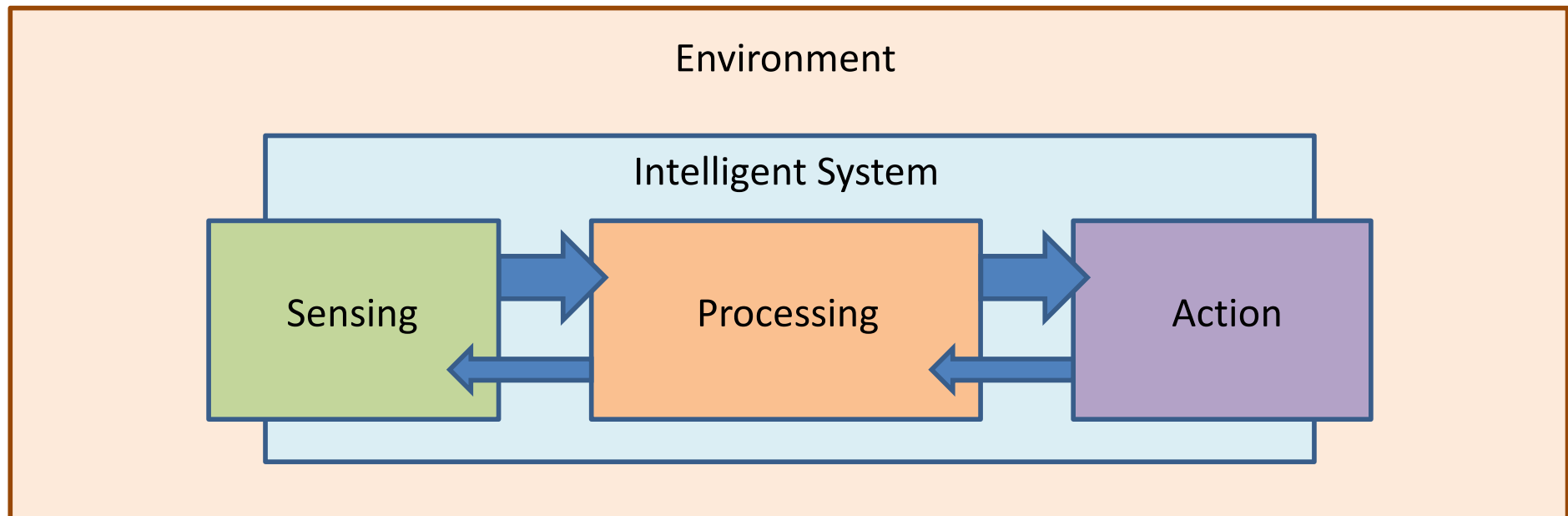
BigDog (2005)



PR2 (UC Berkeley, 2010)



Google Car (2014)



Artificial Intelligence (AI)

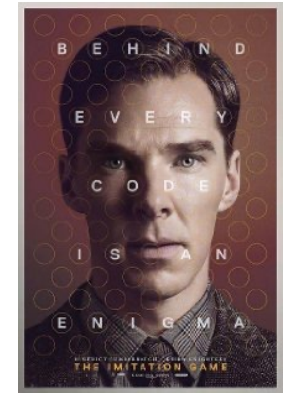
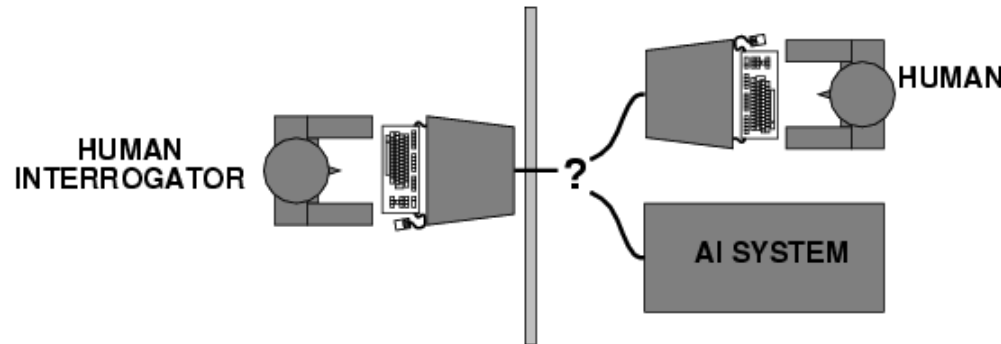
- Heavily focused on (e.g., traditional AI)
 - Processing
 - Discrete world
 - Logic
- Four popular views about AI

Thinking Humanly	Thinking Rationally
Acting Humanly	Acting Rationally

Acting Humanly: Turing Test

Turing (1950) "Computing machinery and intelligence":

- "Can machines think?" → "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game



The Imitation Game (2014)

- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
 - Eugene Goostman (chatterbot) passed the Turing test on June 7, 2014 (10 out of 30 judges). <http://www.princetonai.com/>
- Anticipated all major arguments against AI in following 50 years
 - Chinese room argument (Searle)
- Suggested major components of AI: knowledge, reasoning, language understanding, learning



Problem: Turing test is not **reproducible, constructive**, or amenable to **mathematical analysis**.

Thinking Humanly: Cognitive Science

- 1960s "cognitive revolution": information-processing psychology
- Requires scientific theories of internal activities of the brain
 - What level of abstraction? Knowledge or circuits?
 - How to validate? Requires
 - Predicting and testing behavior of human subjects (top-down)
 - Direct identification from neurological data (bottom-up)
- Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

Thinking Rationally: Laws of Thought

- **Normative (or prescriptive) rather than descriptive**
- Aristotle: what are correct arguments/thought processes?
- Several Greek schools developed various forms of **logic: notation** and **rules of derivation** for thoughts; may or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI
- Problems:
 - Informal or uncertain knowledge cannot be precisely stated formally
 - Big difference between solving a problem “in principle” and solving it in practice

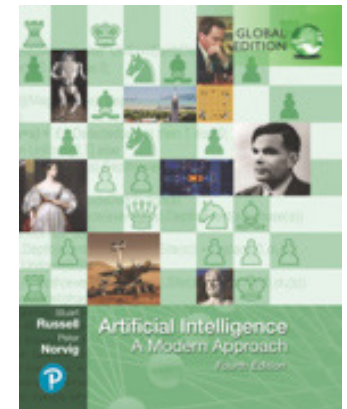
Acting Rationally: Rational Agent

- **Rational behavior: doing the right thing**
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of rational action
- Computational limitations make perfect rationality unachievable
 - Design the best program for given machine resources

COURSE OUTLINE

Course Information

- Instructor: Songhwai Oh (songhwai@snu.ac.kr)
- TAs:
 - Jooyoung Kim (jooyoung.kim@rllab.snu.ac.kr)
 - Hyeondal Son (hyeondal.son@rllab.snu.ac.kr)
 - Seoyoung Lim (seoyoung.lim@rllab.snu.ac.kr)
 - Jaeseok Yang (jaeseok.yang@rllab.snu.ac.kr)
- Textbook
 - Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach, Prentice Hall, 4th Edition, 2020/2021.
 - <http://aima.cs.berkeley.edu/index.html>
- Homepage:
 - <http://rllab.snu.ac.kr/courses/intelligent-systems-2026>
- Class Board:
 - eTL



Topics

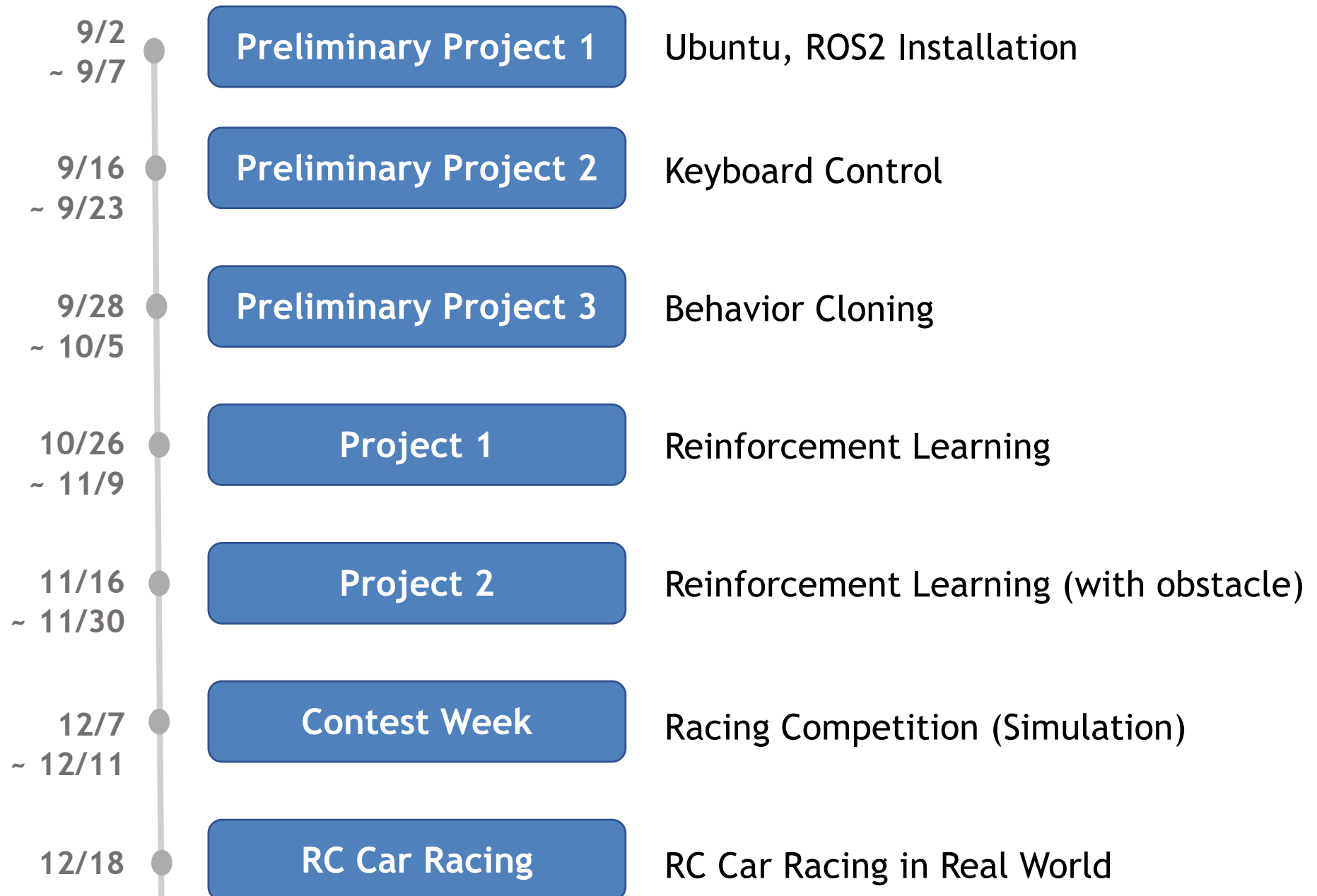
- Review of probability
- Probabilistic Modeling and Inference:
 - Bayesian networks, Hidden Markov models, Kalman filters
 - Markov decision processes
- Machine Learning:
 - Linear classification, Linear regression, Learning with complete data
 - Learning with hidden variables, EM algorithm
 - Nonparametric models, Support vector machines
 - Deep learning
 - Reinforcement learning
- Robotics:
 - Localization and mapping, Motion planning, Planning uncertain movements, Moving
 - Robotic software architectures, Application domain
- Computer Vision:
 - Image formation, Edge detection, Texture, Optical flow, Image segmentation
 - Object recognition, Reconstructing the 3D world

Grading

- Class participation
- Homework assignments
- Midterm (in class)
- **Term project with multiple assignments**
- **(No Final Exam)**

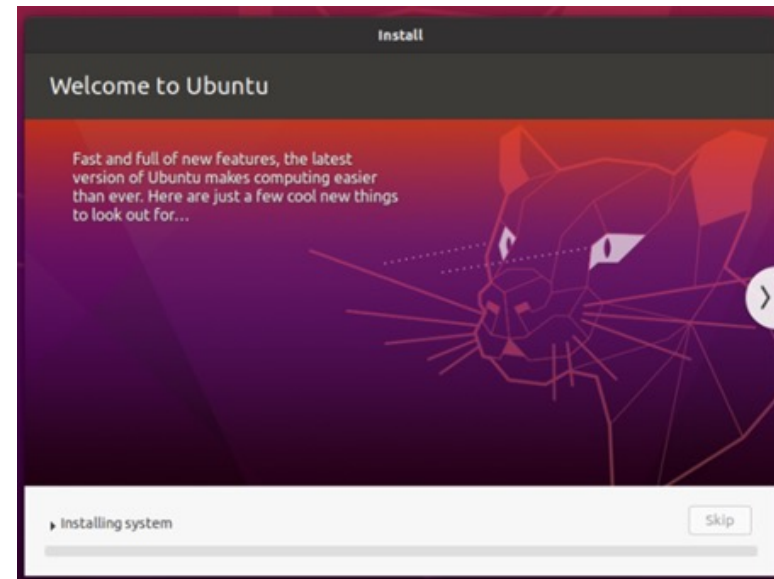
TERM PROJECT

Schedule (* subject to change)



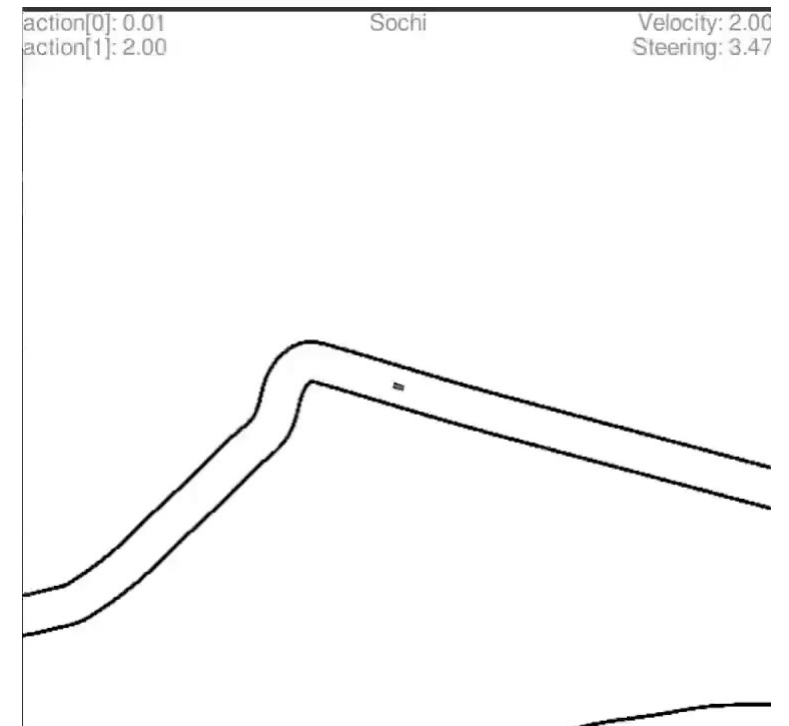
- Ubuntu, ROS2 Installation

- Install Ubuntu 20.04
(<https://releases.ubuntu.com/>)
- Install ROS 2.0 foxy on your Ubuntu
(Make sure that you install ros-foxy)



• Design a Keyboard Controller

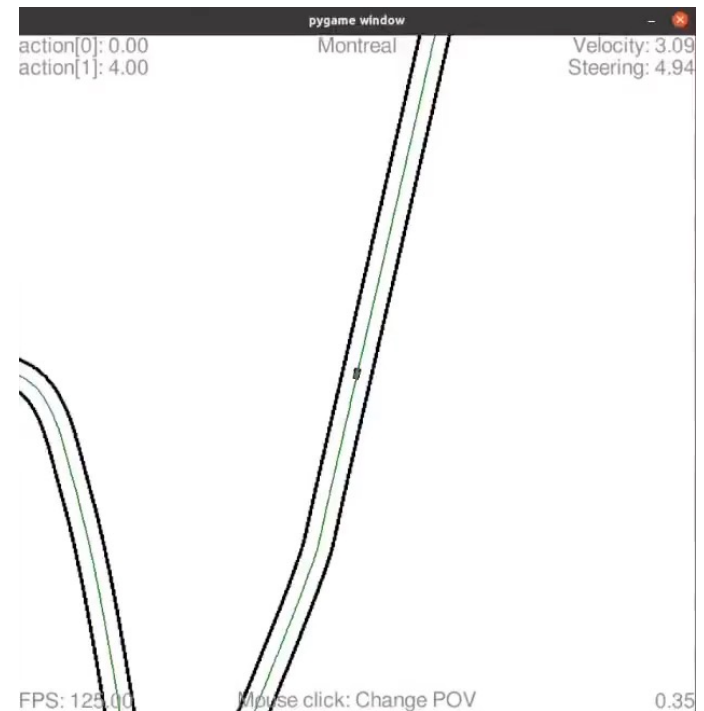
- Implement a keyboard controller using ROS2 communication
- Manually control a race car in a Pygame using keyboard inputs



Keyboard Controller Example

• Expert Data Collection Using Pure Pursuit

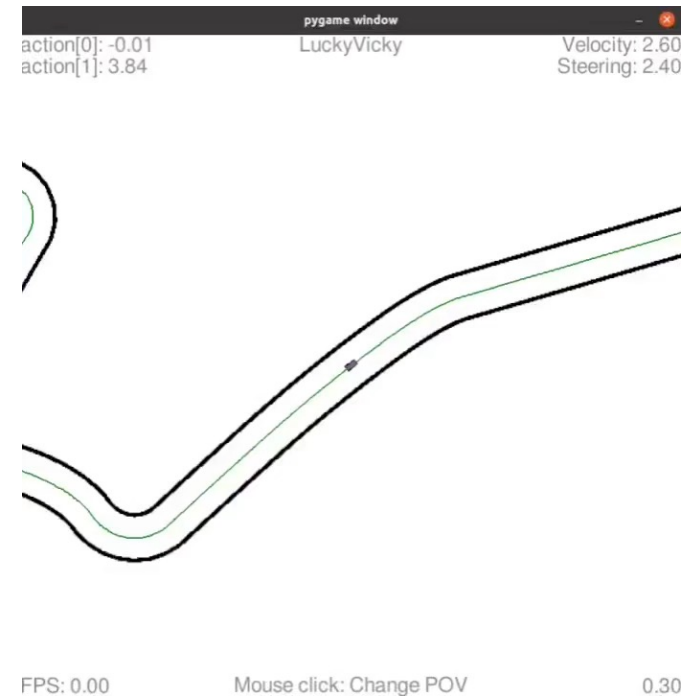
- Implement an algorithm to control a race car to complete the track.
- Use a PID controller to calculate control inputs for the car to follow the track smoothly.
- Collect expert demonstrations for behavior cloning



Pure pursuit Goalpoint Navigation Example

• Behavior Cloning

- Use behavior cloning to imitate expert demonstration
- Control an RC car in Pygame with observations from our custom gym environment

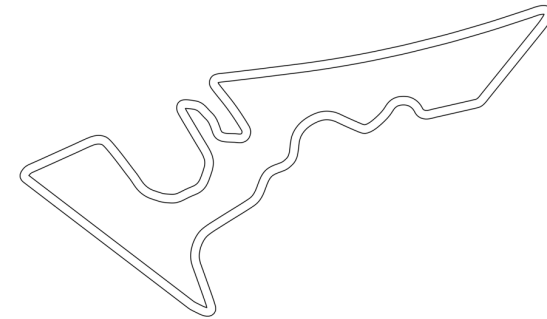


Behavior Cloning Navigation Example

• RC Car Racing Competition

- Fine-tune BC algorithm by adjusting the parameters
- You can also implement alternative learning algorithms.
(e.g., DQN, PPO, ...)

Prepare for contest week after project 2 ends.



RLAB Robot Learning Laboratory											
#SNU #RLAB #RC Car Racing LeaderBoard											
Rank	Map1	Map2	Map3	Map4	Map5	Map6	Map7	Map8	Map9	Map10	Total
1	team_id: DRIVETHROUGH success: true waypoints: 20/20 lap_time: 58.186	team_id: DRIVETHROUGH success: true waypoints: 20/20 lap_time: 43.024	team_id: PATHFINDER success: true waypoints: 20/20 lap_time: 13.895	team_id: ROUTE success: true waypoints: 20/20 lap_time: 41.873	team_id: SAMPLE success: true waypoints: 20/20 lap_time: 24.526	team_id: PATHFINDER success: true waypoints: 20/20 lap_time: 43.849	team_id: DRIVETHROUGH success: true waypoints: 20/20 lap_time: 57.060	team_id: DRIVETHROUGH success: true waypoints: 20/20 lap_time: 48.805	team_id: SAMPLE success: true waypoints: 16/20 lap_time: 58.340	team_id: DRIVETHROUGH success: true waypoints: 20/20 lap_time: 41.264	SAMPLE score: 70
2	team_id: SAMPLE success: false waypoints: 18/20 lap_time: 58.357	team_id: SAMPLE success: true waypoints: 20/20 lap_time: 44.757	team_id: SAMPLE success: true waypoints: 20/20 lap_time: 14.280	team_id: KALMANIACS success: true waypoints: 20/20 lap_time: 43.045	team_id: ROUTE success: true waypoints: 20/20 lap_time: 25.918	team_id: DRIVETHROUGH success: false waypoints: 11/20 lap_time: 30.790	team_id: SAMPLE success: false waypoints: 17/20 lap_time: 58.735	team_id: SAMPLE success: true waypoints: 20/20 lap_time: 52.369	team_id: ROUTE success: true waypoints: 16/20 lap_time: 58.419	team_id: SAMPLE success: true waypoints: 20/20 lap_time: 45.319	DRIVETHROUGH score: 68
3	team_id: ROUTE success: false waypoints: 18/20 lap_time: 58.641	team_id: PATHFINDER success: true waypoints: 20/20 lap_time: 46.302	team_id: KALMANIACS success: true waypoints: 20/20 lap_time: 15.176	team_id: SAMPLE success: false waypoints: 15/20 lap_time: 32.040	team_id: KALMANIACS success: true waypoints: 20/20 lap_time: 26.428	team_id: KALMANIACS success: false waypoints: 11/20 lap_time: 32.278	team_id: KALMANIACS success: false waypoints: 17/20 lap_time: 61.707	team_id: ROUTE success: true waypoints: 20/20 lap_time: 53.666	team_id: KALMANIACS success: false waypoints: 16/20 lap_time: 61.707	team_id: NAVI success: true waypoints: 20/20 lap_time: 45.518	ROUTE score: 54
4	team_id: NAVI success: false waypoints: 17/20 lap_time: 58.408	team_id: ROUTE success: true waypoints: 20/20 lap_time: 46.584	team_id: ROUTE success: true waypoints: 20/20 lap_time: 15.484	team_id: NAVI success: false waypoints: 11/20 lap_time: 23.175	team_id: NAVI success: false waypoints: 10/20 lap_time: 13.311	team_id: ROUTE success: false waypoints: 11/20 lap_time: 33.365	team_id: ROUTE success: false waypoints: 14/20 lap_time: 45.217	team_id: PATHFINDER success: true waypoints: 20/20 lap_time: 56.734	team_id: DRIVETHROUGH success: false waypoints: 15/20 lap_time: 55.096	team_id: ROUTE success: true waypoints: 20/20 lap_time: 47.155	PATHFINDER score: 39
5	team_id: PATHFINDER success: false waypoints: 17/20 lap_time: 59.115	team_id: NAVI success: true waypoints: 20/20 lap_time: 46.832	team_id: DRIVETHROUGH success: false waypoints: 19/20 lap_time: 13.722	team_id: PATHFINDER success: false waypoints: 10/20 lap_time: 18.493	team_id: DRIVETHROUGH success: false waypoints: 7/20 lap_time: 10.069	team_id: SAMPLE success: false waypoints: 6/20 lap_time: 18.110	team_id: NAVI success: false waypoints: 18/20 lap_time: 33.809	team_id: NAVI success: true waypoints: 20/20 lap_time: 57.000	team_id: NAVI success: false waypoints: 15/20 lap_time: 58.784	team_id: KALMANIACS success: true waypoints: 20/20 lap_time: 49.666	KALMANIACS score: 38
6	team_id: KALMANIACS success: false waypoints: 16/20 lap_time: 61.096	team_id: KALMANIACS success: true waypoints: 20/20 lap_time: 50.349	team_id: NAVI success: false waypoints: 13/20 lap_time: 13.981	team_id: DRIVETHROUGH success: false waypoints: 5/20 lap_time: 17.886	team_id: PATHFINDER success: false waypoints: 7/20 lap_time: 12.324	team_id: NAVI success: false waypoints: 8/20 lap_time: 12.981	team_id: PATHFINDER success: false waypoints: 8/20 lap_time: 32.411	team_id: KALMANIACS success: true waypoints: 20/20 lap_time: 58.506	team_id: PATHFINDER success: false waypoints: 13/20 lap_time: 47.040	team_id: PATHFINDER success: false waypoints: 19/20 lap_time: 47.563	NAVI score: 31

- **RC Car Racing in Real World**

- Transfer the algorithm from simulation to the real world
- Competitors will be ranked by the time that the RC car takes to finish the track and the robustness of the algorithm (the number of collisions)
- RC car racing is planned to be held in teams

