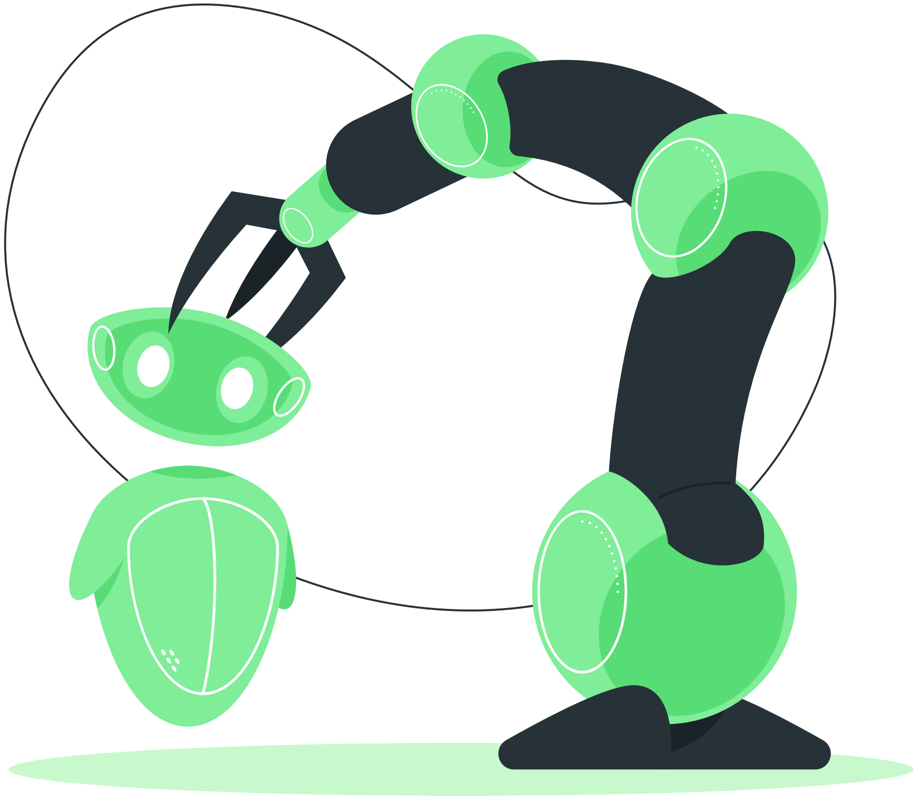
EECS C106B Week 5 Lab

Paper Presentation and
Project 2 Intro



Agenda

1

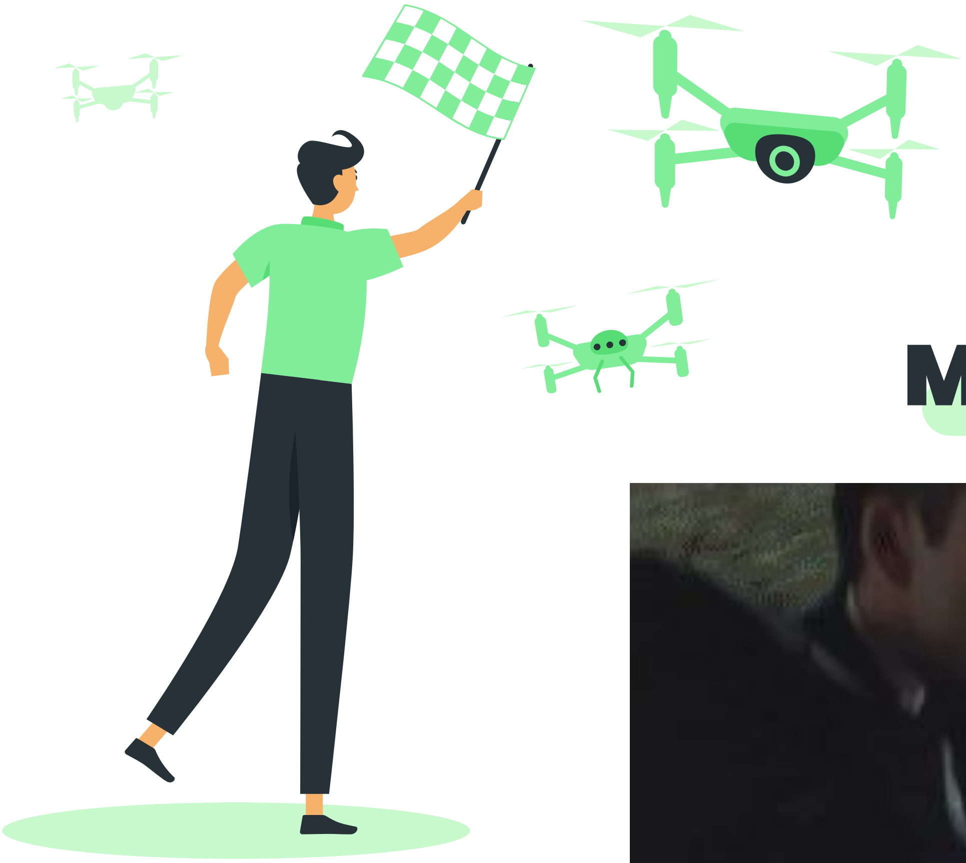
Paper Presentations

Thanks to your peers for presenting Realizing Simultaneous Lane Keeping and Adaptive Speed Regulation on Accessible Mobile Robot Testbeds!

2

Project 2 Intro

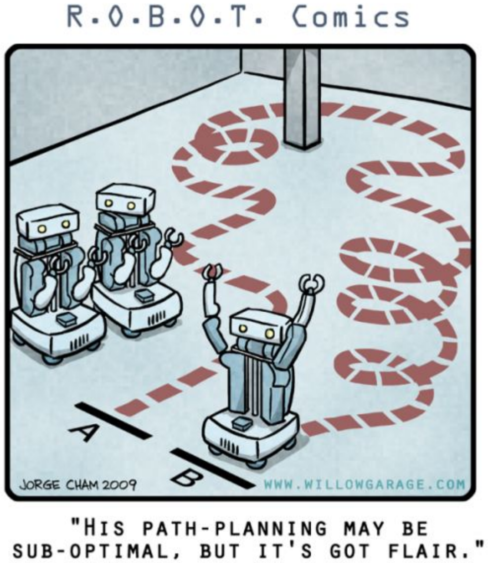
Some relevant info for Project 2



Project 2: Motion Planning

Goals

- Become versed with motion planning problem for nonholonomic systems
  - Bicycle modeled car
- Implement 3 open-loop path planners
  - Optimization
  - RRT
    - Requires tuning!
  - Steering with Sinusoids
- Compare performance of planners in different scenarios



Tasks

1

Simple Motion

Simple drive forward and to the left

2

Parallel Park

Move in a direction that you cannot instantaneously move in

3

Point Turn

Drive to turn around and return to the same spot

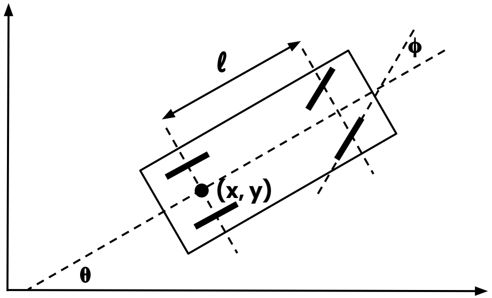
4

Navigation

Avoid obstacles in 2 different maps

Bicycle Modeled Car

- Inputs:
  - Linear velocity u_1
  - Steering rate u_2
- Nonholonomic Constraints
- (For Project) Physical constraints
  - Steering angle
  - Steering rate
  - Linear Velocity
- Simulate through unicycle model 🤔 (STDR sim)
  - Wrapper node handles making unicycle behave like bicycle



$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \\ \frac{1}{l}\tan(\phi) \\ 0 \end{bmatrix} u_1 + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} u_2$$

Unicycle Model (Turtlebot)

Bicycle Model (exaggeration)

Planners

1

Optimization

Format problem as nonlinear optimization problem

2

RRT

Randomly sample the configuration space to build a graph

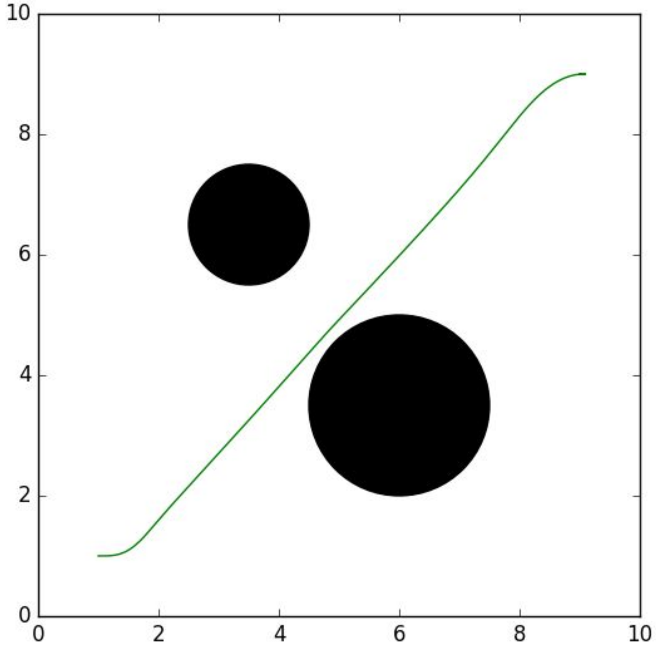
3

Sinusoid

Control inputs with out-of-phase sinusoids

Optimization Planner

- Optimization: minimize cost subject to constraints
- Cost
  - Distance to goal
  - Input
- Constraints:
  - Dynamics
  - Obstacles
  - Start/end configuration



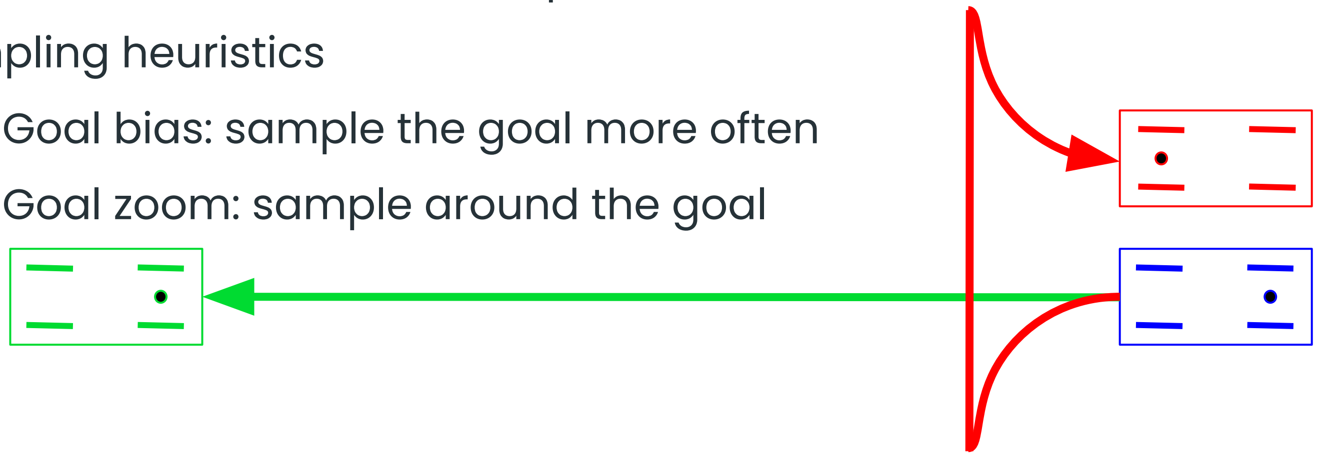
RRT Planner (Algorithm)

- Build graph G
  - Vertices are configurations
  - Edges are motion plans
- Start with start configuration in G
- Sample a configuration and construct a local plan from nearest node in G
- Take a small step along local plan and add new configuration to G
- Repeat until close enough to goal

Steven LaValle reflection on his work

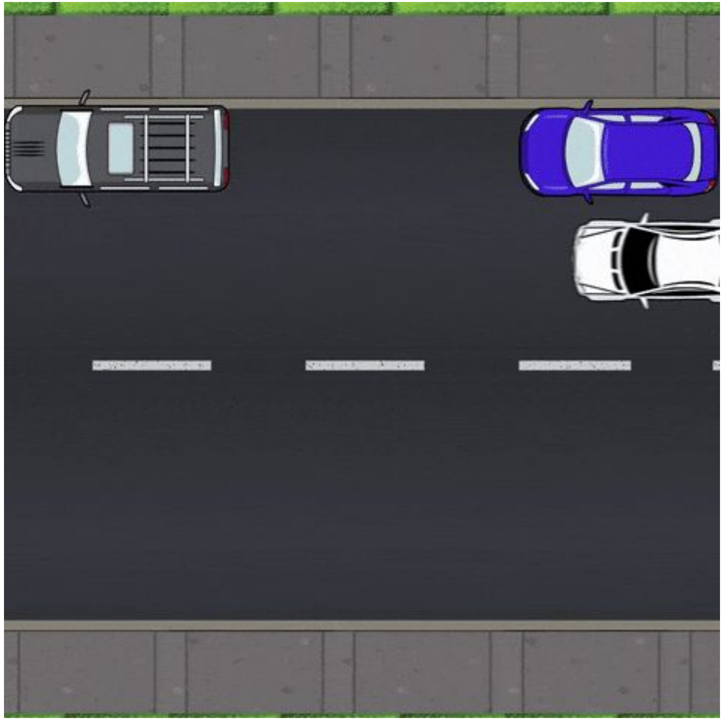
RRT Planner (Considerations)

- Come up with a distance function
  - Also consider heading angle which is periodic
- Create motion primitives
  - Simple (or not, it’s really your choice) motions for time **Δt**
  - Consider directions and speeds
- Sampling heuristics
  - Goal bias: sample the goal more often
  - Goal zoom: sample around the goal



Sinusoid Planner

- Canonical Car Model $\begin{bmatrix} x & \phi & \alpha & y \end{bmatrix}^T$
  - Singularity when **θ** is 90° or -90°
- Alternate Car Model $\begin{bmatrix} y & \phi & \alpha & x \end{bmatrix}^T$
  - Singularity when **θ** is 0° or 180°
- Steps
  - Steer **x** (or **y**)
  - Steer **ϕ**
  - Steer **θ**
  - Steer **y** (or **x**)
- Binary search parameters dynamically
- Constraints on state (how would you handle **y**?) and input



Using the TurtleBots

- Remember to switch them OFF to charge
    - If a TurtleBot is not sufficiently charged for the next group you may lose points
- Carry them by the base, not the acrylic platforms
- Watch where they're going!
    - Be ready to press Ctrl + C
- Refer to the Robot Usage Guide for setup

Timeline of the Near Future

Attend Journal Clubs!

Prepare for your paper presentation!

HW 3

Due 2/22

Project 2

Due 2/28