CSCI 3302
Introduction to Robotics

Alessandro Roncone

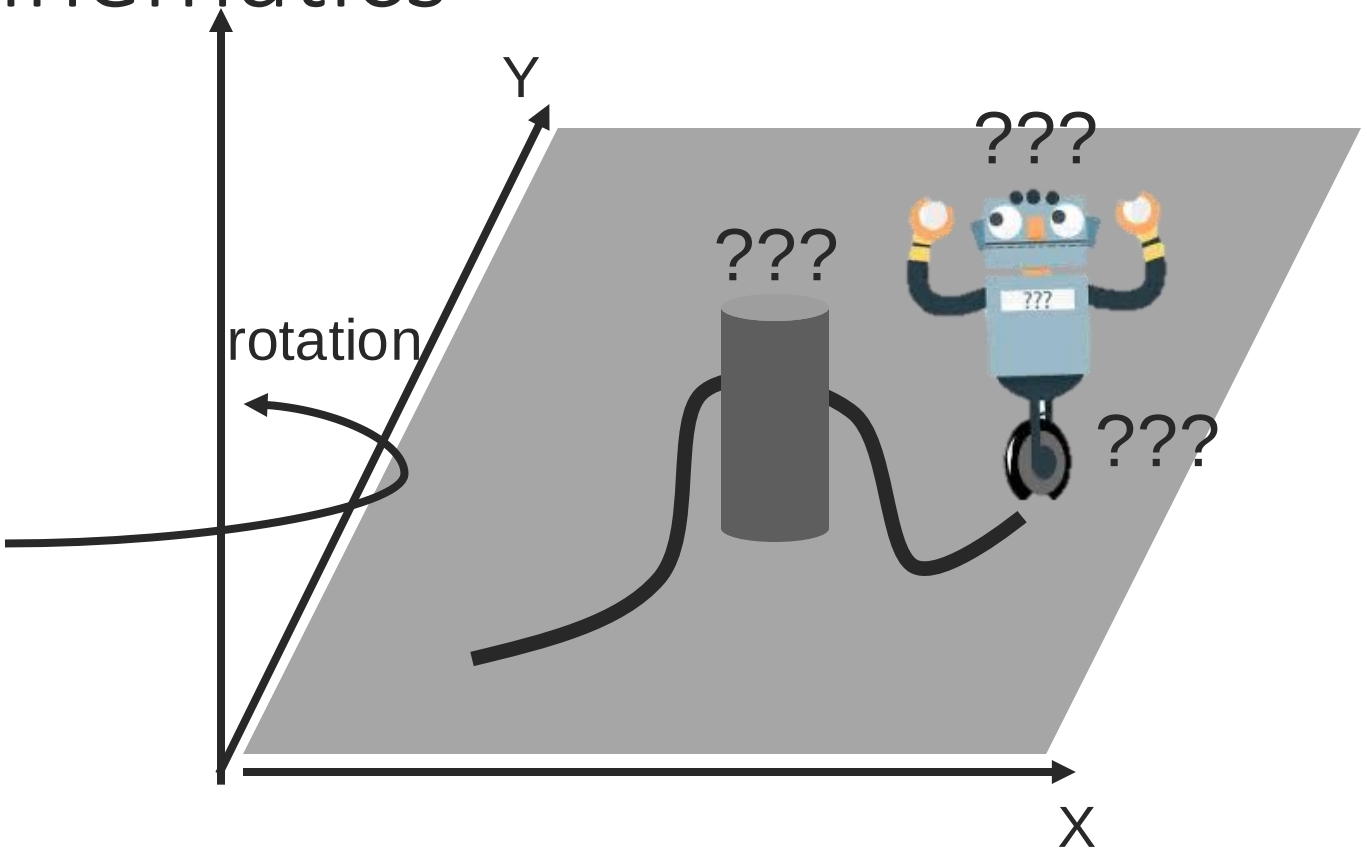
aroncone@colorado.edu

Lab 5
Mapping and Planning

Recap

- Lab 2 – Forward Kinematics [wheel velocities → robot x, y, θ]
- Lab 3 – Inverse Kinematics + Feedback Control
- Lab 4 – Mapping
- Lab 5 [today – March 28] -- Put it all together

Today: Odometry, Mapping and Inverse Kinematics



How can I put it all together?

Lab Setup

TIAGo

240° range

First 83 + last 83 rays thrown away due to hardware design

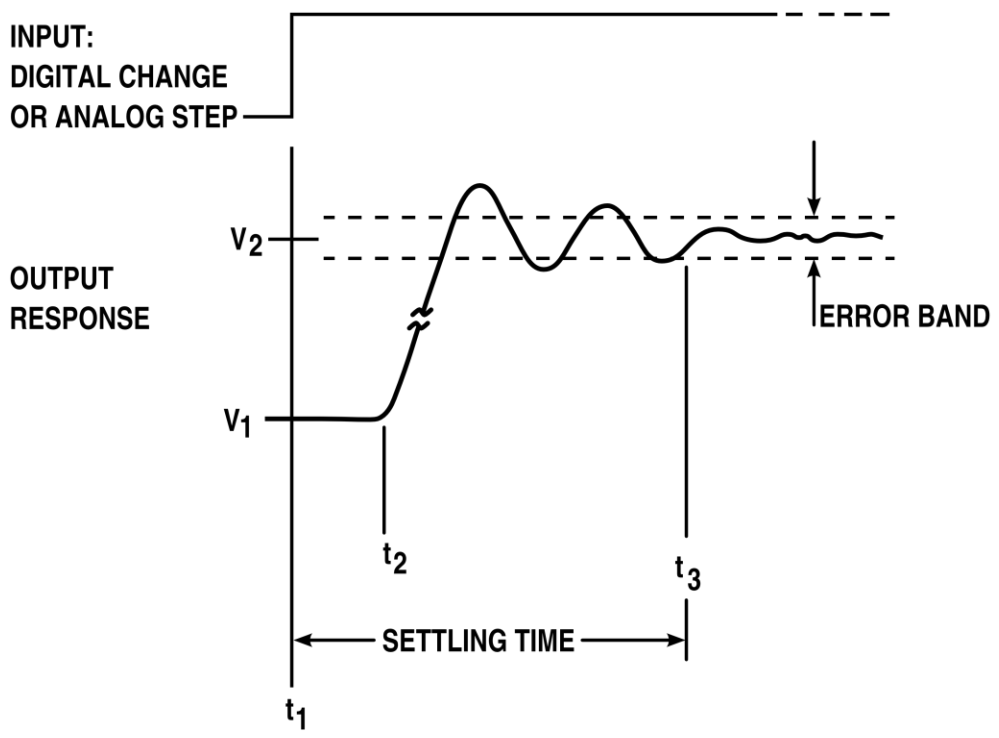
What problems did you run into when using the laser sensor map?

Noise. Obstacles everywhere!

- Sources: reflections, artifacts from robot braking, etc.
- Turn measurements (true/false) into a *probability*
- Grid map stores the probability of a cell being an obstacle or not
- Every positive measurement *increases* the probability
- Use a *threshold* to decide

What problems did you run into when programming a path-following system?

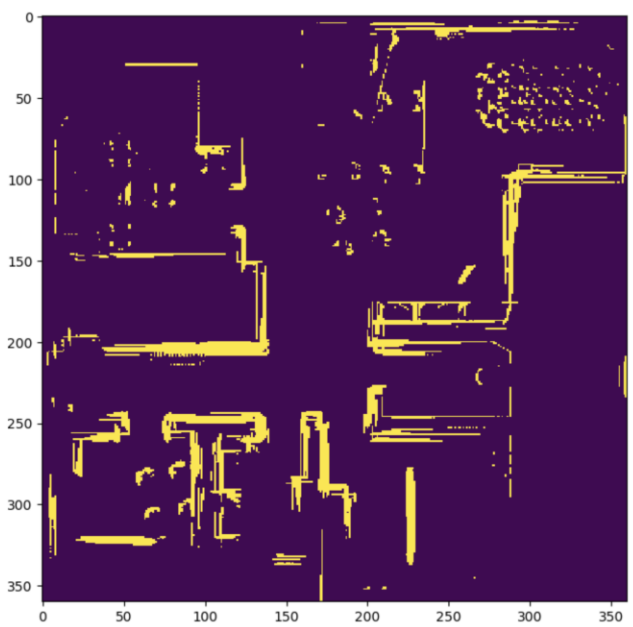
Control issues

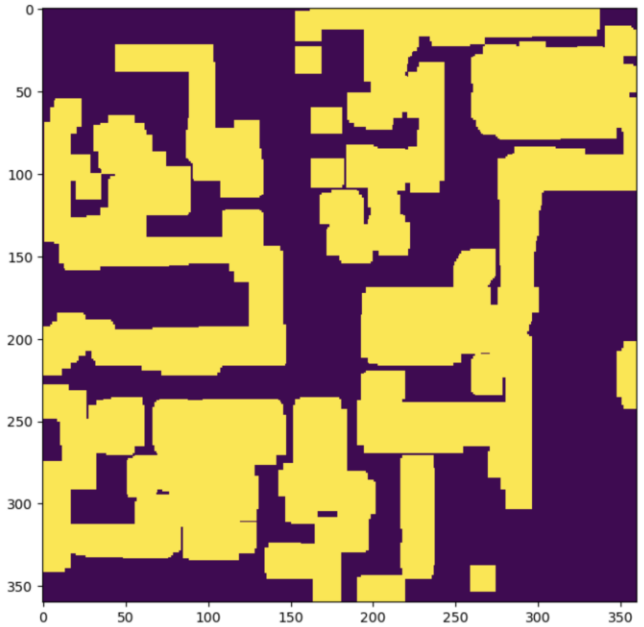


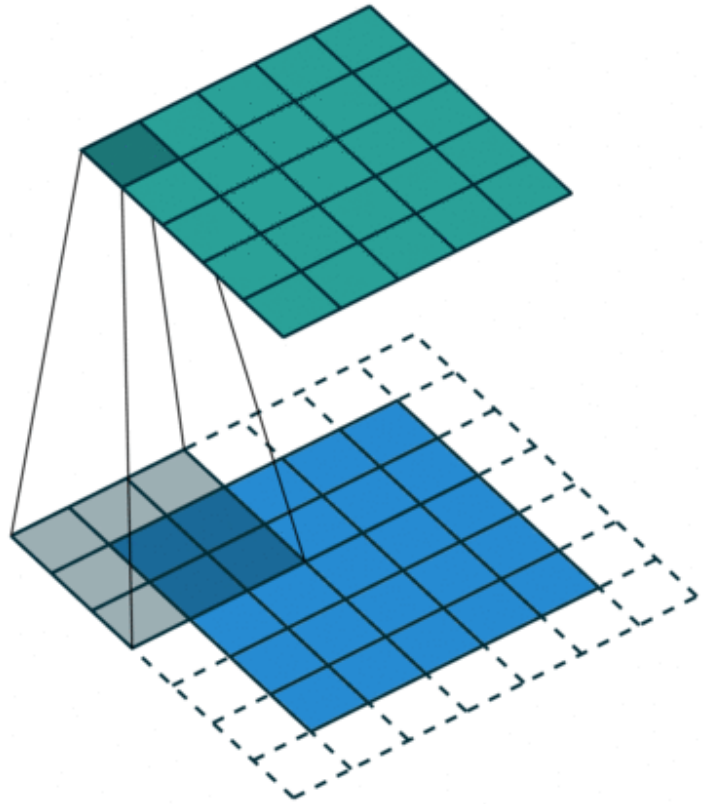
- Find the right trade-offs in your gains
- Minimize settling time
- Minimize tracking error
- *Learn to live with your controller not being perfect and stay away from obstacles*

What parameter do you think will affect planning time the most?

C-SPACE







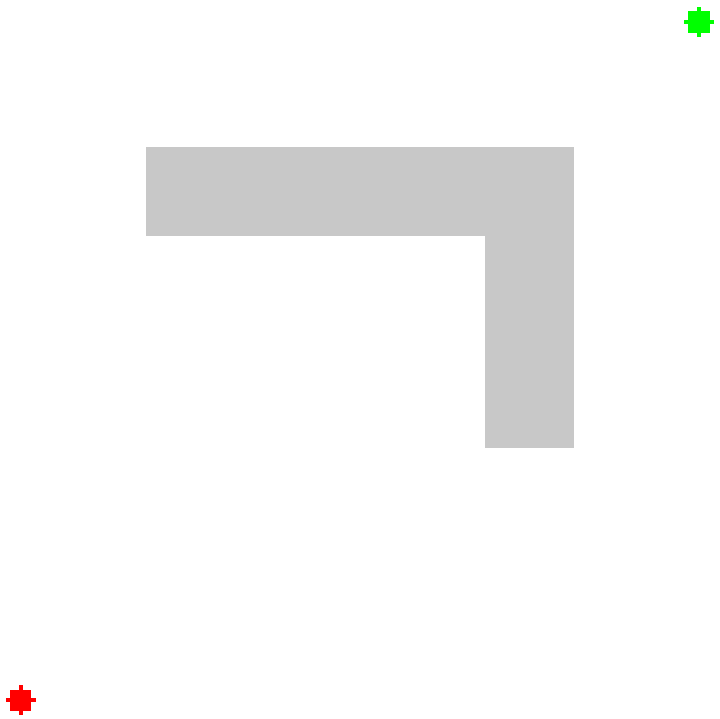
scipy.signal.convolve2d

`scipy.signal.convolve2d(`*in1, in2, mode='full', boundary='fill', fillvalue=0*`)` [source]

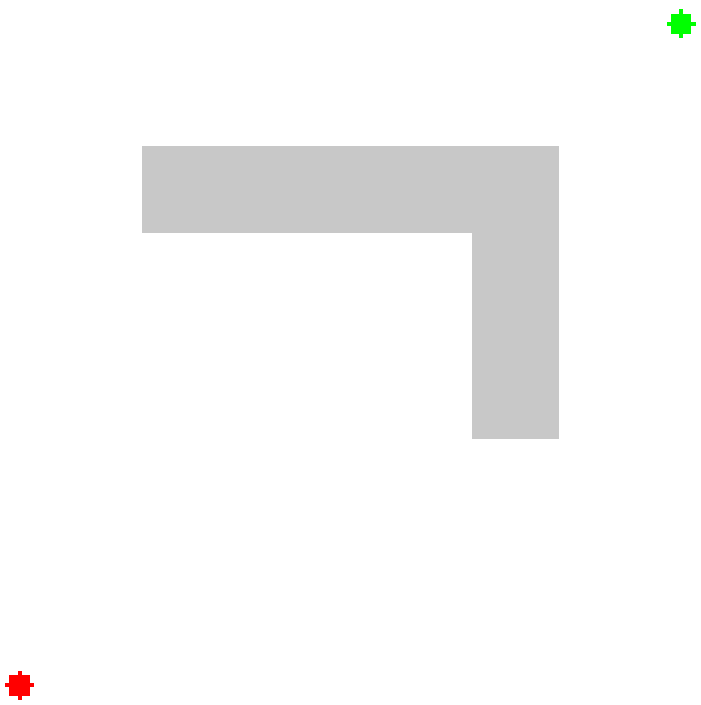
Convolve two 2-dimensional arrays.

Path Planning

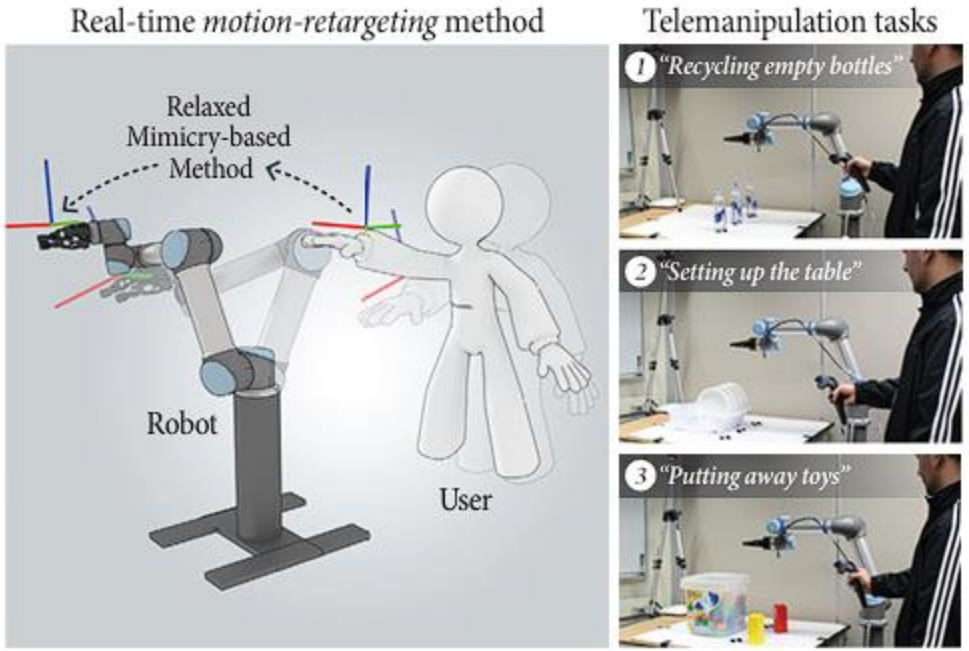
Dijkstra's



A*



Relaxed Inverse Kinematics



- Relaxed IK mode
  - Use various helper function to perform a pick and place operation at given points in the environment

https://dl.acm.org/doi/10.1145/2909824.3020254

4 modes in provided code skeleton

- Manual mode for mapping
  - Use keyboard control to drive around
  - Save generated map to map.npy
- Planner mode for path generation
  - Implement + test planning algorithm on toy map (to parallelize teamwork)
  - Create configuration space. Visualize.
  - Plan path (using A*[highly recommended] or Dijkstra's) in config space. Save planned path to .npy file.
- Autonomous mode for path following
  - Load path from .npy file. Visualize.
  - Execute using feedback control
- Pick and Place mode for moving objects around

This lab is worth 150 points!

FAQs:

- What's due at the end of today?
  - Nothing, this is a 2.5-week lab. Due Friday 04/07 at 11:59pm.
- What do I turn in?
  - ONE person needs to turn in the lab report and code per group.
- We're done! Can we leave?
  - Yep. Lab is meant to provide an interactive problem-solving time. If you complete the work early, you are free to go!

Questions?