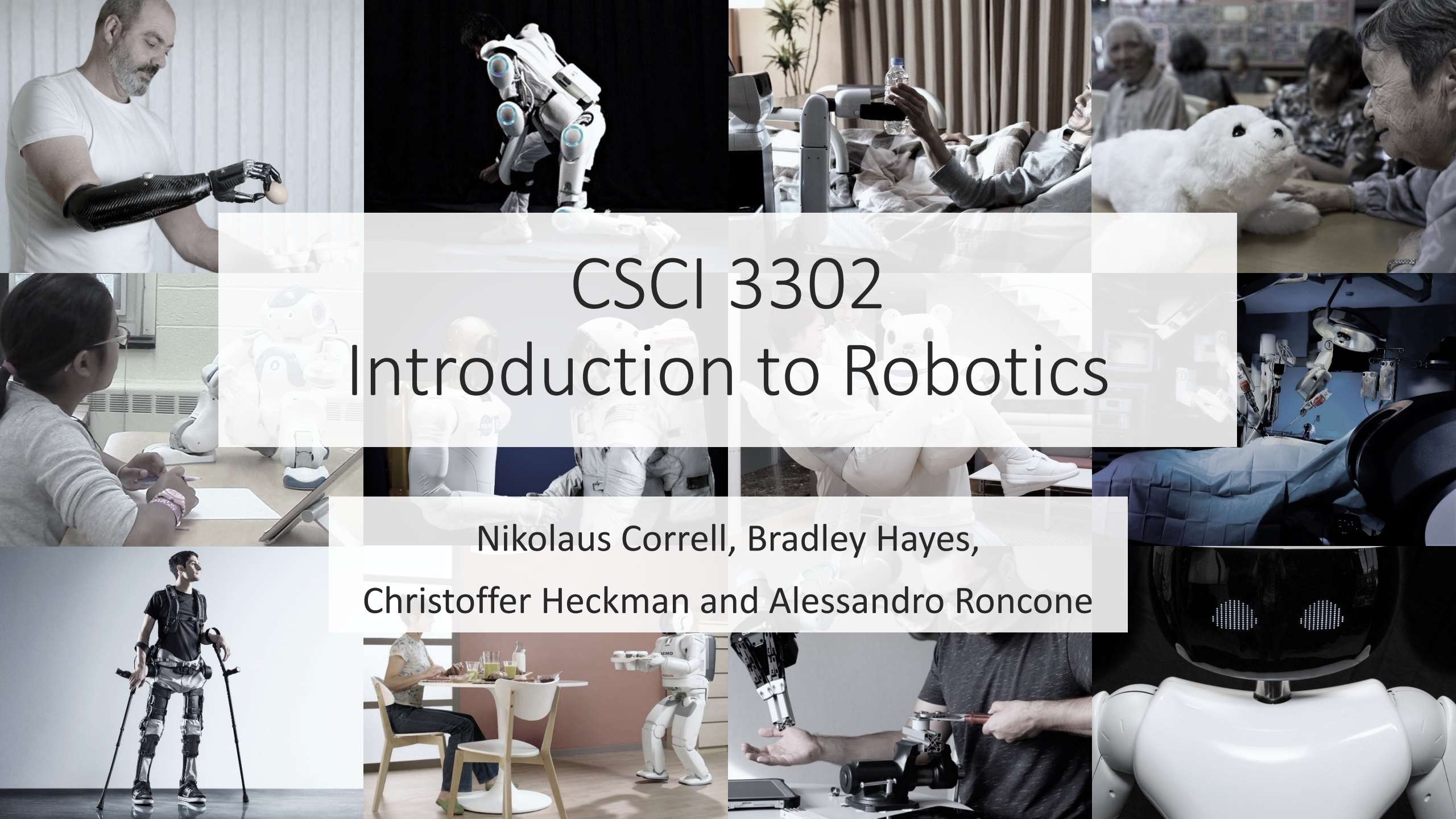

CSCI 3302
Introduction to Robotics

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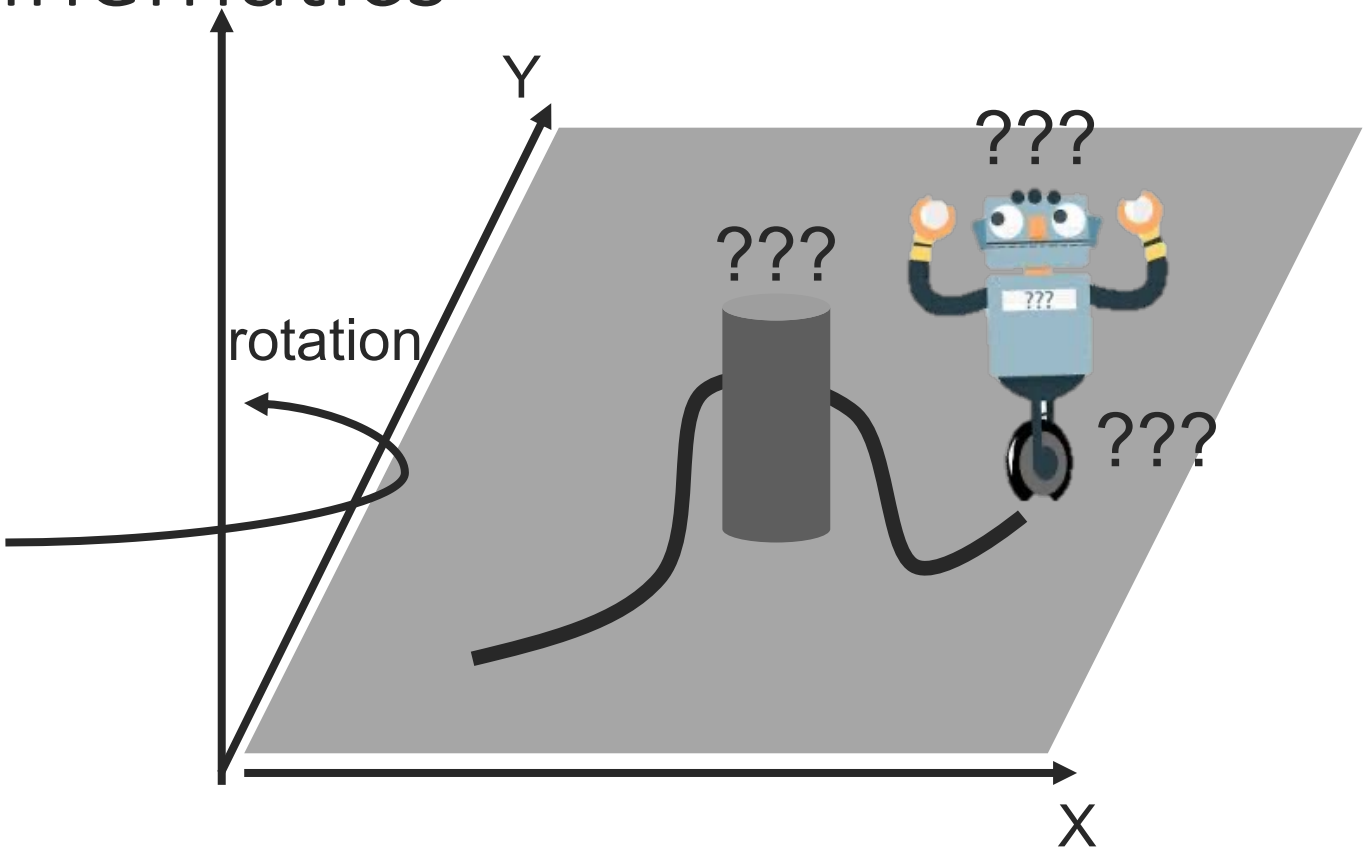
Christoffer Heckman and Alessandro Roncone

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 – 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!

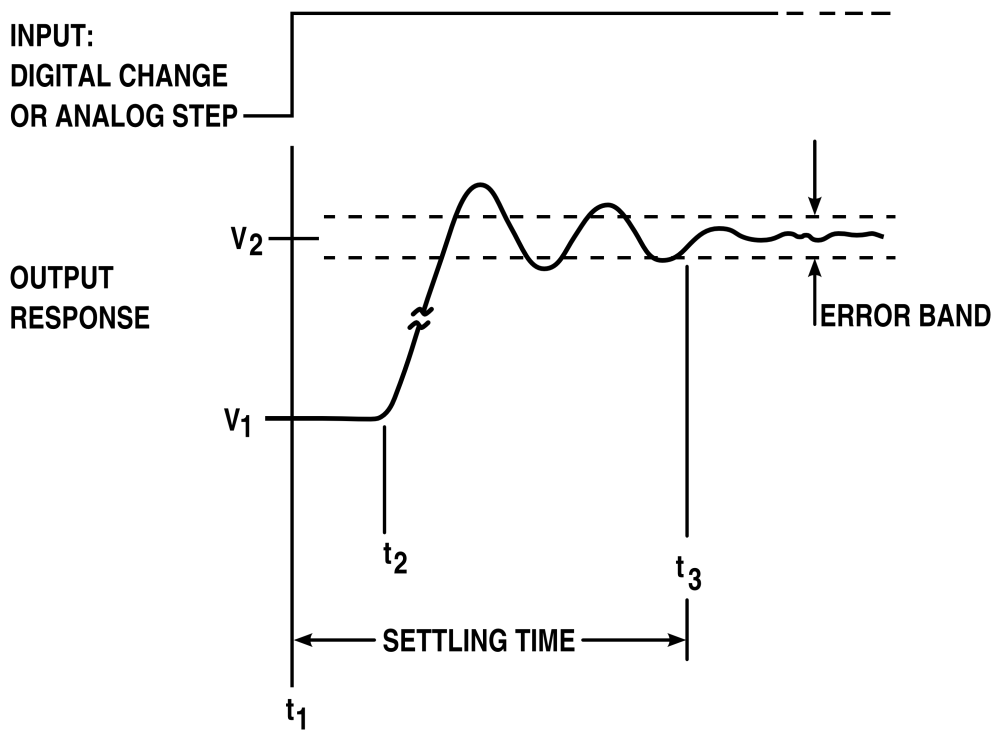
Noise. Obstacles everywhere!

- 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?

The robot might not exactly follow the points and get hung up on obstacles!

Control issues

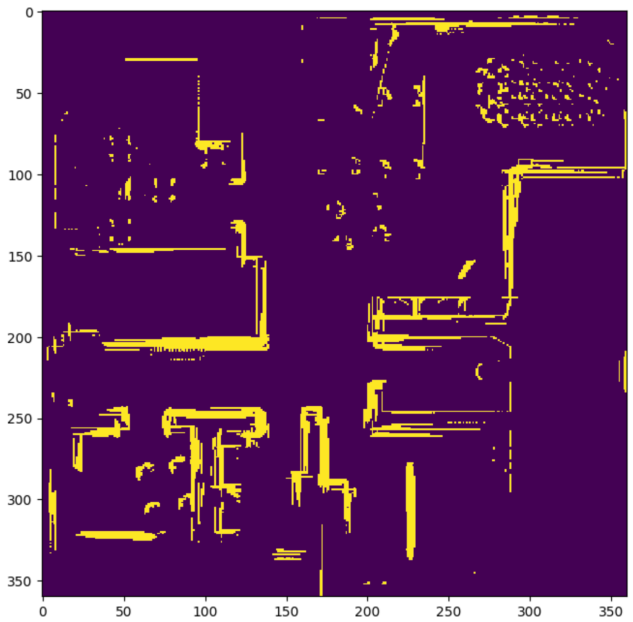


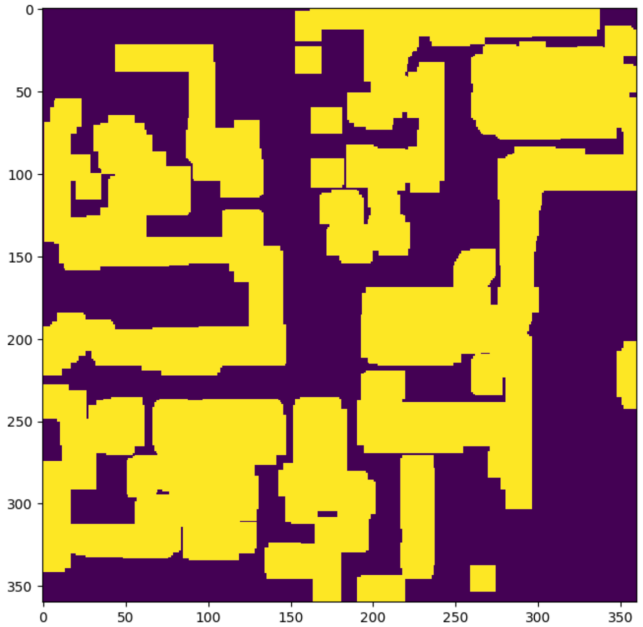
- Find the right trade-offs in your gains
- Minimize settling time
- Minimize tracking error
- *Learn to live with your controller not being perfect and stay away from obstacles*

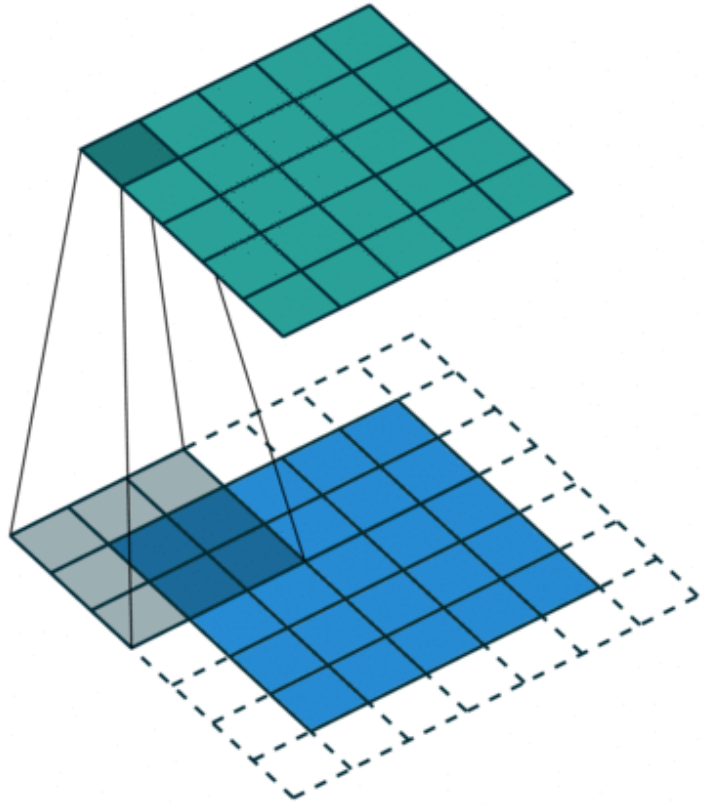
What parameter do you think will affect planning time the most?

Map resolution!

C-SPACE







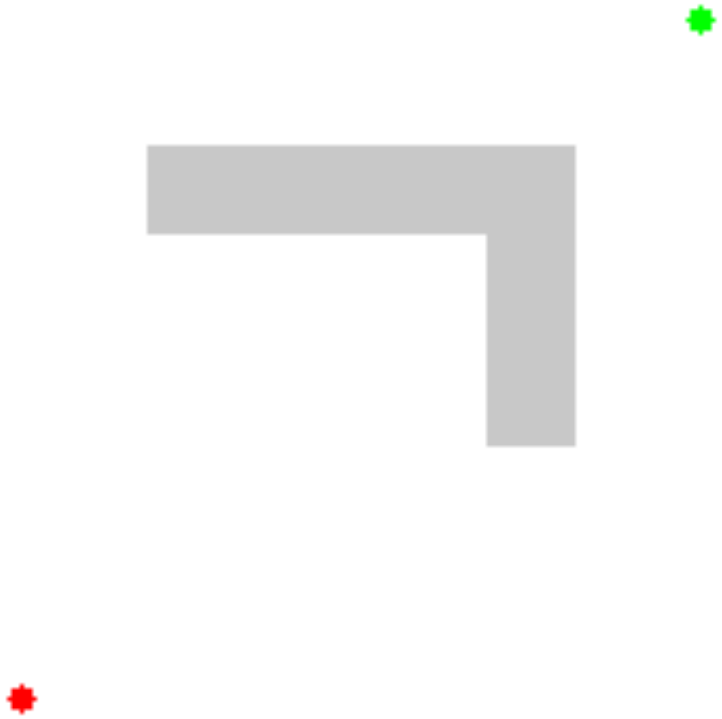
scipy.signal.convolve2d

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

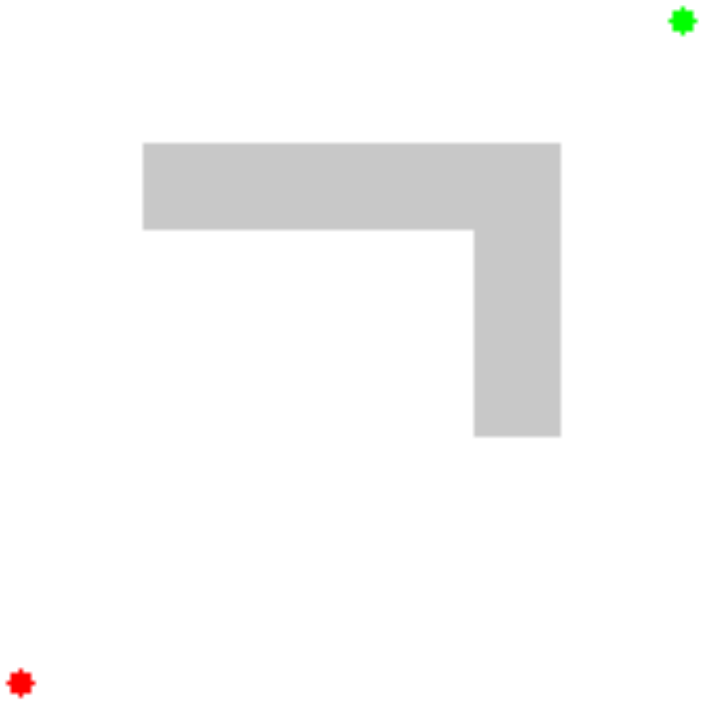
Convolve two 2-dimensional arrays.

Path Planning

Dijkstra's



A*



3 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

This lab is worth 150 points!

FAQs:

- What's due at the end of today?
  - Nothing, this is a 3-week lab.
  - 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?