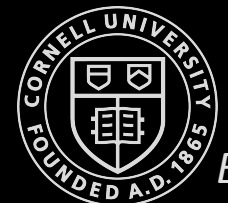
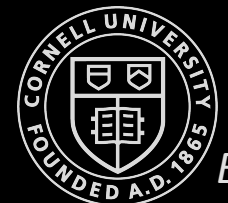


# Grid Localization using Bayes Filter



1. Boot your VM
2. Open lab8.ipynb

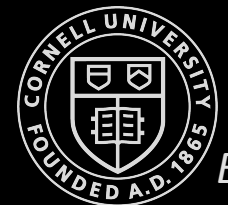
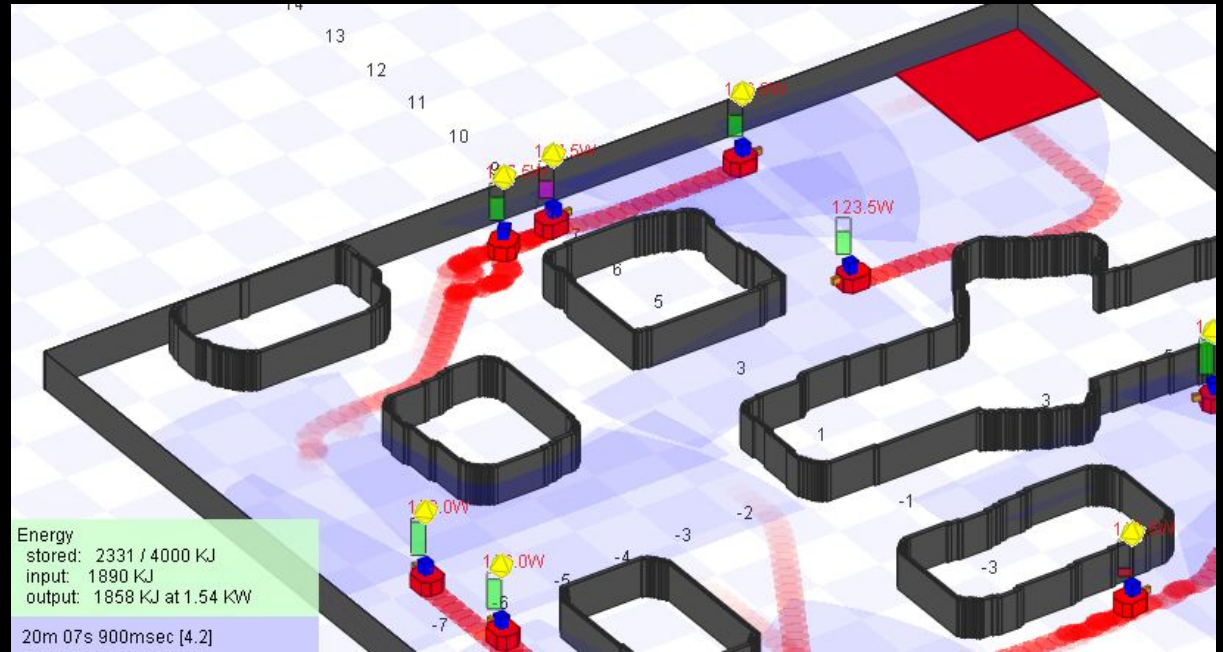


# Lecture Outline

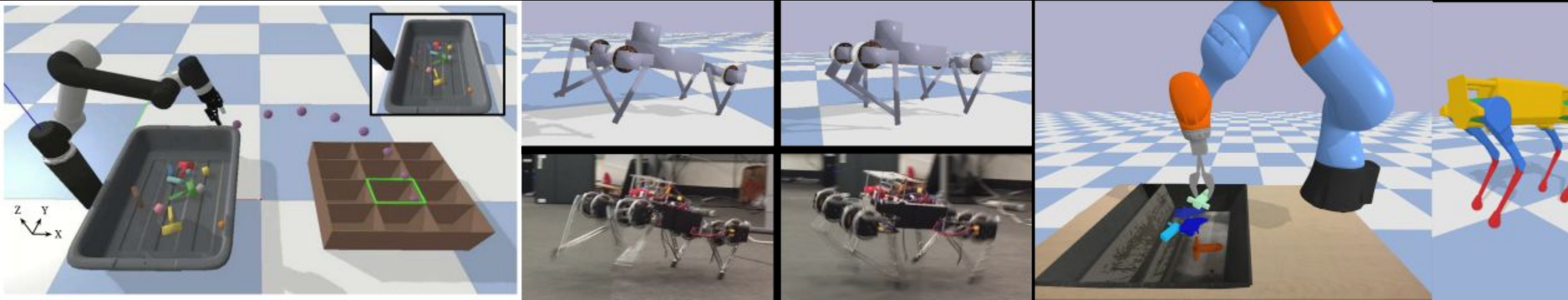
- Under the hood
  - Simulator
    - Robot Motion
    - Simulate odometry and range measurements
    - True Measurements based on the map
  - Plotter
  - Grid localization: System design
- Lab 8:
  - What to do?
  - Exercise
- Lab 9: What to expect?

# Stage Simulator

- Stage is a lightweight, 2.5D robot simulator
- Provides a virtual world populated by mobile robots and sensors, along with various objects for the robots to sense and manipulate
- In development from 1998-2011, as part of the Player Project

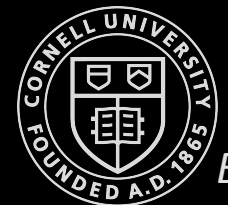


# 3D Simulators

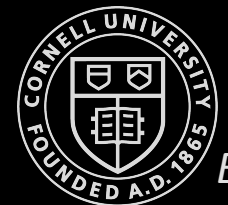
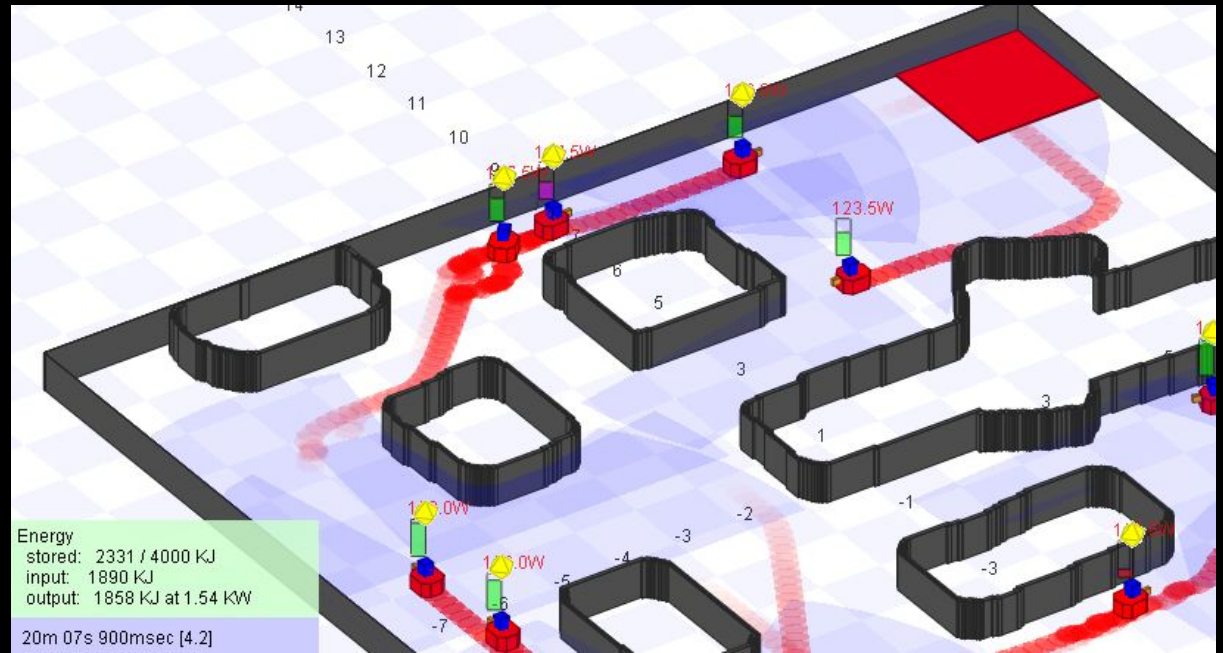


- Gazebo: <http://gazebosim.org/>
- PyBullet: <https://pybullet.org/wordpress/>
- Webots: <https://www.cyberbotics.com/>

They are all open-source projects!

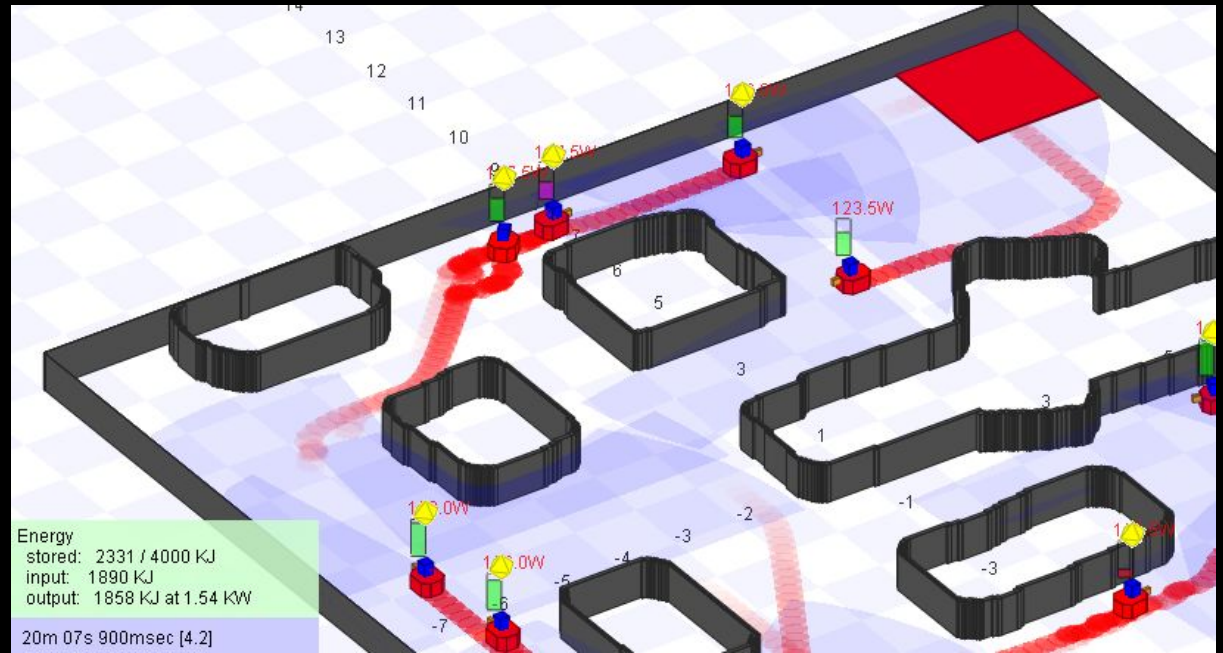


# Simulate Odometry and Observations



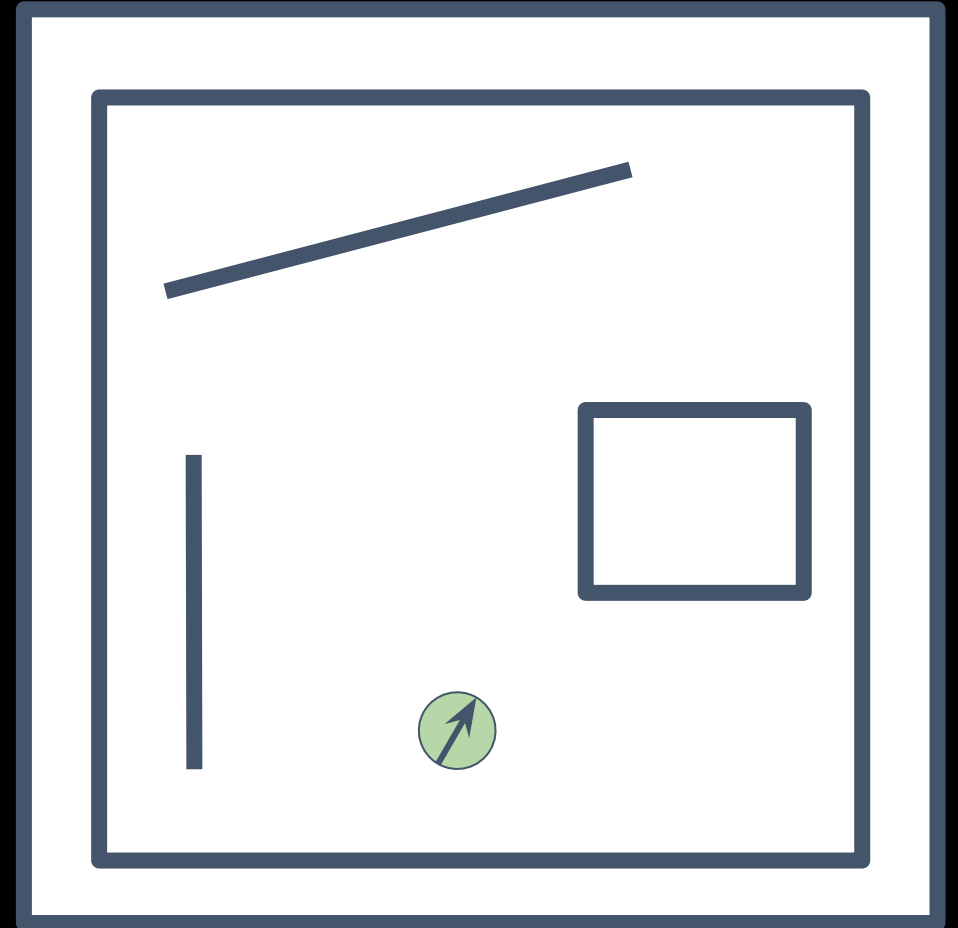
# Simulate Odometry and Observations

- Use the sample odometry motion model algorithm
- Add some IMU drift while you are at it!
- Stage simulates noisy sensor data



# Raycasting: Finding True Measurements

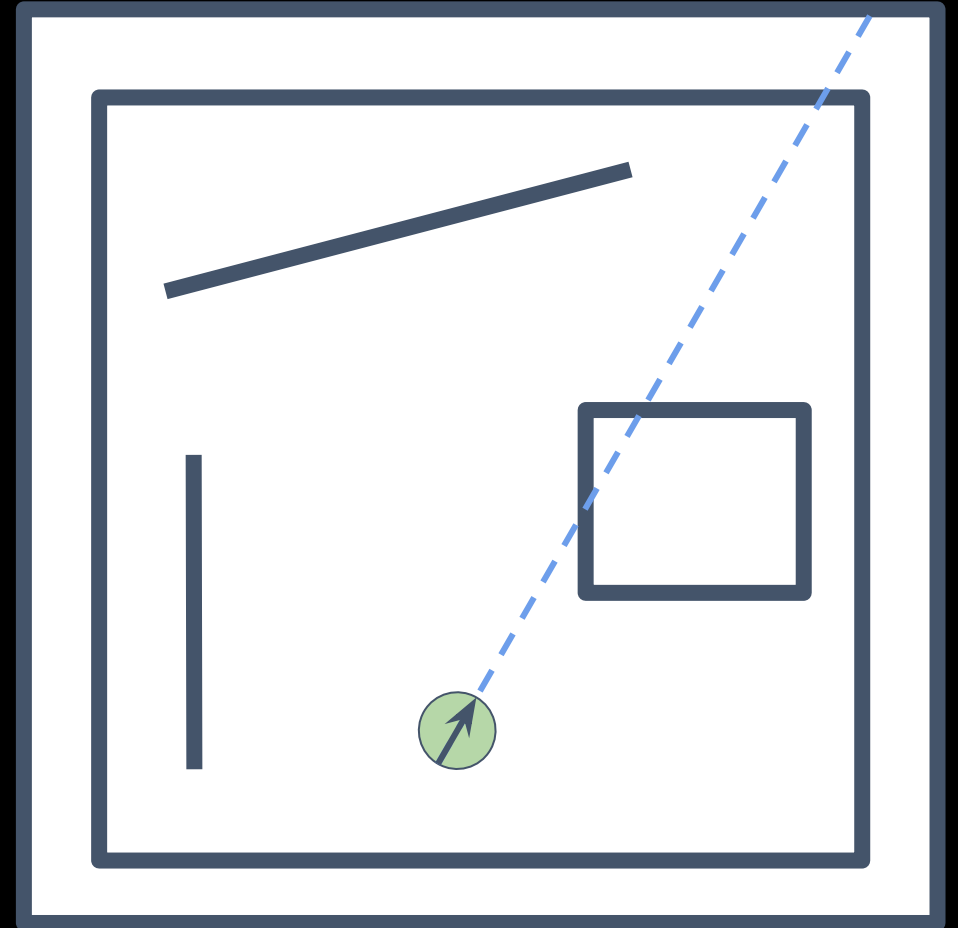
- Use the line segments to find point of intersection with a ray casted from the robot position along the direction of the robot's heading





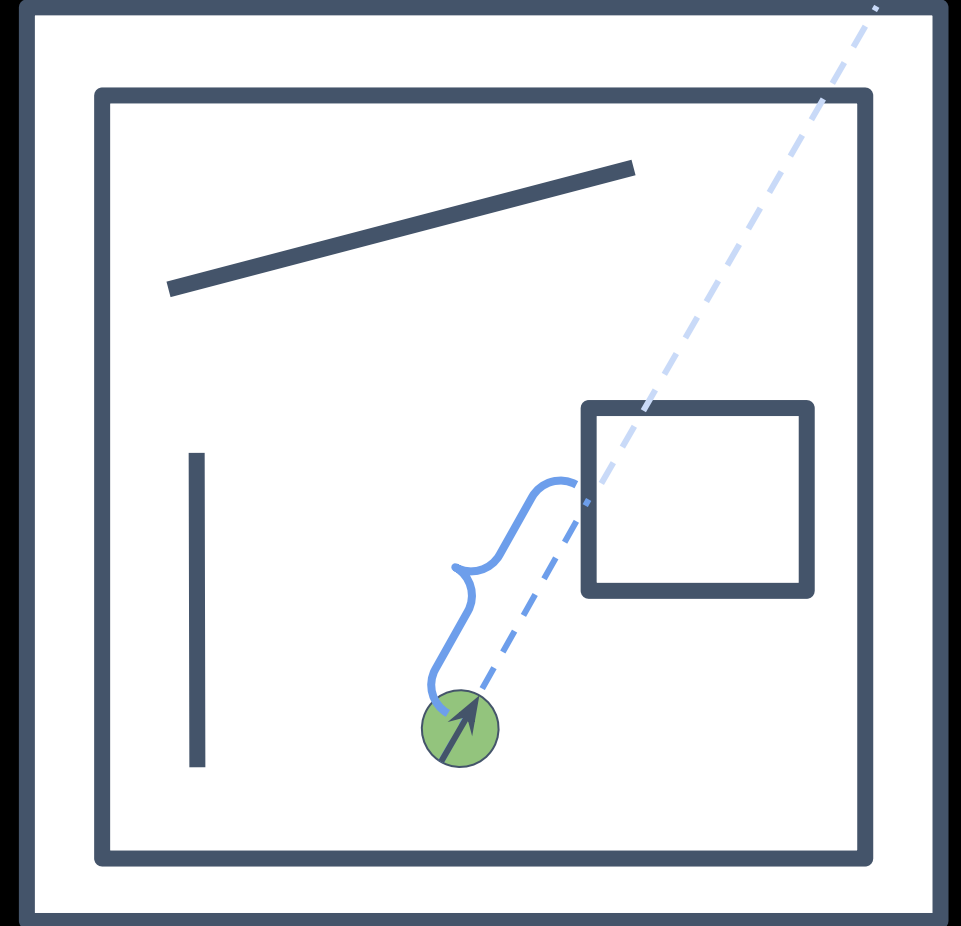
# Raycasting: Finding True Measurements

- Use the line segments to find point of intersection with a ray casted from the robot position along the direction of the robot's heading



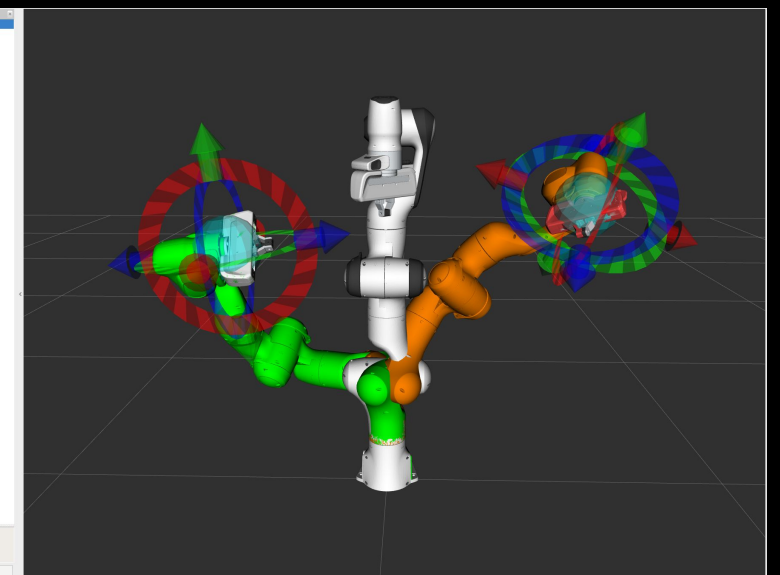
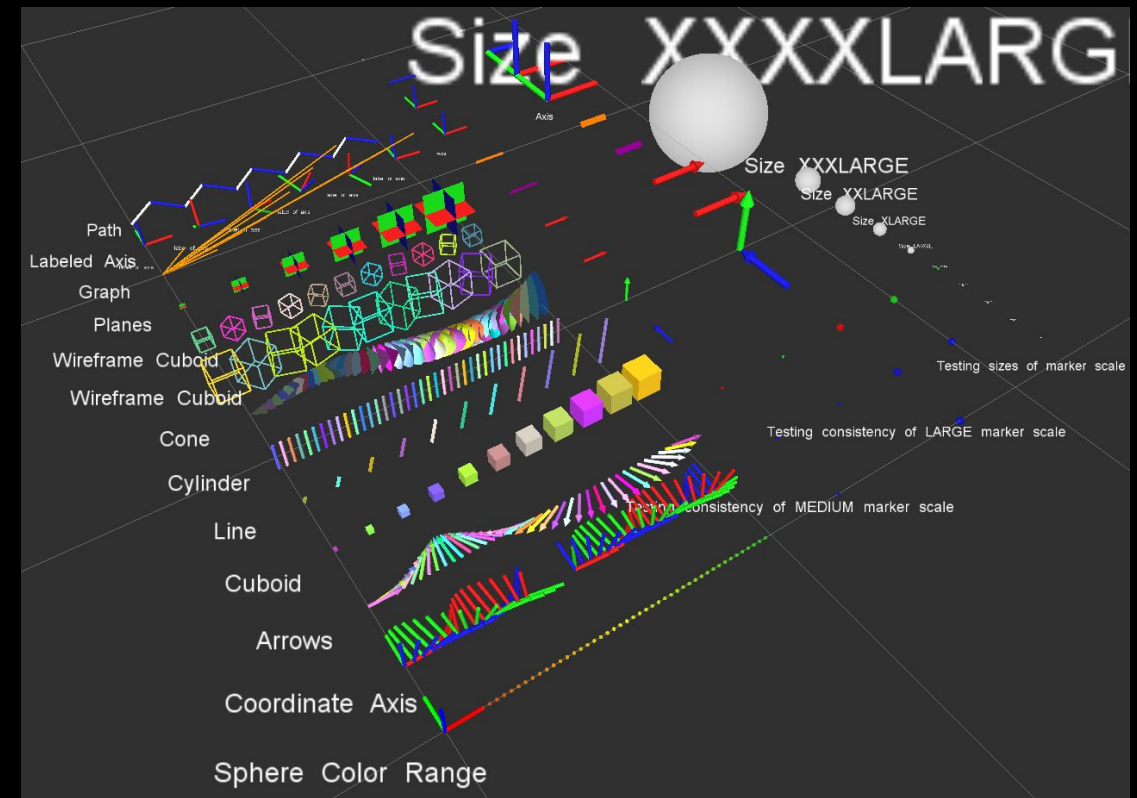
# Raycasting: Finding True Measurements

- Use the line segments to find point of intersection with a ray casted from the robot position along the direction of the robot's heading
- Each grid state has 18 individual measurements
- Compute true measurements for each grid state and store in an array (pre-caching)



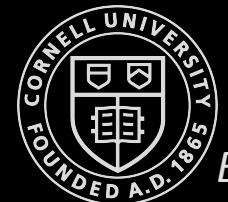
# Simulation vs. Visualization

- **Simulation** is the production of data and **visualization** is the representation of data
- Rviz is a popular 3D visualization tool used in robotics
- For our purposes,
  - Online, lightweight plotting
  - Scatter plots
  - Grid visualizations
  - Toggle
- Plotter tool built using PyQtGraph
- **PyQtGraph** is a pure-python graphics and GUI library built on PyQt4 and Numpy



# Process Communication

- The Robot Operating System (ROS) is a set of software libraries and tools that help you build robot applications.
- From drivers to state-of-the-art algorithms, and with powerful developer tools, ROS has what you need for your next robotics project.
- **And it's all open source.**
- Stage player has a ros wrapper!
- Make ROS wrappers for the plotter tool and Grid Localization code
- Be sneaky and hide all the “ugly” ROS code
  - Bash scripts and Aliases
  - Python scripts



# Grid Localization

Design Model

# Grid Localization

Lab 8

Make sure to read the documentation, Implementation tips and feedback

# In-Class Exercise

# Grid Localization

A working implementation





# Lab 9

- Perform grid localization on the real robot!
  - Offload Bayes Filter to your computer
  - Robot sends data from on-board sensors
  - Grid Localization based on the Map from Lab 7
- We will provide you with an efficient Bayes Filter implementation
- Replace the *VirtualRobot* class with the *RealRobot* class
  - Control the robot
  - Get odometry data
  - Get observation data

