Intro to Robotics

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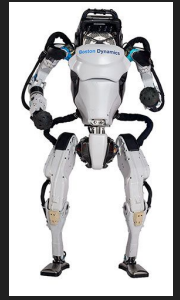
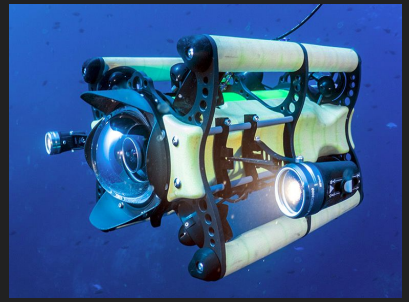
Examples of Robots

Mobile Robots

Aerial Robots



Walking Robots

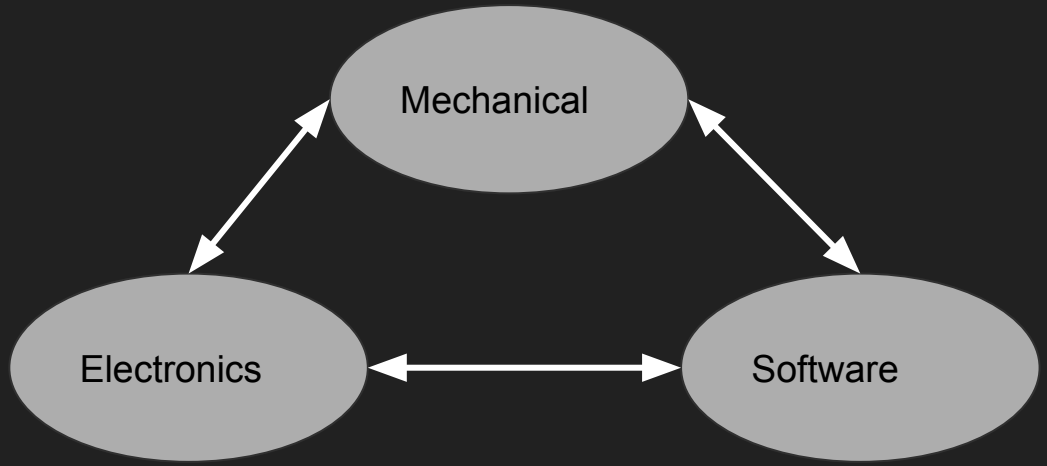


Underwater Robots

Industrial Robots

Big Picture

- Interdisciplinary Field
  - Mechanical Engineering
  - Electrical Engineering
  - Software Engineering



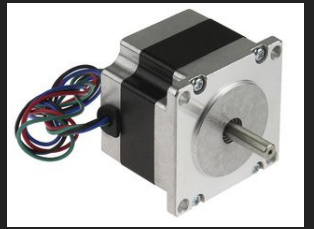
- Overarching Concepts
  - Perception: How do I see and interpret the environment?
  - Localization: Where am I in the world?
  - Motion Planning: What is my next goal?
  - Controls: How do I get to my next goal?

Mechanical

Mechanical Components: Motors

Broad Overview: Motors convert other forms of energy into mechanical energy

- Different types of electric motors
  - Direct Current (DC) motors
    - Great for continuous rotation and high speed applications
    - Brushless vs Brushed Motors
  - Stepper Motors
    - Great for low speed and high position control applications
  - Servo Motors
    - Great for high speed and high torque applications
    - Limited angle of rotation



Want to learn more? [Motor Selection Workshop]

Electrical

Electrical Components: Sensors

Broad Overview: Sensors give us information about the surrounding environment

- LiDAR (Line Detection and Ranging)
  - Emitting a laser light and measuring the reflections
- Radar
  - Emits radio waves to measure distance
- GNSS (Global Navigation Satellite System)/GPS (Global Positioning System)
  - Uses satellites to provide global positioning
- IMU (Inertial measurement Unit)
  - Measures acceleration and rotation
- Cameras
  - Return pictures and videos of surrounding environment

Software

Perception

Broad Overview: how the robot perceives and interprets the environment

- Interpret data from a large variety of sensors
  - Cameras, Lidar (Line Detection and Ranging), Radar, and more
- Utilize computer vision algorithms to interpret data
  - Object Detection, Recognition, and Classification
    - Lanes, Cars, etc

Want to learn more? CS 1674 (Intro to Computer Vision)

Computer Vision Example: Vehicle & Lane Detection

Source

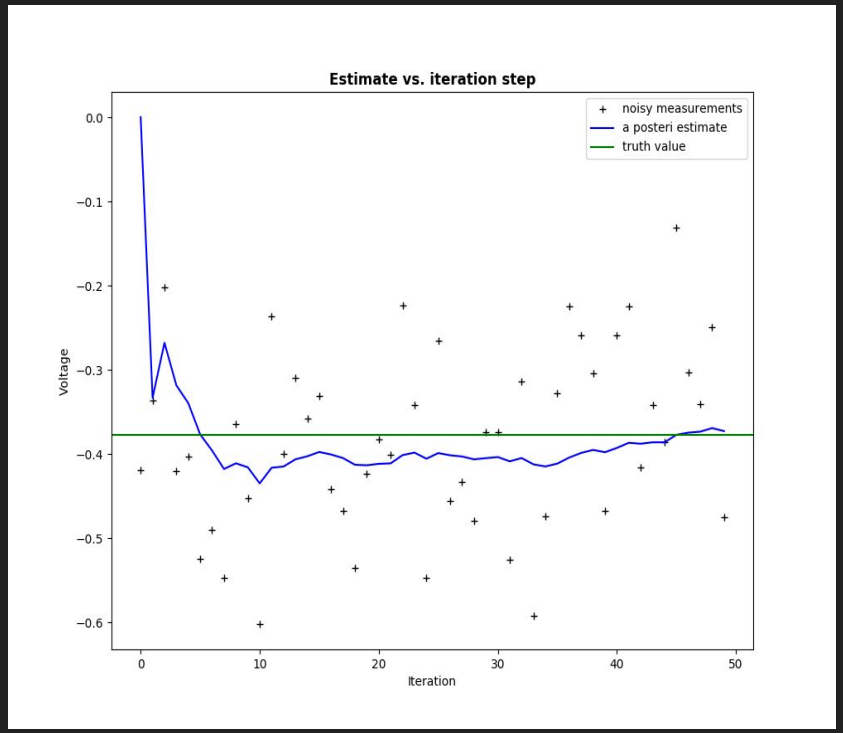
Localization

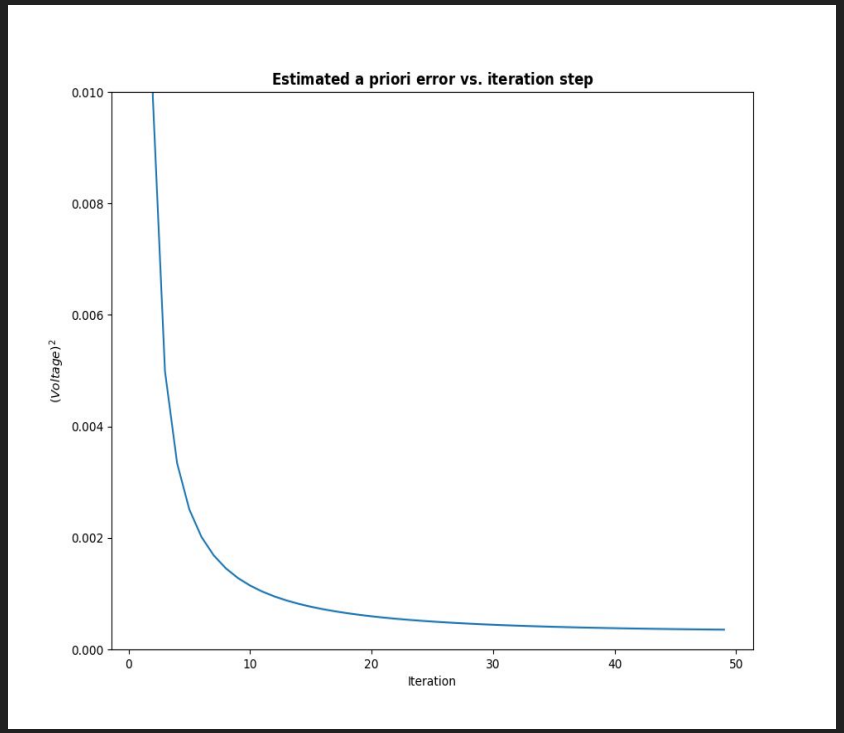
Broad Overview: How the robot infers where it is in the “world”

- Utilize sensor data to form a belief of where the robot may be in the world
- Accomplished through the use of a **Kalman Filter** (and it’s variants)
  - Estimates the robot’s state (position, velocity, etc) over time given a set of measurements
  - Acts similar to a low pass filter on basic level (filters out noise)
  - Prediction and Measurement Phase
    - Predict state → Correct state using measurement
- Utilize multiple sensors to increase precision of measurement

Want to learn more? Intro to Kalman Filters

Kalman Filter Example: Voltage





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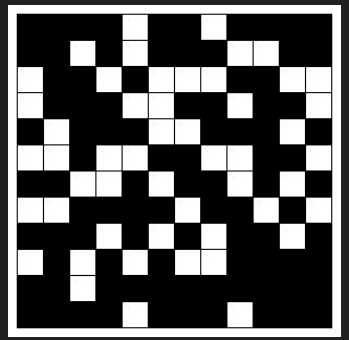
Motion Planning

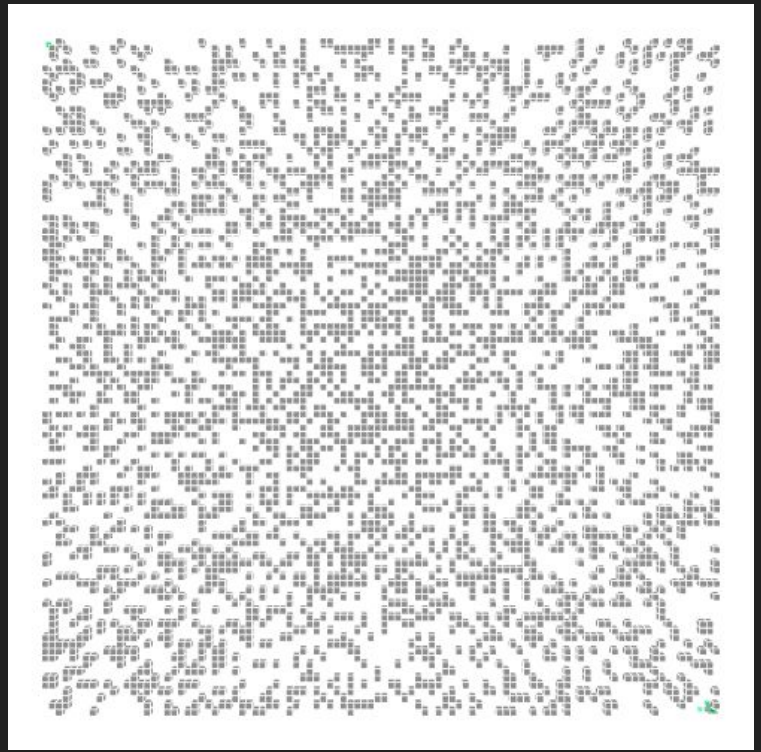
Broad Overview: How a robot reaches its goal in a fast, and efficient manner

- Use different path planning algorithms to plan movement and avoid collisions
  - Simplest representation is a grid
  - Navigate in “free” space
  - Two common performance metrics: path length and time to solution
    - Find shortest path to goal in fastest time
  - A*, D*, Rapidly-Exploring Random Tree (RRT)



Want to learn more? CMU 16-350 (Planning Techniques for Robotics)

Motion Planning Example: A* Algorithm



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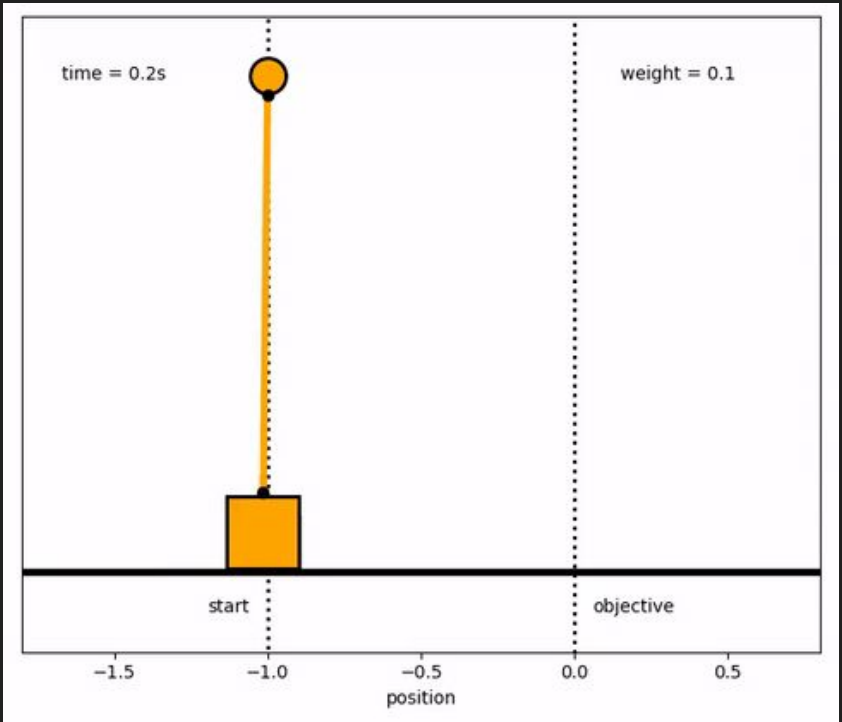
Controls

Broad Overview: Signals sent to the robot to perform an action

- Use mathematical models, vehicle state, and goal point to determine optimal output for desired action
  - Simplest model is an inverted pendulum
  - PID, LQR, iLQR, MPC

Want to learn more? ECE 1570 (Robot Controls)

Controls Example: Inverted Pendulum



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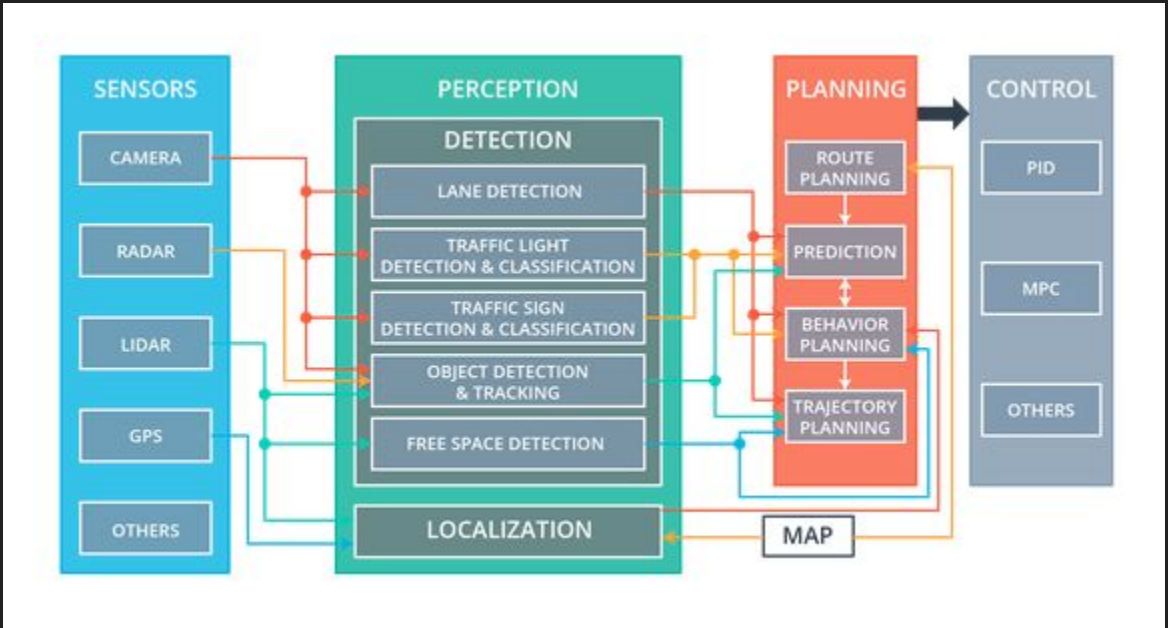
Putting it All Together



Further Resources

- Arduino
  - Arduino Tutorials
- Robot Operating System (ROS)
  - ROS Workshop
- Other Helpful Resources
  - Robot Academy

Questions?