Robotics: Science and Systems
CS 4610/5335

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Times: T/F, 3:25—5:05
130 Hurtig Hall
Course web page:
http://www.ccs.neu.edu/home/rplatt/cs5335_spring2017/index.html
Office Hours: Fridays, 11-12, 526 ISEC, or by Appt
TA: None!

Robots of today

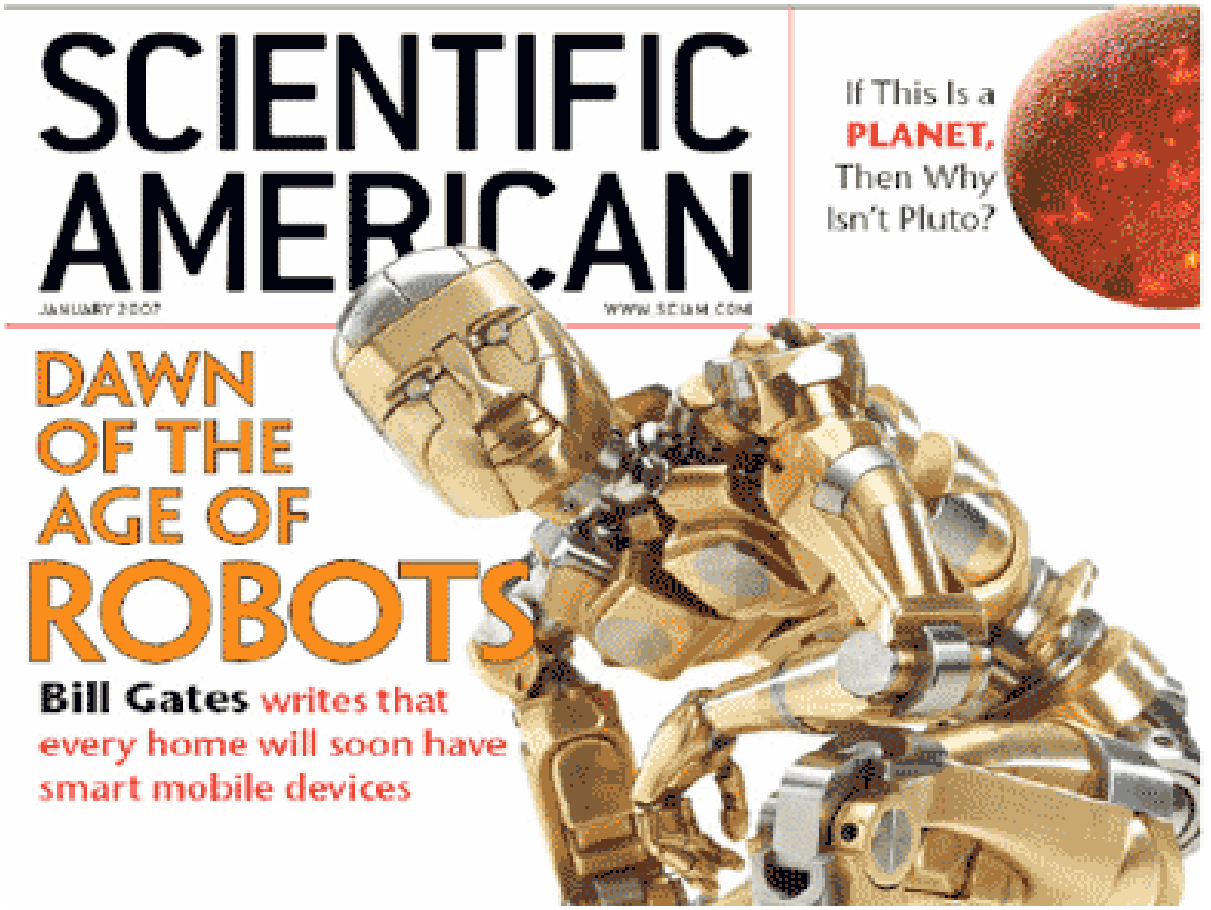
Consumer robots

Military drones

Drones for surveying

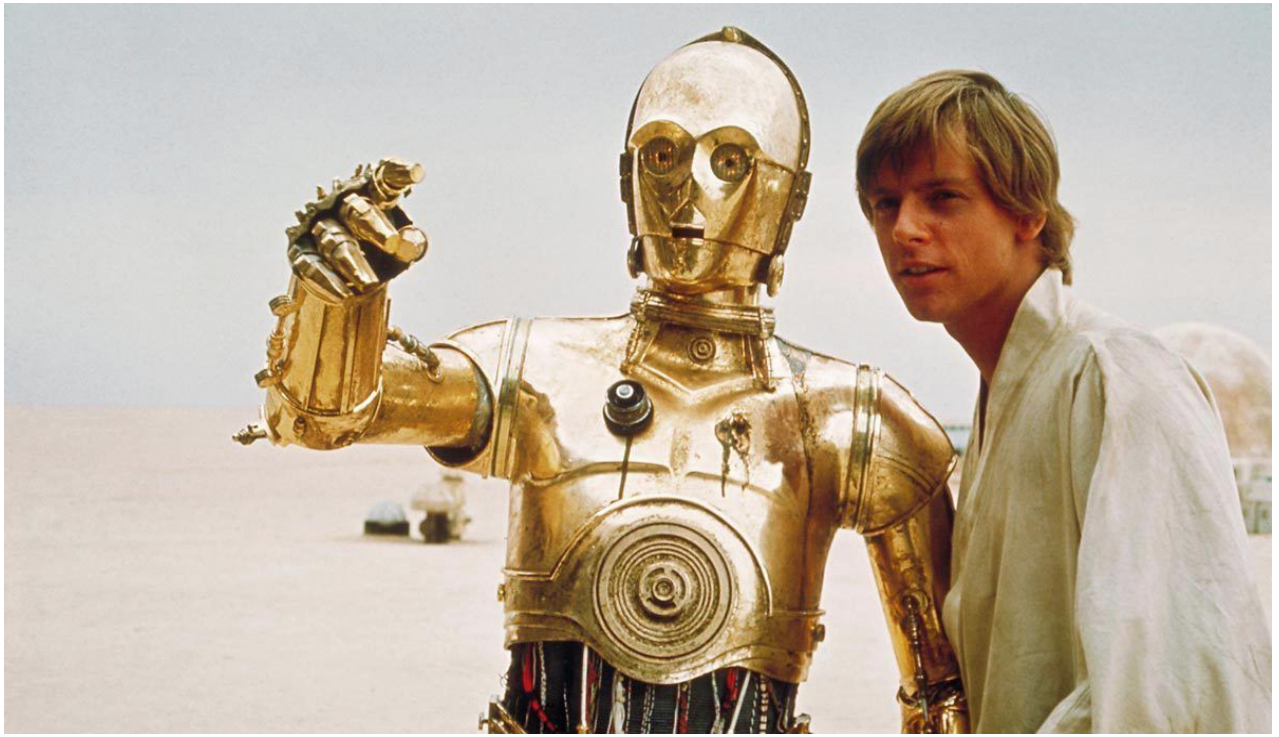
Warehousing

Is Robotics the Next PC Revolution?



"We may be on the verge of a new era, when the PC will get up off the desktop and allow us to see, hear, touch and manipulate objects in places where we are not physically present." … Bill Gates

Robots of tomorrow?



What does our future look like?

Around the corner?

Cheap Hardware

Sensors

Perception

Navigation

Autonomous vehicles

Manipulation

– enabled by improvements in sensors/perception
– direct impact on taxis, trucking
– could change the way cars are used
– legal hurdles
– safety is a big deal
– cyber-security, reliability will be HUGE

Around the corner?

Cheap Hardware

Drones

Sensors

Perception

Navigation

Manipulation

– battery life could kill this one. Okay for some applications, not okay for others.
– enabled by improvements in sensors/perception/control
– legal hurdles, but not as big as w/ cars
– applications: surveying; package handling, ...

Around the corner?

Assistance for elderly; people w/ disabilities

Cheap Hardware

Sensors

Perception

Navigation

Manipulation

– enabled by better perception, manipulation, navigation
– could enable people to retain their independence for longer
– could have a huge impact on where the elderly live
– not clear how good the technology needs to be in order to be valuable
– safety might not be as important as in cars
– some devices require FDA approval

Around the corner?

Cheap Hardware

Sensors

Perception

Navigation

Manipulation

Manufacturing,
Packaging

– kitting applications, assembly
– this continues an existing trend toward complete factory automation
– makes goods cheaper
– eliminates factory assembly/packaging jobs
– creates a smaller number of machine-repair jobs

Around the corner?

Cheap Hardware

Sensors

Perception

Navigation

Manipulation

Domestic assistance

– chores: dishes, laundry, macro-cleanup
– not clear how good the technology needs to be in order to be valuable
– no legal hurdles
– very technically challenging
– this will have a major impact outside of domestic scenarios – can envision this kind of robot being used as an assistant in all kinds of commercial applications

Around the corner?

Cheap Hardware

Sensors

Perception

Navigation

Manipulation

Worker vehicles

– self loading/unloading trucks
– autonomous garbage trucks
– probably far off – but certain applications could happen soon.

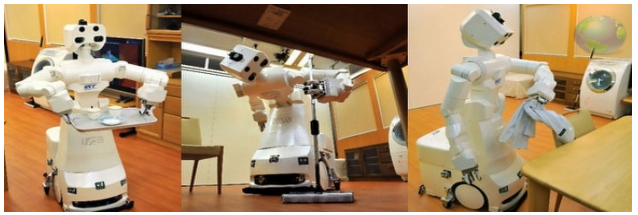
How soon is now?

0 yrs?, 2 yrs?, 5 yrs?, longer?

Surveying applications: now
Package handling: could be a while (batteries)

First deployments in 3-5 yrs.
Depends on cheap hardware; “smarts” are almost there

<3yrs; continued improvements after that



Some applications much sooner than others
Some as soon as 3-5 years

?

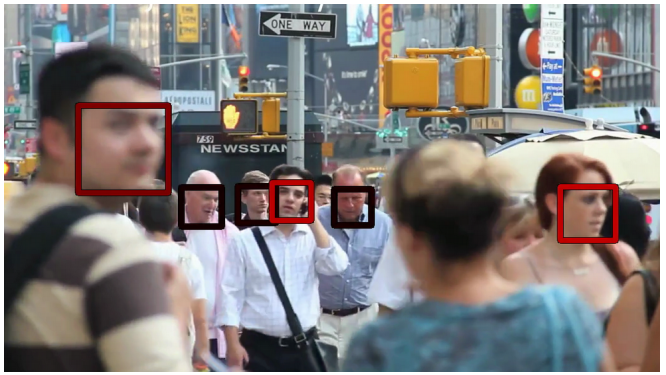
There's a lot I haven't thought of. Think about the common themes in the above.

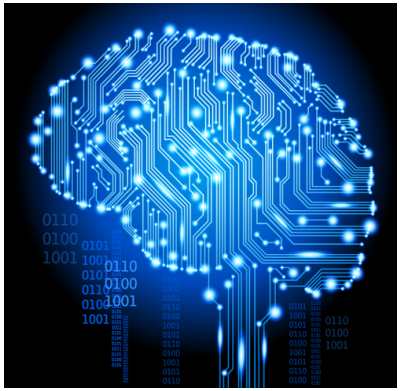
Enabling capabilities

In reality, it's the underlying capabilities that determine what tomorrow's robots will look like.

Enabling capabilities

Cheap Hardware





Perception

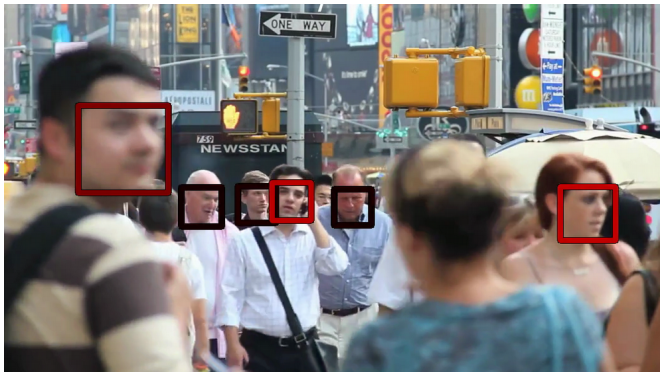
Kinematics, planning, control

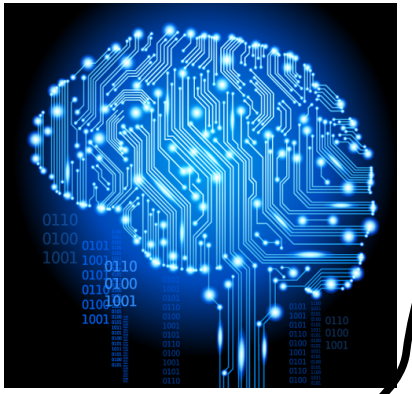
State estimation

Sensors

Focus of this course

Cheap Hardware





Perception

Kinematics, planning, control

State estimation

Sensors

Course Objectives

To understand fundamental algorithms in:

1. kinematics: transforms, forward kinematics, inverse kinematics, differential kinematics

2. planning: c-space, PRM, RRT,

3. perception: point clouds, deep learning

4. state estimation: particle filtering, kalman filtering

5. linear optimal control: LQR (if there's time)

Course Objectives

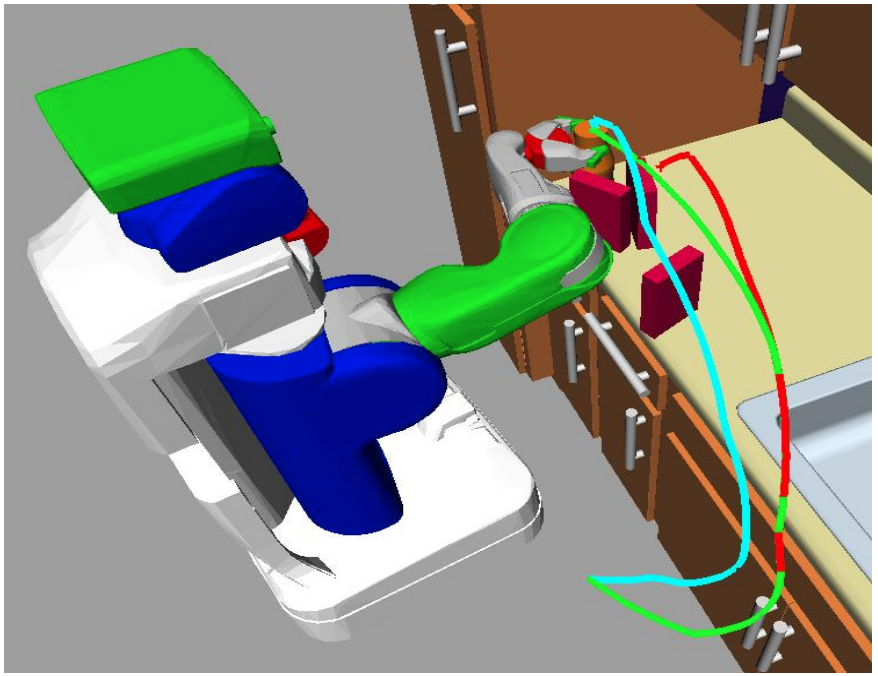
Also:

To introduce you to contemporary research areas and topics (max 2 lectures).

Kinematics

– How do we represent position/orientation targets for the hand?
– How should the robot joints move in order to place the hand in a specific location?
– How do we achieve specific desired hand trajectories?

Planning and Control

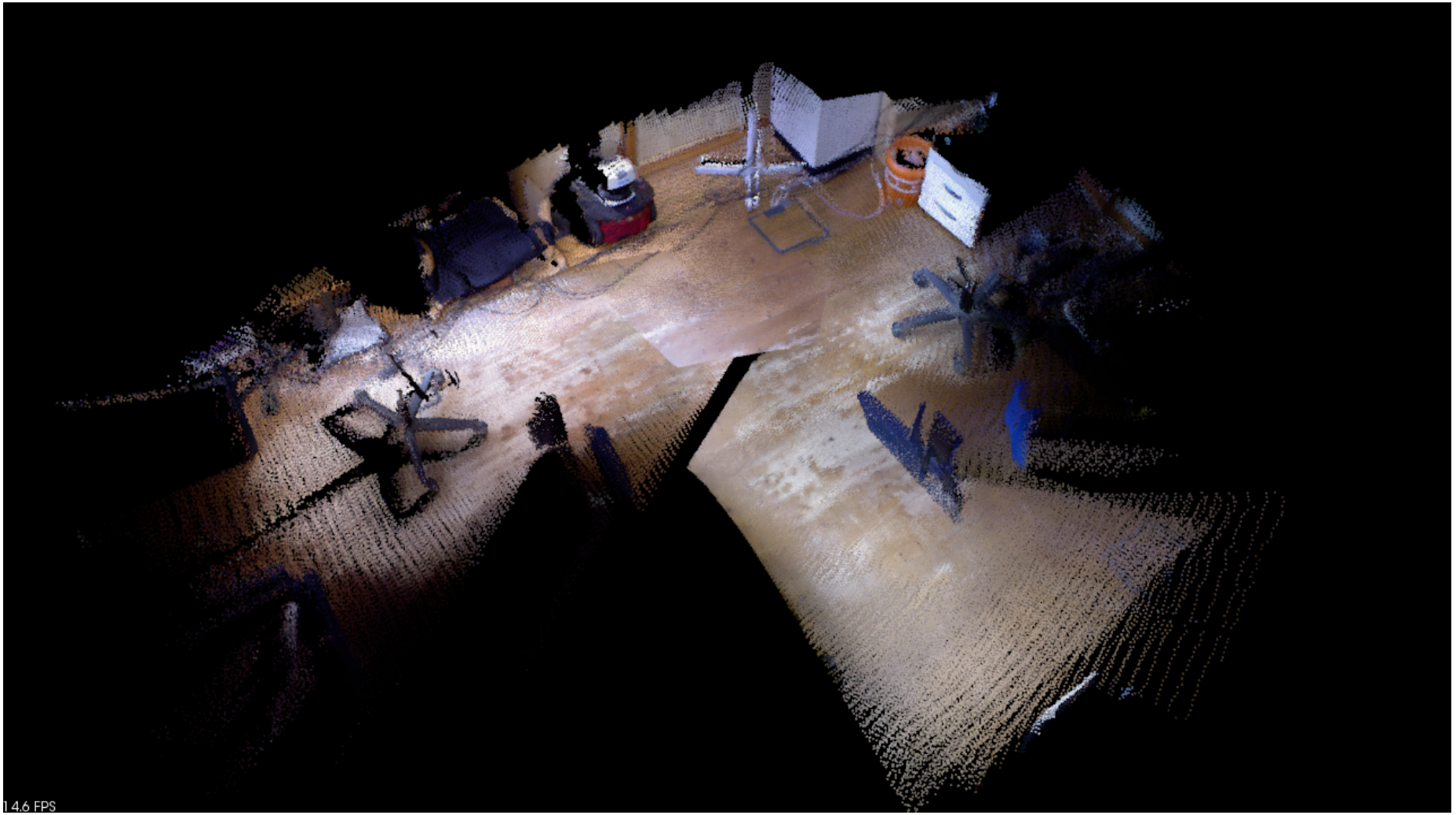


– How should the robot arm move in order to avoid collisions?

– How does this guy remain standing upright?

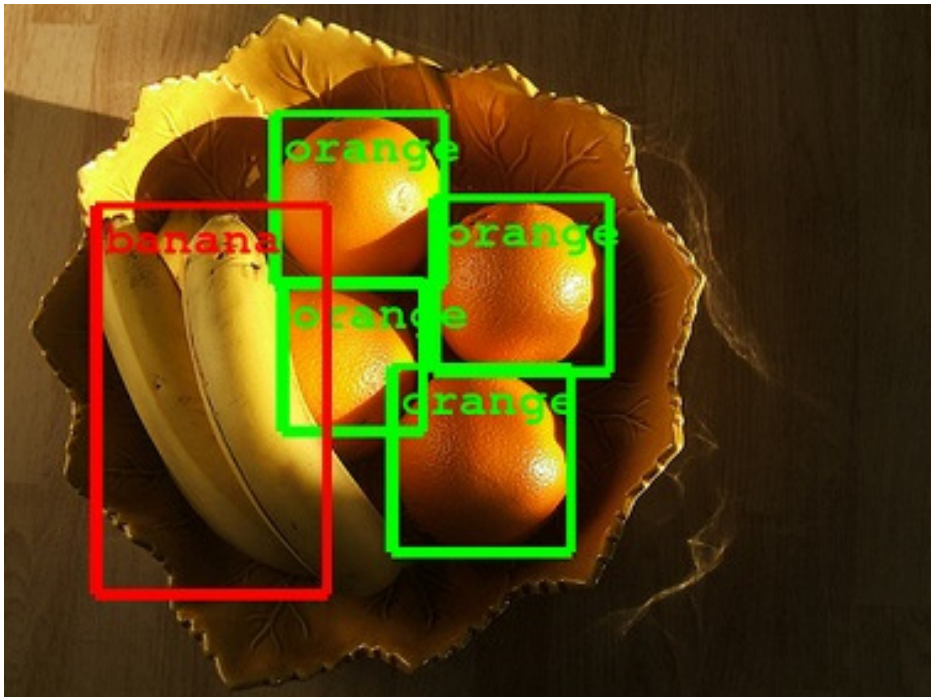
– How does this plane fly?

State estimation

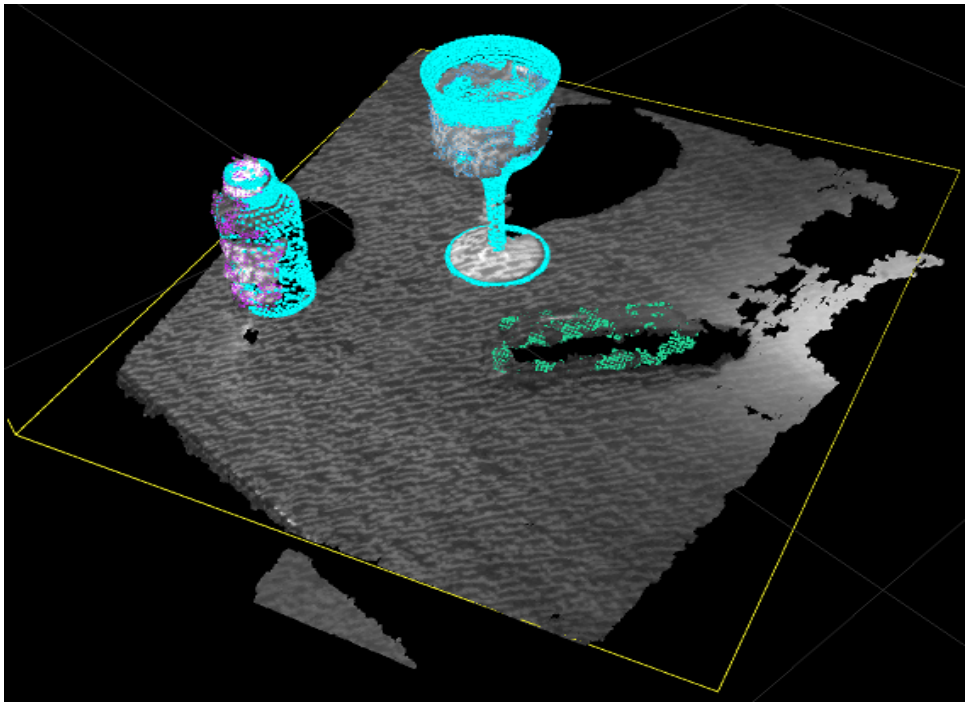


– How can a robot localize itself, given a map?
– How can a robot create a (metric) model of the environment as it moves?

Perception



– Object category detection (RGB)



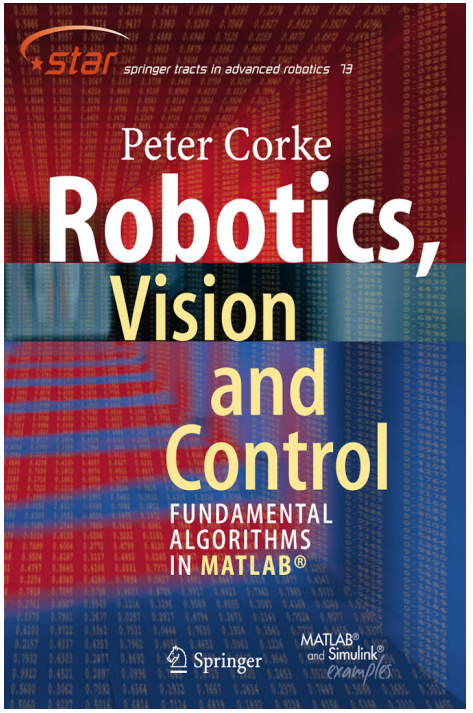
– Object pose estimation (pt cloud)

Course Prerequisites

1. Ability to program in Matlab and Python (or the ability to learn to do this)

2. Comfortable with linear algebra and math in general.

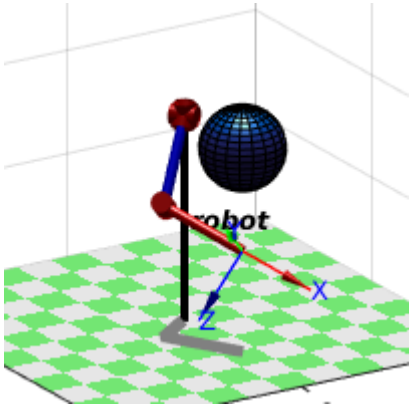
Reading material



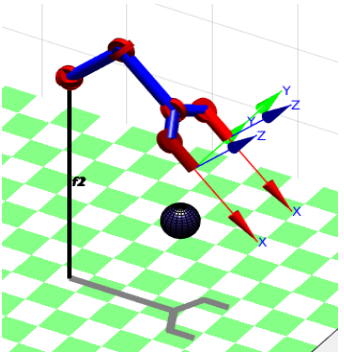
Primary text: Robotics, vision, and control by Peter Corke

Additional text materials will be posted on schedule tab of course webpage.

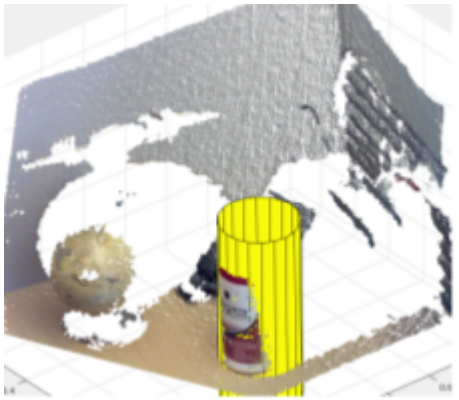
Four MATLAB Assignments



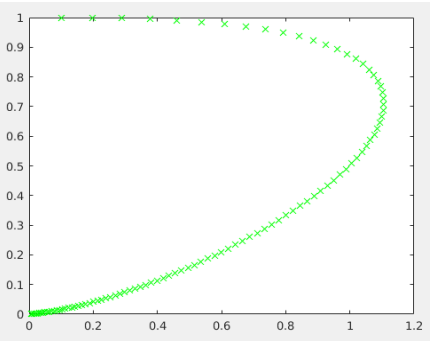
Manipulator planning



Kinematics, Z-O control



Perception



Linear Optimal Control

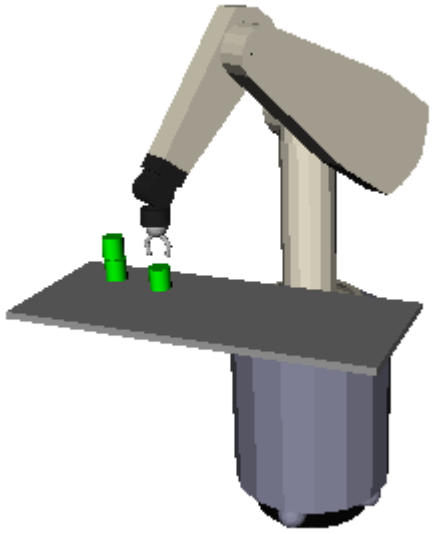
Four MATLAB Assignments

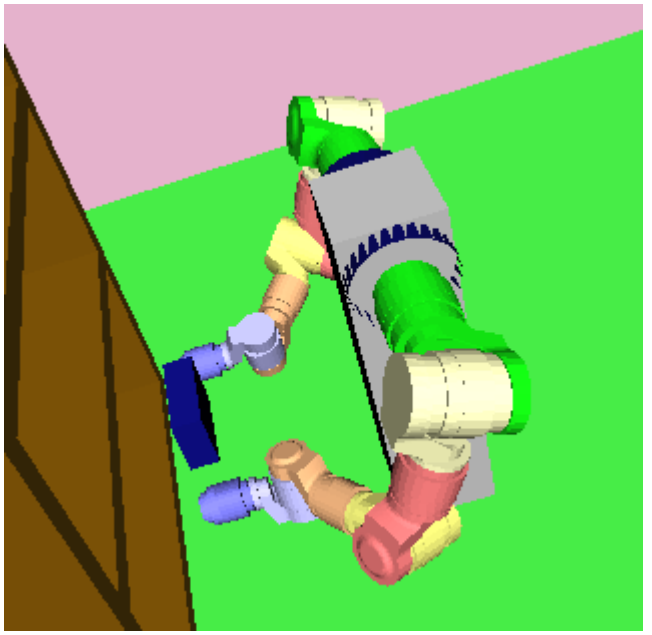
What you need to complete these assignments:

1. MATLAB installed somewhere

2. ability to program in MATLAB
– you can learn on-the-fly if you don't have MATLAB experience
– but, you do need some sort of programming background

Directed Project in OpenRave





1. Manipulation: pick up a box with one or two hands
   – no perception – you know exactly where the box is

2. Perception + Manipulation: locate box with depth sensors and pick it up.

Directed Project in OpenRave

What you need to complete these assignments:

1. OpenRAVE, python 2.7.X installed somewhere
– Ubuntu 14.04 or later installation is preferred, but windows and macos is also possible

2. ability to program in python
– basic python ability will suffice
– but some prior programming experience is needed