CS123

Programming Your Personal Robot

Part 3: Reasoning Under Uncertainty

Topics For Part 3

3.1 The Robot Programming Problem

- What is “robot programming”
- Challenges
- Real World vs. “Virtual” World
  - Mapping and visualizing Hamster’s world
- A decomposition of the “mobile robot programming” problem

3.2 “Modeling” Hamster

- Hamster’s Motion
- Hamster’s Sensors

3.3 Where am I (Localization)

3.4 Plan and Plan Execution

- Planning Under Uncertainty

Class Structure

- Class 1: Basic Concept of Robot Programming
  - Robot Modeling (motion / sensors)
  - Home Work Assignment #3-1 Given Out
- Class 2: Localization (and Sub-goal navigation)
- Class 3: Plan and Plan Execution
  - Home Work Assignment #3-2 Given Out
- Class 4: Discussion of Related Topics / Demo / Race / Lab
  - Motion Planning with Uncertainty
  - Other topics of interest (if time allows)

Objectives

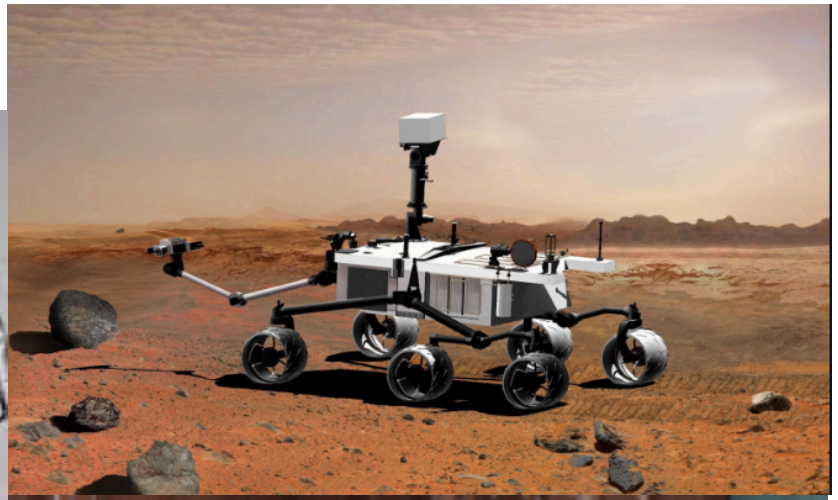
- Expose to the challenges of robot programming
  - Gain a better understanding of the difficulty of programming in the real (physical) world
  - Appreciate the challenges of programming in the real worlds
- Learn basic concepts and techniques
  - Modeling the robot
  - Mapping between the Real (physical) world and Virtual world
  - Localization & Plan Execution
- “Opened” problems
  - No 100% guaranteed solution
  - You can always do better
- “Not well defined” problems
  - Further constraining and decompose the problem

3.1 The Challenge of Robot Programming

Topics

- What is robot programming
- Mobile robot programming
- Physical world vs. virtual world
  - Modeling of Hamster: physical vs. virtual world
  - What does the robot see
  - How to make sense of what the robot see
- Graphic toolkit to help you visualize Hamster
- Homework Assignment Part # 3-1

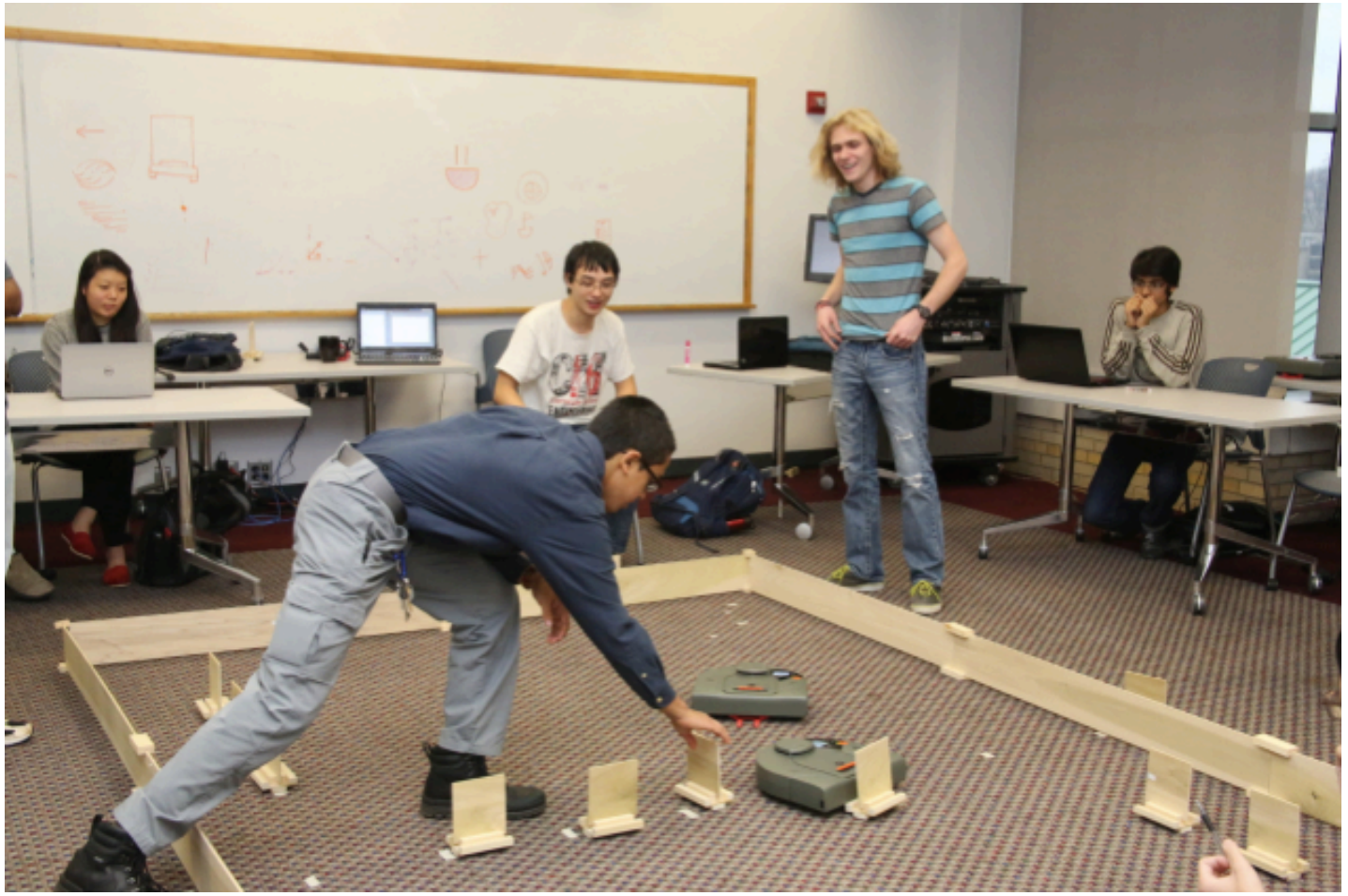
What Is Robot Programming



What is Robot Programming?

- Open-loop
- Closed-loop
- Reactive
- Planned

Mobile Robot Programming Example

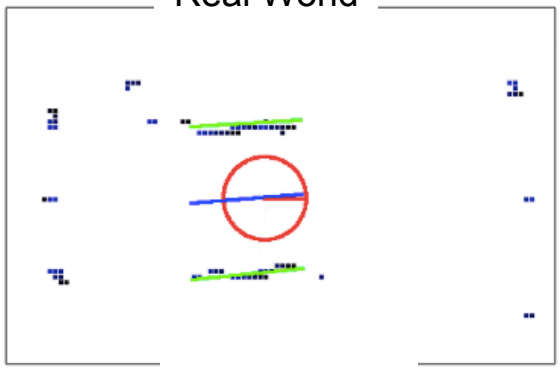


Mobile Robot Programming Example

- Maze

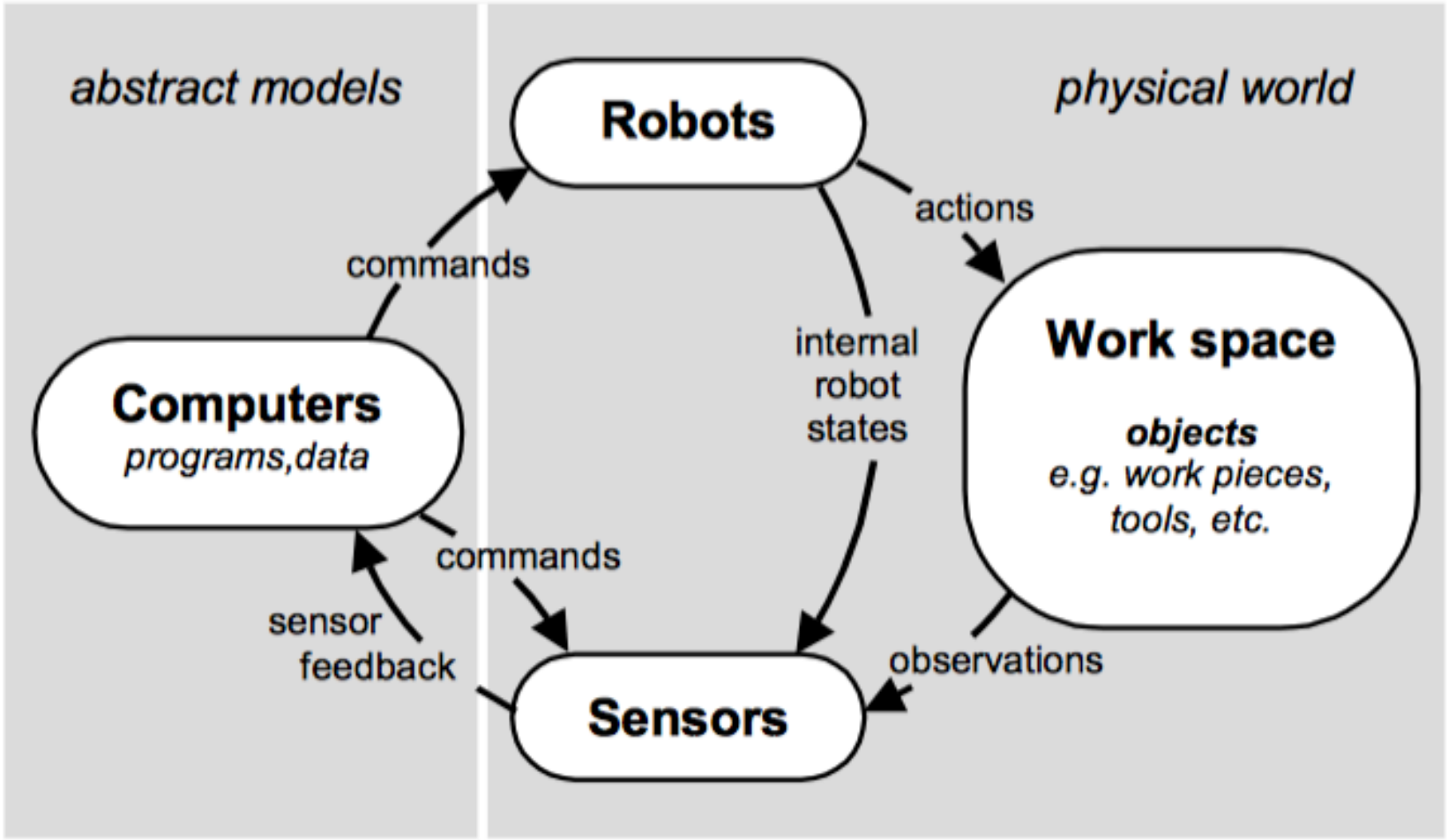
Robot Competition

Real World



Virtual World

A Simplified Paradigm



Virtual World

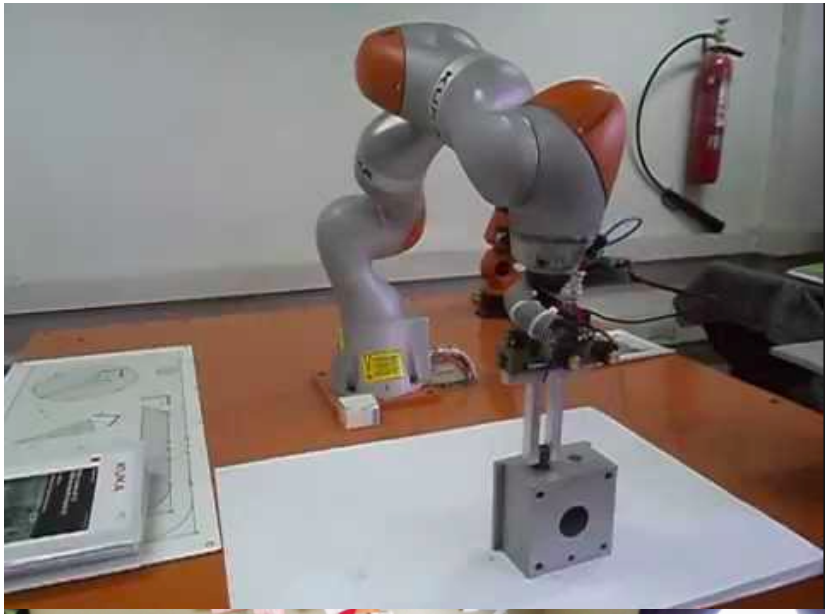
Real (Physical) World

Basic Elements Of Robot Programming

- Model of itself
- Model of the world (mapping virtual world and real world)
- Description of a task
- Description of a “plan” (to achieve task)
  - can be given to the robot
  - can be generated by robot
- A way to recognize success (task completion)
  - and monitoring during plan execution to make sure it’s following the plan

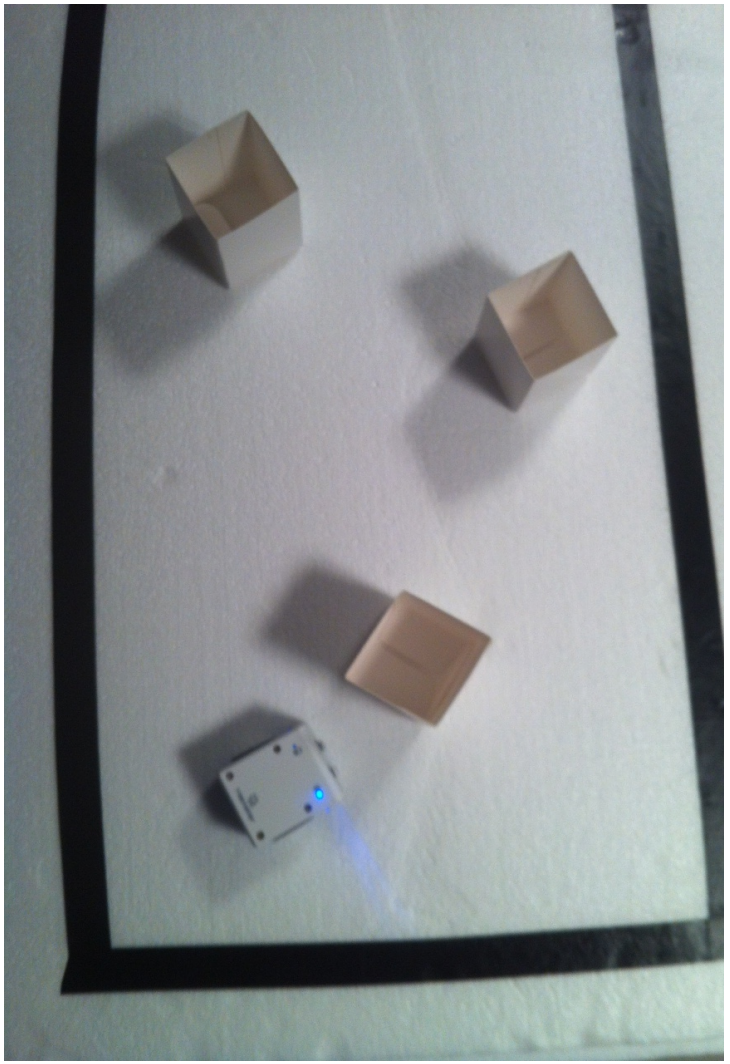
Unique Challenges

- Knowledge of the world incomplete
  - Not available
  - Impractical (too much details)
  - World Changing
- Sensing is imperfect
  - And limited
- Control is inaccurate



Trash Cleaning Example

- Model of itself
- Model of the world
- Description of a task
- Description of a “plan” (to achieve task)
  - can be given to the robot
  - can be generated by robot
- A way to recognize success (task completion)
  - monitoring during plan execution to make sure it’s following the plan



Reactive Is Not Enough

So far we have:

- Very limited knowledge of the world (border and obstacles exist)
- Only “reactive” behaviors

But you can not do too much being completely “reactive”
To do more:

- we need better “knowledge” of the world and
- use this knowledge to generate a “plan”
- ensure “plan” execution

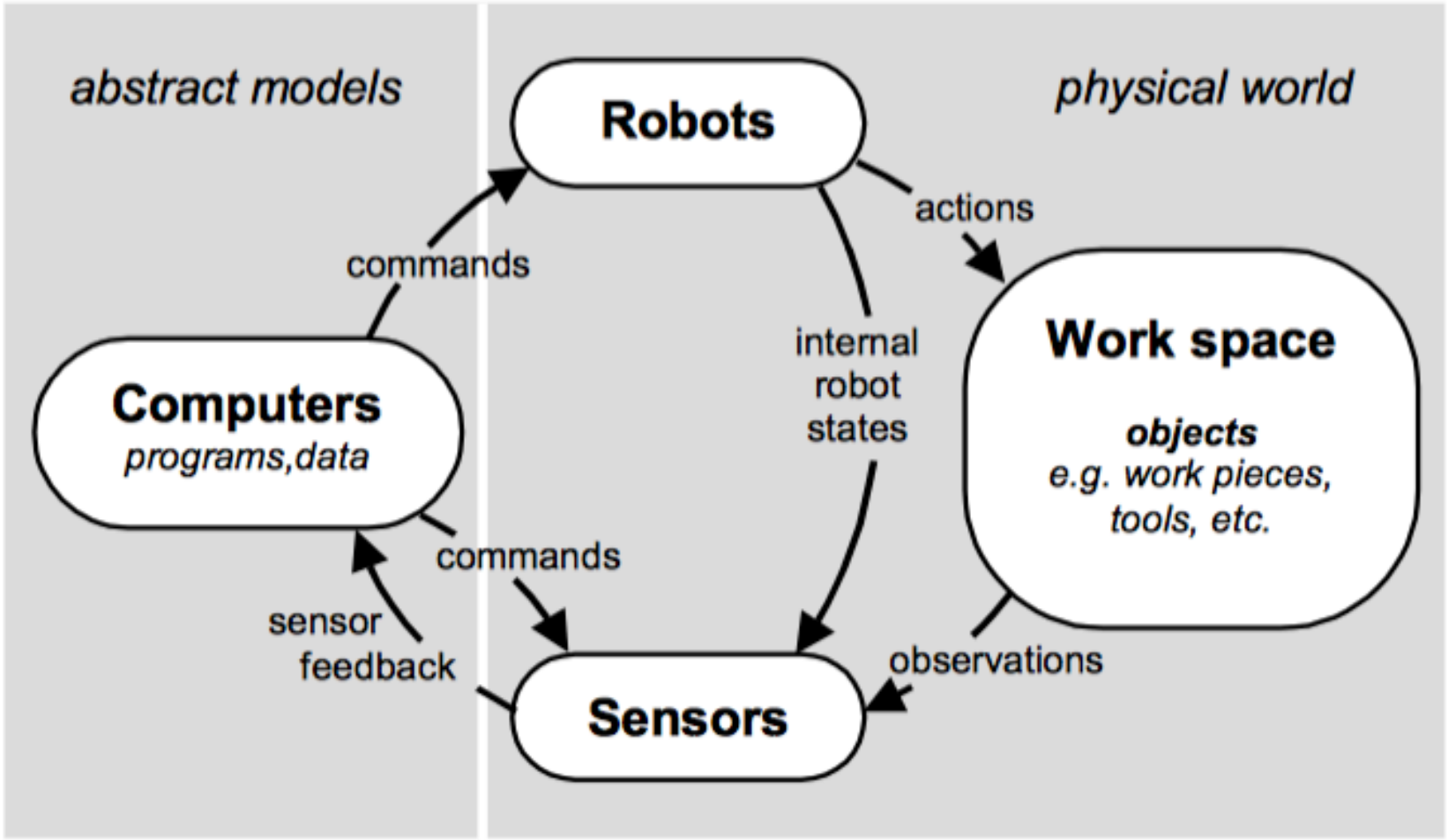
Mobile Robot Programming: Problem Decomposition

- Physical -> Virtual World Mapping
- Localization (Hamster knowing “where he is”)
- Local navigation (going to a specific place / location) : achieving “sub-goal”
- Plan and Plan Execution (execution monitoring)

What Does Hamster See?

- Introduce the GUI Toolkit
- Physical World -> Virtual World Mapping
- Very limited sensing makes hard to do anything
  - Human are “spoiled” by very rich sensors
- Try the “escape problem” by hand (human joystick)
  - only looking at the instant sensor data

Virtual World : Real World “Mapping”

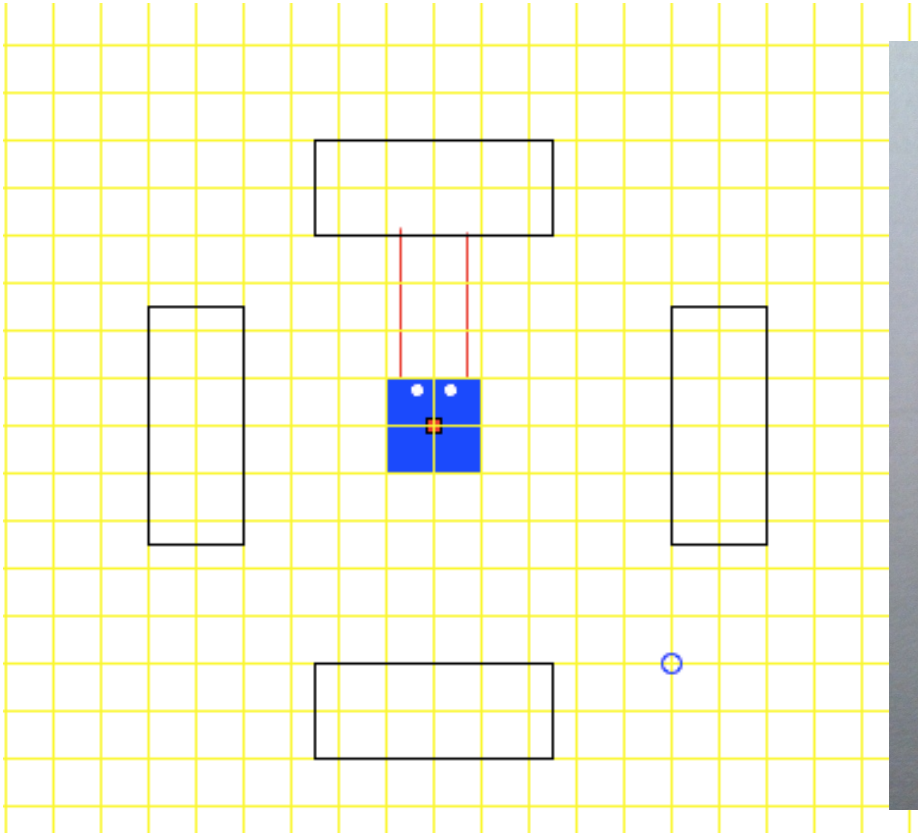


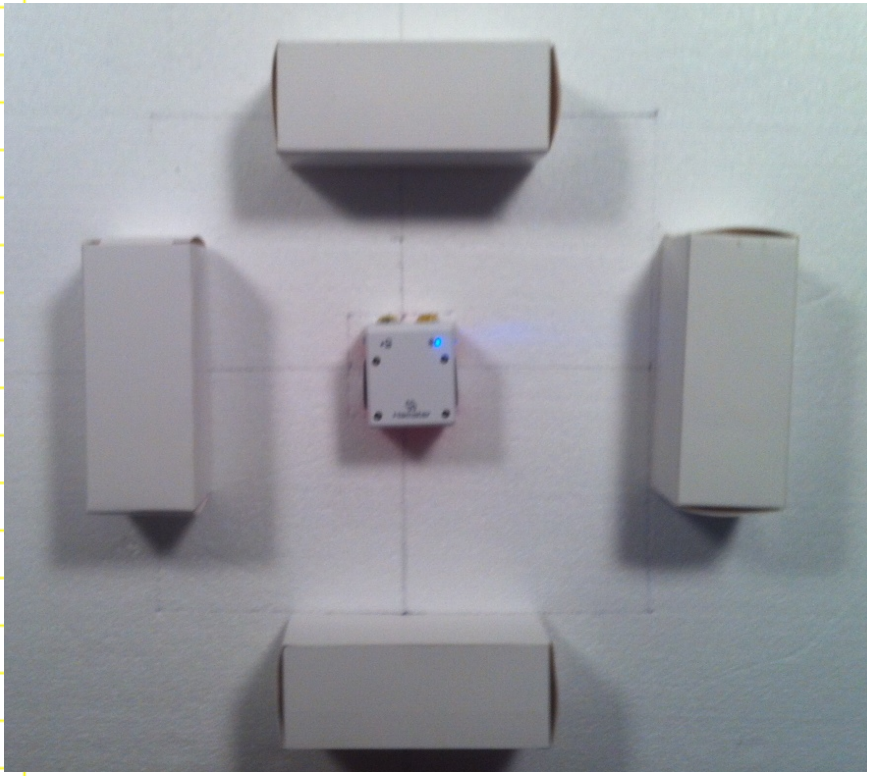
Virtual World

Real (Physical) World

Making Sense of What Hamster See

- Mapping the Physical World to the Virtual World



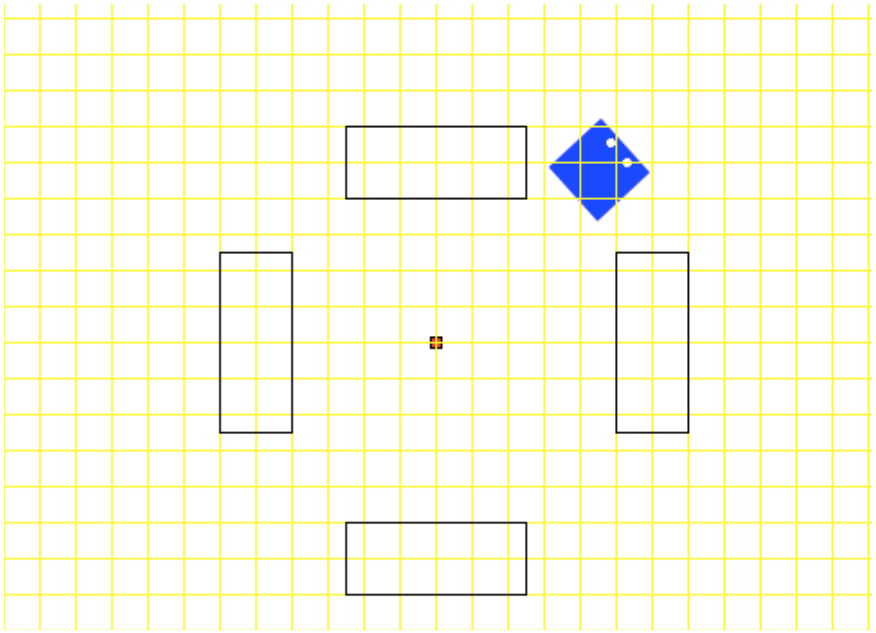


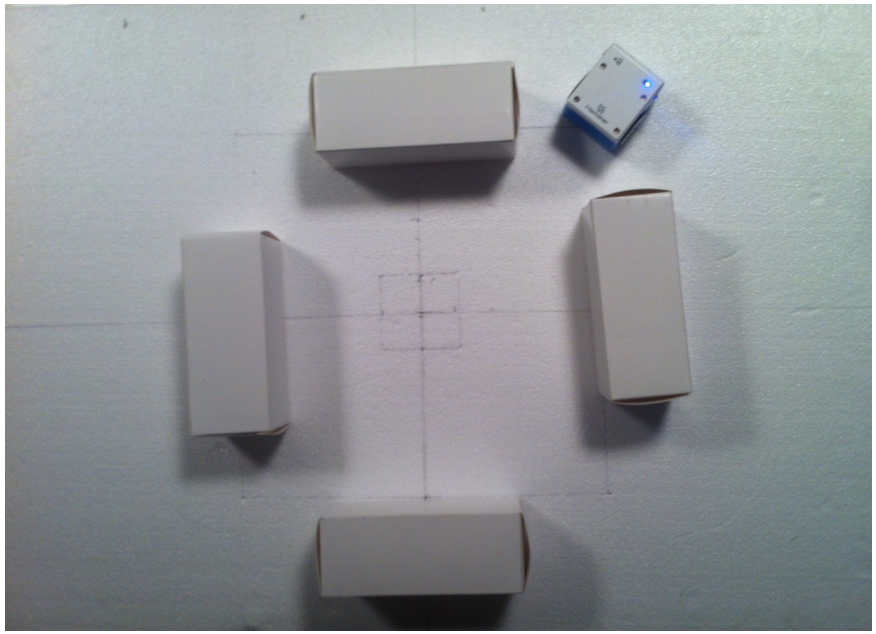
Home Work Part #3-1

- Knowing where you (Hamster) are relative to the “map”
- Going to a set of “goal” locations

(within given error bound of +/- 20 mm: half size of robot)

Note: “The world” is rectilinear and white (boxes)





Home Work #3-1:
“Local” Localization and Navigation

- Base on local (spatial and temporal) information
- Technique will be discussed on Thursday
- But you can first do the “robot modeling” part