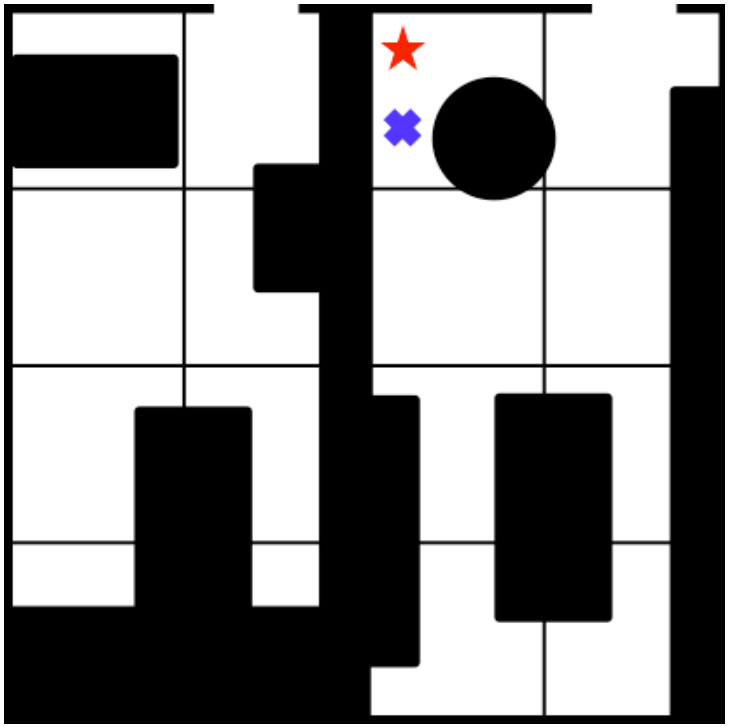
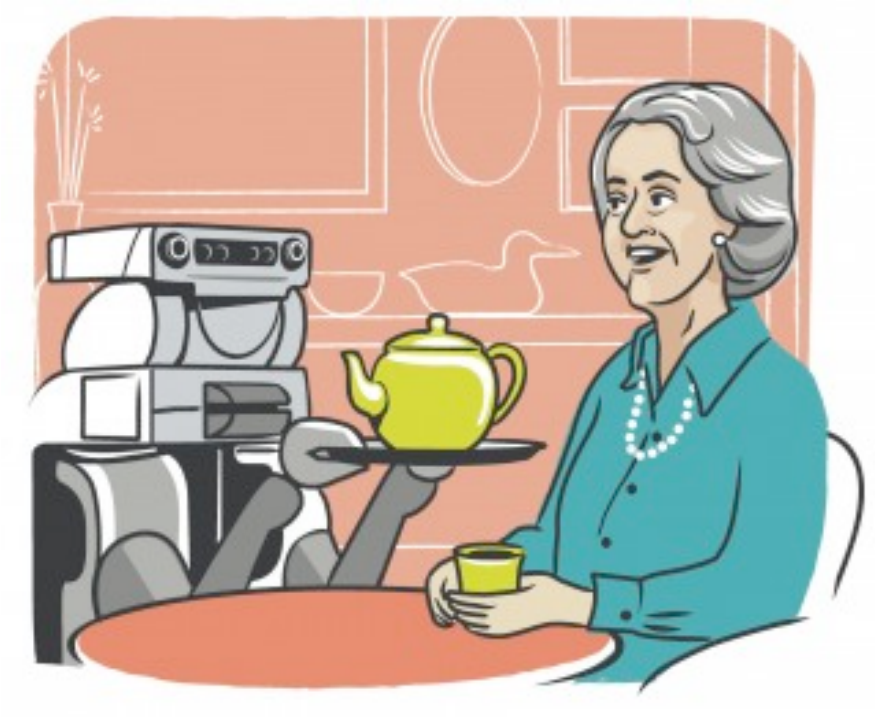
Quiz Review; HRI Ridiculously Fast





Robotics REU

- "Robotics in the Real World"
- REU: Research Experience for Undergraduates
  - NSF-funded research grant
- 10-week summer program, paid:
  - Stipend, plus transportation and lodging funding
- Apply by **February 25-26th**
  - But earlier may be better!

http://robotics.oregonstate.edu/reu
http://www.sure.robotics.gatech.edu

REU: Sample Projects

- Design of Implants for Attaching Muscle and Tendons to Improve Human Hand Function
- Learning from Humans for Robotic Deburring
- SpiderBots
- SpiderSense
- Privacy and telepresence
- Autonomous Research Vessels to Explore Extreme Ocean Environments
- Autonomous Mapping with Teams of Aerial Rotorcraft
- Design and Control of Highly Dynamic Walking and Running Robots
- 3D Printing Soft Robots
- Biodegradable Soft Robotics
- Control of a self-driving wheelchair
- Multi-Robot Coordination
- Grasping

Quiz Review

- The geometry of a robot – that is, the location and connectivity of every point on that robot at a single point in time – is called its _____ .

- Configuration: where is every point on manipulator?
  - Instantaneous description of geometry of a manipulator
- Not State: a set of variables which describe
  - *Change of configuration in time* in response to joint forces

Quiz Review

- The coordinates of a manipulator's end-effector give its _position_ and _orientation_ in global space.

- Solving forward and inverse kinematics problems for a manipulator robot lets us transform between two frames of reference: the global/initial frame, or _Cartesian_ space, and the robot's frame, or _joint_ space.

Quiz Review

- How many parameters are required to fully describe the coordinates of an end-effector in global space?

  6

- What are those parameters? (One word/character per parameter)

  x, y, z; roll, pitch, yaw

Quiz Review

- Solving IK problems: *analytical* vs. *numerical* approaches
  - Analytical approaches try to find an exact solution by calculating the forward kinematics problem in reverse
    - computationally very difficult
  - Numerical approaches use iterative approaches to approximate a solution
- Which of these operations is solving which?

joint angles ➡ end effector coordinates — inverse

end effector coordinates ➡ joint angles — forward

What are DH Parameters?

- Goal: Find transform from link i to link i+1
- Get position & orientation of each link as robot moves:
  - Attach **frames to each link**
  - Compute how the frames change as the robot moves
  - Gives configuration at any point in time
- How do link frames change with robot parameters?
  - Parameterize relationship between adjacent links' frames
- → Table of parameters that defines the relationship between two adjacent frames (links).

Ravi Balasubramanian – CMU
robotics.usc.edu/~aatrash/cs545/

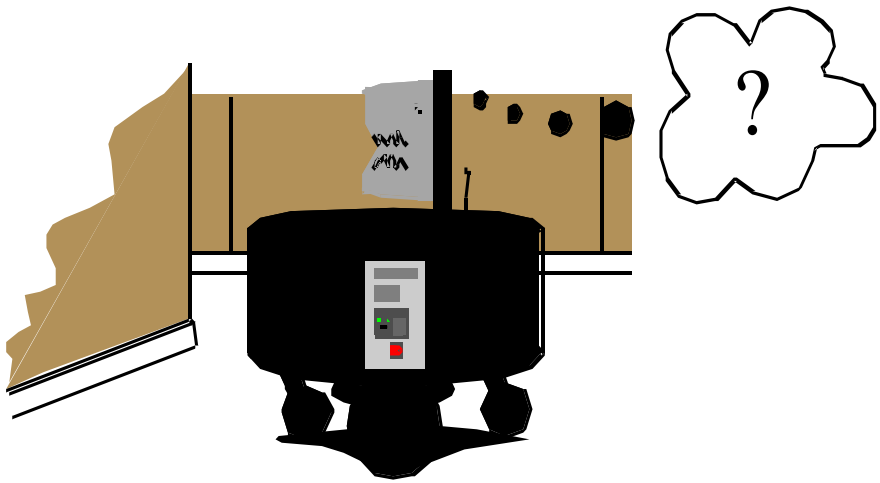
What are DH Parameters?

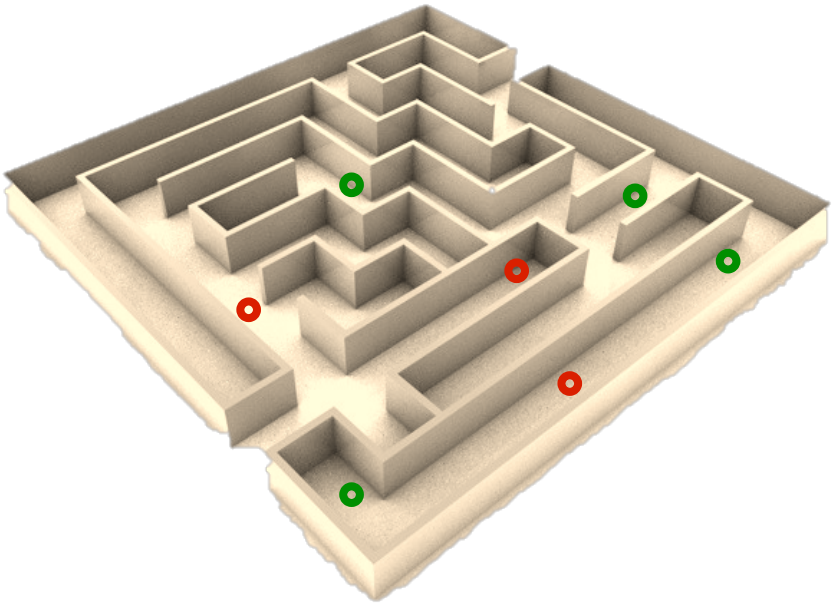
- Goal: Find transform from link i to link i+1
- Get position & orientation of each link as robot moves;
- ➢ Table of parameters that defines the relationship between two adjacent frames (links).

DH parameters describe the relationship between two links that share a joint. They make it easier to write the transformation from link 1's reference frame to link 2's reference frame.

Localization

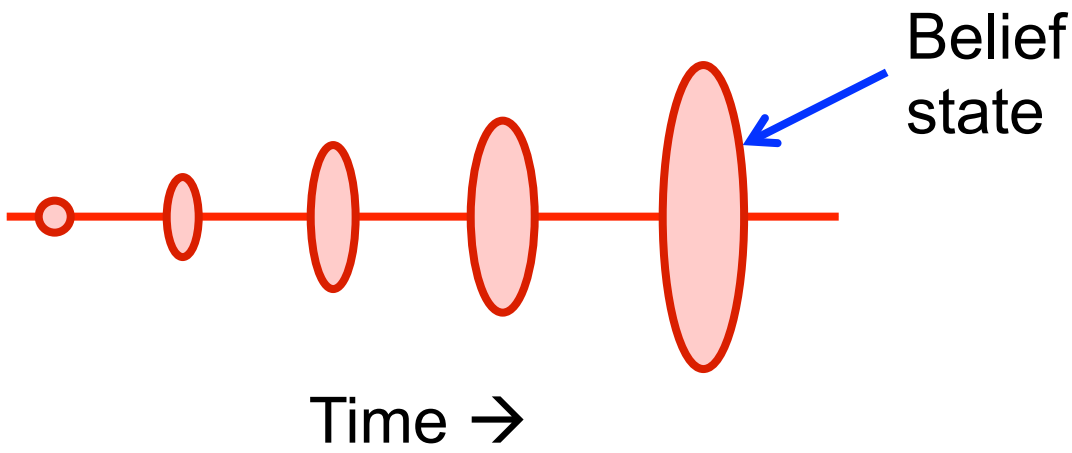
- Define localization
  - Figuring out where the robot is in map/model of environment
  - It is not *mapping* (creating the map) – different operations!
- *Sensor aliasing* is …
  - Different environments produce identical sensor readings.





Quiz Review

- Odometry uses only distance-traveled (odometric) sensors such as wheel encoders. Dead-reckoning uses both odometric and heading sensors.
- What grows faster: distance traveled errors or side-to-side distance errors?



Quiz Review

- If a robot's goal is to patrol corridors in a building looking for trash, behavior based navigation is an alternative to localization-based navigation.

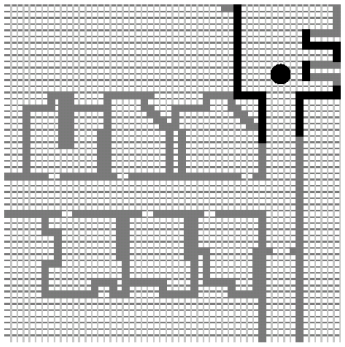
- In probabilistic localization, location updated iteratively, alternating between two kinds of update:

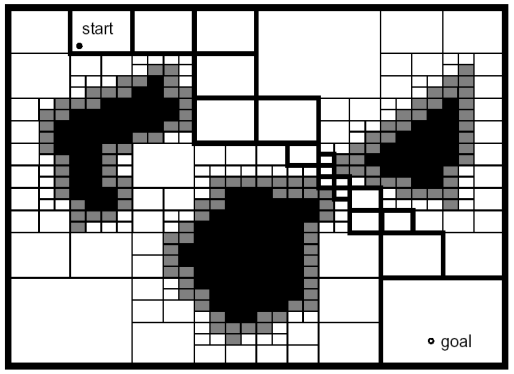
Prediction (action) update

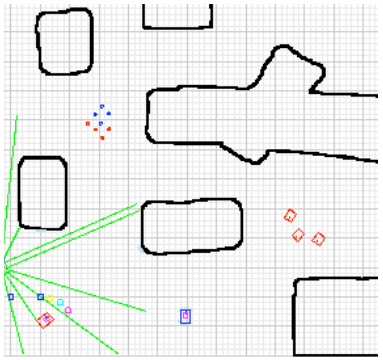
Perception (correction, measurement) update

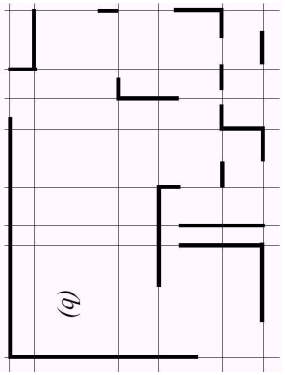
Map Representation

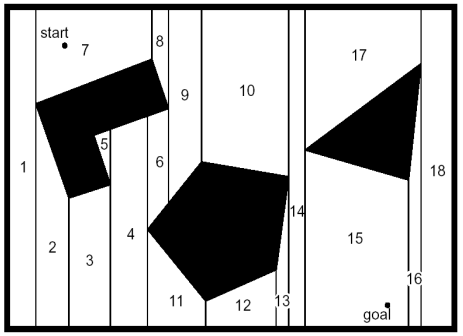
- Name OR describe two map representations

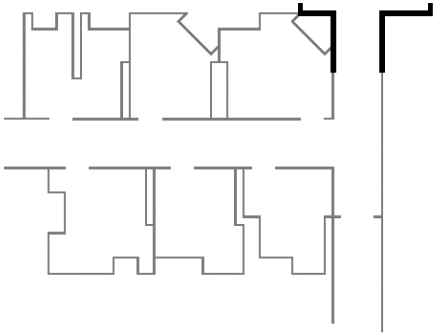


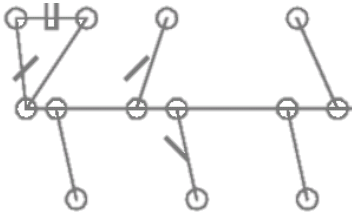


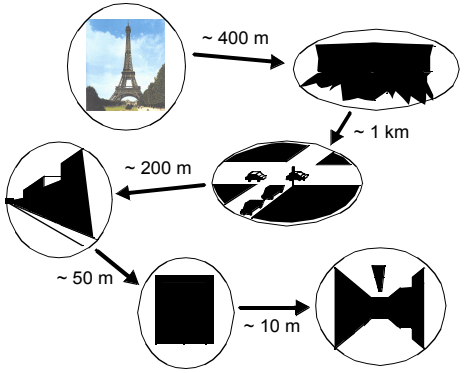










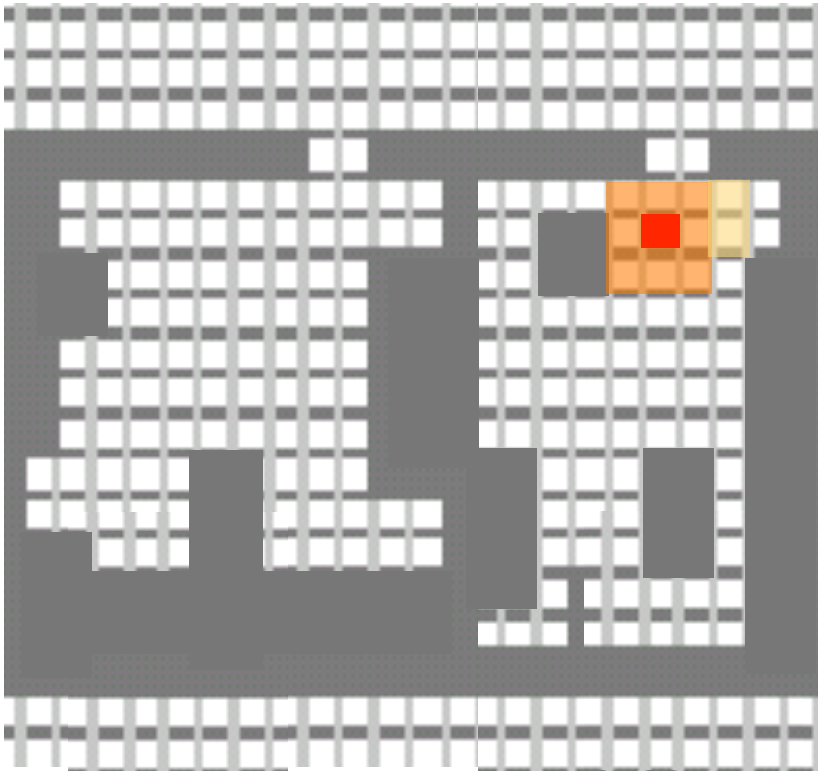


Map Representation

- Must have representations of *map* and *belief state*.
- Which of the following pairs of representations can be used together?

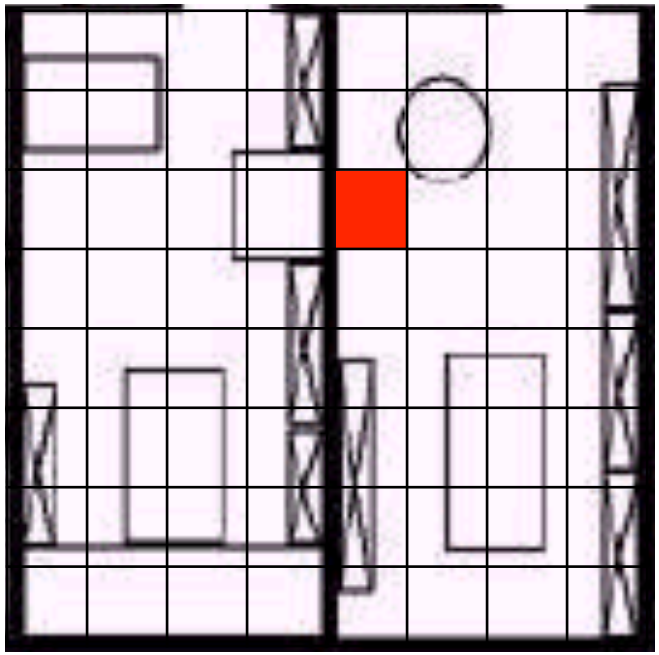
Map Representation

- Must have representations of *map* and *belief state*.
- Which of the following pairs of representations can be used together?
  - A probabilistic belief state in a fixed grid map



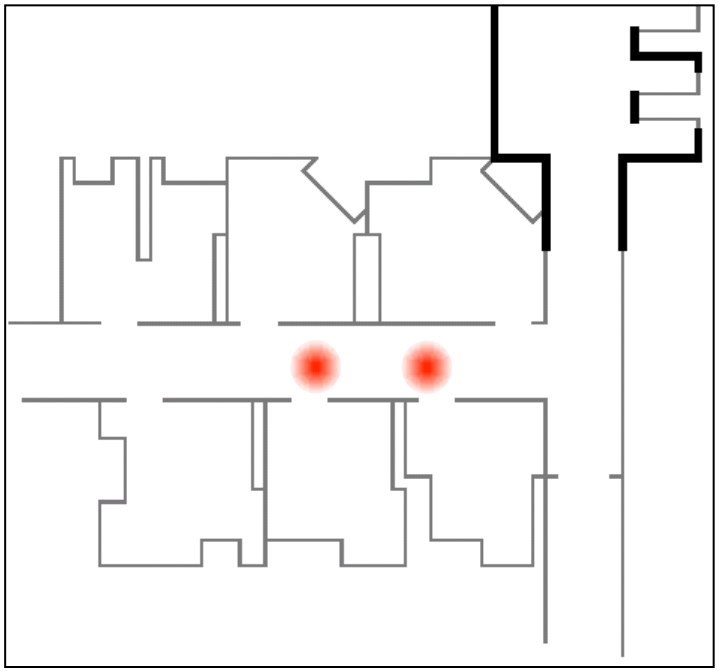
Map Representation

- Must have representations of *map* and *belief state*.
- Which of the following pairs of representations can be used together?
  - A probabilistic belief state in a fixed grid map
  - A point belief state in a fixed grid map



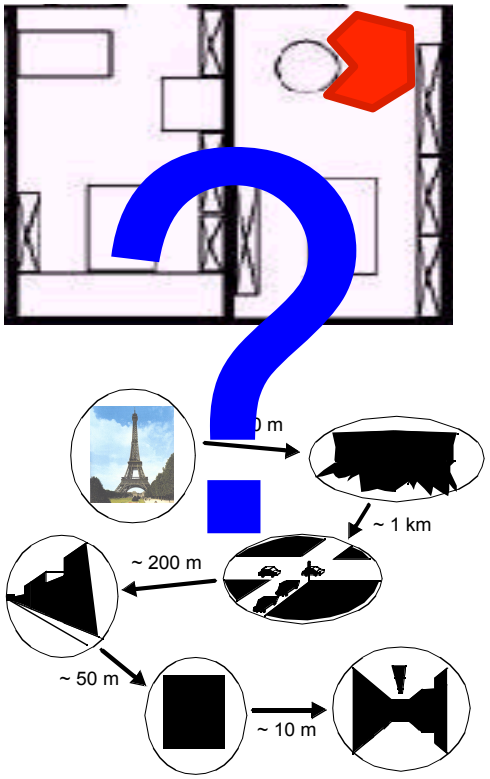
Map Representation

- Must have representations of *map* and *belief state*.
- Which of the following pairs of representations can be used together?
  - A probabilistic belief state in a fixed grid map
  - A point belief state in a fixed grid map
  - A multiple hypothesis belief state in a continuous line map



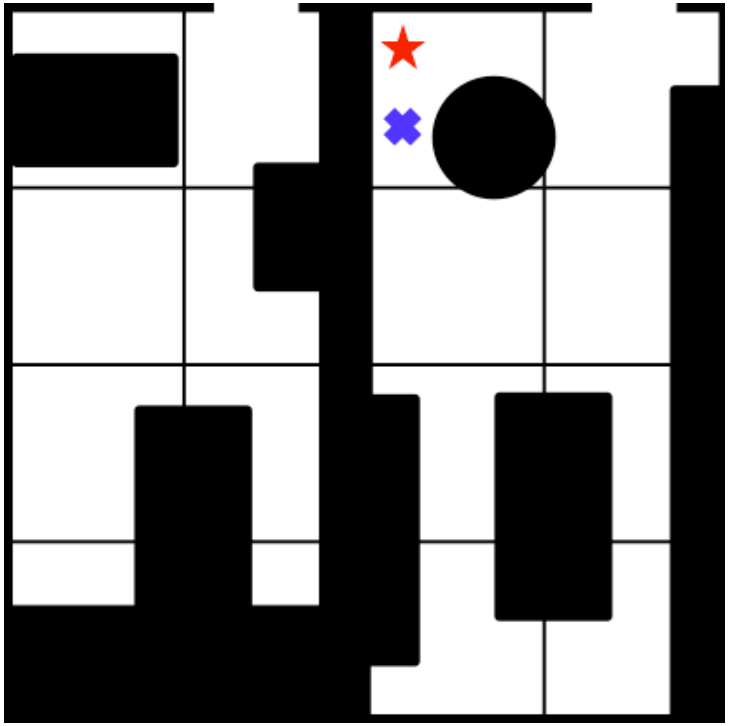
Map Representation

- Must have representations of *map* and *belief state*.
- Which of the following pairs of representations can be used together?
  - A probabilistic belief state in a fixed grid map
  - A point belief state in a fixed grid map
  - A multiple hypothesis belief state in a continuous line map
  - A bounding-box belief state in a topological map



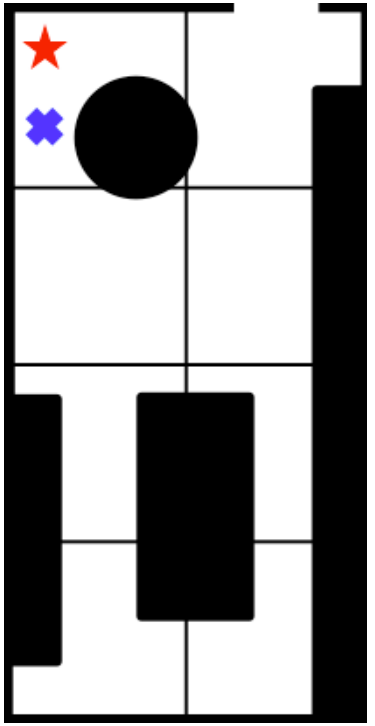
Quiz Review

- *This localization problem uses a fixed-cell grid map representation and probabilistic belief state.*
  - Map is discretized into fixed 1m grid cells
  - Robot enters the room, rotates 90 degrees right and roll 3 meters forward



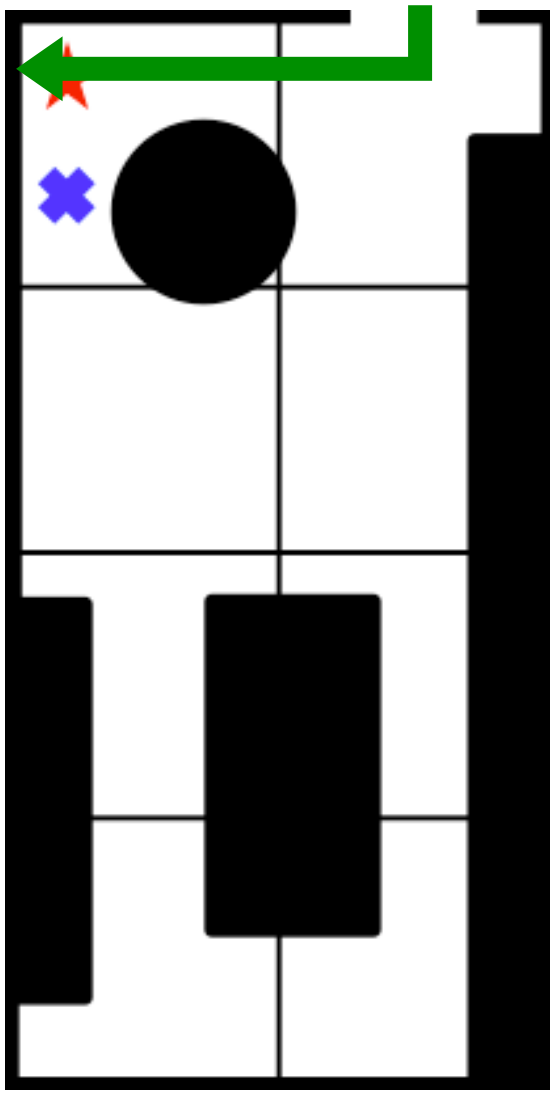
Quiz Review

- *This localization problem uses a fixed-cell grid map representation and probabilistic belief state.*
  - Map is discretized into fixed 1m grid cells
  - Robot enters the room, rotates 90 degrees right and roll 3 meters forward



Quiz Review

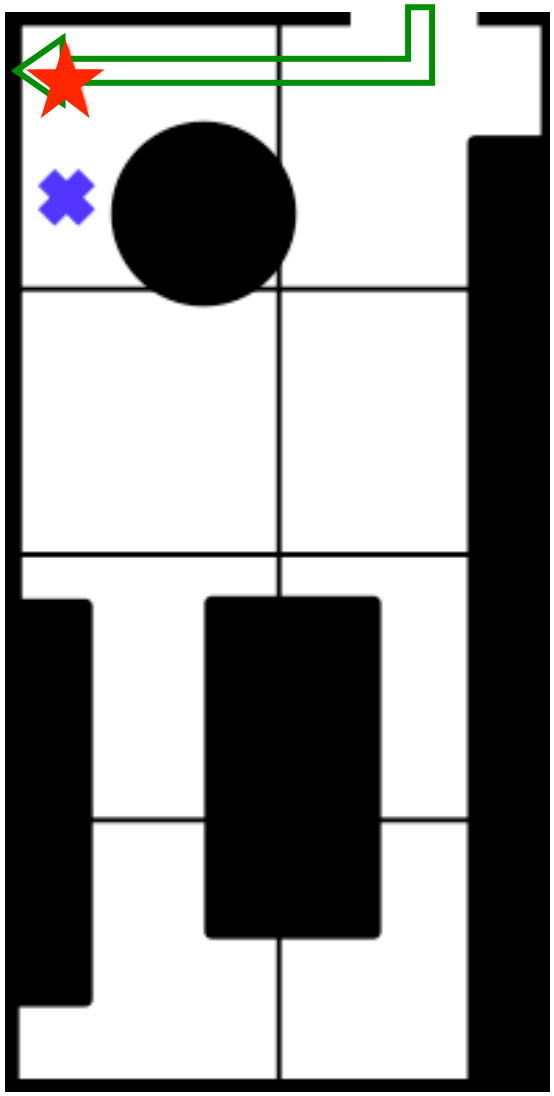
- *This localization problem uses a fixed-cell grid map representation and probabilistic belief state.*
  - Map is discretized into fixed 1m grid cells
  - Robot enters the room, rotates 90 degrees right and roll 3 meters forward



Quiz Review

- *This localization problem uses a fixed-cell grid map representation and probabilistic belief state.*
  - Map is discretized into fixed 1m grid cells
  - Robot enters the room, rotates 90 degrees right and roll 3 meters forward
  - What is the probability it is at x?
  - What is the probability it is at y?

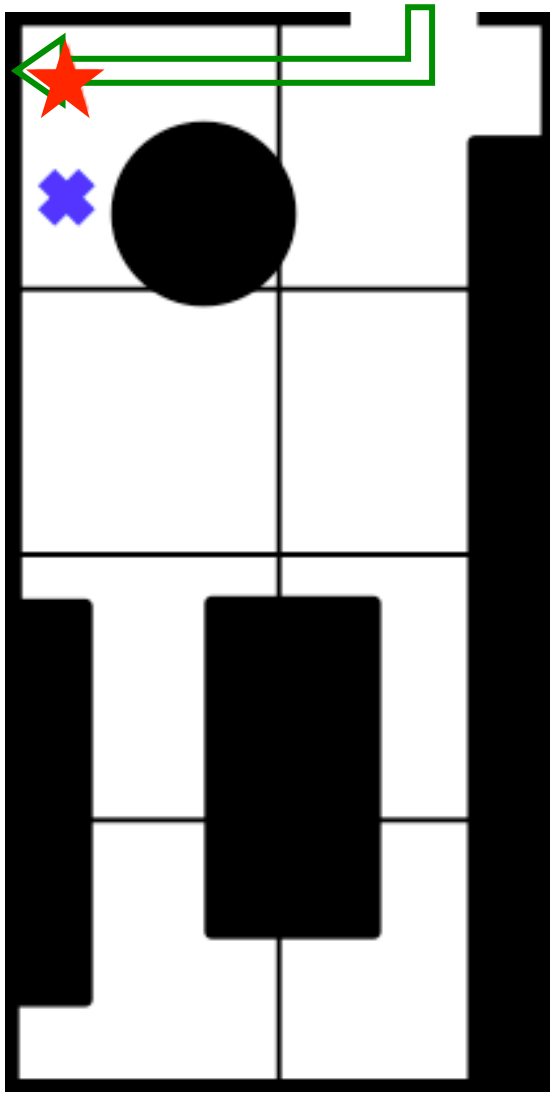
x ? y



Quiz Review

- Map is discretized into fixed 1m grid cells
- What is the probability it is at x?
- What is the probability it is at y?

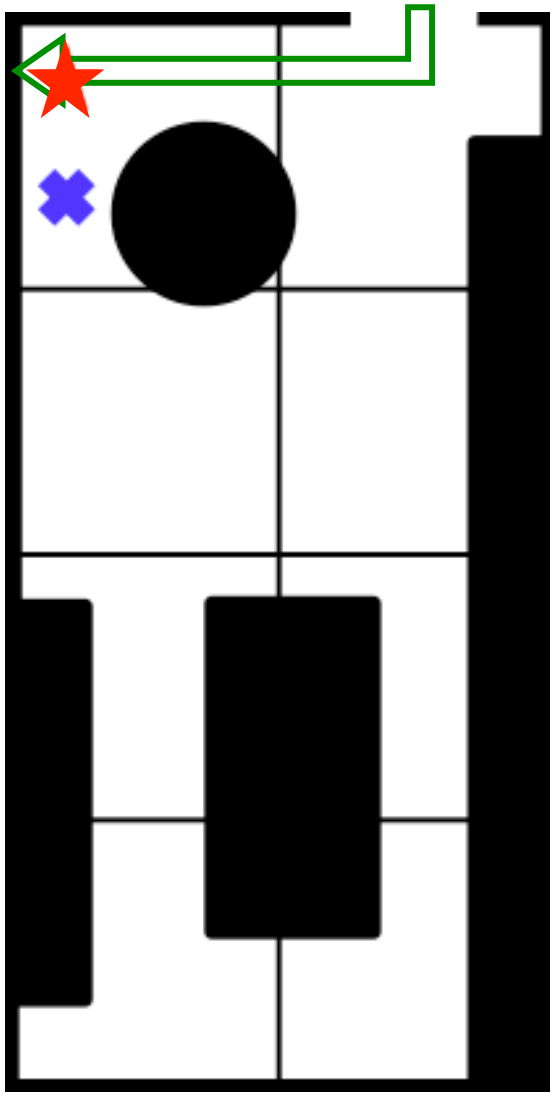
$$x = y$$



Quiz Review

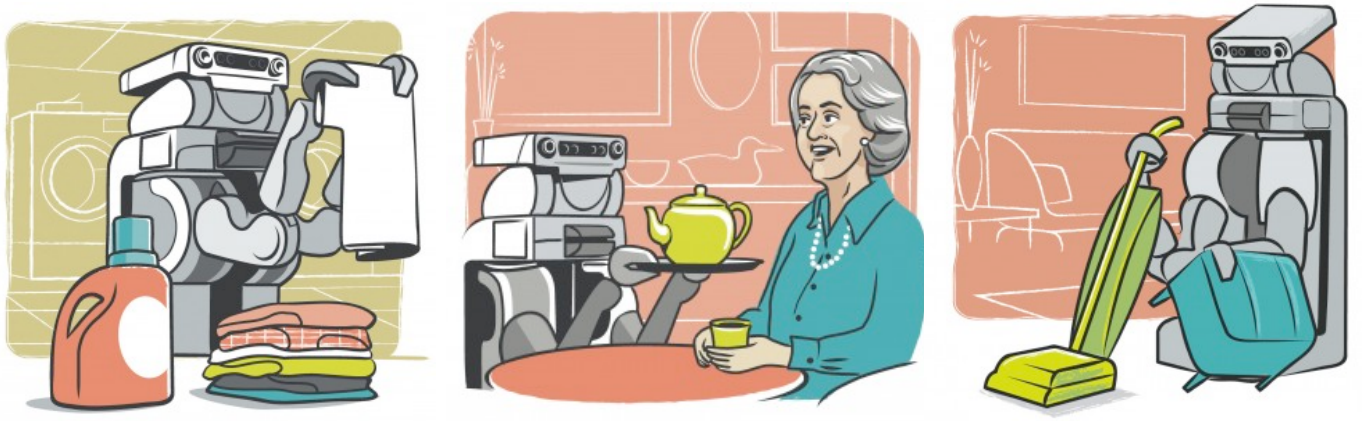
- Map is discretized into fixed 1m grid cells
- What is the probability it is at x?
- What is the probability it is at y?

$$x = y$$



What is HRI?

- Robots are becoming more ubiquitous
- Keep them in safety cages managed by engineers doesn't take advantage of what they could do



- What happens when we put them in human spaces?
- Study of how robots can behave with humans: *HRI*

Human-Robot Interaction

- HRI taxonomy and metrics
- HRI methods
- Assistive and socially-assistive
- Human-robot collaboration
- Collaborative manipulation, human-robot handover
- Natural-language interactions with robots
- Remote teleoperation
- Expressive robot motion
- Navigation around humans
- Perception of humans
- Social learning
- Non-verbal communication: Gestures
- Human-robot dialog
- Remote presence