Introduction to Robotics

Manipulation and Programming

Unit 4: Motion Control

MOBILE ROBOT PART 1 – MODEL-PLAN-ACT APPROACH

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Objectives

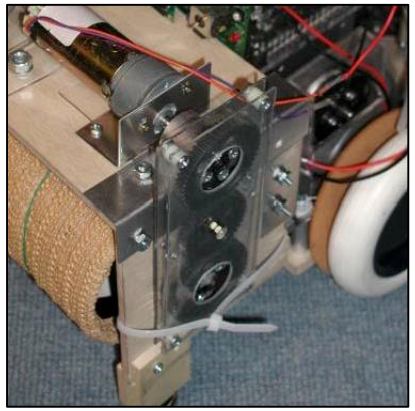
- Mobile Robots
- Model-Plan-Action Approach

Control System for Mobile Robots

SECTION 1

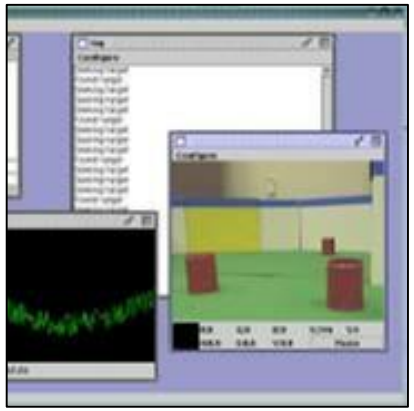
Building a control system for a mobile robot can be very challenging

- Mobile robots are very complex and involve many interacting components



Mechanical

Electrical



Software

- Your control system must integrate these components so that your robot can achieve the desired goal

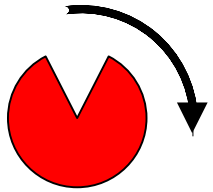
Building a control system for a mobile robot can be very challenging

Just as you must carefully design your robot chassis you must carefully design your robot control system

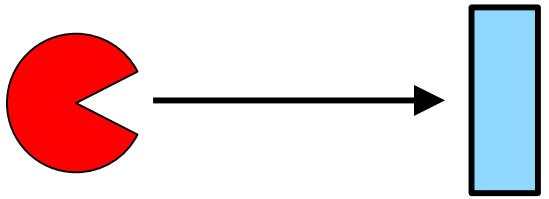
- How will you debug and test your robot?
- What are the performance requirements?
- Can you easily improve aspects of your robot?
- Can you easily integrate new functionality?

Basic primitive of a control system is a behavior

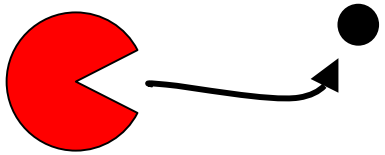
- Behaviors should be well-defined, self-contained, and independently testable



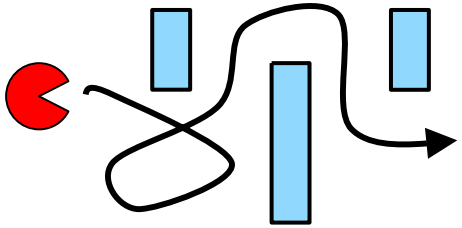
Turn right 90°



Go forward until reach obstacle

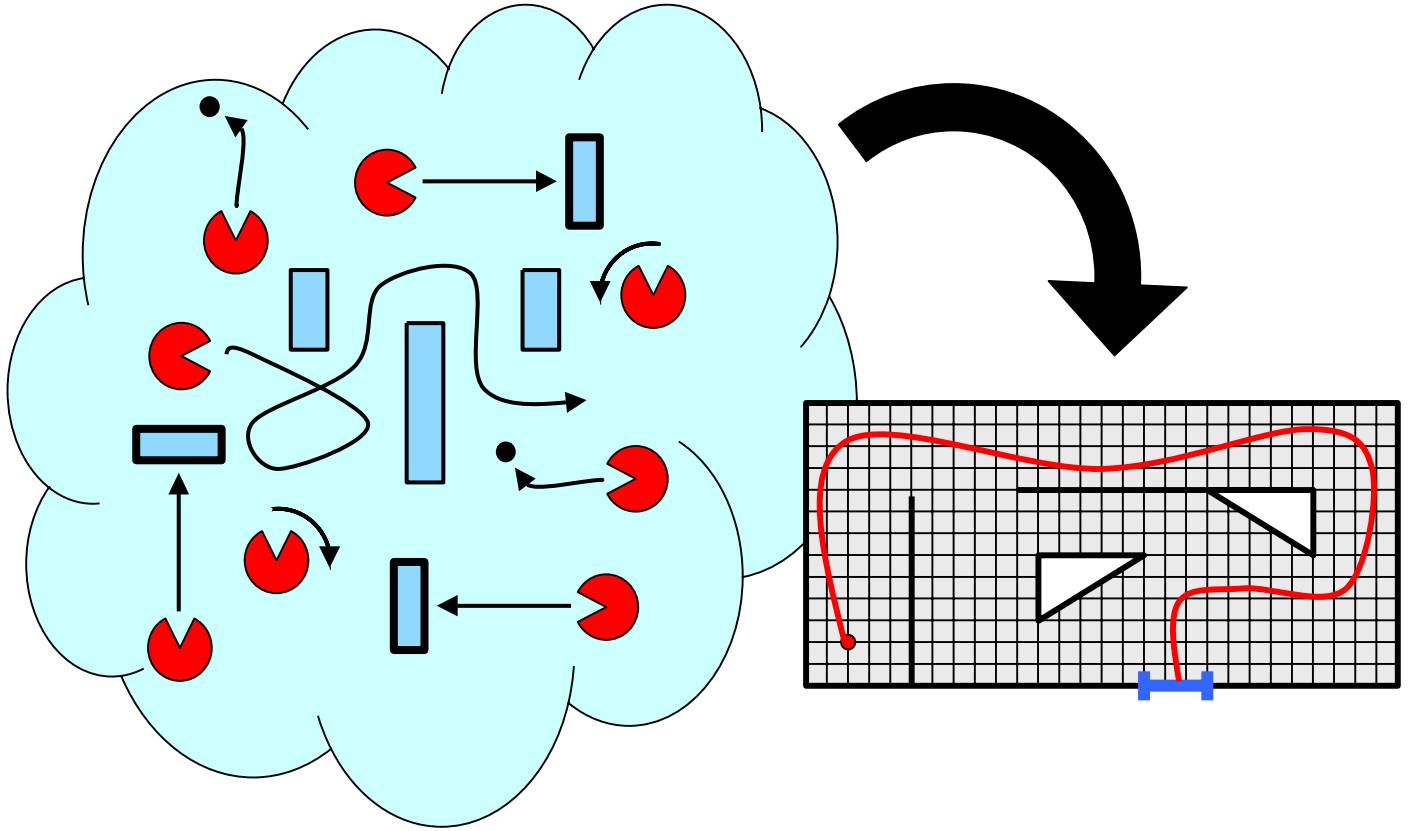


Capture a ball



Explore playing field

Key objective is to compose behaviors so as to achieve the desired goal

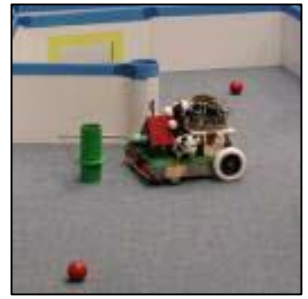


What is model-plan-act approach?

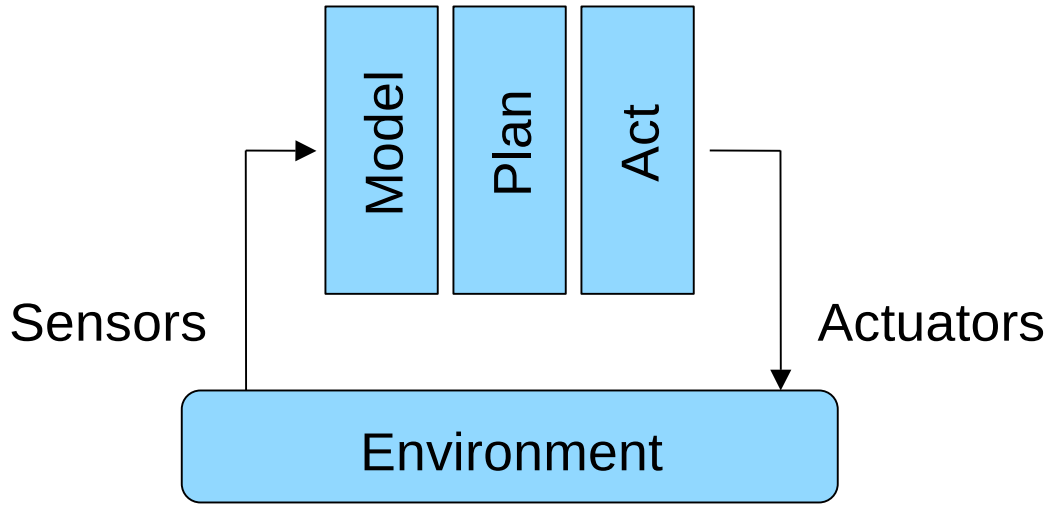
SECTION 1

Objectives

- **High-level control system paradigms**
  - Model-Plan-Act Approach
  - Behavioral Approach
  - Finite State Machine Approach
- Low-level control loops
  - PID controller for motor velocity
  - PID controller for robot drive system

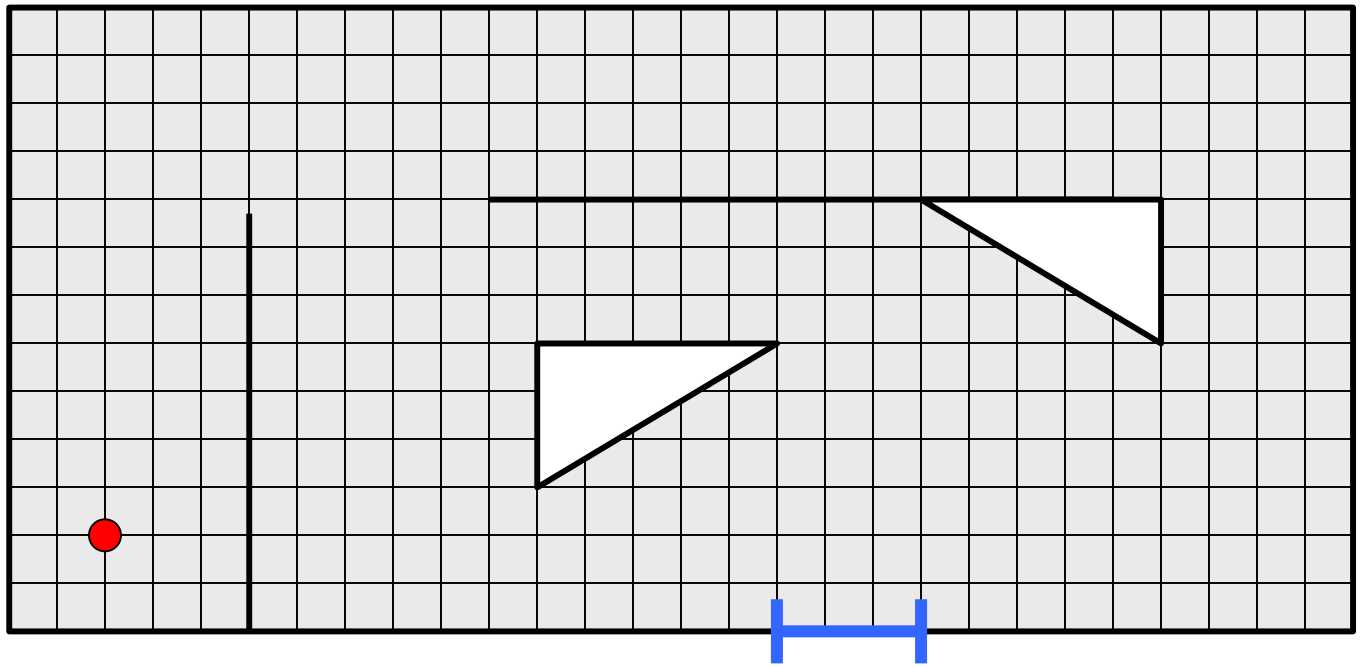


Model-Plan-Act Approach



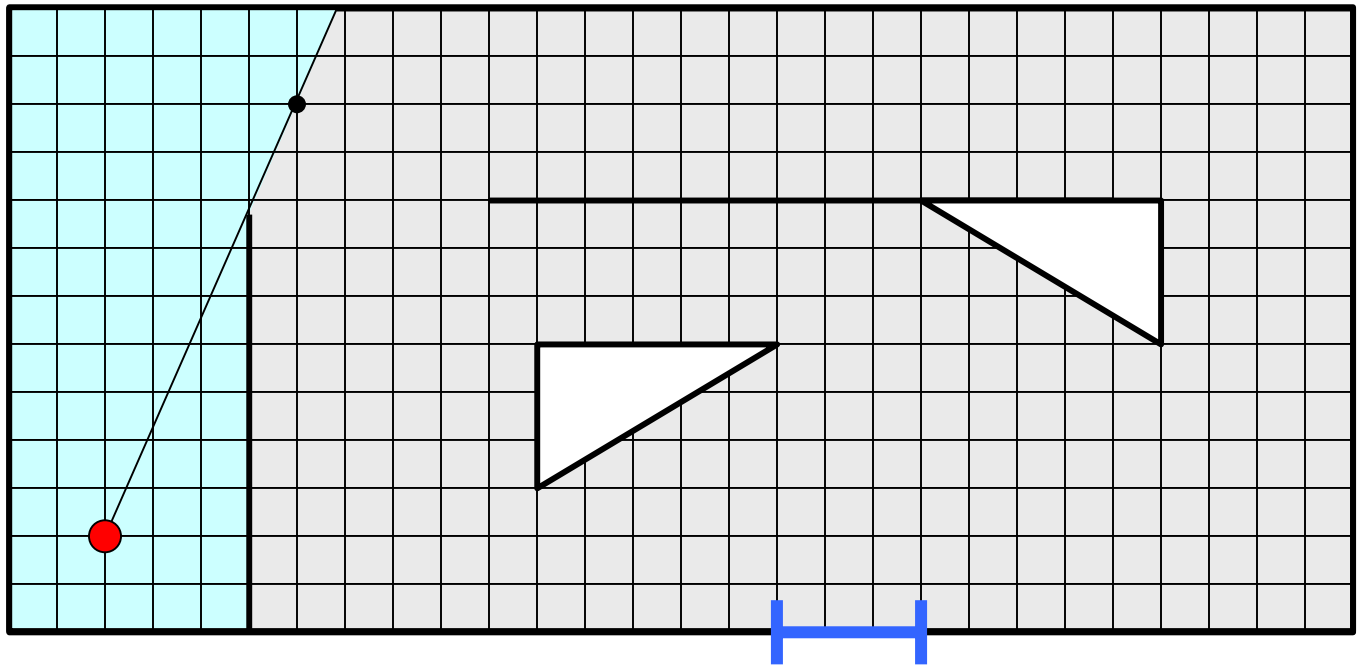
1. Use sensor data to create model of the world
2. Use model to form a sequence of behaviors which will achieve the desired goal
3. Execute the plan

Exploring the playing field using model-plan-act approach



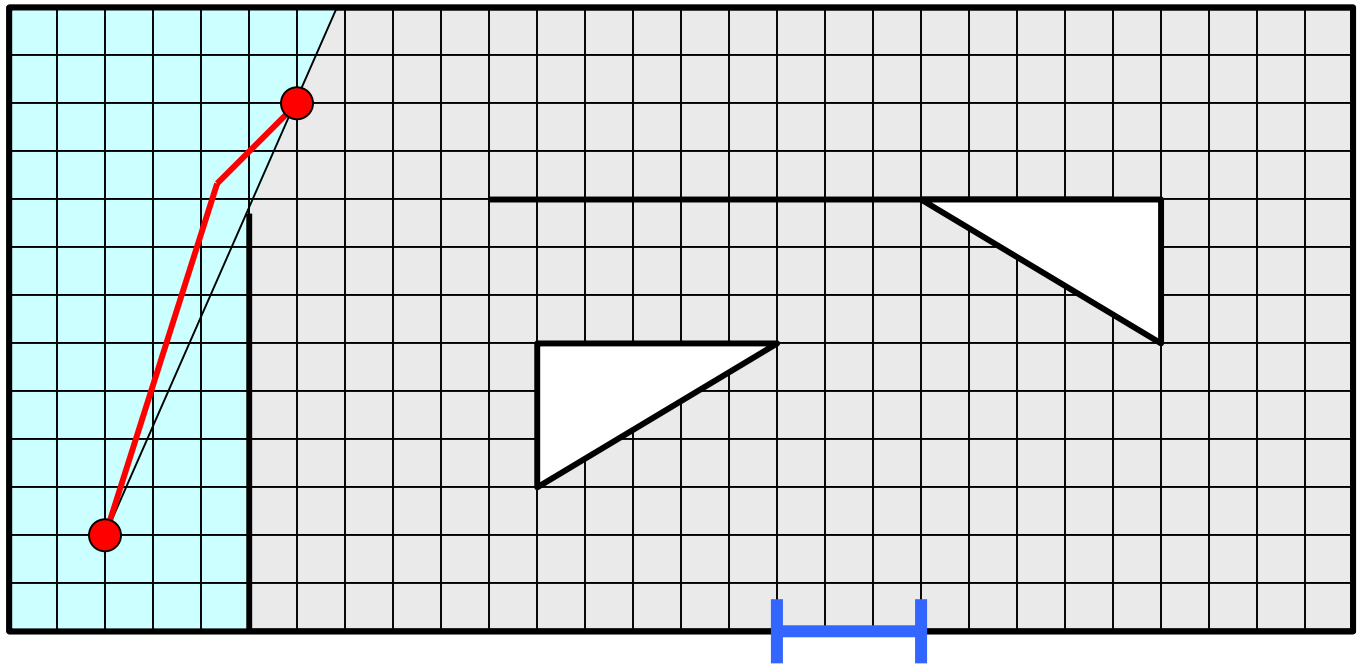
- Red dot is the mobile robot while the blue line is the mousehole

Exploring the playing field using model-plan-act approach



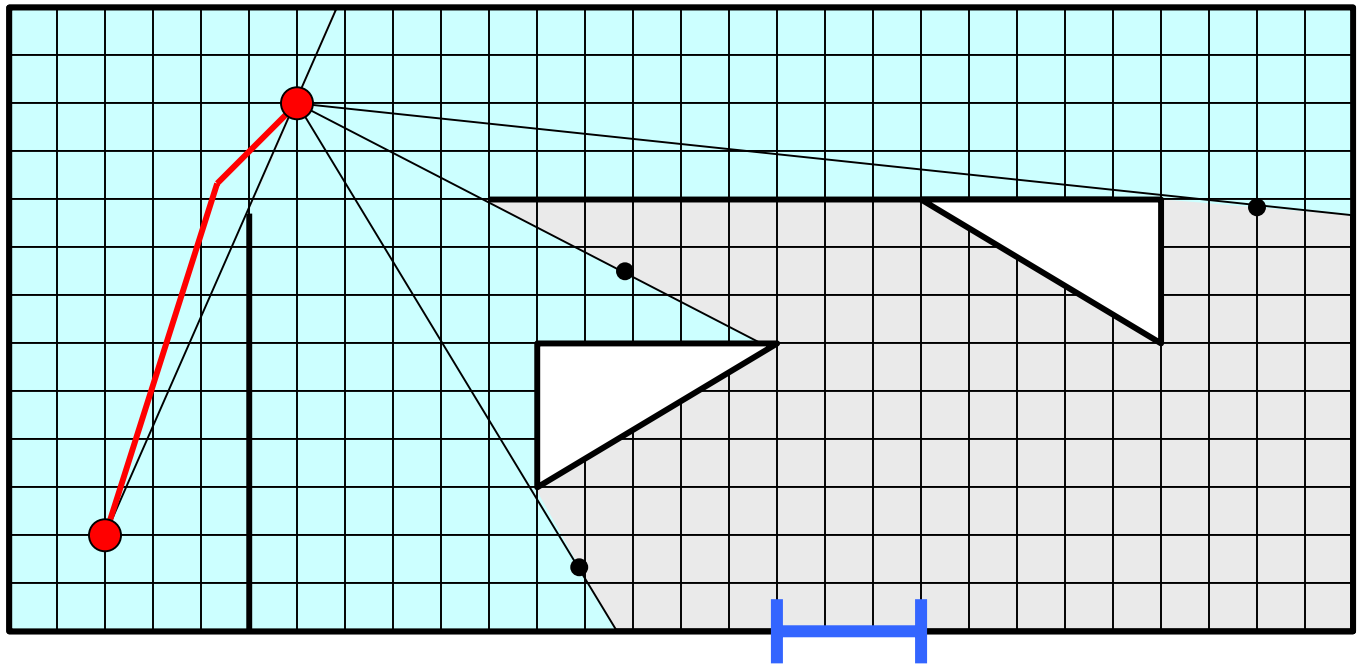
- Robot uses sensors to create local map of the world and identify unexplored areas

Exploring the playing field using model-plan-act approach



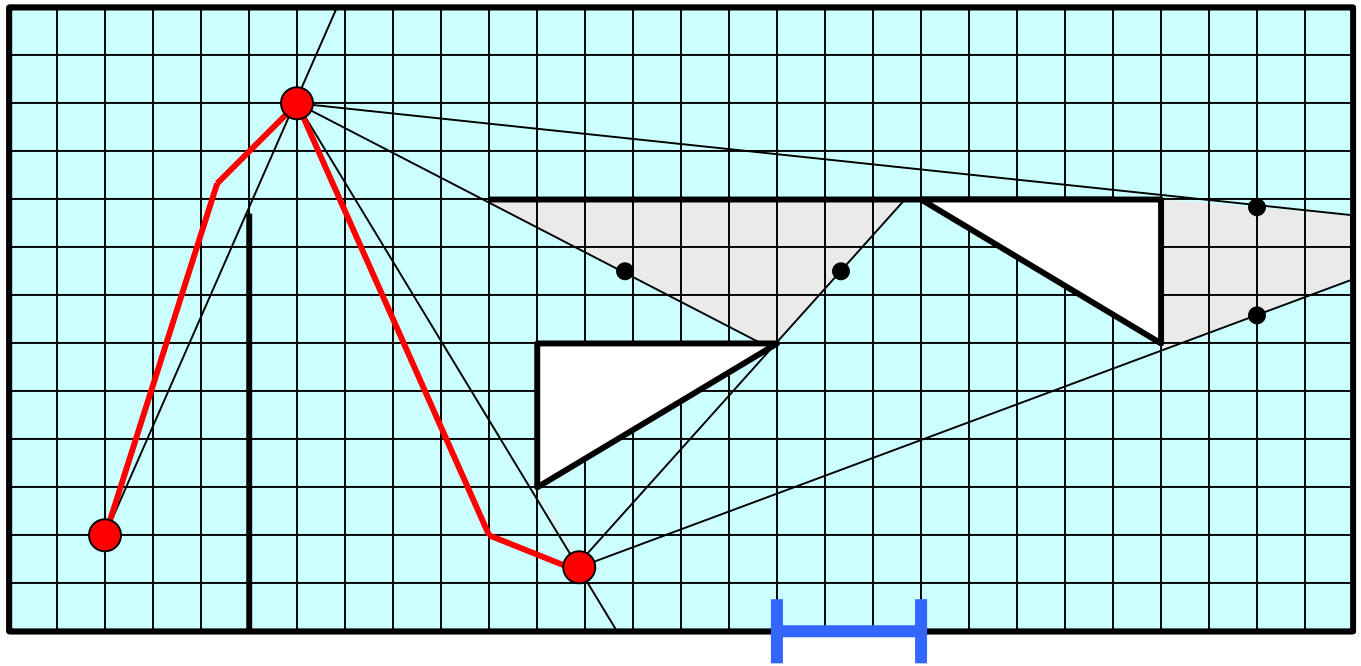
- Robot moves to midpoint of unexplored boundary

Exploring the playing field using model-plan-act approach



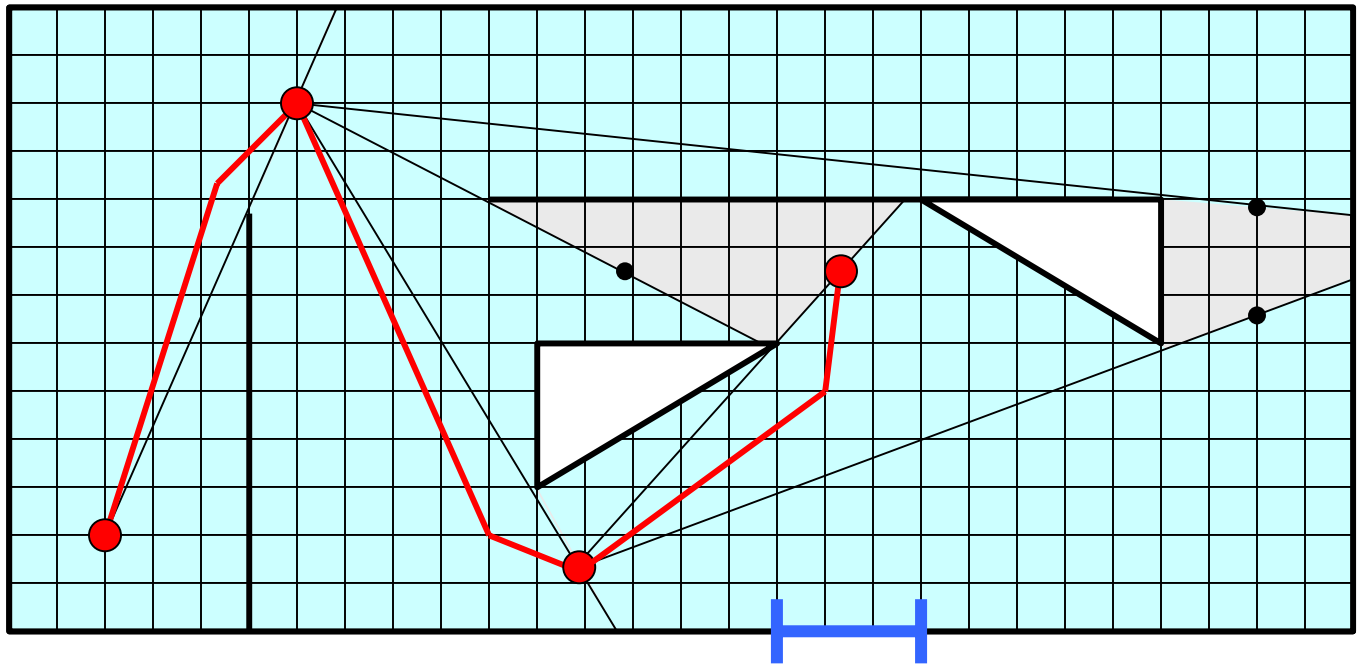
- Robot performs a second sensor scan and must align the new data with the global map

Exploring the playing field using model-plan-act approach



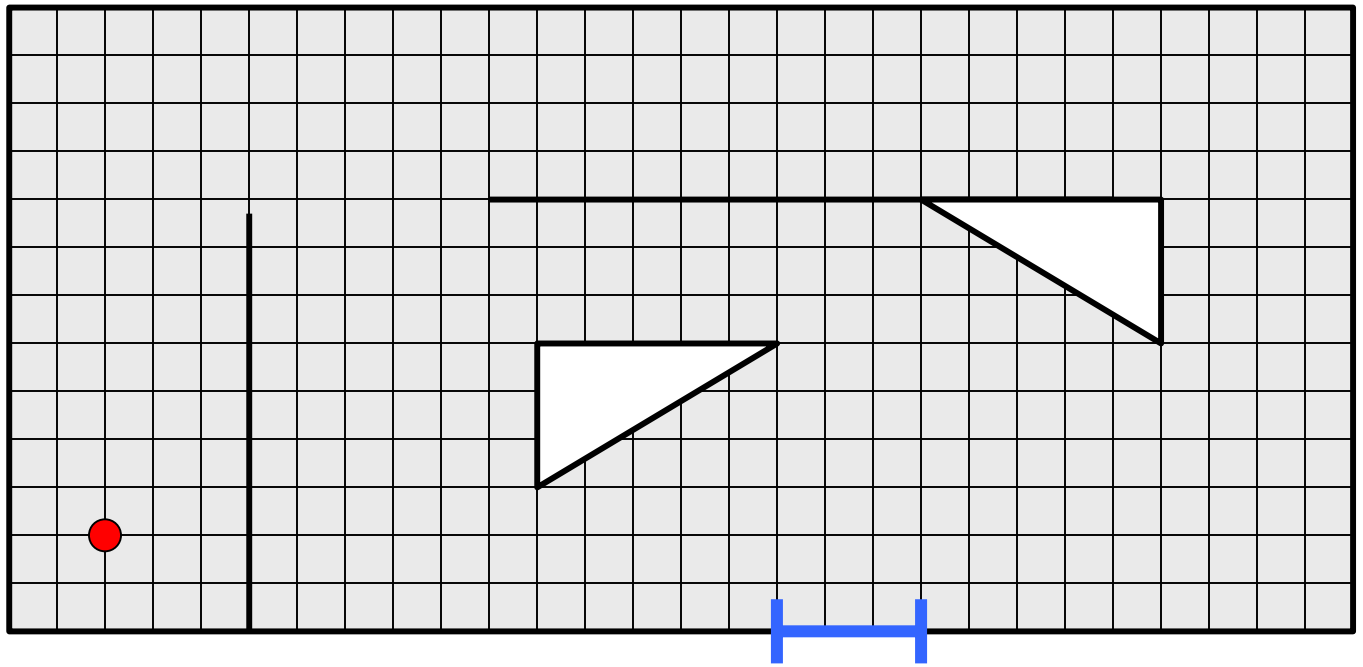
- Robot continues to explore the playing field

Exploring the playing field using model-plan-act approach



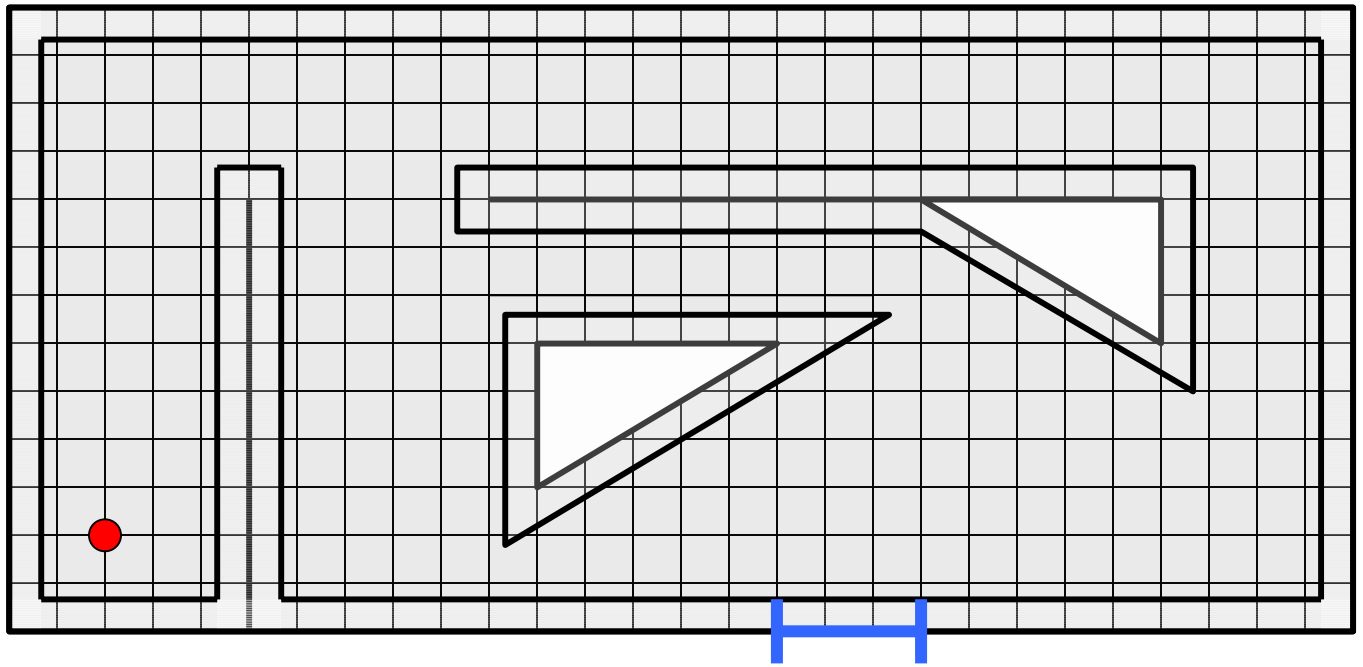
- Robot must recognize when it starts to see areas which it has already explored

Finding a mousehole using model-plan-act approach



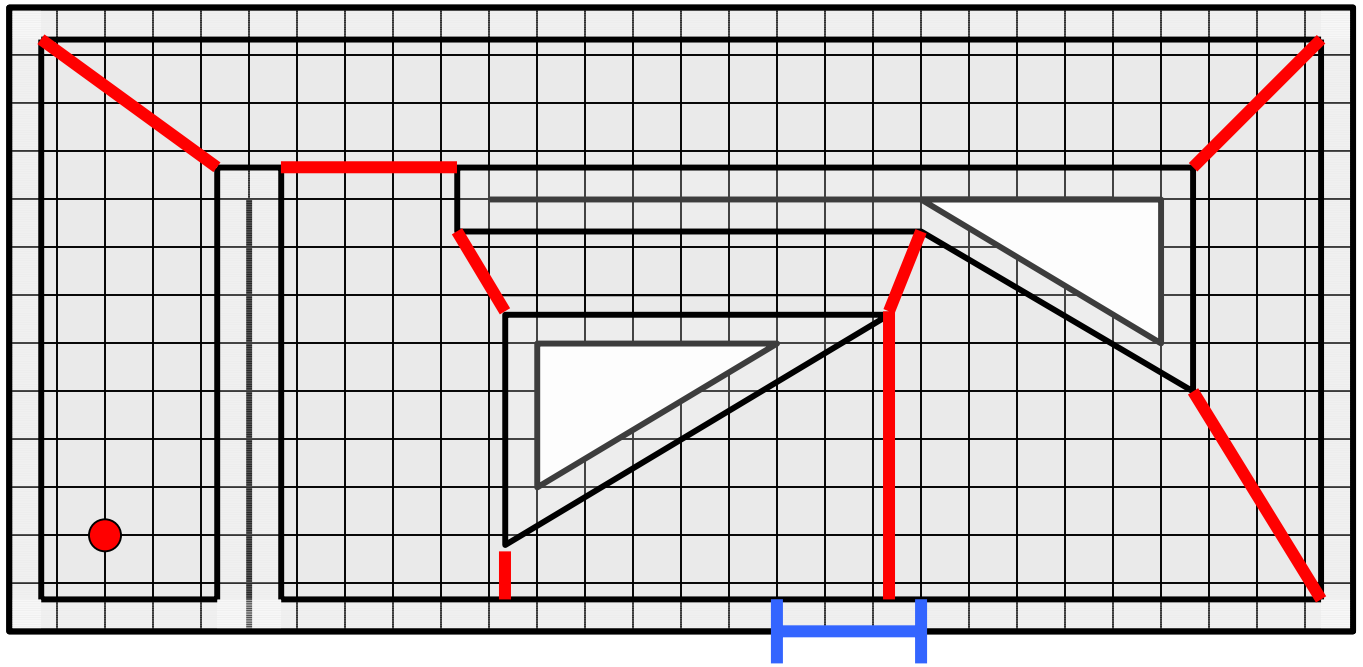
- Given the global map, the goal is to find the mousehole

Finding a mousehole using model-plan-act approach



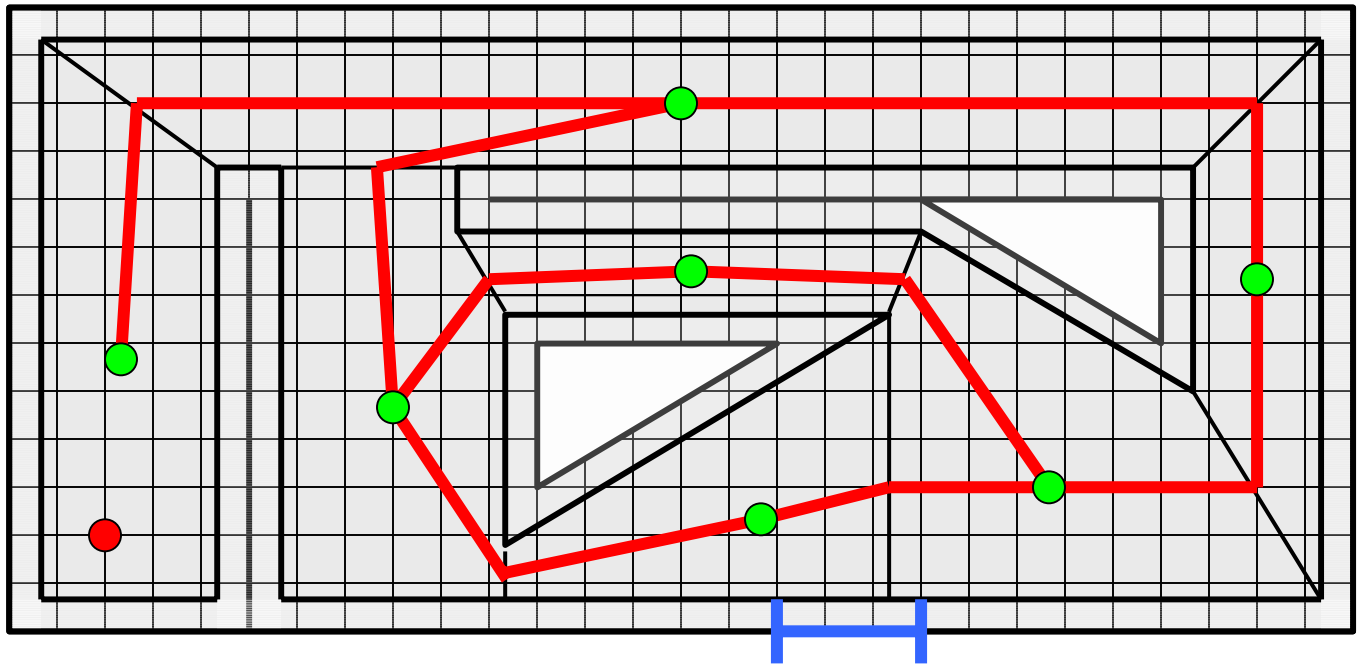
- Transform world into configuration space by convolving robot with all obstacles

Finding a mousehole using model-plan-act approach



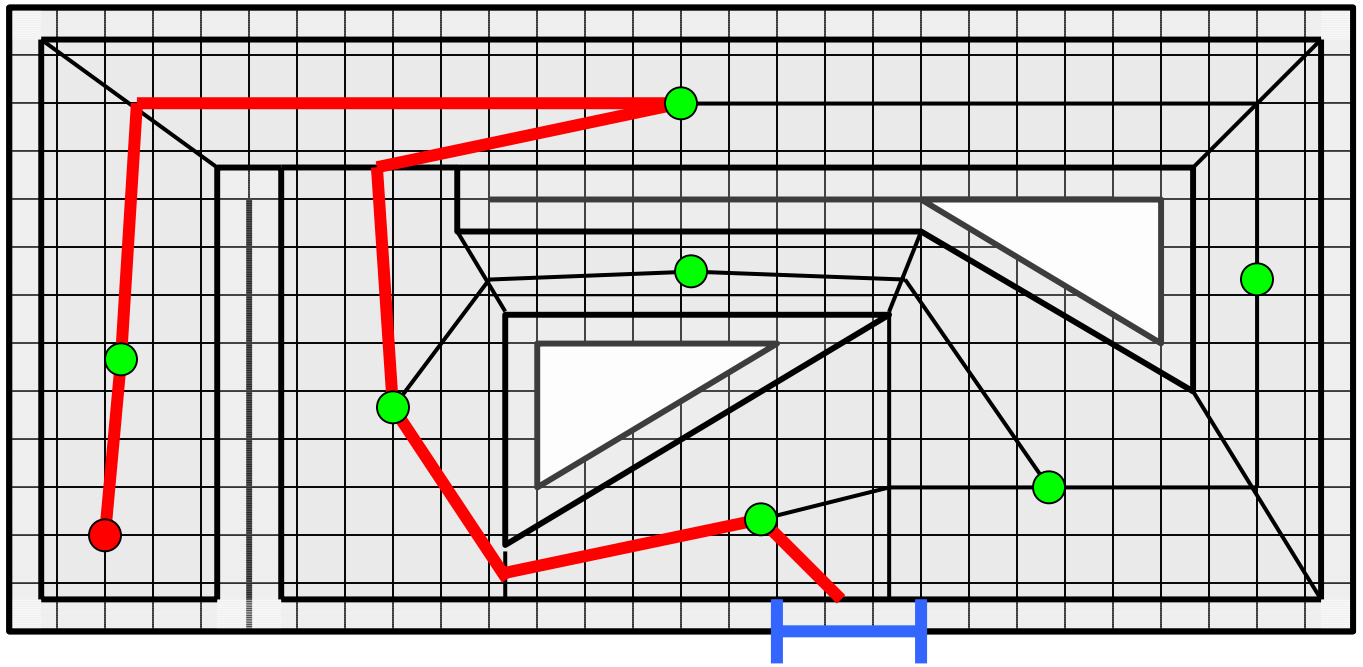
- Decompose world into convex cells
  Trajectory within any cell is free of obstacles

Finding a mousehole using model-plan-act approach



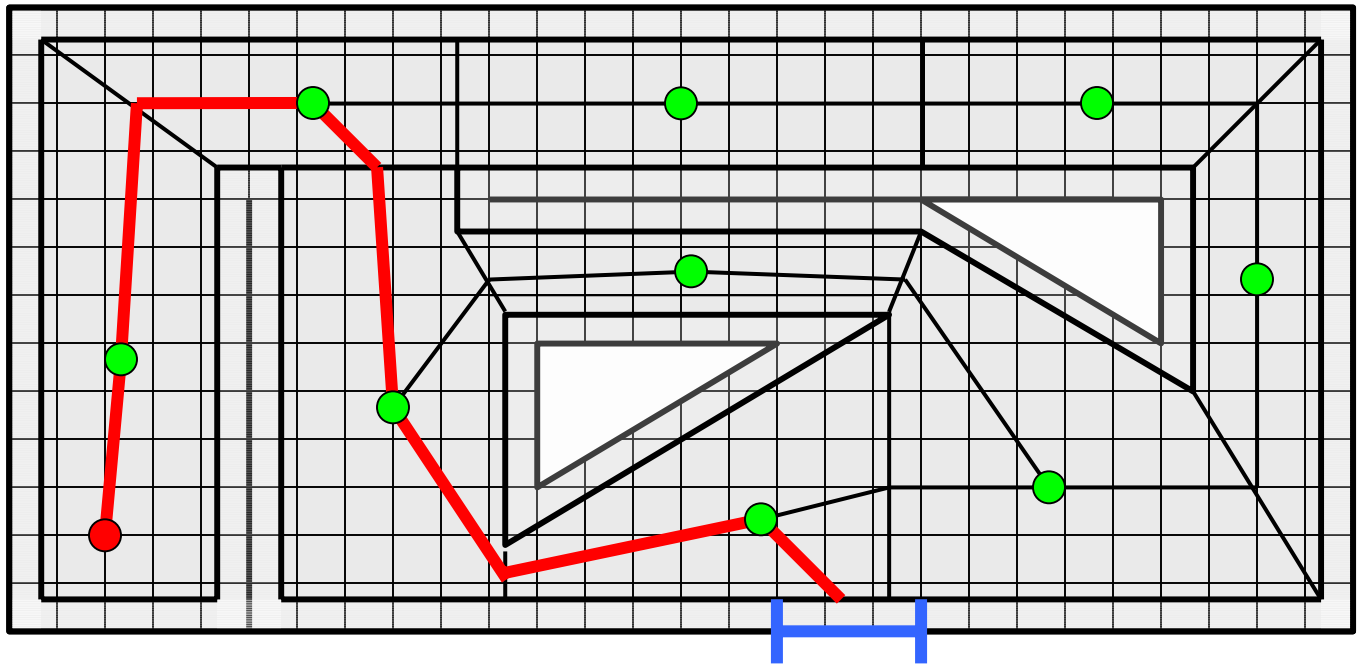
- Connect cell edge midpoints and centroids to get graph of all possible paths

Finding a mousehole using model-plan-act approach



- Use an algorithm (such as the A* algorithm) to find shortest path to goal

Finding a mousehole using model-plan-act approach



- The choice of cell decomposition can greatly influence results

Summary

SECTION 2

Advantages and disadvantages of the model-plan-act approach

Advantages

- Global knowledge in the model enables optimization
- Can make provable guarantees about the plan

Disadvantages

- Must implement all functional units before any testing
- Computationally intensive
- Requires very good sensor data for accurate models
- Models are inherently an approximation
- Works poorly in dynamic environments