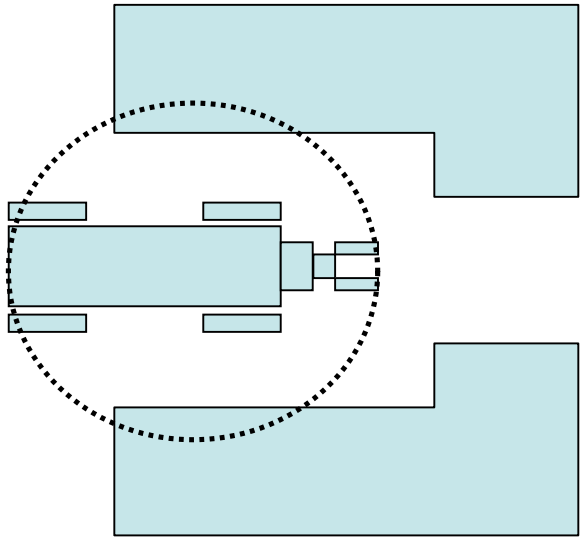
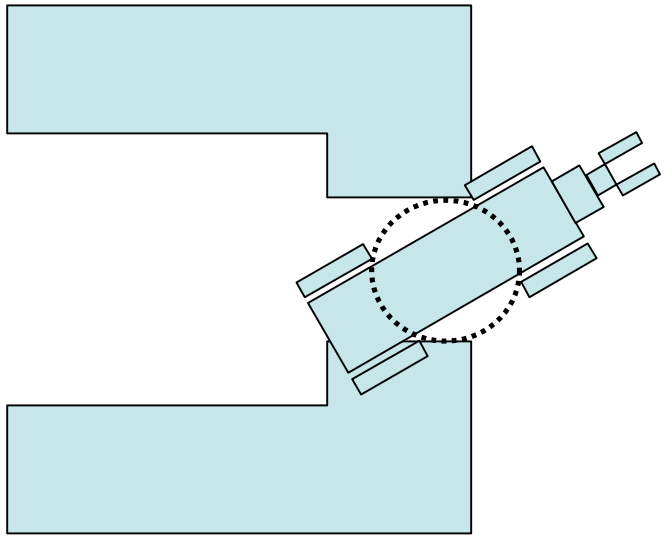
Randomized Algorithms

Scaling Numerical Potential Fields

- The arm makes the robot *really* not round



If we make the bounding box the maximum robot dimension, the robot can't find some valid paths

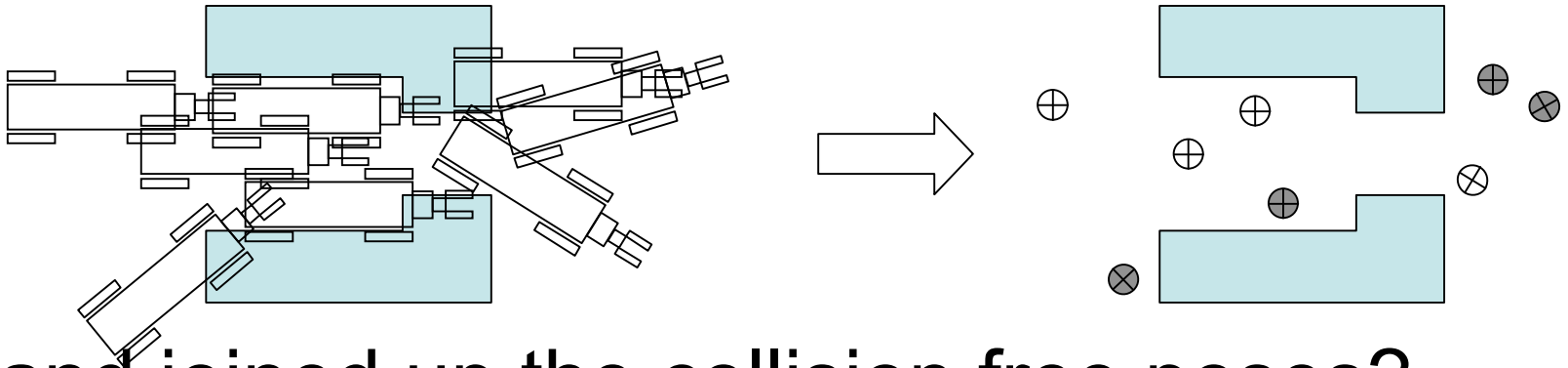


If we make the bounding box the minimum robot dimension, the robot experiences collisions

- We need to plan in a higher dimensional space
  - How many dimensions does this space have?
  - How well will the grid scale?

The Problem Might Be Just The Grid?

- Suppose we sampled poses at random



- and joined up the collision free poses?

- Notice that we now have a graph where nodes have more than just (x,y) attributes

The Algorithm

1) Initialize graph with vertices V={start, goal}
2) Sample a pose ξ
3) Is ξ a collision?
   - If yes, discard ξ and return to 1)
4) Add ξ to set of graph vertices *V*
5) Can the robot get from ξ to some other pose ξ'?
6) If yes, add edge (ξ, ξ') with cost $||\xi-\xi'||$ to set of graph edges E
7) Run Dijkstra's algorithm on graph
8) Does a path exist from start to goal?
   - If yes, return path
   - Else, return to 1

We Need 3 Things

- A way to answer: Is $\xi=(x, y, \theta)$ a collision?
  - This is geometry. Just have to do it.
- A way to answer: Can the robot get from $\xi=(x, y, \theta)$ to $\xi'=(x', y', \theta')$ without collision?
  - A common approximation: does a straight line from ξ to ξ' intersect any obstacles?
  - We can evaluate this in closed form for every point
  - What to do about rotations about a point?
- A sampling strategy
  - A rare strategy: uniform. (Why is this rare?)
  - Gaussian
  - Bridge

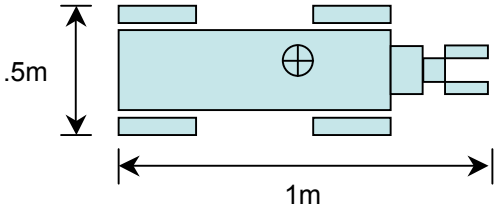
Gaussian Sampling

- Intuition: samples near obstacles are more useful than samples in open space
  - Sample a pose ξ uniformly
  - Sample a distance *d* according to a Gaussian with some predetermined (μ,σ^2)
  - Sample another pose ξ' uniformly in a disc of radius *d*
  - Keep ξ if ξ is in C_{free} and ξ' isn't, or vice versa. Discard both if both are in C_{free} or in C_{obst}.

Bridge Sampling

- Intuition: samples in narrow corridors are more useful than samples in open space
  - Sample a pose ξ uniformly
  - Sample a distance *d* according to a Gaussian with some predetermined (μ,σ^2)
  - Sample another pose ξ' uniformly in a disc of radius *d*
  - Discard both unless both are in C_{obst}.
  - If ξ=midpoint (ξ, ξ') is in C_{free}, then keep ξ''.

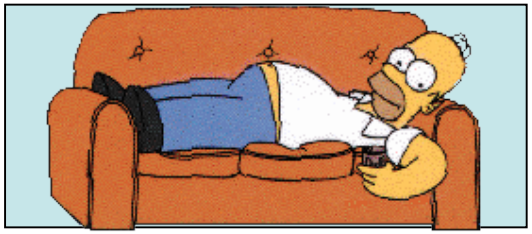
An Example Problem



Assume reference is centre of bounding rectangle.
Assume any intersection of the obstacle with the bounding rectangle is a collision.
Assume point turns are allowed.

Goal: (10,10) ⊕

(5, 7) (7, 7)



(5, 5) (7, 5)

⊕ Start: (1,1)

An Exercise

- Split into pairs
  - One person runs the algorithm
  - The other person answers queries about the world
- Choose a sampling algorithm
- Compute a path from the start to the goal