Day 14

Fundamental Problems in Mobile Robotics

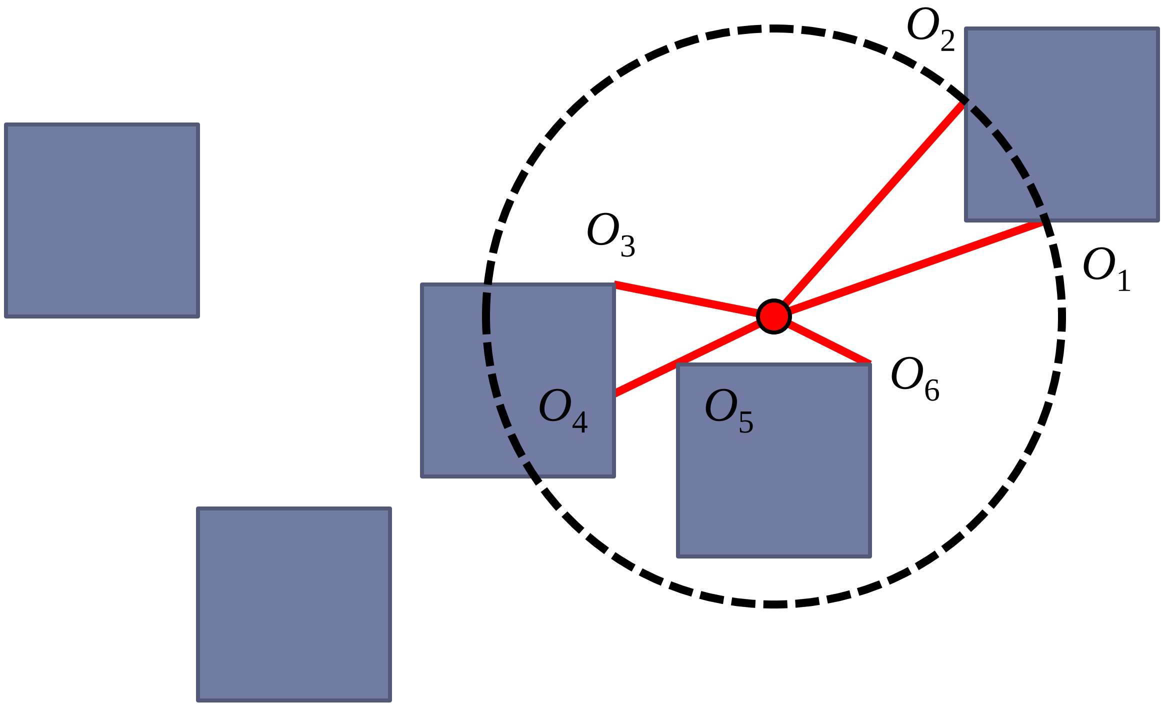
Sensing the Environment

- Bug1 and Bug2 use a perfect contact sensor
- we might be able to achieve better performance if we equip the robot with a more powerful sensor
- a range sensor measures the distance to an obstacle; e.g., laser range finder
  - emits a laser beam into the environment and senses reflections from obstacles
  - essentially unidirectional, but the beam can be rotated to obtain 360 degree coverage

Tangent Bug

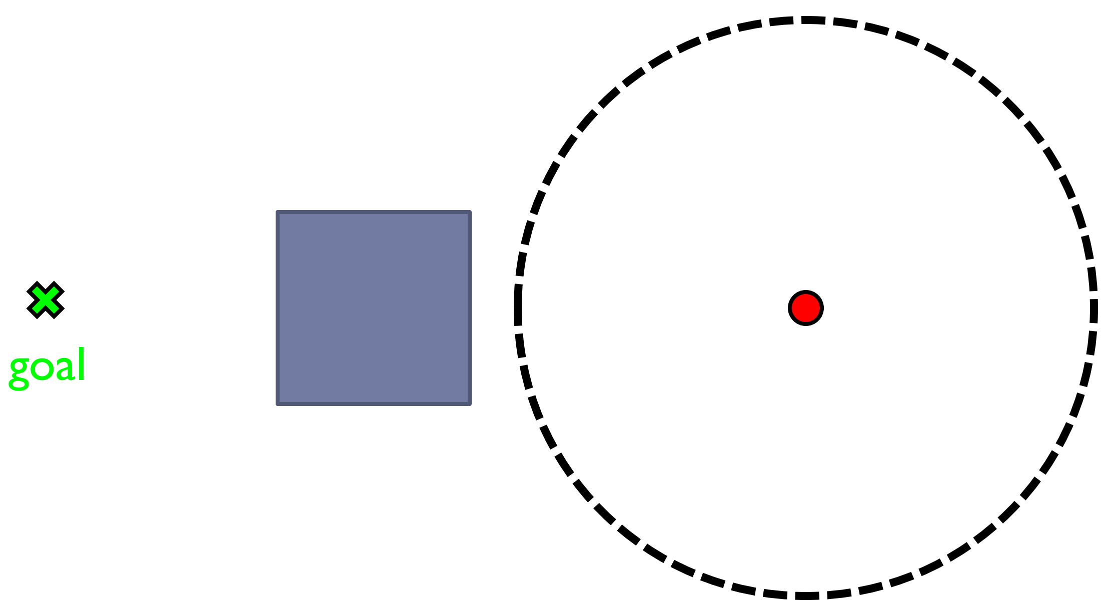
- assumes a perfect 360 degree range finder with a finite range
  - measures the distance $\rho(x, \theta)$ to the first obstacle intersected by the ray from x with angle θ
  - has a maximum range beyond which all distance measurements are considered to be $\rho = \infty$
- the robot looks for discontinuities in $\rho(x, \theta)$

Tangent Bug



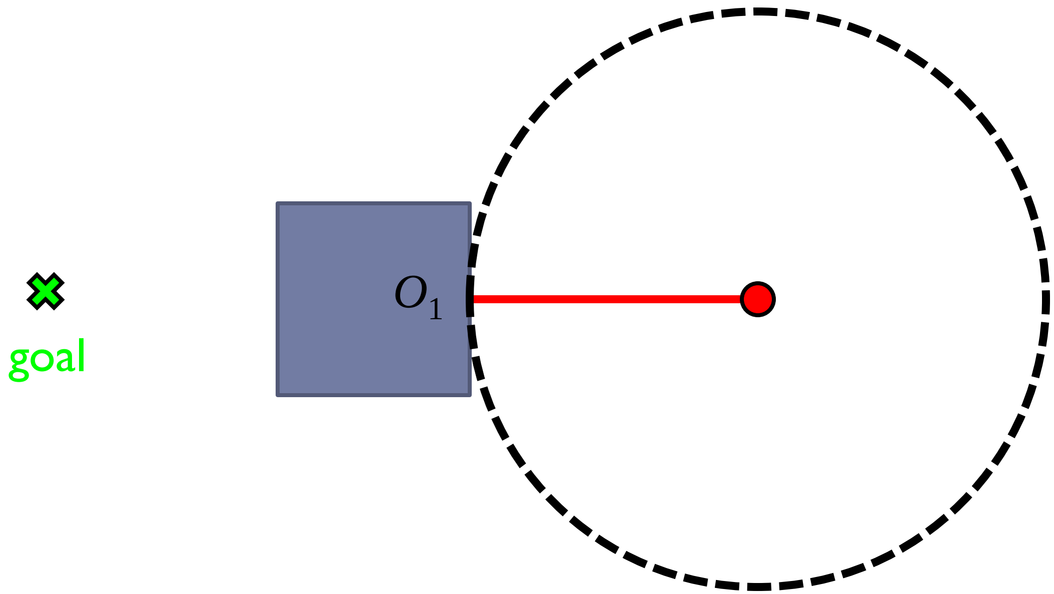
Tangent Bug

- currently, bug thinks goal is reachable



Tangent Bug

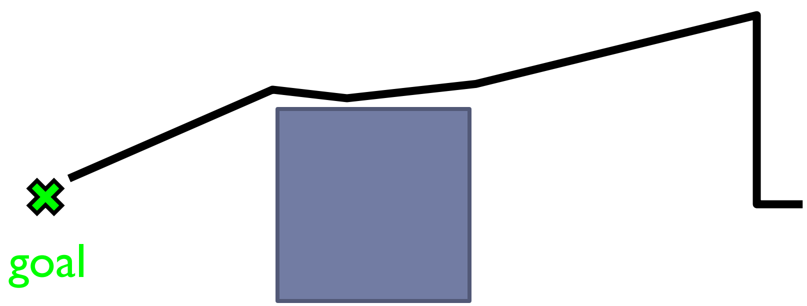
- once the obstacle is sensed, the bug needs to decide how to navigate around the obstacle



- move towards the sensed point O_i that minimizes the distance $d(x, O_i) + d(O_i, q_{\text{goal}})$ (called the heuristic distance)

Tangent Bug

- if the heuristic distance starts to increase, the bug switches to boundary following



- full details
  - *Principles of Robot Motion: Theory, Algorithms, and Implementations*
  - http://www.library.yorku.ca/find/Record/2154237
- nice animation
  - http://www.cs.cmu.edu/~motionplanning/student_gallery/2006/st/hw2pub.htm

Localization for a Point Robot

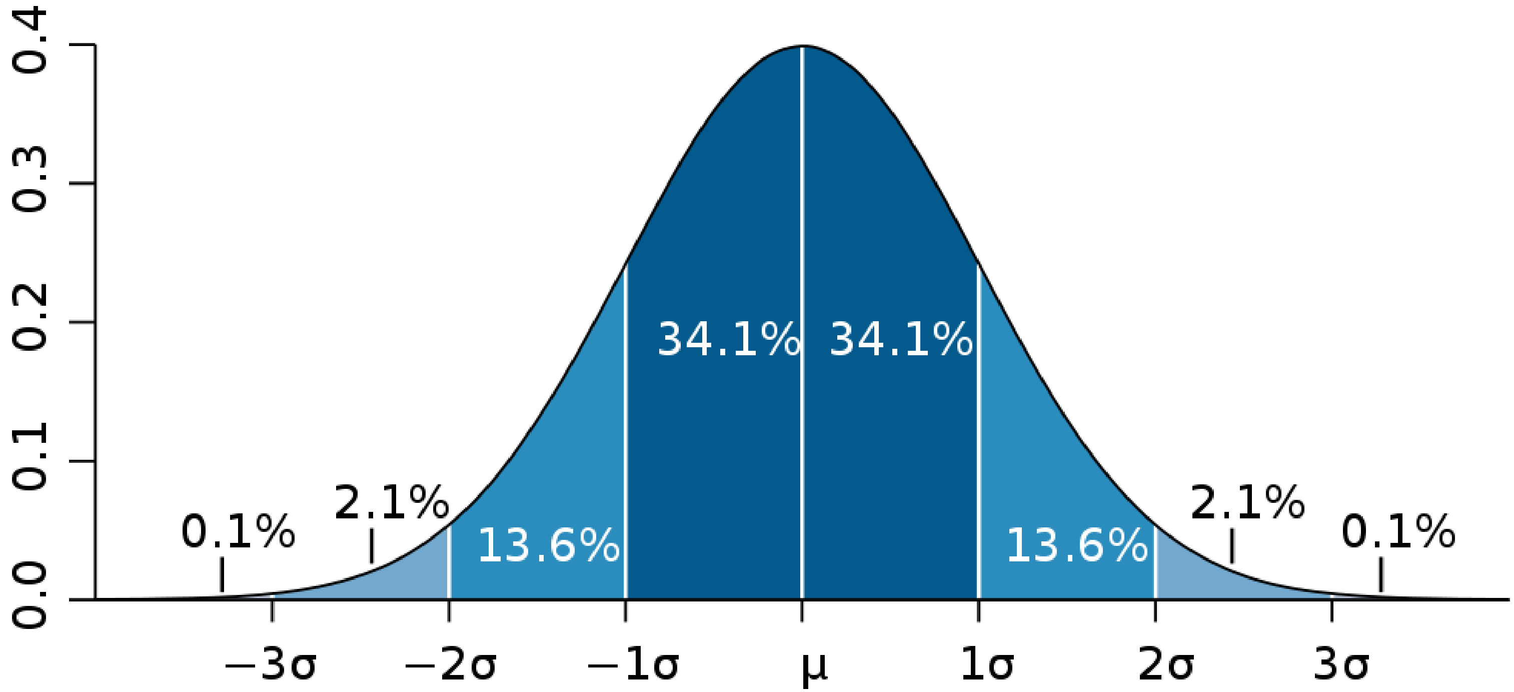
- Bug1 and Bug2 assume that the robot can perfectly sense its position at all times
- consider a $1D$ point robot (moves on the x-axis) that moves a distance Δx_i
  - after taking N steps starting from x_0 it can be shown that (textbook Chapter 2):

$$\mathrm{E}\left[x_N\right] = x_0 + \sum_{i=1}^{N} \Delta x_i$$

$$\mathrm{Var}\left[x_N\right] = N\sigma^2$$

Characterizing Error

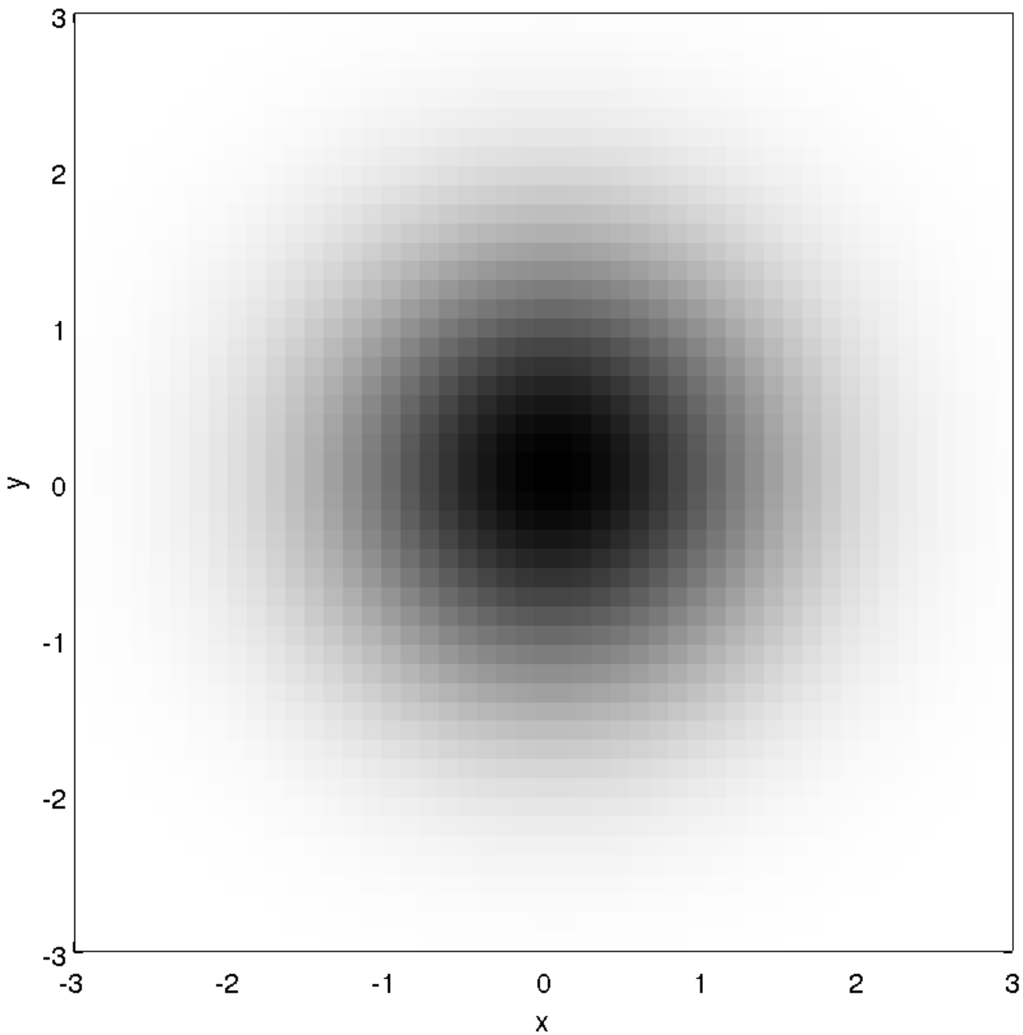
- $1D$ normal, or Gaussian, distribution
  - σ standard deviation
  - $\Sigma = \sigma^2$ variance



Characterizing Error

- in $2D$
  - isotropic

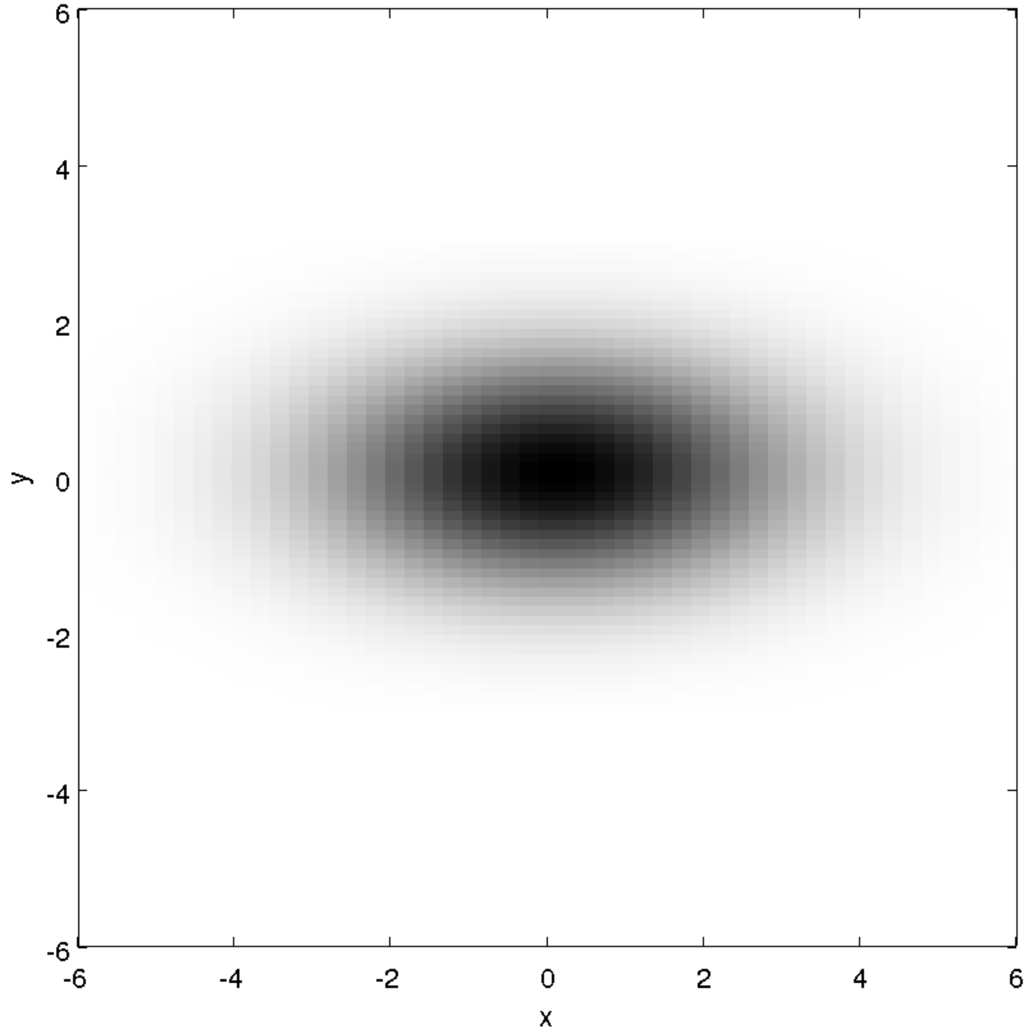
$$\Sigma = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$



Characterizing Error

- in $2D$
  - anisotropic

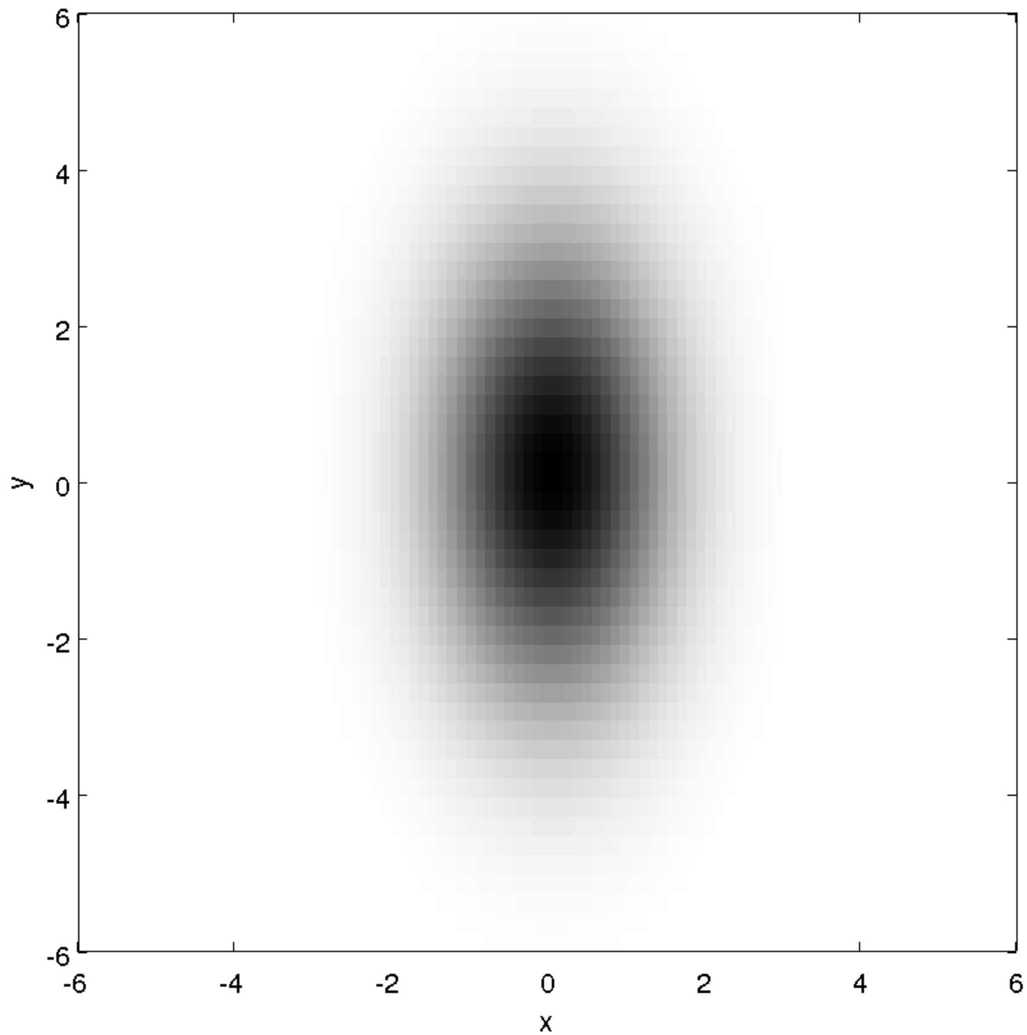
$$\Sigma = \begin{bmatrix} 4 & 0 \\ 0 & 1 \end{bmatrix}$$



Characterizing Error

- in $2D$
  - anisotropic

$$\Sigma = \begin{bmatrix} 1 & 0 \\ 0 & 4 \end{bmatrix}$$



Characterizing Error

- in $2D$
  - anisotropic

$$\Sigma = \begin{bmatrix} 2.5 & 1.5 \\ 1.5 & 2.5 \end{bmatrix}$$