CS 369: Introduction to Robotics

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HAVERFORD
COLLEGE

Admin

- Lab 5 due tomorrow

- Mid-semester feedback form

Outline for today

- Nonparametric filters

Nonparametric filters

- Do not rely on a fixed functional form of the posterior
- Approximate posteriors by a finite number of values, each roughly corresponding to a region in state space
  - Decomposing the state space
  - Drawing random samples from the posterior distribution

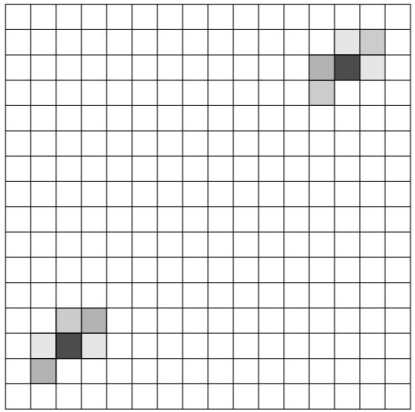
Histogram filter

Decomposes the state space into finitely many regions, and represent the cumulative posterior for each region by a single probability value.

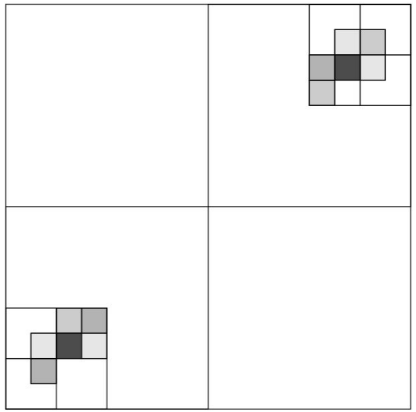
1: **Algorithm Discrete_Bayes_filter**($\{p_{k,t-1}\}, u_t, z_t$):
2: for all k do
3: $\bar{p}_{k,t} = \sum_i p(X_t = x_k \mid u_t, X_{t-1} = x_i)\, p_{i,t-1}$
4: $p_{k,t} = \eta\, p(z_t \mid X_t = x_k)\, \bar{p}_{k,t}$
5: endfor
6: return $\{p_{k,t}\}$

Decomposition techniques

- Static techniques rely on a fixed decomposition that is chosen in advance
- Dynamic techniques adapt the decomposition to the specific shape of the posterior distribution
- Selective updating



Grid representation



Density tree

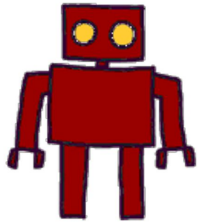
Particle filter

Represents the posterior by a set of random state samples (particles) drawn from this posterior.

1: **Algorithm Particle_filter**($\mathcal{X}_{t-1}, u_t, z_t$):
2: $\bar{\mathcal{X}}_t = \mathcal{X}_t = \emptyset$
3: for $m = 1$ to M do
4: sample $x_t^{[m]} \sim p(x_t \mid u_t, x_{t-1}^{[m]})$
5: $w_t^{[m]} = p(z_t \mid x_t^{[m]})$
6: $\bar{\mathcal{X}}_t = \bar{\mathcal{X}}_t + \langle x_t^{[m]}, w_t^{[m]} \rangle$
7: endfor
8: for $m = 1$ to M do
9: draw i with probability $\propto w_t^{[i]}$
10: add $x_t^{[i]}$ to $\mathcal{X}_t$
11: endfor
12: return $\mathcal{X}_t$

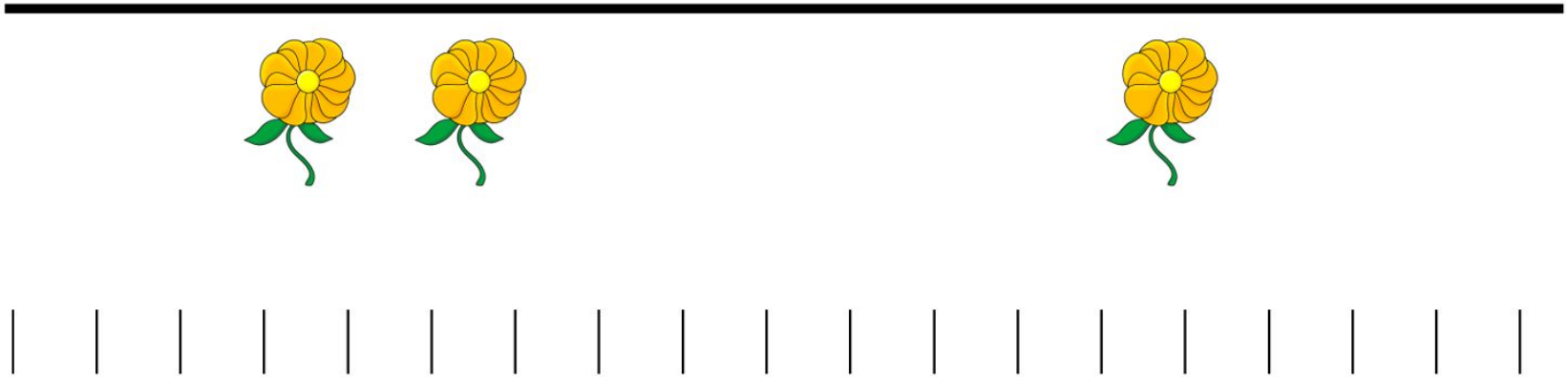
Example revisited

- Same robot and flower garden map
- This time, track samples (particles)

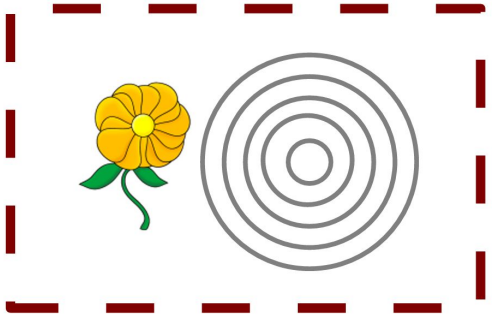


Example revisited

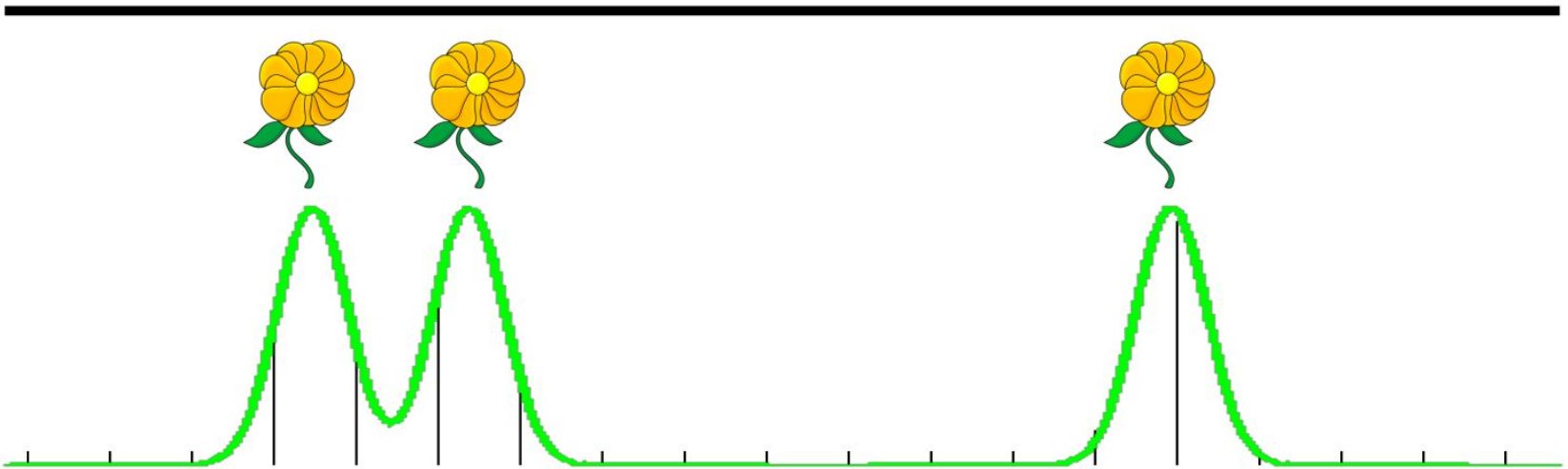
- Initially, no idea where we are
- The particle’s height represents its weight (importance factor)



Example revisited

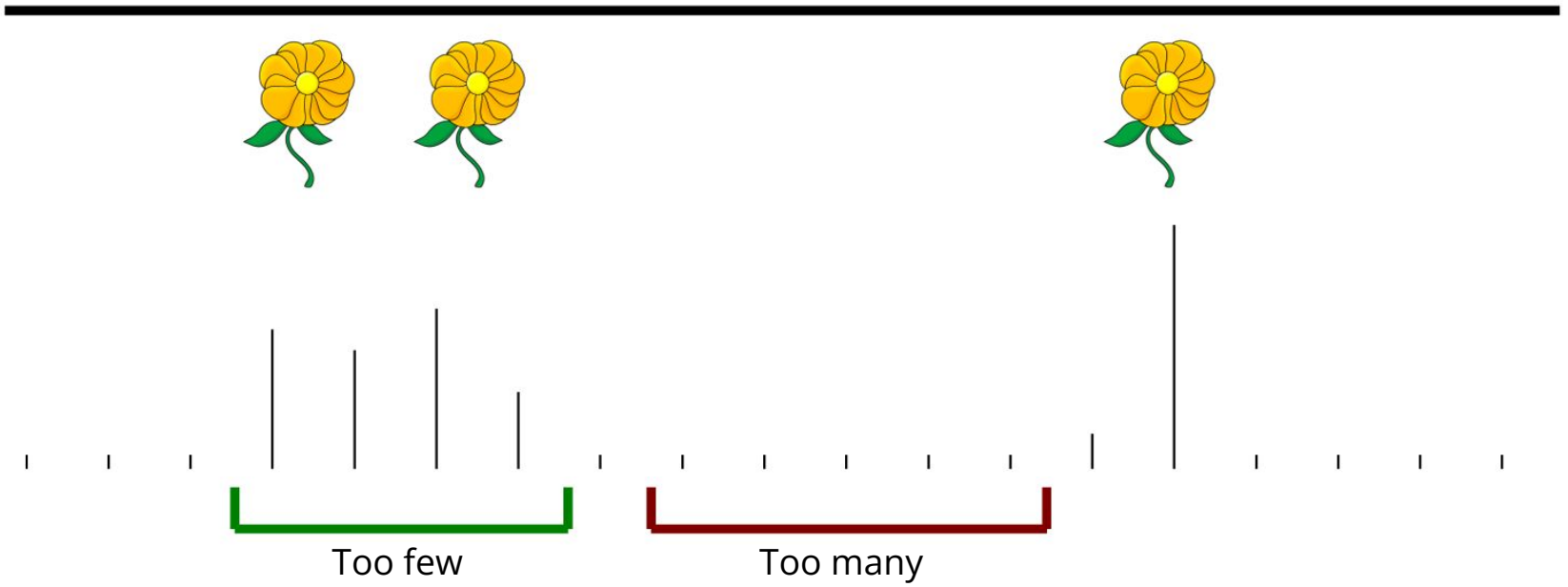


- First observation
- Evaluate sensor model at particles



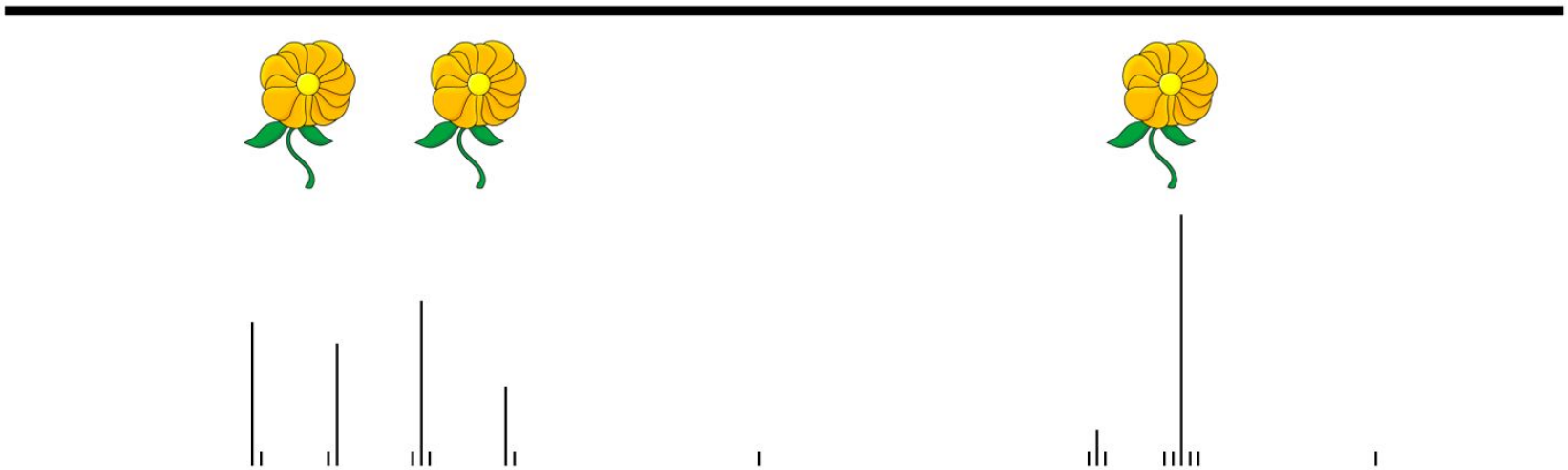
Example revisited

New belief



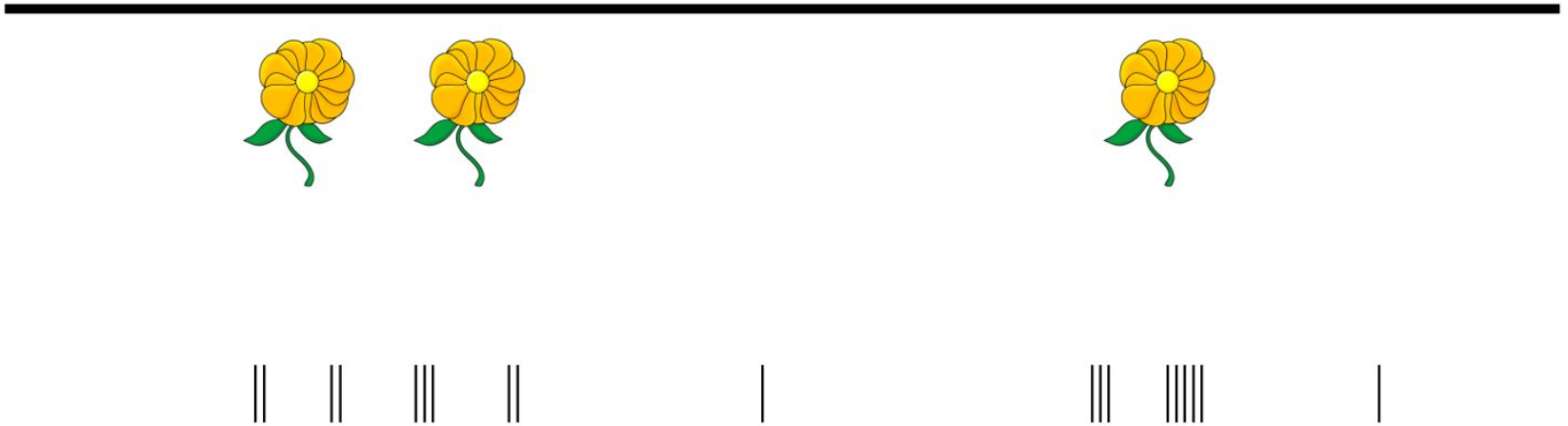
Example revisited

- Resample particles
- Higher weight particles get more particles allocated near them

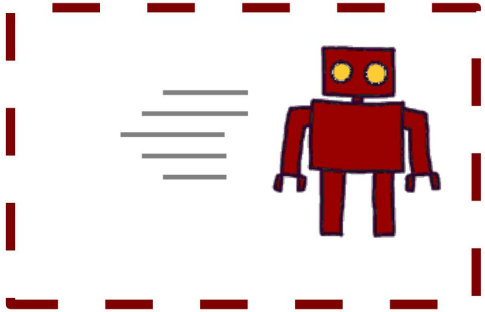


Example revisited

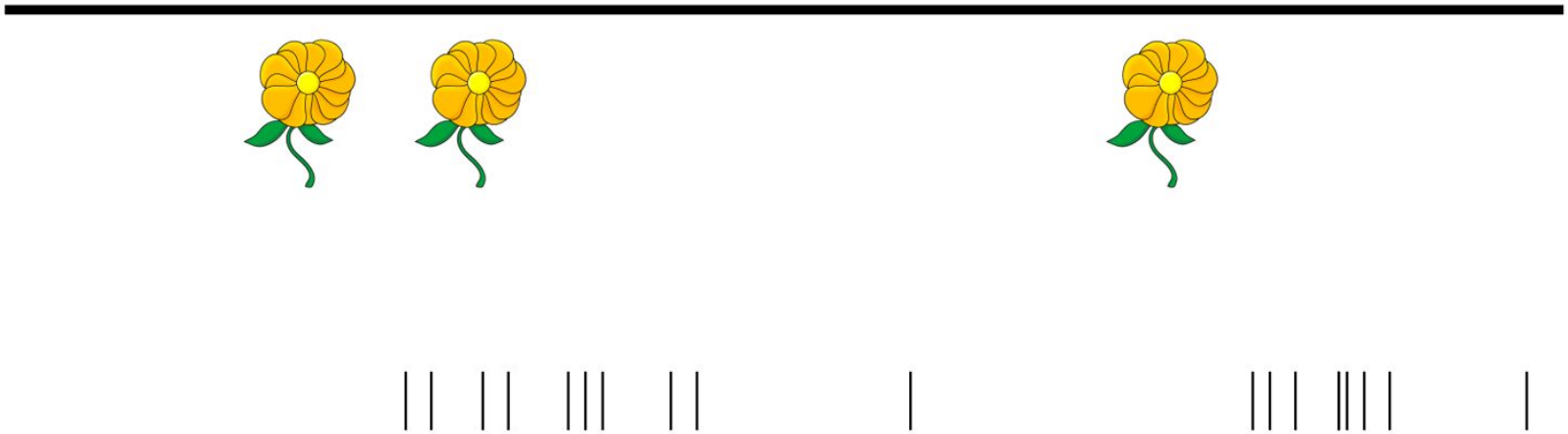
Reset weights



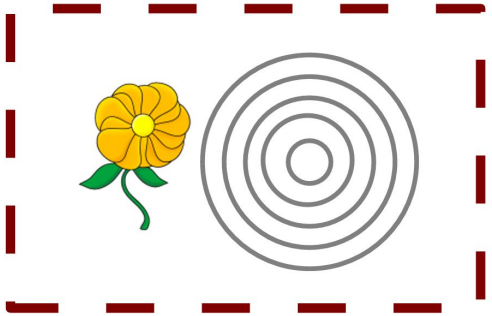
Example revisited



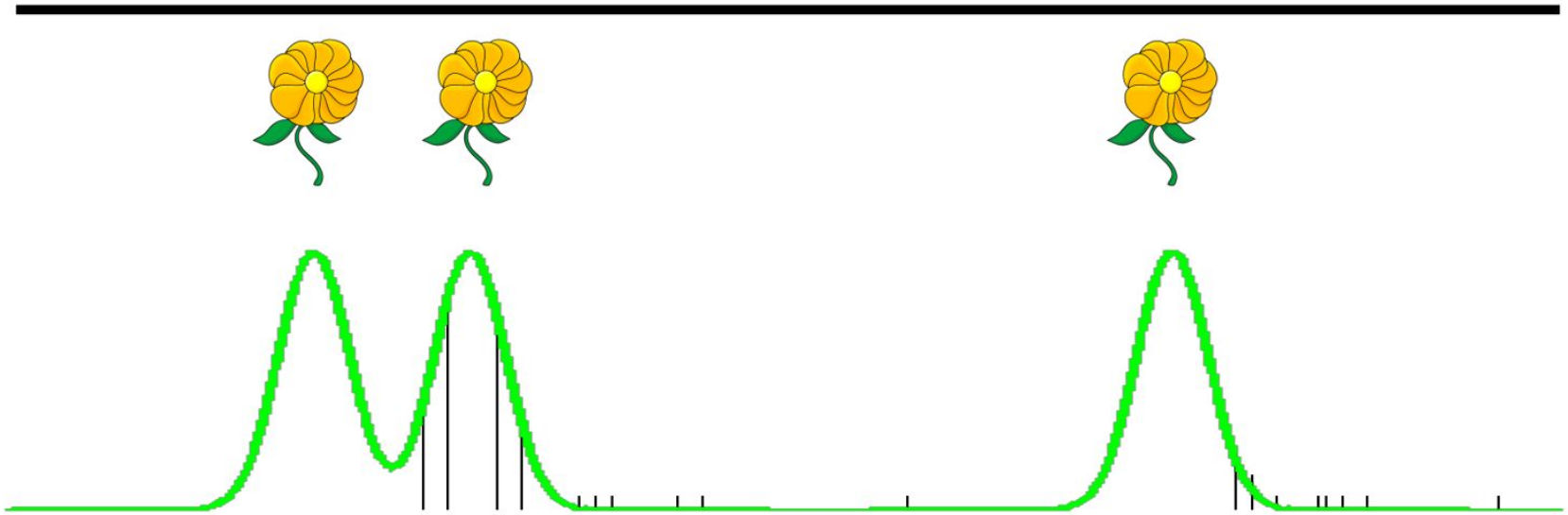
Robot moves, motion update



Example revisited



Observation update



Example revisited

Estimate is best particle