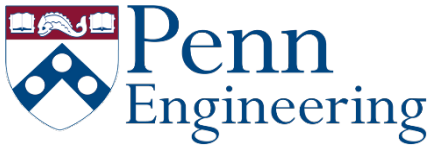
Robotics

Estimation and Learning
with Dan Lee

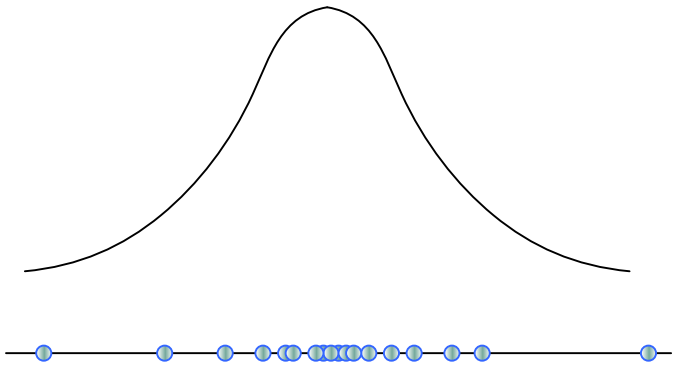
Week 4.
Localization

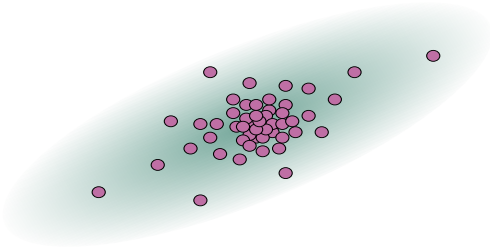
4.3 Particle Filter



Particle Filter

- Samples approximate a probability distribution
- Fast and efficient non-parametric model
- Ability to represent multimodal distributions
  - Mixtures of Gaussians, multi-hypothesis Kalman Filter



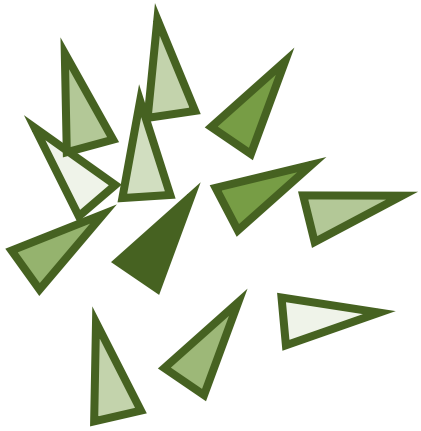


Particle Filter

- Dirac Delta function
  - Sigma is going to zero, Gaussian distribution
- Particle Filter : Limit of Gaussian mixtures when $\sigma \to 0$ (variances shrink to zero)

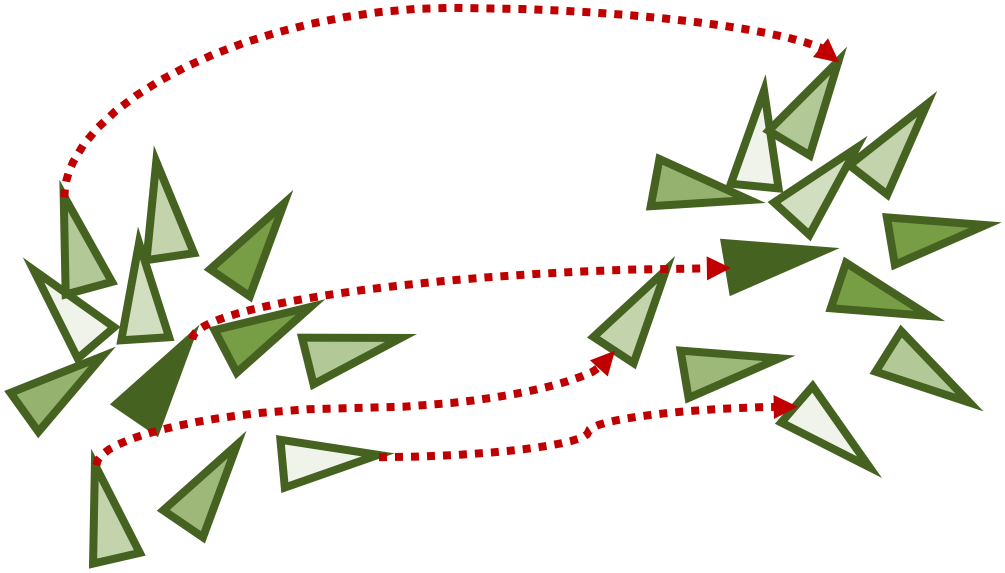
Initial Population

- Initial group of particles represents the underlying distribution of the belief state
- Particle is comprised of (pose, weight)
- Here, darker colors represents a higher *weight*
  - Represents probability, such that *weight = prob(pose)*



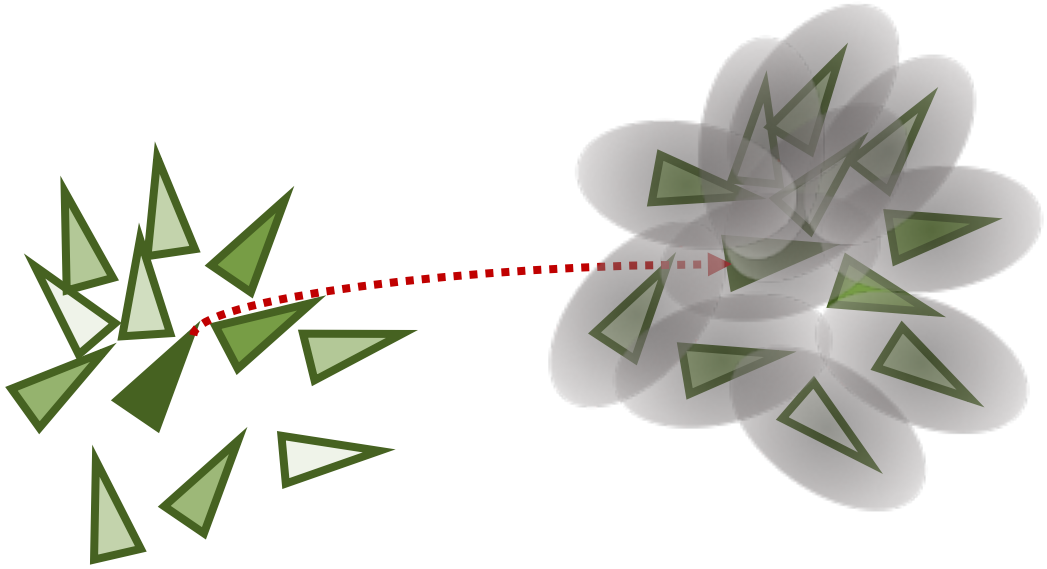
Odometry Update

- Move the particles based on odometry information
- Each particle represents a possible pose, so individually must be moved via its local frame



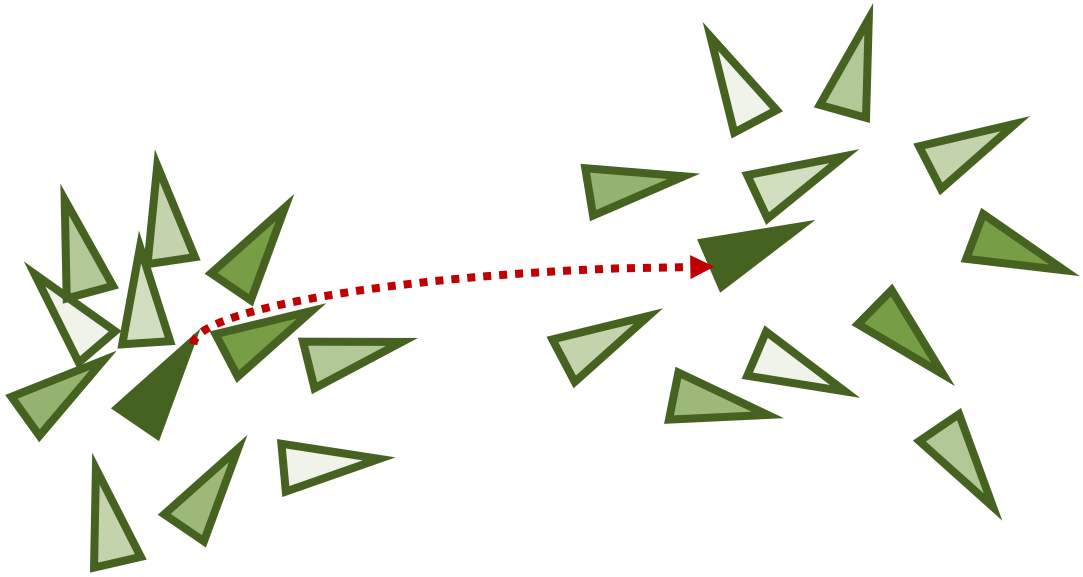
Odometry Update

- Include odometry noise model
- Sampled for each particle from the odometry noise distribution $p_i' = p_i + \mathcal{N}(0, \Sigma)$



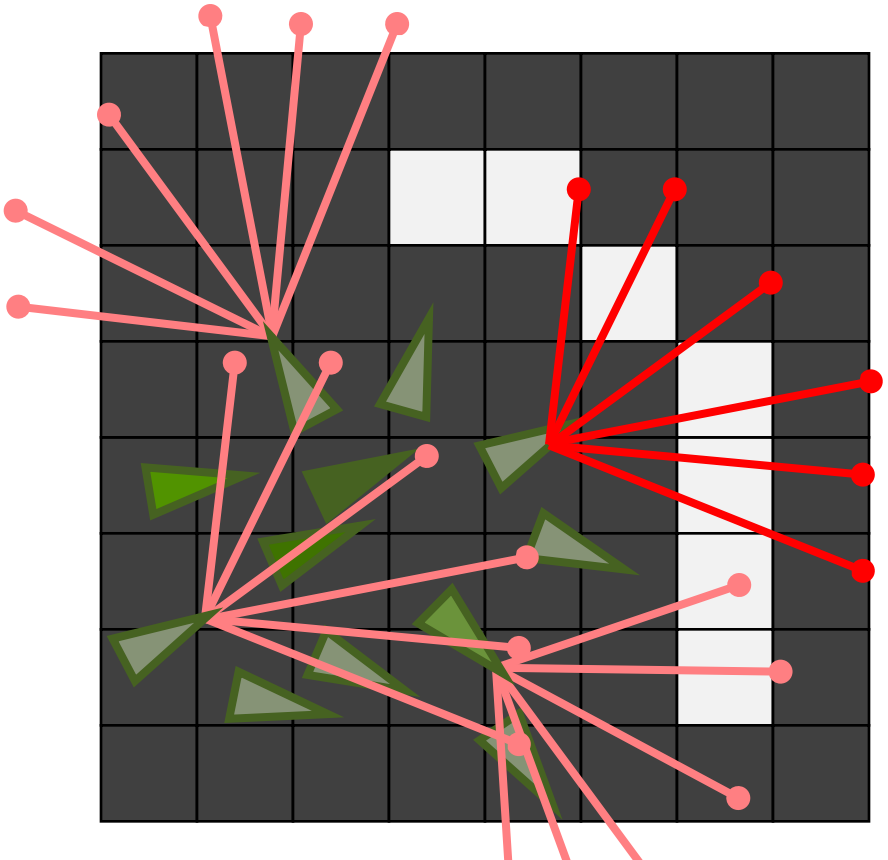
Odometry Update

- Dispersion of particles represents the added uncertainty from moving



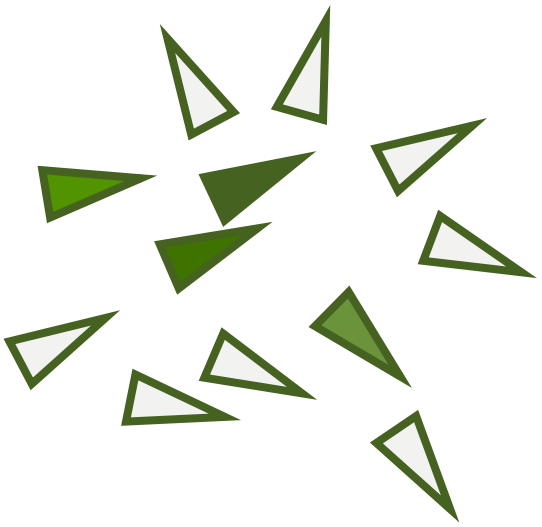
Correlation Update

- The weights of the particles can be updated based on LIDAR correlation data, $w_i' = w_i \cdot corr(p_i)$



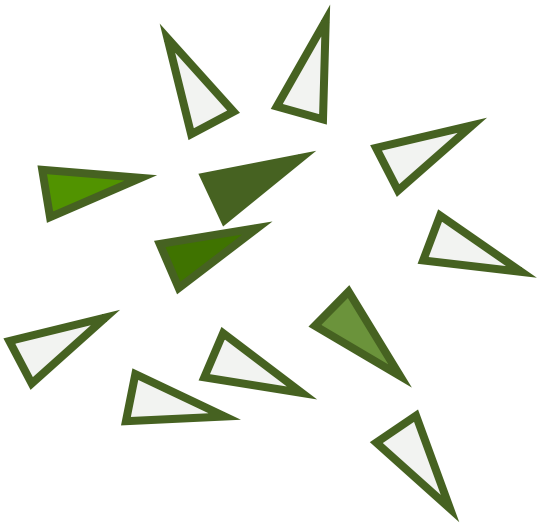
Correlation Update

- The new set of particles capture the distribution after odometry and sensor measurement
- However, this may not be the optimal set to represent the distribution



Particle Resampling

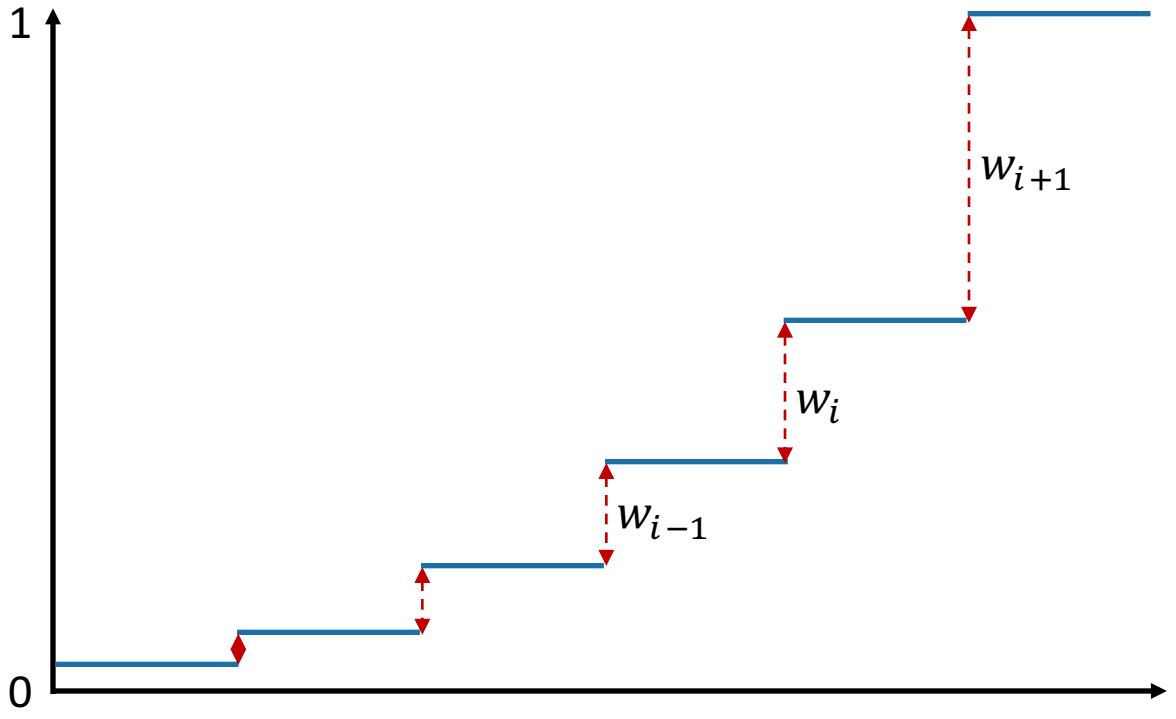
- Check a resampling criterion – the number of effective particles
- If the number of effective particles is too low, then *resample* to increase the effective number



$$n_{effective} = \frac{(\sum_i w_i)^2}{\sum_i w_i^2}$$

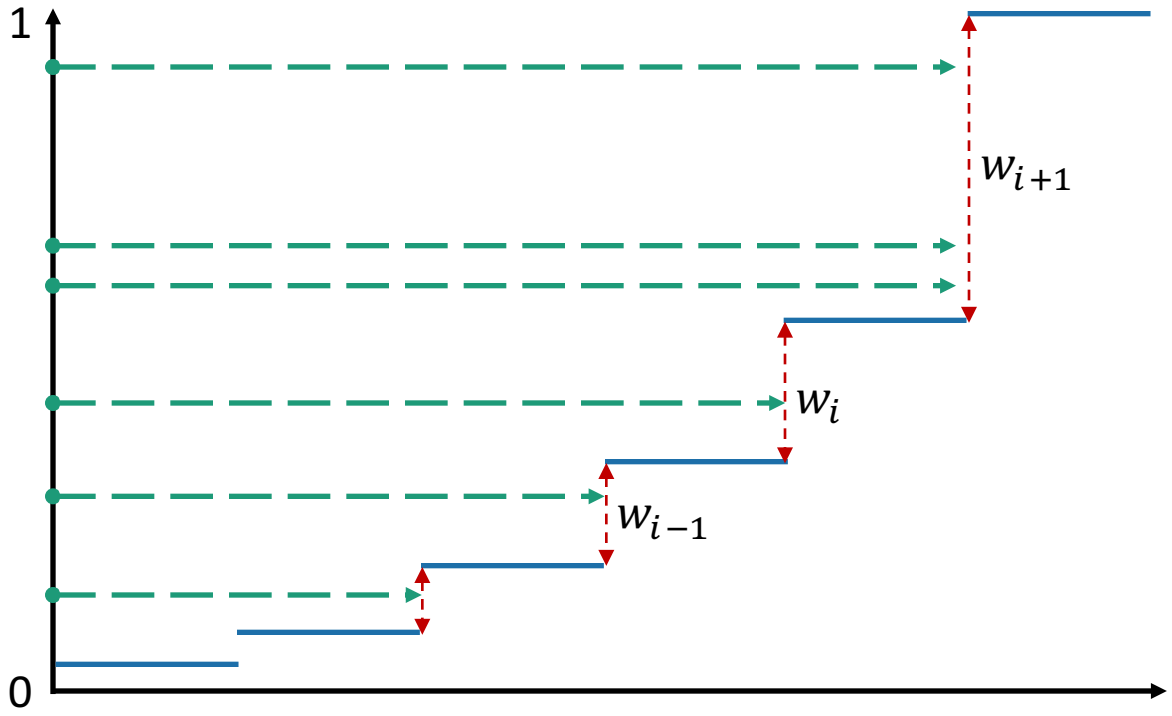
Particle Resampling

- Use the cumulative probability to aid in resampling
- Sum of normalized weights is 1



Particle Resampling

- Sample number uniformly between 0 and 1 of the cumulative range, and find which w_i includes that number



Particle Resampling

- The particles with the indices found in the resampling approach become the new set of particles to be fed into the next odometry update
- Particles may be duplicated, but the odometry noise will differentiate these particles.