An introduction to particle filtering

Sensor fusion & nonlinear filtering

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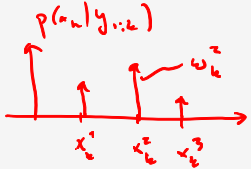
- Gaussian filtering is a useful technique to perform nonlinear filtering.
- Limitations: Gaussian filtering methods do not perform well when
  - the models are highly nonlinear,
  - when the posterior distribution is significantly non-Gaussian, e.g., a multimodal density.
- For such problems we need a different type of approximation to the posterior density!

Basic idea

- Use a non-parametric representation

$$p(\mathbf{x}_k|\mathbf{y}_{1:k}) \approx \sum_{i=1}^{N} w_k^{(i)} \delta(\mathbf{x}_k - \mathbf{x}_k^{(i)})$$



where $\mathbf{x}_k^{(i)}$ are particles and $w_k^{(i)}$ are associated weights.

- Filtering is (essentially) performed by
  1. propagating $\mathbf{x}_{k-1}^{(i)} \rightarrow \mathbf{x}_k^{(i)}$ over time,
  2. updating the weights, $w_k^{(i)}$.
- Basic version: $\mathbf{x}_k^{(i)} \sim p(\mathbf{x}_k|\mathbf{x}_{k-1}^{(i)})$, $w_k^{(i)} \propto w_{k-1}^{(i)} p(\mathbf{y}_k|\mathbf{x}_k^{(i)})$.

After this lecture you should be able to

- explain the concepts of Monte Carlo sampling and importance sampling,
- describe what particle degeneracy is and why resampling is useful,
- and implement a particle filter.