Particle-Based Approximate Inference

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Topics

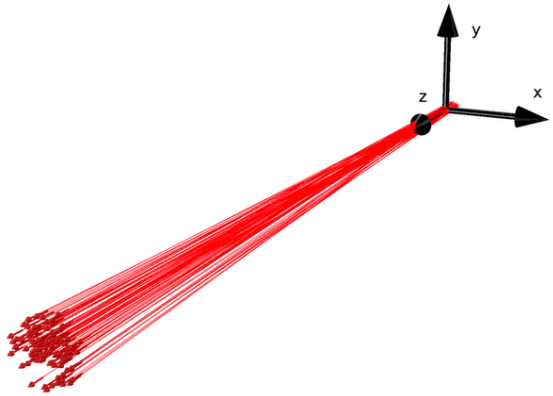
- Approximate Inference Methods
- Terminology of particles (Physics)
- Particle methods and PGMs
- Characterization of Particle Methods
- Task for Particle Methods
- Names of Sampling Methods

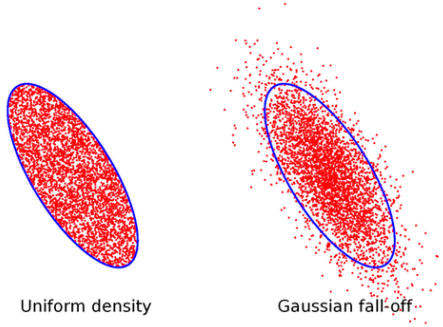
Approximate Inference Methods

- Variational inference methods
  - Lead to algorithms similar to factor manipulation methods of exact inference
- Particle-based methods
  - Very different class of methods
  - We approximate the joint distribution as a set of instantiations to all or some of the variables
    - Instantiations are often called particles
    - They are designed to provide a good representation of the overall probability distribution

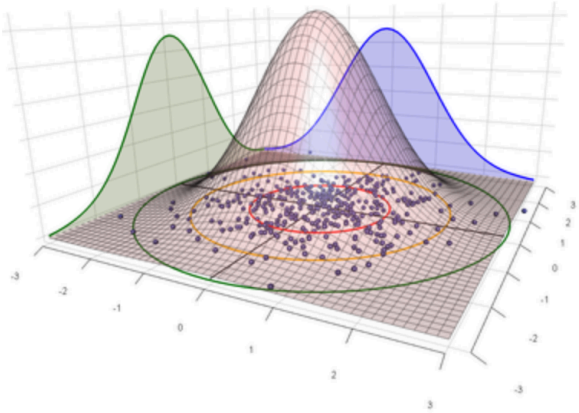
Particles in Physics

- Charged particle beams in phase space
  1. Uniform over ellipse
  2. Gaussian (86% lie within ellipse





- Particles from symmetric 2D Gaussian

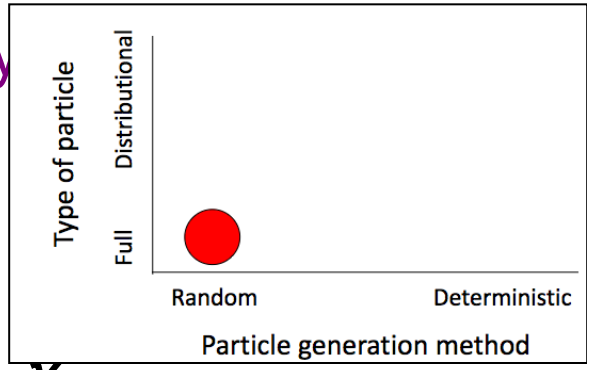


Particle-based Methods in PGMs

- Particle-based methods approximate inference by generating multiple samples from the distribution that a graph factorizes

Two characterizations of Particle Methods

1. Particle generation method
   - Wide variety, two extremes are
     1. Particles from a deterministic process
     2. Sample particles from some distribution
     - Many variations within each category



2. Type of particle
   - Full particles
     - Assignment to all network variables $\boldsymbol{\chi}$
       - Disadvantage: particle occupies only a small part of space
   - Collapsed particle
     - Specifies assignment $\boldsymbol{w}$ to subset of variables $\boldsymbol{W}$
       - Associating with it the conditional distribution $P(\boldsymbol{\chi} \mid \boldsymbol{W})$ or some summary of it

Task for Particle-based Methods

- Given a distribution $P(\boldsymbol{\chi})$ we want to estimate the probability of some event $\boldsymbol{Y}=\boldsymbol{y}$ relative to P for some $\boldsymbol{Y} \varepsilon \boldsymbol{\chi}$ and $\boldsymbol{y} \varepsilon Val(\boldsymbol{Y})$
- More generally we want to estimate the expectation of some function $f(\boldsymbol{\xi})$ relative to P

Methods discussed

1. Forward Sampling
   - Simplest possible method
   - Simply generates samples from original network
2. Likelihood weighting and Importance sampling
   - Significantly improved method
   - Generates samples closer to posterior distribution
3. Markov chain Monte Carlo
   - Sampling process that generates, as it converges, samples arbitrarily close to posterior

- Apply mainly to Bayesian Networks, not Markov networks