Markov Chain Monte Carlo (MCMC)

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- Learn how exploit specifics of your problem to speed up MCMC

Markov Chain Monte Carlo (MCMC)

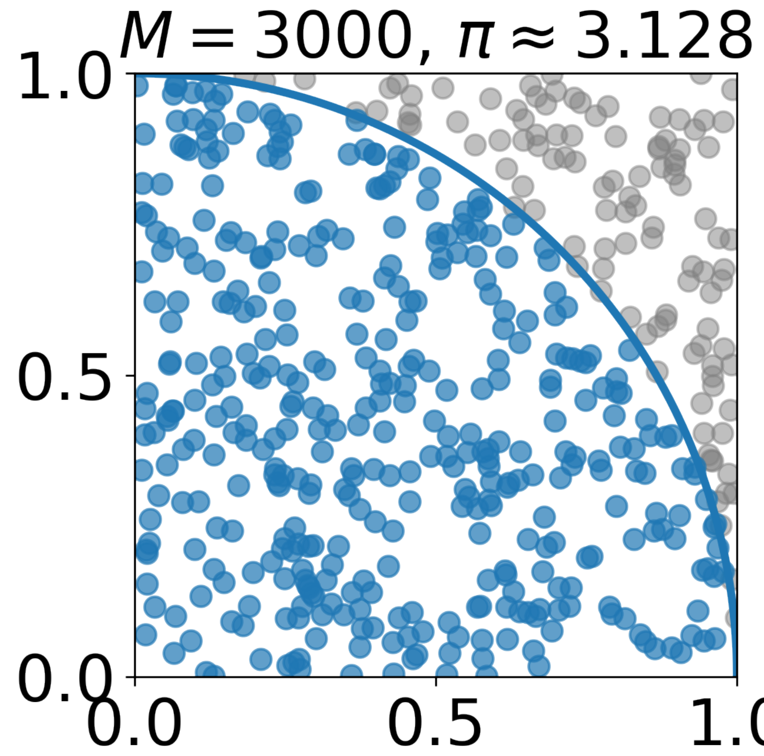
- MCMC — silver bullet of probabilistic modeling
- Learn how exploit specifics of your problem to speed up MCMC
- Understand the limitations

Monte Carlo

Monte Carlo

Monte Carlo

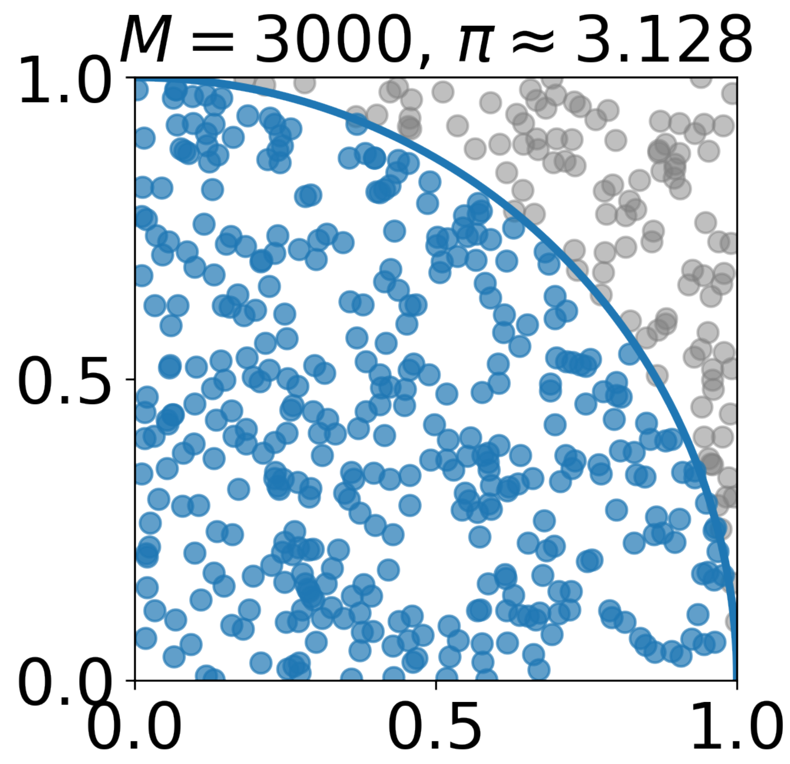
Estimate expected values by sampling



Monte Carlo

Estimate expected values by sampling

$$\frac{\pi}{4} = \mathbb{E}\left[x^2 + y^2 \leq 1\right]$$



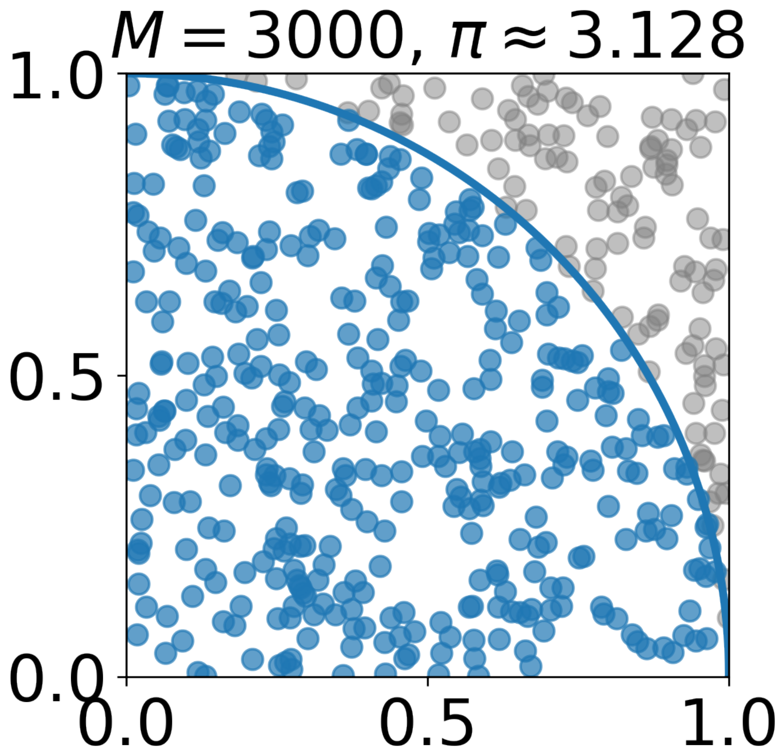
Monte Carlo

Estimate expected values by sampling

$$\frac{\pi}{4} = \mathbb{E}\left[x^2 + y^2 \leq 1\right]$$

$$\approx \frac{1}{M} \sum_{s=1}^{M} [x_s^2 + y_s^2 \leq 1]$$

$$x_s, y_s \sim \mathcal{U}(0, 1)$$



Monte Carlo

Estimate expected values by sampling

$$\mathbb{E}_{p(x)}\, f(x)$$

Monte Carlo

Estimate expected values by sampling

$$\mathbb{E}_{p(x)}\, f(x) \approx \frac{1}{M} \sum_{s=1}^{M} f(x_s)$$

$$x_s \sim p(x)$$

Monte Carlo

Why do we need to estimate expected values?

Monte Carlo

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- Full Bayesian inference (see Week 1)

$$p(y \mid x, Y_{\text{train}}, X_{\text{train}})$$

Monte Carlo

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- Full Bayesian inference (see Week 1)

$$p(y \mid x, Y_{\text{train}}, X_{\text{train}})$$
$$= \int p(y \mid x, w) p(w \mid Y_{\text{train}}, X_{\text{train}}) dw$$

Monte Carlo

Why do we need to estimate expected values?

- Full Bayesian inference (see Week 1)

$$
\begin{aligned}
& p(y \mid x, Y_{\text{train}}, X_{\text{train}}) \\
& = \int p(y \mid x, w) p(w \mid Y_{\text{train}}, X_{\text{train}}) dw \\
& = \mathbb{E}_{p(w \mid Y_{\text{train}}, X_{\text{train}})} p(y \mid x, w)
\end{aligned}
$$

Monte Carlo

Why do we need to estimate expected values?

- Full Bayesian inference (see Week 1)

$$
\begin{aligned}
&p(y \mid x, Y_{\text{train}}, X_{\text{train}}) \\
&= \int p(y \mid x, w) p(w \mid Y_{\text{train}}, X_{\text{train}}) dw \\
&= \mathbb{E}_{p(w \mid Y_{\text{train}}, X_{\text{train}})} p(y \mid x, w)
\end{aligned}
$$

$$
p(w \mid Y_{\text{train}}, X_{\text{train}}) = \frac{p(Y_{\text{train}} \mid X_{\text{train}}, w) p(w)}{Z}
$$

Monte Carlo

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- M-step of EM-algorithm (see Week 2)

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$$\max_{\theta} \mathbb{E}_q \log p(X, T \mid \theta)$$