TEWA 1: Advanced Data Analysis

Lecture 05

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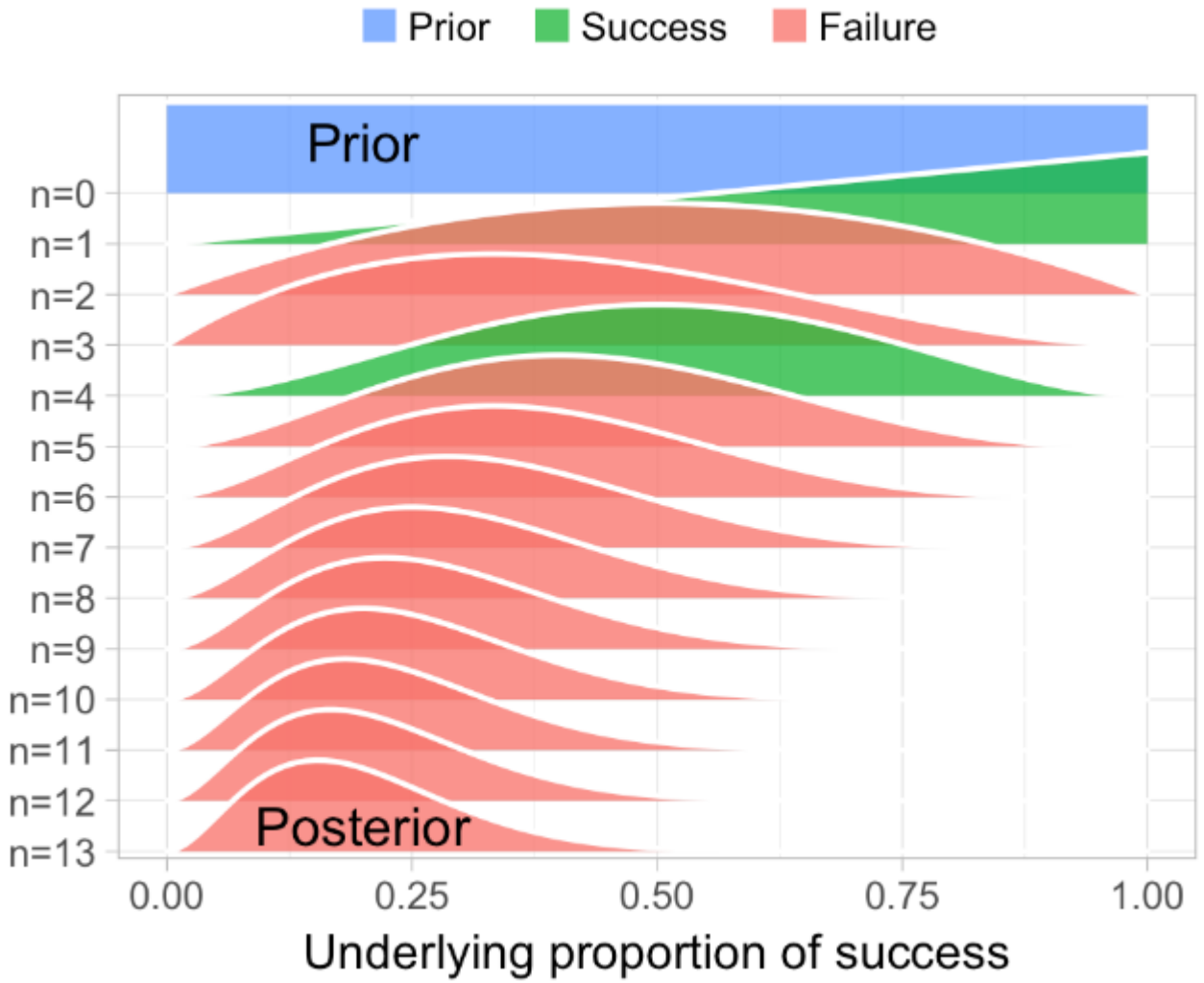
https://github.com/lei-zhang/tewa1_univie

Bayesian warm-up?


Prior
Success
Failure
Prior
n=0
n=1
n=2
n=3
n=4
n=5
n=6
n=7
n=8
n=9
n=10
n=11
n=12
n=13
Posterior
0.00
0.25
0.50
0.75
1.00
Underlying proportion of success

What if I have multiple parameters?

cognitive model
statistics
computing

grid approximation for
2 parameters?
5 parameters?
10 parameters?

$$p(\theta \mid D) = \frac{p(D \mid \theta)p(\theta)}{\int p(D \mid \theta^*)p(\theta^*)d\theta^*}$$

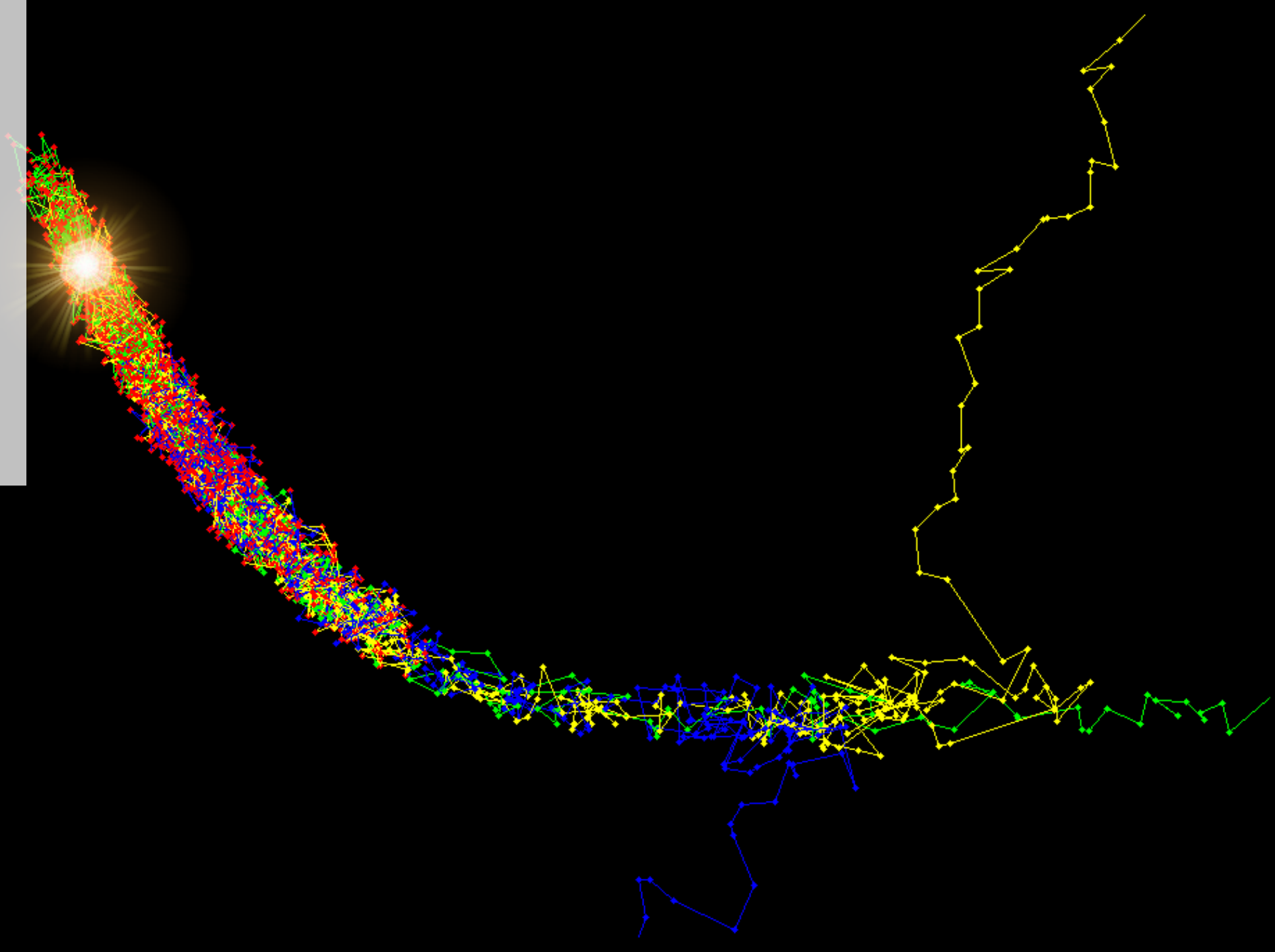
$$p(data) = \int_{All\theta_1} \int_{All\theta_2} p(data, \theta_1, \theta_2) \mathrm{d}\theta_1 \mathrm{d}\theta_2$$

$$p(data) = \int_{\mu_1} \int_{\sigma_1} \dots \int_{\mu_{100}} \int_{\sigma_{100}} \underbrace{p(data \mid \mu_1, \sigma_1, \dots, \mu_{100}, \sigma_{100})}_{\text{likelihood}} \times \underbrace{p(\mu_1, \sigma_1, \dots, \mu_{100}, \sigma_{100})}_{\text{prior}}$$
$$\mathrm{d}\mu_1 \mathrm{d}\sigma_1 \dots \mathrm{d}\mu_{100} \mathrm{d}\sigma_{100},$$

- Analytical solutions (often does not exist)
- Grid approximation (takes too long)
- Markov Chain Monte Carlo

$$p(\theta \mid D) \propto p(D \mid \theta)p(\theta)$$

MARKOV CHAIN MONTE CARLO



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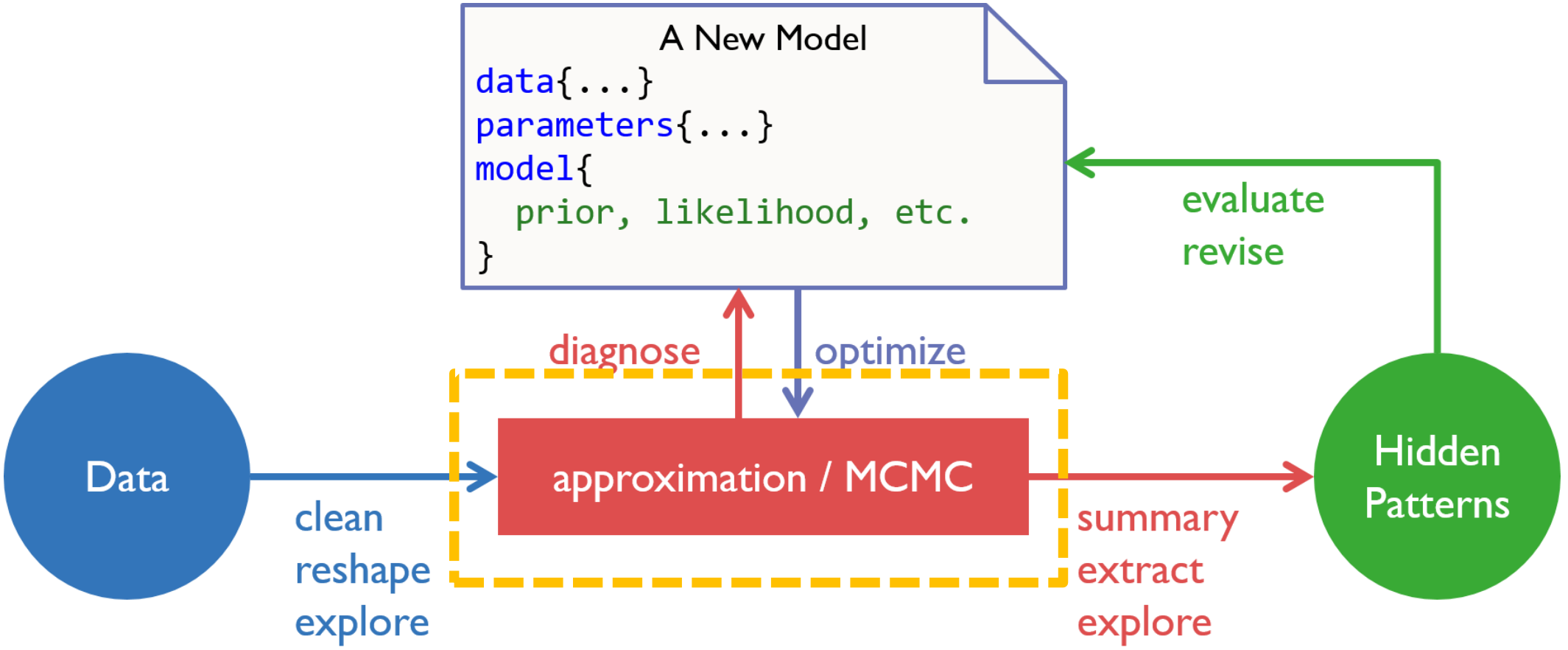

Solving the Problem by Approximation

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$$p(\theta \mid D) \propto p(D \mid \theta)p(\theta)$$

Deterministic Approximation	Stochastic Approximation
→ Variational Bayes	→ Sampling Methods

An MCMC Robot

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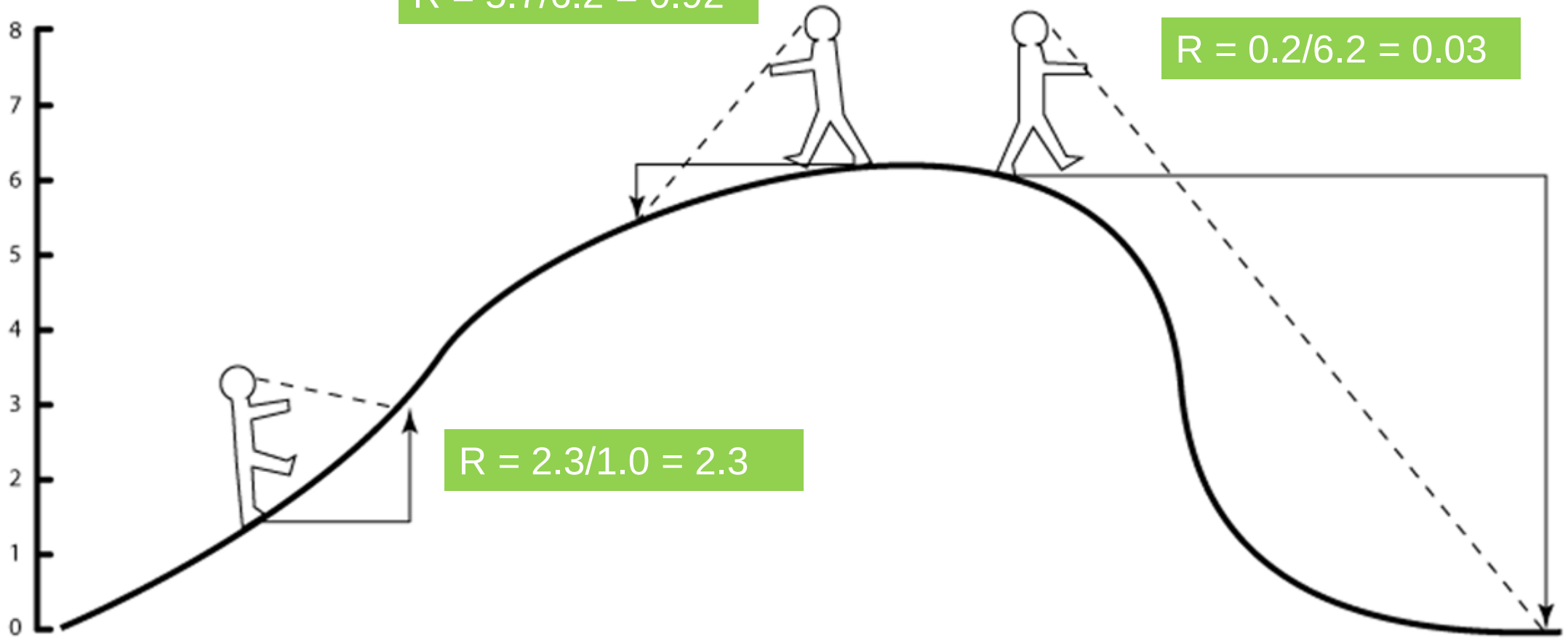
statistics
computing

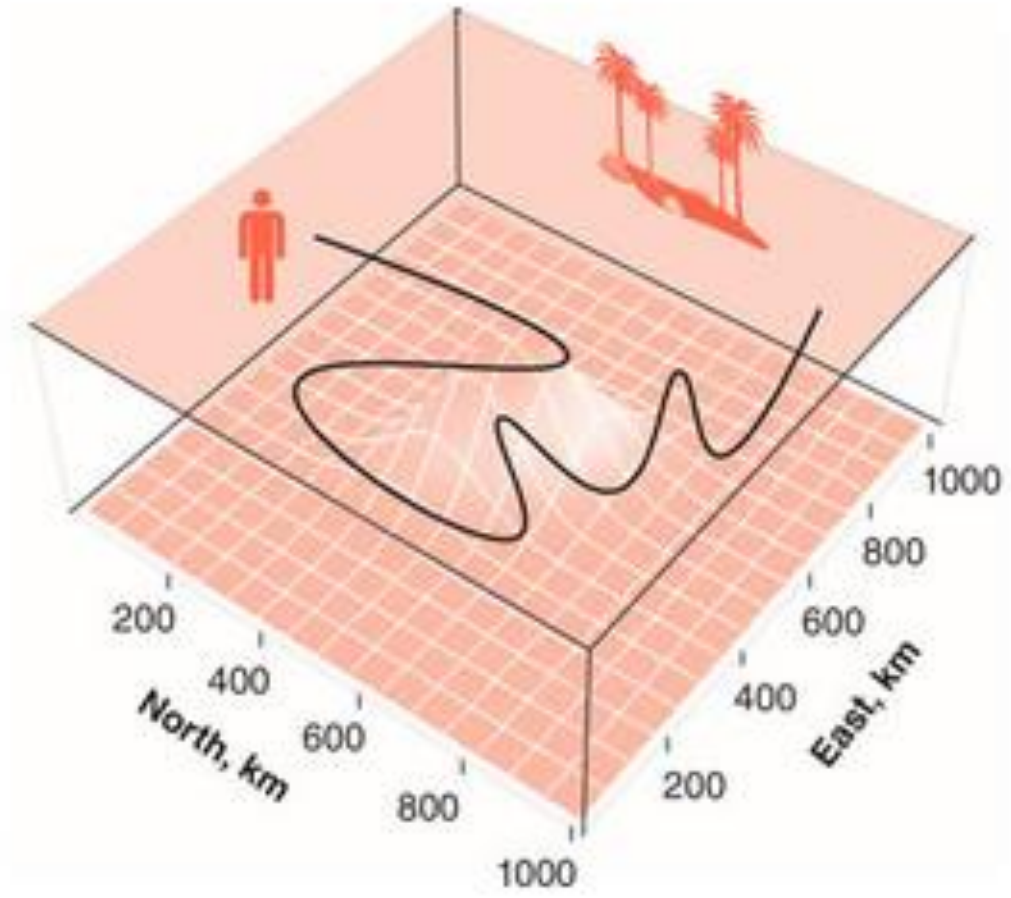
$$p(\theta \mid D) \propto p(D \mid \theta) p(\theta)$$



http://marple.eeb.uconn.edu/mcmcrobot/

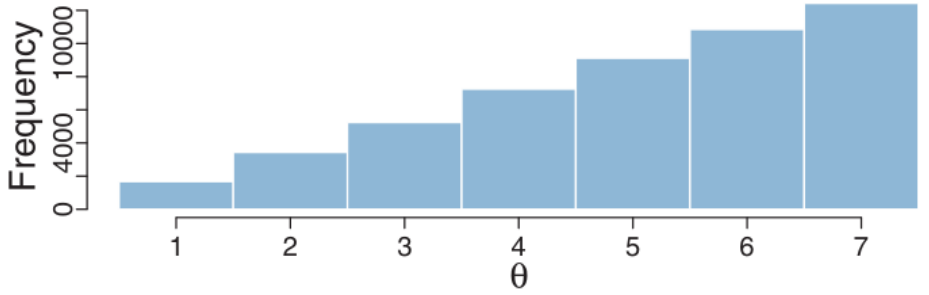
An MCMC Robert in 3D

cognitive model
statistics
computing

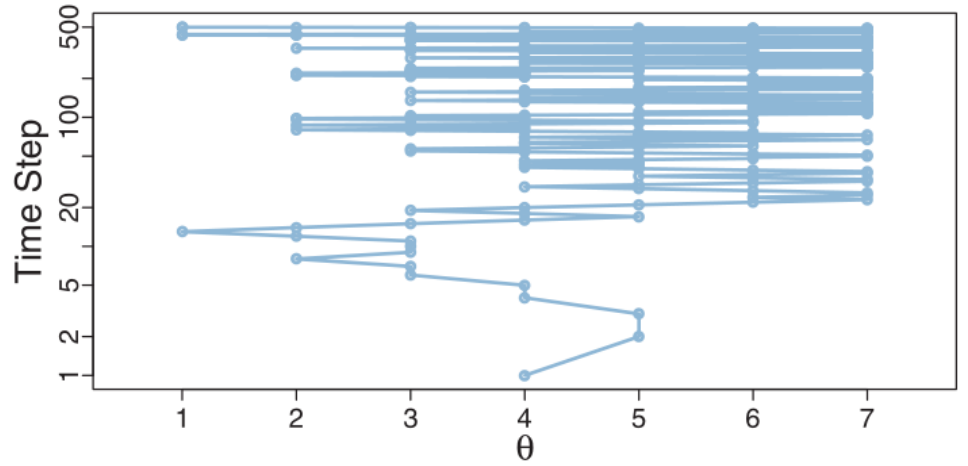


Lambert (2018)

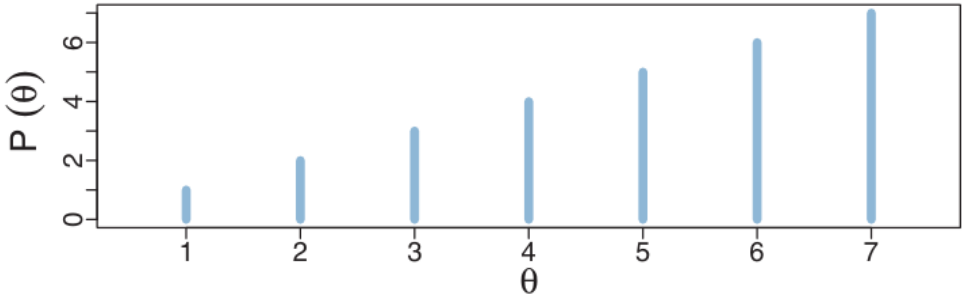
Sampling Example: Discrete



MCMC summary



MCMC trace



True distribution

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computing

Kruschke (2015)

Sampling Example: Continuous

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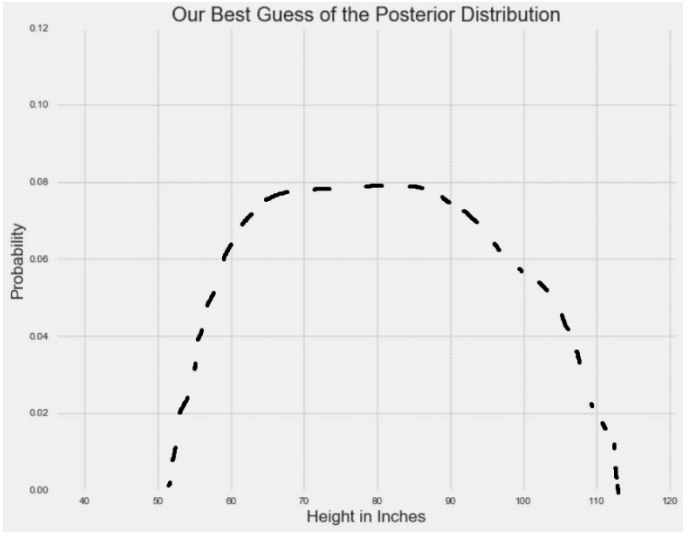
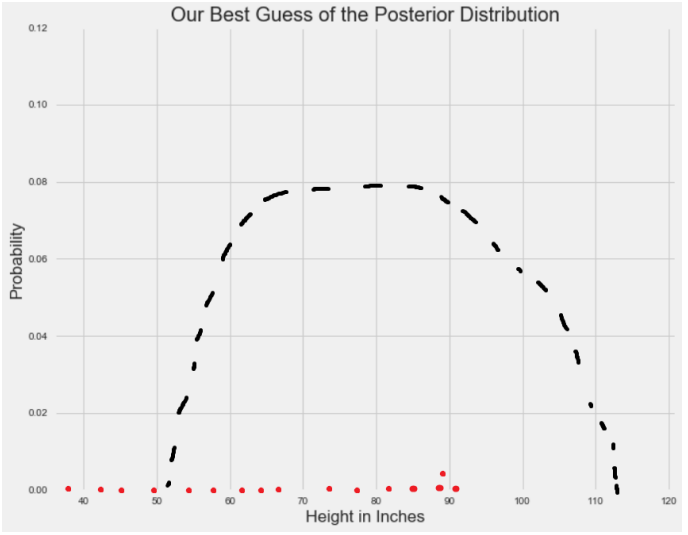
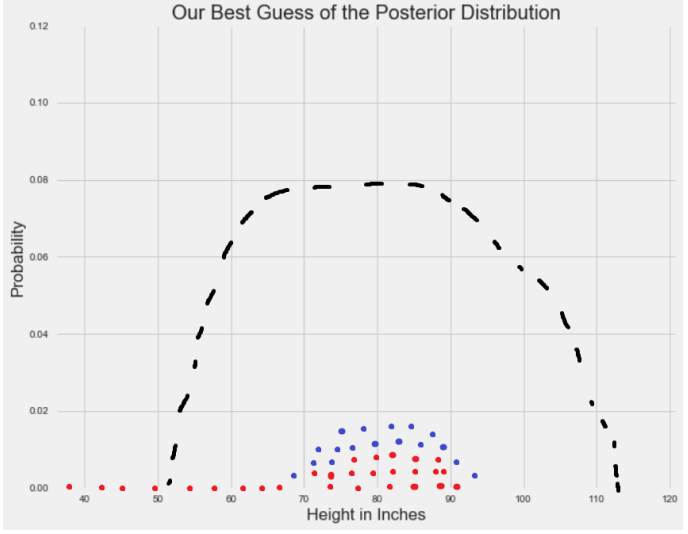
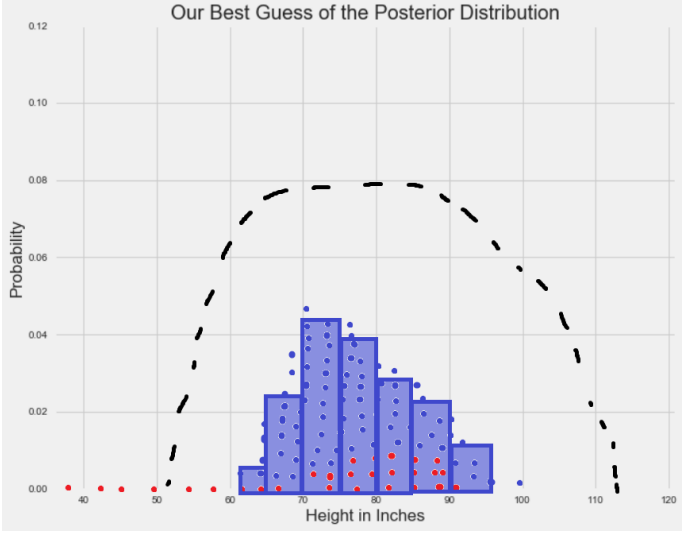
computing





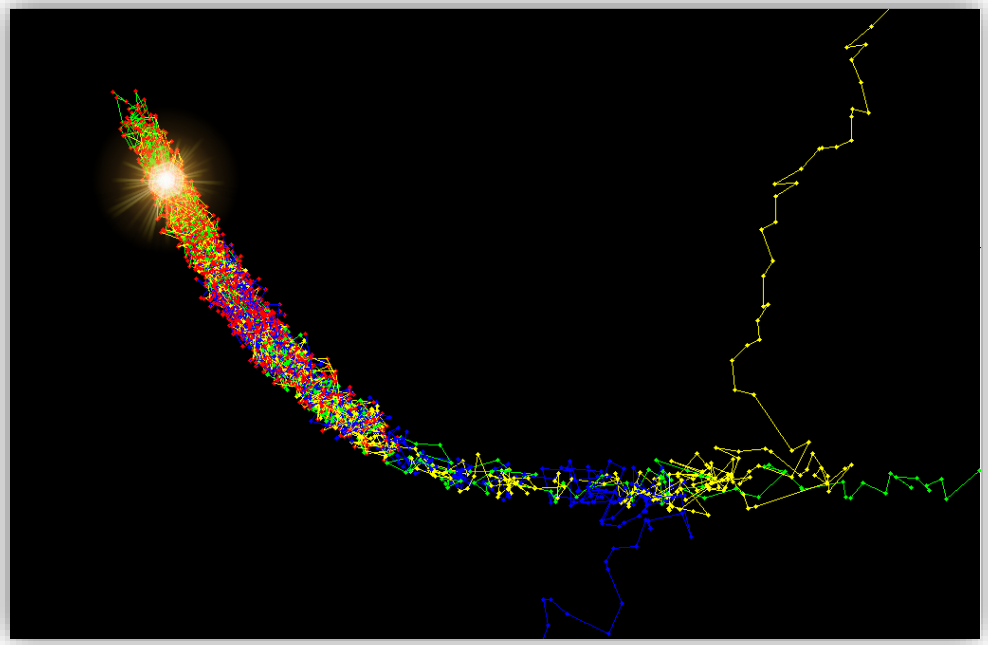


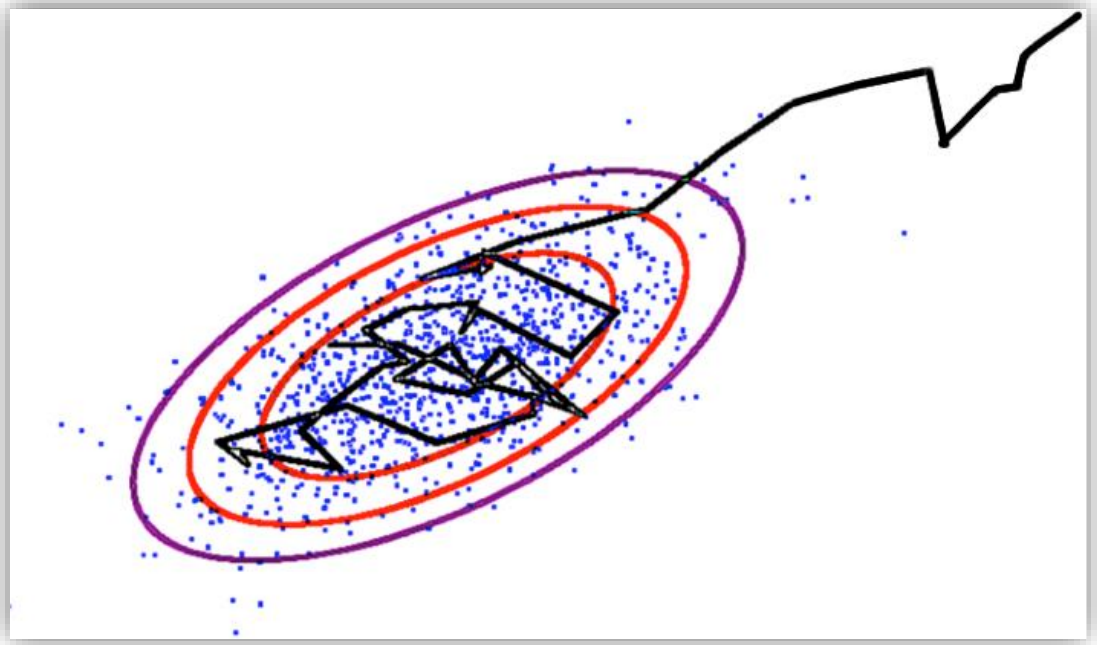


[A Zero-Math Introduction to Markov Chain Monte Carlo Methods]

Visual Example

cognitive model
statistics
computing





Let's watch a video!

cognitive model
statistics
computing

Credit: Thomas Wiecki


ANY
QUESTIONS
?

Happy Computing!