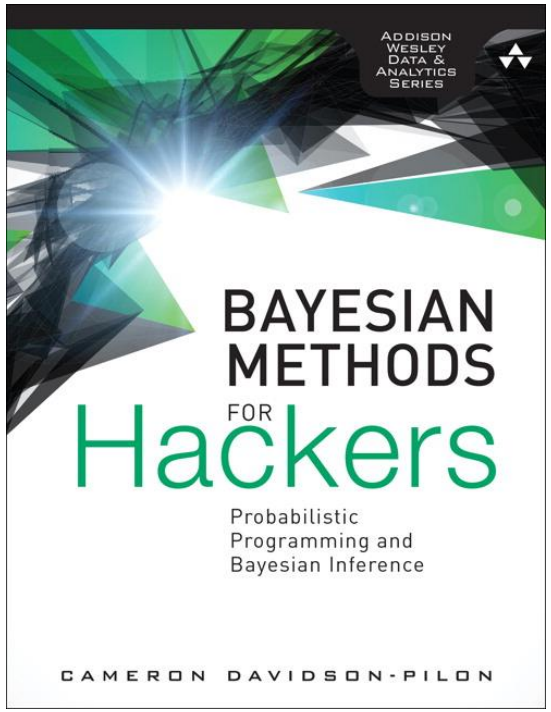
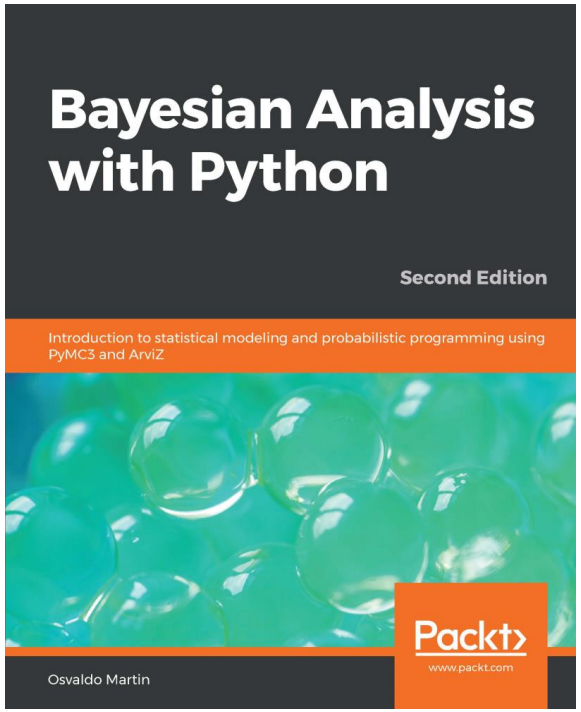
Bayesian modeling

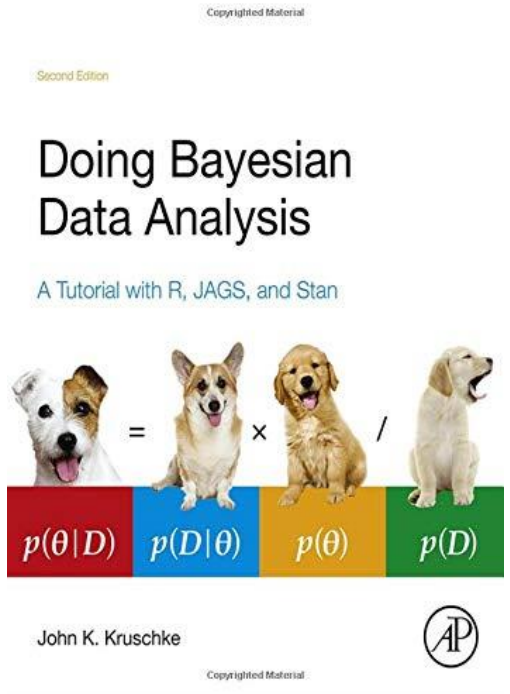
Thinking probalistically

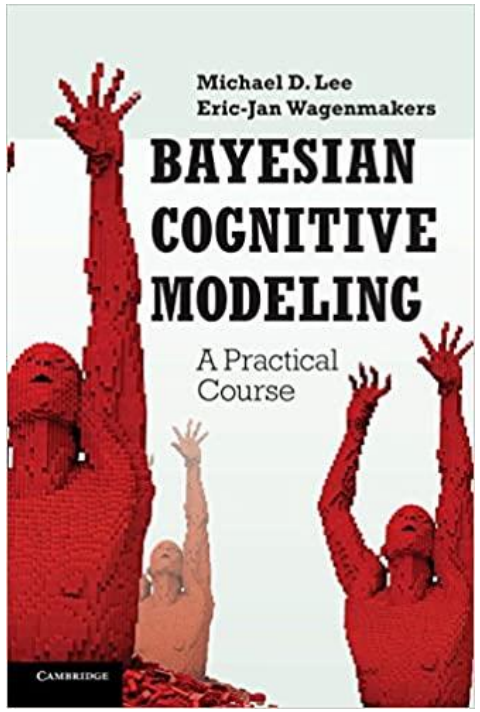
Introduction to PyMC3

Thinking probabilistically









Thinking probabilistically

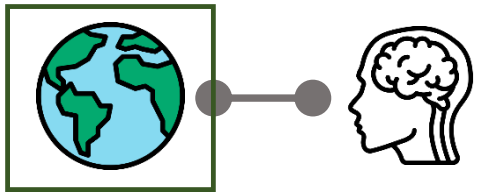
Frequentist

Bayesian

Probability is the long-run frequency of events.

$$f(y|\theta)$$

Fixed

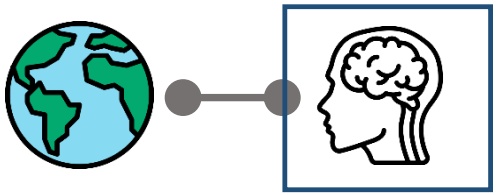


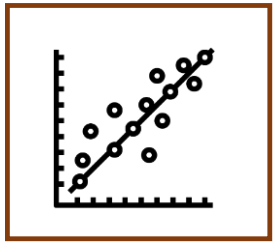
Probability measure the *believability in an event*.

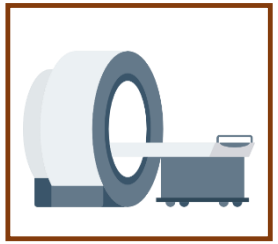
$$p(\theta|y) = \frac{p(y|\theta)p(\theta)}{p(y)}$$

Fixed

Bayesian inference is simply updating your beliefs after considering new evidence.

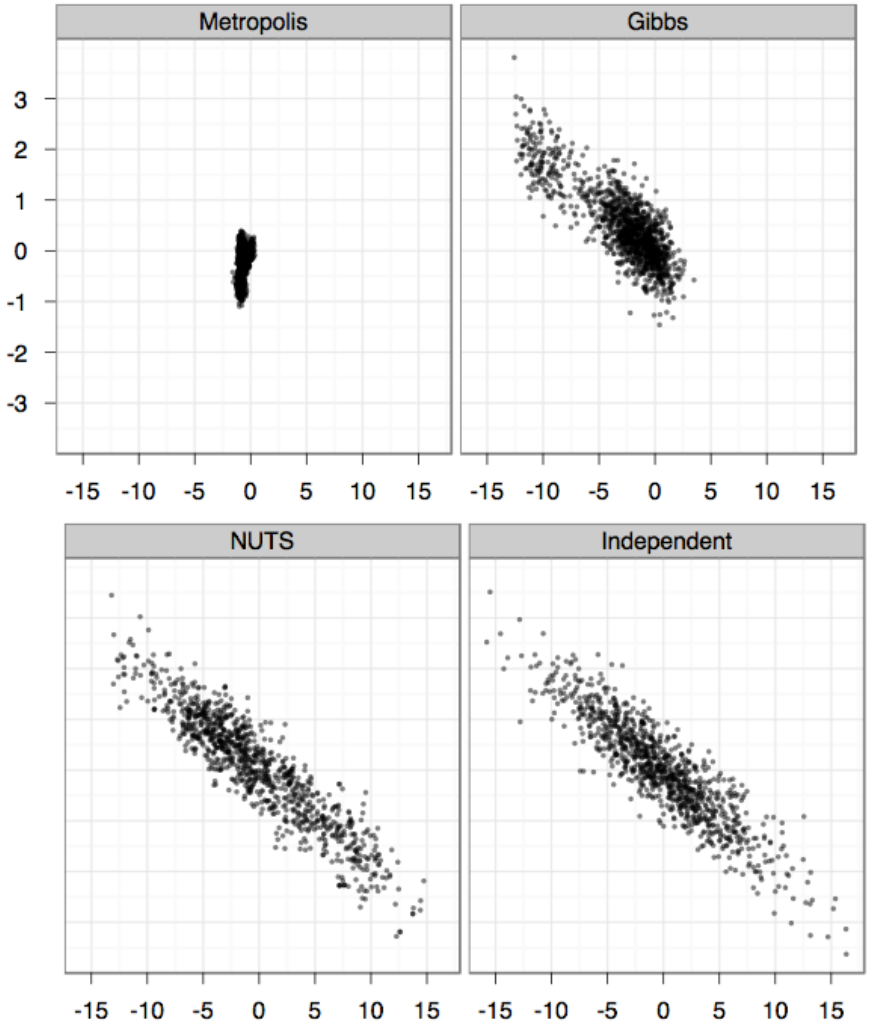






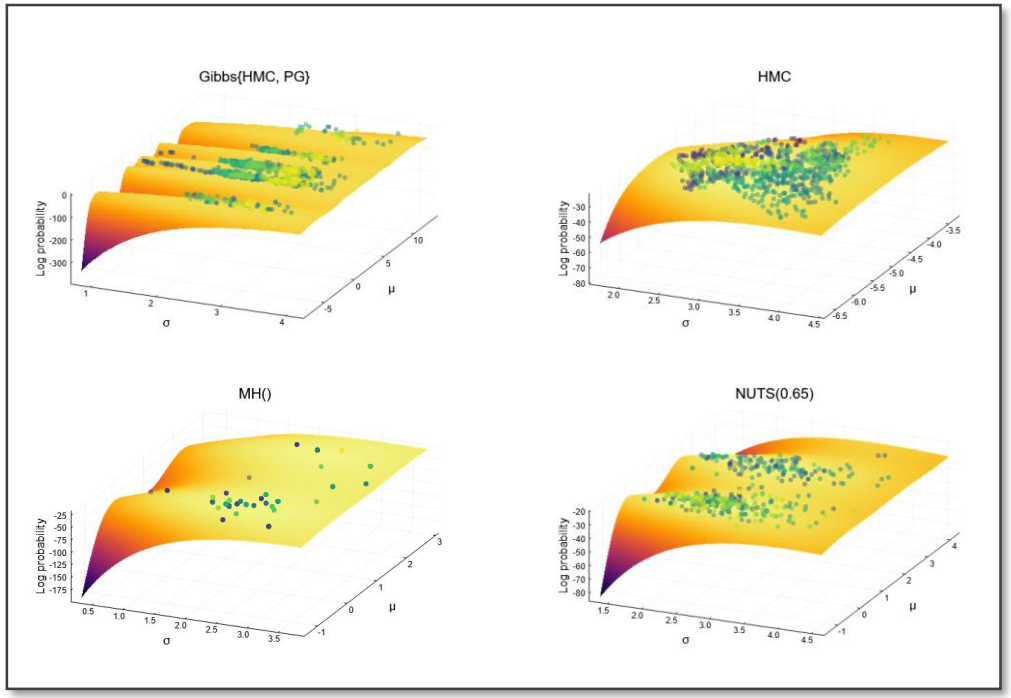
MCMC samplers

- Approximation
  - Variational inference
- Stochastic sampling
  - MCMC methods



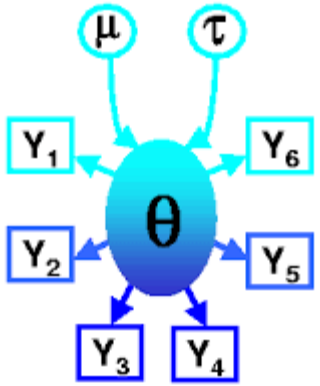
Online demo:

https://chi-feng.github.io/mcmc-demo/



https://turing.ml/dev/docs/using-turing/sampler-viz

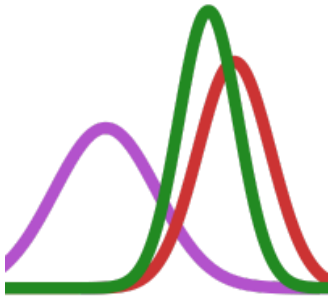
Probabilistic programming languages



BUGS

JAGS

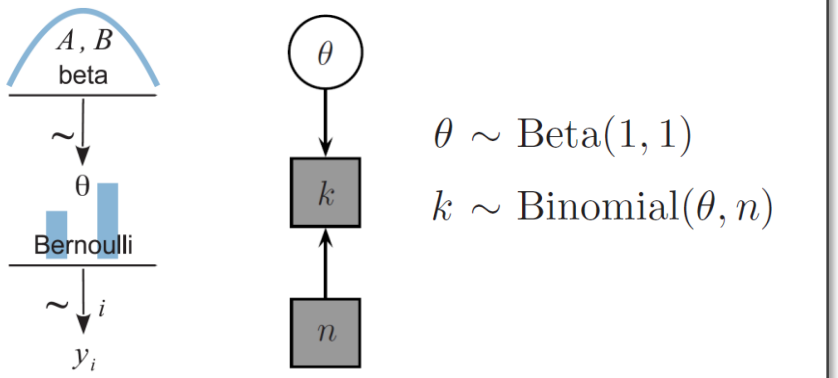
Stan



Turing.jl

Probabilistic programming languages

Graphical model

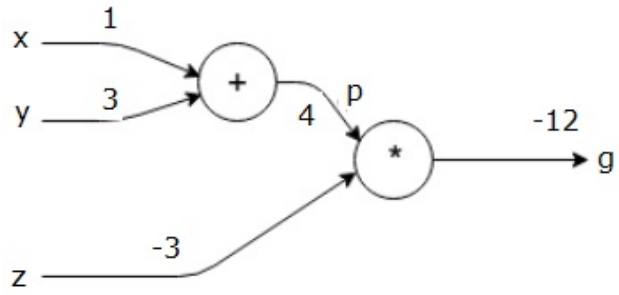


$$\theta \sim \text{Beta}(1, 1)$$

$$k \sim \text{Binomial}(\theta, n)$$

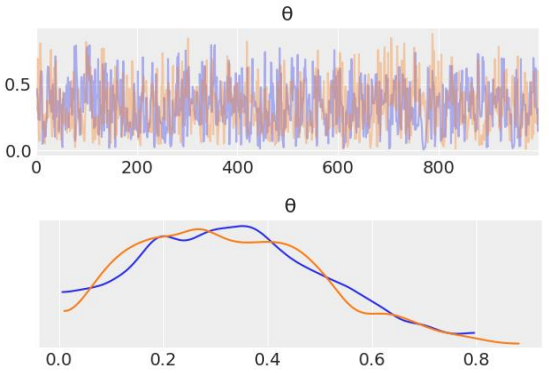
```
with pm.Model() as our_first_model:
  θ = pm.Beta('θ', alpha=1., beta=1.)
  y = pm.Bernoulli('y', p=θ, observed=data)
  trace = pm.sample(1000, random_seed=123)
```

Computational graph



theano

- Automatic differentiation
- GPU computing
- Optimizations



Sampling

Hierarchical/multilevel models

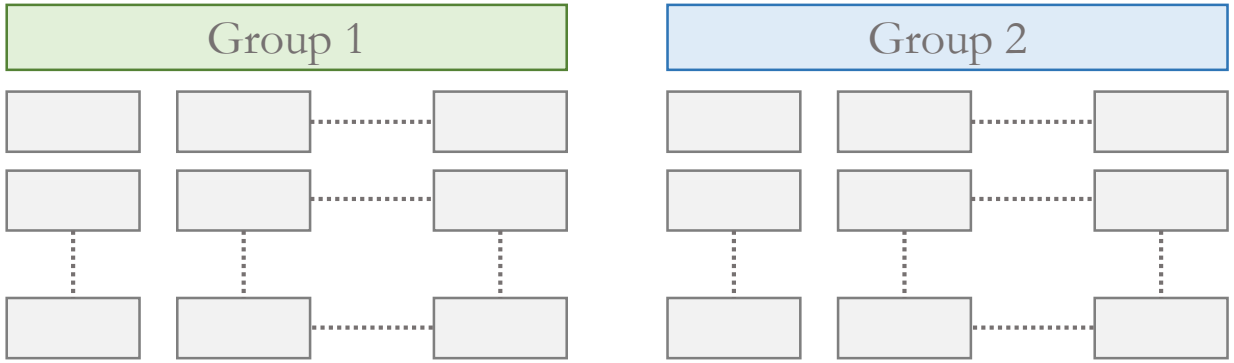
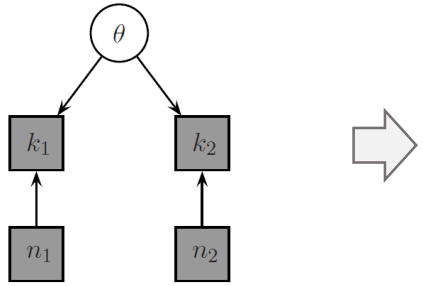
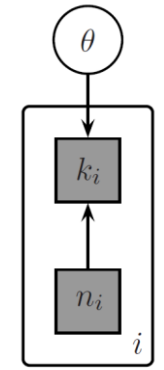


Plate notation

$$k_1 \sim \text{Binomial}(\theta, n_1)$$
$$k_2 \sim \text{Binomial}(\theta, n_2)$$
$$\theta \sim \text{Beta}(1, 1)$$

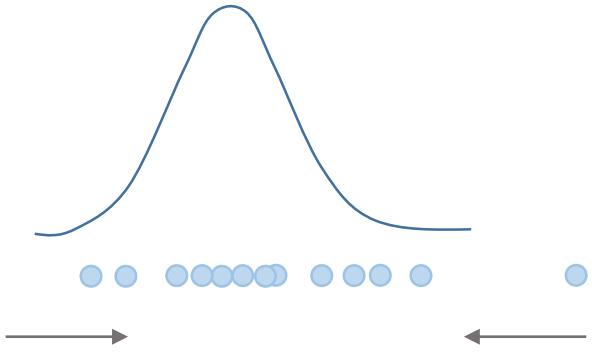


$$k_i \sim \text{Binomial}(\theta, n_i)$$
$$\theta \sim \text{Beta}(1, 1)$$



- Hyperpriors
- Hyperparameters

Shrinkage



Resources

Chris Fonnesbeck - An introduction to Markov Chain Monte Carlo using PyMC3 | PyData London 2019
https://www.youtube.com/watch?v=SS_pqgFziAg

van de Schoot, R., Depaoli, S., King, R., Kramer, B., Märtens, K., Tadesse, M. G., Vannucci, M., Gelman, A., Veen, D., Willemsen, J., & Yau, C. (2021). Bayesian statistics and modelling. Nature Reviews Methods Primers, 1(1). https://doi.org/10.1038/s43586-020-00001-2