Data Analysis 4

Banneker Institute Jul 18 - 22

Goal of this week:

To solidify your knowledge of Bayesian statistics and equip you with the tools to tackle new datasets and complex models

My “Open Question” Policy…

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Ask!

Where we're heading this week..

1. Review of Bayesian statistics and metrics
2. How do we "actually" analyze data?: Typical workflow
3. Graphical models to represent statistical models
4. Working through a toy problem
5. Wrapping up: Realistic considerations and when to ask for help

Bayesian Statistics and Metrics

Bayes' Theorem Revisited

Bayes' Theorem Revisited

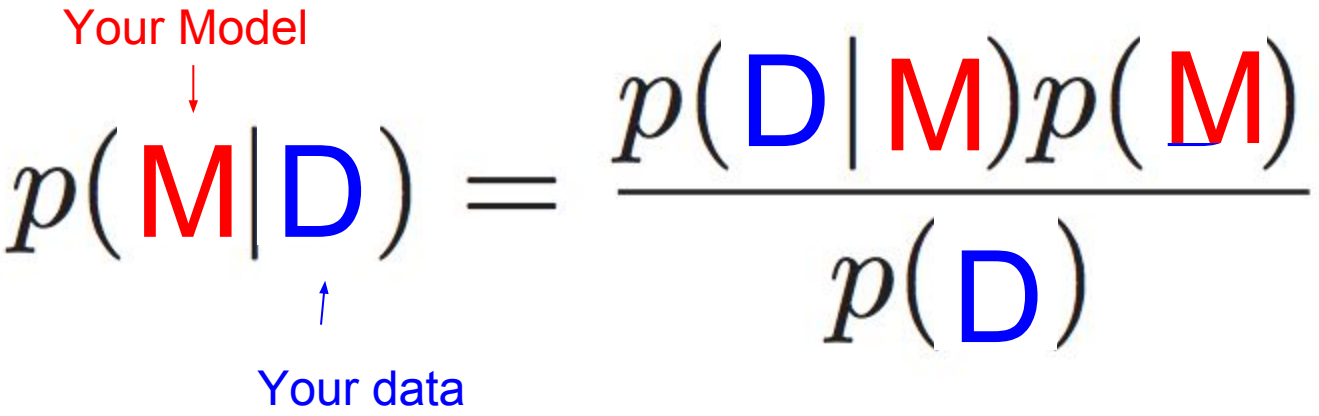
$$p(\mathrm{M}|\mathrm{D}) = \frac{p(\mathrm{D}|\mathrm{M})p(\mathrm{M})}{p(\mathrm{D})}$$

Bayes' Theorem Revisited

Your Model

$$p(\mathrm{M}|\mathrm{D}) = \frac{p(\mathrm{D}|\mathrm{M})p(\mathrm{M})}{p(\mathrm{D})}$$

Bayes' Theorem Revisited



Bayes' Theorem Revisited

Prior

$$p(\mathrm{M}|\mathrm{D}) = \frac{p(\mathrm{D}|\mathrm{M})p(\mathrm{M})}{p(\mathrm{D})}$$

Bayes' Theorem Revisited

Likelihood

$$p(\mathrm{M}|\mathrm{D}) = \frac{p(\mathrm{D}|\mathrm{M})p(\mathrm{M})}{p(\mathrm{D})}$$

Bayes' Theorem Revisited

$$p(\mathrm{M}|\mathrm{D}) = \frac{p(\mathrm{D}|\mathrm{M})p(\mathrm{M})}{p(\mathrm{D})}$$

Posterior

Bayes' Theorem Revisited

$$p(M|D) = \frac{p(D|M)p(M)}{p(D)}$$

The thing we ignore
;]

Practice with Conditional Probability

What is the probability that Dogmeat wins given the fact that it's raining?

	Raining	Not Raining
Dogmeat wins	3	2
Dogmeat loses	1	6

Metrics

What is Chi^2?

Why do we use it?

Metrics

What is Chi^2:

- Geometrically: It's similar to "least squares"
- Mathematically: It's a descendent of a Gaussian Likelihood:

$$p(x_j) = \frac{1}{\sqrt{2\pi\sigma_j^2}} \exp\left(-\frac{1}{2\sigma_j^2}(x_j - \hat{x}_j)^2 \right),$$

where $\hat{x}_j$ is the predicted value of x_j

Metrics

Why do we use it:

- Almost everything is Gaussian (due to the law of large #s)
- It’s “easy”

Metrics

A metric is (typically) a scalar which measures the “goodness” of your model’s fit to the data

It is something you’re trying to optimize

Our Data Analysis Workflow

A Typical Workflow...

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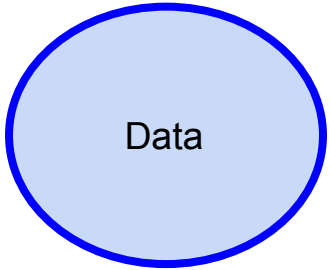

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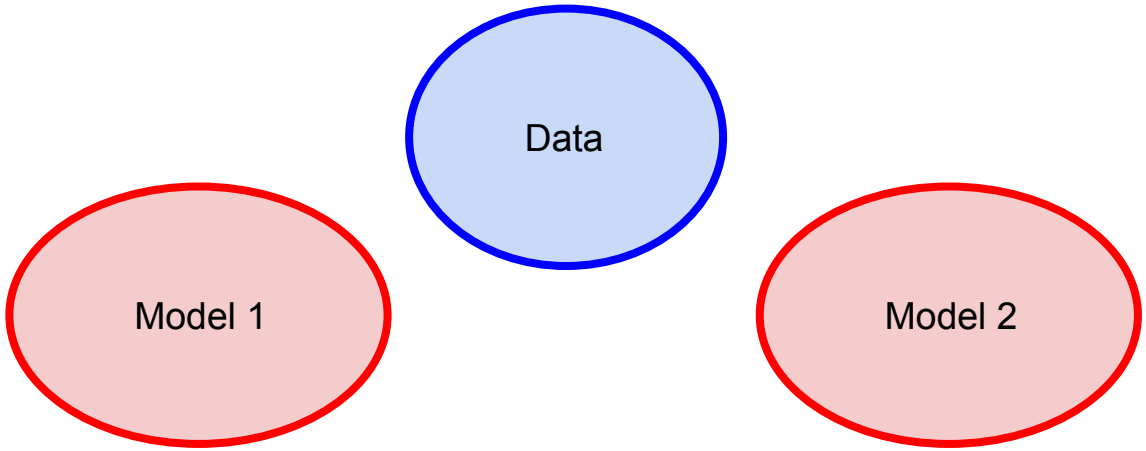

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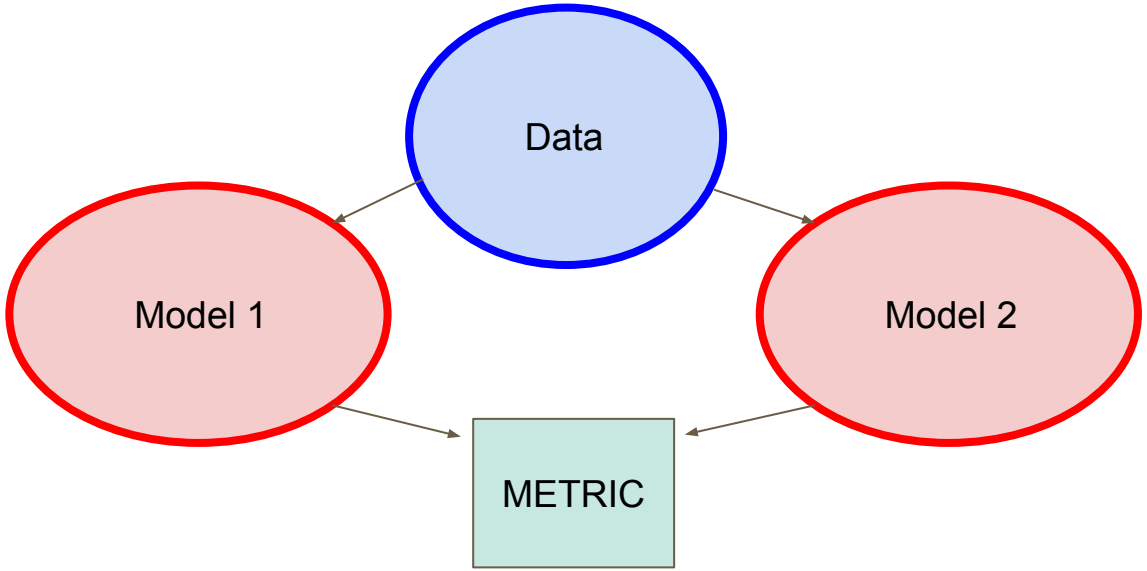

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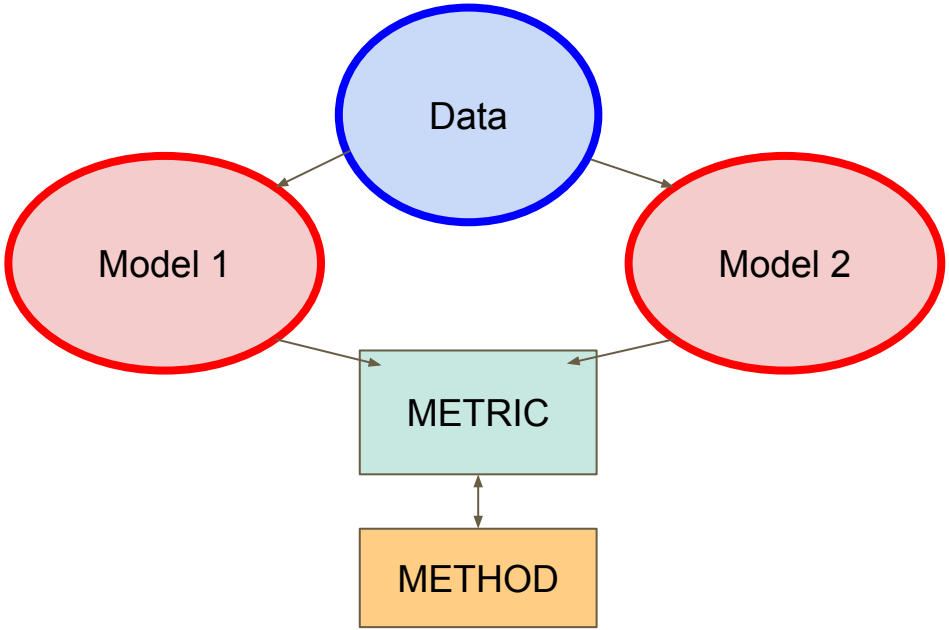

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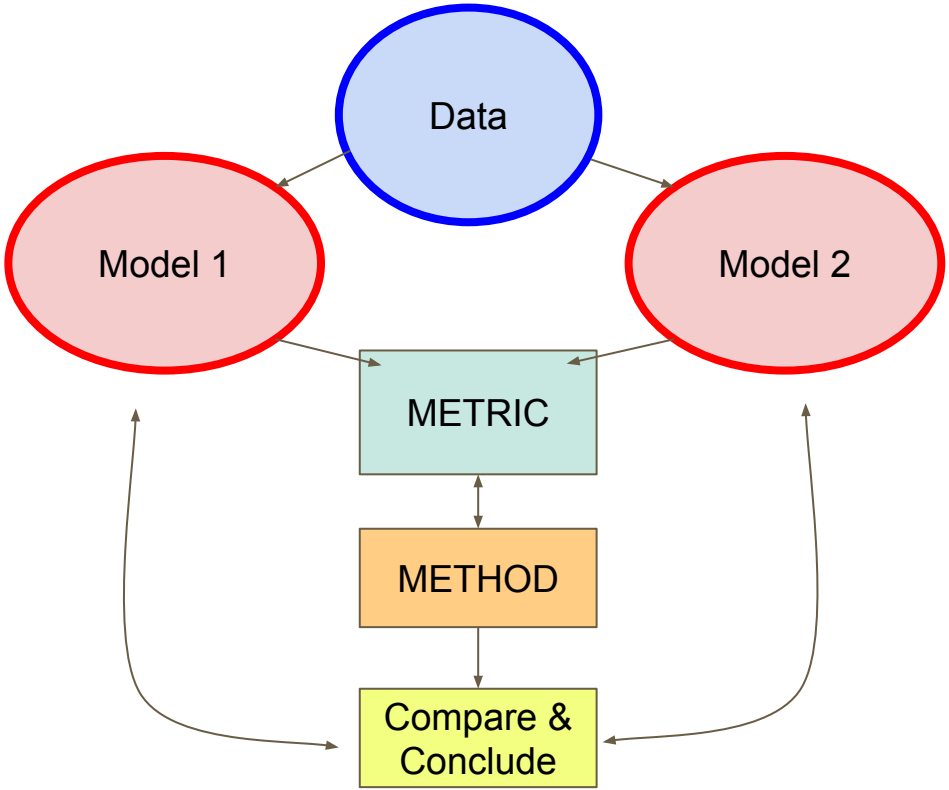

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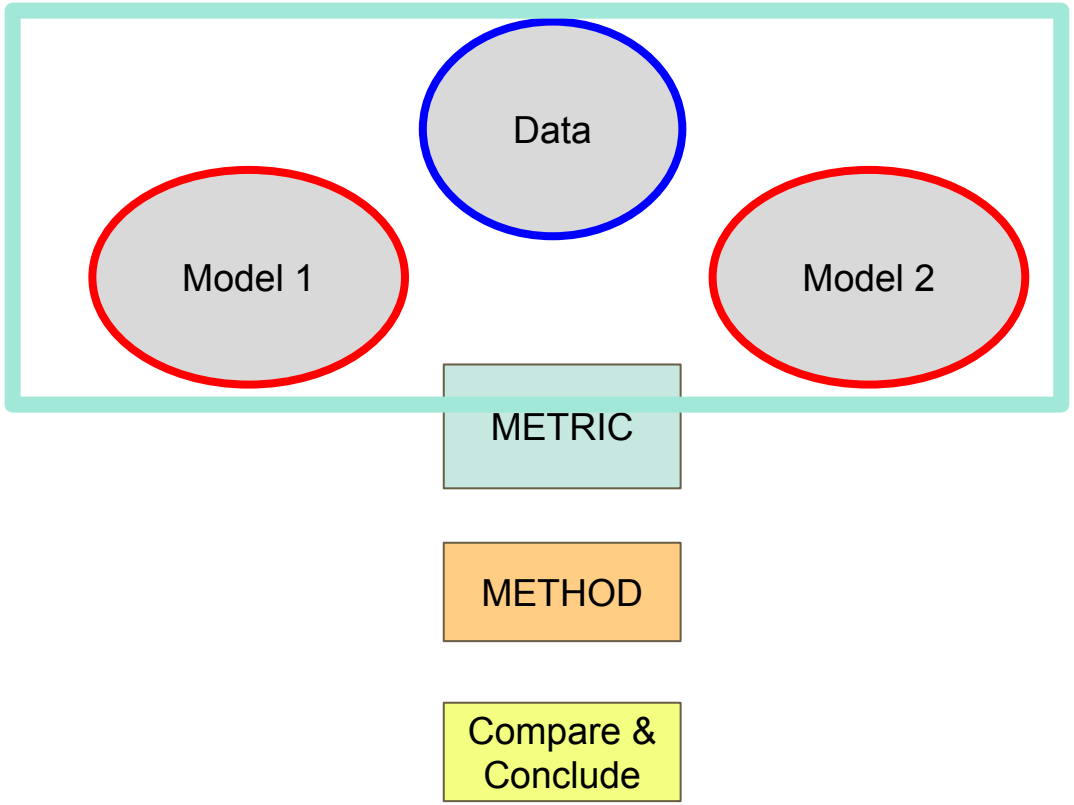
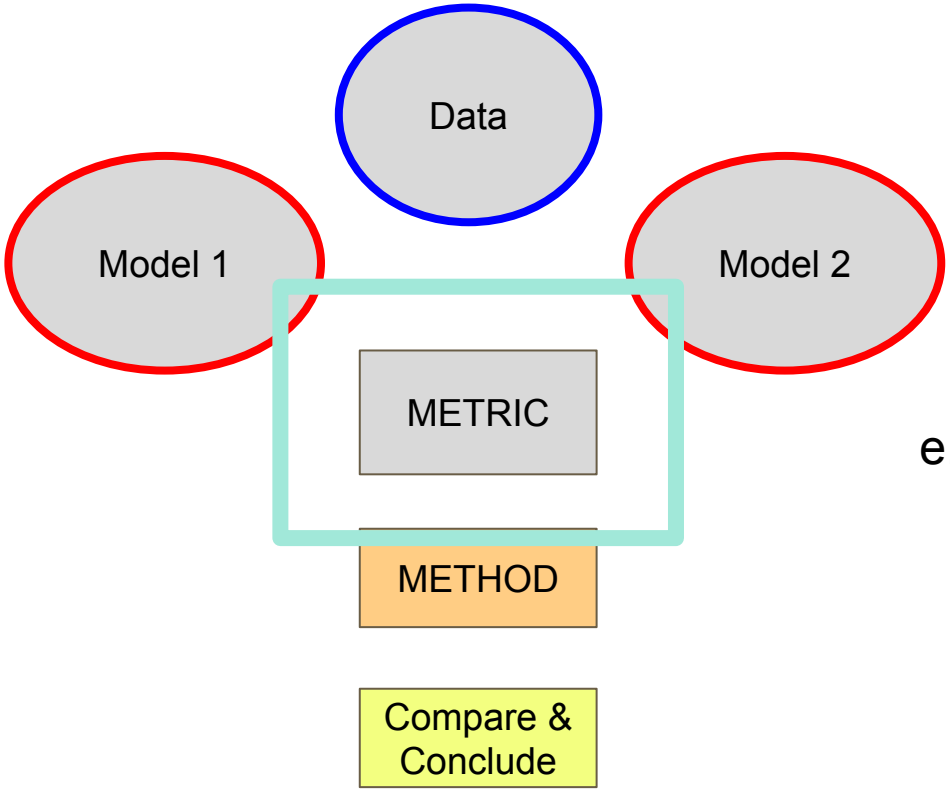


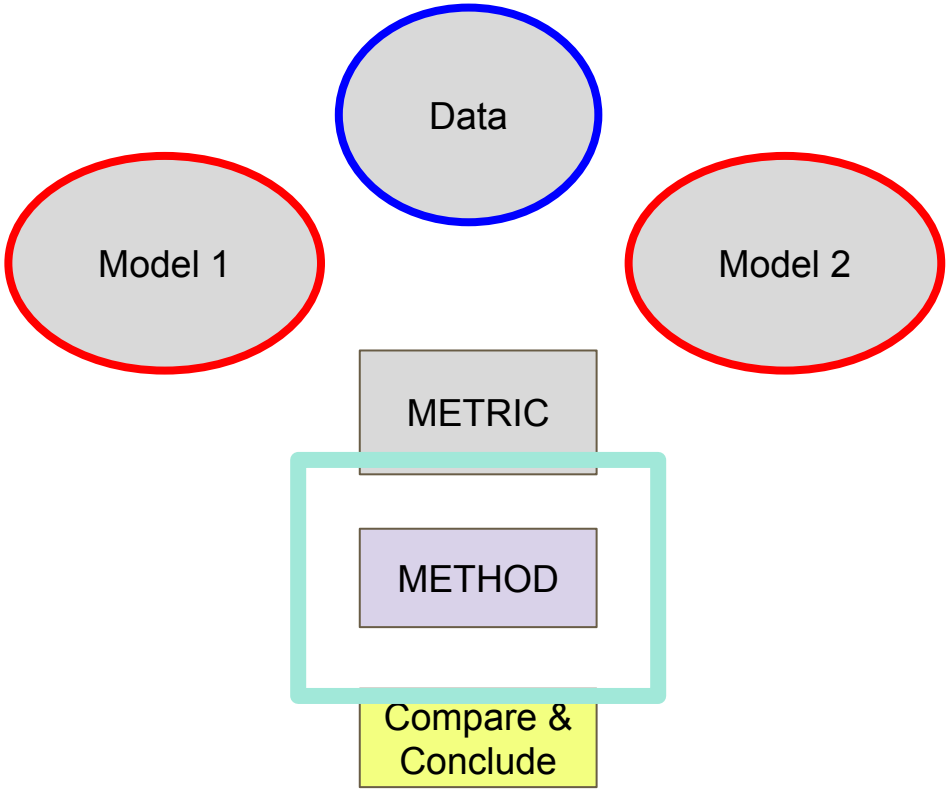
You do this part!
(and map with graphical models)

A Typical Workflow...



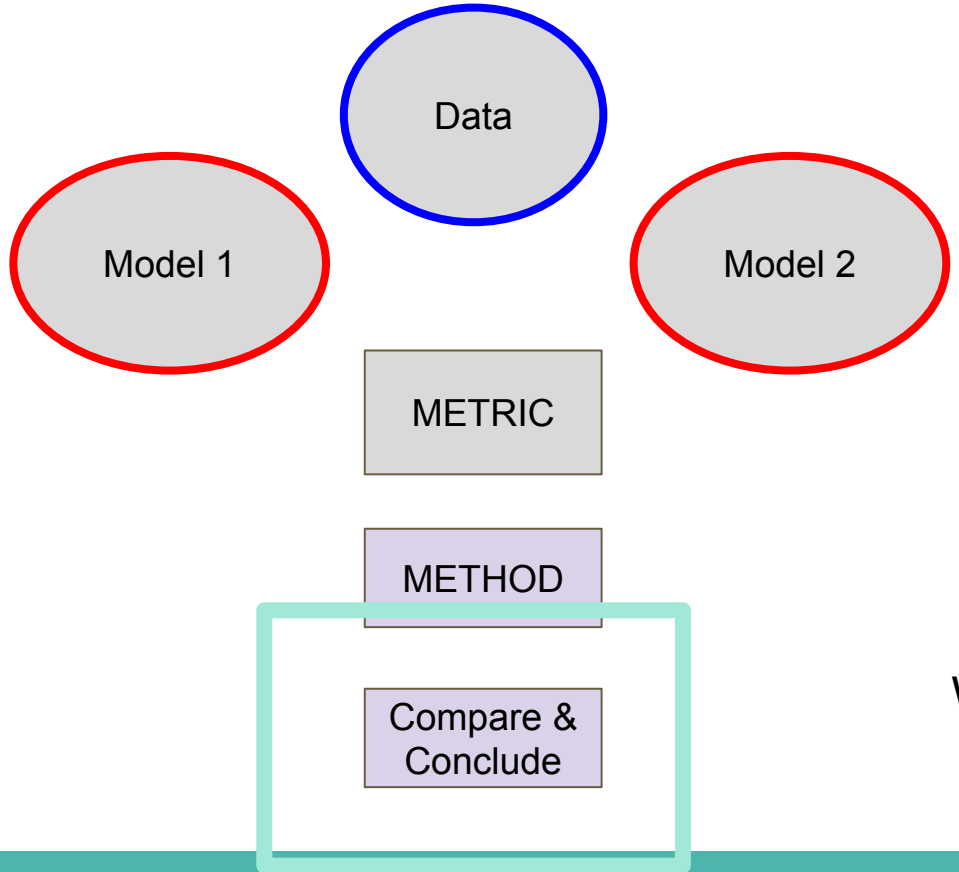
We did this!
e.g. Chi^2 or likelihoods

A Typical Workflow...



We haven't done this!
e.g. Least Squares, MCMC

A Typical Workflow...



We're (probably) NOT doing this!

Questions?