

Jason Preszler

Remember
Side A

The B side

Bayesian
Inference

Examples

Statistics: Side B

Jason Preszler

10/12/2017

My path into Statistics

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Examples

- 1 avoided stats in college, focused on Math and CS
- 2 first job after PhD had me teaching 4 sections of Math 125
- 3 enjoyed teaching it
- 4 previous job got me into statistical modeling and AI

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Frequentist Perspective

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Examples

- All probabilities are relative frequencies
- *How sample is extracted from population* is only source of uncertainty
- population parameters are fixed, random variables come from sample data
- **Goals:** parameter "estimation" or relationship description

EX: 95% confidence interval

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Frequentist Success and Failure

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Examples

Failure

- Not very logical
- Usually getting samples is costly, why replicate over them?
- prediction problems

Success

- good procedures are robust
- parameter estimation
- many successes for traditional experimental data with large effects

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Examples

- Galton created linear regression in the late 1800's
- K. Pearson added correlation and goodness of fit tests by 1900
- Fisher, E. Pearson, Neyman created hypothesis test and confidence interval procedures in 1920's and 30's.
- WWII brought flurry of funding and research problems

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Bayesian Origins

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Examples

In 1763, Rev. Thomas Bayes (posthumously) pub. paper containing:

Theorem (Bayes)

$$P(B|A) = \frac{P(B)P(A|B)}{P(A)}$$

$$Posterior = \frac{Prior \cdot Likelihood}{normalizing\ constant}$$

Using this for **inference** deeply concerns some people (but not Laplace, Gauss, or others).

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Bayesian Features

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Examples

- probabilities represent degrees of belief (subjective)
- must account for uncertainty where it exists
- data is fixed, parameters are random variables

Result Bayesian inference results in a probability distribution for all possible parameter values.

Bayesian Features

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Overview of Bayesian Inference

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Examples

All Bayesian methods follow the same procedure:

- develop prior probability distribution for our "hypothesis"
- Find likelihood distribution of data given our hypothesis
- use Bayes theorem to construct posterior distribution

We then use the posterior to answer questions directly.

Overview of Bayesian Inference

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Examples

Failure

- Computationally infeasible until 1990 on most real problems
- How do we get priors?

Success

- Can easily update models as new data arrives *Today's posterior is tomorrow's prior*
- must articulate assumptions
- more powerful results
- can answer direct questions, not just falsifications.

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Frequentist use of Bayes

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Examples

Typical example of drug or medical test

- Suppose everyone is either clean, C , or a drug user D .
- Let $+$ indicate a positive drug test and $-$ indicate a negative drug test
- It is believed that drug use is rare in the population, $P(D) = 0.01$
- Furthermore, the test has good sensitivity so $P(+|D) = 0.98$. The specificity of the test is also good, $P(-|C) = 0.95$.

•

$$\begin{aligned}
 p(D|+) &= \frac{P(D)P(+|D)}{P(+|D)P(D) + P(+|C)P(C)} \\
 &= \frac{.98 \cdot .01}{.98 \cdot .01 + (1 - .95) \cdot (1 - .01)} \\
 &= 0.165
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Drug Test Continued

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Examples

- So using a good test means that there is a 16.5% chance of a being a drug user given a positive test result.
- This is 16 higher than without the test.
- If we were not looking at a random person, but someone suspected of drug use so $P(D) = 0.5$, then $P(D|+) = 0.95$.

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We will need help organizing and performing

- Early Fall
- Late Spring
- Inter-rater reliability

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