Introductory lecture

Statistical Inference (AMS132)
What this course is …

So far (AMS131):

\[ p(x \mid \theta) \]

Unknown  \quad \text{Known}

What is the number of heads in 6 tosses of a fair coin?

Now (AMS132):

\[ p(x \mid \theta) \]

Known  \quad \text{Unknown}

If 3 heads out of 6 tosses, what is the probability of head?
What this course is …

• An inference course:
  • Estimation: what is the value (or a reasonable set of values) for the parameter?
  • Testing: is the value of the parameter consistent with some theory?

• A melting pot of ideas: there is NOT one single correct procedure!!!!!
Descriptive vs. inferential methods

- Are the features from the two populations the same?
- Are the differences due to noise, or are the underlying processes really different?
Estimation

• How does the lifetime of an electronic component behave?
• What is the trend in global temperature?
• What is the volatility (variability) in the S&P500?
Prediction

• What will the sea temperature be in 30 years?
• What will the value of the S&P500 be tomorrow?
• In some cases, it is hard to see the difference between estimation and prediction (see the lifetime example in the previous slide).
Testing: convicting criminals

In the People v. Collins case, a purse was snatched from an elderly person in a Los Angeles suburb. A couple seen running from the scene were described as a black man with a beard and a mustache and a blond girl with hair in a ponytail. Witnesses said they drove off in a partly yellow car. Malcolm and Janet Collins were arrested. He was black and though clean shaven when arrested had evidence of recently having had a beard and a mustache. She was blond and usually wore her hair in a ponytail. They drove a partly yellow Lincoln. What would you argue if you were the accuser? What if you were the defense?

Reproduced from Grinstead, C. M. and Snell, J. L. *Introduction to Probability* (2nd Revised Edition), American Mathematical Association
Some extra info …

- Man with mustache 1/4
- Girls with blond hair 1/3
- Girl with ponytail 1/10
- Black man with beard 1/10
- Interracial couple in a car 1/1,000
- Partly yellow car 1/10
- Total (assuming indep.) 1/12,000,000
Discovering the Higgs bosom

• Let $X$ be the rate of energy emission.
  $$X \sim \text{Poisson}(	heta + \lambda)$$

  Background rate ("known")                      "Higgs" influence

• Is $\lambda > 0$?

• If so, what is the value of $\lambda \Rightarrow$ Mass of Higgs bosom.
What this course is NOT …

• A modeling course
  • We will take the likelihood (and priors) for granted.
  • No model criticism.
• A course on any specific class of models (although we will frequently use Gaussian distributions).
• A course in computational tools.
Structure of the course

• Review of basic probability: establish common language.
• Point estimation techniques: MOM, MLE, Bayes.
• Interval estimation.
• Brief detour through prediction, both frequentist and Bayesian.
• Hypothesis testing.
The big picture

• Why so many different approaches?
  • Philosophical.
  • Practical.

• When do they give similar results? (and when they don’t).

• Reporting results and deriving conclusions, specially the jargon.