MLE basics

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1 Parameter estimation & likelihood

- simple, universal framework (vs. ANOVA/t-test/linear regression/nonparametrics/etc.): foundation of many other methods
- "roll your own", get better (more precise) answers to a particular question

Why not?

- harder
- specialized procedures may be more efficient/stable/faster etc.
- LRT is asymptotic (unlike e.g. F tests)
- "random effects" are fairly hard to deal with, often required canned software

2 General procedure

- figure out model (ha!)
  - stochastic part (binomial, Poisson, negative binomial, etc.)
  - deterministic part (i.e. effects of continuous covariates (e.g. linear, quadratic, exponential, logistic, Michaelis-Menten), or effects of groups (factors), or interactions among factors, or effects of groups on continuous covariates:

  might reduce to something simpler (multivariate regression, generalized linear model, etc.)

- write down a (negative log) likelihood function: usually a sum of similar elements, but with different parameter values for different times/species/etc.
- find minimum (MLE)
- do **statistical inference**:
  - construct confidence intervals (profile or quadratic/Fisher-information)
  - test **nested** models via Likelihood Ratio Test — corresponds to hypotheses about differences (χ^2 distribution of **deviance**$=-2\log(\mathcal{L})$)
  - look at confidence intervals (testing against zero is equivalent, for profile confidence intervals)
  - IC-based model selection or averaging (examine confidence intervals OR make a statement about which models are selected OR simply make predictions
  - Bayesian analysis: find model probabilities, or look at confidence intervals

3 What do you need to know to start?

- what question do you want to ask? (several different levels: biological, operational (what did you measure?), statistical)
- a little bit of basic probability (e.g. combining independent events)
- some recipes/catalogs of deterministic functions and stochastic distributions
- enough R to write down a likelihood function
- a little bit about optimizers:
  - Nelder-Mead simplex
  - derivative-based (BFGS etc.)
  - stochastic global
  - with/without constraints
- decent starting values for your functions
- `bbmle::mle2`: wrapper for R optimizing functions; allows `data` argument (*), parameters specified as vector or argument list (*), automatically computes profiles, formula interface (*)

now draw some pictures!