Introduction to Random Effects in glmmTMB

Mollie Brooks

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This video covers

- concept of random effects

- nested vs crossed

- temporal and spatial options

- where to find details

- an example with random intercepts and an AR(1) random effect

Concept of random effects in LMMs and GLMMs

- grouping factor with different levels

- levels are usually sampled randomly from a larger population

- account for correlation / lack of independence

  - avoid pseudoreplication (Hurlbert 1984)

  - e.g. repeated measures of a sampling unit are correlated

  - e.g. locations may be correlated to other locations near them

  - e.g. a patient's physiology this year is correlated to last year

Formulas

- random intercepts conditional on grouping variable +(1|gvar)
- random slopes and intercepts conditional on grouping variable +(x|gvar)
- right-hand side is the *grouping variable* (always categorical, usually a factor)
- left-hand side is the *varying term* (most often 1 for intercept)
- multiple random effects (a|g1) + (b|g2) + ...
- terms separated by + are independent

Many specific formulations can be found on the GLMM FAQ website.

New conditional model mean

For LMMs: $\mu = X\beta + Zb$

For GLMMs: $\mu = g^{-1}(X\beta + Zb)$

...but Zb is way more complicated than $X\beta$

$b \sim N(0, \Sigma)$

$b \sim N(0, \sigma_b^2)$ if simple intercept

`glmmTMB` uses Laplace approximation

Nested random effects

- `glmmTMB` can handle both nested or crossed

- only relevant with multiple random effects

- nested if each unit of a lower-level factor appears in exactly one higher-level unit

    - e.g. spatial blocks within spatial sites

    - no need to worry about nesting if lower level is labeled uniquely

    - e.g. if each site A, B, . . . E contains multiple blocks, then code the blocks uniquely

        e.g. A1, A2, . . . B1, B2, . . . , E1, E2, . . .

    - then the two syntaxes (1|a/b) (or (1|a)+(1|a:b)) and (1|a)+(1|b) are equivalent

Crossed random effects

- units of one factor can be measured in multiple units of another factor
- e.g. locations measured in multiple years `(1|location)+(1|year)`

Some other random effect covariance structures

- temporal correlation
  - AR(1)
  - Ornstein–Uhlenbeck
  - differences between `ou` and `ar1`
    - `ou` can handle irregular time points
    - `ou` only allows > 0 correlation between neighboring time points
- spatial correlation
  - exponential
  - Gaussian
  - matern

see `covstruct` vignette for other options

Heliconia GLMM example

- inflorescence count depends on plant size and habitat

- repeated annual measures of plots (location) and individuals

- random individuals

- random plots

- random years

see code_RE.R

Recap

- formulas

- RE go into the conditional mean

- introduced nested and crossed

- introduced temporal and spatial options

- an example wuth random intercepts and AR(1) correlation