36-463/663: Multilevel & Hierarchical Models

To Find Out More…

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Outline

- Stuff you can do in R
- Books on applied MLM/HLM
- Books on Applied Hierarchical Bayes
- Generalized Linear Regression
- Theory of Mixed Models
- AIC, BIC and all that…
- Using Residuals and AIC/BIC/…
- Posterior predictive model checking
- Power analysis

Stuff you can do in R

- For Statistics:
  - Venables & Ripley (2002). *Modern Applied Statistics with S.* (4th ed?) NY: Springer.
- For Data Mining:
  - Hastie, Tibshirani & Freedman (2009). The Elements of Statistical Learning (2nd ed). NY: Springer. http://statweb.stanford.edu/~tibs/ElemStatLearn/
- For R programming:
  - http://www.stat.cmu.edu/~cshalizi/statcomp/ (intro to statistical computing)
  - http://www.stat.cmu.edu/~ryantibs/datamining/ (intro to data mining)

Books on applied MLM/HLM

- Gelman & Hill (2007).
  - We know this book! Wonderful data analysis and applied statistics examples and wisdom. Chock full of ideas.
- Snijders & Bosker (2012). *Multilevel Analysis: An Intro to Basic and Advanced Multilevel Modeling. 2nd Ed.*, Sage.
  - Lots of practical applied statistics wisdom for multilevel models in the social sciences.
- Bryk, A.S., & Raudenbush, S.W. (2001). *Hierarchical Linear Models in Social and Behavioral Research: Applications and Data Analysis Methods (Second Edition).* Newbury Park, CA: Sage Publications.
  - They didn't invent HLM's but they wrote the canonical text on applied HLM's in the social sciences, and this is it.

Books on Applied Hierarchical Bayes

- Lynch (2007*). Introduction to Applied Bayesian Statistics and Estimation for Social Scientists*. New York: Springer.
  - Very nice book. A relatively gentle and far-reaching introduction to modern applied Bayesian statistics.
- Gelman, et al. (2013). *Bayesian Data Analysis, third edition.* London: CRC Press.
  - A standard text in applied Bayesian statistics. Not that easy to learn from, but a great reference.
- Congdon, P (2010). *Applied Bayesian Hierarchical Methods.* NY: Wiley.
  - The latest in Congdon's series of cookbooks for building Bayesian models for practical applications, mostly/entirely with WinBUGS.
- Lunn, et al. (2012). The BUGS Book: A Practical Introduction to Bayesian Analysis. NY: Chapman & Hall/CRC.
  - Practical guide to BUGS, JAGS, etc.

Generalized Linear Regression

- Christensen, R. (1997). *Log-linear models and logistic regression. 2nd Ed.* NY: Springer.
  - Good introduction to theory and applications
- Dobson, A. & Barnett, A. (2008). *An introduction to generalized linear models.* London: CRC Press.
  - A bit more formal but similar to Christensen.
- McCullagh, Peter; Nelder, John (1989). Generalized Linear Models, Second Edition. London: CRC Press.
  - Seminal book on glm's.
- Agresti, A. (2002). *Categorical Data Analsis.* NY: Wiley.
  - Encycopedic but not always satisfying!
- Bishop, Fienberg & Holland (2007 reissue). *Discrete multivariate analysis: theory and practice.* NY: Springer.
  - Seminal book on analyzing discrete data. Well worth owning.

Theory of Mixed Models

- Seminal papers on mixed effects linear models and mixed effects generalized linear models:
  - Laird, NM & Ware, JH (1982). Random-effects models for longitudinal data. *Biometrics, 38,* 963-974.
  - Stiratelli R, Laird N & Ware J (1984). Random-effects models for serial observations with binary response. *Biometrics, 40,* 961-971.
- Discussion of ML estimation and prediction in mixed models:
  - Robinson GK (1991). That BLUP is a good thing: the estimation of random effects. *Statistical Science, 6,* 15-32.
- Modern survey, by the writers of lme4 / lmer()
  - Pinhero, JC & Bates, DM (2009). *Mixed effects models in S and S-Plus, second printing.* NY: Springer.

AIC, BIC and all that…

- AIC:
  - Akaike, H. (1973) Information theory and an extension of the maximum likelihood principle. In *Second International Symposium on Information Theory*, eds B. N. Petrov & F. Caski, pp. 267–281. Budapest: Akademiai Kaido. Reprinted in *Breakthroughs in Statistics*, eds Kotz, S. & Johnson, N. L. (1992), volume I, pp. 599–624. New York: Springer.
  - Akaike, H. (1974) A new look at statistical model identification. *IEEE Transactions on Automatic Control 19,* 716–723.
- BIC:
  - Schwarz, G. (1978) Estimating the dimension of a model. *Annals of Statistics 6,* 461–464.
  - Kass, R & Wasserman L (1995). A reference Bayesian test for nested hypotheses and its relationship to the Schwarz criterion. *JASA, 90*, 928-934.
- DIC:
  - Spiegelhalter, D. J., Best, N. G., Carlin, B. P. and van der Linde, A. (2002) Bayesian measures of model complexity and fit. *JRSSB, 64,* 583–639.
  - Plummer, M (2007). Penalized loss functions for Bayesian model comparison. *Biostatistics, 9,* 523-539.
- General advice (preceding DIC):
  - Kass RE & Raftery AE (1995). Bayes factors. *JASA, 90,* 773-795.
  - Burnham, K. P. and Anderson, D. R. (2002) Model Selection and Multimodel Inference, Second edition, Springer.

Using Residuals and AIC/BIC/…

- AIC/BIC/etc:
  - Bondell HD, Krishna A, & Ghosh SK (2010). Joint variable selection for fixed and random effects in linear mixed-effects models. *Biometrics, 66,* 1069-1077.
  - Kinney, SK & Dunson, DB (2007). Fixed and random effects selection in linear and logistic models. *Biometrics, 63,* 690-698.
  - Saville, BR & Herring, AH (2009). Testing random effects in the linear mixed model using approximate Bayes factors. *Biometrics, 65,* 369-376
  - Vaida, F. & Blanchard S. (2005). Conditional Akaike information for mixed-effects models. *Biometrika, 92,* 351-370.
- Residuals:
  - Nobre, JS & Singer, J (2007). Residual analysis for linear mixed models. *Biometrical Journal, 49,* 863-875.
- Is it a good idea?
  - Raftery AR (1995). Bayesian model selection in social research. *Sociological Methodology, 25,* 111-163. [see also discussion and rejoinder]

Posterior predictive simulation; posterior predictive model checking

- Gelman A, Meng X-L, & Stern, HS. (1996). Posterior Predictive Assessment of Model Fitness Via Realized Discrepancies. *Statistica Sinica 6,* 733-807.
  - [see discussion following article also!]
- An entire Theory and Methods section of JASA is devoted to the theoretical properties of posterior predictive checking, starting with these two articles:
  - Bayarri MJ & Berger JO (2000). P-values for composite null models. JASA, 95, 1127-1142
  - Robins, J, van der Vaart, A & Ventura V (2000). Asymptotic distribution of p-values in composite null models. JASA, 95, 1143-1156

Power analysis

- How to do it in multilevel models:
  - Raudenbush, S. & Liu, X (2000). Statistical power and optimal design for multisite randomized trials. *Psychological Methods, 2,* 199-213
  - Snijders, T. & Bosker, R. (1993). Standard errors and sample sizes in two-level research. *Journal of Educational Statistics, 18,* 237-259.
- Some general considerations:
  - O'Hagan A & Stevens JW (2001). Bayesian assessment of sample size for clinical trials of cost-effectiveness. *Medical Decision Making 21,* 219-230.

Last thoughts

- This is ***always*** a fun class for me!
- Project Part I Grades Out by the end of the weekend I hope (solutions before that!)
- Final exam Dec 8 in class
  - Review session next Tue (Dec 6) in class
- Project Part II due on Blackboard, by Fri Dec 16, Midnight; Grades will be posted Dec 21
- I hope you begin to think flexibly about designing, building and fitting models for data analysis!