Hunter College
STAT 706 General Linear Models I
Course Content (Fall 2016)

Reference books

1. Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models, 2nd edition, by Julian J. Faraway.
2. Linear Models with R, 2nd edition, by Julian J. Faraway.
3. An Introduction to Generalized Linear Models, 3rd edition, by Annette J. Dobson & Adrian G. Barnett.
4. Generalized Linear Models, 2nd edition, by P. McCullagh & J. A. Nelder.

Topic List

1. A brief introduction to R programing. (0.5 lecture)
    - RStudio: a user interface for R.
    - Swirl: learn R in R. Practice R programming and data science interactively in the R console.
    - R Markdown. Create dynamic documents with embedded chunks of R code.
2. Multivariate linear regression model, general linear model, least squares estimation. (0.5 lecture)
3. Generalized linear model. (5 lectures)
    - Review: Newton-Raphson method, Fisher's scoring algorithm, Rao-Cramer lower bound, Cauchy distribution, Gumbel distribution, inverse Gaussian distribution, hazard ratio, Box-Cox transformation.
    - nuisance parameter, systematic effect, link function.
    - Normal (link: identity, log, inverse), Binomial (link: logit, probit, Cauchit, complementary log-log), Gamma (link:inverse, identity, log), Poisson (link: log, identity, square root), inverse Gaussian (link: inversed square, inverse, identity, log), negative binomial.
    - Fisher's scoring method for estimating the coefficients in generalized linear model.

- Measuring goodness of fit, deviance, generalized Pearson's chi-square, residuals.
- R functions: `glm()` in stats, `glm.nb()` in MASS, `survreg()` in survival.
- Reference:
  - Nelder, J., & Wedderburn, R. (1972). Generalized Linear Models. *Journal of the Royal Statistical Society. Series A (General)*, 135(3), 370-384.
  - Pierce, D. A., & Schafer, D. W. (1986). Residuals in Generalized Linear Models. *Journal of the American Statistical Association*, 81, 977-986.
  - Moser, A., Clough-Gorr, K., & Zwahlen, M. (2015). Modeling absolute differences in life expectancy with a censored skew-normal regression approach. *PeerJ* 3, 1162.

4. Quasi-likelihood generalized linear model. (1 lecture)

   - Overdispersion, quasi-likelihood.
   - Fisher's scoring method for estimating the coefficients in quasi-likelihood generalized linear model.
   - Reference:
     - Wedderburn, R. (1974). Quasi-Likelihood Functions, Generalized Linear Models, and the Gauss-Newton Method. *Biometrika*, 61(3), 439-447.

5. Generalized linear mixed model. (4 lectures)

   - Review: projection matrix, Moore-Penrose pseudoinverse, singular value decomposition
   - Fixed effect and random effect.
   - Clustered data, longitudinal data.
   - Linear mixed model, hierarchical model, marginal model.
   - Estimation of fixed/random effect parameters with known covariance structure, weighted least square estimation,
   - profile log likelihood, restricted maximum likelihood, marginal log likelihood.
   - Estimation of fixed/random effect parameters with unknown covariance structure, penalized quasi-likelihood.
   - R functions: `lmer` in lme4, `glmm` in glmm.
   - Reference:
     - Robert A. McLean, R. A., Sanders, W. L., & Stroup, W. W. (1991). A unified approach to mixed linear models. *The American Statistician*, 45, 54-64.

- Breslow, N., & Clayton, D. (1993). Approximate Inference in Generalized Linear Mixed Models. *Journal of the American Statistical Association*, 88(421), 9-25.

6. Recursive estimation: Kalman filter. (1.5 lectures)

   - Review: loss function (squared-error, absolute-error, uniform), risk function, Bayes risk, maximum a posteriori probability (MAP) estimate, conjugate family, Bayes estimation with the Gaussian distribution.
   - Recursive estimation: assumptions, propagation step, update step.
   - Kalman filter: discrete-time state-space signal model, assumptions, Kalman gain, extrapolation/update steps.
   - Reference:
     - Karlman, R. E. (1960). A new approach to linear filtering and prediction problems. *Transactions of the ASME - Journal of Basic Engineering*, 82 (Series D), 35-45.

7. Regression analysis for censored data (1 lecture)

   - Review: survival function, reduced-sample estimate, product-limit estimate
   - Kaplan-Meier (KM) estimator, Kaplan-Meier plot, Greenwoods formula for confidence interval on survival probabilities, complementary log-log transformation.
   - Cox proportional hazards model, partial likelihood.
   - Reference:
     - Kaplan, E. L. and Meier, P. (1958). Nonparametric estimation from incomplete observations. *Journal of the American Statistical Association*, 53, 457-481.
     - Cox, D. R. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society. Series B (Methodological)*, 34, 187-220.

8. Final review (0.5 lecture)