Applied Variance Component Estimation
Course Syllabus

Fall, 2017

Instructors

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Prerequisites

Linear Models in Animal Breeding
Genetic Prediction

Schedule and Credit

This online course will begin the week of October 30, 2017 and will contain 5 weeks of content, ending December 8, 2017. No course material will be presented the week of November 20 in observance of the Thanksgiving holiday and fall break.

The content and rigor is designed be to equivalent to a one credit graduate level course.

Required Texts

No textbook is required for the course, although the following book is recommended as a useful reference:

> Mrode, R. A. 2013. Linear Models for the Prediction of Animal Breeding Values, 3rd Edition. CAB International, Wallingford, Oxfordshire, UK. (ISBN 978 1 84593 981 6)

Course Goals and Description

The goal of this course is to extend upon content covered in linear models and genetic prediction, with specific emphasis on estimation of genetic parameters required to solve mixed models typically used in livestock genetics. Upon successful completion of this course, students should have an applied knowledge of approaches used to estimate the G and R sub-matrices of the mixed model equations. Several tools will be used to demonstrate the models and approaches most commonly used in parameter estimation. Where appropriate, scientific literature that explains the implementation of these components, and some attributes of the solutions obtained will be used. A general knowledge of linear models, matrix algebra, moment statistics, rules of expectation and familiarity with UNIX/Linux Operating Systems will be assumed, including scripting tools such as awk, octave, join, sort, paste, wc, etc. This course will begin in a somewhat historical manner, proceeding on to methods and software currently used for research and field data implementation.

Course Access

Access to course will be through Canvas: http://info.canvas.colostate.edu/login.aspx

This course will be delivered completely online. Teaching will consist of recorded power-point lectures, and hands-on practice.

Academic Integrity

In this course students will be expected to abide by the Colorado State University honor code as outlined below.

Colorado State University expects students to maintain standards of personal integrity that are in harmony with the educational goals of the institution; to observe national, state, and local laws, and University regulations; and to respect the rights, privileges, and property of other people (see Student Rights and Responsibilities)

We take academic integrity seriously. At a minimum, to achieve academic integrity no student will use another's work as his or her own. The Colorado State University presents a guide useful for understanding plagiarism.

Overall Student Assessment

Your final grade will be based on an aggregate sum of points equally distributed among quizzes (4), homework (3), class participation (5 forums), and the final exam, each of which will represent 25% of the final score. Written assessment items will be graded not only on accuracy and completeness of student answers, but academic integrity as well, whereas class participation will be assessed for timeliness, relevance to the current topic, and the comprehensiveness of each forum post itself.

Final letter grades will be assigned based on the ratio of earned points to total available points (on a percentage basis). The minimum percentages earned equate to the following letter grades: (A $\geq$ 90%, B $\geq$ 80%, C $\geq$ 70%, D $\geq$ 60%, and F < 60%) although the instructor reserves the right to lower (but not raise) these minimum requirements.

Course Objectives and Schedule

WK	Dates	Topics & *Weekly Learning Objectives*	Assignments (Due Date)
1	10/30– 11/3	**1. Course Introduction** 1.1 Goals 1.2 Module Motivation **2. Selected Topics Review** 2.1 Review of Expectation 2.2 (Co)variance Algebra 2.3 Linear Functions *(a).* Compute expectations and variances of linear functions of properly defined random variables *(b).* Formulate algebraic properties of random variables. *(c).* Construct linear functions that result in equivalent variance models **3. Classical Models** 3.1 Regression and SS 3.2 SS and Expectation 3.3 Half-Sib Model Example *(a).* Assemble ANOVA tables and properly write expectations in genetic terms. *(b).* Construct a variance model to estimate relevant variance(s) using data from paternal half-sibs.	**1. Presentations** 1.1 Watch Audio 1, 2 & 3 **2. Class Participation** 2.1 Post to Forum 1 (11/3) **3. Assessment** 3.1 Quiz 1 (11/2), Due (11/7)
2	11/6 – 11/10	**1. Fixed Effect Models to Mixed Models** 2.1. Inclusion of random effects *(a).* Describe the underlying need for a random genetic effect. **2. Computational Approaches** 1.1 ANOVA to ML to REML (a). Compare ANOVA, ML and REML and describe the inherent differences between the approaches.	**1. Presentations** 1.1 Watch Audio Visual **2. Class Participation** 2.1 Post to Forum 2 (11/10) **3. Assessment** 3.1 Quiz 2 (11/9), Due (11/14)

WK	Dates	Topics & *Weekly Learning Objectives*	Assignments (Due Date)
3	11/13 – 11/17	**1. Implementation 1** 1.1 Experimental Data 1.2 Using a software package to estimate genetic parameters. *(a).* Use MTDFREML to estimate genetic and residual variance components **2. Variance Models 1** 1.1 Notation for $\mathbf{G}^{-1}$ and $\mathbf{R}^{-1}$ 1.2 Single Traits *(a).* Distinguish among notation(s). *(b).* Communicate the importance of a complete model.	**1. Presentations** 1.1 Watch audio visuals **2. Class Participation** 2.1 Post to Forum 3 (11/17) **3. Assessment** 3.1 Submit HWK 1 (11/13) 3.2 Quiz 3 (11/16), Due (11/28)
4	11/20 – 11/24	Fall Break. No Course Material.	
5	11/27 – 12/1	**1. Variance Models 2** 1.1 Adding Correlated Effects 1.2 Traits with IID Random Effects. 1.3 Multiple traits *(a)*. Describe how covariance differs with correlated versus uncorrelated random effects. *(b)*. Write and interpret a complete multivariate model *(c).* Discuss the implications of multivariate versus univariate models. **2. Implementation 2** 1.1 Experimental Data 1.2 Using a software package to estimate genetic parameters. *(a).* Use MTDFREML to estimate genetic and residual variance components. *(b).* Multiple random components and multiple traits.	**1. Presentations** 1.1 Watch Audiovisuals **2. Class Participation** 2.1 Post to Forum 4 (12/1) **3. Assessment** 3.1 Submit HWK 2 (11/27) 3.2 Quiz 4 (11/30), Due (12/5)

WK	Dates	Topics & *Weekly Learning Objectives*	Assignments (Due Date)
6	12/4 – 12/8	**1. G and R Matrix Stability** 1.1 Eigenvalues and Inversion 1.2 Methods for High-Order Models *(a).* Define the required properties of **G** and **R** in relation to inversion, convergence and stability of random solutions. *(b).* Appreciate the impact of non-singularities of **G** and **R**, limitations on parameter space, and alternatives to ensure components are positive definite. **2. Variance Models 3** 2.1. Markov Chain Monte Carlo Theory 2.2. The Gibbs Sampler *(a)*. Model Notation *(b).* Prior and Conditional Distributions *(c).* Describe the Gibbs sampling algorithm for variance component estimation. **3. Course Wrap Up** 3.1 Instructions for the Final Exam	**1. Presentations** 1.1 Watch Audiovisuals **2. Class Participation** 2.1 Post to Forum 5 (12/8) **3. Assessment** 3.1 Submit HWK 3 (12/8) 3.2 Final Exam (12/8), Due (12/15)