

APSC 5984/20816 Complex Trait Genomics

3 credits

Spring 2020

Instructor

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Time and Location

- MWF 12:20-1:10
- WAL 244

Course Description

This course will cover quantitative genetic analysis of complex trait genomics with emphasis on the use of molecular markers spanning the entire genome. We will discuss statistical methodologies for connecting phenotypes with high-dimensional genomic information to better understand polygenic traits from both prediction and inference perspectives. Topics will include genomic relatedness, linkage disequilibrium, population stratification, genomic heritability, missing heritability, genome-wide association study, genomic prediction, causal inference, and statistical learning. We will use examples from the animal, plant, and human genetics literature. Additional topics will be briefly touched upon, including sequence data, gene expression, epigenetics, and bioinformatics. Homework assignments involve hands-on analysis of simulated and real genomic data available in public repositories. The course will use R/Bioconductor software for statistical computing tools.

Learning Objectives

After taking this course, the student will be able to:

- understand the statistical theory behind commonly used quantitative methods in genomics
- apply statistical methods to high-dimensional genomic data and analyze them using statistical computing tools
- critically review current literature in statistical and quantitative genetics

Texts and Reading Materials

Lecture slides will be provided on the class website. There will be no required textbook.

Tentative schedule

1. Overview of statistical genomics - Prediction vs. Inference
2. Ordinary least-squares and the curse of dimensionality
3. Linkage disequilibrium
4. Relatedness due to expected resemblance - Additive relationships
5. Relatedness due to expected resemblance - Non-additive relationships
6. Relatedness due to genetic markers - Additive relationships
7. Relatedness due to genetic markers - Non-additive relationships
8. Population structure and cryptic relatedness
9. Likelihood and Bayesian approaches in quantitative genetics
10. Whole-genome regression - Penalized regression
11. Whole-genome regression - Bayesian alphabet regression 1
12. Whole-genome regression - Bayesian alphabet regression 2
13. Whole-genome regression - Genomic BLUP 1
14. Whole-genome regression - Genomic BLUP 2
15. Introduction to whole-genome regression software
16. Whole-genome regression - Semi-parametric regression 1
17. Whole-genome regression - Semi-parametric regression 2
18. Estimation of heritability using pedigree and twin data 1
19. Estimation of heritability using pedigree and twin data 2
20. Estimation of heritability using genomic data
21. Population stratification - Principal component analysis
22. Population stratification - Mixed-linear-model association 1
23. Population stratification - Mixed-linear-model association 2
24. Population stratification - Genomic control
25. Missing heritability - Related vs. unrelated individuals
26. Deterministic equations for genome-enabled prediction
27. Statistical genomics of disease - Liability threshold model 1

- 28. Statistical genomics of disease - Liability threshold model 2
- 29. Multiple-trait model
- 30. Genotype x environment interaction
- 31. Student presentation

Grading

There will be bi-weekly take-home projects to analyze simulated or real data sets and the final exam at the end of course. Grades will be based on the data analyses (worth 65% of grade or 65 points), the final exam (worth 25% of grade or 25 points), and class presentation/discussion sessions (worth 10% of grade or 10 points).

The final grade will be based on the following scale:

Points	Grade
> 90	A
85-89	A-
80-84	B+
75-79	B
70-74	B-
65-69	C+
60-64	C
55-59	C-
< 54	F

The Fundamental Beliefs of the VT Graduate Honor Code

The fundamental beliefs underlying and reflected in the Graduate Honor Code are that

- to trust in a person is a positive force in making a person worthy of trust,
- to study, perform research, and teach in an environment that is free from the inconveniences and injustices caused by any form of intellectual dishonesty is a right of every graduate student,
- to live by an Honor System, which places a positive emphasis on honesty as a means of protecting this right, is consistent with, and a contribution to, the University's quest for truth

To read more about honor code policies: <http://ghs.graduateschool.vt.edu/constitution>

Principles of community

Virginia Tech is a public land-grant university, committed to teaching and learning, research, and outreach to the Commonwealth of Virginia, the nation, and the world community. Learning from the experiences that shape Virginia Tech as an institution, we acknowledge those aspects of our legacy that reflected bias and exclusion. Therefore, we adopt and practice the following principles as fundamental to our on-going efforts to increase access and inclusion and to create a community that nurtures learning and growth for all of its members:

- We affirm the inherent dignity and value of every person and strive to maintain a climate for work and learning based on mutual respect and understanding.

- We affirm the right of each person to express thoughts and opinions freely. We encourage open expression within a climate of civility, sensitivity, and mutual respect.
- We affirm the value of human diversity because it enriches our lives and the University. We acknowledge and respect our differences while affirming our common humanity.
- We reject all forms of prejudice and discrimination, including those based on age, color, disability, gender, national origin, political affiliation, race, religion, sexual orientation, and veteran status. We take individual and collective responsibility for helping to eliminate bias and discrimination and for increasing our own understanding of these issues through education, training, and interaction with others.
- We pledge our collective commitment to these principles in the spirit of the Virginia Tech motto of Ut Prosim (That I May Serve).

Students with disabilities

If you have a physical, sensory learning, or psychological disability and require accommodations, please let me know as soon as possible. You will need to register with, and provide documentation of your disability to, Services for Students with Disabilities at <http://www.ssd.vt.edu/>.