ME8873 – Statistical Model Estimation – Spring 2022

Instructors Dr. Levi Wood

Location Howey S104 and/or on BlueJeans, MW, 11am -12:15 pm

Office Hours W3-4 pm via BlueJeans and by appointment

E-mail levi.wood@me.gatech.edu, (write ME 8873 in subject line)

Working Together and Class Operation During COVID-19:

- Attendance: Class attendance is required, but may be in person or via simulcast. If attending online, you must keep your video on to facility participation.
- Masks and if you are feeling sick: I prefer that you wear a mask to limit spread within our class. If you feel sick, I encourage you to attend via simulcast. If you are very sick and won't be attending, please keep me posted! Communication is key!
- Contingency: In case Dr. Wood becomes sick or exposed to COVID-19, or campus shifts to online-only modes (e.g., due to COVID spike), we will aim to keep class operation continuing via online teaching.
- By default, office hours will be held via BlueJeans. Some limited face-to-face office hours may be schedule as needed.
- The midterm exam will be in person.
- Lectures will be recorded.

Recommended Prior Experience: MATH 1553 Linear Algebra, MATH 3215 Probability and Statistics, Knowledge of Coding

Suggested Additional Prior Experience: ISYE 3770 Statistics and Applications, MATH 3670 Probability and Statistics with Applications, ME 3015 Control Systems, ME 6622 Experimental Methods,

Textbook:

None required. Suggested References:

1. Ljung, System Identification: Theory for the User, 2nd Edition

Course Description

In this course, will cover theory and applications needed to interpret and model noisy data, such as from biomechanical instruments or bioanalytical assays.

Course Objectives

Objective 1: To educate students on statistical and deterministic modeling and analysis frameworks for analyzing real "noisy" data.

Objective 2: To provide students with an appreciation for low-order system modeling and contrast this to data-intensive machine learning approaches.

Objective 3: To train students on the concept of parameter and model identifiability and to quantify model predictive power.

Objective 4: To train students how to select appropriate models given underlying dynamics, available data, and context of model use.

Objective 5: To expose students to applications and challenges of data driven modeling in traditional engineering and bio-engineering systems.

Topics Covered

All topics are covered first with a theoretical underpinning, then with an example application.

1. Parametric and non-parametric methods for statistical testing and group comparison
2. Linear model parameter estimation techniques
3. Model structures and orthogonal basis functions
4. Dimensional reduction, including principal component analysis and partial least squares regression
5. Model confidence and statistically significant differences between models.
6. Kalman filtering for state space estimation
7. Maximum likelihood and Bayesian parameter likelihood estimation
8. Machine learning, including Neural and Bayesian networks
9. Asymptotic distribution of parameter estimates, and parameter sensitivity.
10. Experimental design for parameter estimation
11. Metrics for model structure estimation, including Akaike's information criterion

Grading:

Homework: 40% (7 equally weighted assignments)
Midterm: 30%
Final Project: 30%

Examination:

Midterm exam is open-note.

If you think I have made an error in grading your exam, feel free to re-submit it. However, we will not discuss any grading issues until the end of the class period following the return of your exam. Further, if you do decide to resubmit your exam for re-grading, we will re-grade the entire exam.

Homework:

Homework will be submitted to Canvas online. Two homework problems from each assignment will be randomly selected and graded. The homework assignment will be based on the two problems selected. Please check with Dr. Wood if you think a homework problem may have been incorrectly graded.

Citing Your References:

You must document any assistance that you received from any person or any reference to complete your homework assignments. We encourage you to try to work out the problems separately, then meet in study groups to compare your answers, and to combine forces in trying to solve some of the more difficult problems. But you must document the resources you used.

Academic Misconduct:

I expect all students to comply with the Georgia Tech Honor Code. I will refer any evidence of cheating or other violations to the Dean of Students with a recommendation that the penalty be an award of zero points for the graded requirement, and a one letter grade reduction in the course. Cheating includes, but is not limited to: using unauthorized references or notes; copying directly from any source, including friends, classmates, or a solutions manual; allowing another person to copy your work; taking an exam or handing in a graded requirement in someone else's name, or having someone else take an exam or hand in a graded requirement in your name; or asking for a re-grade of a submission that has been altered from its original form.

Resources:

- Canvas: We will post homework and exam solutions, and additional resources as useful.
- Ask questions! In class or one-on-one. Even if your question is simply "I don't get it," we can trace back and determine what we missed. More than likely if you don't get it, someone else won't either!
- If you have a documented disability and require additional assistance, please contact us.

Final Grading:

The following grades for % final averages are guaranteed: A = 90+, B = 80+, C = 70+, D = 60+. Further, at the end of the semester we will list the final averages in descending order, look for natural breaks, and make adjustments if warranted. If your final class average is right at the break between letter grades, we will re-examine your work for the semester, including class participation, to decide which side of the break you belong on. By doing all of your homework assignments, being present for quizzes and being prepared for the exams you can ensure that you have all the possible advantages.

Classroom Policy (Virtual/BlueJeans):

Above all else, we want you to treat this class as a professional setting. Be respectful to us and to your classmates.

- Be courteous in how you address Dr. Wood and your fellow students.
- Don't be texting throughout class! Keep your phone put away.
- You can use your computer or tablet for taking notes, but if you are clearly distracted or are distracting me or your classmates, I will ask you to put it away.

What you can expect from Dr. Wood:

You can expect that I will be respectful in how we address you and answer your questions. If we can't answer your question right away, we will think on it and get back to you. We will return your graded assignments to you as quickly as possible. Usually, one week after they were turned in. If you have constructive ideas for the class, we will be happy to consider them (cool dynamic videos we might want to watch in class, for example!).

Tentative Course Schedule (subject to announced updates):

Week	Date	Topic	HW Assigned (due about 2 weeks later)
1	01/10 M	Course Operation and Introduction	
	01/22 W	Overview of parameter estimation and t-test	
2	01/17 M	No Class: Martin Luther King Holiday	
	01/19 W	Hypothesis testing for parameter estimation problems	HW1
3	01/24 M	Least squares regression I	
	01/26 W	Least squares regression II	
4	01/31 M	Principal and independent component analysis	HW2
	02/02 W	Partial least squares regression	
5	02/07 M	Kalman filtering I	
	02/09 W	Kalman filtering II	
6	02/14 M	Impulse response and time delay operator	HW3
	02/16 W	Linear system models I	
7	03/21 M	Linear system models II	
	02/23 W	Linear system models III	
8	02/28 M	Model confidence and differences between models	HW4
	03/02 W	Machine learning I (neural networks)	
9	03/07 M	Machine learning II (Bayesian networks)	
	03/09 W	**Midterm Exam**	
10	03/14 M	Frequency domain analysis **(Final Project Consultations)**	HW5
	03/16 W	TBD **(Withdrawal deadline on 03/08)**	
11	03/21 M	Spring Break	
	03/23 W	Spring Break	

Week	Date	Topic	HW Assigned (due about 2 weeks later)
12	03/28 M	Informative datasets and experimental design	
	03/30 W	Maximum likelihood estimators	
13	04/04 M	Information theory and Akaike's Information Criterion I	HW6
	04/06 W	Information theory and Akaike's Information Criterion II	
14	04/11 M	The art of system identification I	
	04/13 W	The art of system identification II	HW7
15	04/18 M	TBD	
	04/20W	Final project discussions	
16	04/25 M	Final project discussions	