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North Carolina Agricultural and Technical State University

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NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

Spring 2023 Course Syllabus

College of Science and Technology

Department of Mathematics and Statistics

NOTE: Students are responsible for reading, understanding and following the syllabus.

Graduate Course Information

Course Name: Statistical Computing and Algorithm Analysis

Course Number/Section: STAT 711-00A

Credit Hours: 3.00

Days and Times: No Class Meetings

Class Location: Blackboard (Distance Learning)

Instructor Contact Information

Instructor:

Office Location:

Email Address:

Office Phone:

Communication

Students can expect to receive an answer to all communications (e.g., email, phone, course messages) within 48 hours, i.e., within two business days. If you do not hear from me in 48 hours, please forward the email to me again.

Student Hours

These are times students may visit the professor without an appointment to request the assistance they need.

10:00 AM ☒ / PM ☐ – 11:00 AM ☒ / PM ☐

Monday ☒ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☒

Course Prerequisites

STAT 707

Course Description

This course covers both theoretical and practical issues of statistical computing and algorithms required in modern data science. Students will learn how to develop algorithms for statistical methods and apply them to data science problems. Topics include resampling methods, EM algorithm, Markov chain Monte Carlo simulation, gradient-based optimization, and nonparametric curve fitting.

Student Learning Objectives/Outcomes (SLO)

By the end of the course, students will get to:

1. Recognize the role of computing algorithms in statistical inference and modeling
2. Understand and implement deterministic algorithms commonly used in statistics, such as root finding methods, Newton-Raphson methods, and the EM Algorithm
3. Understand and use common stochastic statistical algorithms, such as Markov Chain Monte Carlo methods, Gibbs sampling, and Metropolis-Hastings algorithms
4. Transform statistical problems into optimization problems and build algorithms to solve these problems
5. Use resampling methods such as the Jackknife and the bootstrap to assess the performance of statistical methods and to conduct statistical inference
6. Execute statistical simulations and algorithms using the statistical programming language R
7. Apply these algorithms to explore data structures using nonparametric smoothing techniques

Required Textbooks and Materials

REQUIRED TEXTS:

Rizo, M. L. (2019). Statistical Computing With R, 2nd Ed, Chapman & Hall/CRC, ISBN-13: 978-1466553323

REQUIRED MATERIALS:

- Access to Blackboard. Course syllabus, lecture notes, test and quiz scores, and mid-term and final grades will be accessible in Blackboard.
- Access to a *computer* with a *webcam* and sufficient *internet* access to take exams securely in Blackboard (Bb), Respondus Lockdown Browser and Webcam Monitor. *Chromebooks are not compatible* with the exam security system in Bb.
- Statistical software: R and/or Python

Suggested Course Materials

SUGGESTED READINGS/TEXTS:

- Voss, J. (2014). An Introduction to Statistical Computing: A Simulation-based Approach, Wiley, ISBN-13: 978-1118357729
- Gentle, J. E. (2002). Elements of Computational Statistics, Springer, ISBN-13: 978-14419-30248
- Weihs, C., Mersmann, A., and Ligges, U. (2013). Foundations of Statistical Algorithms: With References to R Packages, 1st Ed, Chapman & Hall/CRC, ISBN-13: 978-1439878859

Grading Policy

Course Grade Scale [Graduate Level Courses]

92-100	A	78-79	B-
90-91	A-	76-77	C+
88-89	B+	70-75	C
80-87	B	00-69	F

Grading Allocation

Course grades are based on a weighted grading scale of 100%. The breakdown for the course is as follows:

Work	Percentage	Notes
Homework	35%	About 9 HWs (Lowest score will be dropped)
Quizzes	5%	About 8 Quizzes (Lowest score will be dropped)
Project	15%	Complete and submit a statistical computing project
Midterm Exam	20%	Opens on Thursday, 03/25 and closes on Friday, 03/26
Final Exam	25%	Opens on Tuesday, 05/10 and closes on Wednesday, 05/11

Homework (HW)

- You will have a homework assignment due following the discussion of each topic.
- You will need to use R to solve homework problems, and you should submit your detailed answers and code as an MS word file or pdf file generated by R Markdown (other formats will not be accepted).
- Your lowest homework score will be dropped.

Quizzes

- Following the conclusion of each topic, you will be asked to complete a quiz.
- Each quiz may cover conceptual aspects, computational aspects, or both.
- Quizzes covering only conceptual aspects are closed book, closed notes, and closed laptop. You will be allowed to use your laptop for quizzes requiring calculations.
- Your lowest quiz score will be dropped.

Project

- After the midterm, each student will be assigned a statistical computing project to complete.
- Each student will prepare and submit a project report summarizing the results their project.
- The project report should also contain the R code as an Appendix.

Exams

- Each exam will consist of two parts: conceptual part and coding part.
- The conceptual part of the exam will contain multiple choice questions and it will be closed-book and closed-notes. **This part will be taken in-class or using Respondus Lockdown Browser and a Webcam if in-person test-taking is not feasible.**
- The coding part of the exam will contain multiple R coding tasks to solve statistical computing problems. This is a take-home part, but any kind of collaboration is NOT allowed.

Course Policies

Use Of Blackboard as The Learning Management System

Blackboard is the primary online instructional and course communications platform. Students can access the course syllabus, assignments, grades, and learner support resources. Students are encouraged to protect their login credentials, complete a Blackboard orientation and log in daily to course.

[Other Course Policies]

Describe all policies specific to your course, e.g. Make-Up Exams, Late Work, Extra Credit, Special Assignments, Homework, Quizzes, Exams, Academic Dishonesty, Attendance/Participation, or Classroom Citizenship, etc. Utilize any headings as needed. Here you could include any common policies that you feel require special mention.

For GRADUATE STUDENTS: STUDENT RELIGIOUS OBSERVANCE (see 2021-2022 Graduate Catalog, p.57)

Make-Up Exams Only university-recognized excuses (e.g. Immediate Family Loss, Illness, etc.) are accepted. The student should notify the instructor at least 72 hours prior to missing quiz or exam and official documentation should be presented, e.g., Doctor's note. The student missing a quiz or exam with valid documented excuse is responsible to contact the instructor to reschedule for making-up missed quiz or exam.

Extra Credit Any extra credit opportunities will be announced in class and/or via Blackboard.

Late Work Late work shall not be accepted except due to a university-excused absence on due date.

Special Assignments There shall be no special assignments.

Class Schedule [or Course Plan]

SCwR: Statistical Computing with R textbook

ISC: An Introduction to Statistical Computing – Simulation-Based Approach textbook

Week	Date	SUBJECT	READING IN TEXT, ACTIVITY, HOMEWORK, EXAM
Week 1	01/10-01/16	Introduction to Statistical Computing: - The role of optimization in statistical inference - Statistical methods as optimization problems	Chapters 1 & 14 in SCwR
Week 2	01/17-01/23	Optimization Methods (cont'd): - Gradient methods - Newton-Raphson method - Quasi-Newton methods - The EM algorithm	Chapters 1 & 14 in SCwR Start Homework #1
Week 3	01/24-01/30	Random Number Generation: - Pseudo random number generators - The inverse transform method	Chapter 3 in SCwR Chapter 1 in ISC Take Quiz #1 Submit Homework #1 Start Homework #2
Week 4	01/31-02/06	Random Number Generation (cont'd): - The inverse transform method (cont'd) - Rejection sampling	Chapter 3 in SCwR Chapter 1 in ISC Continue Homework #2
Week 5	02/07-02/13	Simulating Statistical Models: - The multivariate normal distribution - Hierarchical models - Markov Chains	Chapter 3.6 in SCwR Chapter 2 in ISC Take Quiz #2 Submit Homework #2 Start Homework #3
Week 6	02/14-02/20	Monte Carlo Methods: - Computing Monte Carlo estimates - The Monte Carlo error - Sample size determination	Chapter 6 in SCwR Chapter 3 in ISC Take Quiz #3 Submit Homework #3 Start Homework #4
Week 7	02/21-02/27	Monte Carlo Methods (cont'd): - Variance reduction methods (importance and stratified sampling) - Monte Carlo methods for inference (estimating bias, variance, and MSE)	Chapter 7.1–7.2 in SCwR Chapter 3.4 in ISC Continue Homework #4
Week 8	02/28-03/06	Monte Carlo Methods (cont'd): - Monte Carlo methods for inference (estimating confidence interval coverage)	Chapter 7.2–7.3 in SCwR Chapter 3.4 in ISC Take Quiz #4 Submit Homework #4 Start Homework #5
Week 9	03/07-03/13	Spring Break	
Week 10	03/14-03/20	Monte Carlo Methods (cont'd): - Monte Carlo methods for inference (estimating test size and power in hypothesis testing)	Chapter 7.2–7.3 in SCwR Chapter 3.4 in ISC Submit Homework #5
Week 11	03/21-03/27	Midterm Exam (Units 1 – 5)	Opens on 03/21 at 12:05am & Closes on 03/22 at 11:59pm
Week 12	03/28-04/03	The Bootstrap & Jackknife	Chapter 8 in SCwR Start Homework #6 Statistical Computing Projects Assigned
Week 13	04/04-04/10	The Bootstrap & Jackknife	Chapter 8 in SCwR Continue Homework #6
Week 14	04/11-04/17	Resampling Regression Models Cross Validation Permutation Tests	Chapters 8, 9.2 & 10 in SCwR Take Quiz #5 Submit Homework #6 Start Homework #7
Week 15	04/18-04/24	Markov Chain Monte Carlo Methods	Chapter 11 in SCwR Chapter 4 in ISC Take Quiz #6 Submit Homework #7

Week 16	04/25-05/01	Nonparametric Probability Density Estimation Nonparametric Regression	Chapter 12 in SCwR Submit Statistical Computing Project
Week 17	05/02-05/06	Review	
	05/09-05/13	Final Exam (Comprehensive)	Opens on 05/10 at 12:05am & Closes on 05/11 at 11:59pm

** These descriptions and timelines are subject to change at the discretion of the instructor.*

Please refer to the Common Policies file for all other University policies. The Common Policies should also be provided to all students or available in the course Blackboard shell.