CS 8803 Syllabus

Special Topics: Counting and Sampling

Fall 2026

Instructor Information

Instructor: Zongchen Chen

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General Course Information

Description

We study the problems of generating random elements from large combinatorial sets (sampling) and estimating the sizes of these sets (counting), with applications to structures such as spanning trees, independent sets, and proper graph colorings. While we place a strong emphasis on Markov Chain Monte Carlo (MCMC) methods—a highly popular class of algorithms for these tasks—we will also explore alternative approaches to sampling and counting beyond MCMC. We discuss advanced mathematical tools for analyzing the convergence rates of Markov chains and recent breakthroughs in establishing optimal mixing times. To bridge theory and practice, the course also involves comparing rigorous mathematical bounds with practical, empirical performance. Additionally, the curriculum introduces formal theorem proving in Lean. This course is designed for graduate students with backgrounds in combinatorics, probability theory, and the analysis of algorithms.

Course Learning Outcomes

Upon successful completion of this course, you should be able to formulate Markov Chain Monte Carlo (MCMC) algorithms, as well as alternative approaches, to efficiently solve sampling and counting problems within large combinatorial sets. You will be prepared to apply advanced mathematical tools to rigorously analyze the convergence rates of specific Markov chains. Furthermore, you should be able to evaluate recent theoretical advancements in algorithm design, establish optimal mixing bounds, and critically compare these theoretical guarantees against practical algorithmic performance. Finally, you will learn to use Lean for formal theorem proving.

Required Course Materials

We will not follow one particular textbook. The lecture notes will be available.

Grading Policy

Participation: 20%; Problem sets: 50%; Final project: 30%.

Letter grades are computed according to the usual brackets: A [90, 100]; B [80, 90); C [70, 80); D [60, 70); F [0, 60).

Description of Graded Components

There will be five to six problem sets and one final project.

Course Policies

Attendance and/or Participation

Attendance will be counted in determining your final grade.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code and the student Code of Conduct.

Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Core IMPACTS

Not applicable.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and

cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.