Cassandra Marcussen

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Research Interests
I am interested in theoretical computer science, probability theory, and combinatorics. In particular, I enjoy thinking about problems related to stochastic processes, randomized algorithms, computational complexity, property testing, and information theory.

Education

Columbia University in the City of New York   2018 - 2022
Double major in Mathematics & Computer Science (Foundations Track: CS Theory)
GPA 4.00, Dean's List (all applicable semesters)

Greenwich High School   2014 - 2018
GPA 4.96, ACT 35

Research Experience and Projects

Independent Research in Theoretical CS   January 2021 - Present
Project: Improving the Query Complexity of Tolerant k-Junta Testing, Distribution-Free Decision List Testing, and Uniformity Testing
Advisor: Professor Xi Chen, Columbia University

· Spring 2021: Property testing for k-juntas under the tolerant testing framework. Worked on constructing a sublinear time algorithm that, given black-box access to a Boolean function f, makes $poly(k, 1/\epsilon)$ queries and can distinguish between functions that are close to k-juntas and far from k' juntas, where $k' = O(k/\epsilon^2)$.

· Summer 2021: Distribution-free property testing for decision lists. Worked on constructing a sublinear time algorithm that, given a Boolean function f and oracle access to sampling of a fixed but unknown distribution over the inputs, tests if f is a decision list or is far from being a decision list with respect to an unknown distribution on the Boolean hypercube.

· Fall 2021 - Present: Senior Thesis on distribution testing using the subcube conditional sampling oracle model. This model is particularly suitable for high-dimensional distributions. The focus is on developing a distribution tester for general distributions over arbitrary alphabets using the subcube conditioning oracle model. I also proved an extended robust version of Pisier's inequality for functions defined over hypergrids.

SMALL REU in Mathematics at Williams   Summer 2021
Project: Algorithms and Complexity in Chip-Firing Games and Graph Gonality
Advisor: Professor Ralph Morrison, Williams College

· Researched algorithms and complexity for graph gonality, and developed the first nontrivial framework for upper and lower bounds on higher gonality.

· Topics researched: higher gonalities of graphs, gonality of circulant graphs, speeding up gonality computation, the behavior of gonality under certain graph operations, scramble number and tree-cut decompositions, and uniform scrambles on graphs.

· The research resulted in five different papers, one of which is available as a preprint and four of which are in preparation.

Research Project in Artificial Intelligence January 2020 - August 2021
Project: Running Predictor of Preterm Birth using Machine Learning Techniques
Advisor: Dr. Ansaf Salleb-Aouissi, Columbia University

· Spring 2020: Genetic algorithm and clustering methods to mine the n (1 to 10) top association rules in a dataset. Implemented the K-Means and G-Means unsupervised learning algorithms in QuantMiner.
· Spring and Summer 2020: Exploratory data analysis using data visualization techniques, clustering, linear regression, and cumulative plots.
· Fall 2020: Investigated the odds ratios of the features in the data set to inform how features are used in the ML models and to iteratively improve the data preprocessing pipeline. Univariate feature analysis and correlation analysis.
· Spring 2021 and Summer 2021: Applied unsupervised learning techniques such as hierarchical clustering to uncover meaningful clusters in the populations of women who had preterm and full-term pregnancies.

Pre-Prints and Technical Reports

Uniform scrambles on graphs [ARXIV], 2021.
L. Cenek, L. Ferguson, E. Gebre, **C. Marcussen**, J. Meintjes, R. Morrison, L. Ostermeyer, S. Ramakrishna.

Data Preparation of the nuMoM2b Dataset [MEDRXIV], 2021.
A. Goretsky, A. Dmitrienko, I. Tang, N. Lari, O. Kunhardt, R. Rashid Khan, **C. Marcussen**, A. Catto, D. Mallia, A. Leshchenko, A. Lin, A. Raja, A. Salleb-Aouissi, Itsik Pe'er, R. Wapner, C. Gyamfi-Bannerman.
Accepted for publication in the Journal of Women's Health and Reproductive Medicine.

Teaching Experience

· TA for **Advanced Algorithms** (COMS 4232) Spring 2022
· TA for **Introduction to Cryptography** (COMS 4261) Spring 2022
· TA for **Analysis of Algorithms I** (CSOR 4231) Summer 2021, Fall 2021
· TA for **Artificial Intelligence** (COMS 4701) Spring 2021
· TA for **Discrete Mathematics: Introduction to Combinatorics and Graph Theory** (COMS 3203) Fall 2020
· Lecturer and TA for **Introduction to Proofs** Fall 2020, Fall 2021
4-week workshop for undergraduate students that teaches how to write and construct proofs, run by the Undergraduate Math Society

Work Experience

Microsoft Research – Real-World Reinforcement Learning Summer 2020
Role: Independent Developer in the Reinforcement Learning Open Source Fest
Project: Parallelized Parsing in C++

· Contributed to Vowpal Wabbit (VW), an open source machine learning system developed by Microsoft Research, through a research programming project that parallelizes the parsing component of VW. Improved the system's runtime by up to 34 percent. Created a separate parallel process for input, and multithreaded the parsing component of the system.

Google   Summer 2020
Role: STEP Software Engineering Intern
Project: Video Vigilance (Computer Vision for Advertisement Safety)

· Worked on Video Vigilance, which uses machine learning and computer vision techniques from the Google Cloud Vision and Video Intelligence APIs to detect unsafe or negative content in video ads. Responsible for workflow of parsing keyframe images, detecting negative content, and displaying results on an html page.

Amazon   Summer 2019
Role: AFE Software Engineering Intern
Project: Issues Platform for the AmazonAPI Team

· Designed and implemented a full-stack web application to streamline the AmazonAPI governance body's API approval process. Programmed in JS, NodeJS, Python, HTML, CSS. The web application provides filters and a search bar to sort APIs by due date of revision, status, alias, or title. Page users can dynamically view and revise submitted APIs and post comments.

· Wrote >100k lines of code over 12 weeks that were pushed to production.

Under My Wing (Mobile Application)   2016 - 2018
Role: Co-Founder and Project Manager

· Under My Wing is a mobile application that seeks to equip women with resources to protect themselves from sexual assault. It is available on the Google Play Store. Under My Wing won Best in Nation and $20k in the 2017 Verizon App Challenge; MIT App Inventor 'Most Innovative' application (2017); Acorda Scientific Excellence Award winner.

Academic Leadership and Seminars

Founder and Leader of the **Columbia Undergraduate Learning Seminar in Theoretical Computer Science**   March 2021 - Present

· Provides students with a collaborative, student-driven environment to learn about theoretical CS. I started six groups for the seminar, running two groups myself and delegating other groups to pairs of graduate and undergraduate students to lead.

· Summer 2021: Organized and ran a group studying the analysis of Boolean functions and property testing.

· Fall 2021: Organized and ran the Theorist's Toolkit group, which surveys various mathematical topics useful in theoretical CS.

· Spring 2022: Organizing and running a group studying high-dimensional probability and applications to computer science.

Mathematics Seminar Organizer:

· AWM Topology Seminar (Summer 2021). Topics covered: Munkres Topology Chapters 2 through 9, which included point-set topology and some algebraic topology.

· AWM Probability Seminar (Summer 2020). Topics covered: the law of large numbers and central limit theorems through the lens of simple random walks, recurrence and transience of simple random walks, Markov chains.

Seminar Participant: UMS Mathematical Logic Seminar (Summer 2021), UMS Geometric Group Theory Seminar (Summer 2020).

President of the **Columbia-Barnard Association for Women in Mathematics**

· President since May 2021. Former Co-Chair of Events.

· Responsibilities and highlights: AWM Student Chapter Award for Scientific Excellence (for the Summer 2020 reading groups, including the Probability Seminar I organized and led).

Conferences and Workshops	Columbia Undergraduate Research Symposium	Fall 2021
	Young Mathematicians Conference (Accepted for Presentation) *Talk:* Bounds on Higher Gonalities of Graphs	Summer 2021
	New Horizons in Theoretical Computer Science	Summer 2021
Talks		

Nets, Covering Numbers, Packing Numbers, and Error-Correcting Codes, TCS Learning Seminar: High-Dimensional Probability and Applications to CS, Spring 2022.

Examples of High-Dimensional Distributions and Isotropy, TCS Learning Seminar: High-Dimensional Probability and Applications to CS, Spring 2022.

Sub-Gaussian Random Variables, TCS Learning Seminar: High-Dimensional Probability and Applications to CS, Spring 2022.

Tiling Invariants, Undergraduate Seminar in Mathematics II, Spring 2022.

Concentration Inequalities, TCS Learning Seminar: High-Dimensional Probability and Applications to CS, Spring 2022.

Error-Correcting Codes, TCS Learning Seminar: A Theorist's Toolkit, Fall 2021.

Asymptotics, TCS Learning Seminar: A Theorist's Toolkit, Fall 2021.

Bounds on Higher Gonalities of Graphs, Young Mathematicians Conference, Summer 2021.

Formal Proof Theory and Connections to Model Theory, UMS Mathematical Logic Seminar, Summer 2021.

The Tychonoff Theorem, Metrization Theorems, and Paracompactness, AWM Topology Seminar, Summer 2021.

Continuous Functions and Examples of Topologies , AWM Topology Seminar, Summer 2021.

Boolean Functions and the Fourier Expansion, TCS Learning Seminar: Analysis of Boolean Functions and Property Testing, Summer 2021.

Survey of Topics in Theoretical CS: NP-Completeness, Analysis of Boolean Functions and Property Testing, Algorithmic Game Theory, and Computational Learning Theory, TCS Learning Seminar, Summer 2021.

Number Theory and Crypography course presentation, short talk, Columbia Association for Women in Mathematics, Spring 2021 and Fall 2021.

Schottky Dynamics and Limit Sets, Undergraduate Seminar in Mathematics I, Spring 2021.

Contradiction, Contrapositive, Cases, and Counterexample, UMS Introduction to Proofs Workshop, Fall 2020 and Fall 2021.

Asymptotic Dimension, UMS Geometric Group Theory Seminar, Summer 2020.

Proof of Central Limit Theorem for Simple Random Walks, AWM Probability Seminar, Summer 2020.

Simple Random Walks: Counting Paths, Mirroring and the Ballot Problem, AWM Probability Seminar, Summer 2020.

Continuous Random Variables, Expectation, and Variance, AWM Probability Seminar, Summer 2020.

Artificial Intelligence: An Overview, Ethics, and Philosophy, Columbia Debate Society Lecture Series, Spring 2020.

Honors and Awards	2020 AWM Student Chapter Award for Scientific Excellence
	National Center for Women & Information Technology: Collegiate Award – National Finalist
	Dolan Prize (Musical Scholarship, 2020-22)
	John Jay Scholar – Columbia University Scholars Program (2018 - 2022)
	Columbia Oxbridge Scholar – Selected to study Math and CS at St. Anne's College, Oxford. Canceled due to COVID-19. (2019)