22^{nd} Annual SIAM Front Range Applied Mathematics Student Conference

March 7^{th}, 2026

Check-in, Welcome and Breakfast: 8:30 – 9:00
Student Commons Building, Room 4126

Morning Session I: 9:00 – 11:00
Student Commons Building, Room 4125

9:00 – 9:20	**Nic Rummel** *University of Colorado Boulder*	A Bifidelity Proximal Quasi-Newton Method for Dense Rigid Body Suspension Collision Resolution
9:25 – 9:45	**Jacob Johns** *University of Colorado Denver*	Into the (Sea) weeds: Kelping Biodiversity Measurement in California
9:50 – 10:10	**Poom Kritpracha** *University of Colorado Boulder*	Disassortativity can induce oscillations in networks of discrete-state excitable systems
10:15 – 10:35	**Gabriel Soffler** *University of Colorado Boulder*	The Trend Persistence Index: A Doeblin-Based Measure of Directional Persistence of Equity Prices.
10:40 – 11:00	**Joe Geisz** *Colorado State University*	Random Knot Models

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Morning Session II: 9:00 – 11:00
Student Commons Building, Room 4017

9:00 – 9:20	**Rachel Snyder** *University of Colorado Denver*	Even and Odd Parking Functions
9:25 – 9:45	**James Hyun** *University of Colorado Boulder*	Optimal Transport: Attractive Toolbox for Network Comparison
9:50 – 10:10	**Baihan Liu** *University of Colorado Denver*	Shifted Total Cut Complex
10:15 – 10:35	**William Miller** *Colorado State University*	Iterated Functions, Bifurcation, and a Bit of Chaos
10:40 – 11:00	**Haoru Yang** *University of Colorado Boulder*	Estimating the Latent Weight of an Idealized Model: Revisiting Mendel's Data Controversy

University of Colorado Denver
CU IN THE CITY

We gratefully acknowledge funding support from CU Denver Dept. of Mathematical and Statistical Sciences and the J.R. Woodhull/Logicon Teaching Professor of Applied Mathematics at CU Boulder.

Coffee Break: 11:05 – 11:30

Industry Panel: 11:30 – 12:30
Student Commons Building, Room 2500

Panelists:

- Riley Lamont, Statistician (Neptune and Company, Inc.)
- Simon Julien, CEO & Co-Founder (Latimer Controls)
- Anna Lieb, Senior Software Engineer (Google)

A group picture will be taken immediately following the industry panel.

Group Photo: 12:30 – 12:35
Student Commons Building, Outside Room 2500

Lunch Break: 12:35 – 1:15
Student Commons Building, Outside Room 2500

Plenary Address: 1:30 – 2:30
Student Commons Building, Room 2500

Prefiltered Component-based Greedy (PreCoG) Scan Method

Joshua French, University of Colorado Denver

Afternoon Session I: 2:45 – 3:55
Student Commons Building, Room 4125

2:45 – 3:05	**Grace Truong** *University of Colorado Denver*	Reducibility Using Kempe Chains
3:10 – 3:30	**Lillian Makhoul** *University of Colorado Denver*	Generalizing Double McCormick Volume Formulas: A Computational Exploration
3:35 – 3:55	**Brady Anderson** *University of Wyoming*	Piecewise Quadratic Finite Volume Element Method for Approximations of Two-Point Boundary Value Problems

Afternoon Session II: 2:45 – 3:55
Student Commons Building, Room 4017

2:45 – 3:05	**Sam Scheuerman** *Colorado State University*	Exploring Offset Geometric Contact
3:10 – 3:30	**Samuel Harris** *University of Colorado Denver*	Inversion Numbers of Directed Graphs
3:35 – 3:55	**Johnathan Rhyne** *University of Colorado Denver*	Increased Performance and Lowered Memory Footprint of Computing the Explicit Q Factor in LAPACK

Afternoon Session III: 2:45 – 3:55
Student Commons Building, Room 4113

2:45 – 3:05	**Rachel Drummond** *University of Colorado Denver*	Your Infrequent But Necessary Reminder of the Math-Origami Connection
3:10 – 3:30	**Melanie Fouque** *University of Colorado Boulder*	Latent Independent Weight Estimation via High-Dimensional Polytope Reduction

Industry Panel

11:30 – 12:30

Riley Lamont

Statistician

Neptune and Company, Inc.

I am a statistician at an environmental consulting company, specializing in applying statistics to complex decision making. My recent projects include power analysis for the National Park Service, harmful algae bloom research along the Ohio River, and developing probability distributions for modeling radioactive waste disposal. I hold an MS in Statistics from CU Denver (2023) and an MA in Teaching from WOU (2021). During my time at CU, I was a research assistant at CU Anschutz and conducted statistical genetics research under Dr. Audrey Hendricks.

Simon Julien

CEO & Co-Founder

Latimer Controls

I completed the BS/MS program in APPM at CU. In that program I did my thesis in power systems controls and dynamics for renewable energy sources. Along with many hats at the startup, I build Latimer Controls' core models for solar real-time estimation, forecasting, and time series simulation.

Anna Lieb

Senior Software Engineer

Google

I am part of the Creative Camera team at Google, where I work on applying AI to help people capture better photos and videos. As an undergraduate, I studied Applied Math and Engineering Physics at CU Boulder. I completed a masters in physics at Cambridge University and then did my PhD at UC Berkeley in Applied Mathematics. Before coming to Google, I worked in consulting and also at a startup. Outside of work, I like to hang out with my family, read novels, and get outside for a hike, run or bike ride.

Plenary Speaker

1:30 – 2:30

Joshua French

University of Colorado Denver

Prefiltered Component-based Greedy (PreCoG) Scan Method

The spatial distribution of disease cases can provide valuable insights into disease spread and risk factors. Identifying disease clusters correctly can lead to the discovery of new risk factors and inform interventions that can help control and prevent the spread of disease. In this regard, we propose a novel scan method, the Prefiltered Component-based Greedy (PreCoG) scan method, which efficiently and accurately detects irregularly-shaped clusters using a prefiltered component-based greedy search algorithm. The PreCoG scan method is computationally efficient, flexible in its ability to detect irregularly-shaped clusters, while still being powerful and having high levels of sensitivity and positive predictive value. To demonstrate its efficacy, we compare its performance to many other scan-based methods. Additionally, we have included this method in the `smerc` R package to make it easy to apply this method to new data sets. Our proposed PreCoG Scan Method offers a unique and innovative approach to cluster detection that can improve the efficiency and accuracy of disease surveillance systems.

About the Speaker

Professor Joshua French is a statistician and data scientist. He is currently the Director of Data Science at the University of Colorado Denver and an Associate Professor in the Department of Mathematical and Statistical Sciences. He is passionate about using statistics and data science to learn from data, developing software to help others learn from data, and training others to do data analysis. His research uses geographically-referenced data to draw conclusions about ecological anomalies, climate extremes, and disease outbreak.

MORNING SESSION I

A Bifidelity Proximal Quasi-Newton Method for Dense Rigid Body Suspension Collision Resolution

Nic Rummel
University of Colorado Boulder

Direct numerical simulation of rigid body suspensions poses computational challenges; resolving collisions represents a fundamental driving computational cost. When one enforces non-overlapping constraints, an optimization problem must be solved at every timestep. In this work, we develop novel algorithms to improve efficiency in collision resolution through a custom proximal quasi-newton method and a bifidelity variant. Numerically, we demonstrate the validity of our approach by applying our methods to Janus particles.

Into the (Sea) weeds: Kelping Biodiversity Measurement in California

Jacob Johns
University of Colorado Denver

It has been well established that an ecosystem is greatly connected and that biodiversity is vital to the health and well-being of the individual organisms in the ecosystem. In the modern day, no ecosystem on land nor water is free from the impact of humans, and biodiversity on islands has been particularly affected by human activity. We explore the decreasing trend in gamma biodiversity from 1980 to 2011 in the waters around San Nicholas Island off the coast of California. We report on time series models that demonstrates a negative trend in biodiversity near the island.

Disassortativity can induce oscillations in networks of discrete-state excitable systems

Poom Kritpracha
University of Colorado Boulder

Networks of discrete-state excitable systems can be used as simple models of activity in functional brain networks, epidemic spreading, and the propagation of social behavior like protest activity or the adoption of innovations. The macroscopic dynamics of such networks has received much attention due to their ability to reproduce many of the experimental observations that support the hypothesis that the brain operates at criticality, the onset of self-sustained activity that occurs as the strength of the coupling between the excitable systems increases. Previous work studying the bifurcations that occur as the excitability of the network is increased has focused mostly on networks without community structure. We study a stochastic discrete-state model with a refractory period on a network with community structure, and study how the dynamics depends on both the structure of the coupling of the communities, and on the network's assortativity, which we quantify by the ratio of intra- to inter-community coupling. Using a mean-field description of the system, we show that additional bifurcations occur as the community structure of the network turns from assortative to disassortative. Depending on the structure of the network of communities, various bifurcations can occur, including period-doubling bifurcations, Hopf bifurcations, and a heteroclinic bifurcation as complete disassortativity is approached. Some of these bifurcations can lead to traveling waves when the network of communities is coupled on a ring structure. We illustrate our theoretical results with numerical simulations on different networks. Figure 1 exhibits an example on how the structure of a network's communities can induce qualitatively different dynamics. Particularly, how the assortativity of the community structure can lead to stable dynamics with relatively low excitation levels or unstable dynamics with large excitation levels.

The Trend Persistence Index: A Doeblin-Based Measure of Directional Persistence of Equity Prices

Gabriel Soffler
University of Colorado Boulder

We model the sequence of daily up-and-down movements in equity prices as a two-state Markov chain and use Doeblin's ergodicity coefficient to decompose the estimated transition matrix into state-independent and state-dependent components. From this decomposition, we introduce a Trend Persistence Index (TPI), a scalar measure of directional persistence that operates exclusively on the sign sequence of returns. Empirical analysis of S&P 500 data across three very different market regimes demonstrates that TPI captures state-dependence in the transition structure, a quantity complementary to magnitude-weighted momentum and trend strength, as measured by Relative Strength Index (RSI), Moving Average Convergence Divergence (MACD), and Average Directional Index (ADX).

Random Knot Models

Joe Geisz
Colorado State University

Mathematical knots can be used for modeling certain types of long molecules called polymers. A natural question is: what is the probability that a knot is unknotted, or what is the probability that it is a given knot type? To investigate such questions numerically a model for sampling random knots is required. In this expository talk I will introduce the very basics of knot theory and discuss a number of models for sampling random knots. These models include random polygons, random jump models, smoothed brownian motion, and the petaluma model.

MORNING SESSION II

Even and Odd Parking Functions

Rachel Snyder
University of Colorado Denver

Parking functions of length n are n-lists whose elements belong to $\{1, 2, ..., n\}$ that we can map to n-permutations. Permutations have a quality of being either even or odd, so we consider a parking function even if it maps to an even permutation and odd if it maps to an odd permutation. In a step towards further research, we developed a formula to determine how many permutations of length n are even and how many are odd.

Optimal Transport: Attractive Toolbox for Network Comparison

James Hyun
University of Colorado Boulder

Network comparison has been extensively studied using the matrix distances or spectral distances. Although these approaches are effective in settings with fixed network size or known node correspondence, they often struggle when networks are heterogeneous or unaligned. Optimal transport (OT) has recently emerged as a powerful alternative for comparing structured data, including graphs, via the Wasserstein distance. In this talk, I will provide an overview of how the Wasserstein distance is used to compare two different networks in one dimension. In addition, I will summarize scalable approximation techniques of the Wasserstein distance in a high dimension from the past literature.

Shifted Total Cut Complex

Baihan Liu
University of Colorado Denver

We introduce shifted total cut complexes, a class of simplicial complexes that are both shifted and total cut complexes. The latter was defined by [Bayer, et,al] in 2022 as a generalization of a graph complex studied by Fröberg (1990) and Eagon and Reiner (1998). In this talk, we give a complete combinatorial description of shifted total cut complexes. We also introduce a new class of graphs, k-sum-threshold graphs, which generalize threshold graphs that are closely related to shifted complexes. We prove that shifted total k-cut complexes correspond exactly to k-sum-threshold graphs and establish several structural propositions.

Iterated Functions, Bifurcation, and a Bit of Chaos

William Miller
Colorado State University

An iterated function is a function composed with itself any number of times. Repeated iteration of an initial value gives rise to a discrete dynamical system. These systems are useful in modeling real world dynamics with discrete time steps. Iterated functions exhibit a variety of strange dynamics, such as self similar and chaotic behavior.

In this presentation, we cover what classifies as an iterated function and provide some tools to study them. We introduce bifurcation diagrams, a beautiful way of visualizing the end behavior of an iterated function. This presentation utilizes various animations and visualizations to demonstrate the fractal and chaotic behavior of these dynamics.

Estimating the Latent Weight of an Idealized Model: Revisiting Mendel's Data Controversy

Haoru Yang
University of Colorado Boulder

Gregor Mendel's pea experiments established the foundation of modern genetics by formulating the law of segregation and introducing quantitative reasoning into biology with his 1866 publication. Nevertheless, his data have received considerable criticism throughout the years, particularly from R. A. Fisher, who in the early 1930s argued that Mendel's data appeared to be falsified. In this talk, we address this accusation from the perspective of latent weights. This newly introduced quantity is the largest expected fraction λ of samples from a probabilistic model P that can be attributed to a specific model Q, making it particularly useful for assessing the fraction of corrupted samples. We estimate and construct 95% confidence intervals for latent weights from Mendel's original data using his theoretical model. We find that the latent weights derived from Mendel's data are consistently slightly larger than expected under his model, and Fisher's misclassification model.

AFTERNOON SESSION I

Reducibility Using Kempe Chains

Grace Truong
University of Colorado Denver

Vizing conjectured that planar graphs with $\Delta(G) \geq 6$ are class 1. It has been proven that planar graphs with$\Delta(G) \geq 7$ are class 1 graphs leaving the $\Delta(G) = 6$ case open. Many have provided partial results for the conjecture using Vizing's Adjacency Lemma to prove reducibility for their discharging proofs. This paper develops a technique for proving reducibility using Kempe Chains instead of Vizing's Adjacency Lemma. Our method is inspired by Bonduelle and Kardos's proof of a case of a related conjecture.

Generalizing Double McCormick Volume Formulas: A Computational Exploration

Lillian Makhoul
University of Colorado Denver

By iteratively applying the standard McCormick inequalities, we obtain a so-called double-McCormick relaxation of the graph of the trilinear monomial over a specified box domain. The specific relaxation obtained depends on which bilinear term we chose to convexify first, resulting in a choice of three distinct double-McCormick relaxations, in addition to the convex hull. In previous work, a triangulation method was used to obtain volume formulas for each of these relaxations, assuming the box domain is contained in the nonnegative orthant. A consequence of this analysis is a ranking of the quality of the three double-McCormick relaxations by volume, meaning that given any box domain in the nonnegative orthant, we know a-priori which double-McCormick relaxation is tightest, and exactly how much "tightness" we are losing with respect to the convex hull. In the case of a general box domain, we have performed a complete case analysis for the convex hull polytope and have obtained a volume formula for each case. Volume formulas for the double-McCormick relaxations in this general setting are yet to be found. Thus, as a first step towards determining a ranking of the relaxations, we computationally explore the quality of the objective function bounds the relaxations produced.

Piecewise Quadratic Finite Volume Element Method for Approximations of Two-Point Boundary Value Problems

Brady Anderson
University of Wyoming

Piecewise linear finite volume element method has often been used for approximating two-point boundary value problems, mainly due to its ability to produce locally conservative flux at a certain dual partition of the domain. Its drawbacks, however, are the discontinuity of the flux and weak imposition of non-Dirichlet conditions. To overcome these, a piecewise quadratic finite volume element method will be proposed. In addition to maintaining the local conservation, the algebraic system is supplied with auxiliary equations to enforce the continuity of the flux. Several numerical examples will be given to demonstrate the performance between the two methods. A simple analysis of the cost of operations for both methods will also be discussed.

AFTERNOON SESSION II

Exploring Offset Geometric Contact

Sam Scheuerman
Colorado State University

In many simulation and graphics applications, we are interested in describing how objects deform from internal and external forces. To be accurate, and therefore useful, these simulations must satisfy certain physical constraints. One important constraint is that the objects we simulate do not pass through themselves or other objects in their vicinity. This phenomenon is known as penetration. In addition to being unphysical, penetration can create significant artifacts and is often difficult to fix once it occurs. To prevent penetration from occurring, modern simulation tools employ algorithms that guarantee the simulation remains penetration-free at each iteration. This can be done in a variety of ways, but two common methods are to use barrier functions or penalty functions. Barrier functions apply a growing force before penetration can occur, while penalty functions apply a growing force right as penetration occurs.

In this talk, we will explore a recent advancement for barrier function methods: offset geometric contact. We focus on offset geometric contact (OGC) for a few reasons. It was developed fairly recently (2025), it can be made highly parallel for faster compute speeds, and it uses a model for contact forces that keeps the forces perpendicular to the object applying the force. This property, that contact forces are normal, is important because it is physically accurate, and moreover is not guaranteed by all barrier function methods.

Inversion Numbers of Directed Graphs

Samuel Harris
University of Colorado Denver

This presentation discusses recent results and conjectures regarding inversion numbers of oriented graphs. We define the inversion number of an oriented graph G as the minimum size of a decycling family of subsets of vertices of G. We focus on three areas: the maximum inversion number of a graph on n vertices, the inversion numbers of dijoins of two oriented graphs, and computational algorithms for deciding the inversion number. The main contribution of this project is a proposed construction of a graph with higher inversion number than that of any other currently known construction. We also provide explicit, rather than asymptotic, bounds on the inversion numbers of graphs up to 11 vertices.

Increased Performance and Lowered Memory Footprint of Computing the Explicit Q Factor in LAPACK

Johnathan Rhyne
University of Colorado Denver

In the context of the Householder QR factorization method, the Q factor is by default returned implicitly. However, explicitly computing the Q factor is a part of many workflows particularly (1) computing an orthonormal basis of the columnspace of a matrix, (2) computing an orthonormal basis of the nullspace of a matrix. We explain a new method for this operation. We found that by increasing the amount of level 3 BLAS routines along with leveraging the structure of the data during the computation, we can increase performance by up to 2x when compared against the state of the art implementation AOCL.

AFTERNOON SESSION III

Your Infrequent But Necessary Reminder of the Math-Origami Connection

Rachel Drummond
University of Colorado Denver

This will be a quick review of some of the cool math-origami connections including dunking on Euclidean compass and straight-edge limitations, andragogy/pedagogy, recent and semi-recent applications in the field, and some hands-on folding of actual paper.

Latent Independent Weight Estimation via High-Dimensional Polytope Reduction

Melanie Fouque
University of Colorado Boulder

The Latent Independent Weight (LIW) of a d-dimensional random binary vector is the largest expected fraction of samples that can be attributed to d independent Bernoulli random variables with possibly different parameters. Determining LIWs requires optimizing an objective function over the vertices of exponentially many polytopes in d-dimensional space—a task that becomes computationally intractable even for moderate values of d. The overarching goal of this talk is to mitigate this complexity by leveraging Principal Component Analysis (PCA) to elucidate optimal vertices. We demonstrate how this dimensionality-reduction technique may provide a practical framework for estimating LIWs in fixed-length random binary strings.