ASSOCIATED COLLEGES OF THE ST. LAWRENCE VALLEY
SUNY CANTON • CLARKSON UNIVERSITY • SUNY POTSDAM • ST. LAWRENCE UNIVERSITY

Mathematics Conference and Competition of Northern New York 2020

(MCCNNY 2020)

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Clarkson University

Conference Organizer

Guangming Yao, gyao@clarkson.edu, Clarkson University
Joel Foisy, foisyjs@potsdam.edu, SUNY Potsdam
Blair Madore, madorebf@potsdam.edu, SUNY Potsdam
Jesse Clark-Stone, stonej@canton.edu, SUNY Canton
Daniel Look, dlook@stlawu.edu, St. Lawrence University

Associated Colleges of the St. Lawrence Valley
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Conference Attendees

First Name	Last Name	Affliliation
Jeff	Weeks	SUNY Canton
Ivan	Ramler	St. Lawrence University
Conner	Shumway	At Lawrence University
Guangming	Yao	Clarkson University
Fred	Saburro	SUNY Canton
Julia	DeTar	Potsdam Math Alliance
Miryam	Veliz Calderon	Potsdam Math Alliance
Daniel	Look	St. Lawrence University
Ed	Harcourt	St. Lawrence University
Amber	Lopata	St. Lawrence University
Brittanie	Rgord	St. Lawrence University
Tanner	Donaldson	SUNY Canton
Jesse	Clark-Stone	SUNY Canton
Kevin	McAdoo	SUNY Canton
Dan	Gagliardi	SUNY Canton
Blair	Madore	SUNY Potsdam
Joel	Foisy	SUNY Potsdam
Christian	Capone	SUNY Potsdam
Michael James	Weirich	SUNY Potsdam
Allexus	Billetts	SUNY Potsdam
Paul	Dougall	SUNY Potsdam Math Alliance
Josh	Lewis	SUNY Potsdam Math Alliance
Megan	Ponce	SUNY Potsdam Math Alliance
Tyler	Deskins	SUNY Potsdam Math Alliance
Johir	Qayum	SUNY Potsdam Math Alliance
Kristen	Goebel	Clarkson University
Corey	Ryder	Clarkson University
David	Russell	Clarkson University
Noah	Chicoin	Clarkson University, student
Kalani	Rubasinghe	Clarkson University
Gabrielle	Taylor	McNair Scholarship Program and CUPO
Mairead	Drake	St Lawrence University
Sky	Jratc	St. Lawrence University
Clare	Jenkins	St. Lawrence University
Kira	Murphy	St. Lawrence University
Alfred	Worrad	Clarkson University
Alissa	Whiteley	Clarkson University
Sathsara	Dias	Clarkson University
Xin	Tao	St. Lawrence University
Haojing	Jia	St. Lawrence University
Richard	Sharpe	SUNY Potsdam
John	Holmlund	SUNY Potsdam
Morgan	Schalizki	SUNY Potsdam
Joe	Skufca	Clarkson University

Presentation Title and Abstract

Keynote Presentation

Title: Non-Euclidean Billiards
Presenter: Dr. Jeff Weeks, American mathematician, a geometric topologist and cosmologist, 1999 MacArthur Fellow
Abstract: After a two-minute introduction to 2D spherical, Euclidean and hyperbolic geometry using fleece surfaces, volunteers will don a VR headset to try their hand at pool in 3D spherical, Euclidean and hyperbolic spaces, with the rest of the audience following along on the lecture hall's main screen. Even experienced geometers may find some surprising optical effects, which we'll explain using the fleece surfaces. The Pool game will remain available after the talk to let as many people as possible try non-Euclidean pool for themselves.

Keynote Presentation

Title: How Data Science Makes Me a Better Gamer
Presenter: Dr. Ivan Ramler, St. Lawrence University
Abstract: While still young and discovering its true nature, the field of Data Science is generally viewed as a multi-disciplinary field whose background stems from Mathematics, Statistics, and Computer Science. One main goal of many data science projects is to extract knowledge from data and use it to assemble predictive tools. One new area of application for data science is in esports (i.e., competitive video games). In this talk, I will describe how applying data science principles to two games improved my gaming experience. The first study involves identifying the prevalence of and impact on game play due to illicit bots in the game League of Legends, and the second showcases several student projects related to understanding gameplay in Clash Royale.

Keynote Presentation

Title: The Science of Intentional Visualization
Presenter: Dr. Joseph Skufca, Clarkson University
Abstract: Scientific communication relies heavily upon pictures, graphs, images, and other visual means of communication. In this talk, we explore a little bit of the theory behind how we communicate quantitative information through visualization - how it works and why we do it. Once we understand how it works, we can develop our ability to build visualizations that communicate most effectively. We show that making good graphs requires that we *intentionally* take advantage of the way our brain processes visual input.

Poster Presentations

Presenter: Alfred Worrad, Senior, Clarkson University, worrada@clarkson.edu
Author: Alfred Worrad, Morgan Reynolds, Sumona Mondal, Shantanu Sur, Marko Budišić
Title: **Analysis of Collective Cell Behavior Through Statistical and Topological Methods**
Abstract: Understanding collective cell migration is extremely important in the context of wound healing and cancer spread. Our motivation is to study the transition from a disordered to a coherent behavior in the presence of an environmental stressor such as change in oxygen or calcium concentrations. This transition can be difficult to detect and analyze, due to the complex nature of the cells' interactions, and imprecise definitions of coherence. We compare two tools for this purpose: order parameters, originating in statistical mechanics, and persistence diagrams, originating in topological data analysis.

The order parameters characterize the coherence of the system based on the similarity of cells' velocities. Persistence diagrams identify topological features, such as connected components and empty regions of space, and track them over varying spatial resolutions, and over time. We consider topological features that survive over larger scale intervals as significant, with their "birth" in time indicating formation of coherence. We evaluate these tools on the Vicsek model of cell aggregation, stochastic models of cell movement, and several experimental data sets that track the movement of cervical cancer cells cultured on a Petri dish.

References:
Topaz, Chad M., Lori Ziegelmeier, and Tom Halverson. 2015. "Topological Data Analysis of Biological Aggregation Models." PLOS ONE 10 (5): e0126383.
Vicsek, Tamás, and Zafeiris, Anna. 2012. "Collective Motion." Physics Reports, Collective motion, 517 (3): 71–140.
McDonald, Nick. 2018. "A Statistical Approach to Analyze Temporal Changes in the Spatial Distribution of Cells In Vitro." Poster presented at Clarkson University 2018 Summer Research and Project Showcase (RAPS), July 27, 2018, Potsdam, New York.

Presenter: Alissa Whiteley, Graduate Student, Clarkson University, Whitelam@Clarkson.edu
Author: Alissa Whiteley
Title: **Modeling and Classifying Crime Hotspots**
Abstract: Crimes occur all over the world, but hotspots are areas that have a high concentration of crime. These areas form and disperse based on many elements. It would be valuable to model the lifespan of hotspots to assist law enforcement in both preventing crimes from occurring and knowing where the hotspots may appear. A few of the different elements that affect the prevalence of crime are repeat or near-repeat crimes and the "broken windows" effect. A discrete model by Short et al. is used to examine the different elements that affect the growth and decay of the hotspots. A lattice, which represents a neighborhood, is used where each site represents a house. Classifying the hotspots generated on a two-dimensional grid would allow police personnel to determine which areas of a neighborhood would benefit the most from a higher volume of police presence. A one-dimensional model, created to classify the hotspots based on their area, average attractiveness, and peak values, gives insight into classifying hotspots on the two-dimensional model.

Presenter: Sathsara Dias, Graduate Student, Clarkson University, diassl@clarkson.edu
Author: Sathsara Dias, Marko Budišić, Brian Helenbrook, Pat Piperni
Title: **Analyzing the Transition to Buffeting of a 2D Airfoil using the Dynamic Mode Decomposition**
Abstract: The Dynamic Mode Decomposition (DMD) algorithm was first introduced in the fluid mechanics community for analyzing the behavior of nonlinear systems. DMD processes empirical data and produces approximations of eigenvalues and eigenvectors ("DMD modes") of the linear Koopman operator that represents the nonlinear dynamics. In fluid dynamics, this approach has been used to both analyze constituent flow patterns in complex flows, and to design control and sensing strategies.

In this work, we focus on predicting the transition to buffeting of a 2D airfoil in a transonic regime. Buffeting is a vibration that occurs as the angle-of-attack increases and the interactions between the shock and flow separation induce limit-cycle oscillations. We demonstrate that this bifurcation can be anticipated by monitoring the spectrum computed by DMD as a subset of eigenvalues becomes unstable. We evaluate the performance of our approach on a synthetic Hopf-bifurcation flow, and on both pseudo-time and time-resolved simulations of a standard 2D airfoil.

Presenter: Xin Tao, Junior, St. Lawrence University, xtao17@stlawu.edu
Author: Xin Tao
Title: **Building an All Voice Reminder**
Abstract: Reminder systems, which allow people to set their devices to remind them to do things, can be helpful to people's daily lives and increase their efficiency. For some elders, they become forgetful about daily things such as taking medicine; automated reminders could help them remember important tasks. For some students, time management is a challenge; using reminder systems, they could keep themselves on track. However, reminder systems also have limitations. Elders may find them difficult to use if they struggle using computers and other devices in general. Some students can be so distracted by social media and computer games that they ignore their reminders, and as a result, they do not follow the plans they make. The purpose of my research is to build a reminder system that operates entirely by voice.

Presenter: Haojing Jia, Senior, St. Lawrence University, hjia16@stlawu.edu
Author: Haojing Jia
Title: **Creating a Statistical Model for Evaluating the Concentration of Smog in China**
Abstract: In 2012, the Chinese Medical Association warned Chinese citizen that h. Measurements by Beijing municipal government in January 2013 showed that highest recorded level of PM2.5 was at nearly 1,000 µg per cubic meter. However, the air treatment effects in those years are not obvious. Our world is developing rapidly in science and technology. However, there is a big problem that influences and threatens human development and that is the pollution. In the case of the development of industry and technology, environment is overloaded. Air pollution is the biggest concern right now. It can be defined as any harmful material that is present in the earth's atmosphere. The causes of pollution can be varied, some are natural, while others are brought by humans. Air pollution is one of the most significant kinds of pollutions, and it causes millions of people to die from respiratory disease.
My goal is to learn the composition of smog in China, for example PM2.5, which is described as fine particles 2.5 micrometers or less in diameter. Then I will explore the impact of industrial emission on air quality by searching the environment department in China and database from Kaggle, which is a statistical website that provides weather data for China. And I will evaluate a statistical model for concentration of PM2.5 which depends on detrended Time Series Model to explore which seasonal aspect causes the highest PM2.5 and analyze the trend in future.

Moreover, I will use different statistical models to understand the relationship between industrial air emissions and PM2.5. This research will give me valuable experience in analyzing statistic; exploring the topics from varied areas, such as science, health, economics; and help me prepare the further statistical studies in graduate school.

Oral Presentations

Presenter: Kristen Goebel, Sophomore, Clarkson University, goebelka@clarkson.edu
Advisor: Kristen Goebel, Kathleen Kavanagh, Lea Jenkins, Devin Kapper, Jordan Patoine
Title: **Approaching Agricultural Management Trade-offs using Agent-Based Modeling**
Abstract: There is an increased need for agricultural management tools due to the growing issue of water scarcity. One tool that is rising in popularity is agent-based modeling. In agent-based modeling, each individual agent is able to make their own decisions based on their own behavior rules, making it possible to represent a heterogeneous population. We are developing an agent-based model that incorporates the variation in farmers' values and tendencies when making decisions to better understand the issue of water scarcity. The model is built in NetLogo, an agent-based modeling program, to allow for simulations to be run to evaluate the impacts of water scarcity and policy change on the agricultural community.

Presenter: Corey Ryder, Senior, Clarkson University, ryderc@clarkson.edu
Author: Corey Ryder
Title: **Disposables vs. Reusables: Using Real World Problems to Motivate Math Modeling and Coding in High School**
Abstract: One problem that many schools, and school districts, are currently confronting is whether they should serve lunch using disposable lunch trays that can be thrown away or reusable trays that can be washed after each use. In this talk I'll share a project I built in R that allows students to identify solutions to the "Disposable vs Reusable" question using math modeling approaches and coding. I'll describe the process that I took to develop the activity and share some preliminary responses from students that have worked through the project.

Presenter: David Russell, Senior, Clarkson University, russeldj@clarkson.edu
Author: David Russell, Kaitlyn Koehler, Kanaththa Priyankara, Dinuka De Silva, Andrea Ferro, Kathleen Kavanagh
Title: **Intelligent Smoke Detector Placement for the International Space Station**
Abstract: Fires aboard the International Space Station (ISS) pose a significant risk to astronauts. The smoke detectors are currently placed by the air return vents and the impacts of this choice have not been modeled. In this work, we seek to place them intelligently using an approach based on simulation and optimization. Our simulation in Fluent models the smoke flows within the microgravity conditions aboard the ISS to predict the smoke concentration over time for a given smoke source. For each smoke source, we can determine the time it would take a smoke detector placed at any point to alarm, which occurs when the smoke concentration exceeds a specified threshold. Using this information and an optimization routine, we place a set of detectors based on the potential for fire at certain locations. The search space is the concatenated locations for a fixed number of detectors. The objective function represents the longest time it takes for any smoke source to be detected given the configuration of detectors. We determine that gradient-based optimization performs poorly since the function landscape has many plateaus and local minima. This is due to the discrete nature of the underlying simulation and the fact that poorly-placed detectors can become entirely unhelpful, thus giving them zero gradient. However, genetic algorithms consistently find low objective function values, suggesting they are robust and well-suited to the problem. We conclude by discussing preliminary work in multi-objective optimization which seeks to not only yield quick alarms but also place detectors in convenient locations.

Presenter: Noah Chicoine, Senior, Clarkson University, chicoinc@clarkson.edu
Author: Noah Chicoine, Alyssa Oswald
Title: Extension of the Human Blood Coagulation Model to Understand the Role of C1-Inhibitor in Hereditary Angioedema
Abstract: Hereditary Angioedema (HAE) is a rare genetic disease characterized by a deficiency of the C1 esterase inhibitor protein (C1-INH) that causes sporadic swelling episodes, which can last for days if left untreated. Typically, synthetic C1-INH is administered to HAE patients to prevent or stop swelling attacks. Administering too much synthetic C1-INH, however, presents a risk of bleeding to the HAE patient, as C1-INH inhibits procoagulant factors in the blood stream. In order to better understand the how C1-INH interacts with the coagulation system, we extend the ordinary differential equations coagulation model developed by Pfizer Inc. to include the dynamics of the C1-INH protein. The new model is used to predict the effects of synthetic C1-INH therapies on the coagulation system by simulating the clotting time of hypothetical HAE patients. Results suggest that HAE patients may be able to withstand synthetic C1-INH treatments that use 3x the normal concentration of C1-INH in the human body before clotting time is affected. In addition, the effects of C1-INH on Hemophilia C patients (procoagulant factor XI deficiency) suggests that the C1-INH inhibition of FXI has a substantial impact on coagulation time.

Presenter: Kalani Rubasinghe, Graduate Student, Clarkson University, rubasik@clarkson.edu
Author: Kalani Rubasinghe
Title: **A localized Radial Basis Function Method for Solving Black-Scholes Equations in 1D and 2D**
Abstract: The Black-Scholes equation is a partial differential equation describing the price evolution of an option depending on volatility, type of option, underlying stock price, strike price, and risk-free rate. In certain cases, it is possible to solve for an exact solution of the model. However numerical simulation is often needed to solve the Black Scholes equation. We introduce the local method of approximated particular solutions, so called LMAPS. Black-Scholes equations are then solved numerically by finite difference scheme in time and LMAPS in space. The experiments show that LMAPS is very efficient and accurate for solving BS equations in both dimensions.

Presenter: Gabrielle Taylor, Senior, Clarkson University, taylorg@clarkson.edu
Author: Gabrielle Taylor, Daniel T. Fuller, Leon Lufkin, Sumona Mondal, Shantanu Sur
Title: **Impacts on patient's Income-Poverty Ratio in relations to Rheumatoid Arthritis with Behavioral and Socioeconomic Factors**
Abstract: Many studies have shown that chronic diseases have large economic burdens on financial health of those afflicted. Conversely, it has been known that debt and financial pressures can increase levels of stress and blood pressure. Incidence of rheumatoid arthritis is strongly influenced by socioeconomic and behavioral factors, as well as health-care finance. Rheumatoid arthritis (RA) is a chronic autoimmune inflammatory disease that most commonly affects the joints. Using the National Health and Nutrition Examination Survey (NHANES) data, we develop regression models to explain participants' income-poverty-ratios (IPR) through associated factors' on reported rheumatoid arthritis diagnosis. Using Akaike Information Criterion, we compare two predictive models by their goodness of fit on the data. Prior to conducting statistical analyses, appropriate preprocessing and data cleaning were done through R Studio 3.6. We focus on the quantification of these associated factors' financial impact on rheumatoid arthritis participants by using ethnicity, age, and stress as predictors. This study is expected to improve the knowledge-base and accurately assess how these factors impact the patient's financial health.

Presenter: Mairead Drake, Senior, St. Lawrence University, medrak16@stlawu.edu
Author: Mairead Drake
Title: **"The story so far": Writing Styles, Authorship, and Naive Bayes**
Abstract: With the proliferation of serial novels, the practice of authors picking up a story where another left off has become more common. However, just because an author continues the work of another does not mean that they retain the feel, characterization, and language of the previous in a way that makes the work feel cohesive, while others excel at mimicking the style of what came before. While the individual can debate how well any given writer succeeds at this, applying a Naive Bayes classifier to sections of the text can allow us to determine likely authorship based on certain stylistic choices as the authors try to tell the same story.

Presenter: Sky Ratcliffe, Junior, St. Lawrence University, sjratc17@stlawu.edu
Author: Sky Ratcliffe
Title: **An Expository Look into the Banach-Tarski Paradox**
Abstract: The proof of the Banach-Tarski Paradox, a theorem in which a solid ball may be split into pieces that are subsequently rearranged to form two solid balls, each identical to the first, utilizes mathematical concepts within group theory with an emphasis on the free group on two generators and the special orthogonal group. This research was conducted with the purpose of creating a companion piece to the proof in hopes of allowing those with little knowledge on the subject to be exposed to an interesting, albeit complicated, theorem. Due to constraints based on the length of the proof, this presentation will mainly consist of an introduction to the relation between the Paradox and group theory, a short proof vital to the big picture, and how the Banach-Tarski Paradox can mathematically occur in three-dimensional space.

Presenter: Clare Jenkins, Senior, St. Lawrence University, cljenk17@stlawu.edu
Author: Clare Jenkins
Title: **Cops and Robbers on Graphs**
Abstract: The game of cops and robbers is a classic vertex-pursuit game played on reflexive graphs. The players, cop(s) and robber, have perfect information and alternate turns moving to adjacent vertices. If there exists a strategy for k cops to catch the robber in a finite number of moves, we designate such a graph k-cop-win with cop number k. We will review some existing results regarding this combinatorial game and describe our ongoing research into outerplanar graphs, a class bounded by cop number 2.

Presenter: Kira Murphy, Senior, St. Lawrence University, knmurp16@stlawu.edu
Author: Kira Murphy
Title: **Bears and Fish: A Variation of Cops and Robbers on Graphs**
Abstract: Cops and Robbers is a vertex-pursuit game that was introduced by Quillot in 1978 and separately by Nowakowski and Winkler in 1983. In the game, there are two players: a cop and a robber. The cop begins by choosing her position on a vertex. The robber moves next by choosing his position on a different vertex. Each player takes turns moving along an edge to an adjacent vertex. The cop wins if she can occupy the same vertex as the robber in a finite number of moves.
This talk will focus on Bears and Fish, a variation of the traditional game of Cops and Robbers. In Bears and Fish, the same rules apply except the bears move on vertices while the fish moves on edges. The game terminates when there are bears on each vertex incident to the fish's current edge. I will discuss upper and lower bounds on b(G), the number of bears required to capture a fish on a graph G, by mapping the moves of the bears to the cops and the moves of the fish to the robbers.