Mathematics emeriti, faculty, and staff at the 2021 Department Potluck

The end of each year is a great opportunity to reflect on our Titan Mathematicians' accomplishments and challenges. Last academic year, 2020-2021, was an historic and exciting year. We continued gaining experience teaching online and hybrid courses. After a long lockdown, we returned to campus in fall 2021 to teach about half of our courses face to face, and half online and hybrid courses. In spring 2022, the plan is to be back to teaching almost all our courses in-person. We will continue to reflect on the opportunities that each delivery mode offers.

This year we celebrate the American Mathematical Society Award that the CSUF Mathematics Department received, the 2022 Award for "Mathematics Programs that Make a Difference." This award was many years in the making and belongs to each and all of us in the department family. In this newsletter, you will read other examples of the CSUF Mathematics Department in action, including research publications, presentations, grants, collaborations with students, and changes in our faculty, among others.

Next year will be another exciting year. The Alumni committee is preparing the Second Alumni Event. The online event is scheduled for March 25, 6:30-8:30pm. Details to come. We are also working on the spring edition of this newsletter.We appreciate suggestions for items to include in future editions. You will find a box for suggestions in this edition.

We would like to take this opportunity to wish you and all of yours, Happy Holidays and a fantastic 2022!

The Alumni Relations Committee
on behalf of the CSUF Mathematics Department

ALUMNI NEWSLETTER

The latest news and updates from the CSUF Mathematics Department

Mathematics professor Dr. Scott Annin in a class lecture

Mathematics Department Wins National 2022 AMS Award

The CSUF Mathematics Department has won the national 2022 American Mathematical Society (AMS) Programs That Make a Difference Award. This is the first time a department within the California State University system has received such an award.

The Programs That Make a Difference Award was set up by AMS to showcase programs that are succesful in addressing the equity gap of underrepresented groups in mathematics. The goal of this award is to recognize outstanding programs that can serve as a model for other programs to emulate.

The Mathematics Department's graduation rates highlight how the department has addressed this equity gap. For example from 2008 to 2020, there were 628 undergraduate students who graduated with a degree in Mathematics. Out of the 628 students, 198 (31%) were underrepresented minorities, 300 (48%) were women, and 327 (52%) were eligible to receive Pell Grants. In the same time span, 340 first-generation students entered the Mathematics Department with 192 (31%) of whom were Latino.

Graduation rates alone were not the only thing that made the Mathematics Department standout. The AMS noted that the Mathematics Department has focused considerable effort in the past decade to to develop a culture of student-faculty research. Since the last decade, dozens of papers were co-authored by faculty and students and published in academic journals such as the Notices of the AMS, Proceedings of the AMS, Houston Journal of Mathematics, Japanese Journal of Mathematics, and Taiwanese Journal of Mathematics.

Continued on next page...

CSUF Alumni students at the MAA student Poster Session at the 2019 Joint Mathematical Meeting in San Diego
Left to right: Cameron Hooper, Freddy Nungaray, Roberto Hernandez, Isabel Serrano, Jasmine Camero, Oscar Rocha Rocha, Alexandro Luna, and Daniel Zelaya

An important component that has helped foster a strong student-faculty research culture at the Mathematics Department is the through the efforts of the Center for Computational and Applied Mathematics (CCAM). The CCAM program helps promote research in computational mathematics through multidisciplinary collaborations of students, faculty, and external partner.

The Mathematics Department will be presented with the prize at the 2022 Joint Mathematics Meeting in Seattle, Washington on January 5, 2022. To read more about the AMS award, please click here.

2nd Mathematics Department Virtual Alumni Night

March 25, 2022 | 6:30 - 8:30 pm
Zoom
More details to come!

Mathematics Department Program Honored for Encouraging Young Women to Pursue STEM Fields

DR. DAVID PAGNI (LEFT) | PROJECT MISS PROGRAM PARTICIPANTS WORK AS A TEAM TO SOLVE MATH PROBLEMS (RIGHT)

The Mathematics Department's Project MISS, or Mathematics Intensive Summer Session, was selected as a finalist for the national 2021 Examples of Excelenica Award. The program - Excelencia in Education - bestows this award to programs that implement evidence-based practices that promote Latinx student success in higher education.

The goals of Project MISS are to aid college bound young women to enhance their mathematics skills and increase the likelihood that participants choose majors and careers in science, technology, engineering, and mathematics fields. Participants have the opportunity to improve their problem-solving abilities, meet other college-bound

Continued on page 3.

young women, explore career options, learn from female role models, and take control of their academic life.

The program was founded by Mathematics professor, Dr. David Pagni, over 32 years ago, and he continues to play a significant role in the administration of the program. Since then there have been about 2,000 students who participated in the program with 98% of them going on to attend college. Many of the participants have identified as Latinx first-generation college students.

Mathematics Department Faculty Awarded over $765,000 in Grant Money

MCCARTHY HALL

During the first quarter of CSUF's 2021-22 fiscal year, the Mathematics Department faculty and lecturers were awarded over $765,000 in grant funding to support various projects across campus to offer more opportunities and resources to students.

1. Dr. David Pagni was awarded $506,806 from the National Science Foundation (NSF) for the project titled "Transitioning Math Majors Into Teaching".

2.Dr. Sam Behseta was awarded $208,000 from the National Science Foundation (NSF) for the "Collaborative Research HDR DSC: Data Science Traning and Practices: Preparing a Diverse Workforce via Academic and Industrial Partnership" project.

3. Dr. Alfonso Agnew was awarded $84,106 from the California Education Learning Lab and Governor's Office of Planning and Research (OPR) via the Regents of the University of California, Irvine for the "Biocalculus Preparation Engagement and Application Program" project

4. Dr. Zair Ibragimov was awarded $20,000 from the National Science Foundation (NSF) for the project titled "California State University Louis Stokes STEM Pathways and Research Alliance 2018-2023". Dr. Ibragimov was also awarded $63,700 from University Enterprises, Inc. for the project titled "California State University Louis Stokes STEM Pathways and Research Alliance 2018-23.

5. Dr. Tien Nguyen was awarded $70,000 from the United States Air Force via Intelligent Fusion Technology for the "NSS Multi-Carrier Broadband Waveforms Adaptation and Onboard Signal Clean-Up Using Game Theoretic, Advanced Machine Learning and Artificial Intelligence" project.

NSF Grant Expands Outreach for Students to enter Data Science Field

MATHEMATICS PROFESSOR SAM BEHSETA (LEFT) AND ASSOCIATE PROFESSOR - JESSICA JAYNES (RIGHT)

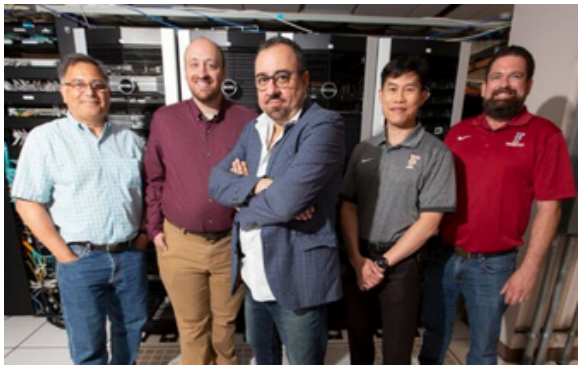
CSUF, in association with University of California, Irvine and Cypress Community College, received a $1.5 million grant from the National Science Foundation. The goal of this grant is to expand outreach to underrepresented students with hopes to encourage them to pursue careers in the field of data science.

Mathematics professor, Sam Behseta, and associate professor, Jessica Jaynes, have been assigned the role of recruiting students in a STEM major to apply for the California Data Science Experience Transformation Program (CADET). The CADET program is open to any STEM major - including students in biology, chemistry and engineering.

Selected students will attend a spring class as well as a summer training camp at UCI where they will collaborate with peers on real world analytics and modeling projects. There, they will also be introduced to projects from data scientists across government and industry. Selected students may also be eligible to receive a $5,000 stipend for their participation.

Through this experience, Behseta and Jaynes hope students will gain the math, statistical, and computer programming skills needed to gain employment as a data scientist in government and industry.

CSUF Awarded U.S. Army Grant of $600,000 for Supercomputer to Advance Faculty, Student Research



FROM LEFT TO RIGHT: EMERIO MARTINEZ, ANDREW PETIT, SAM BEHSETA, WILLIE PENG & JOHN KING

CSUF is acquiring a new high-performance computing (HPC) cluster thanks to a $583,900 U.S. Army grant awarded to researchers at the Center for Computational and Applied Mathematics (CCAM). Researchers at CCAM convinced the U.S. Army that faculty and student researchers will thoroughly utilize the cluster to advance multidisciplinary research across STEM majors and prepare students to enter the workforce with essential data analysis skills.

The HPC cluster is a machine with multiple units called servers or nodes and gives researchers the capability to solve complex computational problems and process large amounts of data in a fraction of the time. The new HPC cluster isn't the first one to be awarded to the University. CCAM acquired its first HPC in 2015 and the Center for Gravitational-Wave Physics and Astronomy also houses their own HPC cluster. The new HPC cluster will reside in the university's Data Center under the Division of Information Technology.

Welcome Dr. Amelia Stone-Johnstone

DR. AMELIA STONE-JOHNSTONE

Dr. Amelia Stone-Johnstone joined the mathematics department Fall 2021. Dr. Stone-Johnstone received her Ph.D. in mathematics and science education in the joint doctoral program at San Diego State University and UC San Diego this year. She mentions how her identity as a mathematician, woman of color, and a daughter of immigrant parents influences how she learns, teaches, and interacts in the math world.

How did you become interested in mathematics and in teaching?

I always loved math! My love was taken to the next level once I participated in an undergraduate project where I learned more about topology, specifically knot theory.

What is your research about?

My research is broadly undergraduate mathematics education and developing academic supports that can help students learn and do mathematics. My dissertation (2021) title is "Supporting students' learning: Unpacking one institution's implementation of the corequisite model."

Tell us about your recent funded projects.
My dissertation is all about student experiences in corequisite courses and since we are piloting one here at CSUF I co-wrote two grant proposals to support us in analyzing the effect that this course is having on our math majors. Both proposals have been funded!

Where can we find you when you are not doing mathematics?
Playing the viola or being silly with my toddler.

Mathematics Department Faculty Promotions

Please join us in congratulating our Mathematics faculty members who have received promotions and distinguished lecturer awards.

TOP ROW, LEFT TO RIGHT: DR. DWIGHT WYNNE, DR. ALISON MARZOCCHI, & DR. TOMMY RATHBUN

BOTTOM ROW, LEFT TO RIGHT: DR. CHRIS LYONS, PROF. ASHLEY THUNE-AGUAYO, & DR. MATT RATHBUN

Tenure & Promotion to Associate Professor

- Dr. Christopher Lyons '20
- Dr. Tommy Murphy '20
- Dr. Matt Rathbun '20

Early Tenure & Promotion to Associate Professor

- Dr. Alison Marzocchi '20

Outstanding Lecturer

- Professor Ashley Thune-Aguayo '20
- Dr. Dwight Wynne '21

Mathematics Professor Featured in AMS/MAA Publication

DR. ROBERTO SOTO

Mathematics associate professor, Roberto Soto, was featured in a book that was co-published by the American Mathematical Society and Mathematical Association of America entitled *Testimonios: Stories of Latinx and Hispanic Mathematicians.*

Per the American Mathematical Society, the publication compiles first-person accounts of the dynamic, diverse, and and complex Latinx and Hispanic mathematical community. The authors portray their own individual stories and highlight their childhood and family upbringing, education, and career paths told in their own perspectives to shed light on their experiences as Latinx/Hispanic mathematicians. The book aims to encourage the next generation of aspiring Latinx and Hispanic mathematicians through the various stories of people like them. To learn more, you can click here.

Hot off the Press: "Tools for humanizing mathematics classes in a virtual world (and beyond)"

Assistant professor of Mathematics, Kristin Kurianski, along with associate professors, Alison Marzocchi and Roberto Soto recently had an article published entitled *Tools for humanizing mathematics classes in a virtual world (and beyond)* in the International Journal of Mathematical Education in Science and Technology.

The professors explore tools math professors can utilize to promote student engagement and foster a sense of belonging in online classrooms. Through their collaborative and createve approach, three tools were devised that can achieve the goals of student belonging and engagement: icebreakers for student engagement, Discord chats for community building, and VoiceThread for peer-to-peer collaboration.

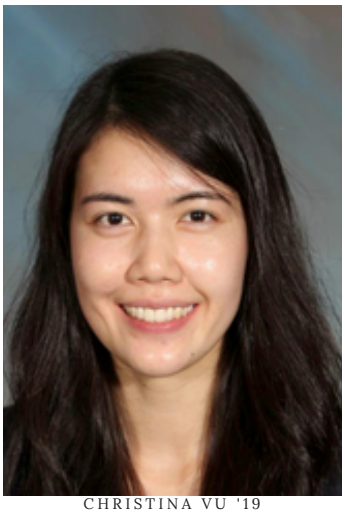
The researchers show how each tool builds upon previous research that supports active learning and equitable math instruction practices. They also discuss ways that these tools can be implemented in face-to-face teaching modalities. DOI: 10.1080/0020739X.2021.1985178

Alumni Spotlight Video: Steve Stawski '92

STEVE STAWSKI '92

Mathematics alumnus, Steve Stawski '92 (Probability and Statistics), explains how the troubleshooting and analytical skills he obtained in his undergraduate career at CSUF has prepared him to become the Director of Electronic Discovery and Forensics for Sony. He offers advice to students looking to get into fields of data science and machine learning and how to stay ahead in the ever-changing field of tech. Learn more by watching his alumni spotlight video here.

Alumni Spotlight Video: Christina Vu '19



CHRISTINA VU '19

Christina Vu '19, details how her M.A. degree in Teaching Mathematics sharpened her mathematical knowledge and skills as a high school math teacher. Vu credits the program for deepening her understanding of mathematical concepts to teach algebra and geometry concepts to her students. Vu details a memorable experience she had with the graduate program in which she partook in a research project on lesson studies at the college-level with Dr. Soto. Lear more by watching her alumni spotlight video here.

DR. MARTY BONSANGE & DR. JENNIFER CLINKENBEARD

Hot off the Press: "A comparison of American student and faculty experiences in mathematics courses during the COVID-19 pandemic"

Dr. Martin Bonsangue and his daughter, Dr. Jennifer Clinkenbeard (Department of Mathematics and Statistics, CSU, Monterey Bay), recently published the article, A *comparison of American student and faculty experiences in mathematics courses during the COVID-19 pandemic*, in the International Journal of Educational Research Open Journal.

Based on responses from more than 2800 students and eighty mathematics faculty members, this study found that while both faculty and students reported feelings of disconnectedness during the pandemic, the two groups may have experienced the impact of virtual learning very differently. https://doi.org/10.1016/j.ijedro.2021.100075

Dr. Ernie Solheid enters Retirement

Ernie Solheid (PhD, UW-Madison) joined the math faculty at CSUF in August 1988. He is an algebraist by training, but his teaching contributions were strongly felt across the lower-division and upper-division pure math curriculum. He was heavily involved in curriculum development and coordination, including the areas of college algebra, precalculus, calculus, and introduction to proof.

DR. ERNIE SOLHEID (2ND FROM LEFT) WITH DR. AGNEW, MATHEMATICS DEPARTMENT CHAIR (LEFT) AND FORMER DEPARTMENT CHAIRS DR. MARTY BONSANGUE (CENTER), DR. PAUL DELAND (2ND FROM RIGHT) AND DR. JIM FRIEL (RIGHT) AT THE 2021 HOLIDAY POTLUCK

Much of his career can be associated with pushing the department into the modern era: He was technologically savvy, and he was heavily leaned on as the department was hurtled into the age of email, the internet, and personal computers in the 1990's. Our early web presence was due to Ernie. He was an early proponent of reform calculus, and while the department was split on its merits, there is much about reform calculus that anticipates the use of technology and active learning in its more accepted 2021 form. Evidently, Ernie was ahead of his time!

He was dedicated to helping students, and it was common to find many students working outside his office. His varied contributions are too numerous to list here, but in addition to the above, he played a leadership role in the Louis Stokes Alliance for Minority Participation program for a period and was one of the main designers of our MH476 and MH 480 smart calculus rooms, which were quite revolutionary at the time.

He had a major impact on many students and math majors in particular. Some of these students completed advanced degrees with the foundation he provided, and some of those would even return to CSUF as faculty. A truly impressive career from a dedicated colleague and educator!

Math Department Alumni, Faculty, and Students Share their Expertise at Mathematics Conference

The California Mathematics Council held its 62nd Annual Math Conference in Palm Springs November 5 and 6, 2021. This year's theme was "Time to Unmute: Amplifying Diverse Voices." The meeting was the first in-person professional learning experience in many months. The program included more than 200 sessions for every grade level and every interest for mathematics teachers, leaders and coaches.

Mathematics teachers and alumni from the CSUF Mathematics Department shared their expertise in many areas, including social justice, diversity, equity and assessment in mathematics learning and teaching. Presenters included the following.

Continued on Page 14...

Marisa Katsuda '18 (B.A. in Mathematics) teaches at the Haskell STEM Academy. Marisa co-presented with her former master teacher, Nick Navarro, a session on Emerging Math-Linguals: Diversity, Equity, Culture, Voices. Marisa is a first-year graduate student in the CSUF Masters in Mathematics Program, Teaching Option.

MARISA KATSUDA (HASKELL STEM ACADEMY) AND NICK NAVARRO (NORWALK HIGH SCHOOL)

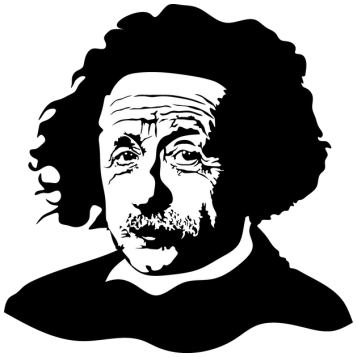
Jessica Alvarado, 02 (B.A. in Mathematics, Teaching Option) and Ryan Kile, 05' (B.A. in Mathematics, Teaching Option) teach at Anaheim High School and co-presented the session Equitable Technology Use To Empower All Students.

Jennifer Fuentes, '04 (MA in Mathematics, Teaching Option) and Karen Clark Yamamoto from Western High School co-presented Unmute Student Thinking Through Structured Strategies.

Scott Johnson, '93 (B.A. in Mathematics, Teaching Option) from Brea Jr. High School and Tor Ormseth from the STEAM Academy @ Burke Middle School (El Rancho Unified School District) co-presented Developing Student Voices Through Project-Based Learning

Ruth Gadea, '13 (B.A. in Mathematics, Teaching Option) and Ramona Martinez co-presented Engaging Students in Self-Assessment, Reflection and Tasks.

Also at the conference, Dr. Marzocchi along with three of her student researchers, Alexis Di Pasqua, Evelyn Pohle, and Emily Rumaldo lead a workshop with 6-12th grade teachers on how to modify mathematics problems/exercises to be more inclusive of diverse ethnicities and genders and to include more authentic examples of STEM careers.



LEFT TO RIGHT: DR. ALISON MARZOCCHI, EMILY RUMALDO, ALEXIS DI PASQUA & EVELYN POHLE

In other news...

DR. GLESSER AND HIS MATH 302 STUDENTS AT CARBON CANYON REGIONAL PARK

Dr. Adam Glesser met with several students from his Fall 2021 Math 302 course at Carbon Canyon Regional Park. Since the course is virtual, he had only ever met one of these students in person and they had never met each other. In an attempt to build community, he hosted a potluck gathering in the park.

EMILY RUMALDO & EFREN ROJAS IN CENTRAL PARK, NEW YORK CITY, NY

Undergraduate students, Efren Rojas and Emily Rumaldo, spent Summer 2021 in New Jersey teaching mathematics to low-income, first-generation high school students in the Upward Bound Math/Science Program. They lived in the dorms while mentoring and teaching the students and they spent their free time in New York City.

SANTA CLAUS (AKA DR. BONSANGUE) WITH THE FAMILY OF CSUF ALUM DWAN HUYNH '11 (M.A. IN MATHEMATICS, TEACHING) DURING THE "SAFE SANTA VISIT, 2021."

Last year, many children missed out on the beloved tradition of visiting with Santa Claus. This year, Dr. Marty Bonsangue had a solution and made this season a little brighter by hosting a drive-through visit with Santa Claus for the CSUF mathematics faculty and alumni. Dr. Bonsangue dressed as Santa Claus and every child in attendance received a Christmas present. The event was a success since each child got a stuffed animal from children's literature, each mommy got a red rose, and smiles were in abundance.

Contribute to the Department

There are many different opportunities to support the Mathematics Department and its students. Use the links below to learn more about donating to various funds associated with the Mathematics Department:

- 70302 (Department of Mathematics): To support the greatest needs in the Mathematics Department.
- 70303 (DeLand Mathematics Fellowship): To support the DeLand Mathematics Fellowships
- 70314 (Stiel Prize for Excellence in Mathematics Endowment): To support an annual scholarship to an exceptional math student as selected by Mathematics faculty.
- 70340 (Math Scholarship Account): Funds provide scholarships, awards, and gift for scholars in the Math Department.
- 70347 (Mathematical Circle): To support research and testing activities in in Mathematics.
- 70348 (Gerald Gannon Fund): To support a graduate scholarship for a student enrolled in the Master of Arts in Teaching program in the Department of Mathematics.
- 70300 (Project MISS): For discretionary use by Project MISS (Mathematics Intensive Summer Session.

Planned Gifts

Planned and Estate giving provides another avenue for supporting the Department, often with beneficial tax implications. If you're interested in learn more, please visit the CSUF Planned Giving site or reach out to us to have a conversation.

Tell us what you think!

If you have any questions, comments, suggestions, feedback, or would like to contribute a story, please contact Dr. Armando Martinez-Cruz at amartinez-cruz@fullerton.edu.

Mathematics Summer Research Program & DeLand Summer Research Posters

The Mathematics Department would like to acknowledge our students who were selected to participate in the Mathematics Summer Research Program and DeLand Summer Research Fellowship during the Summer 2021 term. These summer research programs provide faculty-mentored research opportunities for students. This opportunity provides students with the ability to develop oral and written communication skills, enhances graduate school workforce preparedness, lessens our students financial burden by providing research stipends, and leads to a more robust research infrastructure in our department. Below are a selection of the research posters generated from the student research conducted from these programs.

VIVI NGO

DR. SAM BEHSETA

A Predictive Model for COVID-19 Infection Rate in Orange County, CA

Vivi Ngo [1] and Christian Almendares [1]
Advisor: Dr. Sam Behseta
[1]Department of Mathematics
California State University, Fullerton

Abstract

COVID-19 is a type of coronavirus caused by SARS-CoV-2, this type of virus has never been seen before. COVID-19 is an infections virus that is contracted through contact with another person who has the virus. It predominantly attacks the respiratory system and is an illness that can affect other organs. The President declared a national emergency concerning the coronavirus disease (COVID-19) due to significant risks to the public health and safety of the Nation and safety measures, like social distancing, were incorporated to keep the public health safe.

Background Information and Scientific Goals

On March 11th, 2020, the Coronavirus Disease was declared a pandemic by the World Health Organization, according to the CDC there has been over 15,271,571 cases and 288,762 in the United States within the first ten months the first case was reported. In 2021, variants of the virus that causes COVID-19 are circulating, including in the United States. According to the CDC, the U.S. COVID-19 Vaccination Program began in December 14th, 2020. A total of 36,268,057 COVID-19 cases have been reported as of August 11,2021. COVID-19 spreads from person to person contact that causes issues within our unprepared immune system and it primarily targets the lower respiratory.

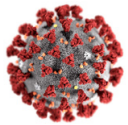


Figure 1. Coronavirus Disease (COVID-19)

In this study we will utilize machine learning, statistical models, including time-series models to address two main goals for this project:

- **Generate Forecasting** daily COVID cases by county in Southern California.
- **Track and Interpret** the rate of vaccinations

In order to predict COVID cases for a specific day we have to not only compile the data into one data set, but also consider the following time range from exposure to development of symptoms.

Data Structure, Time-frame, and Covariates

From these sources we created and updated two primary data sets,

1. **Mobility Data: Google** This data is available by Community Mobility Reports. The reports chart show movement trends over time by geography, across different categories of places. Google collects aggregated data and focuses more on where people spend their time.
2. **Mobility Data: Apple** Apple's Data has some similarities to Googles. Apple tracks mobility in three categories: driving, walking, and transit. Apple collects the data from requested directions. velit lectus faucibus dolor, quis gravida metus mauris gravida turpis.
3. **COVID infection data: USA Facts** USA Facts tracks COVID-19 data daily by state and county. It tracks number of cases and deaths.
4. **COVID Vaccination Data: OC Health Care Agency** The OC Health Care Agency provides updated vaccination data in Orange County, it includes first and second doses administered from Dec. 15,2020.

A Generalized Linear Model for the Time Series of Count Data

Literature Review

- The most frequent theme in all of those is models for prediction of the diagnosis, infection, mortality, and hospitalization rates (Zaobi, 2021). Nevertheless, there is a significantly limited published work, so far, on the statistical or mathematical models for studying the dynamics of COVID-19 fluctuations when viewed through the prism of the economic status of their communities.
- Since economic disparity in the U.S. often correlates with racial disparity, there is an urgent need to tackle the issue, and thereby fill that void in the literature (McLaren, 2020).
- In this work, we draw from the rich and extensive literature on the statistical modeling for the time-series regression, when the response variable is the number of incidents or random occurrences, and the predictors of the model are time dependent as well (for a comprehensive review of the literature, see the references cited in Kedem and Fokianos, 2002).

Modeling

- We would like to be able to build a regression model whose response variable is the rates of infection, and the predictors in the model are mobility and county values. This means, we model the time series of the cases or the response variable with a so-called non-homogeneous Poisson process (Zeger and Qaqish, 1988).
- This approach allows for building a regression model through a mechanism known as generalized linear models or GLM in short(Nelder and Wedderburn, 1972).
- Let's represent the time series of the response by Y_t, where $t \in \mathbb{N}$, represents the time index. We also let X_t to represent a vector of all covariates at time t. Due to our use of Poisson model, we model the conditional expected value of the time series, given the history of the series or $\mathcal{F}_t$, to have an intensity parameter λ_t, or in general, $E(Y_t|\mathcal{F}_t) = \lambda_t$. We can then write the model as:

$$g(\lambda_t) = \beta_0 + \sum_{k=1}^{p} \beta_k h(Y_{t-i_k}) + \sum_{l=1}^{q} \alpha_l g(\lambda_{t-j_l}) + \eta^T \mathbb{X}_t,$$

where h is a transformation function, and g is the so-called *link function* of the generalized linear model. In the case of our model, g is simply the logarithmic function. The parameter vector η reflects the effect of all the covariates, and α and β represent the coefficients for the lagged conditional mean and lagged observations and broadly represent the auto-regressive order of the model and can be determined via the Avutocorrelation and Partial Autocorrelation functions.

Parameter Estimation

All parameters in the model can be updated, iteratively, using a quasi maximum likelihood estimation technique.

Software

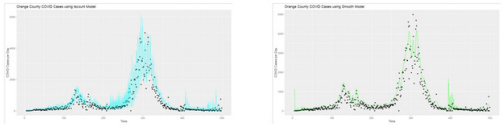
An R package called *tscount* is utilized for modeling and forecasting data. This is coupled with multiple other packages, including the *KernSmooth* package for smoothing splines, and a number of R and Python packages for data wrangling and data preparations.

Predictions and Forecasting

Prediction is implemented in the R package *tscount* using a parametric bootstrap technique for time series.

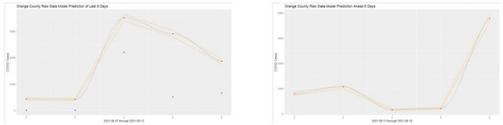
Main Results

We can summarize the main modeling outcomes of our work via two visuals. In the left panel of figure 2, we demonstrate how well the time series model, depicted in green, mimics the nuances of the infection rates in black. We note that a smoothing process, via kernel smoothing splines, can create a curve that represents the patterns of variation of the infection rate, as shown in the right panel of figure 2.



(a) A subfigure 1 (b) A subfigure 2

Figure 2. Left: time series model models the nuances of COVID-19 infection rates in Orange County, CA. Right: A smoothing splines with a Gaussian kernel smooths out the fitted model, allowing for identifying the overall patterns of variation.



(a) A subfigure 3 (b) A subfigure 4

Figure 3. Left: Right:

Future Work

We will further update the model, particularly with the new vaccination data becoming available to us. We will also look at strategies for making our forecasts more precise by reducing the confidence bands of the future bootstrap predictions.

Acknowledgments

This research has been made possible by the generous grant of Dr. Paul DeLand, Mrs. Sara DeLand. We are utterly grateful for their generosity. The authors wish to thank Dr. Sam Behseta for his vision and mentorship. We would also like to thank the Mathematics Department at CSUF, particularly Mr. Abraham Roldan, and Ms. Gwendolyn Lind for her technical support.

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TEAM (Teaching Equity-minded and Active Mathematics) Tool

Carolynn Cao, Christine Gamez, and Evelyn Pohle
Advisor: Dr. Alison Marzocchi


CAROLYNN CAO


CHRISTINE GAMEZ


EVELYN POHLE


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Introduction

Goals

- Provide mathematics instructors with a tool to gradually shift their instruction towards more equity-minded and active mathematics teaching
- Improve students' experiences in mathematics as instructors provide opportunities for every student to succeed
- Over time, improve diversity, equity, and inclusion in STEM

Research Question

- What are the components of an equity-minded and active mathematics classroom?

Literature Review

- "Active classroom engagement is promoted in education research literature and better attends to issues of equity. This could support students' learning, attitudes, sense of belonging, and persistence in STEM" ([2], p. 2)
- "Equitable and inclusive practices promote understanding, capitalize on the cultural wealth of diverse students, foster a sense of belonging that supports students' engagement, and create meaningful relationships" ([4], p. 332)
- "Significant equity gaps in STEM create barriers within the academic pathway" ([4], p. 331)
- "Undergraduate students often appear to be treated as interchangeable entities without acknowledgment of the central role of the individual students, their learning histories, and their personal characteristics" ([3], p. 322).

Methods

- Reviewed extensive literature on equity-minded teaching and active learning in different fields (both STEM and non-STEM)
- Constructed a research-backed self-assessment tool, the TEAM Tool, of components of equity-minded and active mathematics instruction
- Piloted the TEAM Tool with several video clips of live mathematics instruction; refined the Tool
- Utilized the TEAM Tool with three full-length videos of live mathematics instruction; each researcher collected separate data from the videos for each component of the Tool; the research team met to discuss and resolve discrepancies
- Selected a subset of three items from the TEAM Tool for deeper data collection and reflection; these items were selected because of substantial evidence collected during video observations

Results

Does not judge responses

Teacher refrains from distinguishing a "best" way to do things and avoids immediately weighing in on correctness.

Lesson 1: Calculus lesson for STEM majors	Lesson 2: Geometry lesson for future teachers	Lesson 3: Algebra lesson for current and future teachers
Teacher allowed students to share their own unique solutions Nonexample: Teacher said "This one, I try to avoid" when discussing a convergence test	Teacher did not deem any student-generated definitions as "right" or "wrong" Teacher gave students opportunity to critique each other's responses rather than assessing responses herself	Teacher promoted that all ideas are valid Teacher encouraged, "Those are all really good questions" Teacher praised participation

Uses students' real life experiences to connect school learning and students' lives

Students are able to see themselves in the curriculum and use math to examine their lived worlds and experiences.

Lesson 1: Calculus lesson for STEM majors	Lesson 2: Geometry lesson for future teachers	Lesson 3: Algebra lesson for current and future teachers
Teacher talked about how harmonic series are related to music Nonexample: No evidence of students connecting their own lives to the mathematics	Nonexample: Teacher did not connect the material to the students' real life experiences; lesson remained in the abstract mathematics realm	Students were able to relate their patio with patterns during the warm up and teacher agreed that it is important for teachers to relate math with real life Teacher talked about how "sometimes we teach these concepts, but don't really know how to describe it in a tangible way"

Uses multiple approaches to consistently monitor every student's understanding of instructions, directions, procedures, processes, questions, and content

Teacher uses varied active learning strategies as well as a variety of visual aids and props for diverse learning preferences.

Lesson 1: Calculus lesson for STEM majors	Lesson 2: Geometry lesson for future teachers	Lesson 3: Algebra lesson for current and future teachers
Teacher had the activity displayed on the projector, a worksheet, and went through the directions orally Teacher used physical visual aid when describing volume Teacher provided students with videos on different convergence tests Teacher used Desmos	Teacher had the directions projected on the board, explains the directions before the lesson, and explains the directions during the lesson Teacher stated the time the students would have for the activity and projected it using a timer Teacher provided students with sentence starters	Teacher asked students a follow-up question after giving them instructions and students all answered in unison During the activity, students created visual representations as well as mathematical representations

Terms

- **Diversity** refers to group composition and "is defined broadly to include variations in age, gender, identity, race/ethnicity, national origin, socioeconomic status, sexual orientation, and more" ([4], p. 330)
- **Equity** maximizes fairness by providing various pathways for different individuals to be successful ([1] [3])
- **Inclusive strategies** address the needs of every student so that they feel supported, valued, and capable of success ([4], p. 331)

Discussion

Implications

- "As instructors, we have the power in our classrooms to choose to attend explicitly to issues of access, inclusiveness, fairness and equity" ([3], p. 330)
- The TEAM Tool provides a self-assessment tool for instructors to set goals and make gradual improvements
- Help make the classroom a more inclusive place for every student
- Diversify the STEM community

Future Research

- This year we will implement the TEAM Tool with live lessons. We will enact the intended full cycle of pre-observation, observation, post-observation.
- Determine the applicability of the TEAM Tool in other disciplines, both STEM and non-STEM

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Acknowledgements

Thank you to our research advisor, Dr. Marzocchi, to the teachers who allowed us to use recordings of their instruction for our research, and to the Mathematics Department Summer Research Program at CSUF (MSRP) for funding our research.

College of Natural Sciences and Mathematics
Department of Mathematics

To access our poster and the full list of TEAM Tool Items, please scan this QR code or visit this link. https://bit.ly/csufteam →

SCAN ME

Application of Adaptive Lasso for Analyzing Non-regular Two-level Designs

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Abstract

Experimental design is commonly used for identifying factors that affect the response or processes in industrial experiments. Nonregular designs are a popular choice for selecting important main effects and two-factor interactions. In this research, we utilized the analysis strategy of adaptive lasso proposed by Kane and Mandal (2020) to analyze a 12-run Plackett-Burman design from Sahu and Jain (2017). In this experiment, the aim was to identify the process variables that have an impact on the formulation of gedunin-loaded liposomes.

Objective

To explore and implement the analysis strategy of adaptive lasso for nonregular factorial designs introduced by Kane and Mandal (2020) with an application to gedunin-loaded liposome formulations (Sahu and Jain, 2017)

Factorial Design Background

Regular Factorial Designs:

- A full two-level factorial design considers all possible combinations of the factors at two-levels: 2^k where k is the number of factors.
- A two-level fractional factorial design is a subset of a full factorial design: 2^{k-p}, which results in a 2^{-p} fraction of the full 2^k design.
  - A fractional factorial design is selected based on some criteria, such as the minimum aberration criteria. Aliasing is a consequence of using fractional factorial designs. Aliasing enables the reduction of the full factorial design to a fractional factorial design. This consequence results in the inability to estimate certain factorial effects.

Three principles of factorial designs:

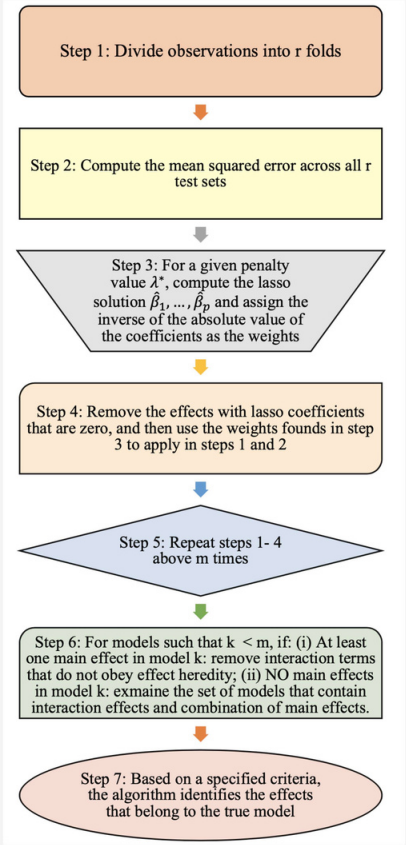
Effect Hierarchy:	Lower order effects are more likely to be important than higher order effects
Effect Sparsity:	The number of relatively important effects in a factorial experiment is small
Effect Heredity:	Significant interactions must have at least one parent main effect significant

Nonregular Designs:

An alternative to regular designs that offer more flexibility in terms of run size as well as estimation of factorial effects. In a nonregular design, factorial effects are partially aliased, known as complex aliasing, which can be used to identify significant interactions that would otherwise be missed. Common nonregular designs include: Placket-Burman designs and orthogonal arrays

Adaptive Lasso for Analyzing Nonregular Designs

Nonregular designs are advantageous for screening, but analysis of them is often complex as existing techniques often do not consider the three principles of factorial designs. Kane and Mandal (2020) introduce the use of adaptive lasso for the analysis of nonregular designs in the following seven steps:



Application: Fabrication of Gedunin-loaded Liposomes

- Sahu and Jain (2017) performed a study on 11 factors for the formulation of gedunin-loaded liposomes and measured four response variables.
- For simplicity we call the 11 factors: *A, B,C, D,E,F,G,H,J,K,L*. Each factor has two levels represented by −1 and 1.
- The four response variables are: vesicle size (VS), zeta potential (ZP), entrapment efficiency (EE), and drug-loading capacity (LC).
- The table below presents a 12-run Placket-Burman design for the 11 factors:

Run	DC (A)	LC (B)	C/L (C)	C/M (D)	O/S (E)	AV (F)	Ph (G)	WBT (H)	RS (J)	RS (K)	UsT (L)	VS	ZP	EE	LC
1	1	-1	-1	-1	1	-1	1	1	-1	1	1	278	20.25	58.45	10.47
2	-1	1	1	-1	1	1	1	-1	-1	-1	1	282	38.15	73.40	3.54
3	-1	1	-1	1	1	-1	1	1	1	-1	-1	682	34.72	80.51	3.86
4	-1	1	1	1	-1	-1	-1	1	-1	1	1	292	39.20	76.31	3.67
5	1	1	1	-1	-1	-1	1	-1	1	1	-1	990	35.71	81.89	7.57
6	-1	-1	1	-1	1	1	-1	1	1	1	-1	451	23.35	51.41	4.89
7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	322	19.39	45.25	4.33
8	1	1	-1	1	1	1	-1	-1	-1	1	-1	612	33.28	83.20	7.68
9	-1	-1	-1	1	-1	1	1	-1	1	1	1	112	20.79	55.61	5.27
10	1	-1	1	1	-1	1	1	1	-1	-1	-1	787	22.75	56.11	10.09
11	1	1	-1	-1	-1	1	-1	1	1	-1	1	258	35.71	87.60	8.05
12	1	-1	1	1	1	-1	-1	-1	1	-1	1	211	25.35	61.71	11.00

Analysis of Gedunin-loaded Liposomes Data using Adaptive Lasso:

Response	Significant Factors
Vesicle size (VS)	Ultrasonication time (UST)
Zeta potential (ZP)	Lipid concentration (LC)
	cholesterol/lecithin ratio(C/L)
Entrapment efficiency (EE)	Lipid concentration (LC)
Drug-loading capacity (LC)	Drug Concentration (DC)
	Lipid concentration (LC)

Conclusions

- In the analysis of all four response variables, the adaptive lasso algorithm identified the significant factors that match the results from Sahu and Jain (2017).
- This is interesting that even with the adaptive lasso algorithm no significant two-factor interactions were identified, but with the lasso algorithm we know that they were at least considered

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Chebyshev-type Orthogonal Matrix Polynomials

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Introduction

Abstract: Orthogonal polynomials play a pivotal role in numerous areas of both pure and applied mathematics, from numerical methods for differential equations to harmonic analysis. Recently, a lot of research interest has focused on matrix-valued orthogonal polynomials (MVOPs), motivated particularly from their appearance in the representation theory of certain Lie groups. With this motivation in mind we explore MVOP's and try to determine better ways of calculating MVOPs related to representation theory.

Weight matrices and MVOPs

A **weight matrix** is a function $W : (a, b) \to M_n(\mathbb{R})$ where $\int_a^b W(x)\|x\|^n dx < \infty, W(x)^T = W(x)$, and $W(x)$ is positive definite for all $x \in (a, b)$. A sequence of **matrix-valued orthogonal polynomials** for a weight matrix $W(x)$ is a sequence of matrix-valued polynomials $P_0(x), P_1(x), \ldots$, unique up to a choice of leading coefficient, satisfying,

- $P_n(x) = \sum_{j=0}^n P_{nj}(x)x^j$ for $P_{nj} \in M_n(\mathbb{R})$ with $\det(P_{nn}) \neq 0$
- $\int_a^b P_n(x)W(x)P_m(x)^T dx = 0, m \neq n$

Three-term recurrence relations

A sequence of orthogonal matrix polynomials always satisfies a three-term recurrence relation, allowing us to express the orthogonal polynomial of degree $n + 1$ in terms of the orthogonal polynomials of degree n and $n - 1$.

Theorem: Let $W(x)$ be a weight matrix and let $\{P_n(x)\}_{n=0}^\infty$ be the associated sequence of orthogonal matrix polynomials. Then there exists a sequence of matrices A_n, B_n, and C_n satisfying

$$xP_n(x) = A_nP_{n+1}(x) + B_nP_n(x) + C_nP_{n-1}(x).$$

Chebyshev-type MVOPs

The **Chebyshev polynomials** are the sequence of polynomials defined by $T_n(\cos(\theta)) = \cos(n\theta)$.

They satisfy the orthogonality condition

$$\int_{-1}^1 T_n(x)T_m(x)\frac{dx}{\sqrt{1-x^2}} = 0, m \neq n$$

as well as the recurrence relation

$$xT_n(x) = \frac{1}{2}T_{n+1}(x) + \frac{1}{2}T_{n-1}(x).$$

Generalizing the Chebyshev weight, we define a **Chebyshev-type weight matrix** to be any weight matrix of the form $W(x) = Q(x)/\sqrt{1-x^2}$ where $Q(x)$ is a matrix-valued polynomial on $[-1, 1]$.

Example: Let,

$$Q(x) = \begin{pmatrix} 1 & x \\ x & \frac{3}{2} + \frac{1}{2}x^2 \end{pmatrix}$$

then by performing Gram-Schmidt with the inner product we get the recursion relation

$$xP_n(x) = (I/2)P_{n+1}(x) + B_nP_n(x) + C_nP_{n-1}(x)$$

where,

$$B_0 = \begin{pmatrix} 0 & 1/3 \\ 1/2 & 0 \end{pmatrix}, B_1 = \begin{pmatrix} 0 & -2/15 \\ -1/4 & 0 \end{pmatrix}, B_n = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \text{ for } n \geq 2$$

and

$$C_0 = \begin{pmatrix} 2/3 & 0 \\ 0 & 5/6 \end{pmatrix}, C_1 = \begin{pmatrix} 3/5 & 0 \\ 0 & 1/2 \end{pmatrix}, C_n = \begin{pmatrix} 1/2 & 0 \\ 0 & 1/2 \end{pmatrix} \text{ for } n \geq 2.$$

Numerical results: eventually Chebyshev recurrence relations

Experimentally, we found that for a wide class of orthogonal matrix polynomials, the three-term recurrence relation quickly became identical to the recurrence relation for Jacobi polynomials. This reminded us of a classical theorem of Szegö.

Theorem (Szegö): Let $w(x) = \frac{1}{q(x)\sqrt{1-x^2}}$, with $q(x)$ a polynomial, be the weight function. We can then factor $q(x)$ as

$$q(\cos\theta) = h(e^{i\theta})h(e^{-i\theta})$$

for $h(x)$ a polynomial and $x = \cos\theta$. Then we determine an explicit expression for our orthogonal polynomials where,

$$P_n(x) = \mathrm{Re}\{e^{in\theta}h(e^{-i\theta})\}, \; n \geq \frac{1}{2}\deg(q(x)).$$

Question: Can we mimic the factorization strategy in Szegö's theorem to obtain a similar explicit formula for the polynomials in the matrix setting?

Birkhoff decomposition

Theorem (Birkhoff): Let $M(z)$ be a matrix-valued function whose entries are Laurent polynomials in z. Then $M(z)$ has a factorization of the form

$$M(z) = M_-(z^{-1})D(z)M_+(z).$$

where $M_\pm(z^{\pm 1})$ has entries which are polynomials in $z^{\pm 1}$ and $D(z)$ is a diagonal matrix whose entries are powers of z and the determinant of $M_\pm(z^{\pm 1})$ is constant.

The Birkhoff decomposition theorem is at the heart of the generalized Riemann-Hilbert problem and is a fundamental ingredient in the classification of isomorphism classes of holomorphic vector bundles on the sphere.

Simple example:

$$\begin{pmatrix} 1 & z+z^{-1} \\ z+z^{-1} & 1+(z+z^{-1})^2 \end{pmatrix} = \begin{pmatrix} \frac{1}{2} & z^{-1} \\ \frac{z^{-1}}{2} & 2+z^{-2} \end{pmatrix}\begin{pmatrix} 1 & z \\ \frac{z}{2} & 1+\frac{z^2}{2} \end{pmatrix}$$

Harder example:

$$\begin{pmatrix} 1 & 0 & \frac{z+z^{-1}}{2} \\ 0 & 1 & \frac{z+z^{-1}}{2} \\ \frac{z+z^{-1}}{2} & \frac{z+z^{-1}}{2} & \frac{(z+z^{-1})^2}{2}+1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & \frac{z^{-1}}{2} \\ 0 & 1 & \frac{z^{-1}}{2} \\ \frac{z^{-1}}{2} & \frac{z^{-1}}{2} & \frac{z^{-2}}{2}+1 \end{pmatrix}\begin{pmatrix} \frac{5}{6} & \frac{-1}{6} & \frac{z}{2} \\ \frac{-1}{6} & \frac{5}{6} & \frac{z}{2} \\ \frac{z}{2} & \frac{z}{2} & \frac{z^2}{2}+\frac{3}{2} \end{pmatrix}$$

Family of examples: Let A be an $n \times n$ matrix with $A^2 = 0$. Then for

$$e^{Az}e^{A^Tz^{-1}} = e^{Bz^{-1}}(I + AA^T - BA + Az), \quad B = A^T(I + AA^T)^{-1}$$

Main theorem 1

Theorem: Let $W(x)$ be a Chebyshev-type weight matrix of the form $W(x) = Q(x)/\sqrt{1-x^2}$ for some matrix-valued polynomial $Q(x)$ whose determinant is a nonzero constant. Then for sufficiently large n, a sequence of orthogonal matrix polynomials for $W(x)$ has the form

$$P_n(x) = \mathrm{Re}\left[e^{in\theta}Q_-(e^{-i\theta})^{-1}\right]$$

where here $x = \cos(\theta)$ and

$$Q\left(\frac{z+z^{-1}}{2}\right) = Q_-(z^{-1})Q_+(z)$$

is the **Birkhoff decomposition** of $Q(\cos(x))$.

Linearizable Chebyshev-type weights

Question: Can we get some explicit expressions for MVOP's with Chebyshev-type weights $W(x) = Q(x)/\sqrt{1-x^2}$ where $\det(Q(x))$ is non-constant?

We appeal to a formula attributed to Christoffel.

Let $q(x) = c(x-\lambda_1)(x-\lambda_2)\cdots(x-\lambda_r)$, $c \neq 0$ then the orthogonal polynomials with weight function $\frac{q(x)}{\sqrt{1-x^2}}$ is given by,

$$q(x)P_n(x) = \begin{vmatrix} T_n(x) & T_{n+1}(x) & \cdots & T_{n+d}(x) \\ T_n(\lambda_1) & T_{n+1}(\lambda_1) & \cdots & T_{n+d}(\lambda_1) \\ \vdots & \vdots & \cdots & \vdots \\ T_n(\lambda_r) & T_{n+1}(\lambda_r) & \cdots & T_{n+d}(\lambda_r) \end{vmatrix}.$$

These Slater-type determinants are closely related to Selberg-type integrals as shown in [3].

Quasideterminants

Let A be an $m \times m$ whose j,k'th entry a_{jk} is an $r \times r$ matrix for all $1 \leq j, k \leq m$. A **quasideterminant** of A is a sort of noncommutative analog of the determinant-normalized cofactor of A, whose value will be an $r \times r$ matrix.

More precisely, if we define a matrix $B = (A^{jk})^{-1}$ with entries b_{jk} (for A^{jk} the submatrix of A omitting row j and column k) then the (j,k)'th quasideterminant of A is

$$\mathrm{qdet}_{j,k}(A) = a_{jk} - \sum_{j' \neq j}\sum_{k' \neq k} a_{j,j'}b_{k'j'}a_{k',k}$$

Scalar case: When $r = 1$, then $\mathrm{qdet}_{j,k}(A) = (-1)^{j+k}\frac{\det(A)}{\det A^{jk}}$.

Main Theorem 2

Theorem: Let $W(x)$ be a Chebyshev-type weight matrix of the form $W(x) = Q(x)/\sqrt{1-x^2}$ for some matrix-valued polynomial $Q(x)$ of degree d with nd distinct eigenvalues. Then we may linearize $Q(x)$ as

$$Q(x) = (xI - A_1)(xI - A_2)\ldots(xI - A_d)$$

and a sequence of orthogonal polynomials for $W(x)$ has the explicit expression in terms of a block Slater-type quasideterminant

$$P_n(x)Q(x) = \mathrm{qdet}_{1,1}\begin{pmatrix} T_n(x) & T_{n+1}(x) & \ldots & T_{n+d}(x) \\ T_n(A_1) & T_{n+1}(A_1) & \ldots & T_{n+d}(A_1) \\ T_n(A_2) & T_{n+1}(A_2) & \ldots & T_{n+d}(A_2) \\ \vdots & \vdots & \ddots & \vdots \\ T_n(A_n) & T_{n+1}(A_n) & \ldots & T_{n+d}(A_n) \end{pmatrix}, \; n \geq d.$$

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Murder Mysteries and Machine Learning

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Abstract

Data analytics and machine learning is a new and growing field in science and mathematics. The applications are endless and the accuracy of a machine's learning skills are continuously improving. The goal of our interdisciplinary project is to use the Natural Language Toolkit (NLTK) to predict the outcome of Agatha Christie's murder mystery novels. Agatha Christie is a well-known author from the 1920s who earned the title of being the Queen of Mystery. Her books consist of several characters and unexpected plot developments that make her stories unpredictable. We use the NLTK package to discern patterns in Agatha Christie's writings and determine if she is as unpredictable as we have been led to believe. This project has the potential to improve on the processes used in data analytics and the techniques used can be applied to multiple fields.

(a) The Mysterious Affair at Styles

(b) The Mystery of the Blue Train

(c) Appointment with Death

Figure: Agatha Christie's Work

Definitions

- **Degree** - The number of connections a character has.
- **Weighted Degree** -The number of connections between each character.
- **Eigenvector** - A value that increases a character's importance based on how many connections they have with a character that has a high number of connections overall.
- **Closeness** - A value that determines a character's importance based on the average distance from all other characters. The lower the value the more important the character is.
- **Betweenness** - Measures how frequently a character is between a connection of two other characters.
- **Page Rank** - A character with a large centrality degree divides a small amount of its importance to each connecting character.

Methods

1. Choose a book and isolate the first five chapters
2. Create a program that identifies characters in the book and run it using spaCy(NLP)
3. Use packages NLTK and networkx to identify and record centrality measures
4. Test out our existing theories/come up with new theories
5. Repeat the process on a new book and compare results

Results

(a) Degree

(b) Betweenness

(c) Closeness

Figure: Data for The Mystery of the Blue Train

Conclusion

Our theories didn't hold during our second round of implementation. May have to modify our theories, the way we applied them, or overall come up with new observations that may better predict the murder.

Future Work

- The three books we analyzed were written about ten years apart from one another. We can evaluate whether the reason our theories did not work is because she improved as a writer.
- We based our theories on a novel with two murders but applied them to books with one murder. We may need to categorize each type of plot and determine a pattern. Then take our observations and test broader theories.

Acknowledgements

- College of Natural Sciences and Mathematics California State University, Fullerton, Department of Mathematics.
- Carmen Romero, Undergraduate Student at Cypress College
- David Nguyen, Undergraduate Student at California State University, Fullerton
- Gustavo Sopena, Graduate Student at California State University, Fullerton

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