Universidad de Puerto Rico en Humacao

SIDIM

SEMINARIO INTERUNIVERSITARIO
DE INVESTIGACIÓN EN CIENCIAS MATEMÁTICAS

Conferenciantes Plenarios:

Hortensia Soto
Colorado State University
Marta Lewicka
University of Pittsburgh
Mahamadi Warma
George Mason University

1-2 de marzo de 2024

http://sidim.org

SIDIM 2024 Sponsors

University of Puerto Rico at Humacao

Department of Mathematics, University of Puerto Rico at Humacao

UPRH-PENN PREM Program, University of Puerto Rico at Humacao.

Municipio Autónomo de Humacao, Centro de Artes Ángel "Lito" Peña

George Mason University, Mathematical Sciences Department

University of Alabama, Department of Mathematics

The Ohio State University, Department of Mathematics

Casualty Actuarial Society

Triple S Salud de Puerto Rico

Contents

1 Charlas Plenarias / Plenary Talks

Creating Metaphors for Linear Algebra Concepts: Developing Cognitive, Behavioral, and Affective Domains

Hortensia Soto, Colorado State University.

In this presentation I will take the audience on a journey of an introductory linear algebra class designed to help students develop a geometric understanding of basic linear algebra concepts. I will share some embodied activities that I implemented in the course and then share metaphors that the students created for basic linear algebra concepts. Preliminary findings of this work suggest that the embodied activities, linguistics, and students' identities informed the metaphors that they created. Moreover, I will showcase how this assessment illustrated students' cognitive understanding of the concepts as well as their behavioral and affective domains. The students expressed all three of these domains (cognitive, behavioral, and affective) via embodiment including gestures, body posture, facial expressions, and tone of voice. In conclusion, I will share the value and challenges of such assessments.

On the Holder regularity of isometric immersions and the Monge-Ampere system

Marta Lewicka, University of Pittsburgh.

Given a smooth two-dimensional Riemannian manifold with positive Gauss curvature, any C^2-regular isometric immersion of it into $\mathbf{R}^3$ must be locally convex. In the 1950's, Nash and Kuiper showed that this is not necessarily true for isometric immersions that are only C^1. The quest for the threshold in terms of the Holder regularity exponent has led to many interesting discoveries and technical improvements, linked to and arising also in the context of the nonlinear elasticity of prestrained thin films.

In my talk, I will review the known flexibility results for the isometric immersion problem, and for the closely related Monge-Ampere system, via convex integration, in function of the dimension and codimension of their solutions.

Control, Optimization and Applications to Fractional PDEs

Mahamadi Warma, George Mason University.

Control Theory is certainly, at present, one of the most interdisciplinary areas of research. Control Theory arises in most modern applications. The same can be said about the very first technological discoveries of the industrial revolution. On the other hand, Control Theory has been a discipline where many mathematical ideas and methods have melt to produce a new body of important Mathematics. Accordingly, it is nowadays a rich crossing point of Engineering and Mathematics. In this talk we will first introduce the general control theory of Partial Differential Equations (PDE) that

includes controllability and optimal control. Secondly, we will make a connection between controllability and optimal control of general PDE with state and/or control constraints. Thirdly, we will apply this theory to fractional control problems with state and/or control constraints. Fractional Parabolic control problems with state constraints will be discussed in details. The talk will be accessible to a large audience avoiding any technical difficulties.

2 Sesiones Temáticas/ Thematic Sessions

2.1 Understanding Animal Behavior through the lens of Artificial Intelligence and Data Science

In this thematic session, we will explore how various subfields of Artificial Intelligence and Data Science can make an impact on the understanding of animal behavior. Behavior is complex and requires models at various levels to capture a complete picture: at biological level, neuronal circuitry is responsible for collecting sensory input, processing it and generating actions, at individual level, each animal takes decisions based on its internal parameters and environment, which generates emerging dynamics at the group and population level due to interaction. Building these models requires large data collection to obtain enough repetitions of specific behaviors and extract reliable statistics. In cases where the raw data is complex, such as images or neuronal signals, Machine Learning approaches can help automatize the decoding of such raw data into interpretable data to be further analyzed in ethological studies. Collecting repeated data for a large amount of individuals may not be achievable, and then computational simulation as multiple agents provides a way to study the effect of the modeled behavior in relation to the environment. These various approaches are complementary and share the need for advanced computational and mathematical models which will be discussed in the session. The talks will present a diversity of computational and mathematical approaches based on Deep Learning, Multi-Agent systems, and Machine Learning models, applied to various animal studies: honeybee foraging behavior, the modeling of fish collective behavior, and tactile exploration in mice. The session will therefore provide a multiplicity of point of views to discuss and engage about the various opportunities for the artificial intelligence and data science community in contributing models and methods to improve the understanding of animal behavior, with potential outcomes on our understanding of the impact of climate change or the fundamental rules of life.

Acknowledgements: This thematic session is supported by the National Science Foundation, award CNS-2318597.

How Artificial Intelligence is reshaping animal studies)

Remi Megret, Department of Computer Science, University of Puerto Rico at Río Piedras.

Artificial Intelligence is evolving rapidly and provides renewed tools for analyzing and generating data in many fields, leading to a revolution in our capacity to handle and gain insight into complex phenomena. Life Sciences tries to uncover potentially very complex mechanisms, which requires increasingly large amounts of data and looking for increasingly complex patterns, requiring improved models and tools in terms of accuracy, computational performance and capacity to represent the

reality of patterns. In the particular case of animal behavior, fine grained analysis requires precise modeling of the actions taken, sometime over large periods of time, which makes automated systems necessary.

In this talk, the revolution enabled by Deep Learning will be discussed and presented with its historical background. Computer Vision models based on Deep Learning will be illustrated for the video analysis of animals, which show how in recent years, we have passed from limited lab settings to potentially unconstrained settings. In particular, will be discussed models pertaining to automatic detection and pose estimation of honeybees, as well as automatic identification of individuals, which are two challenging problems in poorly controlled conditions such as when monitoring animals in the field. These advances will be put in perspective with the accelerating pace of research in the Artificial Intelligence field, up to the recent development of foundational models that are trained once and can be applied in multiple downstream tasks. The limits of these models will also be discussed, such as its high dependency on training data to put in perspective the continued need for alternative approaches, and their relative strengths.

Acknowledgements: This work is supported by award CNS-2318597.from NSF and grant no. 2021-67014-34999 from the USDA NIFA.

Self-organization and Intelligent Multi-Agent Systems for Modeling Natural Ecosystems)

David Flores, Department of Computer Science, University of Puerto Rico at Río Piedras.

Self-organization is a wide range of pattern-forming processes in physical, biological and environmental systems, involving Computer Science for the design of complex, adaptive, efficient and robust systems that can operate autonomously to respond to changes in their environment effectively. Its application covers a wide range of fields, from computer networks to artificial intelligence systems and robotics.

Some of the representative fields and applications in which self-organization is involved are: the resolution of optimization problems taking as inspiration the behavior of swarms of insects or flocks of birds; the self-management and autonomous improvement of computer systems in the face of changes in their operating conditions, known as Autonomic Computing; automatic learning through Artificial Neural Networks, in this field self-organization refers to the ability to learn and adapt from the input data, dynamically adjusting their internal connections to improve performance in specific tasks; the ability of individual entities, called agents, to coordinate and collaborate with each other without centralized management and based on behavioral rules, known as Intelligent Multiagent Systems.

Intelligent Multi-Agent Systems (IMAS) have a significant relationship with Environmental Sciences, as they allow modeling and simulation of complex systems involving interactions between multiple agents in environmental settings. IMAS are used to model natural ecosystems and understand how different species, resources and environmental factors interact. These models can help scientists predict changes in biodiversity, population dynamics and ecosystem functioning in response to disturbances or environmental changes.

In this talk we present a review of the theoretical concepts of IMAS and self-organization, as well as some relevant implementations. In addition, ongoing research of the Computer Science

Department of the University of Puerto Rico will be shown.

Elementary motion sequence detectors in whisker somatosensory cortex)

Keven Laboy, Molecular Sciences Research Center, San Juan.

Much of what is known about sensory coding comes from the visual system, where a good understanding of natural image statistics enables models of visual processing. For example, it's known that neurons in visual cortex generate a sparse code of natural images. Much less is known about how the somatosensory system represents complex tactile stimuli like Braille letters. Here, we describe a somatotopically organized rate code for elementary tactile sequences in primary somatosensory cortex (S1). We reveal that S1 neurons preferentially code for tactile sequences (i.e. tactile motion) over single-point stimuli and that a simple nonlinear transformation synthesizes precise tactile sequence tuning. Neurons in each S1 column were tuned to specific axes of tactile motion suggesting an efficient code for spatiotemporally complex tactile scenes. Overall, this work provides a model for how the S1 whisker map builds an efficient and topographically organized neural code for ethologically relevant multi-whisker stimuli.

3 Charlas Concurrentes / Concurrent Talks

(In alphabetical order using the first name of the speaker.)

An Efficient Implementation and Analysis of Zeta Functions of APN Curves and Their Protograph LDPC Codes for Space Applications

Alec S. Zabel-Mena, et al., Department of Mathematics, University of Puerto Rico at Río Piedras.

Almost perfect non-linear (APN) functions are a class of Boolean functions that have been very important for mathematicians in the last few years. They have their uses in cryptography and coding theory. Here we present constructions of some Protograph Low Density Parity Check (LDPC) codes that we base on some APN functions. We propose that our codes be used for future NASA deep space communications. We compare the performance of our codes with those that have been given by the NASA Jet Propulsion Laboratory (JPL).

We introduce the LDPC code $C_s^{(t)}$, which is based on monomial APN functions. We classify when it is 2-error-correcting. $C_s^{(t)}$ is 2-error-correcting when the corresponding surface (as defined by Janwa and Wilson):

$$f(X,Y,Z) = \frac{X^t + Y^t + Z^t + (X+Y+Z)^t}{(X+Y)(Y+Z)(X+Z)}$$

has no projective rational points over $\mathbb{F}_{2^s}$. We construct a table of the number of projective rational points with distinct coordinates on the surface $f(X,Y,Z)$ for the values $3 \leq t \leq 255$, where t is an odd integer, and for $2 \leq s \leq 21$. We compute the total number of projective

rational points (the number of points with distinct coordinates together with the number of points with non-distinct coordinates) on the corresponding surface defined by Janwa and Wilson (1993) and compute the resulting zeta functions. The complexity of the computation of the projective points is costly. Therefore, we propose and are in the process of implementing an efficient parallel algorithm written in C to construct the tables of projective and rational points. We implement our algorithms on GPU architecture, and on HPCF parallel machines and compare and evaluate their performance. We use these results to construct good protograph LDPC codes for use in NASA deep space communications.

In this talk, we will present our preliminary findings and results. In particular, we present the case of $t = 7$ and $t = 11$, and partial results for $t = 15$.

Acknowledgements: This is joint work with Carlos A. Agrisoni (Purdue University), Heeralal Janwa (University of Puerto Rico at Río Piedras) and José W. Velazques Santiago (University of Puerto Rico at Río Piedras).

Keywords: APN functions, Protograph LDPC codes, NASA deep space communication standards, APN curves and surfaces, Affine and projective rational points over finite fields, Genus and Betti numbers of singular and non-singular curves, Zeta functions of graphs, and varieties. Parallel Computing and HPCF

Arithmetical Structures on Graphs

Alexander Diaz-Lopez, Villanova University.

In this talk we will discuss recent results in the study of arithmetical structures on graphs, which are a generalization of the Laplacian of a graph. They can be defined as integer labelings on the vertices of a graph that satisfy some divisibility condition. Dino Lorenzini originally defined them in order to answer some questions in algebraic geometry, but more recently, they have been studied on their own, particularly with a combinatorics and algebraic lens. In this talk, we will discuss recent enumerative results related to arithmetical structures and some results that classify their associated critical groups.

Acknowledgements: This is joint work with Kassie Archer, Darren Glass, and Joel Louwsma.

A Pilot Study of Methylidyne in the Galactic Center Region using the Arecibo 12-m Telescope

Allison J. Smith, et al., Department of Physics, University of Puerto Rico at Mayagüez.

The Interstellar Medium (ISM) consists of the gas and dust between the stars, the characteristics of which are crucial to our understanding of the star-gas cycle in our Galaxy. We present a map of all three 3.3 GHz transitions of the Methylidyne (CH) molecule toward the Galactic Center region. Currently, this map provides the widest coverage of this important region and illustrates

the distribution of CH as well as its dynamical properties. These results serve as a proof of concept and motivate future surveys of this important set of spectral lines in the galactic plane.

Acknowledgements: This is joint work with Emmanuel J. Morales Butler (University of Puerto Rico at Utuado), D. Anish Roshi (University of Central Florida), Natalia K. Dominguez Rivera (University of Puerto Rico at Humacao), Alexander Rivas-Diaz (University of Puerto Rico at Humacao), and Alexander Cingoranelli (University of Central Florida). This work was supported in part by the NSF Center for Advanced Radio Sciences and Engineering, under Cooperative Agreement Award AST-2132229 and ENCANTO: Enhancing and Nurturing Careers in Astronomy with New Training Opportunities, NSF PAARE Program Award AST-2219150.

Keywords: astronomy, spectroscopy, radio astronomy, molecules, interstellar medium

Medidas de la incertidumbre de una probabilidad

Alvaro Lecompte Montes, Universidad Interamericana de Puerto Rico, Recinto de San Germán.

En el trabajo se revisa el arreglo decreciente de las probabilidades según una medida subyacente para los resultados y el orden parcial entre las distribuciones de probabilidad por su dispersión o incertidumbre. La variable al azar asociada con esta distribución se interpreta como la incertidumbre de un resultado al azar particular en el espacio muestral. Se demuestra como los momentos de esta variable, en particular la media y varianza, son medidas de la dispersión de los datos en el espacio muestral. Estas estadísticas pueden resultar útiles en optimizaciones de los modelos de análisis de datos.

Matemática para los estudiantes "non-STEM"

Ana Helvia Quintero, Department of Mathematics, University of Puerto Rico at Río Piedras.

Para muchos las matemáticas consisten básicamente de una serie de reglas que tienen que aprender de memoria y aplicar, pero que no reflejan ninguna realidad. Por esto se les hace tan difícil la matemática, le temen y en lo posible tratan de evitarla. Los estudiantes "non-STEM" piensan que no necesitan la matemática para nada. Sin embargo, la matemática está presente en mucha de la información que recibimos a diario, y que en ocasiones afecta las decisiones que tenemos que tomar sobre asuntos importantes de nuestra vida. ¿Cómo entonces darles sentido a los conceptos matemáticas? ¿Cómo hacerlos conscientes de la matemática que necesitan entender para muchas decisiones de su vida? ¿Cómo apoyar que pierdan el miedo a la matemática?

Esta presentación presentará las estrategias que utilizo en mis cursos de matemática para estudiantes "non-STEM" para darle sentido a los conceptos matemáticos, para que entiendan cómo afectan sus vidas y para que pierdan el miedo a las matemáticas.

Why is learning so often difficult to achieve?

Andres J. Vazquez-Velez, University of Puerto Rico.

A typical college student today has more learning resources on their campus than ever, yet they are more likely than ever to have adverse learning experiences during their studies. For many students, adverse experiences begin as only a hint of discomfort due to intellectual content that challenges their prior knowledge or personal values. This discomfort, however, causes some students to ruminate upon negative thoughts and feel negative emotions. Cycling through negative thoughts and emotions leads to overt distal behaviors, such as dropping classes. But discomfort also manifests in covert proximal cognition and emotion—sometimes these feelings remain below the students' conscious awareness. Fortunately, feelings manifest in students' physiological responses. This project therefore aims to determine the role that biofeedback plays in sustaining students' efforts to engage with ideas that induce cognitive and emotional discomfort. The team aims to transform intellectual adversity into a resource for learning instead of an obstacle to it. By combining conceptual change theory with theory from positive psychology the proposed research aims to construct generative learning theory that explains how cognition and emotion interact to form the psychological mechanisms responsible for learning during discomfort. The project will achieve this aim by mobilizing technological innovations in neuroimaging (fNIRS) and wearable sensors (EDA) that detect people's covert cognitive activity and arousal states—this will address a critical need neglected by research that uses self-report data and learners' overt talk as the sole metrics used to construct claims regarding learners' cognitive and emotional discomfort. These technologies also augment people's capacity to monitor and reflect upon the emergence of their discomfort and thus deliver to learners a psychological buffer that supports their continued learning—transforming a liability into an asset.

A Bayesian Hierarchical Dynamic Linear Model for Net Migration Rates

Angélica M. Rosario Santos, Department of Mathematics, University of Puerto Rico at Río Piedras.
Luis Pericchi Guerra, Department of Mathematics, University of Puerto Rico at Río Piedras.
Hernando Mattei, Department of Mathematics, University of Puerto Rico at Río Piedras.

Migration forecasting is addressed from the application of traditional and Bayesian methodologies, and its predicted values are used as input for population projections. In particular, Azose & Raftery proposed a novel way to obtain joint probabilistic projections of net migration rates for all countries and for all US states by fitting a Bayesian AR model. This approach allows for a "borrowing strength" across the data for all countries or states. Unlike other demographic indicators, patterns of net migration rates are highly dependent on economic indicators, climatic circumstances, and political or environmental factors. The uncertainty due to these factors could be better understood by representing the AR(1) model as a dynamic linear model.

We proposed a hierarchical dynamic linear model for the net migration rates of seven U.S. states and territories that have recorded negative net migration since 2005. The assumptions of our model allow for a significant reduction in the number of parameters and represent a way to incorporate the complex behavior of the net migration component. Our projections suggest that Puerto Rico will continue to record negative net migration rates, albeit at a lower magnitude. For 2050, the

mean of the projection is -0.0040 bounded by the 95% credibility interval $(-0.0200, -0.0001)$.

The Actuarial Profession

Arnaldo Cruet Rivera, Finance Division, Triple-S Salud.

The actuarial profession plays a pivotal role in managing and mitigating risks in various industries. The profession relies heavily on mathematics, statistics, finance, and business to solve various problems. This abstract provides an overview of the basics of the actuarial profession, its key functions, educational requirements, and an overview of the various applications.

Actuaries are highly skilled professionals who use mathematical and statistical methods to analyze the financial consequences of risk and uncertainty. Primarily employed in insurance, pension, and investment sectors, actuaries are instrumental in designing insurance policies, pension plans, and investment strategies that balance risk and financial stability.

Actuaries typically pursue a rigorous course of study that includes mathematics, statistics, economics, and finance. Many actuaries obtain professional credentials, such as those offered by renowned actuarial societies like the Society of Actuaries (SOA) or the Casualty Actuarial Society (CAS), to validate their expertise and enhance their career prospects.

The core functions of actuaries involve assessing risk, determining premium rates, and projecting future financial outcomes. In the insurance sector, actuaries analyze demographic data, health trends, and historical claims to set insurance premiums that ensure the financial viability of insurance companies. In pension planning, actuaries calculate contributions required to meet future pension obligations while considering factors like life expectancy and market conditions. As part of their daily work, actuaries contribute significantly to investment decision- making by evaluating the financial risks associated with different asset classes.

The actuarial profession has expanded beyond traditional domains, finding applications in diverse fields such as healthcare, government, and consulting. Actuaries in healthcare analyze the financial impact of medical treatments, evaluate health insurance programs, and design cost-effective strategies. Employment for actuaries may be found both in the public and private sectors. Government agencies may employ actuaries to assess the financial implications of policy decisions and demographic changes.

In conclusion, the actuarial profession is a dynamic and multidisciplinary field crucial to managing risks and ensuring financial stability across various industries. Actuaries are valued for their strong mathematical foundation and professional credentials. They provide invaluable insights that drive informed decision-making in a dynamic financial landscape. As the world continues to grapple with uncertainties, the role of actuaries remains in high demand in order to mitigate the impact of risks on individuals, businesses and society.

Keywords: actuarial, actuaries, SOA, risk management, insurance, financial modeling, data analysis, mathematics, statistics

Sistema eficiente para el procesamiento distribuido de información clínica

Benny Rodríguez, Natural Sciences Faculty, University of Puerto Rico at Río Piedras.
Edusmildo Orozco, Natural Sciences Faculty, University of Puerto Rico at Río Piedras.

El procesamiento eficiente de la información de los pacientes es crucial para mejorar su atención médica en los hospitales. La obtención de información actualizada sobre el estado de los pacientes a menudo implica retos que afectan la calidad de la atención. Mejorar la comunicación entre el personal médico y los acompañantes del paciente es vital para superar estos desafíos y garantizar una atención más efectiva y rápida, cumpliendo con los estándares de privacidad y confidencialidad requeridos por la Ley HIPAA. Los hospitales utilizan el estándar HL7 (Health Level 7) para comunicar información médica entre sus sistemas a través del intercambio de mensajes. Cuando se trata de grandes cantidades de mensajes, su procesamiento se convierte en una tarea computacionalmente costosa, afectando el rendimiento de los sistemas y la eficiencia en la comunicación con los pacientes o sus acompañantes.

Siguiendo las tendencias actuales en tecnología, una posible solución podría ser la creación de un sistema basado en inteligencia artificial. Sin embargo, su implementación podría conllevar a riesgos de acceso indebido o respuestas sesgadas, contrarios a la Ley HIPAA. Desde una iniciativa empresarial local, hemos creado una solución secuencial que, a través de una interfaz de programación, permite a los hospitales conectar sus propios sistemas de información de salud e integrarlos con nuestro sistema. Sin embargo, a medida que añadimos más hospitales notamos que nuestro sistema se ralentiza debido a la gran cantidad de mensajes que se deben procesar. En este trabajo presentaremos una versión preliminar de un sistema de computación distribuida basado en la nube con potencial de ser escalable y más costo efectivo para el procesamiento de mensajes HL7. Finalmente, mencionaremos cómo el respaldo de la Universidad juega un papel importante en el impulso y la creación de pequeñas empresas que contribuyen al desarrollo económico de Puerto Rico.

Agradecimientos: Especial agradecimiento al señor Jean C. Moure, CEO de Digital Touch Media, por su liderazgo, confianza y por la oportunidad de colaborar en este proyecto.

Palabras clave: Estándar HL7, Ley HIPAA, Computación distribuida

Plataforma web para la gestión de subastas y procesos de licitaciones municipales

Benny Rodríguez, Natural Sciences Faculty, University of Puerto Rico at Río Piedras.
Carlos J. Corrada Bravo, Natural Sciences Faculty, University of Puerto Rico at Río Piedras.

En el campo de las ciencias de cómputos, nos comprometemos a fomentar la responsabilidad social mediante el desarrollo de tecnologías y soluciones innovadoras que se enfocan en generar un impacto positivo en la sociedad. Una iniciativa que puede ayudar a modernizar y optimizar los procesos de adquisición municipal es la creación de una plataforma web para la gestión de subastas y licitaciones municipales. Los municipios en Puerto Rico realizan subastas manuales o utilizan sistemas obsoletos, lo que puede resultar en falta de transparencia, poca eficiencia y mayor susceptibilidad a errores. Además, esto puede limitar la competencia justa entre proveedores de servicios y puede

afectar la asignación de recursos públicos. Algunos municipios en Puerto Rico, como Caguas, Vega Baja y Peñuelas, han implementado plataformas digitales para la gestión de subastas en respuesta a estos problemas. Sin embargo, muchas de estas plataformas no se adaptan a las necesidades específicas de los municipios.

En este trabajo presentaremos una versión preliminar de una plataforma web que permite a los proveedores de servicios registrarse y presentar ofertas a subastas activas. Además, a través de la plataforma web, las personas encargadas en los municipios pueden evaluar todas las ofertas y seleccionar al mejor licitador para adjudicar una subasta. Se están integrando conceptos de UX/UI (Experiencia de Usuario e Interfaz de Usuario) para crear una interfaz visualmente atractiva y fácil de usar. Esto garantiza que los usuarios tengan una experiencia positiva y sin complicaciones al momento de interactuar con la plataforma web. También, se realizan pruebas de usabilidad cualitativas para recopilar datos de uso, lo que permite mejorar la plataforma web para que los usuarios puedan tener una experiencia fluida y agradable con el sistema.

Agradecimiento: Especial agradecimiento a los profesores Carlos J. Corrada Bravo y José Ortiz Ubarri, cuya guía, experiencia y respaldo continuo han sido esenciales para el progreso de este proyecto y en mi desarrollo profesional.

Palabras clave: Licitaciones Municipales, Gestión de Subastas, Automatización de Procesos, Plataforma Web

Propiedades de los Grafos de los Divisores de Cero de Anillos Conmutativos

Byron Alexander Patiño de la Cruz, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.

En este trabajo se analizan los principales resultados del artículo "The zero-divisor graph of a commutative ring" de los autores David F. Anderson y Philip S. Livingston. Se exponen propiedades y características del grafo de los divisores de cero de anillos conmutativos R con identidad denotados por $\Gamma(R)$; donde su conjunto de vértices es $Z(R)$ y en el que dos vértices diferentes x, y son adyacentes si y solo si $xy = 0$. Se indican algunos de los conceptos básicos de la teoría de anillos y grafos. Por último, se presenta implementaciones en el software `SageMath` para calcular $\Gamma(\mathbb{Z}_n)$ y $\Gamma(\mathbb{Z}_{p^n q})$.

Some New Results in the Even Case of the Exceptional Almost Perfect Nonlinear Conjecture

Carlos A. Agrinsoni Santiago, Department of Mathematics, Purdue University.
Heeralal Janwa, Department of Mathematics, University of Puerto Rico at Río Piedras.
Moises Delgado, Department of Mathematics-Physics, University of Puerto Rico at Cayey.

A function $f : \mathbb{F}_{2^n} \to \mathbb{F}_{2^n}$ almost perfect non-linear (APN) if its directional derivative is two to one at non-zero points. They arise naturally in cryptography, where they minimize the probability

of success of the differential cryptanalysis. A function is said to be exceptional if it is an APN over infinitely many extensions of $\mathbb{F}_{2^n}$. Aubry, McGuire, and Rodier (in 2010, generalizing a 1993 conjecture of Janwa and Wilson on monomials) that up to CCZ equivalence, the only exceptional APN functions are given by the Gold $(2^n + 1)$ and Kasami-welch $(2^{2n} - 2^n + 1)$ monomials.

The last case of the nominal conjecture was resolved in the affirmative by Hernando and McGuire in 2011. Recently, we have resolved the Gold degree case of this conjecture.

Here we present some results in the even degree case of the conjecture. In particular, we extend the results of Caullery (when degree equals $4e$, where e is odd). Furthermore, we also generalize a theorem of Aubry, Issa, and Herbaut (2023). There has been much less progress in the even degree case, and the conjecture is mainly open.

Keywords: Almost Perfect Nonlinear (APN) Conjecture, Absolute Irreducibility, Lang-Weil, Deligne, and Ghorpade-Lachaud bounds on rational points on varieties over finite fields

Proposal for a Teaching Model in Mathematics Focused on Problem-Solving at the Secondary Level in Puerto Rico

Carlos J. Colón-Rivera, Puerto Rico Department of Eduction, Department of Mathematics-Physics, University of Puerto Rico at Cayey.

The purpose of the study was to propose an educational model focused on the solution of mathematical problems at the secondary level, and a systematic review was conducted to assess it. The theoretical framework included heuristic theories and educational models. The six-phase methodology employed in this study involved formulating research questions, literature search, selection of research, data collection, analysis and summary of results, and presentation and discussion of these. Guidelines for systematic reviews and inclusion/exclusion criteria were followed to evaluate the effectiveness of didactic models in the discipline of mathematics with an emphasis on problem-solving in secondary education. Guidance from The Campbell Collaboration (2010), Higgins and Green's Cochrane Handbook (2011) for Systematic Reviews, and the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Syntheses) document were also utilized. Additionally, documented studies from various scientific sources present in databases and indexed publications were examined. Acceptance and rejection criteria were applied to address the research questions posed in this work.

The findings obtained from the systematic review indicated that the proposed model in this research should incorporate features from George Polya Problem-Solving Model and Problem-Based Learning. Therefore, the proposed problem-solving model applied to the profile of secondary-level students in Puerto Rico should include the following steps: (a) focus on the problem, (b) plan the solution to the problem, (c) solve the problem, (d) validate the solution to the problem, and finally, (e) present the solution or solutions.

Acknowledgements: This research was conducted as part of the requirements for obtaining the Doctorate in Instructional Technology and Distance Education from Nova Southeastern University, Abraham S. Fischler College of Education and School of Criminal Justice, Florida.

Keywords: problem-solving, secondary mathematics instruction, learning models in mathematics, active learning in mathematics, academics' achievement in mathematics

Parallelized intelligent multi-agent systems with fuzzy logic models to simulate fish school behavior

Carlos Juan E. Diaz Vargas, Department of Computer Science, University of Puerto Rico at Río Piedras.
David I. Flores Granados, Department of Computer Science, University of Puerto Rico at Río Piedras.

Artificial life is a branch of Computer Science that studies the models of complex biological systems. Some Artificial Life models include self-organizing systems to reproduce complex structures from simple rules and local interactions, without the need for centralized control or coordination. Self-organizing systems can be implemented using Intelligent Multi-Agent Systems (IMAS), where self-organization refers to the ability of individual agents to coordinate and collaborate with each other without centralized coordination. This enables the creation of decentralized, adaptive systems that can efficiently respond to changes in the environment and perform complex tasks.

IMAS are used to model natural ecosystems and understand how different species, resources and environmental factors interact. These models can help scientists predict changes in biodiversity, population dynamics, and ecosystem functioning in response to disturbances or environmental changes. One example of this would be the study of the impact of an invasive species, like the lionfish, in a marine environment.

In this project, we will improve the behavior of some of the fish that appear in a pre-existing AI life program, called Deep Caribbean Reeft, which simulates a Caribbean reef environment. We will do this using IMAS with fuzzy logic models. These models are used to change the behavior of the fish in these simulations from a deterministic one to a linguistic classification one, in which the thresholds of the parameters will no longer be deterministic. We will also work on improving the performance of this project using the Unity engine' Data-Oriented Technology Stack (DOTS). This paradigm applies parallelization and data-oriented programming to better optimize one's project. These changes are done to create more accurate models of fish behavior and to be able to create bigger populations of simulated animals in these environments without loss of performance.

Keywords: intelligent muti-agent systems, self-organization, fuzzy logic, parallelization, fish behavior, DOTS

Structure and count of monomials k-rotation symmetric functions over Galois fields

José E. Calderón Gómez, University of Puerto Rico at Río Piedras.
Luis A. Medina, University of Puerto Rico at Río Piedras.
Carlos A. Molina Salazar, University of Puerto Rico at Arecibo.

Boolean functions are a branch of mathematics that lies in the intersection of combinatory and number theory with many application in different areas. In the late 1990's, Pieprzyk and Qu introduced rotation symmetric Boolean functions. They demonstrated that these functions have efficient and secure cryptographic implementations. In recent years, functions of a subclass of rotation symmetric Boolean functions have been found in examples of Boolean functions that exceed the bent concatenation bound for an odd number of variables. These functions are called k-rotation symmetric Boolean functions. They are a generalization of the concept of rotation symmetric Boolean functions and were introduced by Kavut and Yücel in 2007.

Many results on Boolean functions have been extended to every finite field. In this talk we present results on the structure of monomials k-rotation symmetric polynomials over Galois fields, then we use that structure to provide a count of the number of these monomials.

Acknowledgements: The first author was supported, as a student, by The Puerto Rico Science, Technology and Research Trust (PRST) under agreement number 2020-00124 and by the *Beca por Disertación, Tesis o Proyecto equivalente* (DEGI-UPRRP). The research of the second author was supported by PRST under agreement number 2020-00124 and by FIPI. This content is only the responsibility of the authors and does not necessarily represent the official views of The Puerto Rico Science, Technology and Research Trust.

Keywords: Boolean functions, k-rotation, Galois field

Computation of the Linear Complexity of Families of Multidimensional Periodic Arrays

Cesar F. Bolaños Revelo, Doctoral Program CISE, University of Puerto Rico at Mayagüez.
Dorothy Bollman, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.

Families of periodic arrays are useful in various applications, including multiple target recognition, optical communications, and digital watermarking. These applications require not only good correlation properties, but also a high level of linear complexity in order to ensure cryptographic security. In previous work we showed that our constructions of multidimensional periodic arrays have optimal low cross-correlation with respect to the welch bound. In this presentation, using the Rubio-Sweedler-Taylor algorithm, we present some preliminary results for the linear complexity of our constructions. These results indicate that as the size of the array increases, the linear complexity approaches its maximum value.

Keywords: linear complexity, periodic arrays, watermarking

A generalized double-phase problem over arbitrary domains

Clara Blanco-Drago, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Alejandro Vélez-Santiago, Department of Mathematics, University of Puerto Rico at Río Piedras.

Let $\Omega \subseteq \mathbb{R}^N$ be an arbitrary bounded domain, for $N \geq 2$. We investigate existence, uniqueness, a priori estimates of a generalized eliptic problem with double phase phenomena Robin's type and arbitrary domain, of the form:

$$\begin{cases} \mathcal{A}_p u + \mathcal{J}_q u = f & \text{en } \Omega, \\ \mathcal{B}_p u + \mathcal{K}_q u = 0 & \text{en } \Gamma := \partial\Omega, \end{cases} \tag{1}$$

where

$$\mathcal{A}_p u := -\sum_{i,j=1}^{N} partial_{x_i}(\alpha_{ij}(x)|\partial_{x_j} u|^{p-2}\partial_{x_j} u) + \sum_{i=1}^{N} a_i(x)|\partial_{x_i} u|^{p-2}\partial_{x_i} u + \lambda(x)|u|^{p-2}u,$$

$$\mathcal{J}_q u := -\sum_{i,j=1}^{N} \partial_{x_i}(\omega_{ij}(x)|\partial_{x_j} u|^{q-2}\partial_{x_j} u) + \mu(x)\sum_{i=1}^{N} b_i(x)|\partial_{x_i} u|^{q-2}\partial_{x_i} u,$$

$$\mathcal{B}_p u := \sum_{i,j=1}^{N} (\alpha_{ij}(x)|\partial_{x_j} u|^{p-2}\partial_{x_j} u)\nu_{\sigma_i} + \beta(x)|u|^{p-2}u$$

and

$$\mathcal{K}_q u := \sum_{i,j=1}^{N} (\omega_{ij}(x)|\partial_{x_j} u|^{q-2}\partial_{x_j} u)\nu_{\sigma_i}.$$

We asume that $\mathcal{A}_p$ has a certain quasi-linear eliptic uniformity, in the sense that there exist a constant $c_0 > 0$ such that:

$$\sum_{i,j=1}^{N} \alpha_{ij}|\xi_i|^{p-2}\xi_i\xi_j \geq c_0 \sum_{i=1}^{N} |\xi_i|^p \quad \forall (\xi_1, \ldots, \xi_N) \in \mathbb{R}^N.$$

Similarly, exist constanst c_1, $c_2 > 0$ such that:

$$c_1\mu(x)\sum_{i,j=1}^{N} \|\omega_{ij}\|_\infty |\xi_i|^{q-1}|\xi_j| \geq \sum_{i,j=1}^{N} \omega_{ij}|\xi_i|^{q-2}\xi_i\xi_j \geq c_2\mu(x)\sum_{i=1}^{N} |\xi_i|^q \quad \forall (\xi_1, \ldots, \xi_N) \in \mathbb{R}^N.$$

We also assume that $\mathcal{A}_p$ and $\mathcal{J}_q$ has cetain monotonicity, in the sense that exist constants c_0', $c_3 > 0$ such that:

$$\sum_{i,j=1}^{N} \alpha_{ij}\left(|\xi_i|^{p-2}\xi_i - |\varsigma_i|^{p-2}\varsigma_i\right)(\xi_j - \varsigma_j) \geq c_0' \sum_{i=1}^{N} \left(|\xi_i|^{p-2}\xi_i - |\varsigma_i|^{p-2}\varsigma_i\right)(\xi_i - \varsigma_i)$$

and

$$\sum_{i,j=1}^{N} \omega_{ij} \left(|\xi_i|^{q-2}\xi_i - |\varsigma_i|^{q-2}\varsigma_i\right)(\xi_j - \varsigma_j) \geq c_3\mu(x) \sum_{i=1}^{N} \left(|\xi_i|^{q-2}\xi_i - |\varsigma_i|^{q-2}\varsigma_i\right)(\xi_i - \varsigma_i).$$

Furthemore, we assume that the interior lower-order coefficients are in general unbounded. Under minimal assumptions, we establish the existence of bounded weak solutions to the problem (1).

Keywords: double-phase problems, Robin boundary conditions, weak solutions, a priori estimates

A Bayesian Statistical Spatial Risk Assessment of Extreme Hydrological Hazards and Decision Making in a Climate Change Scenario, with emphasis on Puerto Rico and the Caribbean

David Torres Núñez, Instituto de Estadística y Sistemas Computadorizados de Información, Universidad de Puerto Rico en Rio Piedras.
Luis Pericchi Guerra, Departamento de Matematicas, Universidad de Puerto Rico en Rio Piedras.

We use multivariate hydrological risks models in the case that the variables are extreme. A well-known standard model is using Copulas HT04, Heffernan and Tawn (2004) that proposed a conditional multivariate extreme value model that applies to regions where not all variables are extreme simultaneously and identifies the type of extremal dependence that could include negative dependence. This research explores using Copulas to model extreme rain events for different watershed regions of Puerto Rico Island. The resulting fitted model, following the HT04 model and strategies of estimation, is able to make long-term estimations of extremes, conditional on whether other watershed regions are extreme or not. Puerto Rico Archipelago and the Caribbean have been the center of several floods in recent years. Tropical Cyclones bring heavy rain and flood events. There is an urgent need for the development and implementation of modern statistical and computational methodologies for long-term risk assessment of extreme environmental hazards, such as extreme rainfall and flooding, in Puerto Rico and the Caribbean. It is most worrying that the current estimation of hazards in Puerto Rico (US Department of Commerce, Technical Paper No. 42, 1961 and its update as Technical Paper No. 53) still mainly rests on the restrictive Gumbel model (a critically strong assumption), and simplified ways of estimating predictive probabilities which are known to underestimate the predicted probabilities of disasters often. These new methodological developments merge statistical results in Extreme Value Theory with a Bayesian Statistical Framework using heavily computational Markov chain Monte Carlo Methods of computation. These theoretical and computational developments are particularly relevant for the Caribbean, and specifically to Puerto Rico and the Virgin Islands, given their exposure to diverse meteorological climate conditions. We propose to use Puerto Rico as a case study with clear implications for the rest of the Caribbean. The overall aim is to develop new and examine existing long-term predictive methodologies for assessing long-term risks of environmental hazards, with a particular focus on hydrological extremes with applications to rainfall and flooding. Such methodologies would be useful for agencies dedicated to environmental protection and planning, as well as for educational institutions dedicated to research into the environment and statistical decision analysis.

Keywords: Bayesian Statistics, Markov Chain Monte Carlo Methods, Extreme Value Distribution, Hierarchical Bayes, Spatial Statistics

The state of K-12 computer science education in Puerto Rico: advances, challenges and opportunities

Edusmildo Orozco, et al. University of Puerto Rico at Río Piedras.

Today it is widely accepted that K-12 computer science education is crucial for preparing all students for the 21st century workforce and society. Up to 2023, only 57.5science course, and only 5.8Moreover, disparities in access and participation are still persistent. This highlights the need for more state-level policies and support to make computer science education more equitable and accessible for all students.

In this presentation we will discuss: (a) the current impact of the formerly NSF funded project "Exploring Computer Science for Puerto Rico" (ECS4PR) and other educational initiatives that broaden participation in computing in the Island; (b) the current implementation and challenges of the Governor's Executive Order OE-2023-031 directing the Puerto Rico Department of Education to create a strategic plan to integrate computer science and applied technologies into the teaching curriculum; (c) the opportunities for the UPR to contribute in promoting a sustainable and justice-oriented teacher preparation and teacher re-certification program; and finally, (d) in order to prepare teachers for the responsible integration of artificial intelligence in their curriculum, we will discuss key aspects that must be addressed in any AI professional development program.

Acknowledgements: This is a joint work with Michelle Borrero, College of Natural Sciences, Joseph Carroll-Miranda, Luis López Rivera, Agustín Corchado Vargas, College of Education, University of Puerto Rico at Río Piedras; Elizabeth Ríos, Enid Santiago, María Ortiz, Amabel Soto, Karol Ramírez, Rubén Ortíz, Waleska Albino, Puerto Rico Department of Education; Guillermo López Díaz, Education Service Center Region 13 (Austin, Texas). Special thanks to Brenda Santiago for her excellent administrative work and for her invaluable contributions to each aspect of the project.

Keywords: Exploring Computer Science, Computer Science K-12 Education, Artificial Intelligence

Desafiando mentes jóvenes: Bebras y la Computación creativa

Edwin Flórez, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.

El pensamiento computacional, esencial en la era digital, se refiere a los procesos de razonamiento aplicados en la formulación de problemas y sus soluciones mediante pasos y algoritmos computacionales. Este concepto, popularizado en 2006 por Jeannette Wing de Carnegie Mellon University, es visto como una competencia fundamental y equiparable a habilidades básicas como la lectura, escritura y aritmética. La relevancia de este enfoque ha sido reconocida desde los años 80, destacándose en los trabajos de Seymour Papert del MIT, pero fue a partir de 2006 cuando edu-

cadores, investigadores y políticos globales empezaron a integrar estos conceptos en los currículos educativos.

En noviembre de 2023, estudiantes K-12 de Puerto Rico se unieron a la iniciativa internacional Bebras. Este es un proyecto enfocado a fomentar el pensamiento computacional entre los estudiantes por medio de desafíos estimulantes. Las aspiraciones era llegar a 1000 estudiantes, se superó las expectativas alcanzando una participación de alrededor de 1700 estudiantes de la isla. Este planteamiento representa un paso significativo en la transformación educativa de Puerto Rico, apuntando a una mejor preparación de los jóvenes para un mundo cada vez más orientado a la tecnología y la computación. Con Bebras, Puerto Rico no solo se une a un movimiento global, sino que también marca un hito importante en su trayectoria educativa hacia la inclusión de habilidades computacionales esenciales para el siglo XXI.

Nuestra presentación tratará varios aspectos, entre ellos: una corta exposición sobre el pensamiento computacional, el proceso organizativo del Desafío Bebras, algunas conclusiones preliminares del análisis de datos de los estudiantes participantes, y ejemplos de tareas utilizadas en el desafío. Además, se presentarán algunos planes para continuar y expandir esta iniciativa.

Reconocimientos: Este trabajo fue realizado en colaboración con Arturo Portnoy, Luis Cáceres, Omar Colón, Alcibiades Bustillo, Cesar Bolaños, Sergio Manzanarez, Juan Flórez, y Sebastianhasser Jansasoy (todos de la Universidad de Puerto Rico en Mayagüez), y Angy Coronel (independiente).

Palabras clave: Pensamiento computacional, Resolución de problemas, Educación en informática, Desafíos de programación, Competencia internacional, Algoritmos y lógica, Innovación educativa, Habilidades digitales.

Generalized Quasi-linear Fractional Venttsel'-Type Problems Over Non-Smooth Regions

*Efren Mesino-Espinosa,*Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Alejandro Vélez-Santiago, Department of Mathematics, University of Puerto Rico at Río Piedras.

Let $\Omega \subset \mathbb{R}^N$ be a bonded (ϵ, δ)-domain with boundary a d-set, for $N \geq 2$. We investigate the solvability and establish a priori estimates for the generalized elliptic quasi-linear fractional problem involving the regional fractional p-Laplace operator with Neumann or Robin boundary conditions.

First, we prove the existence and uniqueness of weak solutions for the problem, and we show that such solutions are globally bounded. Moreover, we establish a priori estimates for the difference of weak solutions of our problem. Additionally, we present results on inverse positivity and a weak comparison principle.

Keywords: (ϵ, δ)-domain, d-set, fractional p-Laplace operator, a priori estimates, inverse positivity, weak comparison principle

Visualización de Alto Rendimiento Utilizando el GPU

Elio Ramos Colón, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao.

Los shaders son pequeños códigos que corren en paralelo para cada uno de los pixeles en el visor gráfico de la computadora. Los mismos se caracterizan por un alto nivel de rendimiento debido a que se ejecutan en la unidad de procesamiento gráfico (GPU). Los shaders están detrás de muchos de los efectos visuales y artísticos en juegos y aplicaciones gráficas modernas. El desarrollo de shaders requiere programar en un lenguaje llamado GLSL (OpenGL Shaders Language) el cual tiene una sintaxis parecida a C/C++. En esta charla daremos una breve introducción a los shaders, GLSL, y algunos ejemplos básicos. Consideraremos el problema de visualizar una función compleja en 2D utilizando el método de retrato de fase y su implementación utilizando shaders.

Keywords: shaders, GPU, visualización

Identifying Outliers in Radio Astronomy Data from the 12m AO Telescope Using the Generalized Spectral Kurtosis Estimator

Emmanuel J. Morales Butler, Department of Natural Sciences, University of Puerto Rico at Utuado.

As innovation and technologies associated with man-made transmissions progress, complex and new challenges emerge in radio astronomy due to Radio Frequency Interference (RFI). Hence, novel development of software and hardware to detect and mitigate its effects on scientific data are paramount. In this talk we will discuss the successful implementation of the Generalized Spectral Kurtosis Estimator, a statistical tool with great propensity for performing RFI detection and excision. We demonstrate the effectiveness of this technique using radio astronomical spectroscopic data from the 12 meter telescope at the Arecibo Observatory. Specifically, we employ this procedure on two case studies: a 1° by 1° map of the Milky Way's galactic center and a single-pointing observation on the Rho Ophiuchi star-forming nebula. We observed these objects in molecular emission using the 3.3 GHz transitions of Methylidyne (CH), which sit in the midst of a radio frequency band fraught with RFI commonly attributed to such devices as mobile phones and wireless internet routers. Thus, the procedure we present is applied to multiple types of RFI with a range of characteristics, and represents both a significant step forward in salvaging RFI-damaged astronomical data as well as a more widely useful outlier detection framework for other scientific disciplines in which data is frequently gamma-distributed.

Deformed plate wells detection by means of image filters, keystone corrections and the Hough transform

Emmanuel Rosa Delgado, Department of Mathematics, University of Puerto Rico at Humacao.
Vibha Bansal, Department of Chemistry, University of Puerto Rico at Cayey.
José O. Sotero Esteva, Department of Mathematics, University of Puerto Rico at Humacao.

Applications that use smartphone cameras for visual colorimetric analysis are often developed in combination with components that serve as sample holders, fluidic chambers, or active membranes. Using smartphones as handheld visual colorimetric analysis devices and sample managers with novel flexible materials raises challenges not present when using rigid materials and better-controlled settings. For instance, accurately finding where analytes are is crucial to a correct analysis.

This work has used deformed 96-wells plates as a model of devices that may be used in the field in combination with smartphone applications as colorimetric devices. An algorithm based on the application of the Hough transform followed by an interpolation is developed and tested with plate images that have been deformed in a controlled fashion. The procedure accurately detects the wells in all images of the test sets. Such work has been published in the MRS Advances journal [Rosa Delgado, E., Sotero Esteva, J.O. Detection of wells in images of deformed 96-wells plates. MRS Advances (2024). https://doi.org/10.1557/s43580-023-00754-4]. Currently, a prototype web/computer application/dashboard is being developed through Streamlit implementing the previous algorithm. The objective of the app aims towards replacing expensive analysis equipment and allowing measurements in the field.

Acknowledgements: The authors acknowledge the help of Dr. Vibha Bansal and Dr. Ezio Fasoli's groups from the Departments of Chemistry of the University of Puerto Rico at Cayey and Humacao campuses respectively who provided materials and test images for this work. This work is sponsored by the PENN-UPR Partnerships for Education and Research in Materials program (NSF-DMR-2122102).

Keywords: Hough Transform, deformed 96-wells plates, colorimetric analysis, smartphone applications

A Combinatorial Model for Lane Merging

Erik Insko, Central College.

Imagine you are driving on a road with two lanes where there is a stoplight and soon after, the left lane will have to merge into the right. Some drivers will always stay in the right lane. Others will choose the shortest lane, giving preference to the right lane when the lengths are equal. If ℓ cars pull up to the light in random order, what is the expected length of the right lane? In this talk, we model this problem with binary strings and their associated lattice paths. We answer the expected length question and (time-permitting) discuss some interesting bijections between seemingly disconnected combinatorial objects.

Acknowledgements: This is joint work with Viktoriya Bardenova, Katie Johnson, and Shaun Sullivan.

Linear Model Selection: P-Values vs Probabilities

Fernando Betancourt Vélez, Medical Sciences Campus of University of Puerto Rico and Department of Mathematics, University of Puerto Rico at Río Piedras.
Luis R. Pericchi, Department of Mathematics, University of Puerto Rico at Río Piedras.

Model selection from Linear Models using the classical approach is generally based on p-values using techniques such as stepwise regression or approximate model selection criteria such as AIC or BIC. None of these criteria directly penalizes over-parameterization. In contrast, the Bayesian approach is based on probabilities and incorporates knowledge about the parameters in the modeling process by probabilistically penalizing potential false evidence from multiple comparisons. Bayes updates the a-priori probability of the models with the observed likelihoods with Intrinsic a priori densities, to obtain a posterior distribution, allowing for more robust inference and a more complete explanation of uncertainty. In addition, it allows you to calculate the "Probabilities of Inclusion", that is, add the probabilities of all the models that contain a particular variable such as X_1, which is impossible with p-values. In our talk we will present several examples showing the difference between both criteria, and software to implement the Bayes approach.

Keywords: model selection, Bayesian statistics

Calculating the parameters of Schubert symplectic codes

Fernando L. Piñero, et al. Department of Mathematics, University of Puerto Rico at Ponce.

In this talk we study Schubert polar varieties via associated linear codes. These linear codes are known as Schubert polar codes. Schubert subvarieties are fundamental subvarieties of the Grassmannian, defined with partial flags. Polar subvarieties of the Grassmannian are defined by collections of totally isotropic spaces. Both the Schubert conditions and the polarity conditions may be easily studyied with a transitive group action. In this work we study the interplay between the Schubert conditions and symplectic polarities. In particular, we focus on determining the length, dimension and minimum distance. We also compare Schubert polar codes with similar codes from the Grassmannian.

Acknowledgements: This is joint work with Mackenzie Bookamer (Tulane University), Susana Jaramillo (Whittier College), and Lani Southern (Willamette University).

Keywords: Grassmannian, Schubert varieties, symplectic varieties, finite fields, Hermitian varieties

Epidemiology of Amyotrophic Lateral Sclerosis in Puerto Rico: Spatial distribution of cases

Frances M. Aponte-Caraballo, et al., Department of Biostatistics and Epidemiology, Graduate School of Public Health, Medical Sciences Campus, University of Puerto Rico.

According to the ALS Association, the Amyotrophic Lateral Sclerosis (ALS) is a progressive motor neuron disease with unknown etiology that affects the spinal cord and brain nerve cells. It is characterized by the progressive loss of mobility in the upper and lower extremities with complications of dysphagia, dysarthria, and respiratory insufficiency. In Puerto Rico, the descriptive epidemiology of ALS is scarce, there is no surveillance system, and there is an urgent need for research about risk factors. In addition, local stakeholders suggest that there has been an increase in the burden of the disease in this Hispanic Spanish-speaking population that has experienced consecutive natural disasters in recent years. Therefore, preliminary data on 424 cases identified from January 1, 2018, and December 31, 2022, at the University of Puerto Rico's specialized ALS clinic are being evaluated. The cases were divided into seven regions, according to the Puerto Rico Department of Health. Using a Bayesian spatial disease model, the spatial pattern of ALS at the level of health regions is being investigated. It will allow the identification of the spatial units characterized by unusually high or low relative risk within this model. It is expected that the results of this study contribute to identifying possible clusters of ALS through the archipelago, generate epidemiological hypotheses about potential genetic and environmental risk factors, and inform the allocation of financial and human resources to provide specialized usual and natural disasters related-emergency services that result in a better quality of life for individuals living with ALS and their caregivers.

Acknowledgements: This is joint work with Rosa V. Rosario-Rosado , Brenda Deliz-Roldán and Istoni da Luz Sant'Ana of the Medical Sciences Campus, University of Puerto Rico. Thanks to Marimar Ramirez, MPH, the Puerto Rico ALS Foundation, and the School of Medicine Clinic for their support. This research was supported by RCMI grant U54 MD007600 from the NIMHD-NIH and partially by the Caribbean Hispanic ALS Center for Clinical Trials, ALS Association grant 23-TC-642.

Keywords: ALS, Amyotrophic lateral sclerosis, GIS, health regions, spatial analysis

Visualization of Musical Tension

Gabriel A. Santiago Plaza, Department of Computer Science, University of Puerto Rico at Río Piedras.
Rafael A. Arce Nazario, Department of Computer Science, University of Puerto Rico at Río Piedras.
Rémi Mégret, Department of Computer Science, University of Puerto Rico at Río Piedras.

Humans perceive different emotions when hearing tension in music and experience relaxation as it resolves [5]. This plays a pivotal role in the composition and richness of a score [2,4]. Current methods for music generation using artificial intelligence (AI) fall short when in creating quality musical content within different styles, often generating monotonous melodies. This issue could

be addressed by improving human-computer interaction during the generation process to create musically-enriched pieces that fit within the composers' standards [3]. Because of this, we aim to create an AI-assisted Music Composition Tool that takes into account user-defined tension-building patterns to provide possible harmonic phrases to be added into the composed score. Our focus will be an AI model trained with Caribbean music, in order to aid and cultivate the creativity of composers.

To gather data for model training, we developed an interactive visualization tool that displays a color-coded visual representation of tension within single-track polyphonic MIDI files. In this talk we discuss our implementation of harmonic series from each individual piano note to visualize the interaction of the sound waves that produce harmony. By combining mathematical equations that describe the psychophysical perception of tension [1], we designed geometrical shapes, tension matrices, and colored bar charts in our system to visualize harmony. We believe that our visualization tool can reveal the emotions a score is emitting, which can facilitate the creative process of composing.

The proposed visualizations rely on new numerical data structures that we will generalize in the future into hierarchical music structures that resemble musical tension and release. These structures will be used as key elements in Music Generating Models to give musicians the power to control high levels in harmony and visualize the emotional expressiveness of their music.

Acknowledgements: I would like to thank PR-LSAMP Bridge to the Doctorate Program, funded by the NSF for supporting this project and helping me reach my goals as a PhD Candidate.

Fractional Cauchy Problems and Resolvent Families

Henrry J. Cortez, Department of Mathematics, University of Puerto Rico at Río Piedras.
Valentin Keyantuo, Department of Mathematics, University of Puerto Rico at Río Piedras.

Fractional differential equations have proven to be a useful tool in the modeling of many physical phenomena in several fields of science and technology.

Fractional differential equations provide a mathematical framework for the modeling of phenomena where memory effects are important. Such is the case for various materials and processes for example viscoelasticity.

The study of associated Cauchy problems in Banach spaces involves the notion of fractional resolvent families. The latter can be seen as a generalization of other operator families, namely, semigroups and cosine operator families. We study properties of resolvent families including: associated functional equations, limiting cases (i.e. from resolvent families to semigroups), and the strong continuity of the corresponding dual families, acting on dual Banach spaces with the Radon-Nikodym property. Some references on fractional calculus are Bazhlekova (2001), Gorenflo-K-M et al. (2020), Keyantuo-Lizama-Warma (2016), Mainardi (2010), Mei-Peng-Zhang (2013).

Keywords: fractional derivatives, Banach spaces, semigroups, resolvent family, strong continuity, Radon-Nikodym property

Using Self-explanation Tasks Designed from Principles of Variation Theory to Investigate Undergraduates' Learning of Reading Strategies for Comprehending Mathematical Proofs

Hillary Bermudez, Department of Mathematics and School of Education, Syracuse University.

In this talk, I will focus on the design and implementation of a series of tasks that aimed to support students' engagement with reading and comprehending mathematical proofs. Reading and comprehending mathematical proofs are cognitive processes typically challenging for many undergraduate students in introductory proof courses. However, the ability to read and comprehend proofs can be especially challenging for students who have inequitably been disadvantaged in their mathematics classrooms, such as historically marginalized students, which may result in roadblocks that can hinder their ability to read and reason coherently about mathematical proofs. I argue that if undergraduate mathematics curricula want students to successfully engage with mathematical proofs through equitable learning experiences, research should focus more on the instructional practices used to engage students with proofs in introductory proof courses.

The study I report in this talk investigated students in an introductory proof course and their engagement in a series of tasks designed to stimulate their learning of reading strategies to support their comprehension of mathematical proofs. Specifically, I investigated the impact of the design of five self-explanation tasks, designed through principles of variation, on undergraduates' discernment of reading strategies; and if students' learning of specific reading strategies influenced their comprehension of the proofs they read. The study aimed to answer two questions: How do undergraduate students in an introductory proof course who engage in self-explanation training tasks, designed and implemented using principles from Variation Theory, develop the capacity to use effective reading comprehension strategies to read proof? How does using Variation Theory as a design principle in self-explaining tasks support undergraduates' learning of proof reading strategies and their proof comprehension? I present preliminary findings related to models of students' learning and development of four proof reading strategies from data collected from 17 undergraduate students enrolled in an introductory proof course across a 15-week semester.

Keywords: mathematical proofs, reading, comprehension, introductory proof courses

An Objective and Robust Bayes Factor for the Hypothesis Test One Sample and Two Population Means

Israel A. Almodóvar-Rivera, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Luis R. Pericchi-Guerra, Department of Mathematics, University of Puerto Rico at Río Piedras.

Over 100 years have passed since the discovery of one of the most fundamental statistical tests: the Student's t test. In this work, we propose an objective Bayesian approach for the hypothesis tests of one and two-sample means. The newly proposed Bayes Factors are based on the intrinsic prior and the Berger robust prior, and the Bayesian Information Criterion (BIC) based on the effective sample size (BIC-TESS) are finite sample consistent. Simulation experiments were con-

ducted to study these novel Bayes Factors and the BIC-TESS under different scenarios, providing strong evidence in favor of the true hypothesis, i.e. if the assumption of equal variances holds. Also demonstrating the same qualitative behavior and being reasonably close to each other in practice, particularly for moderate to large sample sizes. Finally, we studied the methodology on Gosset original sleep data and in the comparison of blood pressure in two groups of mice according to their diet.

Keywords: Student's t test; Objective Bayesian analysis, Bayes Factors; intrinsic priors; robust prior

Multidimensional Costas Arrays

Ivelisse Rubio, Department of Computer Science, University of Puerto Rico at Río Piedras.
Jaziel Torres, Department of Mathematics, University of Notre Dame.

A permutation array is a square binary matrix with a single 1 per row and per column. Costas arrays are permutation arrays where any two vectors joining entries with 1's are different. These arrays are useful in radar or sonar applications, digital watermarking and wireless communications. In this talk we present a multidimensional generalization of Costas arrays, extend the Welch and Lempel constructions to multiple dimensions and study some of their properties.

Análisis estadístico de los factores sociales que influyen en el rendimiento académico de los estudiantes de la FAE, UPRRP

Jairo A. Ayala-Godoy, et al., Instituto de Estadística y Sistemas Computarizados de Información, Facultad de Administración de Empresas, Universidad de Puerto Rico Recinto de Río Piedras.

El rendimiento académico con la que ingresan los nuevos estudiantes a la Facultad de Administración de Empresas (FAE) de la Universidad de Puerto Rico, Recinto de Río Piedras (UPRRP) es cada vez más baja. Este rendimiento naturalmente puede verse afectado por múltiples cambios en los factores sociales de la actualidad en Puerto Rico. A partir de este panorama y a la falta de estudios recientes, observamos la necesidad de trabajar un estudio de los factores que determinan el rendimiento académico y, por ende, la eficiencia terminal del programa, situación de gran relevancia para la FAE que cuenta con las acreditaciones AACSB y ABET, donde su indicador de calidad es precisamente la eficiencia terminal.

En esta charla discutiremos algunos resultados preliminares encontrados en un trabajo que llevamos adelantando sobre el tema. La base de datos cuenta con la información de los estudiantes de nuevo ingreso de los últimos 5 años, recogida en tres unidades de la universidad (Asistencia Económica, Registrador y Decanato de Asuntos Académicos). Para el preprocesamiento de los datos se aplicaron diferentes técnicas de minería de datos. Luego de construir la base de datos, se han realizado varios análisis estadísticos y se han implementado diferentes modelos matemáticos, con los que se espera lograr el objetivo de la investigación.

Agradecimientos: Este trabajo fue realizado en colaboración con Daiver Velez-Ramos (University of Puerto Rico at Río Piedras), Oscar Y. Castrillon-Velandia (University of Puerto Rico at Río Piedras), y Rafael Aparicio-Cuello (University of Puerto Rico at Ponce). Esta investigación fue patrocinada por *Research Award Program FAE 2022-2023* de la Universidad de Puerto Rico, Recinto de Río Piedras.

Palabras clave: factores sociales, rendimiento académico, minería de datos, análisis estadístico

Mathematical Modeling of COVID-19 and Disease Informed Neural Network with Human Interactions

Jeremis Morales, et al., Inter American University of Puerto Rico, Applied Science and Mathematics, San German.

The NSF-IHBEM Project INSIGHT presents an epidemiological model of COVID-19 dynamics with human behavior obtained by a collaboration between teams from IAUPR and GMU. The model consists of a Disease Informed Neural Network (DINN) trained using synthetic data obtained from its associated compartmental model that will be analyzed. The compartmental model of COVID-19 integrates an informed individual that alters a normal behavior responding to a perceived increase of the infections in the local environment. In this talk we will present the DINN and its compartmental model. We will introduce a Forward Sensitivity Analysis of variables and Reproduction Number (R0) to the model parameters. Results will be discussed to gain valuable insights and to showcase the importance of mathematics and these diverse tools in health emergencies such as COVID-19.

Acknowledgements: This work was done in collaboration with Carmen Caiseda (Inter American University of Puerto Rico), Alonso Ogueda (Inter American University of Puerto Rico), and Padmanabhan Seshaiyer (George Mason University).

An efficient implementation for real-time data aggregation of transactional data lakes

John Wilson, College of Natural Sciences, University of Puerto Rico at Río Piedras.
Edusmildo Orozco, College of Natural Sciences, University of Puerto Rico at Río Piedras.

Access to real-time analytics for petabyte-sized datasets has diverse applications across various fields, such as medical and finance, especially when dealing with dynamic data. Creating aggregated data for quick insights becomes crucial for making informed decisions with far-reaching consequences. Traditionally, when new data is added to datasets, the entire aggregated dataset is recalculated, posing a challenge as said dataset grows in size. The computational and time requirements for re-aggregation increase proportionally with the dataset's expansion. This recalculating process involves tracking contributions to aggregations and then re-aggregating with new

data points, resulting in significant computational expenses and time delays, affecting the speed of data analysis and, ultimately, undermining its decision-making usefulness.

A data lake is a centralized repository to store all types of structured and unstructured data at any scale. Apache Hudi is an open-source streaming platform developed to create, manage, and update transactional data lakes. In this work we will present a proof-of-concept implementation leveraging Apache Hudi's capabilities to capture real-time changes without the need to recalculate the entire aggregated dataset and show that this approach is adaptable to various aggregations such as Sums, Means, or Counts, where incremental changes are treated as simple differentials to the existing aggregated dataset. This work is motivated by a need to optimize the update logic for aggregated datasets within the medical field, to maintain its cost-effective nature and allow medical practitioners and other roles within this field to execute their work with proper efficiency.

Our preliminary implementation has demonstrated the robustness of our system, highlighting its ability to efficiently manage large workloads at remarkable speed. Moreover, the system proves to be highly cost-effective, achieving this through the minimization of redundant computations. The integration of Spark's Big Data Parallelization System further enhances its cost-effectiveness, speed, and scalability. As a result, we are developing a fast, scalable, and cost-effective solution for real-time data ingestion and the creation of aggregations.

Acknowledgements: We thank Abartys Health for providing the services and tools to implement and test this system, along with providing data to test at a large scale.

Keywords: Apache Hudi, Transactional Data lakes

Affine equivalence of k-rotation symmetric Boolean functions

José E. Calderón Gómez, Department of Mathematics, University of Puerto Rico at Río Piedras.
Carlos A. Molina Salazar, Department of Mathematics, University of Puerto Rico at Río Piedras.
Luis A. Medina, Department of Mathematics, University of Puerto Rico at Río Piedras.

A Boolean function in n variables is a map from $\mathbb{F}_2^n$ to $\mathbb{F}_2$, where $\mathbb{F}_2 = \{0, 1\}$. Two Boolean functions, $F(\mathbf{x})$ and $G(\mathbf{x})$ are affine equivalent if there exist a nonsingular matrix A and a vector $\mathbf{b} \in \mathbb{F}_2^n$ such that $F(A\mathbf{x} + \mathbf{b}) = G(\mathbf{x})$. The importance of affine equivalence lies in the fact that fundamental concepts such as the nonlinearity and balancing of a Boolean function are affine invariants.

In 2007, Kavut and Yücel introduced the family of Boolean functions known as k-rotation symmetric Boolean functions. These functions are fixed by the action of $\langle \sigma_n^k \rangle$, where σ_n is the rotation of n labels. They show that this type of Boolean functions are excellent candidates for efficient implementations. In this talk we present a study of the affine equivalence of k-rotation symmetric Boolean functions when A is a permutation matrix.

Acknowledgements: The first author was supported, as a student, by The Puerto Rico Science, Technology and Research Trust (PRST) under agreement number 2020-00124 and by the *Beca por Disertación, Tesis o Proyecto equivalente* (DEGI-UPRRP). The second author was supported, as a student, by *Fondo Institucional Para la Investigación*(FIPI) of UPRRP. The research of the third author was supported by PRST under agreement number 2020-00124 and by FIPI. This content is

only the responsibility of the authors and does not necessarily represent the official views of The Puerto Rico Science, Technology and Research Trust.

Keywords: Boolean functions, k-rotation, affine equivalence

Experiencias Computacionales en Talleres de Verano en Ciencias de Materiales a Estudiantes de Escuela Superior

José O. Sotero Esteva, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao.
Idalia Ramos Colón, Departamento de Física Aplicada a Electrónica, Universidad de Puerto Rico en Humacao.

En esta charla presentaremos el contenido de experiencias computacionales en el taller de verano Experimenta con PREM que se ha ofrecido por los últimos dieciocho años en la Universidad de Puerto Rico en Humacao y desde hace siete años en la UPR-Cayey, bajo los auspicios del programa UPR-Penn Partnership for Research and Educaction in Materials. Además mostraremos evidencia de cómo los citados talleres aumentan la auto confianza en la estudiante y le encaminan hacia una carrera en investigación en áreas relacionadas a las matemáticas aplicadas, ciencia de cómputos y ciencia de datos. Se concluye que las colaboraciones multidisciplinarias de divulgación también contribuyen a atraer estudiantes a nuestros programas de bachillerato y, más aún, la enriquecen con una visión multidisciplinaria en la que se aprecia la importancia de los dominios de aplicación de nuestras disciplinas.

Simulacros de exámenes en Precálculo I: Una estrategia efectiva para estudiantes de primer semestre

Julian A Jimenez Franco, et al., Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.

La alta tasa de fracaso en los cursos de precálculo es un problema para las instituciones educativas de educación superior y especialmente para los mismos estudiantes. Se ha documentado que el desempeño en el primer examen de estos cursos es clave para que el estudiante termine el curso satisfactoriamente e inclusive para lograr terminar la carrera universitaria. Una estrategia efectiva de estudio y para bajar la ansiedad del estudiante es ofrecer exámenes de simulacro. La utilidad de estos exámenes se magnifica cuando se ofrecen para el primer examen del primer curso universitario de matemáticas. En este trabajo se presentan los resultados del ofrecimiento de simulacros en el curso de Precálculo I de la Universidad de Puerto Rico en Mayagüez. Los estudiantes tuvieron la oportunidad de presentar un examen simulacro con exactamente el mismo formato del examen real y ofrecido en condiciones análogas, por otro lado recibieron su examen corregido y a la misma vez recibieron las soluciones correctas del mismo para que pudieran comparar sus respuestas. Todo esto sucede unos días antes de la fecha del examen real. En este trabajo se muestran los resultados de este proyecto.

Reconocimientos: Este trabajo fue realizado en colaboración con Luis Cáceres, Patrick Gonzalez, Julián Jiménez, y Yeison Rodriguez de la University of Puerto Rico at Mayagüez.

Predicting Outcomes in a Population in Early Recovery from Alcohol Use Disorder

Julian A. Soto-Perez, University of Puerto Rico at Mayagüez.
Grant Brown, Department of Biostatistics, University of Iowa.
Paul Gilbert, Department of Community and Behavioral Health, University of Iowa.

In this project, we'll focus on a cohort of survey respondents who identify as being in recovery/recovering from Alcohol Use Disorder (AUD). Specifically, we will attempt to build Machine Learning models to accurately predict the occurrence of relapse, and will apply interpretable ML techniques to communicate primary drivers of drinking outcomes. ML models used will include Random Forests, Gradient Boosted Trees, Neural Networks, as well as meta- learning techniques such as stacking.

Acknowledgements: The program that hosted the students working in the project was funded by The National Institute of Health, and managed by Dr. Gideon Zamba and Terry Kirk.

Keywords: machine learning, linear regression, behavioral health, public health

Análisis en Competencias Matemáticas: Evaluación de fortalezas y áreas por mejorar en estudiantes de escuela elemental en Puerto Rico

Junior Arauz Aguilar, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Luis Cáceres Duque, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.

El sábado 4 de noviembre de 2023, se realizó la segunda fase de las Olimpiadas Matemáticas de Puerto Rico en la que participaron estudiantes de toda la Isla de niveles elemental y secundario que lograron superar la primera etapa de esta competencia.

El examen de nivel elemental planteado para esta segunda etapa de eliminación consistía en preguntas tanto de selección múltiple como de respuesta abierta. Cada una de estas preguntas fue clasificada en una área de las matemáticas como geometría, álgebra, teoría de números, conteo, entre otras más. Posterior a esta clasificación, se realizó un análisis de dificultad de las preguntas propuestas por área de clasificación para determinar en cuales de ellas los estudiantes de escuela elemental presentan mayor dificultad y en cuales otras presentan fortalezas.

Se hizo un estudio estadístico comparando los resultados en las distintas áreas y en los distintos grados, analizando las áreas de mayor y menor dominio por parte de los estudiantes. En esta charla se presentan los resultados de este estudio.

Modular Square Roots of 1

Lillian González, Department of Computer Science, University of Puerto Rico at Río Piedras.
Ariane Masuda, Department of Mathematics, New York City College of Technology.
Ivelisse Rubio, Department of Computer Science, University of Puerto Rico at Río Piedras.

The operation of extracting modular square roots is frequently used in cryptography and various applications. Given a positive integer N and a quadratic residue a modulo N, the problem involves solving the equation $x^2 \equiv a \pmod{N}$. When N is prime, the solutions can be efficiently computed using Tonelli-Shanks algorithm. Otherwise, the problem becomes more complex and depends on the factorization of N. For instance, one method relies on finding the square roots modulo each prime power that divides N and lifting them to square roots modulo N using the Chinese Remainder Theorem. There are numerous results and algorithms that address special values of a and N. However, it appears that there is no known formula that provides all solutions for any N. Our goal is to provide an explicit formula for solving $x^2 \equiv 1 \pmod{N}$. This formula yields all incongruent solutions precisely. In particular, when a is coprime to N, the exact solutions to $x^2 \equiv a \pmod{N}$ can be obtained by multiplying any particular solution by the solutions to $x^2 \equiv 1 \pmod{N}$.

The Inhomogeneous Diffusion Equation of Wentzell type with Discontinuous Data

Marilin N. Guerrero-Laos, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Alejandro Vélez-Santiago, Department of Mathematics, University of Puerto Rico at Río Piedras.

We investigate the solvability and global regularity for an inhomogeneous Wentzell heat equation involving non-symmetric differential operators with unbounded lower-order measurable coefficients. Under minimal assumptions, we establish the existence of a unique bounded weak solution to our general Wentzell diffusion model, with sharp a priori estimates.

Keywords: Wentzell boundary conditions, non-symmetric differential operators, weak solutions, a priori estimates

The neutralization problem: a formalization of natural language rule-based phonology

Michael Rivera Serrano, Department of Linguistics, Stony Brook University.

A fundamental object studied within rule-based phonology is the phonological rule: a function over phonological strings that, when grouped with other phonological rules in a determined order, create a phonology. These phonologies are used to translate mental representations of sounds into their physical realizations. However, phonologies often produce homophones through a process called

neutralization, which presents a problem to the learner. Although learners distinguish homophones via morphosyntactic and semantic contexts, I explore what kinds of phonological analyses are possible without extra-phonological data. The goal is to investigate the minimum formal machinery required to perform phonological analysis while handling neutralization.

To do so, I build on a formalization for phonological strings and rules done by Bale and Reiss (2018). There, phonological strings are modeled as a particular kind of string over a phonological alphabet enriched with edge markers and phonological rules as functions over these strings such that some segment is either added, replaced, or deleted in a given local environment. I then model a phonological analysis as a pair $\langle f, S(x, f)\rangle$ where f is a phonological rule and $S(x, f) \subseteq [x]_f$ is some subset of the equivalence class of phonological strings $[x]_f$ such that for all $y \in [x]_f$, $f(y) = f(x)$. These can then be used to create generalized neutralizing sets N on a phonological string z, functions from phonological rules to equivalence classes of phonological strings such that $N(f) = \{x : f(x) = z\}$. An algorithm that produces a maximum generalized neutralizing set for any phonological string is constructed.

This model predicts that although learning the specific underlying forms and phonology is impossible under the assumption that learners cannot disambiguate neutralized forms without access to extra-phonological data, one can define the space of all possible phonologies given a finite surface form data set, formally defining the neutralization problem in terms of selecting an element from the set of all possible phonological analyses.

Keywords: mathematical linguistics, applied mathematics, mathematical modeling

ViBEx: A Visualization Tool for Gene Expression Analysis

Michael H. Terrefortes-Rosado, Department of Computer Science, University of Puerto Rico at Río Piedras.
Andrea Nieves-Rivera, Department of Computer Science, University of Puerto Rico at Río Piedras.
Marie Lluberes-Contreras, Department of Computer Science, University of Puerto Rico at Río Piedras.

Variations in the states in the Gene Regulatory Network may have an impact in disease outcomes and drug development. Boolean Networks aid in conceptualizing and understanding complex relationships between genes. Threshold computation methods are used for the binarization of gene expression and the Boolean representation of their Gene Regulatory Network. Because the gene expression binarization may vary based on the threshold computation method, the resulting Boolean representation of the network may also be different based on the binarization method. Lluberes and Seguel proposed a framework for the analysis of gene expression when the resulting binarized values differ among threshold methods. We have created a visualization tool for this framework. In the proposed interface, the user can upload their gene expression dataset and interact with a dashboard to explore the binarization of each gene expression.

Keywords: gene expression, binarization, Boolean networks, visualization

Updates towards the conjecture on exceptional APN functions

Moises Delgado, Department of Mathematics-Physics, University of Puerto Rico at Cayey.
Heeralal Janwa, Department of Mathematics, University of Puerto Rico at Río Piedras.
Carlos A. Agrinsoni Santiago, Department of Mathematics, Purdue University.

Almost perfect nonlinear (APN) functions, defined over finite fields $\mathbb{F}_q$, are related to error-correcting codes and symmetric cryptography. APN functions are called exceptional if they are APN on infinitely many extensions of $\mathbb{F}_q$. A conjecture of Janwa, Wilson, and McGuire, settled in 2009, stated that the only monomial exceptional APN functions were x^{2^k+1} or $x^{2^{2k}-2^k+1}$ (the Gold or the Kasami-Welch functions respectively). A new conjecture of Aubry, McGuire, and Rodier (AMR) states that the only exceptional APN functions are the Gold or the Kasami-Welch monomials just described. Since then, several results have been obtained to prove this conjecture. In this talk, we will give some applications of APN functions. We will also present a recent result that demonstrates that any polynomial of the form $f(x) = x^{2^k+1} + h(x)$ cannot be an excepti onal APN, with natural conditions on $h(x)$, extending substantially several recent results towards the resolution of the AMR conjecture.

Keywords: S-Boxes, Symmetric Crypto-systems, Cyclic Codes, Double Error-Correcting Codes, Almost Perfect Nonlinear (APN) Conjecture, Absolute Irreducibility, Lang-Weil, Deligne, and Ghorpade-Lachaud Bounds on Rational Points on Varieties over Finite Fields

Applying Deep Learning Techniques for Low-Density Parity-Check (LDPC) Decoding

Ollantay Medina-Huamán, Department of Mathematics, University of Puerto Rico at Humacao.

Low-Density Parity-Check (LDPC) codes have a history dating back to the early 1960s. Initially overshadowed by other error-correcting codes, such as Turbo Codes and Reed-Solomon Codes, they have resurfaced as a cornerstone in modern communication systems, thanks to their efficient encoding and decoding capabilities. The Belief Propagation (BP) algorithm is one of the primary methods for decoding LDPC codes. Renowned for its effectiveness and efficiency in numerous scenarios, the BP algorithm can, however, exhibit limitations in terms of complexity and performance under certain conditions. Specifically, it may struggle in scenarios with low signal-to-noise ratios, where its iterative process can converge slowly or not at all.

In this talk, I will briefly explain how LDPC codes function and explore how deep learning techniques can be utilized to provide alternative decoding methods that could rival the BP algorithm in some scenarios.

Keywords: LDPC codes, deep learning, belief propagation, error-correcting codes

Interacciones sociales de los estudiantes de escuela elemental al resolver problemas matemáticos colaborativamente

Eric Figueroa González, Facultad de Educación, University of Puerto Rico at Río Piedras.
Yamily Colón Negrón, Facultad de Educación, University of Puerto Rico at Río Piedras.
Omar Hernández Rodríguez, Facultad de Educación, University of Puerto Rico at Río Piedras.

Presentamos los resultados preliminares de una investigación con estudiantes de quinto grado ($N = 25$) de una escuela de San Juan. Los participantes, que no tenía exposición previa a metodologías colaborativas, fueron divididos en grupos de tres para resolver problemas. Cada subgrupo determinaba como organizarse para resolver el problema. Es decir, no se les proveyó roles ni instrucción alguna sobre cómo debían operar. Al finalizar, cada subgrupo entregaba una única solución en una hoja proporcionada.

Cada grupo contó con una computadora portátil que grabó el proceso. Al terminar cada sesión, se realizó una entrevista a cada subgrupo. Las fuentes de información incluyeron transcripciones de grabaciones, hojas de trabajo individuales, hoja de solución grupal y transcripciones de entrevistas. Para el análisis utilizamos la Teoría Histórico Cultural de la Actividad (Engeström, 1999), identificando acciones, interacciones, herramientas conceptuales, normas, lenguaje y división de tareas.

Observamos que los estudiantes de escuela elemental desarrollan el proceso de resolución de problemas matemáticos de forma colaborativa en continuos de interacciones que se pueden representar como carriles de polos opuestos:

1. Individualización vs. Colaboración: Acciones destinadas a sobresalir frente a acciones realizadas conjuntamente para completar la tarea.

2. Acciones Personales vs. Sociales: Trabajar individualmente frente a participar activamente con otros miembros del equipo.

3. Acciones Espontáneas vs. Concertadas: Acciones sin acuerdo previo frente a acciones mediadas por un acuerdo verbal o no verbal.

4. Aislamiento vs. Participación: No involucrarse en las actividades del equipo frente a promover la intervención activa.

5. Conocimiento Individual vs. Compartido: Dominio individual de conceptos frente a conocimiento común entre todos los miembros del equipo.

6. Discurso Coloquial vs. Formal: Uso de términos cotidianos frente a términos matemáticos precisos.

Es crucial destacar que estos tipos de interacciones no poseen una valoración intrínseca, ya que su importancia puede variar según el contexto. Este estudio contribuirá al diseño de actividades didácticas que fomenten la participación de todos los estudiantes en procesos colaborativos de resolución de problemas.

Palabas claves. Solución de problemas en forma colaborativa, solución de problemas a nivel elemental, solución de problemas

Deformations of rotating disks and spheres under self gravitation

Pablo V. Negrón–Marrero, Department of Mathematics, University of Puerto Rico at Humacao.
Jeyabal Sivaloganathan, Department of Mathematical Sciences, University of Bath.

The problem of determining the configuration of a rotating self-gravitating mass distribution is an old one, dating to the time of Newton itself. Most work to date has been for the case of a fluid, like a star, in which the density, velocity, and gravitational potential are the unknowns. The advantage in this case is that the gravitational potential is given as an integral over space, depending only on the density. However, the deformation of the mass distribution is unknown and the problem becomes a free boundary value problem. For solids, and now working on a known stress free reference configuration, we do not have a free boundary value problem, the density distribution is known or given in this reference configuration, but the gravitational potential now depends on the unknown deformation. In any case, the problem is three dimensional, for fluids requiring the solution of the Navier–Stokes equations coupled with Poisson's equation for the potential, or in solids, the equations of nonlinear elasticity coupled with a version of Poisson's equation in the reference configuration. For rotating bodies, both models include an inertial term. In this paper we give a characterization of the axi–symmetric deformed states for self-gravitating and rotating disks and solid spheres.

Keywords: rotating bodies, self–gravitation, axi–symmetric deformations

Characterization of well posedness for second-order abstract differential equations on function spaces

Rafael Aparicio, Department of Mathematics, University of Puerto Rico at Ponce.
Valentin Keyantuo, Department of Mathematics, University of Puerto Rico at Río Piedras.

We characterize the closed operator densely defined on a Banach space such that the Dirichlet boundary value problem for homogeneous linear second order differential equations, $u''(t)+Au(t) = 0$, is uniformly well-posed.

Keywords: second order differential equations, Dirichlet boundary value problem, uniformly well posedness

Global regularity for general quasi-linear problems over irregular regions

Rafael Gonzalez Pugliese, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Alejandro Vélez-Santiago, Department of Mathematics, University of Puerto Rico at Río Piedras.

We investigate the existence, uniqueness, a priori estimates, and global regularity of a generalized elliptic problem with boundary conditions of Neumann' or Robin's type, of the form:

$$\begin{cases} \mathcal{A}_p u = f & \text{in } \Omega, \\ \mathcal{B}_p u = g & \text{in } \Gamma := \partial\Omega, \end{cases} \tag{2}$$

where

$$\mathcal{A}_p u := -\sum_{i,j=1}^{N} \partial_{x_i}(\alpha_{ij}(x)|\partial_{x_j} u|^{p-2}\partial_{x_j} u) + \sum_{i=1}^{N} b_i(x)|\partial_{x_i} u|^{p-2}\partial_{x_i} u + \lambda(x)|u|^{p-2}u,$$

$$\mathcal{B}_p u := \sum_{i,j=1}^{N} (\alpha_{ij}(x)|\partial_{x_j} u|^{p-2}\partial_{x_j} u)\nu_{\mu_i} + \beta(x)|u|^{p-2}u.$$

We assume that $\mathcal{A}_p$ has a certain quasi-linear elliptic uniformity, in the sense that there exists a constant $c_0 > 0$ such that

$$\sum_{i,j=1}^{N} \alpha_{ij}|\xi_i|^{p-2}\xi_i\xi_j \geq c_0 \sum_{i=1}^{N} |\xi_i|^p.$$

We also assume that $\mathcal{A}_p$ has a certain quasi-linear monotonicity , in the sense that there is a constant $c_0' > 0$ such that

$$\sum_{i,j=1}^{N} \alpha_{ij}\left(|\xi_i|^{p-2}\xi_i - |\varsigma_i|^{p-2}\varsigma_i\right)(\xi_j - \varsigma_j) \geq c_0' \sum_{i=1}^{N} \left(|\xi_i|^{p-2}\xi_i - |\varsigma_i|^{p-2}\varsigma_i\right)(\xi_i - \varsigma_i).$$

Furthermore, the lower-order measurable coefficients are in general unbounded. Under minimal conditions, we show that problem (2) admits a globally Höledr continuous weak solution.

Keywords: Neumann boundary conditions, Robin boundary conditions, $W^{1,p}$-extension domain, d-set, weak solutions, a priori estimates

Algunos resultados sobre τ_n-grafos

Reyes M. Ortiz Albino, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.

La noción de las τ-factorizaciones o τ-productos sobre dominios con integridad surge como un tipo de factorizaciones generalizadas definidas por Anderson y Frazier, en el 2006. Uno de los ejemplos que presentaron fue el concepto de los $\tau_{(n)}$-productos que solo permite que dos elementos

$x, y \in \mathbb{Z} - \{0, \pm 1\}$ se puedan multiplicar si y solo si $n \mid (x - y)$. Similarmente, una $\tau_{(n)}$-factorización de $x \in \mathbb{Z} - \{0, \pm 1\}$, es una expresión de la forma $x = \pm x_1 * x_2 * * * x_n$ donde cada $x_i \in \mathbb{Z} - \{0, \pm 1\}$ y para todo $i \neq j$ $n \mid (x_i - x_j)$. En orden de ocurrencia, estas factorizaciones han sido estudiadas por Frazier, Hamon, Ortiz, Juett, Florescu, Mooney y varios estudiantes de Ortiz.

En esta presentación se proveerá un resumen de las nociones básicas y algunos resultados de la teoría de τ_n-grafos, formalmente definidas por Mooney en el 2013, pero estudiados por Frazier durante el 2006-2007 y Ortiz desde el 2010. Se provee una characterización de estos grafos y ejemplos para visualizar los mismos.

Keywords: generalized factorizations, factorizations, grafos

Analysis of Multi-Step Items in Computer-Assisted Exams in Calculus

Jim Gleason, Department of Mathematics, University of Alabama, Tuscaloosa.
Anna Keefe, Department of Mathematics, University of Alabama, Tuscaloosa.
Roberto Toro-Rodriguez, Department of Mathematics, University of Alabama, Tuscaloosa.

Creating assessments that measure students' skills and understanding involving complex tasks presents a significant challenge for mathematics instructors. Multi-step items involve breaking up complex mathematical problems into smaller units to award partial credit consistently. These items are created in a manner such that students must complete one part of the problem-solving process before receiving the correct answer to that part in order to move on to the next part of the item. We explore the incorporation of these types of items into an integral calculus course and discuss their psychometric properties.

Keywords: calculus, multi-step items, computer-assisted exams

Comparing exposure pathways of enteric pathogens to infants living in low to middle income countries

Shalimar Vargas-Grippo, University of Puerto Rico.

Over half a million children die each year from diarrheal diseases. This burden disproportionately affects those living in low- to middle-income countries. Children in these areas experience a wide range of exposures to pathogens (e.g., milk, food, caregiver hands, soil, animal feces), and it is unclear which exposure pathways are among the most important contributors. In an ongoing study in Nariobi and Kisumu, Kenya, led by Drs. Kelly Baker and Daniel Sewell, structured observational data have been collected on children's behaviors. The goal of this research project is to use Bayesian methodology to combine these data with previous studies in order to estimate the probability of becoming infected from various pathogens from a variety of pathways. The results of this project will provide key information for developing effective intervention strategies for reducing diarrheal disease in children living in low- to middle income countries.

Metodología de Enseñanza en Espiral en Competencias de Matemáticas

Luis F. Cáceres, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.
Victor M. Reyes, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.

La estrategia de enseñanza y aprendizaje a través del modelo de espiral está alineada con los estudios que establecen que la matemática se aprende mejor poco a poco y en periodos de tiempo largos. De esta manera, la retención de los conceptos y destrezas, por parte de los estudiantes, aumenta significativamente. En competencias de matemáticas sucede lo mismo, el aprendizaje se va dando mediante etapas, revisando conceptos y profundizando a medida que se va integrando conocimiento nuevo. En este trabajo estudiamos el aprendizaje en espiral y presentamos ejemplos de esta metodología en olimpiadas matemáticas. En particular mostramos algunos ejemplos en áreas clásicas de competencias matemáticas como geometría, álgebra, conteo y teoría de números. También mostramos ejemplos de distintas olimpiadas, unas de ellas con objetivos de popularización de la matemática y otras orientadas hacia estudiantes talentosos.

Palabras Clave: metodología en espiral, olimpiadas matemáticas, enseñanza aprendizaje

Un sistema tipo Filippov tridimensional para el análisis del control del dengue

Victor Manuel Salcedo-Rosero, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.
Luis Eduardo López-Montenegro, Departamento de Matemáticas, Universidad de Caldas, Colombia.
Ana María Pulecio-Montoya, Departamento de Matemáticas, Universidad de Caldas, Colombia.

En el transcurrir de la ponencia se presenta en un principio un modelo suave donde se estudia el crecimiento de mosquitos hembra adultos *Aedes aegypti* y se acopla a la dinámica de transmisión del virus del dengue en la población humana, la cual está dividida en tres subpoblaciones: susceptibles, infectados y recuperados.

Al modelo se le realiza un análisis de estabilidad local de los puntos de equilibrio con base en el número reproductivo básico de la enfermedad. En seguida, se formula un sistema epidemiológico de tipo *Filippov* en tres dimensiones en el que se hace necesario definir el número reproductivo básico de la enfermedad en términos de un control ε el cual es aplicado cuando la cantidad de personas infectadas supera un umbral Γ. Se definen conjuntos de cruce y deslizamiento, donde en la zona de deslizamiento Σ_s se determina la existencia de puntos tangentes, equilibrios de frontera, puntos de deslizamiento singular y pseudo-equilibrios.

Agradecimientos La colaboración y apoyo recibidos de la Universidad de Puerto Rico - Recinto de Mayagüez, en particular del Departamento de Ciencias Matemáticas, para nuestra participación en el Seminario Interuniversitario de Investigación en Ciencias Matemáticas. Asimismo, expresamos nuestro agradecimiento a la Universidad de Nariño, especialmente a la Facultad de Ciencias Exactas y Naturales, y al Departamento de Matemáticas y Estadística. Adicionalmente, extendemos un agradecimiento especial a la Universidad de Caldas por su colaboración destacada durante el

proceso de investigación.

Palabras clave: sistema de Filippov, dengue, aedes aegypti

Errores cometidos por los estudiantes universitarios en el estudio del límite de una función

Wanda Velázquez-Rosado, et al., Instituto de Estadística y Sistemas Computadorizados de Información, Universidad de Puerto Rico en Río Piedras.

Se investigaron los errores matemáticos que cometieron los estudiantes al realizar ejercicios relacionados con el límite de funciones. Participaron 75 estudiantes matriculados en el curso Métodos Cuantitativos para Administración de Empresas II (MECU 3032) durante el primer semestre 2022-2023. Los datos se obtuvieron de la administración de una prueba sobre el tema de límite de funciones racionales, irracionales y partidas. Se corrigieron las respuestas de los estudiantes en dicha prueba y se categorizaron los errores cometidos. Se realizó un análisis de contenido de las respuestas. Además, se llevó a cabo un análisis de las distribuciones de frecuencia. Se encontró que los estudiantes cometieron diferentes tipos de errores, donde los errores más frecuentes fueron de tipo conceptual. El error más frecuente fue el confundir el concepto del límite con evaluar una función. El segundo tipo de error más frecuente cometido por los estudiantes fue omitir la notación de límite o no escribir de forma adecuada la palabra límite en el proceso. Una de las recomendaciones sugeridas es integrar en el salón de clases ejemplos de los errores cometidos por los estudiantes en diferentes contenidos de matemáticas y cómo atenderlos. Este entendimiento les ayudará a fortalecer el aprendizaje de las matemáticas.

Agradecimientos: Este trabajo fue realizado en colaboración con Aniel Nieves-González, José Vega-Vilca, y Wanda Villafañe-Cepeda de la Universidad de Puerto Rico en Río Piedras.

Palabras claves: errores matemáticos, límite de una función, cálculo, métodos cuantitativoso

4 Afiches / Posters

(In alphabetical order using the first name of the presenter.)

Framework for Estimation of CO2 Sequestration from Sargassum Using Remote Sensing and Neural Networks

Alexander Claudio, Department of Mechanical Engineering, Inter American University of Puerto Rico at Bayamón.
Heerlal Janwa, Department of Mathematics, University of Puerto Rico at Río Piedras.

Puerto Rico is facing a sudden increase in Sargassum, a type of seaweed that was previously present in earlier years on a substantially much smaller scale. This increase in the quantity of Sargassum affects the marine ecosystem and the tourism industry. Factors such as changing ocean currents, nutrient runoff, and climate change are but a few contributing factors that are creating a situation where Sargassum can destroy marine habitats and release harmful gases, impacting local ecosystems and human health. To address this issue, collaborative efforts are needed to monitor the presence and growth of Sargassum in the ocean. A sustainable approach is crucial to protect the region's marine ecosystems and tourism economy. This report discusses the results of a project that used remote sensing satellite imagery to train a convolutional neural network, ERISNet, to detect and quantify Sargassum on the Eastern coast of Puerto Rico. A Python code, PyGIS_CO2_Sensing, was employed to collect training data by importing publicly available images from NASA's MODIS database and converting them into a usable form for ERISNet. Then, the network provides estimates of the Sargassum mass in the region of interest to calculate the overall CO2 content sequestered in the Sargassum.

Acknowledgements: This research was sponsored in part by Puerto Rico NASA Space Grant and Perdue University.

Keywords: sargassum, neural network, remote sensing, CO2 estimation, machine learning

Towards a Nearshore Sargassum Segmentation Model

Andrés Ramos Rodríguez, Department of Computer Science, University of Puerto Rico at Río Piedras.
Rémi Mégret, Department of Computer Science, University of Puerto Rico at Río Piedras.

This work evaluates the feasibility of near-shore Sargassum detection from remote sensing. Since 2011, unprecedented amounts of pelagic sargassum have been inundating the coasts of countries from the West Coast Africa all the way to the Gulf of Mexico. During these events, sargassum accumulates on the shores and becomes a nuisance to local flora and fauna and beach-goers. As it decomposes, it releases hydrogen sulfide which is toxic to humans and releases other gases such as methane. Eventually, when fully decomposed, it becomes a "brown tide" that lingers on the shore and blocks out the sunlight that is necessary for the survival of certain organisms. There is evidence

to show that this *sargassum crisis* is the new normal as these inundations are a consequence of a new source of sargassum called the Great Atlantic Sargassum Belt. Countries affected by sargassum need to create systems that can monitor and forecast sargassum inundations to guide mitigation efforts.

Sargassum detection in open ocean can be achieved using satellite imagery and index based methods. Unfortunately, these methods don't work in near shore environments due to noise caused by water turbidity, waves, sea floor and other vegetation. Recently, machine learning methods have shown great potential in near shore sargassum detection from satellite imagery. These methods are limited by the amount of annotated data and thus they only work for certain geographic regions. In this project, we present progress towards a machine learning based nearshore sargasssum segmentation model. We replicate state of the art results for sargassum detection along the coast of Puerto Rico where a multipredictor Random Forest model was trained for the La Parguera region. In order to evaluate the feasibility of extending this model to other geographic areas, we applied the UMAP dimensionality reduction algorithm. We show that fresh sargassum, decomposing sargassum and mangroves have very well defined clusters which demonstrates the potential of unsupervised machine learning to tackle this problem. Our aim is to leverage the large amounts of unlabelled data together with the limited labelled data to make a generalizable model for sargassum segmentation in satellite imagery.

Acknowledgements: This work is being conducted as part of the Post-Baccalaureate Research Experiences for LSAMP Students in Puerto Rico (PRELS) under the Puerto Rico Louis-Stokes Alliance for Minority Participation (PR-LSAMP) HRD-2008186. This work was supported by the Department of Energy Minority Serving Institution Partnership Program (MSIPP) managed by the Savannah River National Laboratory under BSRA contract 89303321CEM000080.

Keywords: remote sensing, sargassum, machine learning

On the Transient of a family of Boolean Monomial Dynamical Systems

Arnaldo Vera, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Omar Colón-Reyes, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.

An open problem in the theory of discrete dynamical systems is linking the structure of a system with its dynamics. For fixed point systems we are interested in knowing how long it takes the system to stabilize. This work contains an answer for a certain family of systems whose dependency graph is the wedge of cycles of prime length. Specifically, we are providing the transient of a family of monomial dynamical system over $\mathbb{Z}_2$.

Web application for Real-Time Monitoring and Analysis of Bee Behavior from Video

Eduardo J Figueroa-Santiago, et al., Department of Computer Science, University of Puerto Rico at Río Piedras.

The importance of bees in the development of crops, and consequently, our food supply cannot be overlooked. To gain a deeper understanding of bee behavior we use the flower patch experiment, this method is a tool in our efforts to study and support the role that bees play in agricultural ecosystems. This study introduces a web application designed to visualize and monitor the real-time detection, identification, and tracking of bee movements in artificial flower patches that are used for behavioral assays in the field. Traditionally, these experiments involve manually marking each bee with a glued tag or paint, observing the bees, and manually annotating their behavior, focusing on tracking their movements on visited flowers and recording the time spent feeding on sucrose. For this experiment as the numbers of bees increases, so does the possibility of human error. To address this issue, we present an application that streamlines the detection and tracking of flower visits for multiple bees simultaneously.

The application uses web technology to display in real-time the visits detected. The backend uses a YOLOv5 AI model for bee detection, and runs on NVIDIA DeepStream, with state-of-the-art trackers, assigning a unique tracking ID to each bee. Another component is Python code to assessing whether the bees are actively feeding and the duration of each feeding episode, which is stored in a MongoDB database. Additionally, the application can display the image of each bee involved in a flower visit to aid in human validation of the detections directly in the field. This gives the experimenters the possibility to identify specific individual behaviors and intervene by capturing specific individual while running the experiment. The application is designed to provide real-time data visualization with various views, allowing users to monitor individual bee activities or view a list of all bees that visited a flower in a specific experiment. A vital part of the system is its capability to store experiment data and metadata, facilitating easy access to past experiments for analysis and comparison. This application represents a significant advancement in bee behavior research, offering a more efficient and accurate method for data collection and analysis in experimental settings.

Acknowledgements: This is joint work with Josué A. Rodríguez-Cordero (University of Puerto Rico at Río Piedras), Gabriel A. Santiago-Plaza (University of Puerto Rico at Río Piedras), Luke Meyers (Seattle University), Fanfan Noel (University of Puerto Rico at Río Piedras), Rémi Mégret (University of Puerto Rico at Río Piedras), Carlos Corrada Bravo (University of Puerto Rico at Río Piedras), José L. Agosto-Rivera (University of Puerto Rico at Río Piedras), Tugrul Giray (University of Puerto Rico at Río Piedras). This research was supported by USDA/NIFA, award 2021-67014-34999, by the PR-LSAMP Bridge to the Doctorate Program, NSF award 2306079 and by IQ-BIO REU, NSF award 1852259.

Exploring the Environmental Impact of Equine Rhinitis A through Biomathematics and Population Dynamics

Elbelier Rivera Torres, Escuela Especializada en Matemáticas, Ciencias y Tecnología de San Juan.
Daniel Melo Pantoja, Escuela Especializada en Matemáticas, Ciencias y Tecnología de San Juan.

Equine Rhinitis (ERAV) is a little-known disease that affects the respiratory system of equines, causing their airways to become inflamed and obstructed, making it difficult for these animals to breathe (Couetil, 2021). In Southern Ontario, Canada, 58 horses were studied, of which 51 contracted the virus, where 17 could not continue with the research because they were removed from the place, remained infected or died during the research. The remaining 34 infected horses recovered (Rossi, 2019). By studying this disease, we promote conserving environmental resources. In addition, contribute to the knowledge of the disease. For example, better sustainable management, since, if the horses get sick, grazing can change, indirectly affecting the soil, creating erosion, water quality and the vegetation of the place. This simple mathematical model with SIR vital dynamics allows us to study horses without health risk for the researcher, because you are not directly working with the disease, but rather through mathematical modeling. The results showed that the transmission rate is .879, the recovery rate is .667, the birth and mortality rate is 0.00011 and a basic reproductive number is 76.42.

Agradecimientos: Especialmente a la Escuela especializada en Matemáticas Ciencias y Tecnología del municipio de San Juan, Puerto Rico.

Palabras claves: Rhinitis Equina A, modelo SIR, tasa de transmisión, tasa de recuperación, tasa de natalidad y mortalidad y número básico reproductivo, análisis numérico

Observing CH in the Trifid Nebula

Gerally N. Medina Rivera, et al., University of Puerto Rico at Mayagüez.

The Interstellar Medium (ISM) refers to the regions that lie between stars, and consists primarily of gas and dust particles. One of these gases is the Methylidyne (CH) molecule, whose hyperfine, ground state transition produces three spectral lines near the 3.3 GHz radio frequency. These three lines offer essential insights into the properties of diffuse molecular gas in the ISM. This investigation aims to process existing CH data obtained with the upgraded 12-meter radio telescope at the Arecibo Observatory (AO) of the Trifid Nebula (cataloged as M20 and NGC 6514), observed as part of a group of Star Forming Regions along the Milky Way's galactic plane. We present here our spectrum for the molecular cloud and discuss its interpretation, motivating future CH studies of these interesting regions.

Acknowledgements: This is joint work with Allison J. Smith (University of Puerto Rico at Mayagüez), Emmanuel J. Morales Butler (University of Puerto Rico at Utuado), and D. Anish Roshi (University of Central Florida). This work was supported in part by the NSF Center for Advanced Radio Sciences and Engineering, under Cooperative Agreement Award AST-2132229 and

ENCANTO: Enhancing and Nurturing Careers in Astronomy with New Training Opportunities, NSF PAARE Program Award AST-2219150.

Keywords: astronomy, spectroscopy, radio astronomy, molecules, interstellar medium

Molecular Modeling and Visualization for Hotspot Detection in Three-dimensional Protein Structures

Isabel T. Rivera Plata, Department of Computer Science, University of Puerto Rico at Río Piedras.
David Flores Granados, Department of Computer Science, University of Puerto Rico at Río Piedras.

In silico extraction of relevant features of cancer cells is a challenge that is established in several computational methods. Some of these methods have an approach based on the analysis of three-dimensional protein structures from these cells. Our goal is to find mutational "hotspots" embedded within the three-dimensional protein structures. A "hotspot" refers to a specific location in a protein sequence where mutations are frequently observed. These hotspots, denominated drivers, are of particular interest because they may have functional significance, potentially contributing to cancer progression. The importance of using three dimensional structures for this matter derives from the fact that it is more accurate to detect the hotspots using the already folded form of the protein. Hence the need to also use specialized software tools to perform pre- and post-processing tasks that provide input to the computational methods of hotspot detection. A few examples of these are Pymol and Rosetta, a molecular visualization system and molecular modeling suite respectively. Pymol uses Python as its source code, which gives us more liberty to create or modify the code for any specific uses we want. Rosetta, on the other hand, contains algorithms for computational modeling and analysis of 3D protein structures, be it for de novo protein design, structure prediction, among others. For this work, we utilize Rosetta's composite score function which combines chemical and physical properties of a protein in order to determine structure stability. We also perform what is known as a "relax" protocol on the structure, which alters its conformation into a more stable one. The differences effected can be sought through the comparison of structures submitted to Pymol for visualization. We then use quantitative measures provided by the Rosetta application in order to find a relation between energy levels and conformation. Ultimately, we wish to study the biochemical composition of the 3D protein structures to find characteristics in common that can be used to develop an algorithm to detect these in further structures. Detecting these hotspots within proteins that derive from cancerous cells may be important for understanding the molecular mechanisms involved in cancer, and for developing targeted therapeutic strategies that could benefit patients.

Keywords: hotspot, cancer, mutation, protein structure, three-dimensional

On τ_n-factorizations and τ_n-graphs

Jean C. García-Colón, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.
Reyes M. Ortiz-Albino, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez.

The theory of τ_n-graphs or τ_n-irreducible τ_n-factor graphs has been study by Mooney with a paper in 2013, and Ortiz and his students since 2010. The τ_n-graph of a nonzero nonunit integer x is defined to be a graph in which every vertex represents a τ_n-irreducible τ_n-factor of x, up associates. An edge between two vertices v_1 and v_2 represent the existence of a τ_n-factorization for the τ_n-irreducibles τ_n-factors. In 2020, Lopez and Ortiz characterized a family of τ_n-graphs and properties to construct such graphs of nonzero nonunit integers.

This ongoing problem is trying to answer the inverse problem. T his is, given a graph, can we find nonzero nonunit integers such that the τ_n-graphs coincide with such graph? During the process we characterized a family of such graph. We present the idea and examples of this problem.

Keywords: factorizations, graphs

Cloud based data visualizations and automated anomaly detection for web services threat detection

Jesús A. Rodríguez Rivera, Department of Computer Science, University of Puerto Rico at Río Piedras.
José Ortiz-Ubarri, Department of Computer Science, University of Puerto Rico at Río Piedras.

Network services are in a constant threat of cyber-attacks and system administrators need efficient ways to detect them. Web servers produce large amounts of log data that can be analyzed to detect anomalies that could translate into security threats. However, the format of log files and the quantity of requests make it difficult to analyze the raw data in an efficient manner without the use of computation. The goal of our project is to research the combination of data visualizations and automated anomaly detection methods to reduce false alarms and aid system administrators in the interpretation of the data. Our methods of anomaly detection combine signature-based and anomaly-based detection to monitor suspicious activity captured in web access logs. Signature-based methods depend on expected behaviors of anomalies whereas anomaly-based methods signal abnormal values within a dataset. It has been found that a combination of both methods produces more favorable results. For one of the signature-based factors to consider, previous research has found that malicious users produce larger amounts of errors in an access log. In addition, behaviors of already known cyber-attacks are also utilized for signature-based detection.

For our research, a web access log analysis tool was developed, which provides a visual summary of important information from log files. The tool also provides automated anomaly detection which highlights score points on graphs that represent potential security threats. Users can perform in-depth analysis of their access logs by accessing file data through their graphs. Our tool was successful at detecting network attacks such as vulnerability scans, and injection attempts in

the visualizations and highlighted alerts.

Acknowledgements: Special thanks to Jose E. Rodriguez Rios (UPRRP) for providing and performing vulnerability scans for the project. This material is based upon work supported by the National Science Foundation under Grants numbers CNS-2137791, and HRD-1834620. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Keywords: web access logs, vulnerability scan, SQL injection, cross site scripting, anomaly detection

Un Enfoque Bayesiano Para El Estudio De La Propagación Temprana De Brotes De Enfermedades De Carácter Epidémico

Jimmy O. Díaz Portillo, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.
Dámaris Santana Morant, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez.

Estudiar y predecir el comportamiento de los brotes de enfermedades infecciosas desde las fases tempranas de transmisión han sido objetos de permanente atención a lo largo de las décadas. Diversos investigadores han abordado estos aspectos, estudiando tanto las tasas de contagio observadas en tiempo real como en los registros históricos de las incidencias de pandemias pasadas. Los modelos clásicos, en principio, han asumido un crecimiento exponencial de los contagios, pero hallazgos recientes sugieren la necesidad de considerar otros patrones de crecimiento; por ello, han surgido modelos con parámetros de desaceleración que permiten cuantificar la desviación del modelo exponencial.

En este trabajo estudiamos la estimación de los parámetros de uno de estos modelos que considera las incidencias del virus versus sus incidencias acumuladas y que, en una versión equivalente, considera las incidencias acumuladas versus el tiempo transcurrido de contagio. Para la estimación utilizamos un enfoque Bayesiano y lo comparamos con la estimación por mínimos cuadrados en combinación con Bootstrap no paramétrico empleada en otros estudios. Presentaremos los resultados de un estudio de simulación en el que se encuentran ventajas para ambos enfoques.

Palabras clave: pandemia, incidencias, incidencias acumuladas, modelos bayesianos

Development of a User-Friendly, Cost-Effective Network Situational Awareness and Vulnerability Scanner for Resource-Constrained Organizations

José E. Rodríguez-Ríos, Department of Computer Science, University of Puerto Rico at Río Piedras.
José Ortiz-Ubarri, Department of Computer Science, University of Puerto Rico at Río Piedras.

In an era where cyber threats are more prevalent and sophisticated than ever before, the challenge of addressing network vulnerabilities has become a paramount concern, especially for resource-limited organizations. An example of this issue was the catastrophic WannaCry ransomware attack, which wreaked havoc across multiple sectors, including healthcare and education, affecting over 200,000 systems globally. The core of this widespread disruption was a critical yet avoidable factor because of a patched vulnerability that the attackers exploited by not having their software up to date. The lack of dedicated cybersecurity teams or advanced tools for vulnerability detection reveals the dire consequences of inadequate cybersecurity measures. However, our aim is to introduce a cost-effective, user-friendly network vulnerability scanner designed specifically for organizations with limited cybersecurity resources. We proposed a Python-based vulnerability scanner, integrating tools like Nmap for host discovery and OpenVAS to scan for vulnerabilities, with a focus on a simplified, intuitive user interface for non-experts. The scanner's development is driven by the need for accessible cybersecurity tools in smaller organizations, allowing them to effectively identify and address network vulnerabilities without requiring extensive technical knowledge. Our anticipated outcome is to provide essential defense tools to organizations currently vulnerable to cyber threats. This scanner aims to be a good preventive and reportative tool in securing these organizations to proactively enhance their network security.

Keywords: cybersecurity, vulnerability scanner, Resource-Constrained Organizations, network security, user-friendly interface

Binarizing scRNA-seq Data with Alevin Fry Method: Assessing Efficiency in Diabetes and COVID-19 Models

Juan F. Hernandez Jose, Megaprobe Laboratory, University of Puerto Rico at Río Piedras.
Humberto Ortiz Zuazaga, Megaprobe Laboratory, University of Puerto Rico at Río Piedras.

Single-cell RNA sequencing (scRNAseq) data often contains numerous zero counts, previously attributed to technical errors or dropouts. However, recent studies suggest these zeros convey biological significance. Single-cell sequencing has revolutionized the field of genomics by enabling the study of individual cells, and uncovering heterogeneity within complex biological systems. Among the various methods employed for single-cell RNA sequencing (scRNA-seq), the alevin fry method has emerged as a powerful and efficient approach. Currently, our lab is working on differential expression using binarizing data using the Binary Differential Analysis (BDA) on other samples. Recognizing the potential of alternative approaches to generate binarized data for scRNA-seq analyses, we are exploring the application of the alevin fry method. Alevin-fry is a configurable framework for the processing of single-cell and single-nucleus data. This method excels in overcoming challenges associated with traditional scRNA-seq techniques. Our objective is to configure the

alevin fry method to transform FastQ data into a binarized matrix, enhancing analytical outcomes. Typically, scRNA-seq data outputs as a matrix specifying the anticipated counts of each gene and the considered splicing states within each quantified cell. Since this is a separate project from the previously mentioned, we will be employing datasets from two distinct sources: diabetes and COVID-19. These datasets serve as models to assess the efficiency of the alevin fry method in processing scRNA-seq data.

Assessing the Burden of Disease of Gram-Negative Bloodstream Infections in a Brazilian Hospital: A Retrospective Cohort Study from 2015 to 2019

Kevin Soto-Cedeño, et al., Global Health Disparities Research Training Program, Icahn School of Medicine at Mount Sinai, New York.

Bloodstream infections (BSI) are a worldwide health problem associated with significant morbidity and mortality and lead to a substantial financial burden on healthcare systems. This study aimed to estimate the disease burden of BSI caused by Gram-Negative Bacteria (GNB-BSI) in Brazil from 2015 to 2019, measured in disability-adjusted life-years (DALYs).

From April 1, 2015, to March 31, 2019, a retrospective cohort study of adult patients with GNB-BSI was performed in 356-bed private hospital with a 68-bed medical–intensive care unit (ICU) in Salvador, Brazil. Demographic and clinical data was collected through a review of medical records. Bacterial infections were divided as Carbapenem-Resistant Gram-Negative Bacteria (CR-GNB) and Non-Carbapenem-Resistant Gram-Negative Bacteria (Non CR-GNB). DALYs (for CR-GNB, Non CR-GNB and overall infection) were estimated using Monte Carlo simulations with 20,000 iterations and a discount rate of 2.0

A total of 519 cases were identified for analysis. The majority of the cases (67.2%) were Non CR-GNB. The highest overall DALYs was observed in 2018 (754; 95% CI: 516 – 1,033). Infections due to CR-GNB agents had the highest DALYs, specially in 2017, with 7,100 (95% CI: 3,150-12,800) DALYs per 1,000 patient days.

These findings underscore the urgency of addressing bacterial infections as a significant public health issue in Brazil. The estimated burden of bacterial infections serves as a valuable benchmark for future comparisons and interventions.

Acknowledgements: This is joint work with Marcio de Oliveira Silva, Ana Verena Mendes, Adriele Conceição de Castro, Matheus Sales Barbosa, Maria Goreth Barberino, Mitermayer Galvão dos Reis, Ianick Souto Martins, and Joice Reis Neves. We extend our gratitude to the Mount Sinai International Exchange Program for Minority Students, funded by the National Institute of Minority Health and Health Disparities (T37 MD001452). Also to Fundação de Amparo à Pesquisa do Estado da Bahia (FAPESB) /PP-SUS 0014/2018 and Instituto Nacional de Pesquisa em Resistência Antimicrobiana (INPRA), CNPq 465718/2014-0, FAPERGS 17/2551-0000514-7.

Keywords: DALYs, Gram-Negative Bacterial, Carbapenem Resistant

Detection of CH in the Pipe Nebula

Marc A Thys Charneco, University of Puerto Rico at Mayagüez.

The Interstellar Medium (ISM) is the vast expanse of material that exists between stars. Comprised mostly of gas, the ISM contains large aggregations known as nebulae. The Pipe Nebula, classified as a dark nebula due to its high density, is an example of such a structure, giving rise to molecular clouds within its confines. Among the molecules present within these clouds is CH, whose hyperfine ground state transition emits three spectral lines around 3.3 GHz. The Pipe Nebula is of particular interest for a variety of reasons. These include that it is a relatively high-density nebula that, for some reason, is not birthing many stars. Additionally, it has been studied for its strong magnetic field.

All observations were made by the upgraded 12-meter radio telescope at the Arecibo Observatory (AO). The data was processed using a set of Python scripts that encompass the pipeline for the project. This poster aims to present the preliminary results for the detection of CH in the Pipe Nebula and to examine the consequences of these results.

Acknowledgements: This work was supported in part by the NSF Center for Advanced Radio Sciences and Engineering, under Cooperative Agreement Award AST-2132229 and ENCANTO: Enhancing and Nurturing Careers in Astronomy with New Training Opportunities, NSF PAARE Program Award AST-2219150.

Keywords: astronomy, Pipe Nebula, Interstellar Medium, star formation, spectroscopy, radio astronomy, molecules

Physics-informed ML predictions for damped harmonic motion

Michael J. Rivera, Department of Mathematics, University of Puerto Rico at Humacao.
Bruno Abreu, National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign.
Matthew Krafczyk, National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign.

Traditional neural networks used to model learn certain physical processes, such as underdamped harmonic oscillations, is not effective. Models fail to generalize and perform poorly if the data encompasses movement with several oscillations, especially when the inference domain goes beyond the training domain. This is where Physics Informed Machine Learning (PIML) would come in handy. PIML is an emerging area of scientific Machine Learning (ML) that seamlessly integrates domain science knowledge into models. In this work, we trained a PIML model to effectively model underdamped harmonic oscillations, showing that this incorporation process can lead to more efficient, more accurate, and/or more explainable models. The PIML model was more effective than purely data-driven approaches. The physics was incorporated through an extra loss function term coming from residuals of the ordinary differential equation that governs the motion. This work was additionally implemented into the Don't Repeat Yourself Machine Learning (DRYML) library,

which has the purpose of reducing code duplication, automate testing, perform hyper parameter searches, and ease model serialization.

Acknowledgements: This work was sponsored by The future of discovery: training students to build and apply open source machine learning models and tools program (NSF-2050195).

Keywords: physics informed machine learning, neural networks

Algorithmic analysis of gene regulatory networks of Drosophila melanogaster flies raised in microgravity

Miguel E. Cruz Molina, Department of Mathematics, University of Puerto Rico at Río Piedras.
Carlos Agrinsoni, Department of Mathematics, Purdue University, West Lafayette.
Heeralal Janwa, Department of Mathematics, University of Puerto Rico at Río Piedras.

Gene Regulatory Networks (GRNs) are increasingly used in biomolecular analysis. They represent gene coexpression and, among other applications, aid in visualizing established and unknown interactions between genes and revealing their upregulation and downregulation in different environments. Previous work on GRNs has proposed methods for constructing and analyzing these networks, including applying algorithms taken from graph theory and network science. One such algorithm is the Hyperlink Induced Topic Search (HITS) algorithm, which ranks hub and authority vertices by their convergent role in the information flow within the network. Further work done by Janwa, Agrinsoni, and Velev (JAV) has resulted in advanced versions of HITS that consider signed weights and directions.

In this work, we construct GRNs from the differential genetic expression of fruit flies (*Drosophila melanogaster*) reared in microgravity in the International Space Station (ISS). This species is used as a model to study the effects of prolonged exposure to microgravity on genomic expression and physiogenomic remodeling, particularly concerning cardiac contractility. Given the original status of our GRNs as undirected graphs, we discuss methods of establishing edge directionality by computing various metrics of influence between genes. We then apply sequential and parallelized implementations of both the original HITS and the JAV HITS algorithms for our *Drosophila* networks and analyze their performance in terms of efficiency and inference. We finally use visualization tools to show preliminary results of our analysis and make some initial extrapolations on the structure of our networks, and the applicability of our approach based on these results.

Keywords: gene regulatory networks, network model, network analysis, HITS algorithm, hubs and authority nodes, parallel computation, OpenMP

Data Analysis of the Electrical Power System in Puerto Rico from 2013 to 2022

Onix Gonzalez, et al., Technological Institute of Puerto Rico, Manati Campus, Puerto Rico.

The devastation of Puerto Rico's electrical grid during the hurricane Maria period, underscores the importance of the resilience of this system. Using tools, such as Python and Excel, we have been able to quantify how catastrophic this event was and the current state of our electrical grid. The team collected, cleaned and pre-process diverse datasets that include meteorological and grid performance data. We analyzed 2013 – 2022 monthly data that includes maximum power demand and generation data to understand seasonal patterns in the electrical grid and search for a baseline as reference of a natural disaster. We used visualizations, descriptive and inferential statistics to analyze data. Climate data was also obtained and compared to the demand data to better understand the patterns. The insights obtained will be presented for the first time in this poster presentation. We hope that the outcomes of this project will contribute to the conversation of building resilience in our communities and better prepare for future climate challenges that Puerto Rico and other Caribbean islands with similar infrastructure may need to face. This project is result of a collaboration between ITEC-Manati and IAUPR-Bayamon as the Puerto Rican team of the SURE-C^2 (NSF-HSI Program). SURE-C^2 promotes the transition of students from a Technological Institute or Community College students to a University Program through mentorship and group research in mathematical sciences.

Acknowledgements: This is joint work with Daniel Barreiro (Inter American University of Puerto Rico at Bayamón), Jorge Feliciano (Technological Institute of Puerto Rico at Manati), and Carmen Caiseda (Inter American University of Puerto Rico at Bayamón).

Variable Name Reconstruction for Decompilers Using LLMs and Program Analysis

Sergio D. Rodríguez De Jesús, Department of Computer Science, University of Puerto Rico at Río Piedras.
Rafael Arce Nazario, Department of Computer Science, University of Puerto Rico at Río Piedras.

Reverse engineers rely on decompilers for effective binary analysis. While contemporary decompilers excel in many aspects, a persistent challenge lies in the recovery of variable and function names. Addressing this limitation, Xu et al. [1] introduced LmPa, a system that employs language models and program analysis to reconstruct variable names. Notably, LmPa employs GPT-3.5, reflecting a trend towards larger models for improved outcomes. In this context, we propose a hypothesis: smaller models trained on specialized datasets can yield comparable results, enhancing accessibility and minimizing costs. Our proposed architecture, adapted from LmPa, comprises four key components. Firstly, a prompt generator extracts relevant data from decompiled output, generating a series of prompts. Subsequently, a Language Model (LLM) processes these prompts, attempting to produce variable names. A post-processor ensures the validity of the LLM's output. Finally, a name propagator enriches the context for the LLM, contributing to more accurate reconstructions. We expect better results as we repeat these four steps, making the approach iterative in nature.

We are currently exploring a single-pass approach for testing pre-trained LLMs.

Keywords: artificial intelligence, machine learning, decompilers, cybersecurity, binary analysis, large language models

Análisis de la Presencia de Enterococos en las Aguas Costeras de San Gerónimo: Impacto en la Experiencia Turística y Salud Pública

Yedrian J. Nieves Guillen, Escuela Especializada en Matemáticas, Ciencias y Tecnología de San Juan.
Daniel Melo Pantoja, Escuela Especializada en Matemáticas, Ciencias y Tecnología de San Juan.

Puerto Rico, al ser una isla rodeada completamente de agua, requiere una monitorización constante de sus recursos hídricos. El estudio destaca la necesidad de vigilar la calidad del agua para contaminantes químicos y prestar especial atención a las bacterias que pueden afectar la salud pública y el equilibrio ecológico de los ecosistemas acuáticos. El foco de esta investigación es la bacteria Enterococos, bacterias grampositivas que residen en el tracto gastrointestinal de diversos organismos y se han identificado como patógenos oportunistas en humanos. San Gerónimo, una playa en San Juan, fue seleccionada para el análisis debido a las concentraciones elevadas registradas durante un periodo de nueve años, especialmente en meses en que los valores superaban el límite no seguro para actividades recreativas. Factores que contribuyen al aumento de los niveles de Enterococos incluyen descargas ilegales de contaminantes, gestión inadecuada de aguas sanitarias y mantenimiento deficiente de pozos sépticos. Además, se analiza el impacto que tiene el turismo en los niveles de Enterococos, examinando de manera detallada cómo la afluencia turística, especialmente proveniente de los hoteles cercanos, puede influir en la concentración y distribución de esta bacteria a lo largo de diferentes fases temporales. Se busca comprender la correlación entre la actividad turística, las prácticas asociadas a la misma y las variaciones en los niveles de Enterococos, con el objetivo de identificar posibles factores contribuyentes y desarrollar estrategias efectivas para mitigar su impacto en la calidad del agua costera. Además, se relaciona con el desarrollo sostenible, especialmente con la Acción por el Clima, ya que la investigación busca contribuir significativamente a mejorar la calidad del agua costera en Puerto Rico. Las contribuciones incluyen recomendaciones, datos, resultados y conocimiento.

Agradecimientos: Especialmente a la Escuela especializada en Matemáticas Ciencias y Tecnología del municipio de San Juan, Puerto Rico.

Palabras claves: Bacterias, enterococos, grafica, análisis numérico, playa

K-means-directions algorithm for semi-supervised analysis on the sphere

Yeily P. Guzman-Castro, Department of Arts and Sciences, University of Puerto Rico at Mayagüez.

The k-means clustering analysis is a grouping method used to classify a set of data into k clusters. Semi-supervised transductive learning is a learning techniques that have a part of their data labeled and expect to obtain predictions about the unlabeled data with the help of these. Previous authors have created a directional k-means algorithm for semi-supervised data. The data points that are on a sphere, in addition to having the same norm, are measured by the cosine distance instead of the usual Euclidean distance; Other authors have also created a k-means algorithm specifically for large spherical data. In this work, we propose an adaptation of Lloyd's version of k-means for semi-supervised spherical data. We propose a distance function to minimize and provide the update equations for the centroids. By analyzing data with these characteristics using this algorithm, we hope that the additional information provided by the labeled set will improve the performance and accuracy of the results.

Keywords: clustering, k-means algorithm, semi-supervised data, spherical data, minimization

Comparison of dimensionality reduction methods to improve hyperspectral image classification

Yisel N. Sánchez Encinales, Department of Arts and Sciences, University of Puerto Rico at Mayagüez.
Vidya Manian, Department of Electrical and Computer Engineering, University of Puerto Rico at Mayagüez.

The research consists of comparing dimensionality reduction methods on a hyperspectral imaging data set. Hyperspectral imaging is an advanced technique for capturing and processing data across the entire electromagnetic spectrum, allowing the spectrum of each pixel in the image to be studied. However, this type of hyperspectral data presents problems of high feature dimensionality. To solve this problem, dimensionality reduction methods such as Principal Component Analysis, Singular Value Decomposition and Convolutional Autoencoders are applied and compared. These methods are an essential tool to improve the computational efficiency and classification of these images.

In addition, preconditioning and regularization techniques are applied to improve the performance of the models. In particular, in the case of Convolutional Autoencoders, preconditioning is used to improve their training stability and dimensionality reduction efficiency.

Keywords: hyperspectral imaging, dimensionality reduction, image processing, image classification

The Baryonic Tully-Fisher Relation for galaxies with supernova distances

Allison J. Smith, Department of Physics, University of Puerto Rico at Mayagüez.
Yulián Humarán Humarán, Department of Physics, University of Puerto Rico at Mayagüez.

The Baryonic Tully-Fisher Relation (BTFR) is a powerful tool that offers a reliable means of determining distances to galaxies. As an empirical relation between a galaxy's baryonic mass and rotational velocity, the BTFR will obtain precise distance by accurately estimating the gas mass, stellar mass, and rotational velocity for a selected sample of galaxies. In utilizing the BTFR, the distances to the sample of galaxies themselves are one of the largest sources of uncertainty. In order to maximize the robustness and utility of the BTFR the ALFAFA Team plans in reducing data to obtain physical parameters and construct the relation on galaxies hosting Type Ia and II supernovae, where distances are known.

Acknowledgements: This work was supported in part by the NSF Center for Advanced Radio Sciences and Engineering, under Cooperative Agreement Award AST-2132229 and by the Undergraduate ALFALFA Team, supported by NSF AST-2045369.

Keywords: distance of galaxies, baryonic mass, rotational velocity, gas mass, stellar mass

Speaker Index

CASUALTY ACTUARIAL SOCIETY

Liderando el Camino en Seguros Generales a Nivel Global

Más de 100 años de historia (fundada en 1914)

Sobre 10,000 miembros

Presencia en más de 50 países

Cerca de 4,000 candidatos en proceso de obtener membresía

Infórmate más en casact.org y casstudentcentral.org

Conéctese con el representante de la CAS en SIDIM 39

Roberto Perez, FCAS, MAAA

P&C Rate Modeling Actuary and Data Scientist at
National Association of Insurance Commissioners (NAIC)