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1 Conferencias Plenarias (*Invited Presentations*)

The number theory of partitions: The legacy of Euler, Freeman Dyson and Ramanujan

Ken Ono, University of Wisconsin at Madison)

At first glance, the stuff of partitions seems like child's play:

$$4 = 3 + 1 = 2 + 2 = 2 + 1 + 1 = 1 + 1 + 1 + 1.$$

Therefore there are 5 partitions of the number 4. But (as happens in number theory) the seemingly simple business of counting the ways to break a number into parts leads quickly to some difficult and beautiful problems. Partitions play important roles in such diverse areas of mathematics as combinatorics, Lie theory, representation theory, math physics, and the theory of special functions, but we shall concentrate here on their role in number theory. We shall give an account of the impact of Euler, Dyson and Ramanujan on the subject, and describe some of the recent advances in the subject.

Real Estate in Hyperbolic Space: Investment Opportunities for the New Millennium

Mel Slugbate, real estate broker, Slugbate and Mossbutter Real Estate, Williamstown, MA (sponsored by his brother-in-law, Colin Adams, Williams College)

Have you found the new investment climate a bit on the chilly side? Nervous about stocks, bonds and mutual funds? Afraid of risky investments in Euclidean space? Then real estate in hyperbolic space is for you.

We will discuss the enormous potential of this new investment opportunity and describe the many fascinating properties of hyperbolic space that make it such an attractive place to live. This is the financial equivalent of the 1990's dot coms. Don't miss it. Bring your checkbook and credit references! No previous math or real estate background assumed!

Bifurcations of Equilibria in DNA Elasticity

Bernard D. Coleman, Rutgers University

Yoav Biton, David Swigon, and the speaker have been developing a mathematical theory of DNA elasticity that accounts for the dependence of the mechanical properties of a DNA molecule on its nucleotide sequence and the electrostatic forces between the members of that sequence. The theory tells us that the equilibrium configurations of an intrinsically curved DNA molecule in solution can be very sensitive to the concentration of salt in the medium.

For many problems in DNA elasticity a DNA molecule in the familiar Watson-Crick double helical form can be treated as though it is a rod-like structure obtained by stacking dominoes one on top of another with each rotated by approximately one-tenth of a full turn with respect to its immediate predecessor in the stack. In molecular biology these “dominoes” are called base pairs, because each is formed by joining together with hydrogen bonds two nearly planar complementary nucleotide bases. Both the intrinsic geometry (e.g., curvature in the stress-free state) and the elastic properties (e.g., moduli governing bending, twisting, shearing, and coupling between such modes of deformation) depend on the nucleotide sequence in the DNA molecule. Each base pair is covalently attached to the sugar-phosphate backbone chain of one of the two DNA strands that have come together to form the Watson-Crick structure, and as each phosphate group in the backbone chain bears one electronic charge, two such charges are associated with each base pair. It follows that the electrical force exerted at a base pair is strongly dependent on the concentration of salt in the medium and the position in space of even remotely placed base pairs in the same DNA molecule.

The influence of long-range electrostatic forces, and hence of changes in salt concentration, on the configurations of intrinsically curved (and in general non-homogeneous) DNA molecules is not only a matter of general interest in biophysics but is also one that has implications in bioengineering. Research on the topic is expected to have applications to microdevices for imaging and sorting genomic-length DNA molecules. In one such device the DNA is elongated by confinement to a channel with a width of 100 nm. The theory under development will aid in the attainment of an understanding of the way the amount of extension experienced by DNA confined in such a channel is related to the channel diameter, the concentration of salt, and the intrinsic curvature of the DNA. Another application of the theory is the investigation of the possibility that circularized molecules of DNA formed from appropriate sequences of several hundred base-pairs can serve as mesoscale mechano-chemical switches that undergo large changes in configuration upon small changes in salt concentration.

2 Conferencias Concurrentes (*Concurrent Presentations*)

Los resúmenes aparecen en orden alfabético de acuerdo al apellido del primer autor nombrado en el trabajo. (*The abstracts appear in alphabetical order according to the last name of the first listed author.*)

Flattening of 3D data

Robert Acar and Krzysztof Rozga, Department of Mathematics, University of Puerto Rico at Mayagüez, Mayagüez, PR 00680.

The digital library project strives to digitise special collections of libraries; this consists in storing as binary data, photographs of the content of ancient or rare manuscripts. The object is typically not in a flat plane. One collects, along with the photograph of the unflattened object (and the inevitably distorted text), a positional reading of its surface using laserometer. It is then a mathematical problem of how to use the latter information to undo the distortion of the photograph before storing the digitised image. We address two cases: nonsmooth and smooth surface. In the nonsmooth case, we discuss a variational formulation; in the smooth case, we formulate a system of integrable equations. In both cases, we show computational results.

On detection of outliers and their effect in supervised classification

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An outlier is an observation that deviates so much from other observations as to arouse suspicion that it was generated by a different mechanism (Hawkins, 1980). Outlier detection has many applications, such as data cleaning, fraud detection and network intrusion. The existence of outliers can indicate individuals or groups that have behavior very different from the most of the individuals of the dataset. Frequently, outliers are removed to improve accuracy of the estimators. But sometimes the presence of an outlier has a certain meaning, which explanation can be lost if the outlier is deleted.

In this paper we compare detection outlier techniques based on statistical measures, clustering methods and data mining methods. In particular we compare detection of outliers using robust estimators of the center and the covariance matrix for the Mahalanobis distance, detection of outliers using partitioning around medoids (PAM), and two data mining techniques to detect outliers: Bay's algorithm for distance-based outliers (Bay and Schwabacher, 2003) and the LOF a density-based local outlier algorithm (Breuning et al., 2000). The effect of the presence of outliers on the performance of three well-known classifiers is discussed.

Homomorphisms of Sequential Dynamical Systems

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Microarrays allow researchers to simultaneously measure the expression of thousands of genes. They give invaluable insight to the transcriptional state of biological systems. However, the analysis of data from many thousands of genes, with only a few replications is very difficult. Mathematical and computational methods are being developed in order to construct formal models of genetics interactions. There have been a number of attempts to model gene regulatory networks. It is common to describe a genetic network as a parallel systems, but for biologist the interaction of genes have a sequential order. Here we describe the mathematical model sequential dynamical System(SDS), and give a new definition of homomorphism of SDS.

Conjunto De Productividad Para Problemas De Análisis Envolvente De Datos

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El análisis envolvente de datos (DEA por sus siglas en ingles), desarrollado por A. Charnes, W Cooper y E. Rhodes, es un método no paramétrico, basado en programación lineal, para medir la productividad y la eficiencia relativa de unidades de organización como escuelas, hospitales, sucursales bancarias, etc., que utilizan múltiples recursos para producir múltiples productos. El objetivo fundamental de DEA es hallar una frontera de eficiencia, formada por aquellas combinaciones de recursos que optimizan la cantidad de productos fabricados minimizando los costos de producción, y a partir de esta frontera, evaluar la eficiencia relativa de las combinaciones de recursos que no pertenezcan a la misma. El conjunto limitado por la frontera de eficiencia recibe el nombre de conjunto de posible producción. Este conjunto está determinado de forma única por un sistema de postulados. Cuando se estudian los conjuntos de posible producción, obtenidos al resolver un problema usando alguno de los modelos DEA, se observa que las regiones de producción que se obtienen son no acotadas, por tanto estos conjuntos contienen un gran número de combinaciones de recursos, las cuales no se considerarán en la realidad. En este trabajo se mostrará una forma de acotar el conjunto de posible producción de problemas resueltos utilizando DEA y se ilustrará la forma de medir la eficiencia de unidades de toma de desicion (DMU por sus siglas en ingles).

Almost Multiplicative Functionals on the Sequence Algebra $\tilde{\mathcal{A}}$

Gabriela Bulancea, University of Puerto Rico at Cayey.

A linear functional ϕ on a Banach algebra A is *almost multiplicative* (δ -multiplicative, more precisely) if $\|\phi(ab) - \phi(a)\phi(b)\| \leq \delta\|a\|\|b\|$, for $a, b \in A$. One of the main questions that arises in this context is whether, for a given Banach algebra A , an almost multiplicative functional must be near a multiplicative one. A Banach algebra is called *functionally-stable* or *AMNM* if $\forall \epsilon > 0 \exists \delta > 0 \forall \phi$ δ -multiplicative functional on $A \exists \psi$ multiplicative functional on A such that $\|\phi - \psi\| \leq \epsilon$. Johnson and Jarosz showed that most of the classical commutative Banach algebras are functionally-stable, however Sidney provided an example of a uniform algebra which is not functionally-stable. We will present results concerning the properties of the almost multiplicative functionals on the sequence algebra $\tilde{\mathcal{A}}$, where \mathcal{A} is the disc algebra.

Fortaleciendo la Educación: AFAMaC un Programa Abarcador en Ciencias y Matemáticas

Luis F. Cáceres y Arturo Portnoy Departamento de Matemáticas Universidad de Puerto Rico en Mayagüez.

AFAMaC es una alianza entre el Recinto Universitario de Mayagüez, el Departamento de Educación de Puerto Rico y los distritos escolares de Moca, San Sebastián y Mayagüez. Este proyecto pretende mejorar el rendimiento en matemáticas y ciencias de los estudiantes de las escuelas intermedias de los distritos que conforman la alianza, con un programa intensivo de apoyo, mentoría y mejoramiento profesional destinado a aumentar la preparación académica de los 140 maestros de ciencias y matemáticas de estos distritos y a convertirlos en una cohorte elite de maestros que a su vez servirán de mentores a otros maestros. Presentaremos el modelo de mejoramiento profesional que propone AFAMaC, enfatizando sus fortalezas y sus alcances.

Variables Predictoras en el Aprovechamiento Académico en los Cursos de Precálculo de la Universidad De Puerto Rico en Bayamón

Edward A. Caro López, Departamento de Matemáticas Universidad de Puerto Rico en Bayamón.

El Departamento de Matemáticas de la Universidad de Puerto Rico en Bayamón (UPR-B) ofrece tres versiones diferentes de un primer curso de precálculo para los distintos programas académicos de la Institución. El curso Mate 1001 fue diseñado para estudiantes en programas técnicos conducentes a grados asociados. El primer curso de la secuencia diseñada para los estudiantes del Departamento de Administración de Em-

presas (ADEM) es Mate 3011. Finalmente, el curso de Mate 3171 es el curso clásico de precálculo 1 que toman los estudiantes de Ciencias Naturales, Ingeniería, Electrónica (bachillerato) y Ciencias de Cómputos, entre otros.

Determinamos variables predictoras y su peso sobre el aprovechamiento en los tres cursos en discusión. Utilizamos el modelo estadístico no lineal “probit” para el análisis de una base de datos de 5,862 expedientes de estudiantes de nuevo ingreso y se estudia la ejecutoria de estos por curso en el primer semestre. El período que se estudia comprende los años 1995 - 2001. Establecemos una ecuación de regresión no lineal para simular la probabilidad de aprobar los tres cursos en discusión, a base de las variables predictoras de mayor influencia. Indicamos parámetros mínimos a satisfacerse para distintas probabilidades de aprobación para los tres cursos.

T_1 Separation in a Category

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A general notion of T_1 separation with respect to a closure operator is introduced in an arbitrary category \mathcal{X} . This gives rise to a Galois connection between closure operators on \mathcal{X} and subcategories of \mathcal{X} . This Galois connection is used to identify the largest closure operator that has a given subcategory as T_1 objects. This setup can be dualized to yield a notion of T_1 coseparation with associated Galois connection. The composition of the above Galois connections yields the connectedness–disconnectedness Galois connection. All the above concepts and results are discussed and examples are provided.

Existence of superconvergent points for discontinuous Galerkin methods applied to elliptic problems

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It is well known that for twopoint boundary problems we can identify special points that converge at a faster rate than that predicted by global a priori error estimates. This paper presents a theoretical and numerical study of a class of discontinuous Galerkin methods that shows the approximation of the gradient super-converges at the zeros of the Legendre polynomials on a model 1D elliptic problem. Numerical experiments validate the theoretical results. Preliminary numerical experiments of a gradient recovering technique are also presented.

Cota Para La Divisibilidad Del Numero De Soluciones De Una Ecuación Diagonal

Francis N. Castro y Alfonso E. Heras, Universidad de Puerto Rico en Rio Piedras.

Se le ha prestado especial atención a las propiedades de p -divisibilidad del número de soluciones de una ecuación polinomial sobre un cuerpo finito F_q de característica p .

En 1935, Chevalley probó que si $F(X_1, \dots, X_n)$ es un polinomio homogéneo de grado total d , sobre un cuerpo finito F_q de característica p y $n > d$ entonces F tiene un cero no trivial.

Daqing Wan prueba que para la ecuación diagonal, con n monomios de grado d_i cada uno y n variables, si existe un entero $b > 0$ tal que la suma de los recíprocos de los d_i es mayor que b entonces q^b divide al número de soluciones de la ecuación diagonal.

En este trabajo se logra una mejora al teorema de Wan usando el teorema de Adolphson-Sperber, que reduce el estimar la p -divisibilidad del número de soluciones de una ecuación a un problema de optimización lineal entera.

A novel method for obtaining coherent radiation by flowing a beam of molecules over a periodic surface

Mark Chang, Physics Department, University of Puerto Rico at Mayagüez, Mayagüez, PR 00680.

I present a study of a novel quantum electrodynamical effect: that of self induced excitation of a beam of molecules moving above a periodic dielectric or conducting medium. The presence of such a surface near molecules modifies their properties fundamentally, changing their radiation and even the electromagnetic vacuum fluctuations. In particular the energy levels and the radiative decay rates are affected, modulating the molecular transition frequency. I calculate the electric field created by a high frequency dipole moving at constant velocity in one medium near the boundary with another medium and show that this could be a new method for the generation of coherent radiation in a range from the far-infrared to microwaves.

Algorithm for Minimum Laterally Adiabatically-Reduced Fisher Information

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The paper observes that consistent lateral motion of probability within a probability density does not affect the Shannon entropy, i.e. that such movement of probability is an adiabatic or entropy-preserving operation. Next it is observed that if such motion

removes “kinks” in a probability density, it decreases the Fisher information. Then it is found that a minimum of Fisher information due to this procedure must result if all kinks are removed by pushing probability laterally toward the origin on the plus side. Finally an algorithm is developed which will effect this operation, and calculate the resulting minimum laterally adiabatically-reduced Fisher information. Examples are worked out to illustrate the algorithm. Applications may include many processes which occur adiabatically, i.e. without entropy increase. There is the possibility that other adiabatic processes may be discovered which will yield even lower Fisher information, although the author has not found such procedures. If it could be proved that there are no such procedures, the word “laterally” could be removed from the title.

Boolean Monomial Dynamical Systems

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An important problem in the theory of finite dynamical systems is to link the structure of a system with its dynamics. This paper contains such a link for a family of nonlinear systems over the field with two elements. For systems that can be described by monomials (including Boolean AND systems), one can obtain information about the limit cycle structure from the structure of the monomials. In particular, the paper contains a sufficient condition for a monomial system to have only fixed points as limit cycles. This condition depends on the cycle structure of the dependency graph of the system and can be verified in polynomial time.

Interleaver Constructions for Turbo Codes using Almost Perfect Nonlinear Power Functions

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Turbo Codes (TCs) are error correcting codes that are widely used in satellite and wireless communications. They provide “good” error correction capability with low energy consumption. Interleavers play a significant role in the performance of these codes. So far, random and semi-random interleavers constructions are the best known for “good” code performance, but on the downside these constructions have to be stored in memory and the latter isn’t easy to implement.

Our research focuses on the problem of algebraically constructing permutations that generate interleavers for TCs and characterizing the properties of the constructions that are both: easy to implement and perform as good or better than known constructions. We study algebraic constructions of permutations of length $2n$ to be used as interleavers for TCs, using Almost Perfect Nonlinear Power Functions (APN). We considered the Gold, Kasami, Welch and Inverse APNs.

Our simulations demonstrate that several interleavers constructed with APNs perform better than random interleavers. Specifically some cases of the Gold and Kasami constructions of length 29 and the Welch construction as well as some cases of the Gold and Kasami constructions of length 211

The results are intriguing in the fact that they produced “good” codes, but the interleavers used for their construction do not necessarily have good dispersion or spreading, the usual properties of “good” turbo encoders. The next steps are: to characterize the constructions that generate “good” codes, and establish the relation between nonlinearity and good interleavers.

Filters and Ideals of βS

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It is well known that if $(S, +)$ is a discrete semigroup, then $+$ can be uniquely extended to βS , the Stone-Cech compactification of S , so that $(\beta S, +)$ is a compact right topological semigroup, where the points in βS are the ultrafilters on S . Using properties of ultrafilters and compact right topological semigroups, we can prove several Ramsey Theory results. In this presentation I will characterize the closed ideals of βS . I will also give some equivalent statements to the Erdős sum of reciprocal conjecture, which states that whenever A is a set of positive integers and $\sum_{x \in A} \frac{1}{x} = \infty$, then A contains arbitrarily long arithmetic progressions.

Soil Moisture, Soil Temperature And Heat Flux Using Artificial Neural Networks

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ANNs, or Artificial Neural Networks, use a set of processing elements (or nodes) loosely analogous to neurons in the brain. These nodes are interconnected in a network that can then identify patterns in data as it is exposed to the data. In this research, ANNs will be used to predict the soil moisture, soil temperature and heat flux profile for sample

locations at the depths of 2, 4, 8, 20 and 40 inches. The input variables will include data found from remote sensing for the first two inches of soil, soil temperature, precipitation, solar radiation and soil moisture. Finally, the results of the experiment are going to be compared with factual data using Scan Station data from ALMNet. Uses of the research include agriculture, public safety and flood control.

AMGLib++: An Object Oriented Library for Algebraic Multigrid Methods

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Numerical simulations of scientific and industrial applications often require the solution of large sparse linear systems which typically arise from the discretization of Partial Differential Equations (PDE's). In this talk we present, AMGLib++, an Open Source Object Oriented Library for solving sparse linear systems. AMGLib++ provides an abstract framework based on the Algebraic Multigrid method. The library derives its flexibility by using several concepts of the Object Oriented paradigm: abstract data types provide a public interface; data encapsulation prevents unexpected modifications of data, making the code more robust and modular; and, generic programming allows the possibility of extending the library by including userdefined operators designed for particular applications. Finally, we show the main features of the software through some examples and we present some numerical results to test the performance of this library.

Uso de técnicas de clasificación en conglomerados para describir perfiles en grandes bases de datos educativas

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En esta charla se describe el proceso utilizado para encontrar los conglomerados naturales en los que se encuentran agrupados los estudiantes que participaron en el proyecto Quiz, y partir de estos la creación de perfiles de manera no supervisada.. Además, se muestra un panorama general de las principales técnicas de agrupación y validación de conglomerados. Para este propósito se utilizaron cuatro de los algoritmos más representativos de estas técnicas y cuatro medidas de validación (dos combinaciones de estas “agrupación–validación” desarrolladas en este proyecto). El proyecto se desarrolló en varias etapas. En la primera se extrajo la información del sistema, para lo cual se creó una aplicación que extrae información de archivos de texto en diferentes formatos y con estos datos crea una matriz donde cada fila corresponde a un estudiante y cada columna a sus atributos. En la siguiente etapa se procesó la información mediante la eliminación de datos y la asignación de pesos. Luego se adoptó una métrica para determinar lo similar o disimilar que son los estudiantes entre sí. Como se desconocen las clases a las cuales pertenecen

los alumnos y el número de ellas, se diseñó una metodología para identificarlas. Esta metodología consiste de la aplicación de algoritmos de agrupamiento a datos generados aleatoriamente, y normalmente distribuidos que pretenden simular los datos reales. Posteriormente se midió la calidad de los conglomerados formados con las medidas de validación y se compararon estos conglomerados con los conglomerados reales. De esta forma se pudo establecer el comportamiento de los algoritmos con diferentes estructuras de datos y el grado de confiabilidad de las diferentes medidas de validación. Finalmente se aplicó esta metodología para encontrar los conglomerados naturales subyacentes en los datos reales. De la aplicación de esta metodología, resultaron ocho conglomerados que sirvieron para describir ocho perfiles a partir de sus centroides.

New (Explicit) Constructions of Asymptotic Families of Constant Degree Expander Graphs from Algebraic Geometric Codes and Their Generalizations: Their Tanner Codes and Decoding

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New (explicit) constructions of asymptotic families of constant-degree expander graphs are presented. Their parameters and those of their Tanner codes are analyzed. Some of these codes are very suitable for decoding by the algorithms of Sipser and Spielman, Zémor, and Janwa and Lal, Barg and Zémor, and Guruswami and Indyk, and results on minimum distance and decoding performance of some of these codes are presented. Some asymptotic results are also presented. Applications to sparse quasi-random graphs, pseudo-random generators, and cryptography are also discussed.

Maximal regularity for a class of integrodifferential equations with infinite delay in banach spaces

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We use Fourier multiplier theorems to establish maximal regularity results for a class of integrodifferential equations with infinite delay in Banach spaces. Concrete equations of this type arise in viscoelasticity theory. Results are obtained for periodic solutions in the vector valued Lebesgue and Besov spaces. An application to semilinear equations is considered.

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Discretization and Rounding Errors: ODE's and beyond

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Numerical solution of real-world problems is a complex process combining tools from various areas of applied mathematics and computer science. Such process inevitably introduces various types of errors that need to be understood and, hopefully, controlled. The talk discusses the role the discretization and rounding errors: the former arise when numerical model is set to approximate the general mathematical model and the latter further along the road when the actual computational process is carried on. Both types contribute to the total error and absence of their proper integration (including mutual relationship!) into the error analysis of the whole solution process may cause grave consequences. The situation is well understood for the ODE's and both empirical and analytical evidence suggest that same or similar principles hold for general several variables integro-differential equation model.

The Bousfield-Kan Spectral Sequence for Morava K-Theory

José La Luz, Universidad de Puerto Rico en Rio Piedras.

We construct a spectral sequence converging to the E2-term of the Bousfield-Kan spectral sequence for a wide variety of homology theories. Using this, the E2-term of the BKSS based on $K(1)$ -theory for the odd spheres is computed and the unstable $K(1)$ -completion is computed.

Efficiency of the Imputation Methods on the Logistic Regression Model

Víctor López and Julio C. Quintana Díaz, Department of Mathematics, University of Puerto Rico at Mayagüez, Mayagüez, PR 00680.

The MCAR mechanism was used with different missing data probabilities in order to generate iteratively missing values in some data sets, and then to analyze the efficiency of single, hot deck, and multiple imputation methods in a logistic regression model for those data sets. The statistic of interest to compare those methods is the area under the receiver operating characteristic (ROC) curve, called the separation power of the logistic regression model. We are applying different imputation methods using the software R. For the single imputation methods we used the unconditional and conditional mean and mode (IMEAN, ICMEAN, IMOD, ICMOD) and for the Hot Deck imputation the random sampling of the observations and the k-th nearest neighbor imputation (KNN). We also applied a multiple imputation procedure the so-called Federal Reserve Imputation

Technique Zeta (FRITZ) algorithm implemented by Kennickell on the SCF (Survey of Consumer Finances). Several iterations for the separation power were obtained after a generation of missing data with a given probability and then impute these missing values by some imputation method. The average bias between the real separation power and the separation power for all the iterations was calculated for all the imputation methods and some missing data probabilities, and then tested using non-parametric comparison procedures.

Statistical Inferences for a Decreasing Mean Residual Life Distribution

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In survival analysis an important biometric function is the life expectancy at age t , the Mean Residual Life Function (MRLF), $M(t)$, defined by

$$M(t) = E[X - t | X > t],$$

where X is a life distribution, i.e., $X \geq 0$. Grace Yang (1978) produced an empirical estimator, M_n , of M , showed that it is strongly uniformly consistent, and that $\sqrt{n}[M_n - M]$ converges weakly to a mean - zero Gaussian process.

In many applications it is reasonable to assume that M is decreasing, therefore, classes of life distributions have been defined according to some monotonic properties of these functions. Namely, the Decreasing Mean Residual Life (DMRL) class.

For M in the DMRL class we define an order restricted estimator, M_n^* , that is, M_n^* itself is decreasing. We showed this estimator to be strongly uniformly consistent, derived the weakly convergence of the process $\sqrt{n}[M_n^* - M]$. Also, applications and simulation results showing the Mean Square Error of M_n^* to be less than that of M_n will be presented.

Parallel and Distributed Computing for Data Mining: A Review

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Pattern recognition in about supervised and unsupervised classification. There are different techniques to solve classification problem, some of them are: kmeans, bootstrapping, knearest neighbors, support vector machines, and decision trees. These techniques are known as computationally heavy when the number of instances or the number of features are very large. For this reason distributed computing is used to reduce the computational time of such techniques. The objective of this paper is summarize and analyze some parallel approaches for supervised and unsupervised classification algorithms.

Optimization Problems for Mathematical Models of the Urine Concentrating Mechanism

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Mathematical models for the urine concentrating mechanism consist of a system of ordinary differential equations for water transport coupled with a system of partial differential equations for solute transport in the renal tubules. The model equations contain physiological and geometric parameters, which values (when known) has been reported in the literature within ranges of uncertainty. In this work, two optimization problems are formulated for computing sets of parameters and solutions for the model equations. One approach computes sets of parameters, within the parameter ranges, that maximizes a measure of urine concentration efficiency, whereas the other technique finds sets of parameters, within the parameter ranges, that lead to model solutions that are “close” to reported experimental solutions. The numerical methods for solving the model equations and the optimization problems are discussed and a comparison of the results from both methods is presented.

Problemas de Bifurcación Global en Elasticidad Nolineal Tridimensional

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Existen muchos ejemplos en la literatura de la teoría matemática de elasticidad nolineal tridimensional donde se derivan (formalmente) condiciones necesarias para la existencia de bifurcaciones locales. Sin embargo, se han publicados muy pocos análisis rigurosos donde se deriven condiciones suficientes para la existencia de bifurcaciones locales y hasta hace muy poco no se había publicado nada acerca de bifurcaciones globales en ejemplos concretos.

En esta charla discutiremos algunas aplicaciones recientes de métodos de la teoría de grado topológico a problemas de bifurcación global en elasticidad nolineal tridimensional. Daremos especial énfasis a resultados obtenidos por nosotros y nuestros colaboradores y a la relación entre violaciones de la *condición complementaria* y el comportamiento de la ramas de soluciones bifurcantes.

A Second Gradient Model for a Rectangular Slab

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We have noticed in the context of elasticity, that there is a recurrent relation that has not yet been study in depth between violation of the *complementing condition* of the linearized problem and the existence of sequences of bifurcating branches of nontrivial solutions. The complementing condition is an algebraic compatibility requirement between the principal part of a linear differential operator and the corresponding boundary conditions. The failure of the complementing condition has been associated with the phenomenon of *surface wrinkling* in materials. The standard mathematical techniques of degree theory used in elasticity are not applicable when the complementing condition fails. A physically reasonable way around this is to introduce a small additive quadratic second–gradient term in the stored–energy function, which has been proposed as a model for the surface behavior. In this talk, which is a follow up of a talk presented at the SIDIM 2004, we study the boundary value problem for the deformations of a two dimensional rectangular slab with an added second–gradient term. We study the asymptotic behavior of the equation describing the critical loads and show that under certain conditions the limit of these loads correspond to those of the problem with no added higher order term. We discuss the special case of Blatz–Ko type materials and show some numerical results about the disposition and multiplicity of the characteristic loads.

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Decoding a Single Generated Cyclic Code

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A code C over a commutative ring with identity R is a nonempty subset of R^n . It is called cyclic if it is closed under cyclic shifts. A generator matrix G of C is a matrix in which the rows of G generate C and no proper subset of the rows of G generates C . For a given message $u \in R^k$, $k < n$, we can find the corresponding codeword $x = uG \in C \subseteq R^n$. After transmitting the codeword x we could receive a word $y = x + e$, which include some errors. Note that G is not invertible, since isn't square, so we can't decode the estimated message as $u' = x'G^{-1}$. The decoding matrix D of C with a $k \times n$ -generator matrix G is a $n \times k$ -matrix such that $I_k = GD$. Hence, the decoding of the codeword is $xD = u$.

We are going to consider that $R = Z_{p^m}$ for any given prime p . In the case where the cyclic code has a single generator, as in the case when n and p are relatively prime, the

generator matrix G is known. We are going to show a way of computing the decoding matrix D .

Generalized Gröbner Bases and Coding Theory

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Sakata generalized the Berlekemp-Massey algorithm for BCH and Reed-Solomon codes to the multivariate case. This method can be extended further to codes defined by finitely generated domains over a field that are endowed with a suitable valuation. The study of such valuations leads to a generalization of the theory of Gröbner bases, where term orders are replaced by valuations. The present work shows how to work with such valuations computationally. In addition, we discuss the relationship with coding theory and some of the open problems that have arisen.

On The Development Of Complex Dynamics

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In this talk we will discuss briefly the development of complex dynamics, specifically techniques such as quasiconformal surgery. In addition we will talk about how complex dynamics can be related to other dynamical systems such as one sided shifts.

The Brachistochrone Problem Revisited

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The brachistochrone problem consists of finding the curve, joining two (non-horizontal) given points, along which a bead of given mass falls under the influence of gravity in the minimum time. This problem was first posed by Johann Bernoulli in 1696 and solved that same year by Newton, Leibniz, the Bernoulli brothers Johann and Jacob, and de L'Hôpital. The solution of the brachistochrone problem helped to develop the now very important branch of analysis, the calculus of variations. Since then variations of the brachistochrone problem have been presented in many books and papers but the great majority of these expositions assume from the start that the solution curve is a function of x in the xy plane. Although this assumption turns out to be correct, these derivations do not expose a whole variety of problems associated to the brachistochrone problem, in particular those concerning the specification of initial conditions.

In this paper we discuss the solution of the brachistochrone problem as a problem of the calculus of variations among smooth parametrized curves. The equation of motion

of the mass along the tangential direction to the curve, becomes now a differential side condition in the variational formulation. The Euler–Lagrange equations for the resulting variational formulation can be solved explicitly. The variational process leads naturally to the use of the angle of inclination of the tangent to the curve from the horizontal as the parametrization for the solution curve and time integrand. The resulting extremals are sections of a cycloid with the size of the cycloid and the initial angle of inclination as parameters to be determined from the initial and boundary conditions. We then show that the specification of the initial velocity of the particle, which amounts to specifying both the initial speed and initial angle of inclination, in general leads to an inconsistent problem. We show that the following two problems have unique solutions: the initial value problem in which (in addition to the boundary conditions) the initial angle of inclination is given, or that in which the initial speed (kinetic energy) is specified.

Aplicación De Redes: A La Asignación De Cursos A Profesores Y Creación De Horarios

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En toda universidad o institución académica se tiene que crear una oferta de cursos que satisfaga en lo posible la demanda de los estudiantes. Pero esto obviamente no es un proceso trivial. Hay otras entidades que hay que tener en cuenta antes de crear la disponibilidad de cursos. La disponibilidad de profesores es claramente una de ellas, como también la disponibilidad de salones, la creación de horarios entre otras más. La mayoría de los profesores en el ambiente académico en especial en el ambiente universitario tienen otras obligaciones además de dictar sus cursos. Es esta la razón por la cual cada profesor escoge un horario que se le ajuste a sus necesidades, y esta claro que no todos los profesores tienen las mismas preferencias de horarios. Es importante saber que cada profesor desea dictar cursos que se relacionen con su área de interés. Aunque no siempre es esto posible, el departamento tiene que tratar de satisfacer en lo posible las preferencias de cada profesor. Este tema de investigación usa algoritmos de redes para hacer una asignación óptima a cada profesor de acuerdo a sus peticiones y luego asignarles los horarios correspondientes de acuerdo a sus peticiones. Para resolver este problema se utiliza el algoritmo simplex para redes y otros algoritmos de redes.

Finite Field Models For Genetic Networks

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Recently, several researchers have suggested the use of finite fields to model genetic networks. In the multivariable model of R. Laubenbacher [e.g., R. Laubenbacher and B. Stigler, "Dynamical Systems," Adv. in Appl. Math, Vol 26, 2001, pp 237-251], a genetic

network is a directed graph having n numbered nodes such that for each node i there is an associated function $f_i : GF(q)^n \rightarrow GF(q)$. In the univariable model proposed by O. Moreno et al [O. Moreno, D. Bollman, and M. Aviño, "Finite Dynamical Systems, Linear Automata, and Finite Fields," to appear in the International Journal of Computer Research], a genetic network consists of a directed graph having n numbered nodes and a function $f_i : GF(q^n) \rightarrow GF(q^n)$. In this work, we give algorithms for converting data from one model to the other and we compare the advantages and disadvantages of the two models.

La Ley de Newcomb-Benford y sus aplicaciones al Referendum Revocatorio en Venezuela, de Agosto 15, 2004

Luis Raúl Pericchi y David Torres, Universidad de Puerto Rico en Rio Piedras, Imre Mikoss, Universidad Simón Bolívar.

Se analizan los datos del del Referendum Revocatorio Presidencial realizado el 15 de Agosto del 2004, para revocar o no al presidente de Venezuela Hugo Chávez. Este proceso ha estado sujeto a controversia y la oposición presentó documentos en los que se señala que hay indicios de irregularidades y alteración de resultados. En este trabajo, se contrastan los datos con la llamada Ley de Newcomb-Benford, sobre la frecuencia de dígitos significativos, la cual se ha utilizado para detectar datos fraudulentos particularmente de evasión de impuestos. Este ejercicio además de ilustrar una metodología para detectar indicios de posible fraude electoral, motiva la necesidad de juzgar evidencia estadística respecto de hipótesis, en base a un enfoque de Estadística Bayesiana, en lugar del test de hipótesis clásico.

Reconcepciones Matemáticas

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Se presentará el proyecto Reconcepciones Matemáticas. Este consiste de un plan de intervención para las escuelas intermedias de los distritos escolares de Moca, San Sebastián y Mayagez. La propuesta incluye una pre prueba estandarizada de matemáticas y español, así como la distribución de un programado de monitoreo individualizado y continuo de los estudiantes y de materiales de intervención, con los que el programado construye soluciones individualizadas para cada estudiante. El equipo de trabajo incluye tutores que ayudarán a los maestros a insertar estas estrategias de intervención en sus salones de clases. Al final del proyecto se aplicara una post prueba estandarizada de matemáticas y español para determinar la efectividad del plan de intervención. La propuesta es una alternativa para poder atender poblaciones especiales en un salón de clases muy heterogéneo.

Niveles Matemáticos en la Enseñanza de la Física Universitaria

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El trabajo, o ponencia, destaca siete diferentes componentes que tiene el proceso de enseñanza-aprendizaje de la Física, y cómo estas componentes se deben ir profundizando en niveles de maduración sucesivos, cada uno de los cuales puede caracterizarse por un dominio diferente, conceptual y operatorio, de la Matemática. Se señalan los requerimientos matemáticos de cada nivel de estudio de la Física, se sugieren los tipos de carreras a los que pueden corresponder cada nivel matemático como nivel terminal, y se enfatiza la necesidad de madurar nivel por nivel antes de acometer el estudio del nivel más profundo de Física Universitaria (entendiendo por tal la Física del College, no la Física Teórica). Se presentará un manual, Problemas de Matemática en la Física, hecho por el ponente, con problemas de Física (con respuesta de todos, y solución por pasos de muchos), que pueden ser usados por profesores de Matemática en sus cursos. Los problemas están agrupados por las habilidades matemáticas exigidas: Areas y volúmenes; Trigonometría (en triángulos); Ecuaciones con una incógnita (algebraicas, trigonométricas, exponenciales); Sistemas de ecuaciones (lineales, cuadráticas y con funciones trigonométricas); Derivación e Integración (funciones potenciales, seno, coseno, exponencial y logarítmica). Cada problema presenta al final las ecuaciones necesarias para resolverlo y deja al profesor de Matemática, y al estudiante, desarrollar la vía de solución matemática adecuada.

Explorando la Biocomplejidad en un Curso Subgraduado Multidisciplinario

Elio Ramos, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao, Denny S. Fernández del Viso, Departamento de Biología, Universidad de Puerto Rico en Humacao.

Presentamos nuestras experiencias en el proceso de preparación y enseñanza de un curso subgraduado multidisciplinario en donde se combina la matemática, la biología, y la computación. El mismo se viene ofreciendo en la Universidad de Puerto Rico en Humacao desde el 2002 y ha contado con la participación de estudiantes de los programas de bachillerato en Matemáticas Computacionales y Biología. El curso, a cargo de dos profesores de los departamentos de Biología y Matemáticas, consiste de conferencias, trabajos computacionales de laboratorio, y un proyecto final de investigación utilizando como tema central el área de ecología de poblaciones. Durante el semestre los estudiantes tuvieron la oportunidad de realizar proyectos y trabajos de laboratorio en donde se enfatizó la construcción de simulaciones utilizando tres técnicas (i) el enfoque matemático tradicional, basado en la solución analítica y numérica de ecuaciones de diferencias y ecuaciones diferenciales lineales y no-lineales y álgebra de matrices (ii) el enfoque sistodinámico de Forrester: basado en la identificación de niveles, flujos, y bucles de

retroalimentación para la construcción de los modelos (iii) el enfoque basado en agentes: en donde se definen reglas de comportamientos a nivel de los individuos a partir de las cuáles emerge la complejidad. Contrastaremos los tres enfoques y como estos se complementan para facilitar la presentación y comprensión de temas multidisciplinarios avanzados. Específicamente discutiremos como el enfoque sistemodinámico de Forrester resulta ser una herramienta pedagógica efectiva al presentar el efecto del retardo en la dinámica de modelos del tipo logístico y Lotka-Volterra. Además, presentaremos algunas de las simulaciones construidas por los estudiantes, utilizando el enfoque basado en individuos, en las cuáles se incluyó la interacción de varias especies y la dimensión espacial de forma explícita.

Hurricane Landfall Statistics

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Hurricanes' landfall position and time forecasts are valuable at all time periods. During the last quarter century, no statistically significant improvement or degradation is noted for landfall positions forecasts. The improvement in landfall location and time forecast is indispensable for the emergency managers and the public. Storm preparations, evacuations and local economies depend on such predictions. Neumann and Pelissier (1981) evaluated landfall forecast position errors for the single forecast issued closest to the critical time for disseminating warnings (24 h before landfall) for all hurricanes and tropical storms that struck the United States between 1970 - 79. Powell and Abernson (2001) extended Neumann and Pelissier by conveying landfall forecast location and timing uncertainty as a function of forecast lead-time before landfall for all Atlantic basin tropical storms and hurricanes to strike the United States between 1976 and 2000. An update of Powell and Abernson's extension for 2002 and 2003 was developed using the same method. While the forecast time is closer to landfall, the position error is decreasing. Forecasts made within 40 hours of lead-time showed that the landfall was going to occur after the observed time. Forecasts made with more than 40 hours of lead-time showed that the landfall was occurring before the actual landfall occurred.

A generalized version of thermoviscoelasticity theory

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We generalize thermoviscoelasticity theory for a material consisting of two constituents: a solid and a liquid one. It is hoped that such a theory can adequately describe some aspects of thermodynamical deformations of common paper. A paper consists of a network

of cellulose fibres bonded together which exhibit viscoelastic behavior. It expands when wetted and shrinks on drying. Those phenomena are attributed to radial changes of fibres due to absorption of water and their radial shrinkage on drying. We employ a simplified approach to describe a continuum consisting of two constituents. At an instant of time it is characterized by positions of the material points of the mixture, temperature, density of mass and concentration of the liquid constituent. The balance equations for mass, linear momentum and specific energy contain other unknown quantities: stress tensor, heat flux and diffusion flux. The constitutive relations are obtained from an expression for the specific free energy, the entropy production principle plus certain generally accepted theoretical assumptions concerning near equilibrium thermodynamical processes. A system of linear partial integrodifferential equations is obtained generalizing that of Christensen–Naghdi. Next, it is reduced to describe isothermal processes and a relevant initial-boundary-value problem is formulated.

On the Cyclic Decomposition of Dickson Permutation Polynomials

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Let \mathbb{F}_q be the finite field with q elements, $a \in \mathbb{F}_q$. The *Dickson polynomial* $D_i(x, a)$ of degree i is defined by $D_i(x, a) = \sum_{j=0}^{\lfloor \frac{i}{2} \rfloor} \frac{i}{i-j} \binom{i-j}{j} (-a)^j x^{i-2j}$, where $\lfloor \cdot \rfloor$ is the greatest integer function. It is well known that, for $a \neq 0$, $D_i(x, a)$ permutes \mathbb{F}_q if and only if $\gcd(i, q^2 - 1) = 1$. For $a = 0$, $D_i(x, 0) = x^i$ permutes \mathbb{F}_q if and only if $\gcd(i, q - 1) = 1$.

The cycle structure of Dickson permutation polynomials for $a = 0, 1, -1$ has been studied by Lidl and Mullen (1991). Necessary and sufficient conditions for all the cycles of the permutations given by $D_i(x, 0) = x^i$ to have the same length (ignoring the fixed points), were presented in Rubio and Corrada (2004). In this work we present necessary and sufficient conditions for permutations given by $D_i(x, 1)$ to decompose in cycles of the same length.

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Noether's Theorem

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Noether's theorem is an amazing result which lets mathematical physicists get conserved quantities from symmetries of the laws of nature. Time translation symmetry gives conservation of energy; space translation symmetry gives conservation of linear momentum;

rotational symmetry gives conservation of angular momentum, etc. This result, proved in 1915 by Emmy Noether was praised by Einstein as a piece of "penetrating mathematical thinking". We present a short proof, then formulate this theorem in the modern language of Poisson manifolds, Hamiltonian systems and Lie groups and give new examples of conserved quantities, both in infinite dimensions and for supersymmetries.

Embedding lattices into subsemigroup lattices

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We are concerned with the following problem:

Given a class \mathcal{K} of lattices, describe the class $\mathbf{S}(\mathcal{K})$ of lattices embeddable into lattices from \mathcal{K} . In particular, is the class $\mathbf{S}(\mathcal{K})$ a variety?

A class \mathcal{K} of lattices is *lattice-universal* if any lattice embeds into a lattice from \mathcal{K} . In particular, $\mathbf{S}(\mathcal{K})$ coincides with the variety of all lattices, for any lattice-universal class \mathcal{K} . Among the known lattice-universal classes are the class of sublattice lattices of semilattices, the one of commutative nilsemigroups of index 2, the class of lattices of convex subsets of vector spaces, the class of suborder lattices of partial orders. Several examples of classes whose sublattice classes form a proper variety of lattices are also known.

The following two results concern some special classes of subsemigroup lattices and answer two questions from the monograph by L. N. Shevrin and A. Ju. Ovsyannikov *Semigroups and their subsemigroup lattices*, Dordrecht, Kluwer Academic publishers, 1996.

Theorem 2.1. *The class of lattices embeddable into subsemigroup lattices of n -nilpotent semigroups, is a finitely based variety, for any positive integer n .*

Theorem 2.2. *For any lattice L , for any cardinal number κ , the following are equivalent:*

1. *L embeds into the sublattice lattice of a free semilattice of rank κ ;*
2. *L embeds into the subsemigroup lattice of a free semigroup of rank κ ;*
3. *L embeds into the subsemigroup lattice of a free commutative semigroup of rank κ ;*
4. *L embeds into the subsemigroup lattice of a free commutative nilsemigroup of index 2 of rank κ ;*
5. *L embeds into the direct product of finite lower bounded lattices over a set of cardinality κ .*

Mesoscale Mathematical Modeling of Intercalation Materials

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Intercalation materials originally have been discovered by the Chinese about 2700 years ago. Today, the intercalation compounds form a basis for wide range of technologies from superconductors to catalysis. Since the early 1970s the intercalation compounds have been considered as electrode materials for rechargeable lithium batteries. In particular, the active materials in Li-ion battery cells operate by a topotactic reaction where lithium ions are reversibly removed or inserted into a host crystal without significant structural change of the host. In our study of this phenomenon we consider the inserted (removed) ions as charge singularities. We focus our attention at a scale that permits the detection of these types of singularities. Based on the electro-mechanical analogy we develop a mathematical model of the intercalation materials. This model is founded on a proposition of an existence an electrical stress field and an assumption that the internal electrical stress may appear because of the charge singularities in the material structures. For composite conductors with intercalation nano-compounds we combine the electrical stress model with the electromagnetic theory. In order to complete the two-phase model we propose constitutive relationships, which allow us to model the charge-discharge battery processing.

Model for Estimating Population Diversity as the Prediction of Sample needed for full Coverage with Applications in Bioinformatics

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There exist several methods for estimating population diversity using coverage. The biologist and environmental scientist challenge the statistician in order to solve such problem. Here we present an approach for the estimation using coverage model and a population estimator. We apply the method to a data given from microbial diversity presented in the crop of the Hoatzin by molecular analysis of cloned 16S RNA genes.

Thermal Convection in a Vibrating Layer of Viscous Fluid Heated from Above

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The effect of vibration on the stability of a fluid when heated from above is studied in the present work. The investigation is based on numerical solutions of nonlinear Boussinesq equations describing thermal gravitational convection in a fluid. In the absence of

vibration, the state of rest is stable with any heating from above. The presence of vibration leads to a qualitatively new effect: The state of relative rest loses stability when the Rayleigh number passes through a critical value, and nonsteady convective flow is created which oscillates with a frequency equal to half the modulation frequency.

The results obtained in the work allow one to draw an analogy with the problem of the motion of a pendulum with a vibrating suspension point. In the presence of vibration of the suspension point, the earlier unstable upper position of a physical pendulum becomes stable: The pendulum is inverted. In the case of convection, one can, with the help of vibration, produce instability of the fluid with heating from above and sustain a state of relative rest with heating from below.

Clasificación estadística a datos direccionales y su extensión a datos estándares

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Si se tiene un problema de clasificación supervisada donde los vectores de datos son direccionales, es decir, toman valores sobre una esfera k -dimensional, la aplicación de los métodos de reconocimiento de patrones tales como k -vecinos más cercano, análisis de discriminante y clasificación por estimación de densidad por kernel, no tienen buenos resultados en cuanto a tasa de error en la clasificación. Se propone para este tipo de problemas, algoritmos basados en k -vecinos más cercanos direccionales, en estimación de densidad por kernel direccional y en el análisis de discriminante direccional con el supuesto de distribución de von Mises-Fisher. Adicionalmente se presenta una extensión para utilizar los métodos de clasificación para datos direccionales en conjuntos estándar (no direccionales), basándose en la matriz de correlación entre individuos. Se ilustra el rendimiento de los métodos en conjuntos simulados, en datos estándar de aprendizaje de máquinas y en datos de expresión genética tomadas por medio de microarreglos.

Prime elements in a ring of polynomials over a UFD

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Using some properties about divisibility of polynomials, we prove that Unique Factorization Domains (UFD) satisfying certain conditions, have an infinitely many prime elements. This is a generalization of Euclid Theorem about prime integers. This also gives relation between polynomials and prime elements over a UFD . For example, it is well known that in the ring of integers, the primes p such that $p \equiv 1 \pmod{4}$ and the polynomial $x^2 + 1$ are related. We generalize this concept.

3 Talleres (*Workshops*)

Preguntas Conceptuales

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La mayoría de las preguntas que les hacemos a nuestros estudiantes en asignaciones y exámenes de matemáticas son preguntas de procedimientos algorítmicos o de procesos puramente mecánicos. Al limitarnos a preguntas de rutinas, los estudiantes ven las matemáticas como una colección de fórmulas y recetas en las que la destreza cognitiva que más se requiere es la memorización. Habrán observado estudiantes que terminan cursos de matemáticas y hasta grados universitarios en matemáticas y no conocen cuáles son las grandes ideas ni los conceptos unificadores en las matemáticas. Para cambiar esta situación y motivar a nuestros estudiantes a que profundicen su entendimiento conceptual de las matemáticas, tenemos que plantearles preguntas relevantes a su realidad que requieran competencias cognitivas de alto nivel de pensamiento y dominio de las ideas grandes de las matemáticas. Una forma efectiva de desarrollar estas competencias es mediante la solución de problemas pertinentes e interesantes que soliciten la explicación del razonamiento matemático requerido y la interpretación del resultado en el contexto del problema. Este enfoque demanda de estrategias distintas de enseñanza aprendizaje en las matemáticas. En esta presentación se discutirán estrategias y ejemplos que permiten que los educadores distingan entre preguntas conceptuales y preguntas mecánicas. También discutiremos estrategias para el desarrollo de preguntas conceptuales en las matemáticas, basadas en el modelo constructivista y de aprendizaje activo, que fomentan el desarrollo de competencias de pensamiento crítico.

How do the components and structure of a curriculum affect the content knowledge of mathematics teachers?

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The design of school curriculums shapes the future of our societies and defines the skills acquired by their citizens. While making decisions about designing a new curriculum one should not only consider the needs in the discipline taught, but also the social and professional consequences on the learners and the educators of that discipline. This work-session proposes to engage the participants in discussing and comparing various trends in curriculum design, in relation to their effects on mathematics teachers' content knowledge and their consequences on the quality of mathematics and science instruction. The current needs of the Puerto Rican society and the cultural diversity of our research team has triggered doubts and discussions on which is the best curriculum design to choose

depending on three different perspectives: the students', the teachers', and the teacher educators'. In this session we want to bring this cultural diversity to a larger scale and get the audience involved in comparing various types of curriculum from different countries and different philosophies; a task which should engage participants to discuss three major themes: 1. Defining the relationship between teachers' content knowledge and the curriculum in order to support in-service teachers' professional enrichment. 2. Designing curriculum for teaching with understanding, in the light of cultural considerations. 3. Implementing and changing a curriculum according to social demands. We will ask the audience to participate in group discussions aimed at defining research approaches to a list of questions related to these themes. In order to support the discussion, relevant material such as curriculum samples from France, Colombia, Puerto Rico, Canada, USA among others, as well as textbooks and curriculum material, will be provided. The expected outcome is to define guidelines on how to best cooperate in bridging Mathematics and Science education with the needs and demands of our society.

4 Afiches (*Posters*)

Intelligent Driver Model

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Differential equations allow us to simulate complex systems; using this and the dynamic vision we developed a system dynamic simulation of traffic flow. Our main objective was to find a model where the acceleration and velocity were controlled, such that, the collisions among the vehicles were avoided. Necessary elements were identified to create a system dynamic model; such as, levels, converters and flows, as well as the connection that should have among these. To these parameters were assigned real values of a vehicular traffic flow so that the model resembled what we face in our daily routine. We carried out analysis of sensibility; positive and negative loops of retro alimentation were identified, and we begin to work with the leverage of the model. We will show that even in adverse conditions the Intelligent Driver Model (IDM) avoids the collisions totally.

Analysis of Some Properties of Interleavers for Turbo Codes

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Advisor: Ivelisse Rubio, Department of Mathematics, University of Puerto Rico at Humacao.

Errors during information transmission on digital communication are repaired using error control codes. A class of very important error correcting codes are turbo codes because of their low error rate without much energy consumption. By making use of the permutations given by monomials over a finite field F_p it is possible to construct interleavers (an important component of the turbo encoder) with good performance. Since their construction is algebraic it is also possible to characterize monomials that produce permutations with certain properties and, hence, predetermine the properties of the interleavers.

Some important properties we need to consider when constructing an interleaver are the dispersion and spreading factors. Some of our results relate the spreading and dispersion, as well as other factors, with the permutation monomial. In the special case in which $3|(p-2)$ we have characterized monomials with permutations of optimal dispersion as well as good spreading factors. We discuss these and other results related to it.

Solute Flow In A Two-Dimensional Channel With Water-Permeable Walls

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Existing mathematical models that describe water-ion exchange process in renal tubules have been formulated at two different levels of complexity. One approach describes physiological and morphological properties of the system, as a whole, in one-dimensional space variables. A typical model in this category describes the interaction of descending limb of Henle (DLH), ascending limb of Henle (ALH), ascending and descending vas recta (AVR and DVR, respectively), and collecting duct (CD) system. The other approach formulates one-dimensional mathematical models that describe the exchanging processes at the molecular level in a segment of a renal tubule. In this work, we modeled a segment of a renal tubule (e.g., the upper part of the DLH) as a two-dimensional channel with rigid walls. We showed that in a renal tubule the fluid flow is governed by the Stokes equations. Thus, the model consists of a Stokes system of equations coupled with a diffusion-advection equation for the solute with appropriate initial and boundary conditions. We used perturbation methods to obtain approximate steady-state solutions and compared these solutions with the corresponding solutions of the one-dimensional model.

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Conjuntos dominadores perfectos en reticulados

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Se dice que un conjunto dominador S de un grafo G , es perfecto (brevemente PDS), si todo vértice de $G \setminus S$ es adyacente exactamente a un vértice de S . El problema de encontrar un PDS minimal en un grafo planar es NP-completo. Lo mismo es cierto para el problema de encontrar un PDS aislado en un grafo. Esto justifica considerar problemas de existencia de conjuntos dominadores perfectos con condiciones iniciales. En este sentido, presentamos un algoritmo de decision binaria para la búsqueda de aquellos PDS en reticulados rectangulares que extienden a un conjunto de vertices admisibles (el conjunto condición inicial) de uno de sus caminos laterales. Los grafos inducidos por los complementos de estos conjuntos dominadores se representan por un arreglo de pares ordenados de numeros enteros. Se estudian estos arreglos desde un punto de vista algorítmico, permitiéndonos una caracterización de las partes periódicas de los PDS en consideración.

On the Inverse Cusick-Dobbertin Binary m -Sequences

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Let \mathbb{F}_q be a finite fields with $q = 2^n$ elements and let d be a positive inter less than $2^n - 1$. We use the notattion

$$\chi(y) = (-1)^y \text{ where } y \in \mathbb{F}_2.$$

Let

$$u = (a_0, \dots, a_j, \dots)$$

and

$$u[d] = (a_0, a_d, a_{2d}, a_{3d}, \dots, a_{jd}, \dots),$$

denote two binary maximum-length linear shift register sequences(m -sequences) of degree n , so $(d, q - 1) = 1$ and both sequences have period $2^n - 1$. The period crosscorrelation function $C_d(t)$ for u and $u[d]$ is defined by

$$C_d(t) = \sum_{j=1}^{2^n-2} \chi(a_{jd} + a_{j+t}) \quad t = 1, 2, \dots, 2^n - 2.$$

It is known that the crosscorrelation spectrum (values of $C_d(t)$) depends only the d and not on the choice of the m -sequence u . The earliest work on the problem of determining crosscorrelation spectra seems to be due to Gold and Kasami. T. Cusick and H. Dobbertin found a new family of m -sequences with three values : *Let n be even and $n = 2m$ is odd. If $d = 2^m + 2^{(m+1)/2} + 1$, then the spectrum of $C_d(t)$ has precisely three values.*

It is well that if the spectrum of $C_d(t)$ has precisely three values, then the spectrum of $C_{d-1}(t)$ also has three values.

We will compute the inverse of the d given by Cusick-Dobbertin's result.

Una Comparación en Técnicas de Validación de Conglomerados

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Reconocimiento de patrones es la disciplina científica cuyo motivo principal es clasificar objetos en categorías o clases. Dicha clasificación se puede hacer de varias maneras dependiendo del tipo de base de datos que se tenga. Tenemos la clasificación supervisada y la clasificación no-supervisada o clasificación usando conglomerados. Nuestra investigación se concentra en clasificación usando conglomerados, en este caso tenemos bases de datos donde no se conoce a priori a que clase pertenece cada objeto. El motivo principal será revelar la organización de los objetos en la base de datos y dividirlos a medida que se descubren semejanzas y diferencias entre los objetos. Una vez se tienen los conglomerados usando algoritmos de conglomerados, debemos evaluar cuantitativamente los resultados de dicho algoritmo. Las técnicas de validación de conglomerados son las medidas que se utilizan para evaluar los resultados obtenidos. Cuando hablamos de técnicas de validación de conglomerados nos estamos refiriendo a medidas que se utilizan para encontrar la cantidad apropiada de conglomerados o grupos en la que se debería dividir una base de datos. Durante esta investigación se pretende comparar algunas de las técnicas de validación usando diferentes bases de datos y encontrar cual técnica es apropiada dependiendo de la base de datos que se tenga.

Estudio de sistemas dinámicos finitos afines biyectivos

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Un sistema dinámico finito (SDF) es un par (V, f) , donde V es un conjunto finito y $f : V \rightarrow V$ es una función. Si V es un espacio vectorial y f es lineal entonces tenemos un sistema dinámico finito lineal. En las aplicaciones a la genética lo que más interesa es el espacio de estados del SDF, es decir el digrafo que tiene por vértices a V y por aristas los pares ordenados $(x, f(x))$, $x \in V$. Recientemente se obtuvo la descripción completa del

espacio de estados (EE) de un SDF lineal, por esto estamos estudiando el EE de una clase de funciones relacionadas con las lineales, las llamadas afines. Un sistema dinámico afín es un par (V, f) donde $V = \mathbb{Z}_p^n$, y f es la suma de una función lineal y una traslación. Presentamos algunas propiedades de los EE de los SDF lineales afines biyectivos.

Filtered Products in Algebraic Structures

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We studied the concepts of filter and filtered product, which is an operation defined for families of sets (in our case these families consisted of certain algebraic structures). A filter F on a nonempty set I , is a nonempty collection of subsets of I satisfying: 1) the empty set does not belong to F , 2) if $A, B \in F$ then $A \cap B \in F$, and 3) if $A \in F$ and A is contained in B and B is contained in I , then $B \in F$. Meanwhile, the filtered product A_i/F is defined in the following way: let I be a set of indices, F a filter on I , A_i sets with $i \in I$. Then $a \in \prod A_i/F$ if and only if $\{i \in I : a \in A_i\} \in F$.

One of the results that we found is that the filtered product of subgroups of a group G is also a subgroup. We also found analogous results for the following structures: sublattices of a lattice L , ideals of a ring R , and radical ideals of a commutative ring S . When we studied the filtered product of prime ideals and the filtered product of a finite collection of primary ideals, it was found that, in general; this conclusion is not true. We also studied the concept of an ultrafilter on I , which is a filter on I with the additional property that if A is a subset of I , then $A \in F$ or $I - A \in F$. Using ultrafilters instead of filters, we obtained similar results for the mentioned structures.

Permutaciones de \mathbb{Z}_q construidas utilizando diferentes ordenes de monomios

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Una permutación es un arreglo ordenado de un conjunto. Un monomio x^i en $\mathbb{F}_q[x]$ produce una permutación del cuerpo finito \mathbb{F}_q si y solo si $\gcd(i, q - 1) = 1$. Nosotros construimos permutaciones de \mathbb{Z}_q de la siguiente manera: Primero asociamos los elementos de \mathbb{F}_q , $q = p^r$, p primo, a r -tuplos de enteros no-negativos. Luego ordenamos los elementos con diferentes ordenes de monomios. De esta manera se asocian los elementos de \mathbb{F}_q a los elementos de \mathbb{Z}_q . Finalmente aplicamos el monomio x^i para producir la permutación.

Demostremos que permutaciones obtenidas con otros métodos también se pueden obtener con estos ordenes de monomios. Además, utilizando estos ordenamientos obtenemos también permutaciones nuevas para nosotros, algunas de las cuales tienen mejores propiedades de dispersión y esparcimiento que las ya conocidas.

An Optimization Problem for a $\text{Na}^+\text{-K}^+\text{-2Cl}^-$ Cotransporter Model

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An optimization technique was used to compute parameters sets that lead to solutions in agreement to experimental results for a kinetic model of a $\text{Na}^+\text{-K}^+\text{-2Cl}^-$ cotransporter. A cotransporter is an enzyme that mediates the transport of the ions from the cytosol to the lumen and vice versa through a cell membrane. The model parameters consist of reaction rates, disassociation and binding constants, and ion concentrations. The model consists of a system of ordinary differential equations (ODE) for different enzymatic states. From the ODE solution the maximum reaction speed (V_{\max}), which is obtained when all the enzyme had formed the complex with the substrate, and half-maximum reaction speed (K_s) were computed. The optimization problem seeks a set of parameters, within the parameter ranges, that yields values of V_{\max} and K_s “close” to the values reported in the literature. The model equations and the optimization problem were solved numerically and different optimization algorithms were used to solve the optimization problem.

Interpolación de Kernels que Satisfacen Condiciones de Momentos Discretos

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Dado el valor de una función en una rejilla uniforme se desarrollará una técnica para la reconstrucción de la función entre los puntos de la rejilla. La técnica requiere el diseño de un Kernel en un intervalo y que satisface condiciones de momentos discretos. La precisión de la interpolación depende del número de condiciones de momentos que el Kernel satisface. Se considerarán dos clases de Kernel usando polinomios definidos por pedazos: uno con el número máximo de derivadas continuas posibles y otro sin ninguna restricción de regularidad. Se demostrará que estos Kernel están hechos para satisfacer numerosas condiciones de momentos discretos probando que el grado del Spline y el intervalo son suficientemente amplios. Incluimos resultados sobre la precisión máxima que se puede obtener usando los Kernels y ejemplos en una dimensión.

Uniform Central Graphs and Variations of Hypercubes

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An important area of graph theory, especially for industrial telecommunications, is the study of centers of graphs. In particular, we would like to study the so-called Uniform Central Graph (UCG). A graph G is called Uniform Central Graph or UCG if the eccentric sets of all central vertices are the same (Choi and Manickman 1988). The objective of our investigation is the construction of UCG's with any given diameter and radius. In addition our construction shows that there are UCG's with any graph as its center. Also we study the construction of UCG in Hypercubes or Boolean Cube and the subgraphs of hypercube which are called the Fibonacci Cube (Wen-jing, H 1993), the complement of the Fibonacci Cube (Wang, L 2004), and the Lucas Cube (Murani, et al 2001).

Simulación de Flujo de Fluidos en Mems y Nems

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Es conocido que los modelos tradicionales para modelar flujo de fluidos a nivel macroscópico basados en ecuaciones de Navier-Stokes no necesariamente aplican a escalas a nivel micrométrico o nanométrico. Para flujos de líquidos, es imperativo considerar la creciente importancia de las condiciones de frontera, los gradientes de tensión superficial y las características hidrofílicas o hidrofóbicas del material. Los métodos numéricos en estas escalas pueden dividirse en dos categorías principales: discretas (atomistas) y continuas. Los métodos discretos pueden ser combinados con métodos Monte Carlo para aumentar su eficiencia computacional. Pero incluso con esa modificación los métodos discretos son demasiado intensos computacionalmente como para ser prácticos mas allá de escalas de tiempo diminutas. Los métodos continuos pueden estar basados en métodos de elementos finitos (basados en mallas) o sin mallas. Pero a pesar de su eficiencia computacional, su aplicabilidad a estas escalas es cuestionable.

En esta presentación se expondrá el planteamiento general del problema del uso combinado de técnicas discretas y continuas basadas en mallas que permitan construir simulaciones realistas de flujo de fluidos para configuraciones geométricas simples.

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Uso de polinomios ortogonales de gauss-hermite en modelos marginalizados

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En los estudios longitudinales se toman las observaciones sobre una misma unidad secuencialmente de tal manera que se genera dependencia entre ellas. Una forma de encarar este problema es introduciendo efectos aleatorios suponiendo formas distribucionales conocidas de tal manera que se describa la estructura de dependencia. Este enfoque genera los denominados modelos lineales mixtos generalizados o GLMM. El análisis marginal de este tipo de modelos mediante verosimilitud permite encontrar la distribución marginal de la variable respuesta también conocida como distribución marginal inducida o “marginalizada”. El objetivo principal en la tesis es estudiar la distribución marginal inducida en algunos modelos específicos. Sin embargo, el principal problema de estudiar las distribuciones marginales inducidas es que por lo general, las integrales involucradas en los cálculos no tiene una solución analítica, siendo necesario el uso de técnicas de integración numérica tales como la cuadratura de Gauss-Hermite, la cual tiene un uso frecuente en este contexto por su relación directa con la distribución normal. Este trabajo presenta la parte inicial de la tesis, la cual muestra un modelo logístico-normal con su aplicación a una base de datos real. También se expone el uso del programa **R** en integración numérica.

Estudio de sistemas dinámicos finitos afines nilpotentes

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Un sistema dinámico finito lineal (SDF) sobre \mathbb{Z}_p es un par (E, F) , donde E es un espacio vectorial de dimensión finita sobre \mathbb{Z}_p y f es una función lineal. En las aplicaciones lo que más interesa es los espacios de estados (EE) del SDF, es decir el digrafo que tiene por vértices a E y por flechas los pares ordenados $(x, f(x))$, $x \in E$. Entre las aplicaciones de los SDF se encuentra la descripción de las redes genéticas. En este trabajo presentamos propiedades de los sistemas dinámicos (E, f) donde $p = 2$ y f es la suma de una función lineal nilpotente y de una traslación, es decir de los SDF afines y nilpotentes. Se tiene la siguiente conjetura: Para todo SDF (X, f) existe un FDS lineal o afín (Y, g) que extiende (X, f) , es decir que el EE de (X, f) es un subdigrafo del EE de (Y, g) . Para poder demostrar esto es necesario describir los EE de los SDF afines y estamos trabajando en esta dirección. Recientemente el Dr. Hernández (UPR-Cayey) obtuvo la descripción completa de un SDFL, por esto en este trabajo se establecen relaciones del EE de las funciones lineales con el de las afines.

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