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*Fernando E. Berríos Cádiz*, Departamento de Matemáticas, Universidad de  
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*José O. Sotero Esteva*, Departamento de Matemáticas, Universidad de Puerto  
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*Thomas Seaquist*, Department of Mathematics, University of Texas at Arling-  
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*Marcel Muñoz Figueroa*, Department of Engineering, Turabo University

*Christopher Kribs Zaleta*, Department of Mathematics, University of Texas  
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**A tale of regions: a mathematical model for Chagasa disease,**

*Glorimar Meléndez-Rosario*, Department of Mathematical Sciences, Univer-  
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**Optimized strategies for the Mastermind game,**

*Luis O. Miranda Rivera*, Department of Computer Science , University of  
Puerto Rico at Río Piedras

*Javier Cordova*, Department of Computer Science, University of Puerto Rico  
at Río Piedras

*Joel M. Quiles Baker*, Department of Computer Engineering, University of  
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**Parameter estimation for a mathematical model of the sec-dependant translocation system,**

*Monica Nadal*, Department of Mathematics, University of Puerto Rico, Rio Piedras Campus

*Mariano Marcano*, Department of Computer Science, University of Puerto Rico, Rio Piedras Campus

*Monika Musial-Siwiek*, Department of Computer Science, University of Puerto Rico, Rio Piedras Campus

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*Abner J. Ortiz-Camacho*, Department of Mathematics, University of Puerto Rico at Humacao

*Greichaly Cabrera-Cruz*, Department of Mathematics, University of Puerto Rico at Humacao

*Pablo Negrón-Marrero*, Department of Mathematics, University of Puerto Rico at Humacao

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**Programacion con GPUs: alternativas ante la disyuntiva entre transferir datos o regenerarlos,**

*Axel Y. Rivera Rodríguez*, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao

*John E. Morales García*, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao

*José O. Sotero Esteva*, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao

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**Computational implementation of the procrustes analysis for biological uses: bee hybridization,**

*Elisamuel Santiago Ramírez*, Escuela de Ingeniería, Universidad Interamericana de Puerto Rico, Recinto de Bayamón

*Rafael Canales*, Departamento De Ciencias y Matemáticas, Universidad Interamericana de Puerto Rico, Recinto de Bayamón

*Bert Rivera*, Departamento de Ciencias y Matemáticas, Universidad Interamericana de Puerto Rico, Recinto de Bayamón

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# 1. Itinerario global (Global schedule)

Viernes							
Hora	Vestíbulo	Anfiteatro	Q 123	Q 124	Q 125	Q 150	Q 151
<b>Viernes</b>							
4:00-5:00	Registro						
5:00-5:25			D. Collins	R. Arce	E. Suazo	R. Martinez	
5:30-5:55			G. McKee	P. Musial	E. Montes	B. Santiago	
6:00-6:50	Cárteles (Posters)						
7:10-8:00		J. Gúzman					
8:15-9:30	<b>Actividad de Confraternización - Jardines Casa del Rector</b>						
Sábado							
Hora	Vestíbulo	Anfiteatro	Q 123	Q 124	Q 125	Q 150	Q 151
8:00-9:00	Registro						
8:00-9:00	<b>Desayuno - Centro de Estudiantes</b>						
9:00-9:30	Inauguración						
9:30-10:20	R. Nochetto						
10:35-11:00			K. Rios	Xuerong Yong	R. Reyes	E. Perez	
11:00-11:15	<b>Merienda</b>						
11:15-11:40			M. Marcano	F. Castro	A. Vélez	J. Ortiz	
11:45-12:10			A. Nieves	E. Orozco	P. Negrón	S. Molina	
12:15-1:20	<b>Almuerzo - Centro de Estudiantes</b>						
1:30-1:50	Cárteles (Posters)						
1:55-2:20			L. Gordillo	R. Arce	M.E. Pérez	J. Ramos	A. Villanueva
2:25-2:40	<b>Merienda</b>						
2:45-3:35		J. L. Menaldi					
3:50-4:15			J. Vélez	A. Cruz	F. Acosta	F. Sequeira	
4:20-4:45			C. Calderón	J. Farrington	L. Jaimes	N. Gozzer	
4:45-5:15		S. Administrativa					

## 2. Itinerario Detallado (Detailed Schedule)

Horario	Lugar	Actividad
<b>Viernes 26 de febrero</b>		
4:00-5:00	Vestíbulo Edificio de Química	<b>Inscripción y Registro</b>
4:00-9:00	Vestíbulo Edificio de Química	<b>Mesas de Exhibición</b>
5:00-5:25		<b>Conferencias Concurrentes</b>
	Q 123	<i>Toward a mathematical origin of species,</i> Dennis Collins.
	Q 124	<i>The Reconfigurable Computing Laboratory at UPR RP,</i> <u>Rafael A. Arce-Nazario</u> and Edusmildo Orozco.
	Q 125	<i>An approach to construct explicit solutions for Schrodinger equations with time dependent Hamiltonians,</i> Erwin Suazo.
	Q 150	<i>El entendimiento de funciones de dos variables: dominio, rango, unicidad de valor y representaciones,</i> Rafael Martinez Planell.
5:30-5:55		<b>Conferencias Concurrentes</b>
	Q 123	<i>Mathematica 7 in education and research,</i> <u>Ginger Mcgee</u> and Michael Morrison.
	Q 124	<i>Efficient implementation of atomic multi writer-multi reader distributed memory,</i> Burkhard Englert, Chryssis Georgiou, <u>Peter Musial</u> , Nicolas Nicolau, and Alexander Shvartsman.
	Q 125	<i>Violation of the complementing condition and local bifurcation in nonlinear elasticity,</i> Pablo V. Negrón-Marrero and <u>Errol Montes-Pizarro</u> .
	Q 150	<i>Avaluación de destrezas de educación general en el curso de precálculo,</i> <u>Bárbara Santiago</u> e Idalyn Ríos.
6:00-6:50	Vestíbulo	<b>Sesión de Afiches</b>
		<i>Some properties of latin squares - study of mutually orthogonal latin squares,</i> <u>Jeranfer Bermúdez</u> and Lourdes M. Morales.
		<i>Estudio comparativo entre C para CUDA y OpenCL,</i> <u>Jorge A. Fernandez Vidro</u> and José O. Sotero Esteva.
		<i>A simple multinephron model for the urine concentration mechanism,</i> <u>Guillermo Fontánez</u> and Mariano Marcano.

Horario	Lugar	Actividad
		<i>Robust bayesian approach to the analysis of finite population surveys,</i> Jairo Alberto Fuquene Patino.
		<i>Tabla de mortalidad de Puerto Rico,</i> Grisel Hernández Carrasquillo y Alberto Cáceres Díaz.
		<i>Cómputo de cantidad de caminos y polígonos sin intersecciones en una rendija cuadrículada,</i> Francheska I. Lebrón López, Fernando E. Berríos Cádiz, y José O. Sotero Esteva.
		<i>Two strain competition: Trypanosoma cruzi,</i> Xavier Martínez Rivera, Thomas Seaquist, Marcel Muñoz Figueroa, and Christopher Kribs Zaleta.
		<i>Software APKG, de algebra de productos Kronecker a grafos,</i> Richard Martínez y Rafael A. Arce-Nazario.
		<i>A tale of regions: a mathematical model for Chagasa disease,</i> Glorimar Meléndez-Rosario.
		<i>Optimized strategies for the Mastermind game,</i> Luis O. Miranda Rivera, Javier Cordova, and Joel M. Quiles Baker.
		<i>Parameter estimation for a mathematical model of the sec-dependant translocation system,</i> Monica Nadal, Mariano Marcano, and Monika Musial-Siwiek.
		<i>Finite element method simulations of composite materials,</i> Abner J. Ortiz-Camacho, Greichaly Cabrera-Cruz, and Pablo Negrón-Marrero.
		<i>Programación con GPUs: alternativas ante la disyuntiva entre transferir datos o regenerarlos,</i> Axel Y. Rivera Rodríguez, John E. Morales García, y José O. Sotero Esteva.
		<i>Computational implementation of the procrustes analysis for biological uses: bee hybridization,</i> Elisamuel Santiago Ramírez, Rafael Canales, and Bert Rivera.
7:10-8:00	Anfiteatro de Enfermería	<b>Conferencia Plenaria</b> <i>Finite element methods for linear elasticity,</i> Johnny Guzmán
8:15-9:30	Jardines Casa del Rector	<b>Actividad de Confraternización (Cóctel)</b>

Horario	Lugar	Actividad
<b>Sábado 27 de febrero</b>		
8:00-9:00	Centro de Estudiantes	<b>Desayuno</b>
8:00-9:00	Vestíbulo Edificio de Química	<b>Inscripción y Registro</b>
8:00-4:00	Vestíbulo Edificio de Química	<b>Mesas de Exhibición</b>
9:00-9:30	Anfiteatro de Enfermería	<b>Inauguración</b>
9:30-10:20	Anfiteatro de Enfermería	<b>Conferencia Plenaria</b> <i>Fluid biomembranes: modeling and computation,</i> Ricardo Nochetto.
10:35-11:00		<b>Conferencias Concurrentes</b>
	Q 123	<i>On the spatio temporal disease dynamics in populations with discrete time dynamics in one and two spatial dimensions,</i> Karen R. Ríos-Soto.
	Q 124	<i>The asymptotic number of spanning trees in circulant graphs ,</i> Mordecai J. Golin, Xuerong Yong, and Yuanping Zhang.
	Q 125	<i>Comparison of elastic plate theories for micropolar materials,</i> Lev Steinberg and Roberto Carlos Reyes Carranza.
	Q 150	<i>Hiperbolicity and genuine nonlinearity conditions for certain p-systems of conservation laws, weak solutions and the entropy condition,</i> Edgardo Pérez and Krzysztof Rózga.
11:00-11:15		<b>Merienda</b>
11:15-11:40		<b>Conferencias Concurrentes</b>
	Q 123	<i>Mathematical model for the urine concentrating process in the undeveloped kidney of rats,</i> Mariano Marcano.
	Q 124	<i>On the number of solutions of <math>\sum_{i=1}^k \frac{1}{x_i} = 1</math> in distinct odd natural numbers,</i> Rafael A. Arce-Nazario, Francis Castro, and Raúl Figueroa.
	Q 125	<i>The non local Robin Laplacian on extension domains,</i> Alejandro Vélez Santiago.
	Q 150	<i>Teoría de nudos y homología de Khovanov,</i> Juan Ortíz Navarro.
11:45-12:10		<b>Conferencias Concurrentes</b>

Horario	Lugar	Actividad
	Q 123	<i>A Lyapunov function for an epithelial cell model of the thick ascending limb,</i> Aniel Nieves-González.
	Q 124	<i>A parallel algorithm for computing the period of strongly connected components,</i> <u>Edusmildo Orozco</u> and Dorothy Bollman.
	Q 125	<i><math>W_{1,p}</math> quasi convexity and fracture surfaces in strain space,</i> Pablo V. Negrón-Marrero and Jey Sivaloganathan.
	Q 150	<i>Torsion and the K-theory of a recursive subhomogeneous algebra,</i> Sandro Molina Cabrera.
12:10-1:20	Centro de Estudiantes	<b>Almuerzo</b>
1:30-1:50	Vestíbulo de Edificio de Química	<b>Afiches</b>
1:55-2:20		<b>Conferencias Concurrentes</b>
	Q 123	<i>The effects of reducing mating likelihood on population viability,</i> Luis Gordillo.
	Q 124	<i>A systolic array based architecture for implementing multivariate polynomial interpolation tasks,</i> <u>Rafael A. Arce-Nazario</u> , Edusmildo Orozco, and Dorothy Bollman.
	Q 125	<i>Let the outstanding be outstanding: Roberto Clemente and fully robust Bayesian hierarchical models in baseball prediction,</i> Luis Raúl Pericchi and <u>María-Eglée Pérez</u> .
	Q 150	<i>Interior operators and topological connectedness,</i> Gabriele Castellini and <u>Josean Ramos</u> .
	Q 151	<i>Mathematics and string theory,</i> Alfredo Villanueva.
2:25-2:40		<b>Merienda</b>
2:45-3:30	Anfiteatro de Enfermería	<b>Conferencia Plenaria</b> <i>From Calculus to Stochastic Optimal Control,</i> José L. Menaldi.
3:50-4:15		<b>Conferencias Concurrentes</b>
	Q 123	<i>Universal deformation rings of modules over self-injecting algebras,</i> José Velez.
	Q 124	<i>A new algorithm for modular multiplication,</i> <u>Arnaldo Cruz</u> and Dorothy Bollman.
	Q 125	<i>The envelop test, extending then normality plot,</i> <u>Felipe Acosta Archilla</u> and Wolfgang Rolke.

<b>Horario</b>	<b>Lugar</b>	<b>Actividad</b>
	Q 150	<i>Aspectos computacionales del método “Local Discontinuous Galerkin” para mallas no estructuradas en 3D,</i> Filánder Sequeira Chavarría y Paul Castillo.
4:20-4:45		<b>Conferencias Concurrentes</b>
	Q 123	<i>Métodos de optimización en la solución de un problema de la industria editorial,</i> Cindy Calderón Arce y Pedro Vasquez Urbano.
	Q 124	<i>Some experiments with reduced linear modular systems,</i> José J. Farrington Zapata and Edusmildo Orozco.
	Q 125	<i>A methodology for the selection development of the parameter <math>m</math> in Fuzzy <math>c</math>-means: a computational approach,</i> Luis Gabriel Jaimes Bocarejo and Vicenc Torra.
	Q 150	<i>Reexperimentación: nuevo método para la recuperación de parámetros,</i> Nitzy Ruth Gozzer Lozada y Arturo Portnoy.
4:45-5:15	Anfiteatro de Enfermería	<b>Sesión Administrativa</b>

### **3. Resúmenes de Conferencias Plenarias** *(Abstracts of Invited Presentations)*

#### **Finite element methods for linear elasticity**

*Johnny Guzmán, Brown University, Providence, RI.*

Finite element methods are widely used to approximate solutions of many type of partial differential equations. In this talk, I will give a short overview of finite element methods for linear elasticity. I will compare methods that are based on displacement, stress-displacement, stress-displacement-rotation formulations of elasticity. In particular, I will discuss in depth recently introduced mixed finite elements for the stress-displacement-rotation formulation.

#### **Fluid Biomembranes: Modeling and Computation**

*Ricardo Nochetto, Department of Mathematics and Institute for Physical Science and Technology, University of Maryland.*

We study two models for biomembranes. The first one is purely geometric since the equilibrium shapes are the minimizers of the Willmore energy under area and volume constraints. We present a novel method based on ideas from shape differential calculus. The second model incorporates the effect of the inside (bulk) viscous incompressible fluid and leads to more physical dynamics.

We use a parametric approach, which gives rise to fourth order highly nonlinear PDEs on surfaces and involves large domain deformations. We discretize these PDEs in space with an adaptive finite element method (AFEM), with either piecewise linear or quadratic polynomials, and a semi-implicit time stepping scheme. We employ the Taylor-Hood element for the Navier-Stokes equations together with iso-parametric elements, the latter being crucial for the correct approximation of curvature. We discuss several computational tools such as space-time adaptivity and mesh smoothing.

We also discuss a method to execute refinement, coarsening, and smoothing of meshes on manifolds with incomplete information about their geometry and yet preserve position and curvature accuracy. This is a new paradigm in adaptivity.

This work is joint with Andrea Bonito and M. Sebastian Paulette.

#### **From calculus to stochastic optimal control**

*José L. Menaldi, Wayne State University.*

We begin with a typical linear quadratic regulator, where we present four basic questions, namely, identification, controllability, stabilization and observability. Also, we mention more general

models.

Next, we comment on the two main arguments for solving optimal control problems, i.e., the Pontryagin maximum principle and the Bellman dynamic programming. At this point, we want to incorporate some degree of uncertainty to the model and we remark a dramatic change in the mathematical setting. When modeling the noise of the system, we model the evolution of the state as a Stochastic Differential Equation (SDE), where new notions of differentiation and integration are needed. The technical difficulties are so deep, that several chapters are required to deal with the SDE, as an example, we note the technical aspect of the so-called controlled diffusion with jumps in a  $d$ -dimensional space. Finally, we present a simple linear quadratic Gaussian model (based on recent joint papers), where a simple practical change in the initial model produces serious consequences in the mathematical arguments.

## 4. Resúmenes de Conferencias Concurrentes (*Abstracts of Concurrent Presentations*)

### The envelope test, extending the normality plot

*Felipe Acosta Archila*, Department of Mathematics, University of Puerto Rico in Mayagüez  
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We are interested in constructing a formal hypothesis test for normality on top of a graphical procedure. In order to accomplish this, we will add a confidence band to a normality plot. One problem with this approach is that we do not have an analytical form for the confidence band therefore we resort to a Monte Carlo simulation to find an approximation to it. The resulting procedure is what is called the envelope test.

Then we compare the envelope test to other classical normality tests by looking at their power against different alternative distributions, showing that the proposed test is, in most cases, comparable to these.

We also present the differences between the envelope test and other similar procedures available in scientific and commercial software and show that these do not calculate a total coverage confidence band of the appropriate level.

**Keywords:** normality test, envelope, monte carlo

## The Reconfigurable Computing Laboratory at the UPR-RP

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The Reconfigurable Computing Laboratory (RCLab) is being established at the University of Puerto Rico Río Piedras campus, funded by a Major Research Instrumentation award from the National Science Foundation. Reconfigurable computers (also known as hybrid computers) combine the ease of programmability of general purpose processors with the low-power/fine-grained-parallelism of field programmable gate arrays (FPGAs). For an increasing variety of applications (e.g. bioinformatics, signal processing, cryptography) reconfigurable computers represent a higher performance (as high as 1000x) and lower energy (up to 90% reduction) option to traditional high-performance computers. In this talk we will discuss the paradigm behind this technology, programmed activities, and foreseen research/educational endeavors of the RC-Lab, in an effort to motivate educators and researchers from the general community to use this novel computing technology. Finally, we will briefly touch upon some of our current projects that exemplify the methodology, challenges, and advantages of reconfigurable computing.

**Acknowledgements:** This work has been supported in part by the Division of Computer and Network Systems of the National Science Foundation, Award Number 0923152.

**Keywords:** Reconfigurable computing, FPGAs, high-performance computing, computing facilities, bioinformatics, signal processing.

## A systolic array based architecture for implementing multivariate polynomial interpolation tasks

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Multivariate polynomial interpolation is a key computation for the reverse engineering of genetic networks modeled by finite fields. Faster implementations of such algorithms are needed to cope with the increasing quantity and complexity of genetic data. Our implementation of an interpolation methodology to FPGA has led us to identify a systolic array-based hardware architecture that is useful for performing at least three interpolation sub-tasks: Boolean cover, uniqueness, and multivariate polynomial addition. We present a generalization of these algorithms that simplifies mapping to the systolic-array structure, as well as control and storage considerations to guarantee correct results when the input sequence is longer than the processing array. The three interpolation sub-tasks were modeled and implemented to FPGA using the proposed structure, obtaining

speedups up to 172x when compared to a software implementation, while achieving low resource utilization.

**Keywords:** Reconfigurable computing, FPGAs, polynomial interpolation, reverse engineering problem, gene regulatory networks.

## On the number of solutions of $\sum_{i=1}^k \frac{1}{x_i} = 1$ in distinct odd natural numbers

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In this paper we computed all the 245,060 solutions of the equation  $\sum_{i=1}^k \frac{1}{x_i} = 1$  in distinct odd natural numbers for  $k = 11$ . We provide a lower bound for the number of solutions of this equation for any  $k$ , showing that the number of solutions of  $\sum_{i=1}^k \frac{1}{x_i} = 1$  grows exponentially. We give an affirmative answer to a T. Andreescu and D. Andrica comment in **An Introduction to Diophantine Equations** that it is unknown if there are infinitely many positive  $k$ 's for which equation  $\sum_{i=1}^k \frac{1}{x_i} = 1$  admits solutions in distinct odd positive integers. Also, we answer similar questions about the equation  $\sum_{i=1}^{k-1} \frac{1}{x_i} + \frac{1}{\text{lcm}(x_1, \dots, x_{k-1})} = 1$ .

**Keywords:** Egyptian Fractions, Diophantine Equations.

## Aplicación de métodos de optimización en la solución de un problema de la industria editorial

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En la industria editorial, se deben crear planchas o negativos de los documentos que se van a imprimir. Analizando los costos de imprimir documentos, en general, se notó que el costo de crear

un negativo es muy elevado en comparación con el costo de imprimir todas las copias necesarias para satisfacer una cierta demanda. Por otro lado, se observó que en muchas ocasiones no se utilizaba todo el espacio disponible en cada una de las planchas o que si todo el espacio era utilizado muchas veces se imprimían copias de más, las cuales representan un desperdicio o un gasto innecesario para la industria.

Como consecuencia de esto, surge el siguiente problema: suponga que una determinada industria debe imprimir  $n$  gráficos, cierta cantidad de copias para cada uno de ellos, y se tienen planchas rectangulares, todas del mismo tamaño, en las cuales se deben preparar primero los negativos de los dibujos para luego enviarlos a imprimir. Lo que se quiere es utilizar la menor cantidad de planchas de tal forma que minimice la cantidad de copias de cada gráfico que no se utilizarán y además el espacio no utilizado en cada plancha.

En el año 2007, se llevó a cabo un proyecto de investigación para resolver el problema de la industria editorial, desarrollando algoritmos basados en heurísticas, cuyos resultados obtenidos dan una solución al problema en una dimensión.

Esta investigación tiene como objetivo principal desarrollar e implementar algoritmos basados en programación lineal que determinen la solución del problema de la industria editorial, utilizando el método de generación de columnas. Además, se desarrollarán heurísticas para resolver el problema o aplicar programación dinámica para obtener la solución. Actualmente, se han implementando algoritmos basados en el método de generación de columnas y en heurísticas que permiten obtener soluciones al problema en una y dos dimensiones.

**Keywords:** programación Lineal, generación de columnas, problema de la industria editorial

## Interior operators and topological connectedness

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A categorical notion of interior operator is used in topology to define connectedness and disconnectedness with respect to an interior operator. A commutative diagram of Galois connections is used to show a relationship between these notions and the notions of connectedness and disconnectedness with respect to a subclass of topological spaces introduced by Arhangeskii and Wiegandt. Some examples will be provided.

**Keywords:** Categorical Operators, Galois Connections, Topological Connectedness

## Toward a mathematical origin of species

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Adding a new species mathematically involves increasing the dimension of the system of differential equations that describe the interactions of the existing species. Corrado Giannantoni indirectly gave one procedure to do this increase in *Emergy Synthesis* 5 (2009), pp. 581–598, “From Transformity to Ordinality”, based on the emery algebra of H.T. Odum. This paper discusses Giannantoni’s model and alternatives, although not going into DNA and genome changes.

**Keywords:** emery algebra

## A new algorithm for modular multiplication

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Modular multiplication is an expensive operation that is used in a number of important applications, especially in the implementation of public-key cryptosystems. Montgomery multiplication is a well known algorithm commonly used in RSA cryptosystems to speed up modular exponentiation and various improved versions have appeared in the literature. In this work we present a new efficient radix- $r$  modular multiplication algorithm based on Montgomery multiplication and we discuss possible implementations of it in hardware.

## Efficient implementation of atomic multi-writer, multi-reader distributed memory

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In this work we consider quorum-replicated, multi-writer, multi-reader (MWMR) implementations of survivable atomic registers in a distributed message-passing system with processors prone to failures. In this model, implementation efficiency is measured in terms of communication rounds between readers/writers and replica owners. Previous implementations invariably required two rounds of communication. Here we challenge this traditional approach and show that it is possible to have single round read and/or write operations in this setting. We thus devise an algorithm, called SFW, that exploits a new technique called server side ordering (SSO), which (unlike previous approaches) places partial responsibility for the ordering of write operations on the replica owners. With SSO,

fast write operations are introduced for the very first time in the MWMR setting. We prove that our algorithm preserves atomicity in all permissible executions. While algorithm SFW shows that in principle fast writes are possible, we also show that under certain conditions the MWMR model imposes inherent limitations on any quorum-based fast write implementation of a safe read/write register and potentially even restricts the number of writer participants in the system. In this case our algorithm achieves near optimal efficiency. **Keywords:** multi-writer multi-reader memory, efficiency, implementation

## Some experiments with reduced linear modular systems

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Given a nonsingular matrix  $S$  over the integers modulo a prime number, we consider the action of a nonsingular matrix  $M$  that commutes with  $S$  on the cycle structure induced by  $S$ . The resulting system is called a Reduced Linear Modular System (RLMS). Such a system has a cycle structure similar to nonsingular linear modular systems. Of especial interest are those RLMSs which yield the least number of  $MS$ -orbits. The solution to this problem is crucial for optimizing the computation of fast multidimensional Fourier transforms with prime edge-length and linear symmetries in their inputs. It is known that if the characteristic polynomial of  $S$  is irreducible, one can find an RLMS with only one nontrivial  $MS$ -orbit. In this work we explore those RLMSs for which the characteristic polynomial of  $S$  is a nontrivial power of an irreducible polynomial over the integers modulo a prime number.

**Keywords:** reduced linear modular system

## The asymptotic number of spanning trees in circulant graphs

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Let  $T(G)$  be the number of spanning trees in graph  $G$ . In this note we explore the asymptotics of  $T(G)$  when  $G$  is a circulant graph with given jumps.

The circulant graph  $C_n^{s_1, s_2, \dots, s_k}$  is the  $2k$  regular graph with  $n$  vertices labeled  $0, 1, 2, \dots, n-1$ , where node  $i$  has the  $2k$  neighbors  $i \pm s_1, i \pm s_2, \dots, i \pm s_k$  where all the operations are (mód  $n$ ). We give a closed formula for the asymptotic limit  $\lim_{n \rightarrow \infty} T(C_n^{s_1, s_2, \dots, s_k})^{\frac{1}{n}}$  as a function of  $s_1, s_2, \dots, s_k$ . We then extend this by permitting some of the jumps to be linear functions of  $n$ , i.e., letting  $s_i, d_i$

and  $e_i$  be arbitrary integers, and examining

$$\lim_{n \rightarrow \infty} T \left( C_n^{s_1, s_2, \dots, s_k, \lfloor \frac{n}{d_1} \rfloor + e_1, \lfloor \frac{n}{d_2} \rfloor + e_2, \dots, \lfloor \frac{n}{d_l} \rfloor + e_l} \right)^{\frac{1}{n}}. \quad (1)$$

While this limit does not usually exist, we show that there is some  $p$  such that for  $0 \leq q < p$ , there exists  $c_q$  such that the limit (1) restricted to only  $n$  congruent to  $q$  modulo  $p$  does exist and is equal to  $c_q$ . We also give a closed formula for  $c_q$ .

One further consequence of our derivation is that if the  $s_i$  go to infinity (in any arbitrary order) then

$$\lim_{s_1, s_2, \dots, s_k \rightarrow \infty} \lim_{n \rightarrow \infty} T(C_n^{s_1, s_2, \dots, s_k})^{\frac{1}{n}} = 4 \exp \left[ \int_0^1 \int_0^1 \cdots \int_0^1 \ln \left( \sum_{i=1}^k \sin^2 \pi x_i \right) dx_1 dx_2 \cdots dx_k \right].$$

Interestingly, this value is the same as the asymptotic number of spanning trees in the  $k$ -dimensional square lattice obtained in [A. Garcia, M. Noy, and J. Tejel, The asymptotic number of spanning trees in  $d$ -dimensional square lattices, Journal of Combinatorial Mathematics and Combinatorial Computing 44 (2003) 109-113]

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## The effects of reducing mating likelihood on population viability

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The success a species may have invading a patch previously unoccupied is of considerable interest for pest managers and conservation ecologists. Our purpose is to examine how the presence of a reproductive Allee effect, appearing through the failure in the process of fertilization in a two-sex population, affects the survival in an invaded patch. We use a Poisson-Ricker model which includes stochastic demography and sex determination, with the females classified as successfully fertilized or not fertilized. Numerical approximations to the probabilities of extinction and the mean time to extinction are presented for fixed parameter values, from which it is possible to observe how random fluctuations in the sex ratio and mating success contribute to the risk of extinction of a species which started an invasion with small number of individuals. It can also be seen how the reproductive Allee effect changes from strong to weak as the probability of a given female to be fertilized increases.

**Keywords:** Reproductive Allee effect, Poisson-Ricker model, probability of fertilization, population viability.

## Re-experimentación: un nuevo método para la recuperación de parámetros

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Los llamados problemas inversos (mal puestos) frecuentemente se presentan en situaciones reales, en el tratamiento de imágenes, en la geofísica, y en otras disciplinas. Históricamente, ha resultado “más fácil” y más natural resolver un problema directo que un problema inverso. Consideraremos un sistema de masas y resortes, tratando de recuperar las constantes de los resortes y/o de las masas a partir de las frecuencias naturales asociadas con ciertas condiciones de frontera, que frecuentemente es un problema mal condicionado. En 1963, Tikhonov planteó un método de regularización, para solucionar numéricamente estos problemas mal puestos, que lleva su nombre, el cual requiere que se busque un parámetro regularizador óptimo que permite obtener buenas aproximaciones de los resultados. Hallar este parámetro óptimo, en muchos casos, resulta un tanto costoso, numéricamente hablando y no hay ninguna técnica que nos indique que el parámetro hallado funcionará siempre. En este trabajo se plantea un nuevo método denominado método de reexperimentación, el cual nos permitirá obtener en la mayoría de los casos muy buenas aproximaciones y con un costo numérico inferior al de hallar el parámetro de regularización. Para ello, lo que haremos es reformular el problema como un problema de optimización (minimización), definiendo una función objetivo con el método de Tikhonov, y usando reexperimentación lograremos obtener una buenas aproximaciones sin tener que dedicar tanto esfuerzo para calcular el parámetro regularizador óptimo.

**Keywords:** Problemas Inversos, Regularización

## A methodology for the selection of the parameter $m$ in fuzzy $c$ -means: a computational approach

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Several clustering algorithms include one or more parameters to be fixed before its application. This is also the case of fuzzy  $c$ -means, one of the most well known fuzzy clustering algorithms, where two parameters  $c$  and  $m$  are required. The parameter  $c$  corresponds to the number of clusters and  $m$  to the fuzziness of the solutions. The selection of these parameters is a critical issue because a bad selection can blur the clusters in the data. In this work we propose a method for selecting an appropriate parameter  $m$  based on the analysis of sets of data with increasing noise and exhaustive analysis of the behavior of the algorithm with different values of  $m$ .

**Keywords:** clustering, Fuzzy  $c$ -means, privacy preserving datamining

## **A mathematical model for the urine concentrating process in the undeveloped kidney of rats**

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A mathematical model for the urine concentrating mechanism of neonatal rats was formulated. The model assumes an avian-type structure for the renal medullary tubule organization and transport parameter values from neonatal rats. To select model parameters, a nonlinear optimization problem was used to compute them by maximizing a model efficiency measure, which was taken as the ratio of the free-water absorption rate to the total NaCl active transport rate. Efficiency was maximized under the constraints that the model equations were satisfied and the model parameters were within their experimental ranges. Parameter baseline values were obtained from reported means in physiological experiments or estimated using physiological assumptions. By allowing the parameters to vary by  $\pm 50\%$  from baseline values, the maximal model efficiency was 19% above baseline, resulting in only 4% increase in urine osmolality. This is consistent with experimental data from animals and isolated CD from immature rats. Furthermore, when parameter values from the inner stripe of the outer medulla of mature rats were used, the urine osmolality increased by 253% from baseline.

**Acknowledgements:** Research supported by Award Number SC1GM084744 from the National Institute of General Medical Sciences.

**Keywords:** Undeveloped kidney, Mathematical model, Nonlinear optimization

## **El entendimiento de funciones de dos variables: dominio, rango, unicidad de valor y representaciones.**

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We present results of a study of how students understand the general notion of a function of two variables. By that we mean their understanding of domain, possible arbitrary nature of function assignment, uniqueness of function image, and range. This is a continuation of another study (Trigueros & Martínez Planell, 2009) in which student understanding of the graphical representation of such functions was analyzed. Both studies use APOS theory and semiotic representation theory as theoretical background. The former study found that students' graphical understanding of functions of two variables depends on their construction of their  $R^3$  schema, particularly their subschema of subsets of  $R^3$ , and most notably, fundamental planes and projections. The present study finds that few students are able to build a process conception of function of two variables. They show difficulties converting between different function representations; students fail in the coordination of their  $R^3$ , set, and function of one variable schemas, and end up with a preBourbaki notion of

function. The study is based on the qualitative analysis of thirteen student interviews.

**Keywords:** APOS Theory, representations, schema, functions of two variables

## Using Mathematica 7 in education and research

*Ginger McKee*, Academic Initiatives, Wolfram Research, Inc.

*Michael Morrison*, Academic Initiatives, Wolfram Research, Inc.

We'll be discussing a wide variety of practical and theoretical applications. Attendees will not only see new features in the current version of Mathematica but will also receive examples of this functionality to begin using immediately for use in teaching and research on campus. Topics of this technical talk include:

- 2D and 3D visualization
- Dynamic interactivity
- On-demand scientific data
- Example-driven course materials
- Symbolic interface construction
- Practical and theoretical applications

No Mathematica experience is required, and students are encouraged to attend.

**Keywords:** mathematics, research, parallel computing, technology, computer algebra systems, computation, data analysis, modeling, simulation

## Torsion and the K-theory of a recursive subhomogeneous algebra

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We show that the  $K_0$ -group of an inductive limit of recursive subhomogeneous algebras with compact metrizable spaces of dimension at most one as local spectra is torsion free. This proves Li's reduction theorem for the dimension of the local spectra of unital simple AH algebras cannot be improved, that is, the dimension of the local spectra of unital simple AH algebras cannot be further reduced from two to one, even when we use subhomogeneous algebras as building blocks.

**Acknowledgements:** The presenter will like to express his gratitude to Dr. Guihua Gong, Dr. Liangqing Li and to the UPRB Mathematics Department

**Keywords:**  $C^*$ -algebras, K-theory, recursive subhomogeneous algebras

## $W^{1,p}$ quasi convexity and fracture surfaces in strain space

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*Jeyabal Sivaloganathan*, Department Mathematical Sciences, University of Bath, UK

In this talk we discuss some numerical and theoretical results for the characterization of material instabilities in solids of cavitation type. To describe this phenomena we employ a model of nonlinear elasticity which is more appropriate due to the large stresses (potentially infinite) associated with the large expansions involved in such deformations. We give a new characterization, based on what we call the *volume derivative*, of the type of boundary deformations producing holes inside a body which originally had no holes, i.e., no imperfections. We discuss how this characterization might lead to a numerical procedure for computing these critical hole producing three dimensional deformations. For a specific stored energy function and for spherically symmetric boundary deformations, we show that the volume derivative characterization gives exactly the hole producing boundary deformations in this case.

**Acknowledgements:** This research was sponsored in part by an International Joint Project of the Royal Society of London and the University of Puerto Rico at Humacao.

**Keywords:** nonlinear elasticity, quasiconvexity

## Violation of the complementing condition and local bifurcation in nonlinear elasticity

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The complementing condition (CC) is an algebraic compatibility requirement between the principal part of a linear elliptic differential operator and the principal part of the corresponding boundary operators. We study the implications of failure of the CC in the context of nonlinear elasticity. In particular we show that for axisymmetric deformations of cylinders, failure of the CC is equivalent to the existence of sequences of possible bifurcation points accumulating at the point where the CC fails. For non axisymmetric deformations, we show for axial compressions of the cylinder that the CC fails on a full interval of values of the loading parameter, and for the lateral compression problem it fails only for a finite (discrete) number of values.

**Keywords:** complementing condition, bifurcation, nonlinear elasticity

## A Lyapunov function for an epithelial cell model of the thick ascending limb

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*Mariano Marcano*, Department of Computer Science, University of Puerto Rico, Río Piedras Campus

A weak Lyapunov function (wLF) for a Thick Ascending Limb (TAL) Epithelial Cell Model is presented. The TAL is the water-impermeant segment of the renal tubules (nephrons) within the kidney. This segment is heavily involved in electrolyte reabsorption, and is the engine of the urine concentration mechanism in the kidneys. The TAL cell model gives a detailed description of the transport processes that occur in the TAL. The model consists of a system of ordinary differential equations (ODE), which is derived from principles of mass conservation and electroneutrality. The existence of a wLF for an arbitrary equilibrium point demonstrates that the model is Lyapunov stable, and this is done without linearizing the model or assuming anything about the eigenvalues of such linearization. The existence of the wLF is shown by using the cell volume regulation (CVR) property of the cell. Hence, this suggests that the CVR plays an important role in the model and therefore it cannot be ignored.

**Keywords:** Cell Model, Lyapunov stability, kidney, ODE system

## A parallel algorithm for computing the period of strongly connected components

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*Dorothy Bollman*, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez

The period of a strongly connected component (SCC) of a directed graph is defined to be the greatest common divisor of the cycle lengths. In previous work we developed an  $O(n^2 \log n)$  algorithm which makes use of Tarjan's depth first search algorithm for finding SCCs to determine the periods of all SCCs of a directed graph with  $n$  vertices. In applications of interest, such as gene regulatory networks, the graph can be quite large. It is thus of interest to parallelize our algorithm. However, it is difficult to parallelize depth first search. In the present work we present a recursive divide-and-conquer algorithm for computing the SCCs which simultaneously computes their corresponding periods. This algorithm is suitable for implementation on a shared memory architecture.

**Keywords:** period, strongly connected component, parallel algorithm

## Teoría de nudos y homología de Khovanov

*Juan Ortiz Navarro*, Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez

Durante los últimos años la Homología de Khovanov ha demostrado ser una invariante importante dentro de la teoría de nudos. En esta charla veremos ejemplos de objetos algebraicos que funcionan como invariantes de un nudo para luego demostrar como la Homología de Khovanov recupera y explica lo que significan éstos.

**Keywords:** nudos, homología, topología algebraica

## Let the outstanding be outstanding: Roberto Clemente and fully robust Bayesian hierarchical models in baseball prediction

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Modern Statistics is made of the sensible combination of direct evidence (the data directly relevant or the “individual data”) and indirect evidence (the data and knowledge indirectly relevant or the “group data”). The admissible procedures are a combination of the two sources of information, and the advance of technology is making indirect evidence more substantial and ubiquitous. Nevertheless, the usual Exponential Family Hierarchical Modeling with conjugate priors is myopic with respect to large deviations of a single group from the bulk of the groups, leading to to potential excessive (and spurious) shrinkage to the general mean. An example of this situation can be seen in the famous baseball batting average prediction data presented by Efron and Morris (1975, specially on what Efron recently called the “Roberto Clemente Problem”, the fact that by shrinking an outstanding batter prediction was reduced drastically. In this work, we explore Robust Hierarchical Bayesian approaches based on heavy tails priors for obtaining “local shrinkage”, so that only players which are similar affect each other, but they have a smaller influence on players which are exceptional in any direction.

**Keywords:** Bayesian Statistics, Hierarchical models, Robust Bayesian Analysis.

## Hyperbolicity and genuine nonlinearity conditions for certain p-systems of conservation laws, weak solutions and the entropy condition

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We consider a p-system of conservation laws that emerges in one dimensional elasticity theory. Such system is determined by a function  $W$ , called strain-energy function. We consider four forms of  $W$  which are known in the literature. These are St.Venant-Kirchhoff, Ogden, Kirchhoff modified, Blatz-Ko and Ogden forms. In each of those cases we determine the conditions for the parameters  $\mu$ ,  $\lambda$  and  $f$ , under which the corresponding system is hyperbolic and genuinely nonlinear. We establish what it means a weak solution of an initial and boundary value problem. Next we concentrate on a particular problem whose weak solution is obtained in a linear theory by means of D’Alambert’s formula. In cases under consideration the p-systems are nonlinear, so we solve them employing Rankine-Hugoniot conditions. Finally we ask if such solutions satisfy the entropy condition. For a standard entropy function we provide a complete answer, except of the Blatz-Ko and Ogden case. For a general entropy function the result is that for the initial value of velocity function near zero these are, with some exceptions, entropy solutions.

**Keywords:** Conservation laws, hyperbolicity, entropy solutions

## Aspectos computacionales del método “Local Discontinuous Galerkin” para mallas no estructuradas en 3D

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Paul Castillo, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez

En esta presentación se describe una implementación del método “Local Discontinuous Galerkin” (LDG) aplicado a problemas elípticos en 3D. Se discute la implementación de los principales operadores. En particular el uso de aproximaciones de alto orden y de mallas no estructuradas. Estructuras de datos eficientes que permiten un rápido ensamblado del sistema lineal en su formulación mixta son descritas en detalle.

**Keywords:** Métodos de elemento finito discontinuos, aproximaciones de alto orden, mallas no estructuradas, programación orientada a objetos.

## Avaluación de destrezas de educación general en el curso de precálculo Enero 2009 – Diciembre 2009

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Los cursos de Precálculo I (MATE 3171) y Precálculo II (MATE 3172) son cursos que toman estudiantes de la Facultad de Ciencias Naturales de la Universidad de Puerto Rico en Humacao. Típicamente el curso lo toman estudiantes de primer año que han obtenido una puntuación de 650 puntos o más en la prueba del College Board. Esos cursos son cruciales para los estudiantes, pues son básicos en su formación académica y el no poder aprobarlos satisfactoriamente los atrasa hasta un año. Además atienden directamente dos de las competencias de educación general que adquieren los egresados de la UPR-Humacao, a saber: razonamiento cuantitativo y analítico y análisis crítico en la solución de problemas y toma de decisiones. A fin de determinar si los estudiantes logran adquirir estas competencias, utilizamos como instrumentos de avalúo: preguntas pre-seleccionadas en cada examen parcial departamental y la nota final obtenida en el curso. Las preguntas pre-seleccionadas nos brindan información específica sobre las destrezas dominadas por los estudiantes. Recopilamos y analizamos datos correspondientes a todas las secciones en los respectivos semestres. La información generada nos ayuda a culminar el ciclo de avaluación de las destrezas de educación general puesto que brindamos recomendaciones a ser implementadas durante semestres subsiguientes.

Este estudio se llevó a cabo durante los semestres académicos II 2008–2009, para Precálculo II, y I 2009–2010, para Precálculo I. Coordinamos todas las secciones de dichos cursos, a fin de que durante cada semestre en curso se impartiera el mismo examen parcial departamental, con unas preguntas específicas “sagradas” (que nadie podía modificar), en todas las secciones. De esta manera, recopilamos y analizamos datos que nos ayudan a determinar cuál fue el aprovechamiento académico de nuestros estudiantes por áreas. La información nos ayuda a culminar el ciclo de avaluación del aprovechamiento académico puesto que brindamos recomendaciones a ser implementadas durante semestres subsiguientes.

**Keywords:** avalúo, destrezas educación general

## On the spatio-temporal disease dynamics in populations with discrete-time epidemics in one and two spatial dimensions

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The use of integro-difference equations in the study of the role of dispersal on populations with discrete generations has generated interesting mathematical problems and expanded our understanding of their spatio-temporal dynamics. Here, we use discrete-time epidemic models that can be reduced to a single map for the infectious class,  $I_{t+1} = g(I_t)$ , where  $g$  may or may not be monotone. We support our results with new theoretical work. We did modeling, analysis and simulations

to illustrate the role of  $g$  on disease dynamics in one and two spatial dimensions.

**Keywords:** integro-difference equations, epidemic models, discrete time, traveling waves

## Comparison of elastic plate theories for micropolar materials

*Lev Steinberg*, Department of Mathematics, University of Puerto Rico at Mayagüez

*Roberto Carlos Reyes Carranza*, Department of Mathematics, University of Puerto Rico at Mayagüez

The purpose of this presentation is to show a comparison of the theories of micro-polar plates with moderate thickness. The comparison is based on the method of separation variables (special case for elliptic systems of partial differential equations) to the analytical solutions for deformation of the plates under vertical load.

The main comparison was made for the Eringen theory (cases of zero vertical components of  $\acute{o}$  and  $\acute{a}$ ), the extended Reissner and the basic Reissner models.

The difference between these models is in the use of different polynomial approximations of asymmetric stress, couple stress, displacement, and micro-rotation over the plate thickness. All polynomial approximations for the models have been checked for consistency with the elastic equilibrium, boundary conditions and the constitutive relationships.

Extended Reissner model is based on the generalized Hellinger-Prange-Reissner variation principle and strain-displacement relation for the plate approximations. This model produces the extended theory of Cosserat plate, which includes a new form of constitutive relationships.

We obtained analytical solutions for the plate boundary value problem for all models. We compare numerical solutions for a case of syntactic foam plate.

**Keywords:** Reissner model, Linear Elasticity

## An approach to construct explicit solutions for Schroedinger equations with time dependent Hamiltonians

*Erwin Suazo Martinez*, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez

We discuss a method to construct explicit solutions for time dependent Schroedinger equations. Using this method the evolution operator can be expressed as an integral operator with an explicit formula for the kernel in the case of a quadratic Hamiltonian depending on time. The kernel of the evolution operator is given in terms of elementary functions and certain integrals involving a characteristic function. We will discuss several examples and some properties of the time evolution operator that are relevant in the study of the Cauchy initial value problem for the nonlinear Schroedinger equations.

**Acknowledgements:** This presentation is an updated review of joint work with S. K. Suslov, Cordero-Soto and R. Lopez.

**Keywords:** Schroedinger Equation, Quadratic Hamiltonians, Explicit Solutions, Fundamental Solutions.

## Universal deformation rings of modules over self-injective algebras

*José A. Vélez*, Department of Mathematics, University of Iowa

Let  $k$  be an algebraically closed field and let  $\Lambda$  be a finite dimensional self-injective  $k$ -algebra (i.e. the regular left  $\Lambda$ -module  ${}_{\Lambda}\Lambda$  is injective), and let  $V$  be a finitely generated  $\Lambda$ -module. We define the universal deformation ring of  $V$ , denoted by  $R(\Lambda, V)$  and give a sufficient criterion for its existence. We then turn to a particular self-injective algebra  $\Lambda$  and determine the universal deformation rings for some of the  $\Lambda$ -modules  $V$  that satisfy this criterion.

**Acknowledgements:** Advisor: Professor Frauke M. Bleher

**Keywords:** Universal Deformation Rings, Quivers, Self-injective Algebras

## Mathematics and string theory

*Alfredo Villanueva*, Department of Mathematics, University of Puerto Rico at Mayagüez

This talk is an overview and an easy look in String theory and the mathematics behind it. First we will talk about the beginnings, starting on elementary particles and a need for clear understanding of it. Second, we will describe the mathematics needed from undergraduate to graduate level. Finally, we will explain some of the theories and topics related to String theory.

**Keywords:** string theory, mathematical physics

## The nonlocal Robin Laplacian on extension domains

*Alejandro Vélez Santiago*, Department of Mathematics, University of Puerto Rico at Río Piedras

Let  $\Omega \subseteq \mathbb{R}^N$  be a bounded extension domain and let  $\mu$  be an upper  $d$ -Ahlfors measure supported on  $\partial\Omega$  with  $d \in (N - 2, N)$ . We first obtain that the Laplacian with nonlocal Robin boundary condition is well-posed, and moreover existence, uniqueness and regularity of weak solutions of the linear elliptic equation associated with the nonlocal Robin Laplacian are obtained. At the end we turn our attention to the generation of strongly continuous semigroups, and prove that the nonlocal Robin Laplacian generates compact bounded analytic submarkovian  $C_0$ -semigroups of angle  $\pi/2$  on  $L^q(\Omega, dx)$ , for each  $q \in [1, \infty)$ .

**Keywords:** nonlocal Robin boundary conditions, submarkovian semigroups, weak solutions

## 5. Afiches (*Posters*)

### Some properties of latin squares - study of mutually orthogonal latin squares

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Lourdes M. Morales, Department of Computer Science, University of Puerto Rico at Río Piedras

A latin square of order  $n$  is an  $n \times n$  matrix containing  $n$  distinct symbols (usually denoted by the non-negative integers from 0 to  $n - 1$ ) such that each symbol appears in each row and column exactly once. Latin squares have various applications in Coding Theory, Cryptography, Finite Geometries and in the design of statistical experiments, to name a few. Two latin squares of the same order are said to be orthogonal if, when superimposed, all the pairs that are formed are different. In our research we look for new constructions of maximal sets of mutually orthogonal latin squares (MOLS). We present some partial results and conjectures related to this.

**Acknowledgements:** PR-LSAMP, NSF-STEM, the Dept. of Computer Science at the University of Puerto Rico at Río Piedras, Dr. Ivelisse Rubio and the rest of the Emmy Noether Laboratory team.

**Keywords:** latin squares, orthogonality, r-orthogonality, MOLS, mutually orthogonal latin squares

### Estudio comparativo entre C para CUDA y OpenCL

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José O. Sotero Esteva, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao

Las unidades de procesamiento gráfico, GPU por sus siglas en inglés, inicialmente eran un conjunto de algunas decenas de procesadores incorporado en tarjetas gráficas para acelerar el cómputo de imágenes, Hoy las encontramos como tarjetas independientes con cientos de unidades de procesamiento como en el caso de la Tesla producida por la compañía NVIDIA. Además se han establecido como plataformas para cómputos masivamente paralelos para aplicaciones mucho más allá de las gráficas de computadoras. Los GPUs producidos por NVIDIA implantan una arquitectura llamada CUDA (Compute Unified Device Architecture) y provee herramientas de desarrollo de programado que utiliza una versión extendida del lenguaje C. Por otro lado, OpenCL (Open Computing Language) cumple funciones similares al C para CUDA diseñado para ambientes heterogeneos y es de

código abierto. Recientemente se ha publicado una versión de OpenCL para arquitecturas CUDA. En este trabajo se comparan C para CUDA y OpenCL desde dos puntos de vista: la herramientas provistas por ambos para las programación del GPU y rendimiento en la ejecución de los programas para aplicaciones científicas.

**Acknowledgements:** Proyecto auspiciado por el programa Penn-UPR Partnership for Research and Education in Materials (NSF-DMR-0934195).

**Keywords:** paralelismo, GPU, CUDA, OpenCL

## **A simple multinephron model for the urine concentration mechanism.**

*Guillermo Fontáñez*, Department of Computer Science, University of Puerto Rico at Río Piedras

*Mariano Marcano*, Department of Computer Science, University of Puerto Rico at Río Piedras

Urine formation in the kidney is carried out in the renal tubules called nephrons. A simple mathematical model is implemented to simulate the urine concentrating process of a population of nephrons that work in parallel. Considering specific characteristics of each segment of the tubules, assumptions are made that simplify the model from a system of differential equations to a single non-linear equation. The model thus provides a simple and effective means to simulate the urine concentrating mechanism without a high computational load.

**Keywords:** urine concentrating mechanism, nephron, mathematical model

## **Robust Bayesian approach to the analysis of finite population surveys**

*Jairo Alberto Fuquene Patino*, Institute of Statistics, University of Puerto Rico

Little and Zheng (2007) make a comprehensive proposal in an important area where Bayesian methods are hardly used, this area is the approach Bayesian in survey sampling. The choice of these authors are noninformative priors in the Bayesian models to the survey designs. On the other hand, in a recent paper Fuquene, Cook and Pericchi (2009) show that the popular conjugate analysis will be exposed as non-robust and workable alternatives should be available to the practitioners of Clinical Trials. The proposals in Fúquene, Cook and Pericchi (2009) are the analyses based on the heavy-tailed Cauchy Prior and a robust prior originally developed by J.O. Berger (called Berger's prior) for the natural parameter in Exponential Families. Robust priors have bounded influence, in other words the prior is discounted automatically when there are conflicts between prior information and data.

The proposal in this work is to use Cauchy and Berger's robust priors in the Bayesian models to the survey designs. The robust Bayesian Approach is more effective than the particular case

of noninformative priors, as suggested Little and Zheng (2007), because when there is a conflict between prior information and the sample information the Cauchy and Berger's priors effectively becomes a noninformative prior and in this precise sense the prior information is discounted. The behavior of Robust Bayesian methods is qualitative different than noninformative Bayesian methods and arguably much more reasonable and acceptable to the people involved in survey sampling. Finally, we apply this methodology in real and MCMC simulated examples.

**Keywords:** Survey Sampling, Robust Priors, Horvitz-Thompson Estimator

## Tabla de mortalidad de Puerto Rico

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Este trabajo consiste en preparar una tabla de mortalidad de Puerto Rico para personas nacidas en 1966. Las tablas de mortalidad se usan en demografía y para calcular primas de seguros de vida. Las tablas de mortalidad son muy diferentes a las tablas del censo. Las tablas del censo miden la cantidad de población que hay cada año en un lugar determinado incluyendo los nacimientos y los inmigrantes, mientras que las tablas de mortalidad toman una cantidad de persona ya determinada y mide cuantas de éstas van muriendo cada año por un periodo de años prolongado por lo cual aquí no se cuentan los nacimientos ni los inmigrantes. Con estas tablas se determina la probabilidad de defunción. Es difícil hacerlas completamente precisas, pues no es posible seguir la historia de cada miembro de una población inicial ("cohort").

Para la tabla de este trabajo se utilizaron las formulas de la Organización Mundial de la Salud. Se quiere tratar de ver si se puede encontrar una forma tal de que se puedan hacer cada vez mas precisas. Esta tabla se hizo usando la información del censo por cada año por un periodo de 40 años brindada por el Departamento de Salud de Puerto Rico. Se obtuvo la cantidad de población durante cada año y la cantidad de defunciones. Al final se obtiene la esperanza de vida que tiene una persona a cierta edad, esto significa cuantos años mas puede vivir.

Las proyecciones futuras para este trabajo son poder refinar la información para periodo mas allá de 40 años, también ver el fenómeno de la vida temprana de 1 a 5 años al igual que el fenómeno por sexo y lograr hacer una tabla por edades.

**Acknowledgements:** This research has been sponsored in part by the NIH-RISE program of the University of Puerto Rico at Humacao.

**Keywords:** tablas de mortalidad

## Cómputo de cantidad de caminos y polígonos sin intersecciones en una rendija cuadriculada

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Llamamos *rendija cuadriculada* de ancho  $n$  y largo  $m$  al conjunto de puntos en el plano con coordenadas en  $Z_m \times Z_n$ . Trazamos *caminos* en estas rendijas conectando de manera sucesiva puntos adyacentes horizontal o verticalmente. Un *polígono* en esta rendija es un camino que comienza y termina en el mismo punto. Definimos las funciones  $c_n(m)$  y  $p_n(m)$  como la cantidad de caminos o polígonos sin intersecciones que se pueden trazar en rendijas de ancho  $n$  y largo  $m$ . Anteriormente mostramos la construcción de un *digrafo de transferencias* asociado a las posibles conformaciones de polígonos sin intersecciones. En este trabajo mostramos cómo podemos utilizar este digrafo para computar  $c_n(m)$  y  $p_n(m)$  sin tener que hacer búsquedas exhaustivas de trazos en  $Z_m \times Z_n$ .

**Acknowledgements:** Proyecto auspiciado por el programa Penn-UPR Partnership for Research and Education in Materials (NSF-DMR-0934195).

**Keywords:** caminos sin intersección, polígonos sin intersección, teoría de grafos

## Two strain competition: Trypanosoma cruzi

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Chagas disease is a tropical parasitic disease that affects Latin America. The parasite causing Chagas, *Trypanosoma cruzi*, is transmitted by an insect vector of the subfamily Triatominae. Chagas is uncommon in the United States, but is becoming more common in the southern part of the country. This may be due to a more virulent strain type of the parasite moving northward from Mexico and invading the less virulent, native strain type. A region in southern Texas where there is a mixing of two *Triatoma* species is modeled with two different modeling frameworks. A mathematical deterministic model is created to describe the interactions between one host and one vector and determine the outcome of an invasion of a non-native strain type into the region. A stochastic, agent based model is created to determine the effect space and randomness may have on the interactions. Within the models, three modes of parasite transmission are considered to account for the different characteristics of each strain type. We vary the horizontal transmission ability of the invasive strain and run simulations for an equivalent time period of 30000 days (82 years). We find that the horizontal transmission potential of the invasive strain must be about 1.5 times as large as the

other, in order for over 50 percent of the runs to end with the invasive strain dominating. However, in the ODE model, the horizontal transmission of the invasive need only be 1.056 times that of the other strain. We also determine from the ODE model that considering three modes of transmission and no migration of vectors into the region being modeled, it is impossible for the two strains to coexist.

**Acknowledgements:** Carlos Castillo Chavez, Kehinde Salau, Britnee Crawford, Anuj Mubayi

**Keywords:** Chagas, host, vector, strain, horizontal and vertical transmission

## Software APKG, de algebra de productos Kronecker a grafos

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El Algebra de Productos Kronecker (APK) es una forma concisa y práctica de expresar operaciones de procesamiento sobre señales discretas como las transformadas de Fourier y coseno. La interpretación de dichas operaciones como grafos nos ayuda a visualizar su computación e implantación en hardware. El objetivo de nuestro proyecto es desarrollar una herramienta para la visualización y manipulación de expresiones en APK como grafos. Primero, se desarrolló un algoritmo que permite interpretar y dibujar grafos, basado en la descripción provista en un archivo de texto. Cada nodo es representado como un bloque con sus respectivas conexiones de entrada y salida. Luego, se procedió a la manipulación gráfica, dándole al usuario la flexibilidad de hacer cambios en las posiciones de los nodos pero no en las conexiones. Actualmente, el programa provee opciones para desplegar el grafo, modificar la posición de sus nodos sin alterar las aristas, varios modos de enfoque (zoom), así como reescritura al archivo de formato de grafo. Finalmente, se le está añadiendo al programa la habilidad de interpretar ecuaciones algebraicas haciendo uso de la notación polaca y árboles binarios. Toda la implementación se esta realizando bajo el lenguaje de programación orientado a objetos C++ utilizando la biblioteca multiplataforma Qt.

**Acknowledgements:** Departamento de Ciencias de Cómputos de la Universidad de Puerto Rico en Río Piedras

**Keywords:** Algebra de Productos Kronecker, señales discretas, transformadas de Fourier y coseno, grafos, visualización de APK, manipulación

## A tale of regions: a mathematical model for Chagasa disease

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We model the epidemiological interactions between two animal populations: one with a virulent strain of *Trypanosoma cruzi*, which causes Chagasa disease and the other with a non-virulent strain

that provides cross-immunity against the disease. The virulent strains of *T. cruzi* are predominantly found in Latin America. The increased spread of Chagasa disease from its endemic habitat in Latin America to the north, which has recently been observed, has been linked to climate change and deforestation. As a result, a large part of the southern United States is at a higher risk for the disease. The model presented herein describes the effects of the migrating virulent strains on the prevalence and/or possibility of endemicity of Chagasa disease in the U.S. We use an epidemiological modeling paradigm and an analytical framework of nonlinear dynamics to describe the behavior of two populations and their interactions. Depending on certain conditions imposed on reproductive numbers, we found that there are six different scenarios for the two-patch model as a whole. We found that the principle of competitive exclusion prevails in either strain when there is no migration, with the exception of infinitely many stable non-isolated steady states of coexistence on the bifurcation line in the R21-R22 plane. When the migration term is nonzero, we observed that there are two possible situations for patch 2: endemic in strain 1 or coexistence of both strains.

**Acknowledgements:** Christopher Kribs Zaleta, MTBI, Carlos Castillo-Chavez

**Keywords:** Epidemic Models, Chagas disease, Strain

## Optimized strategies for the Mastermind game

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Mastermind is a code-breaking board game for two players in which one player makes a code and the other has to correctly guess it. Over the years, many efficient algorithms, or strategies, have been proposed for the Mastermind game, some with better expected winning results and some which minimize the maximum turn in which the player that guesses can win. Variations of the game have also been discussed, and can be made by adding more colors and pegs to make the game easier or harder to win. The purpose of this research is to present computational results from the implementation of some of the most efficient strategies presented in the literature. We compare the effectiveness of the strategies for the different game variations. By comparing results of the different game variations, we can determine which strategy is considered better in each case.

**Keywords:** Mastermind, games, strategies

## Parameter estimation for a mathematical model of the sec-dependant translocation system

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A nonlinear least-squares problem was formulated to compute parameter values for a mathematical model of the Sec-dependant translocation system. This secretory pathway consists of several steps that prokaryotes use to transport proteins out of the cytoplasm. The optimization consisted of minimizing the distance between model outcomes and published experimental data of translocation kinetics, which were obtained from four proteins with different lengths of amino acid chains. To approximate the solution of the optimization problem, a trust-region reflective method, which is a modification of the Newton's method, was used. Because this method is locally convergent, an exploration of the parameter space was performed by generating a uniformly distributed set of initial iterates. Results demonstrate that the chemical reactions involved in the preprotein translocation do not depend on the preprotein size; although, in an overall view, preprotein needs more time to be translocated as its size increases. These models can be significantly important for the future research related to the function and pathophysiology of biological targets.

**Keywords:** Nonlinear Optimization; Mathematical Models; Sec Translocase; Hydrolysis; Preprotein translocation

## Finite element method simulations of composite materials

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A composite material consists of a mixture of a base material called the matrix, with grains of other materials called the inclusions. These materials are very common in engineering applications like the construction industry. Composite materials have also been used for the production of capacitors with different type of military applications, yet the role of the composite in the efficiency of such a device is not well understood. Modeling composite materials is difficult due to the random nature of such mixtures. Yet if some controls are established during the production process, it is reasonable to assume homogeneity and isotropy. Models for composite materials have been proposed in the literature, for example by Hill (1972), and can be either random or periodic. The main goal of the present work is to study numerical methods based on the finite element method to determine the mechanical properties of periodic composite materials. At the moment we have been studying a simplified version of this problem for a nonlinear Poisson type equation. Since the constitutive function for a composite material is a piecewise defined function of the constitutive functions of

the matrix and inclusions, we take the coefficients in our Poisson type equation to be nonlinear piecewise defined functions, changing behavior in the regions simulating the matrix and inclusions. We present some simulations for this simplified problem that resemble materials with voids (empty inclusions) and with (filled) inclusions.

**Acknowledgements:** This research was supported in part by the PREM Program of the University of Puerto Rico at Humacao (Grant No. DMR-0934195) and the RISE Program of the University of Puerto Rico at Humacao.

**Keywords:** composite materials, finite elements

## Programacion con GPUs: alternativas ante la disyuntiva entre transferir datos o regenerarlos

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Recientemente las Unidades de Procesamiento Gráfico (GPUs) han ganado aceptación como recursos que pueden llevar a cabo cómputos en paralelo. Estos son periferales conectados a unidades de procesamiento principal en las cuales se transfiere datos a través de un bus. El bus permite la transferencia de datos entre memorias a las que tienen acceso directo las distintas unidades de procesamiento, pero este crea un factor limitante para los cómputos en paralelo. Esta limitación se debe a la cantidad de datos que se encuentran empaquetados en cada pulso transferido en el bus. La transferencia de estos pulsos a través del bus es más lenta que la producción de datos. Esto convierte al bus en otro ejemplo de un embudo para la transferencia de datos.

ACEPS es una herramienta para el cómputo de fuerzas electrostáticas en simulaciones de dinámica molecular desarrollada por nuestro grupo. Recientemente, a esta se le añadió la capacidad de utilizar GPUs para calcular las fuerzas. En este trabajo se describe las instancias en que nos enfrentamos al retraso por transferencias de datos y mostramos cuando regenerar datos en el GPU produjo mejor rendimiento que transferirlos y cuando no. Por otro lado, proponemos e ilustramos cómo en aplicaciones interactivas como la nuestra el tiempo de transferencia de datos puede hacerse imperceptible al usuario de la herramienta.

**Acknowledgements:** PREM (NSF-DMR-0934195)

**Keywords:** cómputo en GPU, dinámica molecular, procesamiento en paralelo

## Computational implementation of the procrustes analysis for biological uses: bee hybridization

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Procrustes analysis involves matching configurations with similar transformations to be close as possible according to Euclidean distances. This analysis estimates and obtains a general shape measurement in objects with unusual shapes. The Ordinary Procrustes Analysis is used to fit an object into another object by re-scaling, rotating and translating the objects, so that they are normalized. This is done by assigning points of correspondence between the objects called landmarks. This analysis can be very tedious if done by hand, due to the complexity of the equations and the repetitive times it has to be done for each landmark. Therefore the use of a computer program can facilitate this process and facilitate the work needed for this analysis. The need for such program in a biological research dealing with the heterosis reflected in bees led to make such user friendly software. This is why Procrustes Analysis Tool (PAT) was created. PAT is a user-friendly application, developed using Visual Basic.NET, to carry out the Ordinary Procrustes Analysis on two dimensional objects. Since wing size was one of the most noticeable effects that these hybridized bees had an investigation was carried to see if the wing size of the bees in Puerto Rico had been affected. To verify the size of the wings, a PAT was used in which it analyzed the wing length of thirty different colonies in which ten bees were examined from each colony. The wings were removed, placed on a microscope, and photographed with a digital camera. In the program, pictures were analyzed using twelve different landmarks placed on the intersection of each vein. The program then carries out the Ordinary Procrustes Analysis, which transforms the landmarks into Bookstein coordinates and finally calculates: centroid, centroid size and shape difference. The program resulted in successfully in completing this test and statistical analysis are being carried out comparing with other programs on the market to see if they produce the same results.

**Acknowledgements:** I would like to express my gratitude to J. Trinidad, AMP, Puerto Rico Space Grant Consortium and CREBT-CADEC for their financial support.

**Keywords:** Procrustes Analysis, heterosis.

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