Índice

1. Itinerario global (Global schedule)

Viernes 25 de febrero de 2011 (UPR Humacao)				
Hora	**Teatro**	**Salón A**	**Salón B**	**Salón C**
4:30–6:00	Registro	Sesiones Concurrentes		
5:30–5:55		M. Nadal	J. Sotero	D. Collins
6:00–6:25		P. Negrón	R. Arce	I. Henriquez
6:30–7:00	Receso y Mesas de Auspiciadores			
7:10–8:10	Conf. Plenaria - Francis Castro			
8:10–9:30	Actividad de Confraternización - Plazoleta frente al Teatro			

Sábado 26 de febrero de 2011 (Palmas del Mar)					
Hora	**Flamboyán**	**Almendro**	**Laurel**	**Roble**	**Hora**
8:00–9:00			Registro y desayuno		
8:50–9:00			Bienvenida		
9:00–10:00			Conf. Plenaria - Aleksandar Donev		
10:00–10:05	Mesas de Auspiciadores				
	Sesiones Concurrentes		Sesiones Temáticas		
10:05–10:30	J. Ortiz	D. McGee	K. Ríos-Soto	M. Rojas	10:05–10:40
10:30–10:55	E. Orozco	G. McKee	L. Medina	D. Bollman	10:40–11:05
10:55–11:20	O. Colón	R. Arce	J. Romero	P. Negrón	11:05–11:30
11:20–11:45	O. Yupanqui	R. Martinez	M. Hernández	J.Sotero	11:30–11:55
11:45–12:10	Mesas de Auspiciadores				
12:10–1:10	Almuerzo - Asamblea				
1:10–2:10	Conf. Plenaria - Mario Marazzi				
2:10–2:15	Receso				
	Sesiones Concurrentes				
2:15–2:40	G. Meléndez	A Díaz	J. A. Ortiz	A. Aparicio	
2:40–3:05	L. Gordillo	F. Castro	A. Villanueva	E. Lozano	
3:05–3:30	C. Araujo	R. M. Ortiz	A. Vélez	I. Henriquez	
3:30–3:55	V. Beltran	R. Akhtar	E. Suazo	D. Torres	
3:55–4:10			Refrigerios		
4:10–5:00			Afiches		
5:00	Termina la actividad				

2. Itinerario Detallado (Detailed Schedule)

Horario	Lugar	Actividad
Viernes 25 de febrero		
4:30-6:00	Vestíbulo Teatro	**Registro**
5:30-5:55		**Conferencias Concurrentes**
	Salón A	*Simulated Annealing with a Descent Method for Mathematical Models of Chemical Kinetic Systems,* Mónica Nadal-Quirós and Mariano Marcano.
	Salón B	*Cómputos para simulaciones de dinámica molecular usando GPUs,* Axel Rivera, Fernando Berríos Cádiz, y <u>José O. Sotero Esteva</u>
	Salón C	*Algorithms to measure discrete and continuous symmetry,* Dennis Collins.
6:00-6:25		**Conferencias Concurrentes**
	Salón A	*The volume derivative for the computation of fracture surfaces in strain space* Pablo V. Negrón-Marrero and Jeyabal Sivaloganathan.
	Salón B	*Búsqueda de Arreglos de Costas en GPUs y FPGAs,* Jose Ortiz Ubarri and <u>Rafael Arce Nazario</u>.
	Salón C	*Dispersal patterns of an invasive species with the use of MDiG: Exploring the sensibility of simulations to different parameter values in the case of Mimosa pigra in Puerto Rico,* M. Julio Barragán-Arce and Iván Henriquez.
6:30-7:00	Vestíbulo Teatro	**Receso y Mesas de Exhibición**
7:10-8:10	Teatro	**Conferencia Plenaria:** *On the number of solutions of $\sum_{i=1}^{k} \frac{1}{x_i} = 1$ in distinct odd natural numbers,* Francis Castro
8:10-9:30	Plazoleta frente al Teatro	**Actividad de Confraternización (Cóctel)**
Sábado 26 de febrero		
8:00-9:00	Roble y Laurel	**Registro y desayuno**
8:50-9:00	Roble y Laurel	**Bienvenida**
9:00-10:00	Roble y Laurel	**Conferencia Plenaria:** *A Hybrid Particle-Continuum Approach to Hydrodynamics at Small Scales,* Aleksandar Donev.
10:00-10:05	Pasillo	**Mesas de Exhibición**
		Sesiones Temáticas
10:05-10:40	Laurel	*Epidemic spread of influenza viruses and the role on dispersal and persistence by transient populations* <u>Karen R. Ríos-Soto</u>, Baojun Song, and Carlos Castillo-Chavez.
	Roble	*Mathematics of a Double-Walled Carbon Nanotube Model: Asymptotic and Spectral Analysis* Miriam Rojas-Arenaza.

Horario	Lugar	Actividad
10:40-11:05	Laurel	*Linear recurrences of exponential sums of symmetric boolean functions* Francis Castro, <u>Luis A. Medina</u>, and Ivelisse Rubio.
	Roble	*Optimizing Crystallographic FFTs* Dorothy Bollman and Edusmildo Orozco.
11:05-11:30	Laurel	*Análisis de multi-resolución isotrópico* Juan Romero.
	Roble	*A nonlinear model of an actuator* Pablo V. Negrón-Marrero and Eva Campos.
11:30-11:55	Laurel	*Modelos de fluidos a través de membranas permeables* <u>Marian Hernández Viera</u> and Ricardo Cortez.
	Roble	*Acercamientos a modelos combinatorios y computacionales de dinámica molecular de fluidos a escalas nanométricas* <u>José O. Sotero Esteva</u> and Preston Moore.
		Conferencias Concurrentes
10:05-10:30	Flamboyán	*Symmetries of multi-dimensional periodic arrays* <u>Jose Ortiz Ubarri</u> and Oscar Moreno.
	Almendro	*Using manipulatives to visualize multivariable calculus* Daniel McGee.
10:30-10:55	Flamboyán	*Reduced linear modular systems* <u>Edusmildo Orozco</u> and Dorothy Bollman.
	Almendro	*Mathematica 8 in Education and Research* Ginger McKee.
10:55-11:20	Flamboyán	*On the transient of some non linear discrete dynamical systems* <u>Omar Colón Reyes</u>, Dorothy Bollman, and Oscar Tomaiconza Ataulluco.
	Almendro	*Asserting parallel computational thinking into the undergraduate 4-year computer science curriculum at UPR-RP* Peter Musial, Edusmildo Orozco, and <u>Rafael Arce Nazario</u>.
11:20-11:45	Flamboyán	*Parallel multiplication in finite fields with large characteristic* Oscar Yupanqui Huamán and Dorothy Bollman.
	Almendro	*Student understanding of graphing functions of two variables: an analysis of results using the moments of study of the anthropological theory of the didactic* Rafael Martinez-Planell.
11:45-12:10	Pasillo	**Mesas de Exhibición**
12:10-1:10	Flamboyán y Almendro	**Almuerzo y Sesión Administrativa**
1:10-2:10	Flamboyán y Almendro	**Conferencia Plenaria:** *Instituto de Estadísticas de Puerto Rico: retos y oportunidades,* Mario Marazzi
2:10-2:15	Pasillo	**Receso**
		Conferencias Concurrentes
2:15-2:40	Flamboyán	*Modeling the impact of Batrachochytrium Dendrobatidis in the life history dynamics of Eleutherodactylus Coqui under seasonality in Puerto Rico and Hawaii* <u>Glorimar Melendez-Rosario</u> and Karen Ríos-Soto.
	Almendro	*Arithmetic progressions over quadratic fields* <u>Alexander Dáz</u>, Zachary Flores, and Markus Vasquez.
	Laurel	*La torsion de Reidemeister - Franz de un complejo CW* Juan Ortiz-Navarro.

Horario	Lugar	Actividad
	Roble	*Clustering de "streams" de series de tiempo* Ana María Aparicio Carrasco, y Edgar Acuña Fernandez.
2:40-3:05	Flamboyán	*The spread of pine wilt disease subject to early eradication of infected trees* Luis F. Gordillo.
	Almendro	*Exact divisibility of deformation of symmetric boolean functions* Francis Castro, Luis Medina, and Ivelisse Rubio.
	Laurel	*On Korteweg-de Vries equations* Alfredo Villanueva Cueva.
	Roble	*Comparing edge detection algorithms on grayscale noise image* Elio Lozano.
3:05-3:30	Flamboyán	*Perfect distance-dominating sets in the integer-lattices* Carlos Araujo Martínez and Italo J. Dejter.
	Almendro	*Three frameworks for a general theory of factorization* Reyes M. Ortiz Albino and Daniel D. Anderson.
	Laurel	*Solvability of linear local and nonlocal Robin problems over $C(\overline{\Omega})$* Alejandro Vélez-Santiago.
	Roble	*Digitizing and analyzing plant structure: an illustration with a Garcinia madruno seedling* M. Julio Barragán-Arce, Iván Henriquez, and Isabella Barragán-Herbas.
3:30-3:55	Flamboyán	*Grafo Mariposa* Heeralal Janwa and Viviana Beltrán.
	Almendro	*Bol-Moufang quasigroups defined by a single operation* Reza Akhtar, Ashley Arp, Michael Kaminski, Jasmine VanExel, Davian Vernon, and Cory Washington.
	Laurel	*Soliton-like solutions for nonlinear Schrödinger equation with variable quadratic hamiltonians* Erwin Suazo.
	Roble	*Dynamic Bayesian models for projecting cancer incidence in Puerto Rico* David A. Torres Núñez, and Luis R. Pericchi Guerra.
3:55-4:10	Laurel y Roble	**Receso - Refrigerios**
4:10-5:00	Laurel y Roble	**Afiches (vea las páginas. 23-30) - Cóctel**
5:00		Termina la actividad

3. Resúmenes de Conferencias Plenarias *(Invited Presentations)*

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

Francis Castro, Departament of Mathematics, University of Puerto Rico, Rio Piedras Campus

In this paper we computed all the 245,060 solutions of the equation $\sum_{i=1}^{k} \dfrac{1}{x_i} = 1$ 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 $\sum_{i=1}^{k} \dfrac{1}{x_i} = 1$ 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 $\sum_{i=1}^{k} \dfrac{1}{x_i} = 1$ admits solutions in distinct odd positive integers. Also, we answer similar questions about the equation $\sum_{i=1}^{k-1} \dfrac{1}{x_i} + \dfrac{1}{lcm(x_1, \ldots, x_{k-1})} = 1$.

Keywords: Egyptian Fractions, Diophantine Equations.

A hybrid particle-continuum approach to hydrodynamics at small scales

Aleksandar Donev, Courant Institute, New York University

This work is joint work with John Bell (Lawrence Berkeley National Labs), Alejandro Garcia (San Jose State University), Berni Alder (Lawrence Livermore National Labs), Eric Vanden-Eijnden and Jonathan Goodman (Courant Institute).

I will describe our recent and ongoing research focused on fluid mechanics in regimes where thermal fluctuations are important. Notable examples include flows at micro and nano scales typical of new microfluidic, nanofluidic and microelectromechanical devices; biological systems such as lipid membranes, Brownian molecular motors, nanopores; as well as processes where the effect of fluctuations is amplified by strong non-equilibrium effects, such as combustion of lean flames, capillary dynamics, hydrodynamic instabilities, and others. After introducing particle and continuum methods for fluctuating hydrodynamics, I will describe a hybrid particle-continuum method that employs bidirectional dynamic coupling between a stochastic particle fluid and a fluctuating continuum. Through several examples I will demonstrate that thermal fluctuations have to be consistently included in the continuum component of hybrid calculations in order not to distort the thermal equilibrium in the particle solver. I will discuss the importance of hydrodynamic fluctuations in several physical examples, such as Brownian beads, the adiabatic piston problem, and diffusively mixing fluids.

Instituto de Estadísticas de Puerto Rico: retos y oportunidades

Mario Marazzi Santiago, Instituto de Estadísticas de Puerto Rico

El Instituto de Estadísticas se fundó para promover cambios a los sistemas de recopilación de datos y estadísticas oficiales de Puerto Rico para que éstos sean completos, confiables y de rápido y universal acceso. En sus 3 años desde que inició operaciones, el Instituto ha comenzado a hacer realidad esta misión a través de diversas estrategias e iniciativas, tales como: desarrollo profesional para los que realizan actividades estadísticas en el gobierno, un inventario de las estadísticas de Puerto Rico, un calendario de publicación de estadísticas, producción de estadísticas que hagan falta, proyectos estadísticos para mejorar confiabilidad, entre otros. El Instituto es una entidad autónoma administrativa y fiscalmente del gobierno que promueve el uso de métodos científicos en la medición de las características colectivas de Puerto Rico a través de alianzas con distintos sectores. Para encaminar el cambio cultural necesario que priorice las matemáticas y las ciencias, el Instituto se propone convocar la creación de una comunidad profesional de aprendizaje sobre la metodología estadística, de manera que una a académicos, investigadores, funcionarios pblicos, el sector privado y organizaciones sin fines de lucro.

4. Sesiones Temáticas (*Mini Symposiums*)

4.1. Nuevos insumos a la investigación matemática en Puerto Rico por investigadores jóvenes
(*New influences in mathematical research in Puerto Rico by young researchers*)

Análisis de multi-resolución isotrópico

Juan Romero, Departamento de Ciencias Matemáticas, Universidad de Puerto Rico en Mayagüez

La manera más natural de extender los algoritmos de multi-resolución unidimensionales a dos o tres dimensiones es mediante productos tensoriales. Desde el punto de vista computacional esto es lo menos costoso, pero el resultado del análisis y filtraje puede ser pobre dependiendo del tipo de data. Estos productos tensoriales por su naturaleza favorecen las características verticales u horizontales. Si la data es una imagen médica, por ejemplo, esto tiene la consecuencia que información muy sensitiva para un diagnóstico puede perderse. Los algoritmos isotrópicos no son tan sencillos computacionalmente, pero son muy efectivos en el análisis de data para la cual sus características esenciales no se espera que vengan con predeterminada orientación espacial. En esta charla definiremos y caracterizaremos los AMRI,s en términos del Teorema de Lax - Weiner, y las funciones refinables istrópicas en términos de su soporte en el espacio frecuencial. En particular, no existen funciones refinables isotrópicas con soporte compacto.

Epidemic spread of influenza viruses and the role on dispersal and persistence by transient populations

Karen R. Ríos-Soto, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez
Baojun Song, Department of Mathematical Sciences, Montclair State University
Carlos Castillo-Chavez, Mathematical, Computational and Modeling Science Center, Arizona State University

The recent H1N1 ("swine flu") pandemic and recent H5N1 ("avian flu") outbreaks have brought increased attention to the study of the role of animal populations as reservoirs for pathogens that could invade human populations. It is believed that pigs acquired flu strains from birds and humans, acting as a mixing vessel in generating new influenza viruses. This work studies the interactions between transient and resident bird populations and their role on dispersal and persistence. A metapopulation framework based on a system of nonlinear ordinary differential equations is used to study the transmission dynamics and control of avian diseases. A simplified version of a two-flock mathematical model involving a limited number of migratory and resident bird populations is analyzed. Results show that mixing of bird populations (involving residents and migratory birds) play an important role on the patterns of disease spread.

Keywords: Epidemic Models; Avian Influenza; Mixing Probabilities; Non-linear Ordinary Differential Equations; Basic Reproductive Number

Linear recurrences of exponential sums of symmetric boolean functions

Francis N. Castro, Departamento de Matemáticas, Universidad de Puerto Rico en Río Piedras
Luis A. Medina, Departamento de Matemáticas, Universidad de Puerto Rico en Río Piedras
Ivelisse Rubio, Departamento de Ciencia de Cómputos, Universidad de Puerto Rico en Río Piedras

Boolean functions are one of the most studied objects in mathematics. They are important in many applications, for example, in the design of stream ciphers, block and hash functions. They play a vital role in cryptography as they are used as filter and combination generator of stream ciphers based on linear feed-back shift registers. The subject of Boolean functions can be studied from the point of view of complexity theory or from the algebraic point of view.

In this talk, we give an improvement of the degree of the homogeneous linear recurrence with integer coefficients that exponential sums of symmetric Boolean functions satisfy. This improvement is tight. We also compute the asymptotic behavior of symmetric Boolean functions and provide a formula that allows us to determine if a symmetric boolean function is asymptotically not balanced.

Keywords: Boolean Functions, Exponential Sums, Symmetric Polynomials, Recurrences

Modelos de fluidos a través de membranas permeables

Marian Hernández Viera, Departamento de Matemática-Física, Universidad de Puerto Rico en Cayey
Ricardo Cortez, Department of Mathematics, Tulane University

Para computar fluidos a pequeñas escalas, es conveniente utilizar versiones regularizadas de soluciones singulares conocidas. Combinamos el método de Stokeslets regularizados con "source-doublets" regularizados para resolver las ecuaciones de Stokes en la presencia de membranas permeables a fluidos y/o a alguna concentración. Ejemplos numéricos son utilizados para hallar una relación entre el parámetro de los "source-doublets", β, y la permeabilidad de la membrana y/o el coeficiente de difusión.

Keywords: Ecuaciones de Stokes, Membranas Permeables

4.2. Desarrollos matemáticos y computacionales con aplicaciones al estudio de la materia
(*Mathematical and computational developments with applications to the study of matter*)

Optimizing crystallographic FFTs

Dorothy Bollman, Department of Mathematical Sciences, University of Puerto Rico at Mayagüez
Edusmildo Orozco, Department of Computer Science, University of Puerto Rico at Rio Piedras

Crystalline structures are determined at atomic level by computing several three dimensional discrete Fourier transforms (DFTs) of their energy spectrum. Since crystal structures consist of repeating symmetric unit cells, their spectral data is highly redundant. We discuss methods to reduce these redundancies while siumultaneously preserving the symmetries that allow one to compute the DFTs by fast Fourier transforms (FFTs). We show how a multidimensional FFT with prime edge-length and linear symmetries in its inputs can be computed efficiently in terms of cyclic convolutions.

Mathematics of a double-walled carbon nanotube model: asymptotic and spectral analysis

Miriam Rojas-Arenaza, Department of Mathematics and Physics, University of Puerto Rico at Rio Piedras

During the talk, I will present a recently developed mathematical model for a double-walled carbon nanotube. The model is given as a system of two Timoshenko beams coupled through the Van der Waals forces. Mathematically, it is a system of two coupled hyperbolic partial differential equations equipped with a four-parameter family of dynamical boundary conditions. The system has been reduced to an evolution equation with a non-selfadjoint matrix differential operator that is a dynamics generator. Asymptotic and spectral properties of this generator will be presented in the talk. We proved that it is a unbounded nonselfadjoint operator with compact resolvent, and that the set of complex eigenvalues of the dynamics generators asymptotically splits into four individual spectral branches, which is consistent with the physics of the model. The asymptotical distribution of the eigenvalues along each branch will be discussed.

Keywords: Carbon nanotubes,Timoshenko system, matrix differential operator

A nonlinear model of an actuator

Pablo V. Negrón–Marrero, Department of Mathematics, University of Puerto Rico at Humacao
Eva Campos, Laboratory for Research on the Structure of Matter, University of Pennsylvania

We consider a mixture of carbon nanotubes (CNT's) with a polymer matrix. Laboratory experiments have shown that this composite reacts mechanically to infrared irradiation (IR). Ahir and Terentjev (2005) proposed a model based on linear elasticity in which the mechanical behavior of the CNT is assumed to be that of an incompressible material. The mechanical properties of the polymer do not enter into their model. A stress vs strain test of an actual specimen of this composite shows that at approximately 10% applied pre-strain, there is a crossing of the corresponding stress responses with and without IR stimuli. Ahir and Terentjev's model predicts this crossing at a 20% compression or reduction of the CNT's while actual experimental data shows the crossing at a 1–2% compression. We propose to improve on this by including the mechanical response of the polymer into the model and by using more general models of material response. The actuator process is incorporated into the model as a constitutive equation for the CNT's which changes its behavior in response to an external stimuli. We use a variational model in which the potential energy function corresponds to one for a mixture of two phases. To compute approximate minimizers we use a finite element method which incorporates the requirement that the stresses within the composite are continuous, yet it allows for jump discontinuities in the deformation gradient across interfaces. We perform calculations both in two and three dimensions and compare our numerical results with previous experimental data.

Keywords: actuator, nonlinear model, finite elements

Acercamientos a modelos combinatorios y computacionales de dinámica molecular de fluidos a escalas nanométricas

José O. Sotero Esteva, Departamento de Matemáticas, Universidad de Puerto Rico en Humacao
Preston Moore, Department of Chemistry, University of the Sciences in Philadelphia, Philadelphia, PA

El estudio de propiedades de dinámica de fluidos a escalas nanométricas presenta dificultades particulares ya que los modelos continuos basados en ecuaciones como las Navier-Stokes pierden validez a esas escalas. En este ámbito, los modelos basados en simulaciones de dinámica molecular atómica sigue siendo el recurso principal para simular este tipo de fenómeno. Las simulaciones de dinámica molecular granulados e hbridos de modelos continuos y discretos

son útiles a escalas intermedias. En esta charla se hace un acopio de resultados recientes y proyecciones en el estudio de dos problemas: las medidas de tensión superficial y configuraciones de vesculas de lípidos.

MOSDAS es una herramienta computacional desarrollada en nuestro laboratorio que extiende las capacidades del programado VMD, de uso amplio por investigadores en dinámica molecular, para estudiar interacciones entre moléculas. MOSDAS se mejorado a una para adecuarla al estudio de interacciones entre fluidos y sustratos comenzando con nanogotas de Argón y grafeno. El uso del lenguaje Python en la implantación de MOSDAS utilizando programación orientada a objetos ha demostrado ser una estrategia que ha facilitado tal extensión.

Un modelo granulado de una vesícula compuesta por dos tipos de lípidos se utiliza para estudiar las posibles conformaciones de ésta. Se observa experimentalmente que los lípidos suelen organizarse en la superficie formando patrones que podrían explicar su presencia y utilidad dentro de células biológicas. La simulación inicial que utiliza una técnica Monte Carlo para estudiar las posibles configuraciones no produce los resultados observados. Un estudio estrictamente combinatorio del modelo apunta a que las cantidades de vesculas posibles con distintas configuraciones podrían ser un elemento importante en la explicación del evento observable aparte de la física del sistema.

Finalmente se discute la adecuacidad de este tipo de problema para el desarrollo de investigación en matemática computacional en una institución universitaria de nivel subgraduado.

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

Solvability of linear local and nonlocal Robin problems over $C(\overline{\Omega})$

Alejandro Vélez-Santiago, Department of Mathematics, Iowa State University

Let $\Omega \subset \mathbb{R}^N$ be a bounded Lipschitz domain. We first consider an elliptic boundary value problem with general Robin boundary conditions. The boundary conditions can be either local or nonlocal, depending on the conditions imposed on the elliptic operator. We prove that this boundary value problem is uniquely solvable, and moreover we show that such weak solution is Hölder continuous on $\overline{\Omega}$. We also prove that a realization of the associated differential operator with generalized local or nonlocal Robin boundary conditions generates an analytic C_0-semigroup of angle $\pi/2$ over $C(\overline{\Omega})$. We conclude by applying the elliptic regularity theory to solve the corresponding Cauchy problem over $C(\overline{\Omega})$.

Arithmetic progressions over quadratic fields

Alexander Díaz, University of Puerto Rico at Mayagüez
Zachary Flores, Michigan State University
Markus Vasquez, Oklahoma State University

In 1640 Pierre de Fermat proposed to Bernard Frénicle de Bessy the problem of showing that there is no nonconstant arithmetic progression of four squares over $\mathbb{Q}$. The proof of this proposition was published posthumously in 1780 by Leonhard Euler. However, Euler's proof does not hold over $\mathbb{Q}(\sqrt{D})$ where D is a squarefree integer. Arithmetic progressions of four squares over $\mathbb{Q}(\sqrt{D})$ correspond to rational points on the elliptic curve $E : y^2 = x^3 + 5x^2 + 4x$

and this is related to the quadratic twist $E^{(D)} : y^2 = x^3 + 5Dx^2 + 4D^2x$. We use methods of elliptic curves to discuss the existence of arithmetic progressions of squares over $\mathbb{Q}(\sqrt{D})$.

On Korteweg-de Vries equations

Alfredo Villanueva Cueva, Department of Mathematical Sciences , University of Puerto Rico at Mayagüez

Korteweg-de Vries equations (KdV), provide a way of modeling waves on shallow water surfaces. Begun by John Scott Russell in 1834, his observations and experiments was the beginning of what later was named KdV equations which are nonlinear differential equations. Originating with constant coefficients, they now include time-dependent coefficients, modeling ion-acoustic waves in plasma and acoustic waves on a crystal lattice, there is even a connection with the Fermi-Pasta-Ulam problem. Most of the solutions are given by solitons or by numerical approximations. In this work we study a KdV equation with time-dependant coefficients and give new soliton-like solutions.

Keywords: Korteweg-de Vries equations, soliton-like solutions, time-dependant

Clustering de "streams"de series de tiempo

Ana María Aparicio Carrasco, Departamento de Matemáticas, Universidad de Puerto Rico en Mayagüez
Edgar Acuña Fernandez, Departamento de Matemáticas, Universidad de Puerto Rico en Mayagüez

En los últimos años los avances tecnológicos no solo han resultado en el enorme incremento de la producción de datos, sino que también han facilitado su recolección. Estos datos provienen de sensores, transacciones personales y automatizadas, instrumentos de medición y muchas otras fuentes. Al flujo continuo de datos se le conoce como "Streams"de datos y su principal característica es que se producen en tiempo real y de forma masiva. Actualmente se vienen estudiando muchas técnicas de minería de datos para el tratamiento de "Streams"de datos debido a su gran importancia en el área científica, empresarial y gubernamental. En este trabajo nos enfocamos en Clustering de "Streams", específicamente de series de tiempo. La idea básica del Clustering de "Streams"de series de tiempo es encontrar grupos de variables cuyo comportamiento es similar a lo largo del tiempo. El reto de los algoritmos de clustering para "Streams"de datos es obtener los resultados en una sola pasada bajo un procesamiento rápido e incremental e identificar los cambios en la estructura de los clusters dinámicamente. Como parte de nuestro estudio analizamos el algoritmo de clustering por variables denominado ODAC, el cual es uno de los primeros, y en realidad de los pocos, que se han propuesto bajo este paradigma. Se trata de un algoritmo jerárquico cuya principal característica es que construye los clusters bajo un criterio de división y aglomeración basado en los diámetros de los clusters y soportado por un nivel de significancia prefijado de antemano. Se muestra una implementación en Java del algoritmo ODAC, se aplica a un conjunto de datos real y se realiza validación externa.

Keywords: minería de datos, clustering, data streams

Perfect distance-dominating sets in the integer-lattices

Carlos Araujo Martínez, Departament of Mathematics, University of Puerto Rico at Río Piedras
Italo J. Dejter, Departament of Mathematics, University of Puerto Rico at Río Piedras

Let $\Gamma = (V, E)$ be a graph. As usual, for $S \subset V$, we denote by $[S]$ the subgraph of Γ induced by S. The distance $d(v, S)$ of a vertex $v \in V$ to S is given by $d(v, S) = \text{mín}\{d(v, w); w \in S\}$. A set $S \subset V$ will be said to be a *perfect distance-dominating set* in Γ, or PDDS in Γ, or simply a PDDS, if for each $v \in V$, there exists the unique vertex $w \in S$ such that $d(v, w) = d(v, S)$; that is, for each $v \in V$, there is the unique vertex in S at which the minimum distance from v to S is achieved.

In this work we refine the application of an algebraic construction based on a Molnár's method that allowed a conjecture on the existence of perfect dominating sets (PDS) in the lattice graphs Λ_n over $\mathbb{Z}^n$ and allows now to propose a classification of the lattice-like PDS in Λ_n for which their components are parallel paths. The stage reached is expressed as a pair of conjectures, one for parallel paths P_r with $r > 2$, the other one for parallel paths P_2, respectively associated with cyclic groups and with non-cyclic Abelian groups. Moreover, it is shown that there is no perfect dominating set (PDS) with square components in the lattice graph Λ_3 over $\mathbb{Z}^3$. However, a periodic PDS with square components *and* isolated vertices in Λ_3 is shown to exists, associated with the group $\mathbb{Z}_6 \oplus \mathbb{Z}_3 \oplus \mathbb{Z}_6$ in a fashion inspired in previous works.

Keywords: Perfect dominating set, hypercubes, lattices.

Using manipulatives to visualize multivariable calculus

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Computers are invaluable for visualizing concepts in 3D. However, there are many concepts where the 2D nature of a computer screen can limit their effectiveness. For example, using Riemann sums, a surface can be placed over the xy plane, the direction on the xy plane can be indicated and the concept can be visualized quite easily. However, working with a precise direction and its associated tangent line on a 2D computer screen requires that students visualize and reason about a 3D situation in a virtual 2D environment. A more effective pedagogical approach may be the use of physical 3D manipulatives. In this presentation, we will provide an overview of the 3D manipulatives we are using. We will provide an overview of new materials that are being created to accompany these manipulatives for multivariable calculus and give an overview of initial and new results for this project.

Keywords: manipulatives, multivariable calculus

Dynamic Bayesian models for projecting cancer incidence in Puerto Rico

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Projections of cancer incidence and mortality provide a valuable indication of the current and future situation of the cancer in Puerto Rico. These are invaluable inputs for planning and decision making, and assist in the efficient allocation of resources to meet the future needs for the prevention, detection, and treatment of cancer. We estimate the present and predict the future (2014) of incidence for the top cancer tumor types in Puerto Rico (PR), by gender, age group and primary cancer site, to design public policy. Incidence data from Puerto Rico Central Cancer Registry were obtained for the years 1985 to 2004. The dynamic autoregressive models used in modern epidemiology are function of age-period-cohort (APC). Robust priors were fitted using Bayesian methods. We use model selection using the Deviance Information Criteria (DIC) to compare APC model with Age-period (AP), Age-cohort (AC) and Period-cohort (PC) models. The model produces point estimations as well as probability intervals for 2009 and 2014 by gender and five (5) year age bands. We analyzed the fifteen (15) most important tumors types, including colon, lung and bronchus, breast in situ and malignant, and prostate among others. We introduce a novel robust and stable prior the autoregressive variance, the scaled beta prior of the second kind (Beta2 prior). We found that this leads to a stable convergence of the model at the Markov Chain Monte Carlo (MCMC) implementation. We also produce statistical tools to check the goodness of fit of the selected models.

Algorithms to measure discrete and continuous symmetry

Dennis Glenn Collins, Department of Mathematics, University of Puerto Rico at Mayagüez

Based on the author's algorithm to measure discrete and continuous symmetry, the symmetry of Howe's 60 (discrete) patterns is measured and compared with his pattern-goodness rating of visual patterns. The application of "probes" to evaluate symmetry is discussed in terms of elementary symmetric recognition operations, involving focusing on the distance between two points, then moving the eye to focus on the distance between two other points, and judging the distances are the same, i.e. there is a pair of equal distances.

Reduced linear modular systems

Edusmildo Orozco, Department of Computer Science, University of Puerto Rico, Río Piedras Campus
Dorothy Bollman, Department of Mathematics, University of Puerto Rico at Mayagüez

A linear modular system (LMS) is a pair (Z_p^n, S) where $S : Z_p \to Z_p$ is linear. When S is nonsingular, the LMS induces a cyclic structure on Z_p^n, where each cycle is an equivalence class called an S-orbit. The action of a nonsingular matrix M that commutes with S on the set of S-orbits induces another cyclic system called a reduced linear modular system (RLMS). In this work we will consider current results of two problems related to RLMSs. One, for a given LMS and a nonsingular matrix M, compute the cycle structure of the associated RLMS. Second, for a given LMS find a matrix M such that the resulting RLMS has the least number of cycles. A solution for the second problem is important for optimizing the computation of multidimensional symmetric prime edgelength FFT's.

Comparing edge detection algorithms on grayscale noise image

Elio Lozano, Computer Science Departament, University of Puerto Rico at Bayamón

In this work a comparative study of four edge detection algorithms Canny, Laplacian of Gaussian, Prewitt, and Sobel are presented. These operators based on the first and second derivative on the gray level image are applied to images with and without noise. The objective measures used in this research to compare the accuracy of the edge detection algorithms are root-mean-square error, the root-to-noise ratio, and the peak signal-to-noise ratio. These measures compute the differences between the original image and the reconstructed image generated by these operators. The contribution of this work is the comparison of these algorithms based on time complexity, runtime, and accuracy.

Keywords: Edge Detection, Derivative Filters

Soliton-like solutions for nonlinear Schrödinger equation with variable quadratic hamiltonians

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We construct soliton-like solutions for the nonlinear Schrödinger equation with quadratic time-dependent Hamiltonians. Our general approach includes important examples such as bright and dark solitons and Jacobi elliptic and second Painlevé transcendental solutions, which are important for current research in nonlinear optics and Bose–Einstein condensation.

Keywords: soliton, Schrödinger equation

Exact divisibility of deformation of symmetric boolean functions

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Moreno-Moreno introduced the combinatorial method that they called the covering method. This method provides an elementary way to estimate the divisibility of exponential sums over the binary field. Using this method, they gave an improvement to Ax's theorem for the binary case. Moreno-Castro-Mattson used the covering method to give an elementary proof to Moreno-Moreno's result for finite fields of characteristic 2. Recently, Castro-Randriam-Rubio-Mattson generalized the use of the covering method to any finite field providing an elementary approach to compute the p-divisibility of exponential sums of polynomials over prime fields. The authors obtained several bounds which unify and improve a number of previous results in this direction. Castro-Medina-Rubio used the covering method to compute the exact 2-divisibility of exponential sums of boolean functions with prescribed leading monomials and, as an application, families of boolean functions that are not balanced, and sufficient conditions for the solvability of systems of boolean equations were given. These results generalized previous known results for the binary field. In this paper we consider families of boolean functions where the number of minimal covering is greater than one. This case is much harder than the cases previously considered, where the families have only one minimal covering. Using the covering method, we compute the exact 2-divisibility of exponential sums of polynomials where its leader monomials are symmetric. Also, we compute the exact 2-divisibility of exponential sums of deformations of symmetric or homogeneous boolean functions. Our results provide families of

- non-balanced boolean functions
- "good" candidates for bent, semi-bent or quarter of bent functions
- boolean functions where we determine when the inequality given by the classical results of divisibility is strict or equality.

Keywords: boolean functions, exponential sums, symmetric polynomials

Mathematica 8 in education and research

Ginger McKee, Academic Initiatives, Wolfram Research, Inc.
Michael Morrison, Academic Initiatives, Wolfram Research, Inc.

This talk illustrates capabilities in Mathematica 8 that are directly applicable for use in teaching and research on campus. We'll be discussing a wide variety of practical and theoretical applications. Topics of this technical talk include:

- free form input
- 2D and 3D visualization
- Dynamic interactivity
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- Example-driven course materials
- Symbolic interface construction
- Practical and theoretical applications

With improvements like the new free-form input and expanded areas like finance, statistics, engineering, software development, and image processing, even the most advanced users report learning quite a bit from Mathematica technical talks.

Modeling the impact of Batrachochytrium Dendrobatidis in the life history dynamics of Eleutherodactylus Coqui under seasonality in Puerto Rico and Hawaii

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Karen Ríos-Soto, Department of Mathematics, University of Puerto Rico, Mayagüez Campus

Eleutherodactylus Coqui is a native amphibian in Puerto Rico and invasive species in Hawaii. This specie can be infected by a disease called Batrachochytrium dendrobatidis. Puerto Rico and Hawaii have two main seasons, a wet season and a dry season, although not at the same period of time. E. coqui reproduces the entire year but tend to breed higher during the wet/warm season in Puerto Rico. In contrast, it has been found that the disease tend to affect them more in the dry/cool season. Furthermore, the Hawaiian government wants to eradicate E. coqui populations, based on the fact that E. coqui affects native species and have negative impact in their population. The use of chemical and biological agents, such as B. dendrobatidis has been introduced without successful results. We use two stage-structured models to represent the effects of the disease in the juvenile population and adult population. The E. Coqui can die by the effect of disease or by predator-induced mortality, the Puerto Rican model is a susceptible-infected (SI) model. The Hawaiian model is a susceptible-infected-carrier (SIC) model due to the absence of predators in the population and consequently, longer life-span. The main use of the model was to model the impact of the seasonality in Puerto Rico and Hawaii. The performed of sensitivity analysis on the system equations was to study the effect of the seasonality function on the transmission of the disease by the environment. Numerical results show that the infected population is higher than the susceptible population, in Puerto Rico and in Hawaii. The environmental function causes seasonality on the dynamics of the disease, although is not endemic in Hawaii.

Symmetries of multi-dimensional periodic arrays

Jose Ortiz Ubarri, Department of Computer Science, University of Puerto Rico at Rio Piedras
Oscar Moreno, Gauss Research Laboratory Inc.

Moreno introduced multi-dimensional periodic Costas arrays over elementary abelian groups. In this presentation we will review the Moreno arrays. We will present two generators that produce a group of symmetries of these Costas arrays; which, through exhaustive search, we found that they characterize the group of symmetries for the lengths 3x3x8 and 2x2x2x7. We conjecture that these generators characterize the group of symmetries of the Moreno arrays. Also, we will introduce a three-dimensional sonar, and various computational results obtained during the study of these arrays.

Cómputos para simulaciones de dinámica molecular usando GPUs

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En esta charla se examina las oportunidades y dificultades en la utilización de Unidades de Procesamiento Gráfico de uso general (GPUs por sus siglas en inglés) en tres tipos de cómputos relacionados con simulaciones de dinámica molecular: aproximados de fuerzas electrostáticas, energía total de todo el sistema, energía total en un modelo granulado. Las GPUs son unidades de procesamiento paralelo que se encuentran incorporadas a tarjetas gráficas de mediano a alto rendimiento y en aceleradores gráficos como tarjetas físicamente separadas de la tarjeta gráfica que produce la imagen. En años recientes se han convertido en una alternativa de bajo costo a multiprocesadores con decenas de nodos. Sin embargo, los procesadores de los GPUs no implantan la totalidad del conjunto de instrucciones implantados en CPUs de uso general. La comunicación entre estos y los distintos componentes de memoria requiere de coordinación especial para evitar colisiones que la retrasan.

Nuestros resultados confirman que la transferencia de datos entre el GPU y el computador, que requiere la transferencia de estos por el bus al cual está conectado el GPU, es una barrera al uso eficiente de los primeros. De otra parte, los cómputos de energía total de todo el sistema requieren acceder a todos los posibles pares de átomos en el sistema, o como mínimo, en vecindades suficientemente grandes de átomos. Para este tipo de cómputo la sincronización en el acceso a los datos de modo que se eviten por completo las colisiones es imposible. An así comprobamos qe se puede obtener mejoras de rendimiento por un factor de 20. Para el cómputo de las fuerzas lectrostáticas utilizamos una técnica de aproximación que representa la carga combinada de átomos en una vecindad con un sólo átomo falso. Con esto no sólo se reduce laa cantidad de pares de átomos a considerar si no además se hace posible en acceso a datos con menor nmero de colisiones obteniendo así factores de mejora de 40. En el ltimo caso hemos implantado un modelo granulado que evita las colisiones obteniendo aceleraciones en factores mayores a 50 Todos los factores de acelerecaión se calcularon comparadando con el cómputo en el CPU con un GPU con 512 unidades de procesamiento.

La torsión de Reidemeister - Franz de un complejo CW

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Muchos de los espacios de lentes comparten grupos homológicos sin ni tan siquiera ser homotópicamente equivalentes. La torsión de Reidemeister, introducida por este en los años 30, se utiliza para, entre otras cosas, clasificar estos espacios. En esta charla discutiremos la construcción de la torsión de Reidemeister - Franz para un complejo CW, que es la base para entender estos espacios de lentes.

Dispersal patterns of an invasive species with the use of MDiG: exploring the sensibility of simulations to different parameter values in the case of Mimosa pigra in Puerto Rico

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Invasive species can cause considerable economic losses to a society and its environment. A proper understanding of how species invade a territory can help design efficient sampling strategies and control measures. MDiG is a mathematical model that studies the dispersion of an invasive species by taking explicit account of its dispersal strategies and of landscape heterogeneity. In MDiG short distance dispersion is modeled with cellular automata and long distance dispersion is modeled by drawing random numbers from several probability distributions. On the other hand, the impact of the environment on the survival of the invasive species is modeled with the use of suitability maps. Both modeling components are set up in a GIS framework. In this study we did a rough calibration of MDiG to the case of Mimosa pigra in Puerto Rico. First, we chose plausible dispersion parameter values from data available in the literature. Then we took the survival probabilities to be the predicted suitability index computed by Barragán, Camacho and Auccaille (2011). We assumed an initial distribution and ran the model for a fixed number of periods. We then repeated this exercise a fixed number of times. The center of mass was computed for each simulated final distribution. The whole process was repeated for different parameter values. The resulting centers of mass were compared visually to identify those parameters whose variations most affect the predictions of the model. More careful parameter estimation was suggested for these more influential parameters.

Keywords: dispersal, spread, simulation, invasions, Mimosa pigra, MDIG.

Digitizing and analyzing plant structure: an illustration with a Garcinia madruno seedling

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Plants cannot move. Instead, they rely on the plasticity of their structure in order to make the most out of their surrounding environment. That is why describing and analyzing the distribution of plant constituents in three-dimensional space is so important to plant scientists. Graph theory and other mathematical constructs are providing a helpful conceptual and methodological framework for the efficient representation and analysis of plant form and structure. In addition, they constitute the foundation upon which functional plant modeling can be built. Models that incorporate both plant form and physiology constitute an active and important area of current research that is known as Functional-Structural Plant Modeling. In the present study we illustrate some of the applications of these mathematical tools and concepts. In particular, we measure, encode, digitize and analyze the basic node-level structure of a 3-year old madruño (Garcinia madruno) seedling growing in Western Puerto Rico. Field measurements made for this plant include the three dimensional position of each node, the length and diameter of each internode, as well as the location and dimension (length and width) of each leaf. This information was then encoded in a database that highlights the connections between its constituent parts. A geometric representation of the internodes and leaves were assumed; each internode was modeled as a cone fustrum. These data were digitized in OpenAlea, a software developed for plant modeling. A three-dimensional reconstruction of the tree graph was made. Several features were then analyzed such as the number of nodes and the wood volume per branch. This was then used to obtain the distribution of the number of internodes as well as the wood volume on a restricted set of branches. These types of analyses are useful in characterizing different plant types, or different developmental stages within one plant type.

The spread of pine wilt disease subject to early eradication of infected trees

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Pine wilt disease is currently among the most devastating pine trees plagues on earth. It is caused by the pinewood nematode Bursaphelenchus xylophilus in a perfect, and beautifully synchronized, mutualistic relationship with beetles of the genus Monochamus. The disease has a fast and efficient spread, which turns most of the efforts to control it practically insufficient. We investigate how early eradication of infected pine trees, i.e. eradication of trees which just ceased oleoresin exudation, may affect the disease spread. In contrast to the sole eradication of killed trees, our results show that under an appropriate combination of eradication strategies: (1) There is a significant increase in the minimum pine density below which the disease fails to invade, (2) The region where reproductive Allee effects may take place are significantly enlarged. We also show how to design optimal policies for eradication through stochastic search optimization techniques. We conclude that disease extinction can be reached faster with an appropriate combination of eradication policies, minimizing the damage on healthy pine trees and operational costs at the same time.

Simulated annealing with a descent method for mathematical models of chemical kinetic systems

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Nonlinear optimization approaches were used to compute rate constants for mathematical models of transporters in renal cell membranes. The optimization consisted in minimizing the distance between model fluxes and published experimental fluxes. Two optimization techniques, the simulated annealing method and a descent method, were combined. The simulated annealing makes a rigurous exploration of the parameter surface. This method finds a best approximate instead of a minimum. The descent method improves the exploration by using the simulated annealing approximate as the initial iterate and the derivatives of the objective function. For a data set, trials with the resultant method were made with different initial parameter sets within the parameter surface. Multiple optima were observed to be distributed in different clusters on the parameter surface. In addition, the descent method found an isolated minimum that the simulated annealing failed to find.

On the transient of some non linear discrete dynamical systems

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A discrete dynamical system is a function $f : X \to X$, where X is a finite set. A question of interest is how long it takes for a state to reach an attractor, that is, what is the transient of a state. The transient of f is then defined as the maximum of the transients among all states. Due to applications we are interested when X is the n-fold cartesian product of a finite field with 2 elements. Currently there are no tools to determine the transient of a given nonlinear

f. In this work we consider the simplest boolean monomial dynamical system, that is, a system whose dependency graph is the wedge of an n cycle and an m cycle for coprimes m and n. Our main result is that for such a system, its transient is $(n+1)(m-1)$.

We also prove that the generalization of this problem, that is, obtaining the transient of a boolean monomial dynamical system whose dependency graph is the wedge of any number of cycles with relatively prime lengths, is equivalent to finding the Frobenius number $F(r)$, that is, given r positive integers, find the largest integer, $F(r)$, that cannot be expressed as a non-negative integer linear combination of these numbers. The problem of finding a closed-form solution for $F(r)$, $r > 2$, has been open for more than 200 years.

Keywords: discrete dynamical systems, transients

Parallel multiplication in finite fields with large characteristic

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Finite fields have many important applications in various fields, including signal processing, coding theory, cryptography and, more recently, in genetic networks models. For this reason a great deal of effort has gone into developing highly efficient implementations of finite field arithmetic, especially multiplication. Development of parallel multiplication algorithms has been directed almost exclusively to finite fields of characteristic 2. In this work we make use of results of Bollman, Ferrer and Orozco to develop a parallel algorithm for finite fields with large characteristic and discuss its implementation on a shared memory machine.

Keywords: finite fields, parallel computation

The volume derivative for the computation of fracture surfaces in strain space

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In last year's SIDIM we introduced what we called the *volume derivative* of a stored energy function at a given linear displacement boundary condition. Given such linear boundary condition, the volume derivative is a measure of the energy per unit volume required to open an infinitesimal hole in an initially perfect body. We use the volume derivative for the characterization of cavitation type material instabilities in solids. In particular, we characterize the set of all linear displacement boundary conditions at which cavitation first occurs (*fracture surface*) as the set of all such matrices at which the volume derivative vanishes. We present some new three dimensional examples of this characterization, and both two and three dimensional numerical examples of strain surfaces for certain physically reasonable stored energy functions. The numerics require that we solve a nonlinearly constrained large scale optimization problem. This is done using a penalization method to handle the nonlinear constraint, and a gradient flow iteration together with a finite element method to perform the required minimization.

Keywords: cavitation, volume derivative, fracture surface

Asserting parallel computational thinking into the undergraduate 4-year computer science curriculum at UPR-RP

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The development of parallel computational skills and concepts in undergraduate Computer Science (CS) students is essential, given the current and foreseen computing trends. However, most undergraduate CS programs expose students to these skills implicitly and/or as an elective third/fourth year course (if at all). The goal of our project is to enhance the undergraduate Computer Science curriculum offered at the UPR-RP with Parallel, Computational Thinking (PCT). The project entails a series of educational, assessment and dissemination activities to instill in our students the essential PCT awareness and competencies.

In this talk, we will present our projects vision and highlight some of its ongoing accomplishments and activities. More information about the project and developed materials can be found at:
http://ccom.uprrp.edu/~pmusial/CPATH/.

Búsqueda de arreglos de Costas en GPUs y FPGAs

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Un arreglo de costas tamaño N se define como una permutación $f : \mathbb{N} \to \mathbb{N}$ tal que para todo entero h, i y j, con $1 \le h \le N - 1$ y $1 \le i, j \le N - h$, $f(i + h) - f(i) = f(j + h) - f(j)$ implica que $i = j$. Los arreglos de costas tienen aplicaciones a seguridad y cómunicaciones tales como reconocimiento de objetos, comunicaciones ópticas y marca de agua digital. Actualmente, se conoce el número de arreglos de Costas hasta $N = 28*$ y no se conocen ejemplos de $N = 32$. A pesar de que existen métodos para generar soluciones algebraicas de tamaño infinito (Welch, Lempel, Golomb), estas no son exhaustivas, no existen para todo tamaño N y el tamaño del espacio de posibles soluciones crece factorialmente, por lo que se acostumbra buscar las soluciones de forma computacional. En esta presentación discutiremos el problema de búsqueda de arreglos de Costas desde el punto de vista computacional y explicaremos diseños que estamos desarrollando usando tecnologías de GPGPU y FPGA. Nuestro objetivo es contrastar las abstracciones y patrones de diseño necesarios para estas tecnologías vs. programación orientada a procesadores de uso general, y además resaltar las ventajas en rendimiento de dichas plataformas.

Student understanding of graphing functions of two variables: an analysis of results using the moments of study of the anthropological theory of the didactic

Rafael Martinez-Planell, Department of Mathematics, University of Puerto Rico at Mayagüez

This presentation is based on two previous studies dedicated to student understanding of topics in multivariable calculus. These used Action-Process-Object-Schema (APOS) and Semiotic representation theories and hence were focused on cognitive aspects of student understanding. In Trigueros and Martínez-Planell (2010) we investigated geometric aspects of student understanding of functions of two variables. Then, in Martínez-Planell and Trigueros (2009) we investigated formal aspects of student understanding of functions of two variables: domain, uniqueness of function values, range and the possible arbitrary nature of the functional relation. The main results of the articles will be briefly summarized. The revised genetic decomposition for the concept of a two variable function resulting from the previous studies will be presented. The constructions contemplated in the decomposition were used design a set of student activities to help improve understanding of functions of two variables. After this, well then analyze the institutional dependence of our findings using notions from the Anthropological Theory of the Didactic (ATD).

In particular, findings will be discussed in terms of didactic transposition phenomena, didactical organization of the textbook material and of the proposed activities. The revised genetic decomposition guides our analysis of didactical organization as well as the resulting analysis of proposed activities.

The basic idea of the notion of didactic transposition is that knowledge, as presented by the institutions that produce it, in this case the mathematical community, must by necessity be transformed in order to make it accessible to the community of students. Knowledge is segmented, organized, portions to be taught are discriminated, and new notions may be introduced with the sole purpose of serving as didactical intermediaries. At the level of the institution of higher learning this is evidenced by the chosen textbook, syllabus, study plans, and other curricular documents. At this level, knowledge suffers yet another transposition when taken to the classroom by the individual professor, when he/she chooses what will and will not be presented, the emphasis, what students will be asked in the examinations, etc. After this, there is a last transposition between what the professor presents or requires students to know and what they actually get to understand, in the sense that they may dispose of this knowledge at the end of the course to use in other academic endeavors.

The problem of didactic organization is modeled in ATD with the moments of study.These moments of study allow analyzing and describing the didactic organization of a particular topic based on the way different key didactic functions take place. The moments of study do not imply a specific chronological order. What the theory does say is that in the study of a local mathematical organization, as would be the study of graphs of functions of two variables, there will necessarily occur instances where the class will be involved in activities proper to each of the moments. The moments of study are: moment of the first encounter, moment of exploration of types of tasks and emergence of technique, technological-theoretical moment, moment of practice with the techniques, moment of institutionalization, and moment of evaluation.

According to the ATD, by distinguishing between the different ways of knowing, or practices, the process of didactic transposition also underscores the institutional relativity of knowledge, and thus sets didactical problems away from the characteristics of the individuals in the considered institutions. Hence, they conclude that to understand student difficulties in learning a particular notion it is not enough to study the cognitive aspects of learning. By contrast, and as seen in our previous studies, both APOS and semiotic representation theories focus on the cognitive aspects of learning, by starting from the formal definition of function of two variables as understood by the community of mathematicians (expert knowledge) and studying what has actually been learned by the community of students. Hence, taking into account specific institutional constraints that may affect student learning can potentially enrich our understanding of how students come to understand the notion of a function of two variables and the difficulties they encounter. Further, the analysis of didactical organization using the ATD moments of study can help ensure the institutional feasibility and proper balance of the supplementary activities suggested by the revised genetic decomposition.

Three frameworks for a general theory of factorization

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Daniel D. Anderson, Department of Mathematics, The University of Iowa, Iowa City

We discuss three different frameworks for a general theory of factorization in integral domains: τ-factorization (where τ denotes a symmetric relation on the set of nonzero nonunits of the domain), reduced τ-factorization and Γ-factorization (where Γ denotes a set). We will define all three factorizations and give examples to understand the basic idea. Also, we discuss the generalized notions of an atom, prime and the divides operator. Results on how these notions differ among them and desired structures properties, depending on which type of set or relation is considered.

Bol-Moufang quasigroups defined by a single operation

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Ashley Arp, Black Hills State University
Michael Kaminski, Knox College
Jasmine VanExel, Paine College
Davian Vernon, Morehouse College
Cory Washington, Miami University

A *quasigroup* is a set together with binary operation $*$ whose multiplication table is a Latin square. A quasigroup identity is said to be of *Bol-Moufang type* if its statement involves three variables, two of which occur once on each side and one of which appears twice on both sides; moreover, the order in which the variables appear is the same on both sides, and only one operation appears in the identity. We describe the classification of varieties of quasigroups of Bol-Moufang type where the operation involved is $*$, $/$, or $\backslash$, determining all inclusions among these and providing all necessary counterexamples.

Grafo Mariposa

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Una red de interconexión es un sistema de computadoras, llamados nodos que se conectan usando líneas de comunicación. En general, las redes de interconexión pueden modelarse y representarse usando teoría de grafos finita. Cuando asociamos un grafo a una red de comunicación, los vértices y las aristas del grafo representan los nodos y las líneas de comunicación de la red. Las redes simétricas, como la red hipercubo, son poderosas herramientas computacionales en paralelo, porque los procesos se distribuyen, de forma simétrica, a través de los nodos de la red, mejorando notoriamente el costo computacional. La mayor desventaja que presenta esta red es que el grado de los nodos aumenta de acuerdo con su dimensión. Hay muchas redes de interconexión asociadas al hipercubo, entre estas tenemos la red Mariposa n-dimensional. En este trabajo se encuentra el grupo de automorfismo del grafo mariposa para dimensiones pequeñas.

Keywords: Teoría de grafos, grafo Mariposa.

6. Afiches (*Posters*)

Pursuit problems: generalizations and numerical simulations

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A pursuit problem consists of studying the path followed by an aggressor (the pursuer) to catch a prey. This problem dates back to Zeno's solution of the classic Achilles and the Tourtoise problem, Leonardo Da Vinci and Pierre Bouguer (1732). The term pursuit curve was introduced by George Boole in his Treatise on differential equations of 1859. The usual mathematical model in a pursuit problem is that of a differential equation that describe the relative velocity between the pursuer and prey and in which the speed of the pursuer is proportional to that of the prey. Besides the direct applications to biology, this problem is also important in ballistics and aviation.

In the classical pursuit problem, the prey follows a given known path and the problem is to determine the path followed by the pursuer. Normally the approach in textbooks and papers is to find exact solutions of the model

equations which can only be obtained for fairly simple prey path curves. For more complex situations, numerical methods are the only practical alternative to approximate the solution.

A more realistic situation in a pursuit problem is that in which the prey follows a possibly random path. Another interesting situation is the one in which the pursuer chases more than one prey and has to make decisions on the fly onto which prey to follow. In this paper we will propose models for both of these situations and perform numerical simulations to study the possible resulting trajectories followed by the pursuer.

Keywords: Pursuit Curves, Ordinary Differential Equations (ODE)

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 1920. 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 personas previamente determinada y cuenta cuántos de esos 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 de estos individuos y su esperanza de vida. 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 utilizo las fórmulas de la Organización Mundial de la Salud. Se quiere ver si se puede encontrar formas de hacerlas cada vez más precisas. Esta tabla se hizo usando la información de la población por edades del 2005 de la Junta de Planificación de Puerto Rico y la cantidad de muertes por edad durante ese mismo año del Departamento de Salud de Puerto Rico (www.tendenciaspr.com). Al final se obtiene la esperanza de vida que tiene una persona a cierta edad, esto estima cuántos años mas puede vivir. Las proyecciones futuras para este trabajo son poder refinar la información para un periodo mas allá de 85 años y también ver el fenómeno por sexo.

Keywords: mortalidad

Minimum rank of subgraphs of hypercube

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Let Q_n be a n-dimensional hypercube. A hypercube *cut-complex* is the subgraph induced by the set of vertices on one side of the hyperplane when a $(d-1)$-hyperplane cuts some edges in Q_n. The minimum rank of a simple graph G is the smallest possible rank over all real symmetric matrices whose ij-th entry (for $i \neq j$) is nonzero exactly when $\{i, j\}$ is an edge in G. The minimum rank of selected cut-complexes of Q_n is presented, including the family defined by the *Cartesian product* of $(n-2)$-dimensional hypercube and a path with three vertices denoted by $Q_{n-2}\Box P_3$. Furthermore all cut complexes of small order hypercubes have been calculated.

Ensamblando secuencias de segunda generación

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La biología computacional consiste en estudiar problemas computacionales inspirados en la biología, como el ensamblaje de las secuencias nucleicas de segunda generación (NGS), que pueden generar miles de millones de secuencias en un proyecto. Es necesario implementar un mecanismo computacional óptimo que permita ensamblar las secuencias de manera eficiente, en tiempo razonable. Actualmente, se estudia sobre el pepino de mar (Holothuria glaberrima), por diversas razones referentes a su bondad de regenerarse (S.A., La investigación del Laboratorio de Desarrollo y Neurobiología de la UPR Río Piedras, El Nuevo Día, pág. 77). En este organismo buscamos genes específicos de la regeneración.

Estudié ensambladores como Çelera Assembler", un programa .°pen source", que reconstruye secuencias largas del ADN genómico a partir de datos de NGS. Çelera Assembler"ha permitido muchos avances en la genómica, por ejemplo, la primera secuencia completa del genoma (Myers, 2000). Dado eso, se procedió a estudiar el algoritmo, su funcionamiento y los métodos que utiliza para ensamblar las secuencias. Luego, se aplicó a dos millones de secuencias del pepino de mar. Los resultados obtenidos no coincidieron con los objetivos inicialmente planteados. Sin embargo, se ha optado por estudiar el algoritmo de otros ensambladores.

Spectral algorithms for imaging applications

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Image segmentation is a process that has applications in areas like medicine, security, entertainment, and other areas. The goal of this project is to design new algorithms for problems in computer vision, especially on image segmentation. The idea consist of representing a picture as a graph were the nodes are the pixels of the picture and the weight in the edges is the probability of two adjacent pixels been part of the same object. Concepts of spectral graph theory will be used to perform the image segmentation process. At the end we hope to develop an open source MATLAB toolbox with an implementation of the new algorithms.

Generalization of the BIC: objective and robust Student-t test

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The Student-t test, or the comparison of two normal means, is arguably the most basic and fundamental test of the whole statistics for which standard, conventional and objective Bayesian procedures are needed for everyday practice and for teaching. In this poster, first we argue that the most popular Bayesian Student-t tests are inconsistent and strongly subjective, second we propose objectives procedures that are consistent and third we show a synthesis of this procedures, which essentially give rise to the same test. This is a sort of synthesis of Bayesian procedures. The methods that are used to generate the objective procedures are at first sight are very different: the Theory of Intrinsic Priors and the second is based on a Robust Prior (Berger, 1985) which has given rise to a recent substantial refinement of BIC, called PBIC (Prior based Bayesian Information Criterion). Bayesians have long come to terms with the disadvantages of procedures based on Conjugate Priors, because of the desire of closed forms results and simplicity. The Robust Prior also gives closed form results without the disadvantages of Conjugate priors, and there is the name of the Robust Bayesian Student-t test.

Keywords: Student-t test, Conjugate Prior, Intrinsic Prior, Robust Prior, Bayes Factor, Hypothesis testing, Consistency of Bayes Factors.

Automated creation of virtual network topology and virtual cluster nodes for parallel programming on a single server

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Broadly speaking, a cluster is a collection of two or more interconnected computers known as nodes. Some clusters are predesigned with these interconnections in mind but, generally, they are independent nodes interconnected by a physical network which allows them to communicate and to share memory, disk space and processors. These requirements are common to most parallel computing frameworks. Virtualization of computer clusters allow programmers to develop parallel software without the need to acquire costly hardware and also provide automated configurations. Simple methodologies for the creation of virtual clusters will be needed in a near future when parallelism starts playing a protagonist role in Computer Science programs all throughout the world. Traditionally, virtualization technologies worry only about cpu and memory and neglect other important resources such as disk usage and network topology. Having many virtual machines running at the same time will eventually bring the host operating system to a crawl, will consume vast amounts of disk space, will make it harder for configuring network services among the virtual network, and will, generally, be harder to maintain. Solaris Zones are a form of virtualization that allow us to run isolated processes while sharing the same kernel instance. Thus, zones consume less memory than a traditional virtual machine while Crossbow allows us to create a virtual network for zone interconnections which is a missing feature in most virtualization suites. Here we show a methodology for the automated creation of efficient virtual cluster nodes and virtual network topology for parallel programming on a single server.

Poisson model for infantile asthma

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High prevalence of infantile asthma in Puerto Rico led researchers to aim to predict hospital visits based on airborne fungal spore and pollen concentrations, meteorological factors, and/or air quality measures. In this investigation researchers tried to reproduce results from a similar study in Ottawa, Canada (Dales et al 2000), but obtained a model based solely on average daily temperature instead of on fungal spores, ozone, and relative humidity. This research looks to create a similar model using data in Puerto Rico. Limitations regarding the current data and model are discussed.

Keywords: infantile asthma, fungal spores, poisson model

Producto modular y su conexión con grafos

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Recientemente se ha encontrado una conexión entre las teorías de grafos y de factorizaciones. Este trabajo se ha enfocado particularmente en el caso de las τ_2-factorizaciones y la teoría de grafos. En otras palabras, en la factorización donde se puede multiplicar pares con pares e impares con impares o equivalentemente elementos que pertenecen a la misma clase de equivalencia módulo 2. Presentamos ejemplos y la caracterización del grafo módulo 2 de un número impar. También, se presenta una caracterización de los grafos módulo 2 de números pares.

Keywords: factorizations, graphs

Fitting a von Bertalanffy growth curve for the Virgin Islands Boa using Bayesian Hierarchical Models

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Using mark-recapture data (so individual age is unknown), we use Bayesian Hierarchical models for fitting a von Bertalanffy growth curve for the Virgin Island boa (Epicrates monensis granti). The model structure used was proposed by Zhang, Lessard and Campbell (2009), and it allows variability in the maximum size L8 and in the growth rate k. Different models are fitted and compared to determine differences by sex and other characteristics.

Link between graphs and comaximal factorizations

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For years mathematicians have studied factorization into irreducible elements. But recently, non-atomic factorizations such as the comaximal factorization have been studied. The comaximal factorization (or $\tau_{[\ ]}$-factorization), defined by the relation $\tau_{[\ ]} \{(x,y) \mid [x,y] = 1\}$ a subset of $\mathbb{Z}^{\sharp} \times \mathbb{Z}^{\sharp}$, allows a number to be factorized into elements whose greatest common denominator is 1. We studied the properties of the $\tau_{[\ ]}$-factorization and found that it satisfies the divisive, associative-preservative, symmetric, among other properties. It does not, however, satisfy the reflexive, multiplicative, and transitive properties. The irreducible elements (or atoms) of the comaximal factorization are all prime numbers and powers of prime numbers, while every other number can be $\tau_{[\ ]}$-factorized into at least two elements different from ± 1. We found that the $\tau_{[\ ]}$-factorization is best represented by a complete graph.

A statistical suitability map for Mimosa pigra in Puerto Rico: preliminary results based on presence/absence, temperature and precipitation data

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Environmental conditions are important determinants of the survival of species. Because the environment changes over space, one would expect a corresponding spatial gradient in the presence/absence of an invasive species. This correspondence is important when evaluating the susceptibility of certain regions to the invasion of foreign pests or when predicting the impact of environmental change on existing living organisms. In the present study we compute a suitability map for Mimosa pigra in Puerto Rico. To do this we use spatially indexed data on presence/absence, temperature and precipitation, all originally available in ArcGIS data formats. The data on presence/absence is unusual in that normally only presence data is available for these kind of studies. The statistical model consists of a logistic regression which is estimated in R with presence/absence as the dependent variable and temperature and precipitation as the independent variables. The results include a constant, a temperature parameter and precipitation parameter. The estimated equation was then used to predict the suitability index level of each point in space (pixel) given its temperature and precipitation levels. These data points were then exported back to ArcGIS for visualization purposes. The resulting suitability map performed better visually than a rule based suitability map when overlapping the presence/absence data. This map was used by Barragán and Henríquez (2011) as an input in a mathematical model of the spread of this invasive species over Puerto Rico. In addition, because the data include both presence and absence occurrences, it was possible to estimate the bias introduced if only presence data are used and no amendments are made to the statistical model in order to take into account this non-random data structure. This kind of bias is commonly introduced in the suitability map literature. Several improvements were suggested for future consideration, such as the inclusion of additional variables (e.g., soil use) and the explicit recognition of spatial correlation in the estimation of the regression parameters.

Estimado de la tensión superficial en una nanogota de Argón basada en una simulación por dinámica molecular

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Existe evidencia experimental que demuestra que el comportamiento de la materia a gran escala no necesariamente es igual a su comportamiento a escala atómica. Esta investigación científica se basa en estudiar el comportamiento de los átomos en una nanogota de Argón para recopilar información que nos permita estudiar el fenómeno de la tensión superficial a escalas nanométricas. La tensión superficial es una propiedad de los líquidos causada por las fuerzas intermoleculares que le atribuye a su superficie la facultad de actuar como una lámina elástica. En la primera etapa de este trabajo hemos corroborado la existencia de una fase intermedia de átomos entre la fase líquida y gaseosa de la nanogota líquida. El procedimiento experimental emplea la técnica de dinámica molecular para simular una nanogota de Argón al vacío. La simulación de dinámica molecular es una herramienta que nos permite integrar el uso de la computadora y que provee alternativas para la manipulación de los materiales a nivel atómico. La segunda etapa de este proyecto contempla la simulación de la nanogota de Argón sobre una superficie de grafeno. Para este trabajo, hemos integrado el uso de un interfaz escrito en Python, MoSDAS, que complementa el programa de visualización molecular VMD y ofrece opciones adicionales para el manejo de las estructuras. MoSDAS fue diseñado por un grupo de estudiantes de investigación anterior y hemos aumentado sus utilidades incorporando funciones para construir nuevas estructuras, métodos adicionales para la manipulación de los materiales y gráficos que permiten realizar un análisis mientras ocurre la simulación.

Boundary approximation in the finite element modeling of micropolar plates

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We consider Micropolar (Cosserat) elastic plates. The elastic materials of these plates respond to spin inertia and body and surface couples, as a consequence, they exhibit certain new static effect, couple stresses and more general type of deformation. The Galerkin finite element method (FEM) has been applied to an extension of Reissner plate theory for micropolar plates of moderate thickness. This method allows us to accurately simulate the bending deformation of the micropolar elastic plates of different shapes and boundary conditions. The estimation of the error in L2-norm of the numerical simulation of the bending of a rectangular plate shows quadratic rate of convergence of the method. We will present a new efficient boundary approximation algorithm for the plates of different shapes, which allows us to split the boundary conditions to simpler forms. Preliminary numerical computations for different shapes of domain show convergence to the solution of the system with original boundary condition. We will also discuss theoretical aspects of this type of convergence and its rate.

Food consumption patterns: preliminary data from Puerto Rico

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Obesity is a growing health problem in contemporary Puerto Rico. Overeating and unbalanced diets are among the causes of obesity. In the present study we explore socioeconomic factors behind the food consumption patterns of urban Puerto Rico households. We use data obtained from a representative survey of urban household income and expenditure. This survey was conducted in the period 1999 to 2003 by the Puerto Rico Department of Labor and Human Resources and was originally designed to calculate the Consumer Price Index. In all regressions, the dependent variable was expenditure in some food group. The independent variables used were total spending on consumer goods, level of education of the household head and household size. The estimation method was either ordinary least squares or weighted OLS whenever heteroscedasticity was diagnosed. Several functional forms were estimated. The double-logarithmic function gave the best fit in 11 out of the 16 food groups. An interesting result of the study is that the elasticities of food consumption and of flours consumption with respect to the number of years of education of the head of household were, respectively, -0.79 and -0.05. In other words, more education is associated with less food intake, and a more balanced diet (less carbohydrate consumption). Other education elasticities were equally suggestive: high carbohydrate or fat foods such as baked goods, beef and pork meat had negative elasticities, while healthier white meats had positive elasticities. However, these elasticities were not statistically significant. Income elasticity for aggregate food consumption was 1.83. Income elasticies for individual food groups were all positive, less than one and statistically significant. Only beef meat and fruits had income elasticities greater than 0.50. Hence, for each subgroup, more income increases food consumption but less that proportionally.

Número de Waring en ecuaciones en cuerpos finitos

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El problema del Número de Waring es hallar el número mínimo de variables, $\delta(d,p)$, necesarias para que una ecuación de forma $x_1^d + x_2^d + ... + x_n^d = \beta$ tenga soluciones en los naturales para cualquier número natural β. En nuestro caso, trabajamos con ecuaciones sobre cuerpos finitos F_p, donde p es primo. Existen teoremas que nos permiten el cálculo del número de Waring para ciertos valores de p y d. Otros teoremas nos dan cotas, dependiendo de d, para valores de p tales que $\delta(d,p) = 2$. En general, no es fácil saber cuales son los valores de p y d para los cuales no se conoce el número de Waring. En nuestro trabajo, determinamos casos en los cuales el número de Waring no se conoce y usando programas en C++ computamos algunos de estos valores. Al final deseamos obtener una tabla con resultados de números de Waring sobre cuerpos finitos.

Keywords: Número de Waring, cuerpo finito, solución de ecuaciones

Índice alfabético

Tolson, Peter, 27
Tomaiconza Ataulluco, Oscar, 19
Torres Núñez, David A., 13
Torres-Aponte, Héctor D., 24

Vélez-Santiago, Alejandro, 11
VanExel, Jasmine, 23
Vasquez, Markus, 11
Vernon, Davian, 23
Villanueva Cueva, Alfredo, 12

Washington, Cory, 23

Yupanqui Huamán, Oscar, 20