UNIVERSIDAD DE COSTA RICA

XXII SIMMAC

Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

PROGRAMA Y RESÚMENES

25-28 DE FEBRERO, 2020
SAN JOSÉ, COSTA RICA
SEDE RODRIGO FACIO

CIMPA Centro de Investigación en **Matemática Pura y Aplicada**

http://simmac.ucr.ac.cr/

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XXII Simposio **I**nternacional de **M**étodos **M**atemáticos **A**plicados a las **C**iencias

San José, 25 al 28 Febrero, 2020/ February 25-28th, 2020

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- Vicerrectoría de Administración de la Universidad de Costa Rica.
- Vicerrectoría de Investigación de la Universidad de Costa Rica.
- Vicerrectoría de Vida Estudiantil de la Universidad de Costa Rica.

Dr. Mario Villalobos Arias
Coordinador, SIMMAC

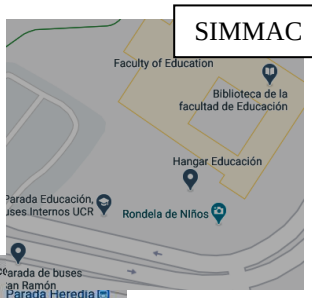
Sesiones / *Sessions*

CODIGO	NOMBRE SESION
SI01	Invited session: Modeling
SIProb1	Invited session: Probability
SI03	Invited session:
SI04	Invited session: Banca 1
SI05	Invited session: Banca 2
SINum1	Inv. session: Numerical solution of PDEs
SINum2	Inv. session: Numerical solution of PDEs
Aprox1	Approximation / Aproximación 1
Aprox2	Approximation / Aproximación 2
Bio1	Biomathematics / Biomatemáticas 1
Bio2	Biomathematics / Biomatemáticas 2
Clas1	Classification / Clasificación
Deq1	Differential Equations / Ecuaciones Diferenciales 1
Deq2	Differential Equations / Ecuaciones Diferenciales 2
DS1	Dynamical Systems / Sistemas Dinámicos
GT1	Geometry and Topology / Geometría y Topología 1
GT2	Geometry and Topology / Geometría y Topología 2
Apl1	Applications / Aplicaciones 1
Apl2	Applications / Aplicaciones 2
OpC1	Optimal Control / Control Óptimo
Prob1	Invited session: Probability 2
Mod1	Modeling / Modelación 1
Mod2	Modeling / Modelación 2
Mst1	Multivariate Statistics / Estadística Multivariada
Num1	Numerical Analysis / Análisis Numérico 1
OR1	Operations Research / Investigación de Operaciones 1
OR2	Operations Research / Investigación de Operaciones 2
Opt1	Optimization / Optimización 1
Opt2	Optimization / Optimización 2
SPr1	Stochastic Processes / Procesos Estocásticos
DatAn1	Análisis de datos / Data Analysis

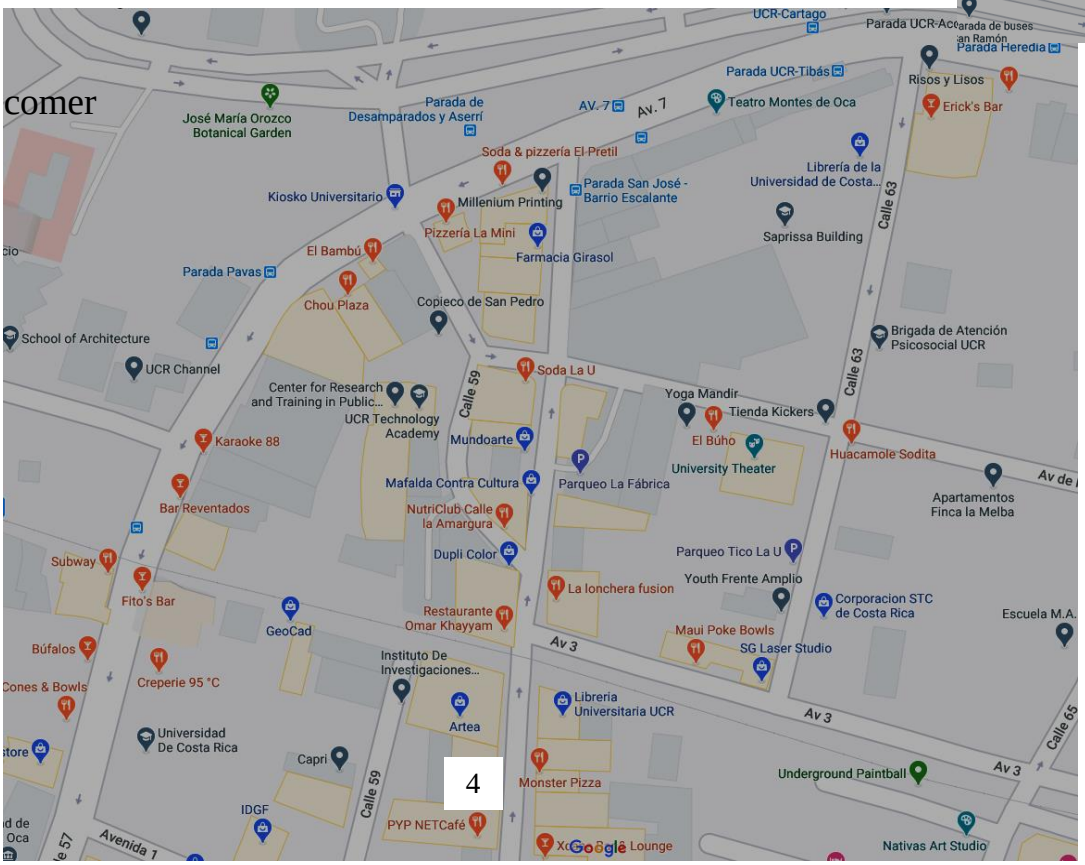
Aulas / *Rooms*

ED: Facultad de Educación / Education Faculty

Auditorio (ED) / *Auditorium*	Primer piso ED / *first floor ED*
Aula 1 (ED) / *Room* 1	Primer piso ED / *first floor ED*
Aula 2 (ED) / *Room* 2	Primer piso ED / *first floor ED*
Aula 3 (ED) / *Room* 3	Primer piso ED / *first floor ED*
Laboratorio / *Laboratory*	Primer piso ED / *first floor ED*
Oficina del SIMMAC / *SIMMAC desk*	Primer piso ED / *first floor ED*
Oficina del CIMPA / *CIMPA office*	Edificio CIMPA-Matemática, Ciudad de la Investigación



Places to eat
Lugares para comer



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XXII SIMMAC
Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

25-28 DE FEBRERO, 2020
SAN JOSÉ, COSTA RICA.
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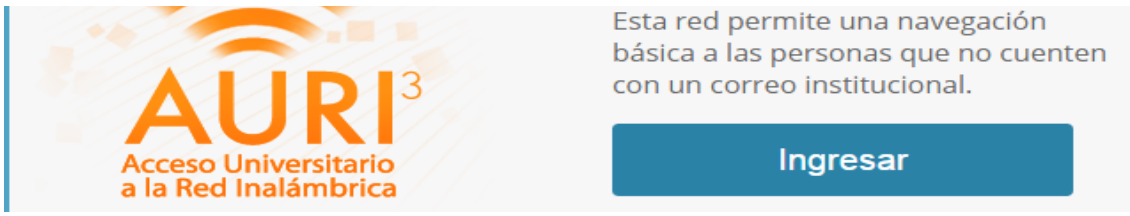

XXII Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

XXII International Symposium on Mathematical Methods Applied to Sciences

XXII SIMMAC Martes / Tuesday 25th

Auditorium													
8:00	-->	∞	Inscripciones / Inscription										
9:30	10:00	am	Inauguración / Opening ceremony										
10:00	10:30	am	Café / Coffee break										
10:30	11:15	am	Opening Plenary Talk / Conferencia Inaugural										
Stefanov, Plamen													
Local and global boundary rigidity													
Chair: *Carlos Montalto*													
11:15	12:00	am	Plenary Talk 2										
Alfaro, Jorge													
Population dynamics with multiple time variables													
Chair: *Carlos Montalto*													
12:00	**02:00**	**pm**	**Tiempo para almuerzo / Time for lunch.**										
Auditorium				**Room 1**						**Room 2**			
Session	**Apl1**		**Applications / Aplicaciones 1**	Session	**Deq1**		**Differential Equations / Ecuaciones Diferenciales 1**			Session	**OR1**		**Operations Research / Investigación de Operaciones 1**
Chair: *Esteban Segura*				Chair: *Daniel Campos*						Chair: *Luis Barboza*			
1	02:00	02:20 pm	Bustamante, R Household Observable Characteristics and Po	4	02:00	02:20 pm	Aguirre, Manuel	Elemental solution of the ultrahyperbolic e		7	02:00	02:20 pm	Arango, Jaime An Goal programming to prioritize public secto
2	02:20	02:40 pm	Mendoza, Carl Evaluate the optimal performance measures	5	02:20	02:40 pm	Villa, José	An extreme theorem on subspaces of integ		8	02:20	02:40 pm	Chacón, Alejandr Design optimization of detention ponds us
3	02:40	03:00 pm	Herrera, Eddy Simulation of Synergism and Antagonism in b	6	02:40	03:00 pm				9	02:40	03:00 pm	Arango, Jaime An Optimal scheduling of tasks in business pro
Session	**Apl2**		**Applications / Aplicaciones 2**	Session	**Deq2**		**Differential Equations / Ecuaciones Diferenciales 2**			Session	**DatAn1**		**Análisis de datos / Data Analysis**
Chair: *Esteban Segura*				Chair: *Daniel Campos*						Chair: *Luis Barboza*			
10	03:05	03:25 pm	Tovar, Luis Mar Applications of Conformal Mapping in Bicom	13	03:05	03:25 pm	Sbitneva, Larissa	Lie methods for smooth loops: The matrix f		16	03:05	03:25 pm	Gallardo-Allen, E Social networks analysis in the process of f
11	03:25	03:45 pm	Teliz, Agustin Experimental and numerical dynamic analysis	14	03:25	03:45 pm	Martín, José Ant	Delay differential models: exact and nonsta		17	03:25	03:45 pm	Norori, David Ge Citizen security of the Adiact Cast of the cit
12	03:45	04:05 pm	Reyes, Alan Ge Automated stenosis detection in X-ray corona	15	03:45	04:05 pm				18	03:45	04:05 pm	
04:05	04:30	pm	Café / Coffee break										
Session	**Num1**		**Numerical Analysis / Análisis Numérico 1**	Session	**OR2**		**Operations Research / Investigación de Operaciones 2**			Session	**Clas1**		**Classification / Clasificación**
Chair: *Juan Gabriel Calvo*				Chair: *Mario Villalobos*						Chair: *David Masís*			
19	04:30	04:50 pm	Torres, Anthon Fractional Newton-Raphson Method and Som	23	04:30	04:50 pm	Jablonsky, Josef	Ranking of decision making units in DEA mo		27	04:30	04:50 pm	Masís, David Hiperbolic Smoothing Fuzzy Clustering Met
20	04:50	05:10 pm	Rico, Carlos Ali Fibonacci n-Recurring Numbers.	24	04:50	05:10 pm	Sarin, Rakesh	Just Society: A Decision Theoretic Foundati		28	04:50	05:10 pm	Campos, Walter (Classification Model of Visible and Invisible
21	05:10	05:30 pm	Morales-Monte Inner Metric for an Approximate Spacetime w	25	05:10	05:30 pm	Bushenkov, Vladi	The decomposition method in the multiple		29	05:10	05:30 pm	Centeno, Óscar Classification in time series: an application
22				26	05:30	05:50 pm	Villa, José	On an extreme theorem on non compact se		30	05:30	05:50 pm	Amaya, Luis Edua Comparison of Optimization Metaheuristic
06:00	**06:30**	**pm**	**Acto Cultural / Act Cultural**										
06:30	**08:00**	**pm**	**Brindis de Bienvenida / Welcome Toast**										

XXII Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

XXII International Symposium on Mathematical Methods Applied to Sciences

XXII SIMMAC: Miércoles / Wednesday 26th

Auditorium	Room 1	Room 2	Room 3
	08:00 09:30 am **Tutorial 2** Ragusa, Maria Alessandra Developing in silico trials to fight Tubercolosis- H2020 STriTuVaD Proje Chair: *Mario Villalobos*	08:00 09:30 am **Tutorial 5** Alvarado, Matías Cancer metastasis and the Immune System Reaction: modeling and sim Chair: *Carlos Montalto*	
09:30 09:50 am Café / Coffee break			
	09:50 11:10 am **Tutorial 2 - cont.** Ragusa, Maria Alessandra Qualitative properties of solutions of Partial Differential Equations Chair: *Mario Villalobos*	09:50 11:10 am **Tutorial 5 - cont.** Alvarado, Matías Cancer metastasis and the Immune System Reaction: modeling and sim Chair: *Carlos Montalto*	
11:15 12:00 Plenary Talk 3 Palau, Sandra Branching processes in random environment Chair: *Pedro Méndez*			
12:00 02:00 pm Tiempo para almuerzo / Time for lunch.			

Auditorium	Room 1	Room 2	Room 3
	Session **SIProb1** **Invited session: Probability** Chair: *Pedro Méndez* 31 02:00 02:20 pm Campos, José Da Asymptotic expansion fo the invarian 32 02:20 02:40 pm Uribe, Gerónimo Caminatas aleatorias con reubicación 33 02:40 03:00 pm Gutiérrez, Jonath Inverting the weak random operator	Session **DS1** **Dynamical Systems / Sistemas Dinámicos** Chair: *Javier Trejos* 34 02:00 02:20 pm Eduarte-Rojas, Ac Chaotic Behaviour of Geodesics in Sp 35 02:20 02:40 pm Méndez, Héctor I Total transitivity in hyperspaces 36 02:40 03:00 pm Larissa, Valmy Spatio temporal process driven by a h	Session **SINum1** **Invited session: Numerical solution of PDEs** Chair: *Filander Sequeira* 37 02:00 02:20 pm Bustinza, Romme A Hybrid High-Order formulation for a 38 02:20 02:40 pm Gatica, Luis F. Analysis of a pseudostress-based HD 39 02:40 03:00 pm Gomez-Vargas, B New mixed finite element methods fo
Session **Bio1** **Biomathematics / Biomatemáticas 1** Chair: *Esteban Segura* 40 03:05 03:25 pm Villegas-Diaz, Rok MetaPipe: A High-Performance Comp 41 03:25 03:45 pm Andrés, Giovana Virotherapy against cancer: analysis o 42 03:45 04:05 pm García, Yury Elen Early pathogen replacement in a two-	Session **prob1** **Invited session: Probability 2** Chair: *Pedro Méndez* 43 03:05 03:25 pm Acuña, Luis Heat content related to isotropic-stab 44 03:25 03:45 pm Fonseca, Christia Semimartingales and their stochastic cal 45 03:45 04:05 pm Romeo, Cutberto Stochastic Optimal Control of a Two-L	Session **Mod1** **Modeling / Modelación 1** Chair: *Javier Trejos* 46 03:05 03:25 pm Gómez, Adrián Fractional Calculus in nano-strucutre 47 03:25 03:45 pm Barboza, Luis Alb State-Space models in Paleoclimate R 48 03:45 04:05 pm Cuervo, Omar An A Monte Carlo Approach to Computir	Session **SINum2** **Invited session: Numerical solution of PDEs** Chair: *Mario A./Filander S.* 49 03:05 03:25 pm Sequeira, Filánde A mixed virtual element method for t 50 03:25 03:45 pm Solano, Manuel A priori and a posteriori error analysis 51 03:45 04:05 pm
04:05 04:30 pm Café / Coffee break			
Session **Bio2** **Biomathematics / Biomatemáticas 2** Chair: *Fabio Sánchez* 52 04:30 04:50 pm Aguirre, Alejandr Fertility and breast cancer mortality i 53 04:50 05:10 pm Sánchez, Fabio Parameter estimates of the 2016-201 54 05:10 05:30 pm Aparicio, Juan Pa Ross-Macdonald models: which one s	Session **Mst1** **Multivariate Statistics / Estadística Multivariada** Chair: *Maikol Solis* 55 04:30 04:50 pm Kalemkerian, Jua An independence test based on recur 56 04:50 05:10 pm Reinecke, Jost Dynamic Longitudinal Models for Crir 57 05:10 05:30 pm Cubero, Mariana Cantonal analysis of traffic congestior	Session **Mod2** **Modeling / Modelación 2** Chair: *Mario Villalobos* 58 04:30 04:50 pm Fernandez, Andre Multilevel Bayesian Structural Equati 59 04:50 05:10 pm Alvarado, Daniel Simulation of Multiple Plasma Eddies 60 05:10 05:30 pm	Session **SINum2** **Invited session: Numerical solution of PDEs** Chair: *Mario A./Filander S.* 61 04:30 04:50 pm Villada, Luis Migu High-order finite-difference WENO sc 62 04:50 05:10 pm Alvarez, Mario A mixed-primal finite element metho 63 05:10 05:30 pm
05:30 06:30 pm	**Poster session / sesión de carteles**		

XXII Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

XXII International Symposium on Mathematical Methods Applied to Sciences

XXII SIMMAC Jueves / Thursday 27th

Auditorium	Laboratory	Room 2
08:00 09:30 am **Tutorial 8** Sbitneva, Larissa Geometry of complex numbers Chair: *Mario Villalobos*	08:00 09:30 am **Tutorial 3** van Dunné, Frans R package development workshop Chair: *Marcela Alfaro*	08:00 09:40 am **Tutorial: Geometría y Topología** Avritzer, Dan Classical Geometry and Moduli of Vector and Higgs Bundles Chair: *Ronald Zuñiga*
09:30 09:50 am Café / Coffee break		
09:50 11:10 am **Tutorial 8 - cont.** Sbitneva, Larissa Geometry of complex numbers Chair: *Mario Villalobos*	09:50 11:10 am **Tutorial 3 - cont.** van Dunné, Frans R package development workshop Chair: *Marcela Alfaro*	Session **GT1** **Geometry and Topology / Geometría y Topología 1** Chair: *Ronald Zuñiga* 64 10:00 10:40 am Zamora Saiz, Alfc Hodge-Euler polynomials of character vari 65 10:40 11:20 am Schmitt, Alexand Relative Geometric Invariant Theory 66 11:20 12:00 am Gadbled, Agnes Categorical action of the braid group of th
11:15 12:00 Plenary Talk 4 Coello, Carlos Where is research in multi-objective evolutionary optimization going? Chair: *Mario Villalobos*		
12:00 01:00 pm Tiempo para almuerzo / Time for lunch.		

12:45 pm Salida para el Paseo del Evento/Departure for Conference Tour

02:30 03:30 pm Visit to Irazu Volcano

04:30 08:00 pm Cena del evento / Conference Dinner

XXII Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

XXII International Symposium on Mathematical Methods Applied to Sciences

XXII SIMMAC Viernes / Friday 28th

Auditorium

08:00 09:30 am **Tutorial 1**
Bustamante, Ronald
Audio Analysis for Classification and Clustering
Chair: *Samaria Montenegro*

09:30 09:50 am Café / Coffee break

09:50 11:10 am **Tutorial 1 - cont.**
Bustamante, Ronald
Audio Analysis for Classification and Clustering
Chair: *Samaria Montenegro*

11:15 12:00 Plenary Talk 5
Perea, José
The underlying topology of data
Chair: *Marcela Alfaro*

12:00 2:00 pm Tiempo para almuerzo / Time for lunch.

Room 1

08:00 09:30 am **Tutorial 6**
Villegas-Diaz, Roberto
Parallel Computing using Rmpi
Chair: *Esteban Segura*

09:50 11:10 am **Tutorial 6 - cont.**
Villegas-Diaz, Roberto
Parallel Computing using Rmpi
Chair: *Esteban Segura*

Room 2

08:00 09:40 am TUT-4 **Tutorial: Geometría y Topología - cont.**
Avritzer, Dan
Classical Geometry and Moduli of Vector and Higgs Bundles
Chair: *Ronald Zuñiga*

Session **GT2** **Geometry and Topology / Geometría y Topología 2**
Chair: *Alfonso Zamora*

66	10:00	10:40 am	Rosales-Ortega, José	A geometric splitting theorem
67	10:40	11:20 am	Sánchez, Jesús	E-infinity Structures in L-Algebras
68	11:20	12:00 am	Zúñiga-Rojas, Ronald Alb	Modular Operads and Higgs Bundles

Auditorium

Session **SI04** **Invited session: Banca 1**
Chair: *Alvaro Guevara*

69	02:00	02:20 pm	Sandí, Ana Rosa	Predictive Modelling of Losses in non-life ir
70	02:20	02:40 pm	Franck, Alexander	How to manage price in times of crisis?
71	02:40	03:00 pm	Arce, Jorge Andrés	The Role of Data Analytics in Banking and F

Session **SI05** **Invited session: Banca 2**
Chair: *Alvaro Guevara*

78	03:05	03:25 pm	Hidalgo, Jorge	Excel, then R: from basic mathematical ope
79	03:25	03:45 pm	Guerrero, Alejandr	The Auditor 4.0
80	03:45	04:05 pm	Guevara, Alvaro	Statistical copulas in finance and their appl

04:00 04:30 pm Café / Coffee break

04:30 05:15 pm Closing Plenary Talk / Conferencia de Clausura
Montenegro, Samaria
Logic and model theory in mathematics.
Chair: *Javier Trejos*

05:15 05:45 pm Clausura / Closing session

Room 1

Session **Aprox1** **Approximation / Aproximación 1**
Chair: *Mario Villalobos*

72	02:00	02:20 pm	Vides, Fredy Ant	On Approximately Cyclic Model Order Redu
73	02:20	02:40 pm	Lobo, Jaime	A multiplicative decomposition for a family
74	02:40	03:00 pm		

Session **Aprox2** **Approximation / Aproximación 2**
Chair: *Jaime Lobo*

81	03:05	03:25 pm	Vides, Fredy Ant	On Algebraic Approximation of Time-Evolu
82	03:25	03:45 pm	Castro, Edwin	Some consequences of the theorem of Kro
83	03:45	04:05 pm		

Room 2

Session **Opt1** **Optimization / Optimización 1**
Chair: *Esteban Segura*

75	02:00	02:20 pm	Hernández, Fernando Jos	Generalized Vehicle Routing Problems (GARP)
76	02:20	02:40 pm	Arango, Jaime Antero	Multivariable nonlinear search with evolutionary
77	02:40	03:00 pm		

Session **Opt2** **Optimization / Optimización 2**
Chair: *Mario Villalobos*

84	03:05	03:25 pm	Villalobos, Mario	Multidimensional scaling in the sphere using sim
85	03:25	03:45 pm	Arango, Jaime Antero	Ant colony algorithm applied to 2D packaging to
86	03:45	04:05 pm		

Social Program
Programa Social

25-28 DE FEBRERO, 2020
SAN JOSÉ, COSTA RICA.
SEDE RODRIGO FACIO

DATE **día**	**TIME** **hora**	**ACTIVITY** **actividad**
Tuesday 25 Martes	9:30 a.m.	Opening Ceremony, Inauguración
Tuesday 25 Martes	6:10 p.m.	Welcome Toast, Brindis de Bienvenida
Thursday 27 Jueves	12:45 p.m.	Departure to the Tour and Conference Dinner, Salida al paseo y Cena del evento
Thursday 27 Jueves	2:30 p.m.	Visit to Irazu Volcano, Visita al Volcán Irazu
Thursday 27 Jueves	6:00 p.m.	Conference Dinner, Cena del evento
Friday 28 Viernes	5:15 pm	Closing , Clausura

Programa / Program

Lunes / Monday, 24

8:00 – ∞: Inscripciones / Registration: `Faculty of Education or CIMPA`.

Martes/Tuesday, 25

8:00 – ∞: Inscripciones / Registration.

9:30 – 10:00 : Inauguración / Opening ceremony `Auditorium`.

10:00 – 10:30 : Café / Coffee break.

10:30– 11:15 Session: Opening Plenary Talk / Conferencia Inaugural (conf1): `Auditorium / Auditorio`.

STEFANOV, P.: Local and global boundary rigidity (pág. 132).

11:15– 12:00 Session: Plenary Talk 2 (conf2): `Auditorium / Auditorio`.

ALFARO, J.: Population dynamics with multiple time variables (pág. 27).

12:00 – 2:00 p.m.: Tiempo para almuerzo / Time for lunch.

02:00– 03:00 Session: Applications / Aplicaciones 1 (Apl1): `Auditorium / Auditorio`.

02:00– 02:20 BUSTAMANTE, R.: Household Observable Characteristics and Poverty Level in Costa Rica (pág. 47).

02:20– 02:40 MENDOZA, C.: (CANCELADA) Evaluate the optimal performance measures of traffic lights located around the Central America and Jean Paul Genie roundabouts, to calculate a common cycle that will speed up the circulation and improve the operability between them. (pág. 99).

02:40– 03:00 HERRERA, E. & PERDOMO, L.F.: Simulation of Synergism and Antagonism in binary mixture models (pág. 84).

02:00 – 03:00 Session: Differential Equations / Ecuaciones Diferenciales 1 (Deq1): `Room/aula 1`.

02:00– 02:20 AGUIRRE, M.A.: Elemental solution of the ultrahyperbolic equation iterated m times $L(u(x)) = f(x)$ (pág. 26).

02:20– 02:40 VILLA, J.: An extreme theorem on subspaces of integrable functions and applications to partial differential equations (pág. 144).

02:00 – 03:00 Session: Operations Research / Investigación de Operaciones 1 (OR1): `Room/aula 2`.

02:00– 02:20 ARANGO, J.: Goal programming to prioritize public sector investment (pág. 40).

02:20– 02:40 CHACÓN, A. & OREAMUNO, R.: Design optimization of detention ponds using metaheuristics: simulated annealing and genetic algorothms. (pág. 58).

02:40– 03:00 ARANGO, J.: Optimal scheduling of tasks in business processes (pág. 35).

03:05 – 04:05 Session: Applications / Aplicaciones 2 (Apl2): `Auditorium / Auditorio`.

03:05– 03:25 TOVAR, L.: Applications of Conformal Mapping in Bicomplex Analysis (pág. 136).

03:25– 03:45 TELIZ, A.: Experimental and numerical dynamic analysis of cantilever beam (pág. 133).

03:45– 04:05 REYES, A. & SÁNCHEZ-CERVANTES, F.: Automated stenosis detection in X-ray coronary angiograms (pág. 112).

03:05 – 04:05 Session: Differential Equations / Ecuaciones Diferenciales 2 (Deq2): `Room/aula 1`.

03:05– 03:25 SBITNEVA, L.: Lie methods for smooth loops: The matrix form for the solution of the differential equations for some variety of Bol loops (pág. 126).

03:25– 03:45 MARTÍN, J. & CASTRO, M.Á. & RODRIGUEZ, F.: Delay differential models: exact and nonstandard numerical solutions (pág. 95).

03:05 – 04:05 Session: Análisis de datos / Data Analysis (DatAn1): `Room/aula 2`.

03:05– 03:25 GALLARDO-ALLEN, E.: Social networks analysis in the process of formulation and implementation of quality public policy: the case of programs accreditation in Costa Rica. (pág. 71).

03:25– 03:45 NORORI, D. & MOLINA, A. & LACAYO, L.: Citizen security of the Adiact Cast of the city of León, Nicaragua, February 2018. (pág. 102).

04:05 – 04:30 : Café / Coffee break.

04:30 – 05:50 Session: Numerical Analysis / Análisis Numérico 1 (Num1): `Auditorium / Auditorio`.

04:30– 04:50 TORRES, A. & BRAMBILA, F.: Fractional Newton-Raphson Method and Some Variants for the Solution of Nonlinear Systems (pág. 135).

04:50– 05:10 RICO, C.: Fibonacci n-Recurring Numbers. (pág. 113).

05:10– 05:30 MORALES, J. & FRUTOS-ALFARO, F.: Inner Metric for an Approximate Spacetime with Mass Quadrupole (pág. 101).

04:30 – 05:50 Session: Operations Research / Investigación de Operaciones 2 (OR2): `Room/aula 1`.

04:30– 04:50 JABLONSKY, J.: Ranking of decision making units in DEA models: A review and comparative study (pág. 86).

04:50– 05:10 SARIN, R.: Just Society: A Decision Theoretic Foundation (pág. 124).

05:10– 05:30 BUSHENKOV, V. & MARQUES, S. & LOTOV, A.: The decomposition method in the multiple criteria integer programming forest management problem in Portugal (pág. 45).

05:30– 05:50 VILLA, J.: On an extreme theorem on non compact sets and the minimax theorem (pág. 146).

04:30 – 05:50 Session: Classification / Clasificación (Clas1): `Room/aula 2`.

04:30– 04:50 MASÍS, D.: Hiperbolic Smoothing Fuzzy Clustering Method (pág. 96).

04:50– 05:10 CAMPOS, W.: Classification Model of Visible and Invisible Urban Underemployment in El Salvador in the years 2008, 2017, 2018. (pág. 51).

05:10– 05:30 CENTENO, Ó.: Classification in time series: an application with economic data (pág. 56).

05:30– 05:50 AMAYA, L. & TREJOS, J.: Comparison of Optimization Metaheuristics Based on Neighborhoods for Clustering Binary Data (pág. 31).

6:00 pm: 6:10 p.m. Cultural presentation/ presentación cultural

6:30 pm: 6:10 p.m. Welcome Toast / brindis de Bienvenida

Dia Miércoles/Wednesday 26

08:00 – 09:30 Session: Tutorial 2 (Tut-2): `Room/aula 1`.

RAGUSA, M.: Developing in silico trials to fight Tubercolosis- H2020 STriTuVaD Project (pág. 108).

08:00 – 09:30 Session: Tutorial 5 (Tut-5): `Room/aula 2`.

ALVARADO, M.: Cancer metastasis and the Immune System Reaction: modeling and simulation (pág. 29).

09:30 – 09:50 : Café / Coffee break.

09:50 – 11:10 Session: Tutorial 2 (Tut-2): `Room/aula 1`.

RAGUSA, M.: Qualitative properties of solutions of Partial Differential Equations (pág. 108).

09:50 – 11:10 Session: Tutorial 5 (Tut-5): `Room/aula 2`.

ALVARADO, M.: Cancer metastasis and the Immune System Reaction: modeling and simulation (pág. 29).

11:15 – 12:00 Session: Plenary Talk 3 (conf3): `Auditorium / Auditorio`.

PALAU, S.: Branching processes in random environment (pág. 105).

12:00 – 2:00 p.m.: Tiempo para almuerzo / Time for lunch.

02:00 – 03:00 Session: Invited session: Probability (SIProb1): `Room/aula 1`.

02:00– 02:20 CAMPOS, J. & RAMÍREZ, A.: Asymptotic expansion fo the invariant measure for ballistic random walk in the low disorder regime (pág. 50).

02:20– 02:40 URIBE, G. & MAILLER, C.: Caminatas aleatorias con reubicación preferencial y árboles recursivos aleatorios (pág. 137).

02:40– 03:00 GUTIÉRREZ, J. & PACHECO, C.G.: Irvirtiendo el operador debil asociado al proceso de Brox con muerte (pág. 80).

02:00 – 03:00 Session: Dynamical Systems / Sistemas Dinámicos (DS1): `Room/aula 2`.

02:00– 02:20 EDUARTE-ROJAS, A. & FRUTOS-ALFARO, F. & CARBONI-MÉNDEZ, R.: Chaotic Behaviour of Geodesics in Spacetime metrics with Quadrupole Moment (pág. 64).

02:20– 02:40 MÉNDEZ, H. & MÉNDEZ, H.: Total transitivity in hyperspaces (pág. 97).

02:40– 03:00 LARISSA, V. & VAILLANT, J.: Spatio temporal process driven by a hidden point process - Application in ecology (pág. 88).

02:00 – 05:10 Session: Invited session: Numerical solution of PDEs (SINum1): `Room/aula 3`.

02:00– 02:20 BUSTINZA, R. & MUNGUIA-LA-COTERA, J.: A Hybrid High-Order formulation for a Neumann problem on general meshes (pág. 49).

02:20– 02:40 GATICA, L. & CAMAÑO, J. & VALLEJOS, E.: Analysis of a pseudostress-based HDG method for the Oseen problem (pág. 74).

02:40– 03:00 GOMEZ-VARGAS, B. & ALVAREZ, M. & GATICA, G.N. & RUIZ-BAIER, R.: New mixed finite element methods for natural convection with phase-change in porous media (pág. 77).

03:05 – 04:05 Session: Biomathematics / Biomatemáticas 1 (Bio1): `Auditorium / Auditorio`.

03:05– 03:25 VILLEGAS-DIAZ, R. & ALAHAKOON, D. & FENNELL, A.: MetaPipe: A High-Performance Computing pipeline for QTL mapping of large metabolic datasets (pág. 149).

03:25– 03:45 ANDRÉS, G. & STARKOV, K.: Virotherapy against cancer: analysis of model dynamics using the localization method of compact invariant sets (pág. 32).

03:45– 04:05 GARCÍA, Y. & CAPISTRÁN, & CHKREBTII, O.A. M. & NOYOLA, D.E. Inference for Stochastic Kinetic Models Using Multiple Data Sources of Acute Respiratory Infections (pág. 72).

03:05 – 04:05 Session: Invited session: Probability 2 (Prob1): `Room/aula 1`.

03:05– 03:25 ACUÑA, L.: Heat content related to isotropic-stable process (pág. 24).

03:25– 03:45 FONSECA, C.: Semimartingales and their stochastic calculus on spaces of distributions (pág. 68).

03:45– 04:05 ROMEO, C. & GONZÁLEZ, L. & CASTILLO, D.: Stochastic Optimal Control of a Two-Level Quantum System. A numerical approach (pág. 115).

03:05 – 04:05 Session: Modeling / Modelación 1 (Mod1): `Room/aula 2`.

03:05– 03:25 GÓMEZ, A. & GENTIL, R.: Fractional Calculus in nano-strucutred (pág. 75).

03:25– 03:45 BARBOZA, L.: State-Space models in Paleoclimate Reconstructions (pág. 44).

03:45– 04:05 CUERVO, O. & GALVIS, J.C.: A Monte Carlo Approach to Computing Stiffness Matrices Arising (pág. 63).

03:05 – 04:05 Session: Invited session: Numerical solution of PDEs (SINum2): `Room/aula 3`.

03:05– 03:25 SEQUEIRA, F. & GATICA, G.N. & MUNAR, M.: A mixed virtual element method for the Boussinesq problem on polygonal meshes (pág. 129).

03:25– 03:45 SOLANO, M. & SÁNCHEZ, N. & SÁNCHEZ-VIZUET, T.: A priori and a posteriori error analysis of an unfitted HDG method for semi-linear elliptic problems (pág. 131).

04:05 – 04:30 : Café / Coffee break.

04:30 – 05:10 Session: Biomathematics / Biomatemáticas 2 (Bio2): `Auditorium / Auditorio`.

04:30– 04:50 AGUIRRE, A.: Fertility and breast cancer mortality in Mexico (pág. 25).

04:50– 05:10 SÁNCHEZ, F. & VÁSQUEZ, P. & BARBOZA, L.: Parameter estimates of the 2016-2017 Zika outbreak in Costa Rica: An Approximate Bayesian Computation (ABC) approach (pág. 119).

05:10– 05:30 APARICIO, J. & SIMOY, I.: Ross-Macdonald models: which one should we use? (pág. 34).

04:30 – 05:30 Session: Multivariate Statistics / Estadística Multivariada (Mst1): `Room/aula 1`.

04:30– 04:50 KALEMKERIAN, J.: An independence test based on recurrence rates (pág. 87).

04:50– 05:10 REINECKE, J. & ERDMANN, A.: Dynamic Longitudinal Models for Criminological Panel Data (pág. 110).

05:10– 05:30 CUBERO, M. & GOMEZ-CAMPOS, S.: Cantonal analysis of traffic congestion in Costa Rica 2018 (pág. 62).

04:30 – 05:30 Session: Modeling / Modelación 2 (Mod2): `Room/aula 2`.

04:30– 04:50 FERNANDEZ, A.: Multilevel Bayesian Structural Equation Modeling with small-variance priors for cross-loadings (pág. 66).

04:50– 05:10 ALVARADO, D. & FRUTOS-ALFARO, F.: Simulation of Multiple Plasma Eddies in 2D (pág. 28).

04:30 – 05:30 Session: Invited session: Numerical solution of PDEs (SINum2): `Room/aula 3`.

04:30– 04:50 VILLADA, L.: High-order finite-difference WENO schemes for models of crowd dynamics (pág. 143).

04:50– 05:10 ALVAREZ, M. & GATICA, G.N. & RUIZ-BAIER, R.: A mixed-primal finite element method for the coupling of Brinkman-Darcy flow and nonlinear transport (pág. 30).

05:30 – 06:30 Session: Poster/Carteles (poster): `Pasillo / Hall`.

CASTRO, A. & ROCHA, M.: Principal Components Analysis (PCA) and Logistic Regression supporting for early fault detection in oil wells (pág. 52).

CASTRO, J. & VARGAS-MASIS, R. & ALFARO, D.: Deep multiple instance learning for the acoustic detection of tropical birds using limited data (pág. 55).

FANAEE, M.: On Lyapunov exponents of hyperbolic homeomorphisms (pág. 65).

MÁRQUEZ, E. & ROMO, M.P.: Application of the fractional differential equation of movement to s1gl, forced to forced vibrations of a shaking table (pág. 91).

MARTÍNEZ, A. & SCOTT, M.: Environmental statistics App, with Shiny (pág. 93).

MARTÍNEZ, A.: Interactive application of the map of Costa Rica with different WMS layers. (pág. 94).

OGASAWARA, H.: A family of the information criteria using the phi-divergence for categorical data (pág. 104).

PASQUIER, C.: Automatic visualization of the variables of a data set (pág. 106).

ROMERO, E.: Genetic programming to obtain mathematical models from turbine data using symbolic regression (pág. 117).

SANTAMARÍA, P.: Geographic information system for territorial development and mobility in Costa Rica, 2019 (pág. 123).

VÁSQUEZ, P. & LORÍA, A. & SANCHEZ, F. & BARBOZA, L.: Climate-Driven Statistical Models as effective predictors of local dengue incidence in Costa Rica (pág. 140).

Jueves/Thursday 27

08:00 – 09:30 Session: Tutorial 8 (Tut-8): `Auditorium / Auditorio`.

SBITNEVA, L.: Geometry of complex numbers (pág. 125).

08:00 – 09:30 Session: Tutorial 3 (Tut-3): `Laboratory`.

VAN DUNNÉ, F. & HERNÁNDEZ, R.: R package development workshop (pág. 138).

08:00 – 09:40 Session: Tutorial Geometría y Topología (Tut-4): `Room/aula 2`.

AVRITZER, D. & GOTHEN, P.: Classical Geometry and Moduli of Vector and Higgs Bundles (pág. 43).

09:30 – 09:50 : Café / Coffee break.

09:30 – 11:10 Session: Tutorial 8 (Tut-8): `Auditorium / Auditorio`.

SBITNEVA, L.: Geometry of complex numbers (pág. 125).

09:30 – 11:10 Session: Tutorial 3 (Tut-3): `Laboratory`.

VAN DUNNÉ, F. & HERNÁNDEZ, R.: R package development workshop (pág. 138).

10:00 – 11:20 Session: Geometry and Topology / Geometría y Topología 1 (GT1): `Room/aula 2`.

10:00– 10:40 ZAMORA SAIZ, A.: Hodge-Euler polynomials of character varieties (pág. 152).

10:40– 11:20 SCHMITT, A.: Relative Geometric Invariant Theory (pág. 128).

11:20– 12:00 GADBLED, A.: Categorical action of the braid group of the cylinder: symplectic aspect (pág. 70).

11:15 – 12:00 Session: Plenary Talk 4 (conf4): `Auditorium / Auditorio`.

COELLO, C.: Where is research in multi-objective evolutionary optimization going? (pág. 60).

12:00 – 12:45 p.m.: Tiempo para almuerzo / Time for lunch.

12:45 : Departure for Conference Tour and Dinner / Salida para el Paseo y Cena del Evento

02:30 – 03:30 p.m.: Visit to Irazu Volcano

04:30 – 08:00 p.m.: Cena del evento / Conference Dinner

Viernes/Friday 28

08:00 – 09:30 Session: Tutorial 1 (Tut-1): `Auditorium / Auditorio`.

BUSTAMANTE, R.: Audio Analysis for Classification and Clustering (pág. 48).

08:00 – 09:30 Session: Tutorial 6 (Tut-6): `Room/aula 1`.

VILLEGAS-DIAZ, R. & FENNELL, A.: Parallel Computing using Rmpi (pág. 150).

08:00 – 09:40 Session: Tutorial Geometría y Topología (Tut-4): `Room/aula 2`.

AVRITZER, D. & GOTHEN, P.: Classical Geometry and Moduli of Vector and Higgs Bundles (pág. 43).

09:30 – 09:50 : Café / Coffee break.

09:50 – 11:10 Session: Tutorial 1 (Tut-1): `Auditorium / Auditorio`.

BUSTAMANTE, R.: Audio Analysis for Classification and Clustering (pág. 48).

09:50 – 11:10 Session: Tutorial 6 (Tut-6): `Room/aula 1`.

VILLEGAS-DIAZ, R. & FENNELL, A.: Parallel Computing using Rmpi (pág. 150).

10:00 – 12:00 Session: Geometry and Topology / Geometría y Topología 2 (GT2): `Room/aula 2`.

10:00– 10:40 ROSALES-ORTEGA, J.: A geometric splitting theorem (pág. 118).
10:40– 11:20 SÁNCHEZ, J.: E-infinity Structures in L-Algebras (pág. 120).
11:20– 12:00 ZÚÑIGA-ROJAS, R. & SÁNCHEZ, J.E.: Modular Operads and Higgs Bundles (pág. 149).

11:15 – 12:00 Session: Plenary Talk 5 (conf5): `Auditorium / Auditorio`.

PEREA, J.: The underlying topology of data (pág. 107).

12:00 – 2:00 p.m.: Tiempo para almuerzo / Time for lunch.

02:00 – 03:00 Session: Invited session: Banca 1 (SI04): `Auditorium / Auditorio`.

02:00– 02:20 SANDÍ, A.: Predictive Modelling of Losses in non-life insurance (pág. 121).
02:20– 02:40 FRANCK, A.: How to manage price in times of crisis? (pág. 69).
02:40– 03:00 ARCE, J.: The Role of Data Analytics in Banking and Financial Services (pág. 42).

02:00 – 03:45 Session: Approximation / Aproximación 1 (Aprox1): `Room/aula 1`.

02:00– 02:20 VIDES, F.: On Approximately Cyclic Model Order Reduction for Data-Driven Systems (pág. 141).
02:20– 02:40 LOBO, J. & VILLALOBOS, M: A multiplicative decomposition for a family of functions of Fresnel integral type and its applications (pág. 89).

02:00 – 02:40 Session: Optimization / Optimización 1 (Opt1): `Room/aula 2`.

02:00– 02:20 HERNÁNDEZ, F. & LOISEAU, I.: Generalized Vehicle Routing Problems (GARP) (pág. 81).
02:20– 02:40 ARANGO, J.: Multivariable nonlinear search with evolutionary algorithm to optimize forecast model parameters (pág. 36).

03:05 – 04:05 Session: Invited session: Banca 2 (SI05): `Auditorium / Auditorio`.

03:05– 03:25 HIDALGO, J.: Excel, then R: from basic mathematical operations to models (pág. 85).

03:25– 03:45 GUERRERO, A.: The Auditor 4.0 (pág. 78).

03:45– 04:05 GUEVARA, A.: Statistical copulas in finance and their applications (pág. 79).

03:05 – 04:05 Session: Approximation / Aproximación 2 (Aprox2): `Room/aula 1`.

03:05– 03:25 VIDES, F.: On Algebraic Approximation of Time-Evolution Operators (pág. 142).

03:25– 03:45 CASTRO, E. & ARGUEDAS, V.: Some consequences of the theorem of Kronecker (pág. 54).

03:05 – 03:45 Session: Optimization / Optimización 2 (Opt2): `Room/aula 2`.

03:05– 03:25 VILLALOBOS, M. & ALVARADO, O.: Multidimensional scaling in the sphere using simulated annealing (pág. 148).

03:25– 03:45 ARANGO, J.: Ant colony algorithm applied to 2D packaging to improve the performance of a storage system (pág. 38).

04:05 – 04:30 : Café / Coffee break.

04:30 – 05:15 Session: Closing Plenary Talk / Conferencia de Clausura (conf6): `Auditorium / Auditorio`.

MONTENEGRO, S.: Logic and model theory in mathematics. (pág. 100).

05:15 – 05:30 : Closing / Clausura

Contributions List[1]

[1] In strict alphabetic order according to the name of the author of the contribution.

Heat content related to isotropic-stable process[I]

Sesión invitada

ACUÑA VALVERDE, LUIS[II]

Costa Rica

Given $X = \{X_t\}_{t\geq 0}$ an isotropic α-stable process in $\mathbb{R}^d$, $0 < \alpha \leq 2$, we discuss the small time behavior of the heat content function, defined as follows:

$$H_\Omega(t) = \int_\Omega \mathbb{P}(X_t \in \Omega | X_o = x)dx,$$

where Ω is a bounded domain with smooth boundary. Applications related to the Schorödinger operator $(\Delta)^{\alpha/2} + 1_\Omega$ are given.

Keywords: covariance function, heat content, stable processes, sets of finite perimeter.

References

[1] L. Acuña Valverde, *Heat content estimates over sets of finite perimeter.* Journal of Mathematical Analysis and Applications, **441**, 104-120, (2016).

[2] L. Acuña Valverde, *Heat content for stable processes in domains of* $\mathbb{R}^d$. The Journal of Geometric Analysis, DOI: 10.1007/s12220-016-9688-9, 1-33, (2016).

[I] Miércoles/Wednesday 26, 03:05 - 03:25, Room/aula 1, session: (Prob1-1), Invited session: Probability 2

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Fertility and breast cancer mortality in Mexico[I]

Communication / Ponencia

AGUIRRE, ALEJANDRO[II]

México

Breast cancer and cervical-uterine cancer are among the leading causes of death among women in Mexico. In recent years the behavior of these causes of death has been contrasting. While in cervical-uterine cancer the differentials are according to expectations (higher mortality of marginalized populations) and the tendency is to decrease mortality over time, with breast cancer the opposite occurs; that is, higher mortality is observed in the most favored groups, and an increasing trend in mortality. Although there are different angles from which research on breast cancer mortality can be approached, this research will analyze the association between fertility and mortality. The use of the indicator of years of life lost (YLL) will be privileged. A characteristic that usually occurs in the lowest strata of the population is a higher fertility. Likewise, a higher proportion of mothers who practice breastfeeding has been observed historically in these strata and there is also a tendency to last for longer periods. This could be provided a protective effect against breast cancer. The purpose of this paper is to try to explore if such a hypothesis is supported.

Keywords: Fertility, breast cancer, mortality.

References

[1] Agudelo, M., A. Aguirre y C. Dávila "Variaciones en los años de vida perdidos por cáncer de mama y cérvico uterino en México según grado de marginación estatal, 1997 y 2007". Revista Chilena de Salud Pública (ISSN 0717-3652), Vol. 14 (1). Escuela de Salud Pública de la Universidad de Chile, Santiago de Chile, 2010.

[2] Arriaga E. "Comentarios sobre algunos índices para medir el nivel y el cambio de la mortalidad". Estudios Demográficos y Urbanos 1996; 11:5-30.

[3] Hermon, C, y V. Veral. "Breast cancer mortality rates are levelling off or beginning to decline in many western countries: analysis of time trends, age-cohort and ageperiod models of breast cancer mortality in 20 countries". British Journal of Cancer (1996) 73, 955-960, 1996. Stockton Press.

[I] Miércoles/Wednesday 26, 04:30 - 04:50, Auditorium / Auditorio, session: (Bio2-1), Biomathematics / Biomatemáticas 2

[II] El Colegio de México, Centro de Estudios Demográficos, Urbanos y Ambientales, México, México, aguirre@colmex.mx

Elemental solution of the ultrahyperbolic equation iterated m times $L(u(x)) = f(x)$[I]

Solución elemental del operador ultrahiperbolico iterado m veces $L(u(x)) = f(x)$

Communication / Ponencia

AGUIRRE, MANUEL A.[II]

Argentina

Let $P(x)$ be a quadratic form defined by (1). We know from [1] that the equation $LPm(u(x_1, \ldots, x_n)) = f(x_1, \ldots, x_n)$ is called ultrahyperbolic, where $P = P(x)$ is defined by (1) and LP by (5). In this article we give a sense the elemental solution of the equation

$$LPm(u(x_1, \ldots, x_n)) = f(x_1, \ldots, x_n),$$

where LPm is the eperator LP iterated $m-$times.

Keywords: distributions, equation, solution, elementary, hyperbolic.

Resumen

Sea $P(x)$ una forma cuadrática definida por la ecuación (1). Sabemos de la referencia [1] que la ecuación $LPm(u(x_1, \ldots, x_n)) = f(x_1, \ldots, x_n)$ es frecuentemente llamada ultrahiperbólica, donde $P = P(x)$ es una forma cuadrática definida por la ecuación (1) y el operador Lp por la ecuación (5). En este artículo se le da un sentido a la solución elemental de la ecuación

$$LPm(u(x_1, \ldots, x_n)) = f(x_1, \ldots, x_n),$$

donde LPm es el operador Lp iterado m veces.

Palabras clave: distribución, ecuación, solución, elemental, ultrahiperbólico.

References

[1] Gelfand I.M. and Shilov G.E.,Generalization Functions,Vol.I,Academic Press,New York,1964.

[2] Aguirre, Manuel A. The Fourier transform of P_+^λ and P_-^λ, International Journal of Mathematics, Vol. 105 (2), 2015.

[3] Aguirre Manuel A., New formulae about the residue of distributions $P_\pm^\lambda$, NEXO Revista Científica, volume 22, 2010.

[4] A. Erdelyi,Ed. Higher Functions, Vol.I, and II, McGraw-Hill,New York,1953.

[I] Martes/Tuesday 25, 02:00 - 02:20, Room/aula 1, session: (Deq1-1), Differential Equations / Ecuaciones Diferenciales 1

[II] Núcleo de Inteligencia Comportamental Empresarial-NICE. Facultad de Ciencias Exactas, Universidad Nacional del Centro, Tandil, Argentina, maguirre.aguirre48@gmail.com

Population dynamics with multiple time variables[I]

Dinámica de poblaciones con múltiples variables de tiempo

Plenary Talk

ALFARO MURILLO, JORGE[II]

Estados Unidos, Costa Rica

Population dynamics is a branch of life sciences that studies how populations evolve with respect to time. Many of the populations studied have heterogeneity in variables that measure the time elapsed since an event. For example, in demography, the age of each person in the population is the time that has elapsed since the person was born. In other systems, some of the variables only make sense in parts of the population. For example, in epidemiology, the time elapsed since an infection.

In this talk we will show how to model these types of problems as dynamic systems represented by a transport equation where the boundary condition is dependent on the state of the system. For these models we will present general conditions for the existence, non-negativity and regularity of solutions. To illustrate the methodology we will develop a model inspired by epidemiology where, in addition to basic results, we will study the dynamics of the system's equilibria.

Keywords: population dynamics, multiple time variables, epidemiology.

Resumen

La dinámica de poblaciones es una rama de las ciencias de la vida que estudia como poblaciones evolucionan con respecto al tiempo. Muchas de las poblaciones estudiadas presentan heterogeneidad en variables que miden el tiempo transcurrido desde un evento. Por ejemplo, en demografía, la edad de cada persona en la población es el tiempo que ha transcurrido desde el nacimiento de la persona. En otros sistemas, algunas de las variables solo tienen sentido en partes de la población. Por ejemplo, en epidemiología, el tiempo transcurrido desde una infección.

En esta charla vamos a mostrar como modelar este tipo de problemas como sistemas dinámicos representados por una ecuación de transporte donde la condición de frontera es dependiente del estado del sistema. Para estos modelos presentaremos condiciones generales para la existencia, no-negatividad y regularidad de soluciones. Para ilustrar la metodología vamos a desarrollar un modelo inspirado en epidemiología en donde además de resultados básicos, estudiaremos la dinámica de los equilibrios del sistema.

Palabras clave: dinámica de poblaciones, múltiples variables de tiempo, epidemiología.

[I] Martes/Tuesday 25, 11:15 - 12:00, Auditorium / Auditorio, session: (conf2), Plenary Talk 2

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Simulation of Multiple Plasma Eddies in 2D[I]

Simulación de Torbellinos Múltiples de Plasma en 2 D

Communication / Ponencia

ALVARADO, DANIEL[II] Frutos-Alfaro, Francisco[III]

Costa Rica

In this contribution, we present the simulations of convective plasma cells of the Sun in two dimensions. With a simple stream function, it is possible to visualize multiple $n \times n$ convective cells. To obtain the simulation, we solve the magnetic diffusion equation with a fourth order scheme. Some applications for this simulations are also presented.

Keywords: Plasmas, MHD, computer simulation, physical processes.

Resumen

En esta contribución, presentamos las simulaciones de celdas convectivas de plasma solar en dos dimensiones. Con una función de corriente sencilla es posible visualizar múltiples celdas convectivas de tamaño $n \times n$. Para obtener la simulación, resolvemos la ecuación de difusión magnética con un esquema de cuarto orden. Algunas aplicaciones de esta simulación son también presentadas.

Palabras clave: Plasmas, MHD, sumlación por computera, procesos físicos.

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[I] Miércoles/Wednesday 26, 05:10 - 05:30, Room/aula 2, session: (mod2-3), Modeling / Modelación 2

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Cancer metastasis and the Immune System Reaction: modeling and simulation[I]

Metástasis en cáncer y reacción del sistema inmune: modelado y simulación

Short course / Curso corto

ALVARADO, MATÍAS[II]

México

Cancer Metastasis and the Immune System reaction is a biological, physiological and chemical process; this competitive process is highly complex to analyze. For the better understanding of that process we use a Theory of Games approach and the mathematical Ising model from Thermodynamics; these formal tools back the algorithmic simulations on the tumor immune interaction. Achievements on the modeling and simulation, on recognition and bounding in cancer metastasis by the immune system reaction, are outlined in the short course.

Keywords: Cancer metastasis, Immune System, Ising model, computer simulation, Game Theory.

Resumen

La metástasis en cáncer versus el sistema inmune (MCvSI) es un proceso biológico, fisiológico y químico, competitivo y complejo de analizar. Para la mejor comprensión de él, aplicamos modelos matemáticos de la Termodinámica y la Teoría de Juegos, y, ejecutamos simulaciones algorítmicas. Logros en el modelado y simulación para el reconocimiento y control de la metástasis ante la reacción del sistema inmune se presentan en este curso breve.

Palabras clave: Metástasis en cáncer, sistema inmune, Modelo de Ising, Simulación computacional, Teoría de Juegos.

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[I] Miércoles/Wednesday 26, 08:00 - 11:20, Room/aula 2, session: (Tut-5), Tutorial 5

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A mixed-primal finite element method for the coupling of Brinkman-Darcy flow and nonlinear transport[I]

Invited Session / Sesión invitada

ALVAREZ, MARIO[II] Gatica, Gabriel N.[III] Ruiz-Baier, Ricardo[IV]

Costa Rica, Chile, UK

In this talk we present the mathematical and numerical analysis of a model describing the interfacial flow-transport interaction in a porous-fluidic domain. The medium consists of a highly permeable material, where the flow of an incompressible viscous fluid is governed by Brinkman equations (written in terms of vorticity, velocity and pressure), and a porous medium where Darcy's law describes fluid motion. Gravity and the local fluctuations of a scalar field (representing for instance, the solids volume fraction, or the concentration of a contaminant) are the main drivers of the fluid patterns on the whole domain, and the Brinkman-Darcy equations are coupled to a nonlinear transport equation accounting for mass balance of the scalar concentration.

We introduce a mixed-primal variational formulation of the problem and establish existence and uniqueness of solution using fixed-point arguments and small-data assumptions. A family of Galerkin discretisations that produce divergence-free discrete velocities is also presented and analysed using similar tools to those employed in the continuous problem. Convergence of the resulting mixed-primal finite element method is proven, and some numerical examples confirming the theoretical error bounds and illustrating the performance of the proposed discrete scheme are reported.

Keywords: Nonlinear transport, Brinkman-Darcy coupling, vorticity-based formulation, fixed-point theory, mixed finite elements, error analysis.

Mathematics Subject Classification (2010): 65N30, 76S05, 65N12, 65N15.

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[1] ALVAREZ, M., GATICA, G.N., RUIZ-BAIER, R., *A mixed-primal finite element approximation of a sedimentation-consolidation system*. M3AS: Math. Models Methods Appl. Sci., 26 (2016), no. 5, 867–900.

[2] ALVAREZ, M., GATICA, G.N., RUIZ-BAIER, R., *Analysis of a vorticity-based fully-mixed formulation for the 3D Brinkman-Darcy problem*. Comput. Methods Appl. Mech. Engrg., 307 (2016), 68-95.

[I] Miércoles/Wednesday 26, 04:50 - 05:10, Room/aula 3, session: (Sinum2-4), Invited session: Numerical solution of PDEs

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Comparison of Optimization Metaheuristics Based on Neighborhoods for Clustering Binary Data[I]

Comparación de Metaheurísticas de Optimización Basadas en Vecindarios para la Clasificación de Datos Binarios

Communication / Ponencia

AMAYA BRICEÑO, LUIS EDUARDO[II] Trejos Zelaya, Javier[III]

Costa Rica

The methods of clustering consist of strategies which look for determining groups, under the generalized principle that objects (individuals) belonging to the same group, present characteristics of greater similarity to each other (with regard to some previously selected criterion), compared with the individuals that were assigned to other groups. Since the problem is NP-hard and methods of partitioning generally and local optima of the criteria to optimize, we have sought to improve them by using combinatorial optimization heuristics, techniques such as simulated annealing, tabu search, threshold accepting, genetic algorithms or ant colonies, among others, these methods have provided superior results to those obtained with "classical" methods such as $k-$means, dynamic clouds or hierarchical classification. In the present work, we focus on the classification in the presence of binary data by applying simulated annealing, tabu search and threshold accepting. The implemented algorithms were based on the concept of neighborhoods, this is, given a partition, we define a neighborhood by the change in the class assignment of a single object.

In this work, using two aggregation criteria of the Sum and L1, chosen among other studied, have the particularity of being summative: in the Sum, it is the simple sum between objects which belong to the same class, over all the classes, and the case of the criterion L1 it is defined a central or centroid object for each class as a vector of medians, and the criterion is the sum of distances L1 of objects to their centroid. The obtained results are very promising; they have been compared with those obtained with the k-means method and the ascending hierarchical classification, on real and simulated data, these last, with its difeerent characteristics were generated by a Monte Carlo experiment. In no instance did classical methods achieve better results than those found with our methods.

Keywords: Clustering, simulated annealing, aggregation criteria.

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[3] Kirkpatrick, S.; Gelatt, D.; Vecchi, M.P. (1983) "Optimization by simulated annealing", Science. 220:671-680.

[I] Martes/Tuesday 25, 05:30 - 05:50, Room/aula 2, session: (Clas1-4), Classification / Clasificación

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Virotherapy against cancer: analysis of model dynamics using the localization method of compact invariant sets[I]

Viroterapia aplicada contra el Cáncer: Análisis de sus efectos mediante el método de Localización de Conjuntos Compactos Invariantes.

Communication / Ponencia

ANDRÉS GARFIAS, GIOVANA[II] Starkov, Konstantin[III]

México

Cancer has been qualified as one of the silent epidemics of the 21st century, becoming the second leading cause of death both in Latin America and worldwide. Virotherapy is one of effective cancer treatments in which genetically altered viruses are applied with the goal to infect cancer cells and replicate in them but leave healthy host cells unharmed. Because of poor understanding interactions between viruses, cancer cells and the immune system in many cases the clinical research is based on trial and error. Therefore it is very important to carefully analyze more adequate mathematical models describing these kind of interactions in order to elaborate more effective cancer treatments. The focus of our research is to study several mathematical models describing cancer- immune system interactions under the action of virotherapy with help of the localization method of compact invariant sets [1], LaSalle theorem and Lyapunov stability theory. These models have been derived in papers [2,3,4] and defined by ordinary differential equations. We compute ultimate upper and lower bounds for concentrations of interacting cell populations in the tumor environment and describe the polytope in $R^n_{+,0}$ which contains the attracting set of the system.

Further, we present the existence conditions of convergence dynamics for models given in [2,3,4] in case when all w-limit sets are located in the tumor- free plane and these sets are equilibrium points of the system. This type of ultimate behavior is interpreted as the tumor eradication and the optimistic health prognosis for a patient may be done. Besides, conditions for the tumor persistence are got in some cases. Tumor eradication process is illustrated by numerical simulation. Some of our results have been published in the paper [5].

Keywords: Virotherapy, compact invariant sets, tumor free equilibrium point, convergence dynamics.

Resumen

El Cáncer ha llegado a ser calificado como una de las epidemias silenciosas del siglo XXI, llevándole a convertirse en la segunda causa de muerte tanto en América Latina, como a nivel mundial. El hecho de ser una enfermedad multifactorial, que cambia y no solo interactúa, con las condiciones presentes en su microsistema de desarrollo, provoca que en un gran número de casos las terapias convencionales aplicadas solo logren el control de la enfermedad, mas no su erradicación, dejando secuelas de moderadas a graves en el paciente.

[I] Miércoles/Wednesday 26, 03:25 - 03:45, Auditorium / Auditorio, session: (Bio1-2), Biomathematics / Biomatemáticas 1

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Al utilizar la Viroterapia, se focaliza la acción de un vector viral sobre una zona tumoral; un virus genéticamente modificado infecta las células tumorales destruyéndolas, permitiendo que el sistema inmune, anteriormente inactivo participe en la eliminación tumoral antes de que el virus pudiese llegar a infectar a las células sanas del organismo.

El enfoque de nuestras investigaciones, consiste en aplicar el método de Localización de Conjuntos Compactos Invariantes [1], el Teorema de LaSalle y la Teoría de estabilidad de Lyapunov a modelos matemáticos de ecuaciones diferenciales ordinarias que describen la dinámica cáncer-tumor-inmunidad bajo efectos de la Viroterapia [2,3,4], con el fin de establecer los límites ínfimos y supremos de las poblaciones celulares interactuantes en ambiente tumoral, encapsulando la región de acción de la terapia en un politopo ubicado en $R^n_{+,0}$ Se presentan algunas de las condiciones necesarias para la convergencia dinámica publicadas en [5], y resultados obtenidos para las condiciones de erradicación y/o persistencia tumoral para los modelos [3,4], analizando las situaciones cuando los conjuntos w-límite en el plano libre de tumor son los puntos de equilibrio del sistema. Finalmente se presentan las principales implicaciones biológicas obtenidas de los estudios realizados.

Palabras clave: Viroterapia, conjuntos compactos invariantes, punto de equilibrio libre de tumor, convergencia dinámica.

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Ross-Macdonald models: which one should we use?[I]

Communication / Ponencia

APARICIO, JUAN PABLO[II] Simoy, Ignacio

argentina

Ross-Macdonald models are the building blocks of most vector-borne disease models. Even for the same disease, different authors use different model formulations, but a study of the dynamical consequences of assuming different hypotheses is missing. In this work we present different formulations of the basic Ross-Macdonald model together with a careful discussion of the assumptions behind each model. The most general model presented is an agent based model for which arbitrary distributions for latency and infectious periods for both, host and vectors, is considered. At population level we also developed a deterministic Volterra integral equations model for which also arbitrary distributions in the waiting times are included. We compare the model solutions using different distributions for the infectious and latency periods using statistics, like the epidemic peak, or epidemic final size, to characterize the epidemic curves. The basic reproduction number (R_0) for each formulation is computed and compared with empirical estimations obtained with the agent based models. The importance of considering realistic distributions for the latent and infectious periods is highlighted and discussed. We also show that seasonality is a key driver of vector-borne vector-disease dynamics shaping the epidemic curve and its duration.

Keywords: vector-borne diseases, model selection, agent based models, deterministic models.

Mathematics Subject Classification (2010): 92B05

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[I] Miércoles/Wednesday 26, 05:10 - 05:30, Auditorium / Auditorio, session: (Bio2-3), Biomathematics / Biomatemáticas 2

[II] universidad nacional de salta, fisica, vaqueros, argentina,

Optimal scheduling of tasks in business processes[I]

Secuenciación óptima de tareas en procesos de negocio

Communication / Ponencia

ARANGO MARIN, JAIME ANTERO[II]

Colombia

The programming of the activities of the business processes is a daily necessity of the companies to make better use of their resources and to meet the needs of their internal and external clients. The efficiency and effectiveness of organizations is directly related to the ability to respond to different requirements, so the allocation of resources and the sequencing of tasks can mean substantial differences in costs and time, directly impacting business competitiveness.

The project assumes the business problem of managing its business processes based on the standard of description and administration of BPM processes (Bussiness process management) (Zairi 1997). The objective is to distribute workloads and sequence the requirements of internal and external customers of the company so that all requests can be met efficiently.

It is found that a large group of business processes is assimilated to the productive configuration known as the hybrid flexible flow shop. The problem is modeled considering real work environment situations: sequence-dependent task change times, malleability of batch sizes, variable transfer batch, objective function of minimizing average delay, unrelated parallel resources and more than 2 stages To sequence, a modified genetic algorithm is proposed with population generated by classical priority rules, and randomly completed, variable mutation rate and allocation of resources in parallel using a flexibility index based on a heuristic related to constraint theory. The algorithm is tested with models based on real business processes to validate their ability to positively impact the performance of organizations, obtaining better performance results than traditional methods.

The results show the possibility of making the management of business processes more efficient by applying intelligent techniques for sequencing and optimal assignment of tasks, as well as to verify the ability of the genetic algorithm to obtain high quality solutions in adequate computational times at operation needs of current business.

Keywords: Business process management, Scheduling, Hybrid Flexible Flow shop, Genetic Algorithms.

References

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[I] Martes/Tuesday 25, 02:40 - 03:00, Room/aula 2, session: (OR1-3), Operations Research / Investigación de Operaciones 1

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Multivariable nonlinear search with evolutionary algorithm to optimize forecast model parameters[I]

Búsqueda no lineal multivariable con algoritmo evolutivo para optimizar parámetros de modelos de pronósticos

Communication / Ponencia

ARANGO MARIN, JAIME ANTERO[II]

Colombia

Sales forecasting models are a mathematical tool of increasing use in commercial and industrial companies to improve their demand management processes and support decision-making at the tactical and operational levels.

The performance of forecast models such as simple exponential smoothing, double exponential smoothing, Holt and Winters, depends largely on the calculation of attenuation parameters to weigh the importance of the latest information versus that of historical behavior. The Winters model, for example, handles three parameters; the first for the base of the forecast, the second for the trend and the third for the seasonal variation (Hanke & Wichern, 2006).

In real implementations of these models for companies that require frequent calculations of forecasts for thousands of items, it is important to compute their projections with parameters that minimize the probability of forecast errors and improve the prediction performance.

Therefore, a tool that can be integrated into the forecast calculation, with good performance and low computational cost, is required to determine the values of the parameters that minimize the forecast error, in each of the thousands of time series that must be processed to determine the quantities to order and keep in inventory of each of the items.

It is proposed, therefore, an evolutionary algorithm that starts from a population of $(2^p + 1) * n$ randomly generated individuals, where p is the number of parameters of the model, and n the number of parents. In each of the individuals in the population, the objective function that can be an error indicator such as the mean squared error, the percentage of the mean absolute error or the mean absolute difference is evaluated. Individuals are ordered from best to worst value of the objective function. The best n individuals remain in the population, and from each of them 2^p new individuals are generated by adding or subtracting to each parameter a random number between 0 and $1/F_(i + 2)$, i being the current iteration and $F_(i + 2)$, the $(i + 2)-$th number of the Fibonacci series. If the value of the parameter is very close to zero or one, its possible change is limited so that it does not leave the interval [0,1].

Once the new individuals have been generated, their objective function is evaluated and according to their value, they are reordered to choose the new parents. The process continues until the difference between the best and the worst of the parents is less than a e, close to zero that is set as the convergence criterion.

In tests performed on sets of more than 2000 time series, most of the time the algorithm converges in less than 10 iterations, with values very close to those obtained with algorithms such as GRG2, proposed by (Lasdon,

[I]Viernes/Friday 28, 02:20 - 02:40, Room/aula 2, session: (Opt1-2), Optimization / Optimización 1

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Waren, Jain, & Ratner, 1976), with computational times of less than 0.1 seconds for each time series of 90 data. The complete model is being implemented for use in commercial and industrial companies with the need to calculate forecasts for a significant number of items several times per week.

Keywords: Nonlinear programming, evolutionary algorithms, forecasting.

Resumen

Los modelos de pronósticos de ventas son una herramienta matemática de creciente utilización en empresas comerciales e industriales para mejorar sus procesos de gestión de la demanda y soportar la toma de decisiones en los niveles táctico y operativo.

El desempeño de modelos de pronósticos como los de suavización exponencial simple, suavización exponencial doble, Holt y Winters, depende en gran medida del cálculo de los parámetros de atenuación para ponderar la importancia de la información más reciente frente a la del comportamiento histórico. El modelo Winters, por ejemplo, maneja tres parámetros; el primero para la base del pronóstico, el segundo para la tendencia y el tercero para la variación estacional (Hanke & Wichern, 2006).

En implementaciones reales de estos modelos para empresas que requieren calcular frecuentemente pronósticos para miles de ítems, es importante computar sus proyecciones con parámetros que minimicen la probabilidad de error de los pronósticos y mejore el desempeño de la predicción.

Se requiere, por lo tanto, una herramienta que se pueda integrar al cálculo del pronóstico, con buen desempeño y bajo costo computacional, que permita determinar los valores de los parámetros que minimizan el error del pronóstico, en cada uno de los miles de series de tiempo que se deben procesar para determinar las cantidades a pedir y a mantener en inventario de cada uno de los ítems.

Se propone, por lo tanto, un algoritmo evolutivo que parte de una población de $(2^p + 1) * n$ individuos generados aleatoriamente, siendo p el número de parámetros del modelo, y n el número de padres. En cada uno de los individuos de la población se evalúa la función objetivo que puede ser un indicador de error como el error medio al cuadrado, el porcentaje del error medio absoluto o la diferencia absoluta media. Se ordenan los individuos de mejor a peor valor de la función objetivo. Los mejores n individuos se mantienen en la población, y a partir de cada uno de ellos se generan 2^p nuevos individuos sumando o restando a cada parámetro un número aleatorio entre 0 y $1/F_(i+2)$, siendo i la iteración actual y $F_(i+2)$, el $(i+2)-$ésimo número de la serie de Fibonacci. Si el valor del parámetro está muy cerca del cero o del uno se limita su posible cambio para que no se salga del intervalo [0,1].

Una vez generados los nuevos individuos, se evalúa su función objetivo y de acuerdo al valor de ésta, se vuelven a ordenar para escoger los nuevos p padres. El proceso continúa hasta que la diferencia entre el mejor y el peor de los p padres sea menor que un e, cercano a cero que se fija como criterio de convergencia.

En las pruebas realizadas sobre conjuntos de más de 2000 series de tiempo, la mayoría de las veces el algoritmo converge en menos de 10 iteraciones, con valores muy cercanos a los que se obtienen con algoritmos como el GRG2, propuesto por (Lasdon, Waren, Jain, & Ratner, 1976), con tiempos computacionales de menos de 0,1 segundos para cada serie de tiempo de 90 datos.

El modelo completo está en vía de implementación para su uso en empresas comerciales e industriales con necesidad de calcular pronósticos para un significativo número de ítems varias veces por semana.

Palabras clave: Programación no lineal, algoritmos evolutivos, pronósticos.

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Ant colony algorithm applied to 2D packaging to improve the performance of a storage system[I]

Algoritmo de colonia de hormigas aplicado al empaquetamiento en 2D para mejorar el desempeño de un sistema de almacenamiento

Communication / Ponencia

ARANGO MARÍN, JAIME ANTERO[II]

Colombia

In a warehouse for the storage of large products, it is necessary to distribute the area of the floor of the warehouse in such a way that minimizes the movements of entry and exit of materials, reducing the total operation time.

The problem is similar to two-dimensional packaging. For its solution, an optimization algorithm by ant colony is proposed (Dorigo & Di Caro, 1999) in which the products to be stored are the points of the route and the travel time of the crane bridge is the distance between those points. The ants are randomly located at different points of the route and pheromones are added inversely proportional to the distance (travel time). An evaporation factor of the pheromones and the updating of the routes with better value of the objective function is established.

When all the ants follow the same route, the process is terminated and the solution is used as an optimal sequence to locate the materials in the warehouse starting at the northwest corner and moving to the east end and then immediately following south, and so on until the product list is exhausted or the available space on the floor of the warehouse is covered.

The results obtained show good computational performance and good quality solutions compared to those obtained with other solution techniques.

Keywords: 2d packing, ant colony optimization, metaheuristics, storage logistics.

Resumen

En una bodega de almacenamiento de productos de gran tamaño, se requiere distribuir el area del piso de la bodega de tal manera que se minimicen los desplazamientos de entrada y salida de materiales, reduciendo el tiempo total de operación.

El problema se asimila al empaquetamiento en dos dimensiones. Para su solución se plantea un algoritmo de optimización por colonia de hormigas (Dorigo & Di Caro , 1999) en el que los productos a almacenar son los puntos de la ruta y el tiempo de desplazamiento del puente grúa es la distancia entre esos puntos. Las hormigas se ubican aleatoriamente en diferentes puntos de la ruta y se van agregando feromonas inversamente proporcionales a la distancia (tiempo de recorrido). Se establece un factor de evaporación de las feromonas y la actualización de las rutas con mejor valor de la función objetivo.

[I] Viernes/Friday 28, 03:25 - 03:45, Room/aula 2, session: (Opt2-2), Optimization / Optimización 2

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Cuando todas las hormigas siguen la misma ruta se da por terminado el proceso y la solución se utiliza como secuencia óptima para ubicar los materiales en la bodega iniciando en la esquina noroeste y desplazándose hasta el extremo este para luego seguir inmediatemente al sur, y así sucesivamente hasta agotar la lista de productos o copar el espacio disponible en el piso de la bodega.

Los resultados obtenidos muestran un buen desempeño computacional y soluciones de buena calidad comparadas con las obtenidas con otras técnicas de solución.

Palabras clave: empaquetamiento en 2D, colonia de hormigas, metaheurísticas, logística de almacenamiento.

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Goal programming to prioritize public sector investment[I]

Programación por metas para priorizar inversión del sector público

Communication / Ponencia

ARANGO MARÍN, JAIME ANTERO[II]

Colombia

The problem arises of making public spending more effective and efficient, seeking the best use of resources. The decision variables correspond to the values to be assigned to the different programs, subprograms and projects of a development plan of a territorial entity or a state service company. The objectives are: 1. Maximize the social impact, measured in terms of individual benefits (such as jobs, grants, contracts, scholarships) and collective benefits (such as service coverage, access to opportunities, improvement of environmental conditions); and 2. Minimize the environmental impact, measured by an indicator such as carbon footprint or generation of non-reusable or usable waste.

There are restrictions such as the availability of resources (which is limited by the projected collection of taxes and contributions), the obligation to comply with priority programs established by current regulations, the size of the population potentially benefited, the characteristics of the geographic region of interest , and the priorities established in the government plan or the work program of the expenditure executor.

The problem, due to its characteristics, can generally be assimilated to a backpack type problem, where the items are the development plan programs and the capacity of the backpack is the availability of resources. However, unlike the classic problem, it is not a binary model because it is not about choosing the beneficiary programs of resources, but about determining in what proportion they will be distributed.

It can also be considered as a transport problem where the origins are the available resources and the destinations are the programs of the development plan, and the costs are the indicators of environmental impact. In that case, you should also study alternatives other than the classic model to allow partial contributions to some programs and to incorporate the two objectives simultaneously.

We choose to model a problem of programming by goals. The decision variables are real numbers, and the objectives can be weighted or prioritized according to the decision maker's criteria. As both the objective function and the restrictions can be non-linear expressions, it is posed as a non-linear optimization problem, which is modeled to be solved with different solution tools looking for the one that does it most efficiently. The work of (Zhang, 2016) that involves quantitative and qualitative variables has been taken as a guide and has been adapted to a more general problem. Tests are being done with different case studies, looking for the most appropriate configuration. The work is in progress.

Keywords: goal programming, public budget, operations research.

Resumen

Se plantea el problema de hacer más eficaz y eficiente el gasto público, buscando el mejor uso de los recursos. Las variables de decisión corresponden a los valores a asignar a los diferentes programas, subprogramas y

[I] Martes/Tuesday 25, 02:00 - 02:20, Room/aula 2, session: (OR1-1), Operations Research / Investigación de Operaciones 1

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proyectos de un plan de desarrollo de una entidad territorial o una empresa estatal de servicios. Los objetivos son: 1. Maximizar el impacto social, medido en términos de beneficios individuales (como empleos, auxilios, contratos, becas) y beneficios colectivos (como cobertura de servicios, acceso a oportunidades, mejoramiento de condiciones del entorno); y 2. Minimizar el impacto ambiental, medido por un indicador como huella de carbono o generación de desechos no reutilizables o aprovechables.

Se tienen restricciones como la disponibilidad de recursos (que está limitada por el recaudo proyectado de impuestos y contribuciones), la obligatoriedad de cumplir con programas prioritarios establecidos por normas vigentes, el tamaño de la población potencialmente beneficiada, las características de la región geográfica de interés, y las prioridades establecidas en el plan de gobierno o el programa de trabajo del ejecutor del gasto.

El problema, por sus características puede asimilarse en general a un problema tipo mochila, donde los ítems son los programas del plan de desarrollo y la capacidad de la mochila es la disponibilidad de recursos. Sin embargo, a diferencia del problema clásico, no es un modelo binario pues no se trata de elegir los programas beneficiarios de recursos, sino de determinar en qué proporción se van a distribuir estos.

También se puede plantear como un problema del transporte donde los orígenes son los recursos disponibles y los destinos son los programas del plan de desarrollo, y los costos son los indicadores de impacto ambiental. En ese caso se debe igualmente estudiar alternativas diferentes a la del modelo clásico para permitir aportes parciales a algunos programas y para incorporar los dos objetivos simultáneamente.

Se elige modelar un problema de programación por metas. Las variables de decisión son números reales, y los objetivos se pueden ponderar o priorizar según el criterio del tomador de decisiones. Como tanto la función objetivo como las restricciones pueden ser expresiones no lineales, se plantea como un problema de optimización no lineal, que se modela para ser resuelto con diferentes herramientas de solución buscando la que lo haga con mayor eficiencia.

Se ha tomado como guía el trabajo de (Zhang, 2016) que involucra variables cuantitativas y cualitativas y se ha adaptado a una problemática más general. Se están haciendo pruebas con diferentes casos de estudio, buscando la configuración más apropiada. El trabajo está en progreso.

Palabras clave: programación por metas, presupuesto público, investigación de operaciones.

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The Role of Data Analytics in Banking and Financial Services[I]

Communications (20 minutes) / Ponencias (20 minutos)

ARCE GARRO, JORGE ANDRÉS[II]

Costa Rica

The analysis of large volumes of data is a pillar for the creation of new businesses in the banking sector. The Banks can monitor and assess large amounts of customer data and create customized products and services specific to individual consumers.

Keywords: Banking, Data Analysis, Big Data.

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[I] Viernes/Friday 28, 02:40 - 03:00, Auditorium / Auditorio, session: (si04-3), Invited session: Banca 1

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Classical Geometry and Moduli of Vector and Higgs Bundles[I]

Short course / Curso corto

AVRITZER, DAN[II] Gothen, Peter[III]

Brazil

We give an introduction to fundamental objects of geometry the projective space, the Grassmannian of lines in 3-space, quadratic complexes and Kummer surfaces. We apply these objects to the study of the moduli of vector bundles following a classical paper of Narasimhan and Ramanan. We generalize these results to the moduli of Higgs bundles following a recent joint work with Peter Gothen.

Keywords: Kummer surface, vector bundles, Higgs bundles.

References

[1] M.S. Narasimhan and S. Ramanan, Moduli of Vector Bundles

[2] D.Avritzer and P.Gothen, Quadratic Complexes and Higgs Bundles

[I] Jueves/Thursday 27 , Viernes/Friday 28, 08:00 - 09:40, Room/aula 2, session: (Tut-4), Geometría y Topología

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State-Space models in Paleoclimate Reconstructions[I]

Modelos de Espacio-Estado en Reconstrucciones Paleoclimáticas

Communication / Ponencia

BARBOZA CHINCHILLA, LUIS ALBERTO[II]

Costa Rica

The process of paleoclimate reconstruction in distinct time periods requires the usage of different sources of information: (1) observed temperatures, (2) proxy biological data that approximates the temperature behavior and (3) approximations of physical variables such as Greenhouse-gases activity, solar irradiance and vulcanism. In this talk we will discuss a set of state-space models that tries to reconstruct the mean temperature of the Northern-Hemisphere during the Common Era by combining all these information sources under different temporal dependence schemes. The fitting process is completely bayesian and we use approximation techniques that guarantee computational efficiency.

Keywords: Paleoclimate reconstruction, Bayesian Statistics, INLA.

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[I] Miércoles/Wednesday 26, 04:50 - 05:10, Room/aula 2, session: (mod2-2), Modeling / Modelación 2

[II] Universidad de Costa Rica, Matemática-CIMPA, San José, Costa Rica, lbarbo@gmail.com

The decomposition method in the multiple criteria integer programming forest management problem in Portugal[I]

Communication / Ponencia

BUSHENKOV, VLADIMIR[II] Marques, Susete[III] Lotov, Alexander[IV]

Portugal, Russia

The Interactive Decision Mapping (IDM) technique [1] has been successfully used for several decades to analyze multiple criteria economic and environmental problems with a large number of variables [2-3]. The IDM technique applies interactive visualization and animation of the Pareto frontier in the form of decision maps, i.e. collections of the objective tradeoff curves. By studying the decision maps, the decision makers learn the efficient feasible combinations of the objective values and objective tradeoffs.

To implement the IDM technique, the Edgeworth-Pareto hull (EPH), that is, the largest set that has the same Pareto frontier as the original multi-objective problem, is approximated in advance. This task is computationally difficult, especially for the models with integer variables, which is typical case for forest management problems. To solve this problem, decomposition methods were proposed that are based on the approximation of EPH for subsystems (blocks) with their subsequent combination to build the EPH of the entire system [4-5].

We apply the IDM method to the Vale de Sousa region in Portugal, fragmented into a large number of private properties. Private properties are joined in three districts (three blocks). The decomposition method for constructing the EPH allows us to obtain a good approximation of the Pareto frontier and to implement a two-level decision support system in which upper level decision makers representing the interests of the entire region interact with lower level decision makers representing the interests of forest owners.

The regional forestry model with integer variables is briefly described, computation results are presented and the decision-making process in the two-level system is outlined.

Keywords: multiple criteria optimization, goal method, decision support systems, integer programming, forest management.

Mathematics Subject Classification (2010): 90C29, 90B50

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[I] Martes/Tuesday 25, 05:10 - 05:30, Room/aula 1, session: (OR2-3), Operations Research / Investigación de Operaciones 2

[II] University of Évora, Mathematics Department, Évora, Portugal, bushen@uevora.pt

[III] Forest Research Centre, School of Agriculture, University of Lisbon, Lisbon, Portugal, smarques@isa.ulisboa.pt

[IV] Federal Research Center “Computer Science and Control" of Russian Academy of Sciences, Moscow, Russia, avlotov

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Household Observable Characteristics and Poverty Level in Costa Rica[I]

Communication / Ponencia

BUSTAMANTE MEDINA, RONALD[II]

Costa Rica

We study how observable features from households and individuals from those households relate to poverty levels based on income.

We create new relevant features. We analyse different models such as logistic regression, random forests and gradient boosting as alternatives to proxy means tests and we analyze the most important features for each model.

We will use the F1−score to assess the performance of those models.

Keywords: Classification, Proxy Means Tests, Poverty, Machine Learning.

Mathematics Subject Classification (2010): 62-07

References

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[I] Martes/Tuesday 25, 02:00 - 02:20, Auditorium / Auditorio, session: (Apl1-1), Applications / Aplicaciones 1

[II] Universidad de Costa RIca, CIMPA - Escuela de Matemática, San José, Costa Rica, bustam@gmail.com

Audio Analysis for Classification and Clustering[I]

Análisis de audio para clasificación y clústering

Short course / Curso corto

BUSTAMANTE MEDINA, RONALD[II]

Costa Rica

In the first part of the course we will study the type of features we can extract from an audio file, and how these features relate to human perception.

Next we mention some possibilities for segmentation in order to perform classification and clustering. We give some examples in which we choose a suitable set of features according to the problem to solve (for example the type of sound we want to classify) and we evaluate different models (such as support vector machines, random forests and convolutional neural networks for supervised classification, and $k-$means and spectral clustering and autoencoders for unsupervised classification).

Finally we mention some applications as pattern detection and sequence generation, speech recognition and trigger word detection.

Keywords: audio, classification, clustering, machine learning, speech recognition.

Mathematics Subject Classification (2010): 68T10, 97R40, 68T50

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[I] Jueves/Thursday 27, 08:00 - 11:20, Auditorium / Auditorio, session: (Tut-1), Tutorial 1

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A Hybrid High-Order formulation for a Neumann problem on general meshes[I]

Invited Session / Sesión invitada

BUSTINZA, ROMMEL[II] Munguia-La-Cotera, Jonathan[III]

Chile

In this talk, we introduce a Hybrid High-Order (HHO) method for an elliptic diffusion problem with Neumann boundary condition. The proposed method has several features, such as: i) the support of arbitrary approximation order polynomial at mesh elements and faces on general polyhedral meshes, ii) the design of a local (element-wise) discrete gradient reconstruction operator and a local stabilization term, that weakly enforces the matching between local element- and face- based on degrees of Freedom (DOF), and iii) cheap computational cost, thanks to static condensation and compact stencil. We prove the well-posedness of our HHO formulation, and obtain the optimal error estimates, according to [3]. Implementation aspects are throughly discussed. Finally, some numerical examples are provided, which are in agreement with our theoretical results.

Keywords: a priori error estimate, hybrid high order method, polytopal meshes, reconstruction operator.

Mathematics Subject Classification (2010): 65N15, 65N30

References

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[2] DI PIETRO, D. A. ; ERN, A.; LEMAIRE, S., *An arbitrary-order and compact-stencil discretization of diffusion on general meshes based on local reconstruction operators.* Computer Methods in Applied Mathematics, 14 (4), 461-472, 2014. %Published online. DOI: 10.1515/cmam-2014-0018.

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[I] Miércoles/Wednesday 26, 02:00 - 02:20, Room/aula 3, session: (SINum1-1), Invited session: Numerical solution of PDEs

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Asymptotic expansion fo the invariant measure for ballistic random walk in the low disorder regime[I]

Expansión Asintótica de la medida invariante para caminatas aleatorias balísticas en un régimen de bajo desorden

Communication / Ponencia

CAMPOS FERNÁNDEZ, JOSÉ DAVID[II] Ramírez, Alejandro[III]

Costa Rica, Chile

We consider a random walk in random environment in the low disorder regime on $\mathbb{Z}^d$. That is, the probability that the random walk jumps from a site x to a nearest neighboring site $x + e$ is given by $p(e) + \epsilon\xi(x, e)$, where $p(e)$ is deterministic, $\{\{\xi(x, e) : |e|_1 = 1\} : x \in \mathbb{Z}^d\}$ are i.i.d. and $\epsilon > 0$ is a parameter which is eventually chosen small enough. We establish an asymptotic expansion in ϵ for the invariant measure of the environmental process whenever a ballisticity condition is satisfied. As an application of our expansion, we derive a numerical expression up to first order in ϵ for the invariant measure of random perturbations of the simple symmetric random walk in dimensions $d = 2$. This work is a collaboration with Alejandro F. Ramírez.

Keywords: Keywords: Random walk in random environment, Green function, invariant measure.

Mathematics Subject Classification (2010): 60Jxx

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[I] Miércoles/Wednesday 26, 02:00 - 02:20, Room/aula 1, session: (SIProb1-1), Invited session: Probability

[II] Universidad de Costa Rica, Escuela de Matemática, Montes de Oca, Costa Rica, josedavid.campos@ucr.ac.cr

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Classification Model of Visible and Invisible Urban Underemployment in El Salvador in the years 2008, 2017, 2018.[I]

Communication / Ponencia

CAMPOS GRANADOS, WALTER OTONIEL[II]

El Salvador

Underemployment in the labor market is a phenomenon that affects economies such as El Salvador, and in general, developing economies. The Multi-Purpose Household Survey (EHPM), which is carried out every year by the General Directorate of Statistics and Censuses of El Salvador, is analyzed and supervised classification methods are implemented to determine the best model that allows people to be classified as Full or Underemployed.

Keywords: Occupied Full, Underemployed, Supervised Classification, Cross Validation.

Resumen

El subempleo en el mercado laboral es un fenómeno que afecta a economías como las de El Salvador, y en general, economías en vías de desarrollo. Se analiza la Encuesta de Hogares de Propósitos Múltiples (EHPM), que realiza cada año la Dirección General de Estadística y Censos de El Salvador y se implementan métodos de clasificación supervisada para determinar el mejor modelo que permita clasificar a las personas como Ocupado Pleno o Subempleado.

Palabras clave: Ocupado Pleno, Subempleado, Clasificación Supervisada, Validación Cruzada.

References

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[I] Martes/Tuesday 25, 04:50 - 05:10, Room/aula 2, session: (Clas1-2), Classification / Clasificación

[II] Universidad de El Salvador, Matemática, San Salvador, El Salvador, walteroto@gmail.com

Principal Components Analysis (PCA) and Logistic Regression supporting for early fault detection in oil wells[I]

Poster / Cartel

CASTRO, ANTONIO ORESTES[II] Rocha Santos, Mayara De Jesus

Brazil

Early fault detection in oil and gas systems is very important because it can prevent unnecessary costs in repairing operations and save millions of dollars in workovers. Also, it can reduce non-productive time caused by major faults that demand stopping the production of oil and gas. Detecting early stages of a fault situation is an old concern of the Petroleum Industry. The present paper raises assumptions for supporting the modeling process of early fault detection systems based on a dataset containing data from real wells and using the Principal Components Analysis (PCA) approach combined with a Logistic Regression.

The PCA is a technique that provides a variables reduction, instead of handle 10 variables the PCA combines these variables in 2 new variables that better explain the dataset. In this work such technique was used to facilitate a better visualization and understanding about the classification of problems occurred in petroleum production like: abrupt increase in BSW, spurious closure of DHSV, severe slugging, flow instability, productivity loss, quick restriction in PCK, scaling in PCK and hydrate in production lines. The dataset includes 10 variables measured per second from 21 real wells.

The application of PCA enables the researchers to visualize relationships between different wells that show the same problems and how different anomalies can be related when looking at their variability. Then, the Logistic Regression allows the dataset classification into 2 classes: “normal” and “abnormal”. Besides, it helps the comprehension of the transition process between these classes. division helps formulating better detection algorithms.

By using PCA and Logistic Regression it was possible see which set of variables is better for detecting a specific type of problem. The application of these techniques boosts the modeling of early detection systems in oil and gas production. In addition, the assumptions led to conclusions about how to put groups of variables and abnormalities together and how much time a well stands a steady normal condition. Other conclusions that can be made regard the significance of transient information for fault detection modeling and the need for a well by well analyses.

These results show that using PCA for treating and transforming the data brings important contributions for early fault detection modeling, it allowed the insight about how variables and abnormal events were related. Therefore, the present paper has significant contribution: it raises important assumptions that help to build solid knowledge about the anomalies behavior and help researches to implement a better modeling strategy.

Keywords: PCA, detection, logistic regression.

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

[II] Universidade Federal Fluminense, Engenharia de Produção, NITERÓI, Brasil, orestesh004@GMAIL.COM

References

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Some consequences of the theorem of Kronecker[I]

Algunas consecuencias del teorema de Kronecker

Communication / Ponencia

CASTRO, EDWIN[II] Arguedas, Vernor[III]

Costa Rica

In this article we present a unified formulation of Kronecker's theorem and two consequences thereof, one of the which allows in certain cases to determine if the convergence is a irrational number

Keywords: Kronecker's theorem, dense sets, some convergence of series to an irrational number.

Mathematics Subject Classification (2010): 11B05,11B99

Resumen

En este artículo presentamos una formulación unificada del teorema de Kronecker y dos consecuencias del mismo, una de las cuales permite en ciertos caso determinar si la convergencia es un número irracional.

Palabras clave: Palabras clave: Teorema de Kronecker, conjuntos densos, cierta convergencia de series a un número irracional.

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[I] Viernes/Friday 28, 03:25 - 03:45, Room/aula 1, session: (Aprox2-2), Approximation / Aproximación 2

[II] Universidad de Costa Rica, CIMPA, CIMPA, San Pedro de Montes de Oca, Costa Rica, hyperion32001@gmail.com

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Deep multiple instance learning for the acoustic detection of tropical birds using limited data[I]

Posters / Carteles

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Costa Rica

Deep learning algorithms have produced state of the art results for acoustic bird detection and classification. However, thousands of bird vocalizations have to be manually tagged by experts to train these algorithms. We use three strategies to reduce this manual work: simpler labels, fewer labels, and less labeled data. The Multiple Instance Learning (MIL) approach provides a framework to simplify and reduce the number of labels, as each recording (bag) is modeled as a collection of smaller audio segments (instances) and is associated with a single label that indicates if at least one bird was present in the recording. In this work, we propose a deep neural network architecture based on the MIL framework to predict the presence or absence of tropical birds in one-minute recordings. As only a relatively small number of training observations (1600) are used to train the algorithm, we compare the performance of the network using log mel-scaled spectrogram and mel-frequency cepstral coefficients. The proposed deep MIL network achieved a 0.96 AUC and 0.90 F_1 score performance on the test set, using a log mel-scaled spectrogram as data representation.

Keywords: Deep learning, multiple instance learning, bird acoustic detection, weak labels, limited data.

Mathematics Subject Classification (2010): Artificial Intelligence

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[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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Classification in time series: an application with economic data[I]

Clasificación en series temporales: una aplicación con datos económicos

Communication / Ponencia

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The research for similarities of data from time series could be useful by not having to describe the n series a posteriori in the relationship exploration. Univariate time series, although they consist of many values, can be treated as an observation. Grouping can be useful when finding patterns in data sets that consist of different time series and then simplify time behavior. Grouping in univariate time series data is a way of addressing this type of problem. The present work applies the grouping as an unsupervised technique in the analysis of 17 economic series. It uses both a method of k-medoids as well as hierarchical, from the distance of DTW (Dynamic Time Warping). In the evaluation of the optimal number of clusters, the Silhouette, Score, Calinski-Harabasz, Davies-Bouldin and Dunn index were used. The results show that an approximation of 6 clusters makes it possible to adequately describe the series put into question. In addition, an average profile by grouping allows seeing the temporal trends and thus approximating the temporal pattern of the series.

Keywords: classification, time series, validation index, profiles, R.

Mathematics Subject Classification (2010): 62H30

Resumen

La búsqueda de similitudes de datos a partir de series temporales podría resultar útil al no tener que describir las n series a posteriori en la exploración de relaciones. Las series de tiempo univariadas, aunque consisten en muchos valores, pueden tratarse como una observación. La agrupación puede ser útil al encontrar patrones en conjuntos de datos que consisten en diversas series de tiempo para luego simplificar el comportamiento temporal. El agrupamiento en los datos de series temporales univariadas es una forma de abordar este tipo de problemática. El presente trabajo aplica la agrupación como técnica no supervisada en el análisis de 17 series económicas. Se utiliza tanto un método de k-medoids así como jerárquico, a partir de la distancia de DTW (Dynamic Time Warping). En la evaluación del número óptimo de clusters, se utilizaron los índices de Silhouette, Score, Calinski-Harabasz, Davies-Bouldin y Dunn. Los resultados muestran que una aproximación de 6 agrupamientos permite describir de forma adecuada las series puestas en causa. Además, un perfil medio por agrupamiento permite ver las tendencias temporales y así aproximar el patrón temporal de las series.

Palabras clave: clasificación, series temporales, índices de validación, perfiles, R.

[I] Martes/Tuesday 25, 05:10 - 05:30, Room/aula 2, session: (Clas1-3), Classification / Clasificación

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Design optimization of detention ponds using metaheuristics: simulated annealing and genetic algorothms.[I]

Optimización del Diseño de Lagunas de Detención utilizando metaheurísticas

Communication / Ponencia

CHACÓN VARGAS, ALEJANDRO[II] Oreamuno Vega, Rafael[III]

Costa Rica

Cuando se urbanizan terrenos o cuando se cambia el uso que un terreno tenía previamente, se altera la forma como ese terreno responde a eventos de lluvia. Usualmente se acortan las distancias de descarga y se reduce el tiempo en el cual el agua producto de la lluvia alcanza los cauces u obras de drenaje. Esto provoca que se incrementen los caudales máximos que se descargan y por lo tanto se aumenta el riesgo de inundación aguas abajo y la erosión del cauce.

Una de las obras más frecuentes para mitigar este problema, es la de la laguna de detención. Esta obra busca amortiguar de forma dinámica la respuesta a los eventos de lluvia, de forma tal que el caudal descargado al cauce receptor sea igual o menor al que existía antes de que se diera el proceso de urbanización. El diseño de este tipo de obras tradicionalmente se ha basado en un método de prueba y error, en el cual se varían las dimensiones de la laguna, las estructuras de descarga en función del patrón de la lluvia de diseño y las restricciones normativas.

En este trabajo se aborda el problema de optimizar el diseño de lagunas de detención de aguas pluviales, utilizando dos metaheurísticas, con el objetivo de evitar el proceso de prueba y error, el cual además de ser lento y algo tedioso, no garantiza que se obtenga una solución óptima en cuanto a desempeño del sistema y a costos constructivos.

Se utilizan dos metaheuristicas, a saber: algoritmos genéticos y sobrecalentamiento simulado. Esto con el objetivo de comparar el desempeño de ambas y determinar cuál es la más adecuada para este problema.

El problema de optimización se puede resumir en minimizar la función de costo de la laguna, dada por:

$$min\, C = \alpha_E V + \alpha_T A$$

sujeto a las siguientes restricciones:

$$Q_d \leq \beta Q_v$$

$$Z_d \leq Z_a$$

$$N_f \geq N_a$$

En donde, C es el costo total de la laguna, α_E y α_T son el costo de excavación y del terreno respectivamente, V es el volumen de excavación, A es el área del terreno a afectar por la laguna, Q_d es el caudal pico máximo posdesarrollo, β es el porcentaje de reducción de caudales según normativa vigente, Q_v es el caudal pico presdesarrollo, Z_d y Z_a son las profundidades al pico posdesarrollo y la admisible, respectivamente; N_f y N_a son los niveles mínimo y admisible de fondo de laguna respectivamente.

[I] Martes/Tuesday 25, 02:20 - 02:40, Room/aula 2, session: (OR1-2), Operations Research / Investigación de Operaciones 1

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Para cada posble solución que los algoritmos evalúen, la primera restricción se implementa utilizando una versión simplificada de la ecuación de balance de masa en un sistema. Esta ecuación usualmente recibe el nombre en el campo de la hidrología de tránsito de piscina nivelada. La ecuación diferencial a utilizar es la siguiente:

$$\frac{dS}{dt} = I - O$$

en donde S es el almacenamiento en la laguna, I es la entrada de agua a la laguna, la cual es expresada a través de una función de variación del caudal con respecto al tiempo para toda la duración de la tormenta de diseño; y O es la salida de agua de la laguna, la cual se expresa a través de una función que describe las relaciones de caudal en función de la geometría de las estructuras de descarga.

Para comparar el desempeño de ambos algoritmos se aplicó cada algoritmo a 36 casos de diseño, para un total de 72 diseños. Estos casos corresponden al considerar:

- 2 algoritmos
- 3 tipos de tormentas de diseño: corta duración, larga duración y picos sucesivos
- 2 costos de excavación
- 2 costos del terreno

Palabras clave: Optimización de lagunas de detención, Sobrecalentamiento simulado, Algoritmo genético, Curva de descarga, Balance de masas, Distribución temporal de la lluvia.

Keywords: Optimization, Detention Ponds, Methahuristics.

Palabras clave: Optimización de lagunas de detención, Metaheurística, Curva de descarga, Balance de masa.

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[3] Chow, Ven Te (1994) *Hidrología Aplicada*, isbn: 958 600 17117, McGraw Hill Interamericana.

Where is research in multi-objective evolutionary optimization going?[I]

¿Hacia dónde va la investigación en optimización evolutiva multi-objetivo?

Plenary Talk / Conferencia Plenaria

COELLO COELLO, CARLOS[II]

México

The first multi-objective evolutionary algorithm was published in 1985. However, it was until the late 1990s when the so-called evolutionary multi-objective optimization started to gain popularity as a research area. Over these 35 years, there have been several important advances in the area, including the development of different families of algorithms, test problems, performance indicators, hybrid methods and real-world applications, among many others. In the first part of this talk we will take a quick look at some of these advances, mainly emphasizing the most important recent achievements. In the second part of the talk, there will be a critical analysis of the research by analogy that has proliferated in recent years in specialized journals and conferences (perhaps as a side effect of the high volume of publications that this area has experienced). Much of this research has a very low level of innovation and almost zero contribution in scientific terms, but it is backed up by a large number of tables and statistical analyzes. In the third and last part of the talk, some of the future research challenges for this area will be briefly mentioned, which, after 35 years of existence, is just beginning its maturity stage.

Keywords: optimization, evolutionary algorithms, multi-objective optimization.

Mathematics Subject Classification (2010): 90C59, 68W20

Resumen

El primer algoritmo evolutivo multi-objetivo se publicó en 1985. Sin embargo, fue hasta a finales de los 1990s cuando la denominada optimización evolutiva multi-objetivo comenzó a ganar popularidad como área de investigación. A lo largo de estos 35 años, se han producido diferentes avances muy importantes en el área, incluyendo el desarrollo de diferentes familias de algoritmos, problemas de prueba, indicadores de desempeño, métodos híbridos y aplicaciones del mundo real, entre muchos otros. En la primera parte de esta plática se dará un vistazo rápido a algunos de estos avances, enfatizando principalmente los logros recientes más importantes. En la segunda parte de la plática, se hará un análisis crítico sobre la investigación por analogía que ha proliferado en años recientes en las revistas y congresos especializados (tal vez como un efecto colateral de la abundancia de publicaciones que ha experimentado esta área). Mucha de esta investigación cuenta con un nivel muy bajo de innovación y con un aporte casi nulo en términos cien9ficos, pero va respaldado por un gran número de tablas y análisis estadísticos. En la tercera y última parte de la plática, se mencionarán brevemente algunos de los retos de investigación futuros para esta área que, tras 35 años de existencia, apenas comienza su etapa de madurez.

[I] Jueves/Thursday 27, 11:15 - 12:00, Auditorium / Auditorio, session: (conf4), Plenary Talk 4

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Palabras clave: optimización, algoritmos evolutivos, optimización multi-objetivo.

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[4] Luis Miguel Antonio, José A. Molinet Berenguer and Carlos A. Coello Coello, "Evolutionary Many-Objective Optimization Based on Linear Assignment Problem Transformations", Soft Computing, Vol. 22, No. 16, pp. 5491–5512, August 2018.

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Cantonal analysis of traffic congestion in Costa Rica 2018[I]

Análisis Cantonal de la congestión vial en Costa Rica 2018

Communication / Ponencia

CUBERO CORELLA, MARIANA[II] Gomez-Campos, Steffan

Costa Rica

According with the National Institute on Statistics and Census of Costa Rica in 2015 were reported 1 346 344 vehicles, and 40 000 kilometers of streets and highways. That's why we want to understand how a urban mobility problem can be reduced to a more simple analysis using historical data available to create insights and visualizations. We want to create a classification of the intensity of the traffic saturation considering morning rush hours during weekdays all over the country according to data captured by Waze navigation system. Waze data was obtained from the Ministry of Public Works and Transportation of Costa Rica and WAZE developers in a collaboration with the State of the Nation Program. We created an indicator with four levels of intensity: low, medium, high and extreme. This helps to visualize the general condition the traffic congestion all over the country. Also, this is a helpful tool to compare this condition between the different regions of the country and detecting problematic areas in every canton.

Keywords: Rush hours, Visualization, Waze, Traffic Jam.

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[I] Miércoles/Wednesday 26, 05:10 - 05:30, Room/aula 1, session: (Mst1-3), Multivariate Statistics / Estadística Multivariada

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A Monte Carlo Approach to Computing Stiffness Matrices Arising[I]

Communication / Ponencia

CUERVO FERNÁNDEZ, OMAR ANDRÉS[II] Galvis Arrieta, Juan Carlos[III]

Colombia

We use a Monte Carlo method to assemble finite element matrices for polynomial Chaos approximations of elliptic equations with random coefficients. In this approach, all required expectations are approximated by a Monte Carlo method. The resulting methodology requires dealing with sparse block-diagonal matrices instead of block-full matrices. This leads to the solution of a coupled system of elliptic equations where the coupling is given by a Kronecker product matrix involving polynomial evaluation matrices. This generalizes the Classical Monte Carlo approximation and Collocation method for approximating functionals of solutions of these equations.

Keywords: Polynomial Chaos, Random Elliptic Partial Differential Equations, Monte Carlo Integration.

Mathematics Subject Classification (2010): 60H15, 60H30, 60H35, 60H40, 65M60, 65N12, 65N15, 65N30

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[I] Miércoles/Wednesday 26, 03:45 - 04:05, Room/aula 2, session: (mod1-3), Modeling / Modelación 1

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Chaotic Behaviour of Geodesics in Spacetime metrics with Quadrupole Moment[I]

Comportamiento Caótico de Geodésicas en Espacio-tiempos con Momento Cuadripolar

Communication / Ponencia

EDUARTE-ROJAS, ADRIAN FRANCISCO[II] Frutos-Alfaro, Francisco[III]
Carboni-Méndez, Rodrigo[IV]

Costa Rica

In the study of orbits near black holes where the relativistic behaviour is present, the orbits could have odd peculiarities such that if two near orbits at the beginning of the motion could have very different time evolution. In order to study the chaotic motion of test particles with unitary mass we have used Kerr-like metrics with mass quadrupole moment and solve numerically the equations of motion via a C program. The program, we have implemented finds the orbits with different initial conditions and later selects only a few points to construct a Poincare section of the orbit, so the initial orbit problem its transformed into a problem of fixed points, this makes easier to study the chaotic regions of the motion. Moreover, we compare with other metrics possessing mass quadrupole moment

Keywords: Keywords: Geodesics, general relativity, metrics, Poincare section, chaos.

Resumen

En el estudio de órbitas alrededor de agujeros negros donde los efectos relativistas están presentes, las órbitas presentan extrañas peculiaridades como dos órbitas cercanas cuando comienzan su movimiento pueden presentar evoluciones temporales muy diferentes. Para estudiar el movimiento caótico de partículas de prueba con masa unitaria usamos una métrica tipo Kerr con momento de masa cuadrupolar y resolvemos numéricamente las ecuaciones de movimiento utilizando un programa escrito en C. El programa que hemos implementado encuentra las órbitas con diferentes condiciones iniciales y después selecciona unos cuantos puntos para construir una sección de Poincare de la órbita, así el problema inicial de órbitas se transforma en un problema de puntos fijos, lo cual hace fácil el análisis de las regiones caóticas del movimiento. Aún más se compara con otras métricas que poseen momento cuadrupolar

Palabras clave: Geodésicas, relatividad general, métricas, sección de Poincare, caos.

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[1] F. Frutos-Alfaro (2016). Approximate Kerr-like Metric with Quadrupole, International Journal of Astronomy and Astrophysics, 6, 334-345.

[I] Miércoles/Wednesday 26, 02:00 - 02:20, Room/aula 2, session: (DS1-1), Dynamical Systems / Sistemas Dinámicos

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On Lyapunov exponents of hyperbolic homeomorphisms[I]

Poster / Cartel

FANAEE, MOHAMMAD[II]

Brazil

We give a new proof for simplicity of Lyapunov exponents over hyperbolic homeomorphisms. We prove that Lyapunov exponents have multiplicity 1 for typical cocycles over hyperbolic homemorphisms. This work is on a paper of Avila and Viana 2007 whom prove a criteroin for Lyapunov exponents of a cocycle has the multiplicity 1. Indeed we show that this criterion is "typica" in the Banach space of Holder continuous cocycles.

Keywords: Lyapunov exponents, Hyperbolic homeomorphisms.

Mathematics Subject Classification (2010): 37H15

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[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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Multilevel Bayesian Structural Equation Modeling with small-variance priors for cross-loadings[I]

Modelado de ecuaciones estructurales multinivel con estimación Bayesiana y varianzas pequeñas en las distribuciones a priori de las cargas factoriales cruzadas

Communication / Ponencia

FERNANDEZ, ANDRES[II]

Costa Rica

In the last decade, the use of very small variance prior of cross-factor loadings has been discussed in the context of estimating confirmatory factor analysis models or structural equations with a Bayesian approach (Muthén, B., & Asparouhov, T , 2012, 2013) Traditionally, researches that relies on confirmatory factor analysis establish cross-factor loadings as equal to zero, meaning that the particular indicator has no relation to the latent factor or construct for which the factor load has been established as exactly equal to zero.

However, the indicator variables are rarely perfectly pure construction indicators, especially in the study of social sciences, which implies that significant levels of association with multiple constructs can occur. In fact, in the reflexive logic of factor analysis, latent factors are those that have an influence on the indicators, rather than the other way around. This means that establishing small cross-loads reflects the influence of the factor on the relevant part of the construction of the indicators, rather than the indicators having an impact on the nature of the factor itself.

For this reason, this research addresses this discussion in the context of Multilevel Bayesian Structural Equation Models (ML-BSEM) by proposing models in which the estimation of parameters in cross factor loadings will be released. Therefore, it is necessary to examine whether for this type of models the discussion described in the literature is maintained and if there are gains in the goodness of fit of the models by allowing that condition.

This will be done by evaluating the possible effects on the parameter estimates, the hypothesis tests associated with them, as well as the tests of goodness of fit of models, which may vary according to the definition of the prior distributions of the cross loadings, from little informative or diffuse to very informative, in the context of estimating Multilevel Bayesian Structural Equation Models. For this, in addition, robustness will be analyzed for different scenarios in which hierarchical models can operate, such as different group sizes at the high level, different sample sizes in the low level groups and different intensities of the intraclass correlation.

In general terms, the results show that the goodness of fit when comparing weakly informative priors and diffuse priors distributions for the cross-loadings tends to be similar, especially for large samples and ICC values; However, when there is little data, a small number of groups and low ICC values, the use of very informative prior distributions with small variance priors for the cross loadings does produce better fit.

Keywords: Bayesian, priors, multilevel, structural.

[I] Miércoles/Wednesday 26, 04:30 - 04:50, Room/aula 2, session: (Mod2-1), Modeling / Modelación 2

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Resumen

Los modelos de ecuaciones estructurales multinivel han ganado popularidad en los últimos años debido a la aparición de software estadisticos que permiten realizar estimaciones para datos que presentan estructuras jerárquicas. Si bien algunas de las principales limitaciones para su estimación han sido evaluadas y corregidas con el paso del tiempo y las mejoras en los algoritmos de estimación de diversos software, su reciente aparición aún plantea algunos retos pendientes.

La estimación Bayesiana via Cadenas de Markov Monte Carlo da cuenta de una buena parte de la mejora en la estimación de los modelos de ecuaciones estructurales multinivel (donde la estimación Bayesiana produce estimaciones al menos tan buenas como las estimaciones frecuentistas, y en muchos casos superiores), pero su aplicación en el contexto de modelos de factores aún se ha visto restringida a muchos de los supuestos que usualmente eran establecidos en este tipo de modelos debido, precisamente, a los problemas de convergencia que se presentaban con los métodos de estimación frecuentista. Particularmente, garantizar que el modelo esté sobre-identificado es una de las recomendaciones prácticas que por décadas se han aplicado en el análisis factorial. Un modelo está sobre-identificado si el número de parámetros desconocidos es menor al número de elementos conocidos. La diferencia entre ambos números de parámetros es por ende positiva y son los grados de libertad. Usualmente, para evitar problemas de convergencia del modelo, un minimo de tres indicadores por cada variable latente es sugerido, además de establecer las cargas cruzadas como exactamente iguales a cero, todo con el objetivo de disminuir las posibilidades de no convergencia del modelo desde un enfoque frecuentista.

Pero en la última década se ha discutido el uso de varianzas muy pequeñas en las distribuciones a priori de las cargas factoriales cruzadas en el contexto de la estimación de modelos de análisis factorial confirmatorio o de ecuaciones estructurales con enfoque Bayesiano. Tradicionalmente, las investigaciones que incursionan en el uso del análisis factorial confirmatorio establecen las cargas factoriales cruzadas como iguales a cero, queriendo indicar con esto que el indicador particular no tiene ninguna relación con el factor latente o constructo para el cual la carga factorial ha sido establecida como exactamente igual a cero. Sin embargo, las variables indicadoras rara vez son indicadores de construcción perfectamente puros, especialmente en el estudio de las ciencias sociales, lo que implica que se pueden presentar niveles significativos de asociación con múltiples constructos.

De hecho, en la lógica reflexiva de los análisis factoriales, los factores latentes son los que tienen una influencia en los indicadores, en lugar de a la inversa. Esto quiere decir que establecer pequeñas cargas cruzadas refleja la influencia del factor en la parte relevante de la construcción de los indicadores, en lugar de que los indicadores tengan un impacto en la naturaleza del factor en si. Por tal motivo, esta investigación aborda esta discusión en el contexto de modelos de ecuaciones estructurales Bayesianos multinivel (ML-BSEM) al plantear modelos en los que será liberada la estimación de parámetros en las cargas factoriales cruzadas. Por lo tanto, es necesario examinar si para este tipo de modelos se mantiene la discusión descrita en la literatura y si existen ganancias en la bondad de ajuste de los modelos al permitir esa condición.

Esto se hará evaluando los posibles efectos sobre las estimaciones de los parámetros, las pruebas de hipótesis asociadas a los mismos, asi como las pruebas de bondad de ajuste de modelos, que pueden variar según la definición de las distribuciones a priori de las cargas factoriales cruzadas, desde poco informativas o difusas hasta muy informativas, en el contexto de estimación de modelos de ecuaciones estructurales Bayesianos multinivel. Para esto, además, será analizada la robustez para distintos escenarios en los cuales pueden operar los modelos jerárquicos, como distintos tamaños de grupos en el nivel alto, distintos tamaños de muestra en los grupos del nivel bajo y diferentes intensidades de la correlación intraclase.

Palabras clave: Bayesiano, priori, multinivel.

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Semimartingales and their stochastic calculus on spaces of distributions[I]

Invited Session / Sesión invitada

FONSECA MORA, CHRISTIAN[II]

Costa Rica

The purpose of this talk is to announce several new developments on the theory of semimartingales and their stochastic calculus in spaces of distributions, or more generally, on duals of nuclear spaces. We will start with some sufficient conditions for a cylindrical semimartingale defined on a nuclear space Φ to have a Φ'-valued càdlàg semimartingale version (here Φ' denotes the strong dual of Φ). In particular, we show the existence of càdlàg versions to Φ'-valued semimartingales. Our results generalize those obtained by Üstünel [6]. Latter, we show that that under some general conditions every semimartingale taking values in the dual of a nuclear space has a canonical representation. Our results extends those obtained by Pérez-Abreu [4] for the case of the dual of a nuclear Fréchet space (e.g. for $\mathcal{S}'(\mathbb{R}^d)$) to the context of the dual of a general nuclear space (this includes all the spaces of distributions).

Furthermore, the concept of predictable characteristics is introduced and we show how it is used to establish necessary and sufficient conditions for a Φ'-valued semimartingale to be a Φ'-valued Lévy process. In the last part of the talk we introduce a novel theory of stochastic integration with respect to (cylindrical) semimartingales. Our constructed integral generalizes that introduced by the author for cylindrical martingales [1] and extends previous work by Üstünel [5] on stochastic integration with respect to semimartingales in some duals of nuclear spaces.

Keywords: cylindrical semimartingales, semimartingales, dual of a nuclear space, semimartingale canonical representation, Lévy processes, stochastic integral.

Mathematics Subject Classification (2010): 60B11, 60G17, 60G20, 60G48, 60H05.

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[I] Miércoles/Wednesday 26, 03:25 - 03:45, Room/aula 1, session: (Prob1-2), Invited session: Probability 2

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How to manage price in times of crisis?[I]

¿Cómo administrar el precio en tiempos de crisis?

Invited Session / Sesión invitada Bancos

FRANCK MURILLO, ALEXANDER[II]

Costa Rica

¿Cómo administrar el precio en tiempos de crisis?

En el año 2016 Costa Rica registró por primera vez en la historia un 0% de inflación. Un aporte importante a este comportamiento tuvo el sector de consumo masivo (por ejemplo, el sector de Alimentos y Bebidas presentó precios nominales menores al año anterior en los primeros meses de 2016). Los indicios de desaceleración económica que está presentando el país actualmente de nuevo se acompañan de bajas de precio importantes, en muchas ocasiones de manera indiscriminada. Por ende se plantea la pregunta de ¿Cómo administrar el precio en tiempos de crisis?

Koppermill Analytics ha usado un enfoque de Revenue Management en el sector de CPG para optimizar el manejo de precios en esta coyuntura, apalancados en una estrategia de dos pasos: (1) segmentación de clientes y (2) modelación de elasticidades.

Para la segmentación de clientes hemos utilizado un enfoque de definición de grupos con cluster jerárquico, y la determinación de perfiles con probabilidades diferenciadas de pertenecer a esos grupos basados en árboles de regresión (CART). Sobre estos grupos de clientes se modelan elasticidades de manera indirecta (usando sell-in) con base en los propios datos de las empresas con base en modelos de regresión múltiple, y se deciden estrategias cross-portfolio en grupos dirigidos de clientes, ya sea de manera temporal o permanente.

La aplicación de estos modelos ha servido a nuestros clientes para validar sus variables determinantes para establecer los planes de marketing, así como poder valorar y calcular sus indicadores de retorno en términos de rentabilidad.

Keywords: Revenue Management, Pricing, Marketing, Segmentation.

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[I] Viernes/Friday 28, 02:20 - 02:40, Auditorium / Auditorio, session: (si04-2), Invited session: Banca 1

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Categorical action of the braid group of the cylinder: symplectic aspect[I]

Invited Session / Sesión invitada

GADBLED, AGNES[II]

Suecia

Khovanov and Seidel gave in 2000 an action of the classical braid group on a category of algebraic nature that categorifies the Burau representation. They proved the faithfulness of this action through the study of curves in a punctured disk (while Burau representation is not faithful for braids with five strands or more). In a recent article with Anne-Laure Thiel and Emmanuel Wagner, we extended this result to the braid group of the cylinder. The work of Khovanov and Seidel also had a symplectic aspect that we now generalize. In this talk, I will explain the strategy and tools to get a symplectic monodromy in our case and prove its injectivity. If time permits, I will explain how this action lifts to a symplectic categorical representation on a Fukaya category that should be related to the algebraic categorical representation.

This is a joint work in progress with Anne-Laure Thiel and Emmanuel Wagner.

Keywords: braid group, categorical representation, symplectic manifolds.

Mathematics Subject Classification (2010): 20F35, 18E30, 53D40

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[I] Jueves/Thursday 27, 11:20 - 12:00, Room/aula 2, session: (Gt1-3), Geometry and Topology / Geometría y Topología 1

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Social networks analysis in the process of formulation and implementation of quality public policy: the case of programs accreditation in Costa Rica[I]

Communication / Ponencia

GALLARDO-ALLEN, EUGENIA[II]

Costa Rica

In order to analyze the formulation and implementation of the accreditation of programs in Costa Rican universities from an approach where the actors are fundamental in the results of public policy, the statistical technique of social network analysis was used. For this analysis, the interactions of actors were identified in the minutes of the National Accreditation Council (CNA) and in the media in the period between 1999-2016.

The network analysis helps to identify the actors, proximity and centrality indicators to describe the position of the actors in the network. In addition, it allows to reveal if it has a strategic position to achieve the best resources, clarify the goals of its agents and how its political influence is used (Zurbriggen, 2011).

Among the main results when performing the ARS, low density was found in both formulation and implementation (about 1%). The actors with the greatest connections (centrality) in 1999 and 2000 are the CNA and members of this instance such as Clara Zomer, Arturo Jofré, which evidences the leading role of the CNA in the framework of this policy. The CNA, for example, is related to government authorities (MEP, Executive Power) and Legislative Assembly (Deputies and Social Affairs Commission), to bring this policy to the government's agenda.

Regarding the measure of centrality (nodes with more connections), it is observed that until 2006, the node presenting the highest indicator is the SINAES and, after this year, the CNA exceeds the SINAES in this indicator. This result is interesting because it indicates that in the first years of the implementation of accreditation this instance establishes a greater amount of institutional relations and in subsequent years they concentrate on the decision-making body. This also indicates a consolidation of this instance that was not evident in the first years of the study period. Institutional actors such as universities, careers, CONARE, CFIA and international institutions such as ANECA, RIACES and CCA have high centrality indicators. These nodes or actors with a high centrality indicator can become collaborative facilitating entities in the implementation of complex changes, since they are points that offer opportunities for exchange of support, knowledge and other types of resources, as well as, disseminate information and strategies that facilitate the necessary changes to improve certain problems of the Costa Rican higher education system.

Keywords: Social Network Analysis, public policies, accreditation.

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[I] Martes/Tuesday 25, 03:05 - 03:25, Room/aula 2, session: (DatAn1-1), Análisis de datos / Data Analysis

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Inference for Stochastic Kinetic Models Using Multiple Data Sources of Acute Respiratory Infections[I]

Communication / Ponencia

GARCÍA PUERTA, YURY ELENA[II] Capistrán, Marcos A.[III] Chkrebtii, Oksana A.[IV]
Noyola, Daniel E.[V]

Costa Rica

Influenza and respiratory syncytial virus (RSV) are the leading etiological agents of seasonal acute respiratory infections (ARI) around the world. Medical doctors typically base the diagnosis of ARI on patients' symptoms alone, and do not always conduct virological tests necessary to identify individual viruses, which limits the ability to study the interaction between multiple pathogens and make public health recommendations. We consider a stochastic kinetic model (SKM) for two interacting ARI pathogens circulating in a large population and an empirically motivated background process for infections with other pathogens causing similar symptoms. An extended marginal sampling approach based on the Linear Noise Approximation to the SKM integrates multiple data sources and additional model components. This work aims to illustrate that it is possible to identify virus circulation time at the San Luis Potosí population by detection of RSV (or influenza) in hospitalized children. We infer the parameters defining the pathogens' dynamics and interaction within a Bayesian hierarchical model and explore the posterior trajectories of infections for each illness based on aggregate infection reports from six epidemic seasons collected by the state health department, and a subset of virological tests from a sentinel program at a general hospital in San Luis Potosí, México. We interpret the results based on real and simulated data and make recommendations for future data collection strategies.

Keywords: Power spectral density, Two-pathogen model, Influenza vaccination effects, Interaction between viruses.

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[I] Miércoles/Wednesday 26, 03:25 - 03:45, Room/aula 2, session: (Mod1-2), Modeling / Modelación 1

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Analysis of a pseudostress-based HDG method for the Oseen problem[I]

Sesión Invitada

GATICA, LUIS F.[II] Camaño, Jessika[III] Vallejos, Eduard[IV]

Chile

In this talk we introduce and analyse a hybridizable discontinuous Galerkin (HDG) method for numerically solving the Ossen equations of incompressible fluid flow with non-homogeneous Dirichlet boundary conditions. We considered a fully-mixed formulation in which the main unknowns are given by the pseudostress, the velocity and the trace of the velocity, whereas the pressure is easily recovered through a simple postprocessing. We show that the corresponding discrete scheme is well-posed. In particular, we use the projection-based error analysis in order to obtain optimally convergent approximations for all unknowns. Finally, we provide several numerical results illustrating the good performance of the proposed scheme and confirming the optimal order of convergence provided by the HDG approximation.

Keywords: Oseen equations, hybridizable discontinuous Galerkin (HDG) method, incompressible flow, Navier–Stokes equations.

Mathematics Subject Classification (2010): 65N12, 65N15, 65N30, 76D07.

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[I] Miércoles/Wednesday 26, 02:20 - 02:40, Room/aula 3, session: (SINum1-2), Invited session: Numerical solution of PDEs

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Fractional Calculus in nano-strucutred[I]

Communication / Ponencia

GÓMEZ, ADRIÁN[II] Gentil Rodríguez, Ronald

Colombia

Many semiconductors exhibit a dispersive behavior in their transient current transport dynamics. this phenomenon is defined as the long tail phenomenon that can be understood as the deviation of the normal Gaussian diffusion process. The low mobility of the charge carriers observed in the (organic, disordered, porous or nanostructures) semiconductors is determined by the presence of this behavior in the curve of the transient current density. This behavior of long tail is due to the fact that charge carriers that are located at deep energy levels require more transit time to escape the limit of mobility. In the normal diffusion transport model, it is assumed that the charge carrier is a random walker whose trajectory follows a Gaussian distribution and the mean square of the displacement (MSD) of the trajectory is linearly proportional to the diffusion time, $\langle x^2(t)\rangle \propto t$. However, it has been known that the MSD of charge carrier that moves in a disordered material is given as $\langle x^2(t)\rangle \propto t^\alpha$ where α is the dispersive parameter with $0 < \alpha < 1$. This type of transport dynamics of the charge carriers is classified as anomalous.

Among several organic semiconductors are P3HT, PCBM, pentacene, MDMO-PPV, among others. There are many applications that present this materials, some of them are organic optoelectronics (oled) and in organic FETs. Another area of greater application for organic and polymeric transistors are the radio frequency identification devices (RFID tags) and organic solar cells.

A model is applied using the variable-order time fractional drift-diffusion equation for estimating the density of charge carriers in a nano-structure thin film. The approach of the solution is made through a scheme of finite differences and simulation using the Matlab programming language.

In this conference is presented the benefits to use the fractional calculus in the generalizations in the equations that model the anomalous transport are such as the models were unified for the transport of normal and anomalous energy, the efficiency of the representation of the model by the fractional time derivative allows to have integrated memory effects in the times of jump of the charge carriers, it was found that the fractional derivative is calculated using integral derivatives and derivatives that allow the use of known tools for their discretization and physically, the device, as it is manufactured, makes it easier to determine initial and constant measurements for estimating the solutions.

Fractional Calculus, Nono-strucutres, finite difference.

Mathematics Subject Classification (2010): 26A33

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[I] Miércoles/Wednesday 26, 03:05 - 03:25, Room/aula 2, session: (Mod1-1), Modeling / Modelación 1

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[2] G.-W. Hsieh, J.-Y. Wu, K. Ogata, K.-Y. Cheng, Dual layer semiconducting nanocomposite of silicon nanowire and polythiophene for organic-based field effect transistors, Organic Electronics. 35 (2016) 158-163. doi:10.1016/j.orgel.2016.05.020.

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New mixed finite element methods for natural convection with phase-change in porous media[I]

Sesión Invitada

GOMEZ-VARGAS, BRYAN[II] Alvarez, Mario[III] Gatica, Gabriel N.[IV]
Ruiz-Baier, Ricardo[V]

Chile, Russia, UK, Costa Rica

This article is concerned with the mathematical and numerical analysis of a steady phase change problem for non-isothermal incompressible viscous flow. The system is formulated in terms of pseudostress, strain rate and velocity for the Navier-Stokes-Brinkman equation, whereas temperature, normal heat flux on the boundary, and an auxiliary unknown are introduced for the energy conservation equation. In addition, and as one of the novelties of our approach, the symmetry of the pseudostress is imposed in an ultra-weak sense, thanks to which the usual introduction of the vorticity as an additional unknown is no longer needed. Then, for the mathematical analysis two variational formulations are proposed, namely mixed-primal and fully-mixed approaches, and the solvability of the resulting coupled formulations is established by combining fixed-point arguments, Sobolev embedding theorems and certain regularity assumptions. We then construct corresponding Galerkin discretizations based on adequate finite element spaces, and derive optimal a priori error estimates. Finally, numerical experiments in 2D and 3D illustrate the interest of this scheme and validate the theory.

Keywords: Natural convection, viscous flow in porous media, change of phase, mixed–primal formulation, fully–mixed formulation, fixed-point theory, finite element methods.

Mathematics Subject Classification (2010): 65N30, 65N12, 65N15, 76R05, 76D07.

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[I] Miércoles/Wednesday 26, 02:40 - 03:00, Room/aula 3, session: (SINum1-3), Invited session: Numerical solution of PDEs

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The Auditor 4.0[I]

El Auditor 4.0

GUERRERO TROYO, ALEJANDRA[II]

Costa Rica

The audit process must evolve with the use of increasingly thechnological tools. Auditor 4.0 is how we call the adaptation of new trends from the smart industry 4.0, in the face of digital transformation occurring at the Banco Nacional de Costa Rica. For this, , we has been working with the use of predictive models in order to perform more efficient inspection studies of the different areas of the bank.

Keywords: Keywords: Data, analysis, auditor, bank.

Resumen

El proceso de auditoría debe evolucionar con el uso de herramientas cada vez más tecnológicas. El auditor 4.0 es como llamamos, en la auditoría del Banco Nacional, a la adaptación de nuevas tendencias de la industria inteligente 4.0, de cara a la transformación digital. Para ello, se ha venido trabajando con el análisis de datos y en el uso de modelos predictivos, esto con el fin de realizar de forma más eficiente los estudios de fiscalización de las diferentes áreas del banco.

Palabras clave: Palabras clave: datos, analisis, auditor, banco.

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[I] Viernes/Friday 28, 03:25 - 03:45, Auditorium / Auditorio, session: (SI05-2), Invited session: Banca 2

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Statistical copulas in finance and their applications[I]

Cópulas estadísticas en finanzas y sus aplicaciones

Communication / Ponencia

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In this talk, we will describe the concept of statistical copulas and how they can be used to model dependence structure of financial and actuarial data sets. Several examples and applications will be discussed.

Keywords: Copulas, finance, tail dependence, applied mathematics.

Mathematics Subject Classification (2010): 62P05

Resumen

En esta charla, se describirá el concepto de cópulas estadísticas y como se pueden utilizar para modelar estructuras de dependencia en conjuntos de datos en finanzas y actuariado. Se discutirán varios ejemplos y aplicaciones.

Palabras clave: Copulas, finanzas, dependencia de colas, matemáticas aplicadas,

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[I] Viernes/Friday 28, 03:45 - 04:05, Auditorium / Auditorio, session: (si05-3), Invited session: Banca 2

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Inverting the weak random operator associated to the killed Brox diffusion[I]

Invirtiendo el operador débil asociado al proceso de Brox con muerte

Sesión Invitada

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We analyze a weak random operator, initially motivated from processes in random environment. In particular we work with the weak random operator associated to the killing Brox diffusion. Intuitively speaking these operators are ill-defined, but using bilinear forms one can deal with them in a rigorous way.

This point of view can be found for instance in the work Skorohod [5], and it remarkably helps to carry out specific calculations. In this work, we find explicitly the inverse of such weak operators, by provinding the forms of the so-called Green kernel.

To find the kernel we give explicitly two homogeneous solutions in terms of integrals of geometric Brownian motion. Important tools that we use are the Sturm-Liouville theory and the stochastic calculus.

Keywords: Green kernel, weak random operators, Sturm-Liouville theory, Geometric Brownian, bilinear forms.

Mathematics Subject Classification (2010): 60K37, 60H25

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[I] Miércoles/Wednesday 26, 02:40 - 03:00, Room/aula 1, session: (SIProb1-3), Invited session: Probability

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Generalized Vehicle Routing Problems (GARP)[I]

Problemas de Ruteo de Vehículos Generalizados (GARP)

Communication / Ponencia

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Nicaragua

The Generalized Vehicle Routing Problem (GVRP) is one of the problems little studied in the current Operations Research literature. Its importance lies in the wide variety of applications it has in real life. Broadly speaking, the GVRP is a variant of the classic and most studied problem of vehicle routing.

These problems have multiple variations which depend on the nature of the problem to be solved and the characteristics of the company where the study is applied. These can be found in the capacity of the vehicles, the frequency of visits to the customer until they meet their demand, in the types of deliveries and collection, as well as in the times and conditions of delivery. The well-known and well-studied Classic Business Travel Problem (TSP) is a particular case of VRPG. Most routing problems belong to the NP - Hard class. Given the computational complexity of the Generalized Vehicle Routing Problem with a heterogeneous fleet, it becomes difficult to solve it with exact methods, in a reasonable time. The NP-Completeness theory states that exact and efficient algorithms are unlikely to exist for the class of NP-difficult problems. One way to deal with NP hardness is to relax the optimality requirement and instead look for solutions that are probably close to the optimum. This is the main idea behind the approximation algorithms, which are called heuristic or metaheuristic.

A vehicle routing problem may have different objectives to optimize, for example, minimizing the total transport time or minimizing the number of vehicles used or minimizing the sum of customer waiting times, or a combination thereof. To try to solve some of these vehicle routing problems, as well as other cases of NP-hard combinatorial optimization problems, a particular model must be proposed and specific methods developed to solve it, that is, a successful heuristic or metaheuristic in one of them they can help design or implement algorithms that provide good solutions for another. It is important to note that some instances with hundreds of clients are satisfactorily solved exactly for some variants of the problem; however, there are other small instances that have not been resolved yet.

The purpose of the research is to work with a variant of the VRP called a generalized vehicle routing problem that has been very sparsely addressed. In this case, the clients are grouped into clusters, and only one client of each cluster needs to be visited. In this sense, we want to determine a set of routes for a set of vehicles with capacity restrictions that must be visited exactly one customer per group. The demand of the clients of each group is satisfied with the client that is chosen to visit. As in most of the cases mentioned above, here the objective is to minimize transportation costs.

Heuristic algorithms will be designed and implemented based on a method of successive approximations for the Generalized vehicle routing problem. To achieve this purpose, an exhaustive study of the vehicle routing problem (VRP and TSP) and its variants is made. In addition, a state of the art of the different heuristic

[I] Viernes/Friday 28, 02:00 - 02:20, Room/aula 2, session: (Opt1-1), Optimization / Optimización 1

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and metaheuristic algorithms for (VRP, TSP and GVRP) is carefully carried out. Subsequently, new models, heuristic algorithmic based on metaheuristic techniques for the problem of generalized vehicle routing (GARP), and some of its variants are proposed and applied. In the case of the GVRP, the idea is to develop, at least one heuristic type Ants Colony in which we already have experience and we have obtained very good results for the VRP, Tabu Search and Random Key Genetic Algorithm type with the heuristics, with which we they have given very good results for CARP and other variants of VRP. Based on these results, other metaheuristics and / or hybrid approaches are developed.

Finally, we contribute to the dissemination of new scientific research that leads to the expansion and improvement of the study, the generation of new knowledge, since it is a young area within the discipline of Education in Nicaragua.

Keywords: Optimization, Routing Problem, NP-Hard, Heuristics, Metaheuristics, Cluster.

Mathematics Subject Classification (2010): 90Cxx

Resumen

El problema de ruteo de vehículos generalizados (GVRP por sus siglas en inglés Generalite Vehicle Routing Problem) es uno de los problemas poco estudiados en la literatura actual de Investigación de Operaciones. Su importancia radica en la gran variedad de aplicaciones que tiene en la vida real. A grandes rasgos, el GVRP es una variante del problema clásico y más estudiado de ruteo de vehículos.

Estos problemas tienen múltiples variaciones las cuales dependen de la naturaleza del problema a resolver y de las características de la empresa en donde se aplica el estudio. Estas pueden encontrarse en la capacidad de los vehículos, la frecuencia de visitas al cliente hasta cumplir con su demanda, en los tipos de entregas y recolección, así como en los tiempos y condicionantes de la entrega. El conocido y muy estudiado Problema Clásico del Viajante de Comercio (TSP) es un caso particular de VRPG. La mayoría de los problemas de ruteo pertenecen a la clase NP - Hard. Dada la complejidad computacional del Problema de Ruteo de Vehículos Generalizados con flota heterogénea se vuelve difícil de resolverlo con métodos exactos, en un tiempo razonable. La teoría de NP-Completitud plantea que los algoritmos exactos y eficientes son poco probable que exista para la clase de problemas NP-difíciles. Una forma de hacer frente a la dureza NP es relajar el requisito de optimalidad y en su lugar buscar soluciones que estén probablemente cerca del óptimo. Esta es la idea principal detrás de los algoritmos de aproximación, que tienen por nombre heurísticos o metaheurísticos. Un problema de ruteo de vehículos puede tener diferentes objetivos a optimizar, por ejemplo, minimizar el tiempo total de transporte o minimizar el número de vehículos utilizados o minimizar la suma de los tiempos de espera de los clientes, o una combinación de los mismos. Para intentar resolver alguno de estos problemas de ruteo de vehículos, al igual que otros casos de problemas de optimización combinatoria NP-hard, hay que proponer un modelo particular y desarrollar métodos específicos para resolverlo, es decir un heurístico o metaheurística exitosa en uno de ellos pueden ayudar diseñar o implementar algoritmos que provean buenas soluciones para otra. Es importante observar, que algunas instancias con cienes de clientes son resueltas satisfactoriamente en forma exacta para algunas variantes del problema; sin embargo, hay otras instancias pequeñas que no han sido resueltas aún.

La finalidad de la investigación se centra en trabajar con una variante del VRP llamada problema de ruteo de vehículos generalizado que ha sido muy escasamente abordada. En este caso, los clientes están agrupados en clústers, y sólo un cliente de cada clúster necesita ser visitado. En este sentido, se quiere determinar un conjunto de rutas para un conjunto de vehículos con restricciones de capacidad que deben visitar exactamente un cliente por grupo. La demanda de los clientes de cada grupo se satisface con en el cliente que se elige para visitar. Como en la mayoría de los casos antes mencionados, acá el objetivo es minimizar los costos de transporte.

Se diseñarán e implementarán algoritmos heurísticos basados en un método de aproximaciones sucesivas para el problema de ruteo de vehículos Generalizados. Para lograr esta finalidad se hace un estudio exhaustivo del problema de ruteo de vehículos (VRP y TSP) y sus variantes. Además, se realiza detenidamente un estado del arte de los diferentes algoritmos heurísticos y metaheurísticos existentes para (VRP, TSP y GVRP). Posteriormente, se propone y se aplican nuevos modelos, algorítmicos heurísticos basados en técnicas metaheurísticas

para el problema de ruteo de vehículos generalizado (GARP), y en algunas de sus variantes. En el caso del GVRP, la idea es desarrollar, al menos una heurísticas tipo Colonia de Hormigas en las cuales ya tenemos experiencia y hemos obtenido muy buenos resultados para el VRP, Tabu Search y tipo Random Key Genetic Algorithm, heurísticas con las cuales nos han dado muy buenos resultados para el CARP y para otras variantes del VRP. En función de estos resultados se desarrollan otras metaheurísticas y/o enfoques híbridos.

Por último, contribuimos a la difusión de nuevas investigaciones científicas que conllevan a la ampliación y mejora del estudio, la generación de nuevos conocimientos, ya que es un área joven dentro de la disciplina de la Educación en Nicaragua.

Palabras clave: Optimización, Problema de Ruteo, NP-Hard, Heurísticos, Metaheurísticas, Clúster.

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Simulation of Synergism and Antagonism in binary mixture models[I]

Simulación de sinergia y Antagonismo en modelos de mezclas binarias

Communication / Ponencia

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Colombia

In this work, we present a methodology used to simulate the response of binary mixtures, which is based on the concept of concentration addition (CA) and the independent action AI. Both concepts are based on prior knowledge of the individual response. CA assumes that the elements of a mix that share a strictly similar mechanism of action. In contrast, AI is based on the idea of acting completely independently.

For the estimation process, the concept of Combination Index (CI) was used, which computationally simulates the specific effects of the mixture: synergism, additivity and antagonism The model was applied to chemical compounds of essential oils where using the probit model, the individual response Cl50 for the fumigant action was determined and the synergistic factor based on the CI for the simulation of the mixed effects was calculated. The results show that the simulation model based on the IC is an efficient alternative to the response surface method and that despite an optimal individual response, the mixture is not necessarily synergistic.

Keywords: Simulation, mixtures, Combination Index, synergism, essential oils.

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[I] Martes/Tuesday 25, 02:40 - 03:00, Auditorium / Auditorio, session: (Apl1-3), Applications / Aplicaciones 1

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Excel, then R: from basic mathematical operations to models[I]

Excel, luego R: de las operaciones básicas matemáticas a los modelos

Communication / Ponencia

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Costa Rica

The extraction, transformation and loading (ETL) of the data, base process in order to have data available by units responsible for analysis and management such as business intelligence teams, entails critical validations that ensure reliability on the information to be used, such checks at the level of commercial banks are generally given by means of basic mathematical operations. So with programs like Excel the objectives of the first stage are achieved.

Data such as credit portfolio, obtained through the steps outlined in the previous paragraph, is key for different areas within a banking entity. Business, for example, will use it as an input for portfolio development, risk as long as it will be understood as the amount of exposure, the customer satisfaction units to quantify the economic impact of all clients who file a complaint in case they decide to withdraw from the bank. From there the need arises for models developed in languages such as R.

The exhibition will present cases applied in banking, which allow to illustrate exercises required by different areas of a commercial bank, of how from validated data these are analyzed and modeled, to later be exposed the results.

Keywords: Data analysis, business intelligence, commercial bank, statistical model.

Mathematics Subject Classification (2010): 62-07

Resumen

La extracción, transformación y carga (ETL por sus siglas en inglés) de los datos, proceso base con el fin de tener datos disponibles por unidades encargadas de análisis y gestión como lo son los equipos de inteligencia de negocios, conlleva validaciones críticas que aseguren confiabilidad sobre la información a utilizar, dichas comprobaciones a nivel de bancos comerciales generalmente se da por medio de las operaciones matemáticas básicas. Así que con programas como Excel se alcanzan los objetivos de la primera etapa.

Un dato como el de cartera de crédito, obtenido por medio de los pasos expuestos en el párrafo anterior, es clave para diferentes áreas dentro de una entidad bancaria. Negocio por ejemplo lo utilizará como insumo para desarrollo de portafolio, riesgo en tanto lo entenderá como monto de exposición, las unidades de satisfacción al cliente para cuantificar el impacto económico del conjunto de clientes que presenten alguna queja en caso de que decidan retirarse del banco. A partir de ahí surge la necesidad de modelos desarrollados en lenguajes como R.

En la exposición se presentarán casos aplicados en banca de personas, que permitan ilustrar ejercicios requeridos por diferentes áreas de un banco comercial, de cómo a partir de datos validados estos son analizados y modelados, para posteriormente ser expuestos los resultados.

Palabras clave: Análisis de datos, inteligencia de negocios, banco comercial, modelo estadístico.

[I] Viernes/Friday 28, 03:05 - 03:25, Auditorium / Auditorio, session: (SI05-1), Invited session: Banca 2

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Ranking of decision making units in DEA models: A review and comparative study[I]

Communication / Ponencia

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Data envelopment analysis (DEA) is a non-parametric technique for evaluation of relative efficiency of decision making units (DMUs) described by multiple inputs and outputs. It is based on solving linear programming problems. Since 1978 when basic DEA model was introduced many its modifications were formulated. Multi-stage DEA models with serial or parallel structure, multi-period DEA models, inter-temporal models and integer DEA models belong among the most important ones.

DEA models usually split DMUs into two basic groups, efficient and inefficient. Efficiency score of inefficient units allows their ranking but efficient units cannot be ranked directly because of their maximum identical efficiency scores. There were introduced various models for ranking of efficient DMUs in the past and the research in this field is not finished yet. Ranking models are based on different methodological principles - super-efficiency models, cross efficiency evaluation, pessimistic and optimistic models, goal programming, and others. The aim of this paper is to summarize main approaches for ranking of DMUs in several classes of DEA models (traditional models, network models, multi-period models). The comparison is made on several randomly generated data sets (independent data sets for each class of models). Numerical experiments are performed using own procedures written in LINGO modelling language.

Keywords: data envelopment analysis, network models, ranking, efficiency.

Mathematics Subject Classification (2010): 90B50

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[I] Martes/Tuesday 25, 04:30 - 04:50, Room/aula 1, session: (OR2-1), Operations Research / Investigación de Operaciones 2

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An independence test based on recurrence rates[I]

Communication / Ponencia

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Uruguay

A new test of independence between random elements is presented in this article. The test is based on a functional of the Cramer-von Mises type, which is applied to a U-process that is defined from the recurrence rates. Theorems of asymptotic distribution under H0, and consistency under a wide class of alternatives are obtained. The results under contiguous alternatives are also shown. The test has a very good behaviour under several alternatives, which shows that in many cases there is clearly larger power when compared to other tests that are widely used in literature. In addition, the new test could be used for discrete or continuous time series. Also, we include some applications of the test.

Keywords: independence tests, recurrence rates, U-process.

Mathematics Subject Classification (2010): 62H15, 62H20.

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[I] Miércoles/Wednesday 26, 04:30 - 04:50, Room/aula 1, session: (Mst1-1), Multivariate Statistics / Estadística Multivariada

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Spatiotemporal process driven by a hidden point process - Application in ecology[I]

Communication / Ponencia

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Guadeloupe

In ecology and epidemiology, spatiotemporal distributions of events can be described by point processes. Situations for which there exists a hidden process which contributes to random effects on the intensity of an observed process are considered. Some studies are based on counts of events in sampling units and some others on event spatial positions or occurrence dates.

Modelling a point process is equivalent to modelling either its intensity or its driving measure. In our study, a process N on a measured space is considered. The intensity lambda at any spatial location of occurrences between several pairs of consecutive observation is expressed as a linear combination of kernels centered on contributing events.

We proposed a model extended to the case where there exist contributions to the intensity process associated with a hidden process. This latter process describes hidden environmental effects on the observed intensity. We focus on statistical procedures providing inference tools in a bayesian framework when observing data consisting of spatial locations of occurrences between several pairs of consecutive observation. The case study concerns these kinds of data. Estimations of the parameters of the proposed model are carried out.

The proposed model allows describing a phenomenon consisting of occurrences at spatial positions and dates caused by hidden events. A hybrid Gibbs-Metropolis-Hastings MCMC algorithm is proposed and allows the following parameters to be obtained a posteriori: expected number of hidden events per unit of space and time, expected contribution per hidden event, degree of spatial influence of hidden events, degree of temporal influence of hidden events and degree of correlation of contributions of hidden events. The application to artificial and real data shows the potential of the method.

Keywords: point process, hidden process, bayesian inference, ecology, epidemiology.
Mathematics Subject Classification (2010): 60, 62

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[I] Miércoles/Wednesday 26, 02:40 - 03:00, Room/aula 2, session: (DS1-3), Dynamical Systems / Sistemas Dinámicos

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A multiplicative decomposition for a family of functions of Fresnel integral type and its applications[I]

Una descomposición multiplicativa para una familia de funciones de tipo integral de Fresnel y sus aplicaciones

Communication / Ponencia

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Costa Rica

We consider a parametric family of functions, generalized complementary Fresnel integrals (FCI), denoted by s_α, c_α with real parameter $\alpha > 0$, and domain $\mathbb{R}_+$, defined as follows:

$$s_\alpha(t) = \int_t^\infty \frac{\sin(u)}{u^\alpha} du, \quad c_\alpha(t) = \int_t^\infty \frac{\cos(u)}{u^\alpha} du, \quad t > 0, 0 < \alpha,$$

In this work we present the following multiplicative decomposition formula:

$$c_\alpha(t) + i s_\alpha(t) \ = \ e^{it}(g_\alpha(t) + i f_\alpha(t)), \quad \text{for } \alpha > 0, t > 0,$$

where

$$g_\alpha(t) = \frac{1}{\Gamma(\alpha)} \int_0^\infty \frac{\exp(-ty) y^\alpha}{1+y^2} dy, \quad f_\alpha(t) = \frac{1}{\Gamma(\alpha)} \int_0^\infty \frac{\exp(-ty) y^{\alpha-1}}{1+y^2} dy.$$

We give account of the applications of this decomposition in the study of the zeros of this functions (location of zeros and dependence with respect the parameter) that have appeared in some works of last years (see [1, 2]). We expose with some details a recent application about the evaluation of the classical integrals of Dirichtlet and Generalized Fresnel Integral.

Keywords: Complementary Fresnel Integral, Lommel type functions, location intervals, dependence of the parameter, evaluation of integrals.

Mathematics Subject Classification (2010): 26D15, 33E20

Resumen

Considere la familia paramétrica de funciones integrales de Fresnel generalizadas (FCI) definidas por: s_α, c_α con parámetro real $\alpha > 0$, con dominio $\mathbb{R}_+$, como sigue:

$$s_\alpha(t) = \int_t^\infty \frac{\sin(u)}{u^\alpha} du, \quad c_\alpha(t) = \int_t^\infty \frac{\cos(u)}{u^\alpha} du, \quad t > 0, 0 < \alpha,$$

[I] Viernes/Friday 28, 02:20 - 02:40, Room/aula 1, session: (Aprox1-2), Approximation / Aproximación 1

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En este trabajo se presenta una fórmula de descomposición multiplicativa para esta familia de funciones dada por:

$$c_\alpha(t) + is_\alpha(t) \;=\; e^{it}(g_\alpha(t) + if_\alpha(t)), \quad \text{para } \alpha > 0, t > 0,$$

donde se tiene:

$$g_\alpha(t) = \frac{1}{\Gamma(\alpha)} \int_0^\infty \frac{\exp(-ty)y^\alpha}{1+y^2} dy, \quad f_\alpha(t) = \frac{1}{\Gamma(\alpha)} \int_0^\infty \frac{\exp(-ty)y^{\alpha-1}}{1+y^2} dy.$$

Damos cuenta de las aplicaciones de esta descomposición en el estudio de los ceros de estas funciones (localización de los ceros y dependencia con respecto al parámetro) que son parte de los resultados obtenidos en los últimos años (ver [1, 2]). Expondremos con más detalle una aplicación más reciente sobre las evaluaciones de las integrales clásicas de Dirichtlet y las generalizadas de Fresnel.

Palabras clave: Integral complementaria de Fresnel, funciones de tipo Lommel, intervalos de localización, dependencia del parámetro, evaluación de integrales.

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Application of the fractional differential equation of movement to s1gl, forced to forced vibrations of a shaking table[I]

Aplicación de la ecuación diferencial fraccionaria de movimiento a s1gl sometido a vibraciones forzadas de una mesa vibradora

Poster / Cartel

MÁRQUEZ QUINTOS, ERICK[II] Romo Organista, Miguel Pedro[III]

México

It has a hydraulic shaking table of a one freedom degree , MVH1GL, which was modified in order to obtain a better behavior in the output response of the device. Experiments are models that represent systems of a one degree of freedom, 1GL, subjected to harmonic or random type signals, which are studied with the fractional differential equation of p/q order of motion and the results are compared with the ordinary differential equation of order two. The results obtained show a better approximation with the differential equations of fractional order p/q. This work can have a projection in terms of modeling various engineering problems, such as in the subject of structures subjected to systems and vibrations; unique ground deposit response; dynamic soil-structure interaction, to name a few.

Keywords: fractional motion equition, shaking table, one freedom degree.

Mathematics Subject Classification (2010): Ordinary differential equations

Resumen

Se tiene una mesa vibradora hidráulica de un grado de libertad, MVH1GL, que fue modificada con el objetivo de obtener un mejor comportamiento en la respuesta de salida del dispositivo. Los experimentos son modelos que representan sistemas de un grado de libertad, 1GL, sometidos a señales de tipo armónica o aleatoria, los cuales se estudian con la ecuación diferencial fraccionaria de orden p/q de movimiento y los resultados se comparan con la ecuación diferencial ordinaria de orden dos. Los resultados obtenidos muestran una mejor aproximación con las ecuaciones diferenciales de orden fraccionaria p/q. Este trabajo puede tener una proyección en lo referente a la modelación de diversos problemas de la ingeniería, tales como en el tema de las estructuras sometidas a sismos y vibraciones; respuesta única de depósito de suelo; interacción dinámica suelo-estructura, por mencionar algunos.

Palabras clave: ecuación diferencial fraccionaria de movimiento, mesa vibradora, sistemas de un grado de libertad.

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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References

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[3] Ivo Petras. Fractional-order nonlinear systems: modeling, analysis and simulation. Springer Science & Business Media, 2011.

[4] Richard Herrmann. Fractional calculus: An introduction for physicists. World Scientific, 2011.

[5] Vladimir V Kulish and José L Lage. Application of fractional calculus to fluid mechanics. Journal of Fluids Engineering, 124(3):803-806, 2002.

Environmental statistics App, with Shiny[I]

Aplicación de estadísticas ambientales, con Shiny

Poster / Cartel

MARTÍNEZ MUÑOZ, ALLAN[II] Scott Zúñiga, Marcos[III]

Costa Rica

This poster is about an interactive application developed in R using Shiny package, for this the data provided by MINAE entities was organized, and a code that creates tables, graphs and summary statistics was developed.

You can access to the application in the next link: https://appminae.shinyapps.io/appilac/

Keywords: R, Shiny, application, interactive.

Resumen

Este póster trata sobre una aplicación interactiva desarrollada en R utilizando el paquete Shiny, para esto se organizaron los datos proporcionados por las entidades MINAE y se desarrolló un código que crea tablas, gráficos y estadísticas resumidas.

Puede acceder a la aplicación en el siguiente enlace: https://appminae.shinyapps.io/appilac/

Palabras clave: R, Shiny, applicación, interactiva.

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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Interactive application of the map of Costa Rica with different WMS layers.[I]

Aplicación interactiva del mapa de Costa Rica con diferentes capas WMS.

Poster / Cartel

MARTÍNEZ MUÑOZ, ALLAN[II]

Costa Rica

This poster is an application developed in R, with the shiny and leaflet libraries, this application connects WMS services and uses the available layers to be projected on the map of Costa Rica.

Among the features are: Load temporary layers, lat / long location and create figures. You can access the application at the following link: https://appminae.shinyapps.io/Geovisor_app/

Keywords: Application, R, shiny, WMS.

Resumen

Este poster se trata de una aplicación desarrollada en R, con la librerias shiny y leaflet, esta aplicación se conecta servicios WMS y utiliza las capas disponibles para que se proyecten en el mapa de Costa Rica. Entre las funcionalidades están: Cargar capas temporales, ubicación lat/long y crear figuras.

Puede acceder a la aplicación en el siguiente link: https://appminae.shinyapps.io/Geovisor_app/

Palabras clave: Applicación, R, shiny, WMS.

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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Delay differential models: exact and nonstandard numerical solutions[I]

Modelos diferenciales con retardo: Soluciones numéricas exactas y no estándar

Communication / Ponencia

MARTÍN ALUSTIZA, JOSÉ ANTONIO[II] Castro, María Ángeles[III]
Rodriguez, Francisco[IV]

España

Delay differential equations (DDE) have become basic tools in the mathematical modelling of scientific and technical problems that require considering time lags or hereditary characteristics [1]. For ordinary or partial differential problems, the use of nonstandard finite difference (NSFD) numerical schemes [2] have been increasingly popular in recent years. NSFD numerical methods can be constructed that provide exact numerical solutions for particular models, and that can be able to preserve dynamic properties of the original differential problems.

For delay differential models, the construction of NSFD numerical methods has been less developed. Some recent works have addressed the proposal of NSFD methods that are exact for linear differential models, and have analysed their dynamical properties [3, 4, 5]. In this communication we present the strategies to derive new families of NSFD methods for delay differential models, describe the dynamic consistency properties of the new methods, and discuss possible extensions.

Keywords: Delay equations, Numerical solutions, NSFD schemes, Dynamic consistency.

Mathematics Subject Classification (2010): 34K06, 34K28, 65L03, 65L12

References

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[2] R.E. Mickens, *Nonstandard Finite Difference Models of Differential Equations*, World Scientific, Singapore, 1994.

[3] S.M. Garba, A.B. Gumel, A.S. Hassan, J.M.-S. Lubuma, Switching from exact scheme to nonstandard finite difference scheme for linear delay differential equation, Appl. Math. Comput. 258 (2015) 388–403.

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[I] Martes/Tuesday 25, 03:25 - 03:45, Room/aula 1, session: (Deq2-2), Differential Equations / Ecuaciones Diferenciales 2

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Hiperbolic Smoothing Fuzzy Clustering Method[I]

Contribución a la Clasificación Difusa mediante un Método de Suavizamiento Hiperbólico

Communication / Ponencia

MASÍS FLORES, DAVID[II]

Costa Rica

In this applied research project, a hyperbolic smoothing method developed by Xavier was implemented, with the objective of classifying objects in a fuzzy way. This method is an extension of Xavier's original, which is based on numerical smoothing techniques that allow conversion from a strongly non-dierectable problem into dierentiable subproblems of optimization without restrictions of low dimension, by using a diferentiable function of infnite class. The programming of the algorithm was carried out using the statistical software R and the results obtained were compared with the traditional c-means method, which is a variation of the Bezdek k-means method for fuzzy clustering.

Keywords: Hiperbolic Smoothing, Fuzzy Clustering, k-Means.

References

[1] Bezdek, J.; Ehrlich, R.; Full, W. (1984) "FCM: the fuzzy c-means clustering algorithm", Computer and Geosciences 10 (2-3): 191-203.

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[4] Trejos, J.; Castillo, W.; Gonzalez, J. (2014) "Analisis Multivariado de Datos: Metodos y Aplicaciones", Editorial Universidad de Costa Rica, San Jose. Xavier, A. (2010) "The hyperbolic smoothing clustering method", Pattern Recog-nition 43: 731737.

[I] Martes/Tuesday 25, 04:30 - 04:50, Room/aula 2, session: (Clas1-1), Classification / Clasificación

[II] Instituto Tecnológico de Costa Rica, Matemática, Cartago, Costa Rica, colomf06@gmailcom

Total transitivity in hyperspaces[I]

Total transitividad en hiperespacios

Communication / Ponencia

MÉNDEZ GÓMEZ, HÉCTOR BRYAN[II] Méndez Gómez, Héctor[III]

Costa Rica

Given a continuous function $f\colon X \longrightarrow X$ defined in a topological space X, we say that f is topologically transitive if f connects all non-trivial parts of X, this concept was introduced by Birkhoff in 1920. We also say that f is totally transitive if for all positive integers n the iterated ones of f, which we denote by f^n, are topologically transitive. It is clear that the property of being totally transitive implies topological transitivity, but generally not reciprocally. The objective of this talk is to verify that both concepts, of topological transitivity and totally transitivity, are equivalent when we consider the dynamic system $\overline{f}\colon \mathcal{K}(X) \longrightarrow \mathcal{K}(X)$, where $\mathcal{K}(X)$ denotes the hyperspace of non-empty compact subsets of X, which is a topological space with the Vietoris topology, and $\overline{f}$ is naturally defined as the image of a compact subset of X under the function f.

Keywords: Keywords: topological transitive, totally transitive, mixing, weakly mixing, hyperspaces.

Mathematics Subject Classification (2010): 37-02

Resumen

Dada una función continua $f\colon X \longrightarrow X$ definida en un espacio topológico X, decimos que f es topológicamente transitiva si f conecta todas las partes no triviales de X, este concepto fue introducido por Birkhoff en 1920. Decimos también que f es totalmente transitiva si para todo entero positivo n las iteradas de f, que denotamos por f^n, son topológicamente transitivas. Es claro que la propiedad de ser totalmente transitiva implica la transitividad topológica, pero en general no reciprocamente. El objetivo de esta charla es verificar que ambos conpcetos, de total transitividad y transitividad topológica, son equivalentes cuando consideramos el sistema dinámico $\overline{f}\colon \mathcal{K}(X) \longrightarrow \mathcal{K}(X)$, donde $\mathcal{K}(X)$ denota el (hiper)espacio de subconjuntos compactos no vacíos de X, el cual es un espacio topológico con la topología de Vietoris, y $\overline{f}$ es definida de forma natural como la imagen de un subconjunto compacto de X bajo la función f.

Palabras clave: transitividad topológica, totalmente transitivo, hiperespacio, mezclante, débilmente mezclante.

References

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[2] J. L. G. Guirao, D. Kwietniak, M. Lampart, P. Oprocha, and A. Peris, *Chaos on hyperspaces*, Nonlinear Anal. **71** (2009), no. 1-2, 1-8.

[I] Miércoles/Wednesday 26, 02:20 - 02:40, Room/aula 2, session: (DS1-2), Dynamical Systems / Sistemas Dinámicos

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[III] Universidad de Costa Rica, San José, Costa Rica, hector.mendez@ucr.ac.cr

[3] G. Liao, L. Wang, and Y. Zhang, *Transitivity, mixing and chaos for a class of set-valued mappings*, Sci. China Ser. A **49** (2006), no. 1, 1-8.

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Evaluate the optimal performance measures of traffic lights located around the Central America and Jean Paul Genie roundabouts, to calculate a common cycle that will speed up the circulation and improve the operability between them[I]

Evaluar las medidas de rendimiento óptimos de los semáforos ubicados en los alrededores de las rotondas Centroamérica y Jean Paul Genie, para calcular un ciclo común que permitan agilizar la circulación y mejorar la operatividad entre ellas

Communication / Ponencia

MENDOZA GALÁN, CARLOS ALBERTO[II]

Nicaragua

In this investigation, the cycles of the five traffic lights installed around the roundabouts, Central America and Jean Paul Genie, were reviewed to propose operation as traffic lights with a common cycle between them, applying the previous results in order to speed up vehicular congestion in this place considered as critical point. To achieve this purpose, the optimal cycle times of the traffic lights studied were determined two to two, then the best ratio was evaluated through a mathematical PLE model, then a simulation scheme was designed in the WinQSB to evaluate the operation of the network model that involves the two roundabouts in terms of maximizing the time between their cycles.

Keywords: Webster Method, Saturation Flow, Traffic Light Cycle, Matches, Simulation.

Mathematics Subject Classification (2010):

References

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[3] Webster, F. (1958). Traffic Signal Settings. (H. M. Road Research, Ed.) Road Research Technical Paper(39)

[I] CANCELADA Martes/Tuesday 25, 02:20 - 02:40, Auditorium / Auditorio, session: (Apl1-2), Applications / Aplicaciones 1

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Logic and model theory in mathematics[I]

Lógica y teoría de modelos en las matemáticas

Plenary Talk / Conferencia Plenaria

MONTENEGRO GUZMÁN, SAMARIA[II]

Costa Rica

Mathematical logic arises as an attempt to formalize mathematics. One transcendental and landmark result in the development of mathematical logic is Gödel's Completeness Theorem. The Completeness Theorem establishes a correspondence between the syntax and semantics of first-order logic and marked the beginning of a new area of study of logic, model theory.

In this talk we will focus on model theory, which is responsible for the study of mathematical structures, such as fields, groups, graphs, etc., from a mathematical logic perspective. Model theory has many interactions with many areas of mathematics such as algebra, number theory, combinatorics, etc.

In this area, one of the main objects of study are the models of theories in a formal language, as well as the classification of these theories. Shelah in [1] classified complete first order theories by their ability to encode certain combinatorial configurations. In the last decades the properties of these classes of theories and their models have been studied from the point of view of logic. In the case of algebraic structures, many model theoretical properties are closely related to algebraic properties, giving in this way new methods to attack algebraic problems. We will give some important aspects in the development of mathematical logic, in particular in model theory. We will explain some of the main applications and the current development within the area of mathematics.

Keywords: Logic, Model Theory, Completeness Theorem.

Mathematics Subject Classification (2010): 03C65, 03C07.

References

[1] S. Shelah Classification theory and the number of nonisomorphic models. volume 92 of Studies in Logic and the Foundations of Mathematics. North-Holland Publishing Co., Amsterdam, second edition (1990).

[I] Viernes/Friday 28, 04:30 - 05:15, Auditorium / Auditorio, session: (conf6), Closing Plenary Talk / Conferencia de Clausura

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Inner Metric for an Approximate Spacetime with Mass Quadrupole[I]

Métrica Interna de un Espacio-tiempo Aproximado con Cuadrupolo Masivo

Communication / Ponencia

MORALES-MONTENEGRO, JULIO[II] Frutos-Alfaro, Francisco[III]

Costa Rica

A space-time is presented with rotation in a perfect fluid, suitable for neutron stars, with several state equations: a rigid equation, defined by its adiabatic coefficient, a soft equation and a synthetic equation, which can be used to restrict Adiabatic coefficient values. It seeks to obtain the mass and radius of the neutron star, and compare it with the model without rotation (Tolman-Oppenheimer-Volkov) and with astronomical measurements of neutron stars. This can be used to restrict equations of state of nuclear matter and check nuclear theories.

Keywords: General relativity, neutron stars, inner solutions, equations of state.

Mathematics Subject Classification (2010): 83-02, 83-08.

Resumen

Se presenta un espacio-tiempo con rotación en un fluido perfecto, adecuado para estrellas de neutrones, con varias ecuaciones de estado: una ecuación rígida, definida mediante su coeficiente adiabático, una ecuación suave y una ecuación sintética, la cual se puede utilizar para restringir valores del coeficiente adiabático. Se busca obtener la masa y el radio de la estrella de neutrones, y compararlo con el modelo sin rotación (Tolman-Oppenheimer-Volkov) y con mediciones astronómicas de estrellas de neutrones. Esto se puede utilizar para restringir ecuaciones de estado de la materia nuclear y comprobar teorías nucleares.

Palabras clave: Relatividad general, estrellas de neutrones, soluciones internas, ecuaciones de estado.

References

[1] F. Frutos-Alfaro (2016). Approximate Kerr-like Metric with Quadrupole, International Journal of Astronomy and Astrophysics, 6, 334-345.

[I] Martes/Tuesday 25, 05:10 - 05:30, Auditorium / Auditorio, session: (Num1-3), Numerical Analysis / Análisis Numérico 1

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Citizen security of the Adiact Cast of the city of León, Nicaragua, February 2018.[I]

Seguridad ciudadana del Reparto Adiact de la ciudad de León, Nicaragua, febrero de 2018.

Communication / Ponencia

NORORI ROMERO, DAVID GEOVANI[II] Molina Membreño, Adalila[III]
Lacayo Martinez, Leydi[IV]

Nicaragua

Insecurity is a global problem, at Central America level the problem of insecurity is very felt; Nicaragua has been considered for years the safest country in Central America and the city of León, the safest in Nicaragua. However, there is concern on the part of the national authorities, in relation to this problem, especially in the peripheral area of the city of León.

Citizen insecurity is one of the main factors that influence the behavior of residents, altering aspects of their daily lives such as displacement, coexistence between neighbors, family or friends, the distrust of being in some neighborhoods at certain times and other activities that are affected by various agents related to the collective perception of the population with respect to some sectors of the cities that are known for their high crime rates.

The Adiact cast is marked as one of the dangerous sectors of the city of León, in which there is a lot of insecurity, due to several factors such as: drug use, alcoholism, irresponsibility of parents, unemployment, lack of education , lack of lighting. The interest of this study is focused on analyzing the perception that the residents themselves have in the Adiact distribution, located north of the indigenous town of Sutiava in the city of León, about the insecurity that may exist in it. The opinion of local people and actors can give a better vision of what this serious problem can generate and generate opinions about possible solutions to combat each of the problems that cause this insecurity.

Villagers are the most aware of the dangers that exist in the cast itself, as well as its main incidence factors, what are the most frequent crimes and what actions are taken by the authorities to face the problem that exists with regard to insecurity.

This investigative work was carried out with the support of the National Police of the city of León, since they have a list of the areas most affected by insecurity within the city and have an interest in the perception of the residents regarding this. This investigation involved 30 people in field work, including 24 students and 6 professors and 6 police officers. The field work consisted of a survey of the residents, the group was divided through the three sectors into which the cast is divided, each group had two police officers to ensure the safety of the pollsters.

The present work is part of a group of investigations that have been carried out and are planned to continue, with the aim of analyzing the perception of citizens about the insecurity in the areas of greatest risk in the city, among which is a work already done in the Rubén Darío Cast.

[I] Martes/Tuesday 25, 03:25 - 03:45, Room/aula 2, session: (DatAn1-2), Análisis de datos / Data Analysis

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It was planned to continue with the Distributions present in the list of interest of the police, but the citizen's perception of insecurity has probably changed after the events that have occurred since April last year, so the option of repeating should be considered the survey in the two deals in which it has already been carried out.

Keywords: citizen security, descriptive analysis, surveys.

Mathematics Subject Classification (2010): 82-02

Resumen

La inseguridad es un problema global, a nivel de Centro América el problema de la inseguridad es muy sentido; Nicaragua ha sido considerado durante años el país más seguro de Centro América y la ciudad de León, la más segura de Nicaragua. Sin embargo, hay preocupación por parte de las autoridades nacionales, en relación a esta problemática, sobre todo en el área periférica de la ciudad de León.

La inseguridad ciudadana es uno de los principales factores que influyen dentro del comportamiento de los pobladores, alterando aspectos de su día a día como son desplazamiento, convivencia entre vecinos, familiares o amigos, la desconfianza de estar en algunos vecindarios a determinadas horas y otras actividades que se ven afectados por diversos agentes relacionados con la percepción colectiva de la población con respecto a algunos sectores de las ciudades que son conocidos por sus altos índices delictivos.

El reparto Adiact está marcado como uno de los sectores peligrosos de la ciudad de León, en el que existe mucha inseguridad, debido a varios factores como son algunos: expendios de drogas, alcoholismo, irresponsabilidad de los padres de familia, desempleo, falta de educación, falta de iluminación.

El interés de este estudio se centra en analizar la percepción, que tienen los propios pobladores en el reparto Adiact, ubicado al norte del pueblo indígena de Sutiava de la ciudad de León, sobre la inseguridad que pueda existir en este. La opinión de los pobladores y actores locales, puede dar una mejor visión de lo que puede generar este grave problema y generar opiniones acerca de posibles soluciones para combatir cada uno de las problemáticas que causan esta inseguridad.

Los pobladores son los más conscientes acerca de los peligros que existen en el propio Reparto, así como sus principales factores de incidencia, cuáles son los delitos más frecuentes y que acciones toman las autoridades para enfrentar la problemática que hay con respecto a la inseguridad.

Este trabajo investigativo fue llevado con acompañamiento de la Policía Nacional de la ciudad de León, ya que ellos tienen una lista de las áreas más afectadas por la inseguridad dentro de la ciudad y tienen el interés en la percepción de los pobladores con respecto a esta.

Esta investigación Involucró a 30 personas en trabajo de campo, entre los cuales se encontraron 24 estudiantes y 6 profesores y 6 oficiales de policía. El trabajo de campo consistió en una encuesta realizada a los pobladores, el grupo se dividió a través de los tres sectores en los que está dividido el Reparto, cada grupo contaba con dos oficiales de policía para garantizar la seguridad de los encuestadores.

El presente trabajo, es parte de un grupo de investigaciones que se han realizado y se planean continuar, con el objetivo de analizar la percepción de la ciudadanía sobre la inseguridad existente en las zonas de mayor riesgo en la ciudad, entre los cuales se encuentra un trabajo ya realizado en el Reparto Rubén Darío.

Se paneaba continuar con los Repartos presentes en la lista de interés de la policía, pero la percepción ciudadana acerca de la inseguridad probablemente ha cambiado después de los sucesos ocurridos desde el mes de abril el año pasado por lo que se debería considerar la opción de repetir la encuesta en los dos repartos en los que ya se ha realizado.

Palabras clave: seguridad ciudadana, analisis descriptivos, encuestas.

References

[1] HERNANDO SANZ, Felipe (2008). La seguridad en las ciudades. El nuevo enfoque de la "geoprevención". Geocrítica en http://www.ub.edu/geocrit/-xcol/413.htm

[2] HERNANDO SANZ, Felipe (coord.) (2007). Atlas de la Seguridad de Madrid. Madrid, Observatorio de la Seguridad, Ayuntamiento de Madrid, 298 p.

[3] HERNANDO SANZ, Felipe. (2006) "Eclecticismo y diversidad e en la geografía del crimen y la delincuencia en el cambio de siglo" en Anales de Geografía de la Universidad Complutense, vol. 26, 2006, Madrid, p. 9-30. nto su seguridad objetiva, como la subjetiva.

A family of the information criteria using the phi-divergence for categorical data[I]

Poster / Cartel

OGASAWARA, HARUHIKO[II]

Japan

The risk of the phi-divergence of a statistical model for categorical data is defined using two independent sets of data. The asymptotic bias of the phi-divergence based on current data as an estimator of the risk is shown to be equal to the negative penalty term of the Akaike information criterion (AIC). Though the higher-order asymptotic bias is derived, the higher-order bias depends on the form of the phi-divergence and the estimation method of parameters using a possible different form of the phi-divergence. An approximation to the higher-order bias is obtained based on the simple result of the saturated model. The information criteria using this approximation yield improved results in simulations for model selection. Some cases of the phi-divergences show advantages over the AIC in simulations.

Keywords: power divergence, risk, model selection, asymptotic bias, Akaike information criterion.

Mathematics Subject Classification (2010): 62F12

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[1] Ogasawara, H. (2019). Asymptotic cumulants of the minimum phi-divergence estimator for categorical data under possible model misspecification. Communications in Statistics - Theory and Methods (online published).

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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Branching processes in random environment[I]

Plenary Talk / Conferencia Plenaria

PALAU, SANDRA[II]

México

In this talk we are going to study branching processes and its extension when the offspring distribution is changing over time. We are going to analice the extinction probability, its asymptotic behaviour and, finally the process conditioned on survival.

Keywords: branching processes, offspring distribution, asymptotic behaviour.

[I] Miércoles/Wednesday 26, 11:15 - 12:00, Auditorium / Auditorio, session: (conf3), Plenary Talk 3

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Automatic visualization of the variables of a data set[I]

Visualización automática de las variables de un conjunto de datos

Poster / Cartel

PASQUIER JARAMILLO, CARLOS[II]

Costa Rica

Currently, data visualization tools can generate good visualizations of the data, however, these visualizations are subject to the user's decisions about which visualization gives a better representation of the data. Therefore, is important to find a way to generates the best visualizations automatically. So, I propose a tool that can automatically generate the best possible visualization of data set variables, using advanced machine learning predictive tools, specifically, using decision tree models.

Keywords: data visualization,learning (artificial intelligence),pattern classification.

Resumen

Actualmente, las herramientas de visualización de datos pueden generar buenas visualizaciones de los datos, sin embargo, estas visualizaciones están sujetas a las decisiones del usuario sobre qué visualización proporciona una mejor representación de los datos. Por lo tanto, es importante encontrar una manera de generar las mejores visualizaciones automáticamente. Por lo tanto, propongo una herramienta que pueda generar automáticamente la mejor visualización posible de las variables del conjunto de datos, utilizando herramientas predictivas avanzadas de aprendizaje automático, específicamente, utilizando modelos de árbol de decisión.

Palabras clave: visualización de datos ,aprendizaje (inteligencia artificial) , clasificación de patrones

References

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[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (Poster), Poster/Carteles

[II] Universidad de Costa Rica, Matemática, San José, Costa Rica, capasquierj@hotmail.com

The underlying topology of data[I]

Plenary Talk / Conferencia Plenaria

PEREA, JOSÉ[II]

Estados Unidos

Topology, and particularly algebraic topology, seeks to develop computable invariants that describe the overall shape of abstract spaces. This talk will be about how such invariants can be used to analyze scientific data sets. I will use several examples to illustrate real applications of these ideas.

Keywords: Topology, algebraic topology, computable invariants.

[I]Viernes/Friday 28, 11:15 - 12:00, Auditorium / Auditorio, session: (conf5), Plenary Talk 5

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Qualitative properties of solutions of Partial Differential Equations[I]

Propiedades cualitativas de soluciones de ecuaciones diferenciales parciales

Short course / Curso corto

RAGUSA, MARIA ALESSANDRA[II]

Italia

Aim of this course is to study the action of some integral operators, useful to obtain regularity properties of solutions of partial differential equations having discontinuous coefficients.

The mini course consists of 2 parts:

The first:

08:00 09:30: "Developing in silico trials to fight Tubercolosis- H2020 STriTuVaD Project"

and the second part:

09:50-11:10: "Qualitative properties of solutions of Partial Differential Equations".

Keywords: Partial Differential Equations, Existence, Uniqueness and Regularity results, Discontinuous coefficients.

Mathematics Subject Classification (2010): 35J05, 35J25, 49N60, 58E20

Resumen

El objetivo de este curso es estudiar la acción de alguna integral operadores, útiles para obtener propiedades de regularidad de soluciones de ecuaciones diferenciales parciales que tienen discontinuas coeficientes.

El mini curso consta de 2 partes:

La primera:

08:00 09:30: "Desarrollo de ensayos en sílice para combatir la tubercolosis - Proyecto STriTuVaD H2020"

y la segunda parte:

09: 50-11: 10: "Propiedades cualitativas de soluciones de ecuaciones diferenciales parciales".

Palabras clave: Ecuaciones diferenciales parciales, resultados de existencia, unicidad y regularidad, coeficientes discontinuo.

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[2] Maria Alessandra Ragusa and Christopher Goodrich Holder continuity of weak solutions of p- Laplacian PDEs with VMO coefficients, Nonlinear Analysis, 185, 336- 355, (2019).

[I] Miércoles/Wednesday 26, 08:00 - 11:20, Room/aula 1, session: (Tut-2), Tutorial 2

[II] University of Catania, Mathematics and Computer Science, Catania, Italia, maragusa@dmi.unict.it

[3] Vagif Guliyev, Ramin Guliyev, Maria Alessandra Ragusa, Mehriben Omarova, Schrodinger type operators on local generalized Morrey spaces related to certain nonnegative potentials, Discrete and Continuous Dynamical Systems - B 25 (2), (2020).

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Dynamic Longitudinal Models for Criminological Panel Data[I]

Modelos longitudinales dinámicos para datos de panel criminológico

Communication / Ponencia

REINECKE, JOST[II] Erdmann, Anke[III]

Germany

The relationship between victims and offenders have been studied in various ways with longitudinal panel data. Previous analyses based on latent growth and cross-lagged panel models pointed out that the developments of victimization and offending are parallel processes that expose similar stability and mutual influence over the period of adolescence and early adulthood (Erdmann & Reinecke, 2018, 2019).

The statistical analysis will show the treatment of the panel data using multivariate statistical techniques with (1) models assuming discrete time as well as (2) models assuming continuous time. An example for the first type (1) is the so-called random intercept cross-lagged panel model that separates the within-person process from stable between-person differences via the inclusion of random intercepts (Hamaker et al., 2015). An example from the second type (2) is the so-called stochastic differential equation model outlined and discussed in Montford, Oud & Voelkle (2018).

Seven consecutive waves of the panel study "'Crime in the Modern City"' are used (Boers et al., 2010) for the present analyses, which contain information about German adolescents from the age of 14 to 20 years.

In this paper model results are presented using the software M*plus* (Muthén & Muthén, 1998-2017) and the R-module `ctsem` (Driver, Oud & Voelkle, 2017).

Keywords: Multivariate Statistics, Discrete Time, Continuous Time, Structural Equation Model, Stochastic Differential Equation Model.

Mathematics Subject Classification (2010): 62, 62H12, 62H15.

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[I] Miércoles/Wednesday 26, 04:50 - 05:10, Room/aula 1, session: (Mst1-2), Multivariate Statistics / Estadística Multivariada

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[III] University of Bielefeld, Bielefeld, Germany, Anke.Erdmann@uni-bielefeld.de

[4] Erdmann, A. & Reinecke, J. (2019). What Influences the Victimization of High-Level Offenders? A Dual Trajectory Analysis of the Victim-Offender Overlap From the Perspective of Routine Activities With Peer Groups. Journal of Interpersonal Violence, DOI: 10.1177/0886260519854556 (Online first).

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Automated stenosis detection in X-ray coronary angiograms[I]

Communication / Ponencia

REYES FIGUEROA, ALAN GERARDO[II] Sánchez-Cervantes, Fernando[III]

México

We propose a framework for stenosis detection in X-ray coronary angiograms. Our detector uses a convolutional neural network (CNN) as model. The approach builds upon the hypothesis that the stenosis detection on real images can be learned from synthetic data, if enough pairs of ideal examples are provided.

In a first stage, we produce synthetic images, in which the vessel structure are approximated by cubic Bézier curves. The synthetic images are filled with background and illumination changes similar to real X-ray angiogram data. Subsequently, we train a typical CNN architecture to extract important features over images and the inferential detection process.

We conducted experiments over 15 real coronary angiograms. The inference process is done locally, using a sliding window scheme. Our results indicate that the detection methodology is promising if both image and vessel segmentation mask are given. Significant limitations were found due to changes in illumination and the presence of medical artefacts.

Keywords: Medical imaging, automated medical assistance, computer vision, neural networks, detection algorithms.

Mathematics Subject Classification (2010): 62P10, 68T10, 68T45, 68U10, 62H35

References

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[3] M. Zreik, R. W. van Hamersvelt, J. M. Wolterink, T. Leiner, M. A. Viergever, and I. Igum (2019). "A recurrent CNN for automatic detection and classification of coronary artery plaque and stenosis in coronary CT angiography", *IEEE Transactions on Medical Imaging* 38(7):1588–1598.

[I] Martes/Tuesday 25, 03:45 - 04:05, Auditorium / Auditorio, session: (Apl2-3), Applications / Aplicaciones 2

[II] CIMAT, Cómputo Matemático, Guanajuato, México, agreyes@cimat.mx

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Fibonacci n-Recurring Numbers.[I]

Números de Fibonacci n-Recurrentes.

Communication / Ponencia

RICO ACEVEDO, CARLOS ALIRIO[II]

Brazil

Let $(F_n)_{n\geq 0}$ be the Fibonacci sequence given by the recurrence $F_{n+2} = F_{n+1} + F_n$, for $n \geq 0$, where $F_0 = 0$ and $F_1 = 1$.There are several generalizations of this sequence and also several interesting identities. We extends this concept for functions $F(\mathbf{x} + 2I_n) = F(\mathbf{x} + I_n) + F(\mathbf{x})$ for $\mathbf{x} \in \mathbb{N}^n$ and I_n is n-tuples where the entries are all one, called *Fibonacci n-recurring numbers.* We start with case $n = 2$, for which establised the initial conditions whit Fibobacci numbres, and this called *double-recurrence Fibonacci numbers* [1]. Furthermore, We investigate the case when initial conditions are second-order linear homogeneous recurrence and exhibit a formula to calculate the values of this double recurrence, only in terms of Fibonacci numbers. Then, we determine some properties and relations, which are extended to any integer n>0. On the other hand, we determine the relation between Hosoya triangle [5], the complete binary Fibonacci trees cite [A178523] oeis and Harman Fibonacci numbers [3].

Keywords: Fibonacci Numbers, Recurrence Sequences, Harman Numbers.

Mathematics Subject Classification (2010): 11B39, 11J86

Resumen

Sea $(F_n)_{n\geq 0}$ la sucessión de Fibonacci dada por la recurrencia $F_{n+2} = F_{n+1} + F_n$, para $n \geq 0$, donde $F_0 = 0$ y $F_1 = 1$. Existen diversas e interesantes generalizaciones de esta sucesión. En este documento, se extiende esta idea a funciones de la forma $F(\mathbf{x} + 2I_n) = F(\mathbf{x} + I_n) + F(\mathbf{x})$ para $\mathbf{x} \in \mathbb{N}^n$ e I_n la n-úpla donde las entradas son todas uno, llamadas *Números de Fibonacci n-recurrentes.* Se muestra inicialmente el caso para $n = 2$, donde se establece la forma de las condiciones iniciales a partir de sucesiones de números de Fibonnacci, las cuales son llamadas *Doble Fibonacci* [1]. Esta función es generalizada y se estudia el caso cuando las condiciones iniciales son sucesiones recurrentes de segundo grado, exibiendo una forma de calcular sus valores solo en terminos de números de Fibonacci. Despues, se determinan algunas propiedades y relaciones las cuales son extendidas para cualquier entero $n > 0$. Por otra parte se mostrara su relación con el triángulo de Hosoya [5], los arboles de Fibonacci binarios completos [2, A178523],y se hace diferencia con los Números de Fibonacci Complejos de Harman [3].

Palabras clave: Números de Fibonacci, Sucesiones Recurrentes, Números de Harman.

[I] Martes/Tuesday 25, 04:50 - 05:10, Auditorium / Auditorio, session: (Num1-2), Numerical Analysis / Análisis Numérico 1

[II] Universidade De Brasilia, Matemática, Brasilia, Brasil, alirio@mat.unb.br

References

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[5] Hosoya H.,Fibonacci Triangle, The Fibonacci Quaterly 2 (2),173-178, 1976.

Stochastic Optimal Control of a Two-Level Quantum System: A numerical approach[I]

Communication / Ponencia

ROMEO MELÉNDEZ, CUTBERTO[II] González Santos, Leopoldo[III]
Castillo Fernandez, David[IV]

México

We study the control of the stochastic evolution of a two-level quan- tum system in the presence of two electromagnetic random pulses, modeled by a Wiener process. The evolution of this system is determined by the stochas- tic Schrödinger equation dependent on time.

We set up the quantum optimal control problem by choosing a functional cost of Bolza type. By applying the Pontryagin Maximum Stochastic Principle to an extended Hamiltonian we ob- tain the stochastic optimal controls, in terms of the co-state. We propose an iterative algorithm to solve numerically the corresponding stochastic differential equations using the Euler-Maruyama method and we obtain the optimal trajec- tories on the Bloch sphere. Finally, we investigate a type of stochastic stability of numerical simulations and his relation with the stability of the correspond- ing stochastic differential equation, namely the moment exponential stability. We prove that the numerical scheme used is p-moment exponentially stable, for $p \in [0, 1]$ and stable for trajectories.

Keywords: Stochastic Optimal Control, Pontryagin Maximum Stochastic Principle, Euler-Maruyama method.

Mathematics Subject Classification (2010): 49

Resumen

Se estudia el problema de controlar la evolución estocástica de un sistema cuántico de dos niveles en presencia de dos pulsos electromagnéticos aleatorios modelados por procesos de Wiener. La evolución de este sistema está determinada por la ecuación de Schrodinger estocástica dependiente del tiempo.

Se establece el problema de control optimo cuántico eligiendo un costo funcional del tipo Bolza y se aplica el Principio del Máximo Estocástico de Pontryagin a un Hamiltoniano extendido para obtener los controles óptimos en términos del vector adjunto correspondiente. Se propone un algoritmo iterativo para resolver numéricamente las ecuaciones del proceso estocástico obtenido, utilizando el método de Euler-Maruyama y se proyectan en la esfera de Bloch las trayectorias correspondientes a los controles óptimos. Finalmente, investigamos un tipo de estabilidad estocástica del esquema numérico y su relación con la estabilidad de la correspondiente ecuación deiferencial estocástica, específicamente se prueba que el esquema numérico utilizado es exponencialmente estable en p-momentos, para p en [0,1] y es estable por trayectorias.

Palabras clave: Control Optimal Estocástico, Principio del Máximo Estocástico de Pontryagin, Método de Euler-Maruyama.

[I] Miércoles/Wednesday 26, 03:45 - 04:05, Room/aula 1, session: (Prob1-3), Invited session: Probability 2

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[III] Universidad Nacional Autónoma de México, Ciudad de México,México, lgs@unam.mx

[IV] Universidad Autónoma Metropolitana-Azcapotzalco, Ciudad de México, México, david_castillo_2004@yahoo.com.mx

References

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Genetic programming to obtain mathematical models from turbine data using symbolic regression[I]

Poster / Cartel

ROMERO PICHARDO, ERICK JACOB[II]

México

This document describes how to find a mathematical model from data of turbines using genetic programming, particularly is explained how symbolic regression was used to obtain the model.

Keywords: Genetic programming, symbolic regression.

Mathematics Subject Classification (2010): 68U99

References

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[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

[II] Centro de Investigación De Matemáticas, Modelación y Optimización, Metepec, México, erickjacobrp@gmail.com

A geometric splitting theorem[I]

Un teorema de división geométrica

Communication / Ponencia

ROSALES-ORTEGA, JOSÉ[II]

Costa Rica

Let $G = G_1 \cdots G_l$ be a connected noncompact semisimple Lie group with Lie algebra $\mathfrak{g}_1 \oplus \mathfrak{g}_2 \oplus \cdots \oplus \mathfrak{g}_l$ acting topologically transitive on a manifold M. We obtain a geometric splitting of the metric on M that consider metrics on each G_i. Also we obtained a result about the isometry group of the manifold $G \times \tilde{N}$, where $\tilde{N}$ is the universal covering of a leaf N of the normal foliation to the G-orbits.

Keywords: semisimple Lie groups, bi-invariant metric, local freeness.

Mathematics Subject Classification (2010): 22, 53

Resumen

Se $G = G_1 \cdots G_l$ un grupo de Lie conexo no compacto semisimple con álgebra de Lie algebra $\mathfrak{g}_1 \oplus \mathfrak{g}_2 \oplus \cdots \oplus \mathfrak{g}_l$ actuando de forma topologicamente transitiva sobre una variedad M. Obtenemos un teorema de división geométrica sobre la variedad M que considera una métrica sobre cada G_i. También obtenemos un teorema sobre el grupo de isometrías de $G \times \tilde{N}$, donde $\tilde{N}$es la cubierta universal de una hoja N de la foliación normal a las G-órbitas.

Palabras clave: grupos de Lie semisimples, métrica bi invariante, acción localmente libre.

References

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[2] P. Petersen, *Riemannian Geometry*, Springer, New York, 2016.

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[4] J. Rosales-Ortega, *Foliations by G-actions*. Bol. Soc. Paran. Mat. (3s.) **v. 33** 2 (2015): pp. 79-87.

[I] Viernes/Friday 28, 10:00 - 10:40, Room/aula 2, session: (GT2-1), Geometry and Topology / Geometría y Topología 2

[II] UCR-ITCR, Escuela de Matemática, San José-Cartago, Costa Rica, rosalesortega@gmail.com

Parameter estimates of the 2016-2017 Zika outbreak in Costa Rica: An Approximate Bayesian Computation (ABC) approach[I]

Communication / Ponencia

SÁNCHEZ, FABIO[II] Vásquez, Paola[III] Barboza, Luis[IV]

Costa Rica

In Costa Rica, the first known cases of Zika were reported in 2016. We looked at the 2016-2017 Zika outbreak and explored the transmission dynamics using weekly reported data. A nonlinear differential equation single-outbreak model with sexual transmission, as well as host availability for vector-feeding was used to estimate key parameters, fit the data and compute the *basic reproductive number*, $\mathcal{R}_0$, distribution. Furthermore, a sensitivity and elasticity analysis was computed based on the $\mathcal{R}_0$ parameters.

Keywords: Zika virus, basic reproductive number, Approximate Bayesian Computation, public health, epidemic models.

Mathematics Subject Classification (2010): 92B05, 92D25

References

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[I] Miércoles/Wednesday 26, 04:50 - 05:10, Auditorium / Auditorio, session: (Bio2-2), Biomathematics / Biomatemáticas 2

[II] Universidad de Costa Rica, Escuela de Matemática, San Jose, Costa Rica, fabio.sanchez@ucr.ac.cr

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E-infinity Structures in L-Algebras[I]

Estructuras E-Infinito en L-Álgebras

Communication / Ponencia

SÁNCHEZ GUEVARA, JESÚS[II]

Costa Rica

$\mathcal{L}$-algebras are intended as algebraic models for homotopy types. $\mathcal{L}$-algebras were introduced by Alain Prouté in several talks since the eighties. In this talk we will describe an E_∞-coalgebra structure on the main element of an $\mathcal{L}$-algebra, which is inspired by a similar structure on chain complexes studied in detail by (Smith, Operads and algebraic homotopy, 2000). Our E_∞-coalgebra structure shows that the canonical $\mathcal{L}$-algebra of spaces contains as much homotopy information as the E_∞-coalgebras usually associated to these spaces.

Keywords: L-Algebra, Operads, Homotopy, E_∞-coalgebra.

Mathematics Subject Classification (2010): Algebraic topology

References

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[I] Viernes/Friday 28, 10:40 - 11:20, Room/aula 2, session: (GT2-2), Geometry and Topology / Geometría y Topología 2

[II] Universidad de Costa Rica, Matemáticas, San Pedro, Costa Rica, jesus.sanchez_g@ucr.ac.cr

Predictive Modelling of Losses in non-life insurance[I]

Modelación predictiva de siniestros en seguros de no vida

Communication / Ponencia

SANDÍ CORRALES, ANA ROSA[II]

Costa Rica

Non-life insurance pricing has been inclined to define premiums for homogeneous risk groups. The most common estimation techniques in the past were of the univariate type, which have limitations when there is little information and in terms of omitting the correlation that exists with possible predictive variables. Four types of multivariate models were chosen to estimate claims of an accident and health insurance: ordinary linear, generalized linear, additive and mixed linear. The latter was also analysed from a Bayesian perspective. To achieve a better ?t, a logarithmic transformation of the response variable was required, implying that the modelling should focus on the positive observations of the losses. Performance is analysed both within the sample and in subsequent years, proving to be quite effective despite having different approaches.

Keywords: insurance, pricing, predictive modelling, linear models, additive models, mixed models, Bayesian models, software R.

Mathematics Subject Classification (2010): 62P05

Resumen

La tari?cación de los seguros de no vida se ha inclinado por de?nir primas para grupos de riesgo homogéneos. Las técnicas de estimaciónmás comunes en el pasado fueron de tipo univariado, que tienen limitantes cuando hay poca información y en cuanto a que omiten la correlación que existe con posibles variables predictoras. Se escogieron cuatro tipos de modelos multivariados para estimar los siniestros un seguro de accidentes y salud: lineales ordinarios, lineales generalizados, aditivos y lineales mixtos. El último se analizó adicionalmente desde una perspectiva bayesiana. Para lograr un mejor ajuste, se requirió hacer una transformación logarítmica de la variable respuesta, implicando que la modelación se centrara en las observaciones positivas de los reclamos. Se analizó el desempeño tanto dentro de la muestra como en años consecutivos, resultando ser bastante efectivos a pesar de tener diferentes planteamientos.

Palabras clave: Seguros, tarificación, modelación predictiva, modelos lineales, modelos aditivos, modelos mixtos, modelos bayesianos, paquete estadístico R.

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[I] Viernes/Friday 28, 02:00 - 02:20, Auditorium / Auditorio, session: (SI04-1), Invited session: Banca 1

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Geographic information system for territorial development and mobility in Costa Rica, 2019[I]

Sistema de información geográfico para el desarrollo territorial y la movilidad en Costa Rica, 2019

Poster / Cartel

SANTAMARÍA GUZMÁN, PATRICK[II]

Costa Rica

Costa Rica faces challenges to implement an efficient territorial development model, as this is currently insufficient to provide a good quality of life for all its inhabitants. The main causes are the centralization of productive activities and human settlements. Part of all the dimensions that territorial development includes, is the planification of urban and rural mobility: one of the main concerns in Costa Rica due to the problems with traffic congestion. This project proposes strategies for the creation of public policies, using a geographic information system with sociodemographic indicators and information related to the characterization of transport and mobility of the country, evidencing traffic congestion problems and conformation of the country's road structure at the spatial level. In addition, it provides a tool for analysis of territorial conglomerates in the economic, demographic, social dimensions, among others; since they are necessary to execute the plans in all the territories and establish similar characteristics between them.

Keywords: territorial, movility, road, congestion, urban.

Resumen

Costa Rica enfrenta dificultades para implementar un modelo de desarrollo territorial eficiente, pues actualmente este es insuficiente para brindar una buena calidad de vida a todos sus habitantes; entre las principales causas se encuentran la centralización de las actividades productivas y de asentamientos humanos. Desde las múltiples dimensiones que engloba el desarrollo territorial, se encuentra la planeación de la movilidad urbana y rural, una de las mayores preocupaciones en Costa Rica debido a los grandes problemas de congestionamiento vial. Este proyecto establece insumos para la creación de políticas públicas, a través de un sistema de información geográfico con indicadores sociodemográficos e información referente a la caracterización del transporte y la movilidad del país, evidenciando problemas de congestionamiento vial y conformación de la estructura vial del país a nivel espacial. Además, proporciona una herramienta de análisis de conglomerados territoriales en dimensiones económicas, demográficas, sociales, entre otras; esto como insumo para establecer planes de acción en los territorios, basados en características comunes presentes en los mismos.

Palabras clave: territorial, movilidad, vial, congestión, urbana.

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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Just Society: A Decision Theoretic Foundation[I]

Communication / Ponencia

SARIN, RAKESH[II]

USA

In this paper, I will provide foundations of a just society using decision theory perspective. I will compare the approach with Utilitarian Theory and Rawls' Theory of Justice.

Keywords: probability, decision theory, utility, ambiguity.

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[I] Martes/Tuesday 25, 04:50 - 05:10, Room/aula 1, session: (OR2-2), Operations Research / Investigación de Operaciones 2

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Geometry of complex numbers[I]

Geometría de números complejos

Short course / Curso corto

SBITNEVA, LARISSA[II]

México

In this minicourse the participants will familiarise with some new ideas of using complex numbers and the matrix algebra with beneits which they provide to descover the geometries beyond the euclidian geometry.

Keywords: Complex plane, Pencils of circles, Stereographic projection, Transformations.

Mathematics Subject Classification (2010): 51M05

Resumen

En este minicurso los participantes se familiarizarán con ideas nuevas del uso de los números complejos, con el aparato algebraico de matrices y con los beneficios que ellos traen para descubrir las geometrías más allá de la geometría euclidiana.

Palabras clave: Plano Complejo, Haz de círculos, Proyección estereográfica, Transformaciones.

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[1] H. Schwerdtfeger, Geometry of Complex Numbers, Circle Geometry, Moebius Transformation, Non-Euclidean Geometry, Dover Publications Inc. US New York.1979.

[I] Jueves/Thursday 27, 08:00 - 11:20, Auditorium / Auditorio, session: (Tut-8), Tutorial 8

[II] Universidad Autónoma del Estado de Morelos, Centro de Investigaciones en Ciencias, Cuernavaca, México, larissa@uaem.mx

Lie methods for smooth loops: The matrix form for the solution of the differential equations for some variety of Bol loops[I]

Métodos de Lie para lazos suaves: Forma matricial para la solución de ecuaciones diferenciales para una clase de lazos de Bol

Communication / Ponencia

SBITNEVA, LARISSA[II]

México

The methods of investigations of the continuous transformation groups, based on the differential equations and their integrability conditions, had been created by Sophus Lie y permitted the development of the infinitesimal theory, which was turned into the theory of Lie groups and Lie algebras, later on.

This approach being applied to smooth loops has permitted the development of the infinitesimal theory of smooth loops generalizing the Lie group theory, since any loop with the associativity property for its binary operation is a group.

We give a brief review of the theorems, analogues to the three Lie theorems, for smooth Bol loops and demonstrate how we obtain the solution of the differential equation for the functions which express the binary operation in the explicit form for some special variety of Bol loops The left Bol loops with the automorphic inverse property are well known as the left Bruck loops in the theory of nonassociative algebraic structures where they are also called as K-loops, as well, the corresponding nonassociative algebraic structures have been found in applications to Special Relativity, as the construction of gyrogroups (here the gyrocommutative property of a gyrogroup represents an explicit form of the Bruck identity).

The smooth left Bol loops satisfying the Bruck identity play important role in the theory of symmetric spaces of E. Cartan, both identities being the characteristic for any smooth loop to be a geodesic loop of the affine connection for such spaces. Thus the symmetric spaces provide an adequate geometric setting for gyrocommutative gyrogroups.

In our presentation we deal, in particular, with the dual construction of smooth right Bol loops.

Being smooth right Bol loops they admit the application of the general theory of Smooth Bol loops-Bol algebas, presented in Chapter 5 of the monograph Smooth Quasigroups and Loops (by L. Sabinin, Kluwer Academic Publishers, 1999).

Analyzing the integrability conditions for the differential equations of an arbitrary smooth right Bol loop we obtain the matrix form of the corresponding differential equations on the structure functions (an analog of the structure constants).

For the case of smooth right Bruck loops and due to another specification of the characteristic conditions on the right Bol Algebra, it is shown how the explicit expression for the structure functions can be presented in the form of series of hyperbolic functions. After some calculations the left vector fields can be expressed in matrix form. Then, according to an analog of the Lie's third inverse theorem for Bol algebras the existence and uniqueness of the law of composition is established.

[I] Martes/Tuesday 25, 03:05 - 03:25, Room/aula 1, session: (Deq2-1), Differential Equations / Ecuaciones Diferenciales 2

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Keywords: differential equations, integrability conditions, Lie theorems, smooth Bol loops, gyrocommutative gyrogroups.

Mathematics Subject Classification (2010): 20N05, 53C35, 53C22, 22A30, 83A05

Resumen

Los métodos para el estudio de grupos de transformaciones continuos, basados en las ecuaciones diferenciales y sus condiciones de integrabilidad, fueron creados por Sophus Lie y permitieron desarrollar la teoría infinitesimal, lo que luego se convirtió en la teoría de grupos y algebras de Lie. Los métodos análogos han sido aplicados al estudio de lazos suaves, pues, un lazo suave con la operación binaria asociativa es un grupo.

Presentamos una breve exposición de los teoremas, análogas a los tres teoremas de Lie, para los lazos suaves de Bol, y se reconstruye la solución de ecuación diferencial para las funciones coordenadas de la operación binaria en la forma explícita para una clase especial de lazos de Bol.

Los lazos izquierdos de Bol con la propiedad automorfa inversa son conocidos como lazos de Bruck en la teoría de estructuras algebraicas no asociativas, los llaman también como K-lazos. Además estas estructuras algebraicas han sido encontradas en las aplicaciones a la Teoría de Relatividad Especial, correspondiendo a los gyrgrupos (mostramos que la propiedad de gyroconmutatividad representa explícitamente la identidad de Bruck).

Los lazos suaves con las identidades de Bol izquierdo y de Bruck juegan papel importante en la teoría de espacios simétricos de Elie Cartan, siendo ambas identidades características para cualquier lazo suave servir como un lazo geodésico de conexión afín de dichos espacios geométricos.

Así, la geometría subyacente de los gyrogrupos gyroconmutativos es la geometría de los espacios simétricos.

Nosotros enfocamos, en particular, en la construcción dual de lazos suave con la identidad de Bol derecha.

Siendo lazos de Bol derechos, estos lazos admiten la aplicación de la teoría general de los lazos suaves de Bol y álgebras correspondientes de Bol, presentado en el Capítulo 5 de la Monografía Smooth quasigroups and loops (L. Sabinin, Kluver Academic Publishers, 1999).

Analizando las condiciones de integrabilidad para las ecuaciones diferenciales de un lazo arbitrario suave con la propiedad de Bol derecha, obtenemos la forma matricial para la solución correspondiente a la ecuación diferencial de las coordenadas de funciones estructurales (un análogo de constantes estructurales de álgebra de Lie).

Para el caso de los lazos suaves de Bol derecho y Bruck así como para otras condiciones específicas sobre sobre el álgebra de Bol, demostramos cómo las funciones estructurales pueden ser expresadas en la forma explícita por medio de funciones hiperbólicas.

Con los cálculos se puede expresar los campos vectoriales izquierdos, lo que permite aplicar el tercer teorema inverso de Lie para los lazos de Bol, estableciendo la existencia y unicidad de la ley de composición del lazo.

Palabras clave: ecuaciones diferenciales, condiciones de integrabilidad, teoremas de Lie, lazos suaves de Bol, gyrogrupos gyroconmutativos.

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Relative Geometric Invariant Theory[I]

Communication / Ponencia

SCHMITT, ALEXANDER[II]

Germany

Given the action of a (reductive affine algebraic) group G on a quasi-projective algebraic variety X, it is quite a subtle task to form the quotient as an algebraic variety. Based on Hilbert's groundbreaking work on invariant theory, Mumford devised a theory for finding G-invariant open subsets in X for which the quotient does exist. The elements in that open subset are called the semistable points. Mumford's theory has important applications to the construction of moduli spaces. Even if one uses other methods for constructing quotients or moduli spaces, e.g., stacks, the notion of semistability is often of great interest. Relative geometric invariant theory starts with a G-equivariant projective morphism f:X->Y between quasi-projective varieties on which G acts and seeks to construct quotients V, W of suitable G-invariant open subsets of X and Y, respectively, such that f induces a morphism g:V->W. We will survey results of Reichstein, Gulbrandsen, Halle, Hulek, and Zhang on this topic as well as simplifications and additions by the speaker.

Keywords: Group action, categorical quotient, semistable point, equivariant projective morphism.

Mathematics Subject Classification (2010): 14L24

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[4] Schmitt, Alexander H. W.: Semistability and instability in products and applications. String-Math 2014, 201-214, Proc. Sympos. Pure Math., 93, Amer. Math. Soc., Providence, RI, 2016.

[5] Schmitt, Alexander H. W.: A remark on relative geometric invariant theory for quasi-projective varieties. Math. Nachr. 292 (2019), no. 2, 428-435.

[I] Jueves/Thursday 27, 10:40 - 11:20, Room/aula 2, session: (GT1-2), Geometry and Topology / Geometría y Topología 1

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A mixed virtual element method for the Boussinesq problem on polygonal meshes[I]

Invited Session / Sesión invitada

SEQUEIRA, FILÁNDER A.[II] Gatica, Gabriel N.[III] Munar, Mauricio[IV]

Chile, Costa Rica

In this work we introduce and analyze a mixed virtual element method (mixed-VEM) for the two-dimensional stationary Boussinesq problem. The continuous formulation is based on the introduction of a pseudostress tensor depending nonlinearly on the velocity, which allows to obtain an equivalent model in which the main unknowns are given by the aforementioned pseudostress tensor, the velocity and the temperature, whereas the pressure is computed via a postprocessing formula. In addition, an augmented approach together with a fixed point strategy is used to analyze the well-posedness of the resulting continuous formulation. Regarding the discrete problem, we follow the approach employed in a previous work dealing with the Navier-Stokes equations, and couple it with a VEM for the convection-diffusion equation modelling the temperature. More precisely, we use a mixed-VEM for the scheme associated with the fluid equations in such a way that the pseudostress and the velocity are approximated on virtual element subspaces of $\mathbb{H}(\mathrm{div})$ and $\mathbf{H}^1$, respectively, whereas a VEM is proposed to approximate the temperature on a virtual element subspace of H^1. In this way, we make use of the L^2-orthogonal projectors onto suitable polynomial spaces, which allows the explicit integration of the terms that appear in the bilinear and trilinear forms involved in the scheme for the fluid equations. On the other hand, in order to manipulate the bilinear form associated to the heat equations, we define a suitable projector onto a space of polynomials to deal with the fact that the diffusion tensor, which represents the thermal conductivity, is variable. Next, the corresponding solvability analysis is performed using again appropriate fixed-point arguments. Further, Strang-type estimates are applied to derive the *a priori* error estimates for the components of the virtual element solution as well as for the fully computable projections of them and the postprocessed pressure. Finally, the corresponding rates of convergence are also established.

Keywords: Boussinesq problem, pseudostress-based formulation, augmented formulation, mixed virtual element method, high-order approximations.

Mathematics Subject Classification (2010): 65N30, 65N12, 65N15, 76D07.

[I] Miércoles/Wednesday 26, 03:05 - 03:25, Room/aula 3, session: (SINum2-1), Invited session: Numerical solution of PDEs

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[0] This research was partially supported by CONICYT-Chile through the project AFB170001 of the PIA Program: Concurso Apoyo a Centros Científicos y Tecnológicos de Excelencia con Financiamiento Basal, and the Becas-CONICYT Programme for foreign students; by Centro de Investigación en Ingeniería Matemática (CI^{2}MA), Universidad de Concepción; and by Universidad Nacional, Costa Rica, through the project 0103-18.

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A priori and a posteriori error analysis of an unfitted HDG method for semi-linear elliptic problems[I]

Invited Session / Sesión invitada

SOLANO, MANUEL[II] Sánchez, Nestor[III] Sánchez-Vizuet, Tonatiuh[IV]

Chile, Costa Rica, USA

We present *a priori* and *a posteriori* error analysis of a high order hybridizable discontinuous Galerkin (HDG) method applied to a semi-linear elliptic problem posed on a piecewise curved, non polygonal domain. This problem comes from an application to plasma physics, where the magnetic equilibrium in axisymmetric fusion reactors can be described in terms of the solution of an equation of this type. We approximate Ω by a polygonal subdomain Ω_h and propose an HDG discretization, which is shown to be optimal under mild assumptions related to the non-linear source term and the distance between the boundaries of the polygonal subdomain Ω_h and the true domain Ω. Moreover, a local non-linear post-processing of the scalar unknown is proposed and shown to provide an additional order of convergence. A reliable and locally efficient *a posteriori* error estimator that takes into account the error in the approximation of the boundary data of Ω_h is also provided.

Keywords: Hybridizable discontinuous Galerkin (HDG), curved boundary, semi-linear elliptic equations, a posteriori error estimates.

Mathematics Subject Classification (2010): 65N30, 65N15.

References

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[3] Tonatiuh Sánchez-Vizuet and Manuel E. Solano, *A Hybridizable Discontinuous Galerkin solver for the Grad-Shafranov equation*. Computer Physics Communications, vol. 235, pp 120-132 (2019).

[I] Miércoles/Wednesday 26, 03:25 - 03:45, Room/aula 3, session: (SINum2-2), Invited session: Numerical solution of PDEs

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Local and global boundary rigidity[I]

Plenary Talk / Conferencia Plenaria

STEFANOV, PLAMEN[II]

Estados Unidos

The boundary rigidity problem consist of recovering a Riemannian metric in a domain, up to an isometry, from the distance between boundary points. We show that in dimensions three and higher, knowing the distance near a fixed strictly convex boundary point allows us to reconstruct the metric inside the domain near that point, and that this reconstruction is stable. We also prove semi-global and global results under certain an assumption of the existence of a strictly convex foliation. The problem can be reformulated as a recovery of the metric from the arrival times of waves between boundary points; which is known as travel-time tomography. The interest in this problem is motivated by imaging problems in seismology: to recover the sub-surface structure of the Earth given travel times from the propagation of seismic waves. In oil exploration, the seismic signals are man-made and the problem is local in nature. In particular, we can recover locally the compressional and the shear wave speeds for the elastic Earth model, given local information.

The talk is based on joint work with G.Uhlmann (UW-Seatle) and A.Vasy (Stanford). We will also present results for a recovery of a Lorentzian metric from red shifts motivated by the problem of observing cosmic strings.

Keywords: boundary rigidity problem, Riemannian metric, travel-time tomography.

[I]Martes/Tuesday 25, 10:30 - 11:15, Auditorium / Auditorio, session: (conf1), Opening Plenary Talk / Conferencia Inaugural

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Experimental and numerical dynamic analysis of cantilever beam[I]

Análisis dinámico, experimental y numérico, de una viga en voladizo

Communication / Ponencia

TELIZ BERHOUET, AGUSTIN[II]

Uruguay

Vibrations in structures have been studied for decades and more frequently by numerical analysis. This paper presents the study of vibrations in a cantilever beam through experimental analysis and numerical analysis. For the experimental analysis an accelerometer placed at the end of the beam was used and the accelerations produced in the bar were sampled when a pulse input was applied. The Fast Fourier Transform (FFT) found the frequency spectrum at which the bar oscillates, the fundamental frequency of the system (bar-accelerometer) and the damping coefficient linked to the fundamental frequency. In addition, the first natural frequency analytical calculation was performed, where the difference between the analytical and experimental results amounts to 13.5% (the analytical solution considers the mass of the accelerometer uniformly distributed along the bar). On the other hand, using linear dynamics and the Finite Element Method (FEM) the numerical solution was found imposing the same conditions as in the experiment. From the EMF the bar was discretized into isoparametric triangular elements using quadratic interpolation. For the dynamic analysis, the Newmark Method was implemented, using the Trapeze Method, using the modal decomposition of displacements. The damping matrix was found in such a way that the damping associated with the first mode is equal to that found experimentally. To achieve reliable values, a time step of 1×10^{-7} seconds was proposed, being less than that required in the Centered Differences Method. As a result, the lower natural frequencies found by the MEF, considering the mass of the accelerometer at the free end, differs from that found experimentally by 0.037% and 13.5% of the analytical solution. When the acceleration is found as a function of time for a point at the end of the beam, the solution approximates considerably to the experimental one. In turn, when finding the frequency spectrum by the FFT, the maximum is given in the fundamental frequency, generating a curve similar to the experimental one. The developed computer codes are capable of solving solutions with arbitrary initial conditions. A simple example like a cantilever beam, these analyzes show the great approximation that is achieved from a numerical analysis and the efficiency of working with decomposition modes.

Keywords: Finite Element Method, Dynamic analysis, Newmark Method, Modal decomposition.

Mathematics Subject Classification (2010): 65Zxx

Resumen

Desde hace décadas se estudian las vibraciones en estructuras y con mayor frecuencia mediante análisis numéricos. En este trabajo se presenta el estudio de vibraciones en una viga en voladizo mediante análisis experimental y análisis numérico. Para el análisis experimental se utilizó un acelerómetro colocado en el extremo de la viga y se muestrearon las aceleraciones producidas en la barra al aplicarle una entrada impulso.

[I]Martes/Tuesday 25, 03:25 - 03:45, Auditorium / Auditorio, session: (Apl2-2), Applications / Aplicaciones 2

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Mediante la Fast Fourier Transform (FFT) se halló el espectro de frecuencias a las cuales oscila la probeta, la frecuencia fundamental del sistema (probeta-acelerómetro) y el coeficiente de amortiguamiento vinculado a la frecuencia fundamental. Además, se realizó el cálculo analítico de la primer frecuencia natural, donde la diferencia entre el resultado analítico y el experimental asciende a 13.5% (la solución analítica considera la masa del acelerómetro uniformemente distribuida a lo largo de la barra). Por otra parte, utilizando dinámica lineal y el Método de Elementos Finitos (MEF) se halló la solución numérica imponiendo las mismas condiciones que en el experimento. A partir del MEF la probeta se discretizó en elementos triangulares isoparamétricos utilizando interpolación cuadrática. Para el análisis dinámico se implementó el Método de Newmark, utilizando el Método del Trapecio, realizando la descomposición modal de los desplazamientos. La matriz de amortiguamiento se halló de tal manera que el amortiguamiento asociado al primer modo sea igual al hallado de forma experimental. Para lograr valores confiables se propuso un paso temporal de 1×10^{-7} segundos, siendo menor al requerido en el Método de Diferencias Centradas. Como resultado, la menor de las frecuencias naturales halladas mediante el MEF, considerando la masa del acelerómetro en el extremo libre, difiere de la hallada experimentalmente en un 0.037% y en 13.5% de la solución analítica. Al hallar la aceleración en función del tiempo para un punto en el extremo de la viga, la solución se aproxima considerablemente a la experimental. A su vez, al hallar el espectro de frecuencias mediante la FFT, el máximo se da en la frecuencia fundamental, generando una curva similar a la experimental. Además, los códigos computacionales desarrollados son capaces de resolver soluciones con condiciones iniciales arbitrarias. Siendo un ejemplo simple como una viga en voladizo, estos análisis muestran la gran aproximación que se logra a partir de un análisis numérico y lo eficiente de trabajar con la descomposición en modos.

Palabras clave: Método de elementos finitos, Análisis dinámico, Método de Newmark, Descomposición modal.

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Fractional Newton-Raphson Method and Some Variants for the Solution of Nonlinear Systems[I]

Método de Newton-Raphson Fraccional y Algunas Variantes para la Solución de Sistemas No-lineales

Communication / Ponencia

TORRES HERNANDEZ, ANTHONY[II] Brambila Paz, Fernando[III]

México

In the following work we present some novelty numerical methods valid for one and several variables, which using fractional derivatives, allow to find solutions for some nonlinear systems in the complex space using real initial conditions. The origin of these methods is the fractional Newton-Raphson method, but unlike the latter, the orders of fractional derivatives that we propose in this work are functions.

Keywords: Newton's Method, Fractional Calculus, Fractional Derivative of Riemann-Liouville.

Mathematics Subject Classification (2010): 65H04

Resumen

En el siguiente trabajo se presentan algunos métodos numéricos novedosos validos para una y varias variables, los cuales haciendo uso de la derivada fraccional, permiten encontrar soluciones para algunos sistemas no lineales en el espacio complejo utilizando condiciones iniciales reales. El origen de estos métodos es el método de Newton-Raphson fraccional, pero a diferencia de este último, los ordenes de las derivadas fraccionales que proponen en este trabajo son funciones.

Palabras clave: Método de Newton, Cálculo Fraccional, Derivada Fraccional de Riemann-Liouville.

References

[1] https://arxiv.org/pdf/1710.07634.pdf,

[2] https://arxiv.org/pdf/1804.08445.pdf,

[3] https://arxiv.org/pdf/1908.01453.pdf,

[4] https://www.intechopen.com/books/fractal-analysis-applications-in-physics-engineering-and-technology

[I] Martes/Tuesday 25, 04:30 - 04:50, Auditorium / Auditorio, session: (Num1-1), Numerical Analysis / Análisis Numérico 1

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Applications of Conformal Mapping in Bicomplex Analysis[I]

Aplicaciones del mapeo conforme an Análisis BIcomplejo

Communication / Ponencia

TOVAR SÁNCHEZ, LUIS MANUEL[II]

México

Bicomplex Analysis is an amphibious between Two Complex Variables theory , Classical one Complex Analysis , and Quaternionic Analisis too. The concept of angle between bicomplex curves is defined and also it is possible to define the concept of Conformal Mapping. Then the applications to Physics of that concepts results natural. In this talk I present a cocentrate of the previous subjects and applications

Keywords: Bicomplex Analysis, Conformal Mapping.

Mathematics Subject Classification (2010): 32, 35, 43

Resumen

El Análisis Bicomplejo es un anfibio entre la Teoría de dos Varibles Complejas, la teoría clásica de una Variable Compleja y el Análisis Cuaterniónico. En esta tería es posible definir el ángulo entre curvas bicomplejas y trabajar el concepto de Mapeo Conforme. De donde resulta natural sus aplicaciones a la Física. En esta plática se presenta un concentrado de lo anterior y sus aplicaciones

Palabras clave: Analisis Bicomplejo, Mapeo Conforme.

References

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[I] Martes/Tuesday 25, 03:05 - 03:25, Auditorium / Auditorio, session: (Apl2-1), Applications / Aplicaciones 2

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Caminatas aleatorias con reubicación preferencial y árboles recursivos aleatorios[I]

Invited Session / Sesión invitada

URIBE, GERÓNIMO[II] Mailler, Cécile[III]

México

Considere un proceso estocástico que se comporta como una caminata aleatoria simple y simétrica en dimensión d, excepto que, con una cierta probabilidad fija, en cada paso, elige comportarse distinto al saltar a un sitio dado con una probabilidad proporcional al tiempo que ya pasó allí . Este proceso ha sido analizado en la literatura de física bajo el nombre de “caminata aleatoria con reubicaciones preferenciales”, donde se argumenta que la posición del caminante después de n pasos, escalada por log(n), converge a una variable aleatoria gaussiana. Debido a la escala espacial logarítmica, se dice que el proceso experimenta una "difusión lenta". Hablaremos sobre la prueba rigurosa del teorema del límite central descrito anteriormente al asociar a la caminata una familia creciente de árboles recursivos aleatorios con pesos en los vértices y una cadena de Markov indexada por este árbol.

Palabras clave: Árbol recursivo aleatorio, Caminata aleatoria con memoria, Teorema límite central, Difusión lenta.

[I]Miércoles/Wednesday 26, 02:20 - 02:40, Room/aula 1, session: (SIProb1-2), Invited session: Probability

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R package development workshop[I]

Taller: Crear paquetes R

Short course / Curso corto

VAN DUNNÉ, FRANS[II] Hernández Mora, Ronny[III]

Costa Rica

Being able to share R code in packages is one of the reasons why the statistical language R has had such marked growth. R packages allow any user to extend the functionality of R as they have it installed with additional functions.

There are three characteristics that contribute to the usefulness of R packages. First, once R code is packaged, it can be distributed either privately (for example within a research group or a department in a company) or publicly (for example in central repositories such as CRAN or Bioconductor). Second R packages have a standardized structure that facilitates their creation and also their maintenance. It forces authors to follow best practices that have been developed and refined over the years by thousands of authors. This includes technical documentation along with user documentation, both of which are contained within R. Third, when writing packages it is easier to incorporate automatic tests into the code. In the long term, this is an excellent way to ensure the quality of the code and to be able to work error-free.

With everything and everything, as R packages are easier to socialize (share, work together, read, review) the quality of the code they contain tends to be greater than code in shared scripts. We will start the workshop explaining what an R package is and the benefits of using it. Then we put into practice an example of a generic code which we will take from a script to a package using the tools available to facilitate the process. In this way, we can see in action the ease of use and flexibility of using packages to share code.

More details:

https://docs.google.com/document/d/142aCc2IhRvzFvTXcZQInHEokVxQFZse43a33aoo1a5M/edit?usp=sharing

Keywords: R packages, computational statistics, reproducibility.

Mathematics Subject Classification (2010): 68N01 62-07 62-04

Resumen

El poder compartir código R en paquetes es una de las razones por las cuales el lenguaje estadístico R ha tenido un crecimiento tan marcado. Paquetes R permiten que cualquier usuario puede extender la funcionalidad de R como lo tienen instalado con funciones adicionales.

Hay tres características que contribuyen a la utilidad de los paquetes R. Primero, una vez que código R está empaquetado, se puede distribuir ya sea de forma privada (por ejemplo dentro de un grupo de investigación o una departamento en una empresa) o de forma pública (por ejemplo en repositorios centrales como el CRAN o Bioconductor).

[I] Jueves/Thursday 27, 08:00 - 11:20, Laboratory, session: (Tut-3), Tutorial 3

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Segundo paquetes R tienen una estructura estandarizada lo que facilita su creación y también su mantenimiento. Obliga a autores a seguir mejores prácticas que se han desarrollado y refinado durante años por miles de autores. Esto incluye documentación técnica a la par de documentación para usuarios, las cuales ambas están contenidas dentro de un paquete R. Tercero, al escribir paquetes es más fácil incorporar pruebas automáticas al código. Esto a largo plazo es una excelente forma de asegurar la calidad del código, y poder trabajar libre de errores.

Con todo y todo, como paquetes R son más fáciles de socializar (compartir, trabajar juntos, leer, revisar) la calidad del código que contienen tiende a ser mayor que código en scripts compartidos. Arrancamos el taller explicando qué es un paquete R los beneficios de utilizarlo. Después lo llevamos a la práctica un ejemplo de código genérico el cual vamos a llevar de un script a un paquete usando las herramientas disponibles para facilitar el proceso. De esta manera podremos ver en acción la facilidad de uso y flexibilidad de usar paquetes para compartir código.

Más detalles:
https://docs.google.com/document/d/142aCc2IhRvzFvTXcZQInHEokVxQFZse43a33aoo1a5M/edit?usp=sharing

Palabras clave: Paquetes R, estadística computacional, reproducibilidad.

Climate-Driven Statistical Models as effective predictors of local dengue incidence in Costa Rica[I]

Variables climáticas como predictores de la incidencia de dengue en Costa Rica

Poster / Cartel

VÁSQUEZ BRENES, PAOLA[II] Loría, Antonio[III] Sanchez, Fabio[IV] Barboza, Luis[V]

Costa Rica

Climate has been an important factor in shaping the distribution and incidence of dengue cases in tropical and subtropical countries. In Costa Rica, a tropical country with distinctive micro-climates, dengue has been endemic since its introduction in 1993, inflicting substantial economic, social, and public health repercussions. Using the number of dengue reported cases and climate data from 2007-2017, we fitted a prediction model applying a Generalized Additive Model (GAM) and Random Forest (RF) approach, which allowed us to retrospectively predict the relative risk of dengue in five climatological diverse municipalities around the country.

Keywords: Mosquito-borne diseases, dengue, climate variables, generalized additive models, random forest.

References

[1] P.Vásquez, A.Loría, F. Sanchez, L.A.Barboza, Climate-driven statistical models as effective predictors of local dengue incidence in Costa Rica: A generalized additive model and random forest approach, Revista de Matemática: Teoría y Aplicaciones, 27(2020), 1-21, DOI 10.15517/rmta.v27i1.39931.

[I] Miércoles/Wednesday 26, 05:30 - 06:30, Pasillo / Hall, session: (poster), Poster/Carteles

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On Approximately Cyclic Model Order Reduction for Data-Driven Systems[I]

Communication / Ponencia

VIDES ROMERO, FREDY ANTONIO[II]

Honduras

In this talk, some novel theoretical and computational techniques for constrained approximation of data-driven dynamical systems, are presented. The motivation for the development of these techniques came from structure-preserving matrix approximation problems that appear in the fields of system identification and model predictive control, for data-driven systems and processes. The research reported in this talk is focused on finite-state approximation of data-driven dynamical systems, in the sense of [3].

From a topological perspective, the notion of cyclic control that we propose in this talk can be seen as a matrix extension of the so called Kirby Torus Trick, that was introduced by R. Kirby in [2]. This extension and the corresponding matrix computations, were partially inspired by some questions raised by M. H. Freedman along the lines of [1]. In order to perform the previously mentioned computations, we use elementary tools from operator K-Theory, to compute matrix analogies of the surgical cuts corresponding to Kirby's torus trick, these matrix surgical cuts have a direct effect on the spectrum of the corresponding unitary representation of the evolution operator corresponding to a given data-driven system.

Once we perform the previously mentioned surgical cuts on the spectrum of the unitary operator that models the dynamical behavior of the system under study, the connectivity problems on the state space of the system can be easily and efficiently computed in terms of the topologically pre-processed matrices.

The connections of the aforementioned topological techniques with a generic algorihm for cyclic finite-state approximation (in the sense of [3]) of data-driven systems, are outlined. Some numerical implementations of the aforementioned techniques in the simulation, and model predictive control of data-driven systems in fluid dynamics, are outlined as well.

Keywords: Operator K-Theory, Closed-loop control system, state transition matrix, model order reduction, pseudospectrum.

Mathematics Subject Classification (2010): 93B28, 47N70 (primary) and 93C57, 93B40 (secondary)

References

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[2] Kirby R. C. Stable homeomorphisms and the annulus conjecture. Ann. of Math., Second Series, Vol. 89, No. 3 (May, 1969), pp. 575-582

[3] Vides F. On Cyclic Finite-State Approximation of Data-Driven Systems. (2019). In press.

[I] Viernes/Friday 28, 02:00 - 02:20, Room/aula 1, session: (Aprox1-1), Approximation / Aproximación 1

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On Algebraic Approximation of Time-Evolution Operators[I]

Communication / Ponencia

VIDES ROMERO, FREDY ANTONIO[II]

Honduras

In this talk, some novel theoretical techniques for the algebraic approximation of time-evolution operators for dynamical systems, are presented. The motivation for the development of these techniques came from matrix approximation problems that appear in the fields of system identification and model predictive control, for dynamical systems and vector time series. The research reported in this talk is focused on algebraic approximation of data-driven dynamical systems, in the sense of [2]. For the study reported in this talk, we build on the abstract machinery introduced by Brockett and Willsky in [1]. Our contribution is the application of some of the operator theoretic techniques developed in [2] to extend the results in [1] to data-driven systems, and to obtain new theoretical and computational procedures for the approximation of data-driven systems, using discrete-time systems whose time evolution is determined by finite sets of transition matrices or by vector time series.

More specifically, given $\varepsilon > 0$, and a multiphysical model whose evolution can be interpreted in terms of a countable set of states $\Sigma = \{x_n\}_{n\geq 1} \subset \mathbf{C}^N$ for some positive integer N, we study the existence problem for: a polynomial $p_{m,r,\varepsilon} \in \mathbb{C}[z]$ determined by the expression $p_{m,r,\varepsilon}(z) = z^m - z^r$ for some integers $0 \leq r \leq m \leq N$, a $*$-representation $(\varphi_{m,r,\varepsilon}, \mathbb{C}^n)$ of the universal unital C^*-algebra $A_{m,r,\varepsilon} = C_1^*\langle z | p_{m,r,\varepsilon}(z) = 0\rangle$ and a linear map $\kappa_{m,r,\varepsilon} : \mathbb{C}^{n\times n} \to \mathbb{C}^{N\times N}$ with $n \leq N$, such that $\|\kappa_{m,r,\varepsilon} \circ \varphi_{m,r,\varepsilon}(z^k)x_1 - x_{k+1}\|_2 \leq \varepsilon$ for each $k \geq 1$ and each $x_{k+1} \in \Sigma$, where $\|\cdot\|_2$ denotes the Euclidean norm.

The triple $(A_{m,r,\varepsilon}, \varphi_{m,r,\varepsilon}, \kappa_{m,r,\varepsilon})$ described before is called an ε-approximate algebraic cyclic representation (**AACR**) for Σ, and we write $Ind_\varepsilon(\Sigma)$ to denote the pair (m', r') of smallest integers such that there is a cyclic control $(A_{m',r',\varepsilon}, \varphi_{m',r',\varepsilon}, \kappa_{m,r,\varepsilon})$ for Σ.

The solvability of the existence problem of an AACR for a dynamical system determined by a set of states $\Sigma = \{x_n\}_{n\geq 1} \subset \mathbf{C}^N$ for some positive integer N, is addressed. Some numerical implementations of the aforementioned techniques in the simulation, and model predictive control of dynamical systems in structural mechanics, are outlined.

Keywords: Universal C*-algebra, $*$-homomorphism, joint spectrum, pseudospectrum.

Mathematics Subject Classification (2010): 93B28, 47N70 (primary) and 93C57, 93B40 (secondary)

References

[1] R. Brockett and A. Willsky. Finite group homomorphic sequential systems. IEEE Transactions on Automatic Control. Vol. 17, No. 4, pp. 483-490. 1972.

[2] Vides F. On uniform connectivity of algebraic matrix sets. Banach J. Math. Anal., Vol. 13, No. 4, pp. 918-943. 2019.

[I] Viernes/Friday 28, 03:05 - 03:25, Room/aula 1, session: (Aprox2-1), Approximation / Aproximación 2

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High-order finite-difference WENO schemes for models of crowd dynamics[I]

Invited Session / Sesión invitada

VILLADA, LUIS MIGUEL[II]

Chile

In this talk, we are concerned with the numerical approximation of a class of nonlocal systems of conservation laws in two space dimensions for the macroscopic modelling of pedestrian flow. The resulting dynamics captures various well-known patterns of crowd movements, such as the clogging of exits and the spontaneous formation of lines patterns.

Keywords: Keywords: Nonlocal system of conservation laws, Finite Difference WENO schemes, crowd dynamics.

Mathematics Subject Classification (2010): 35L65, 65M08, 90B20

References

[1] R. Colombo and E. Rossi. *Nonlocal conservation laws in bounded domains.* SIAM Journal on Mathematical Analysis 50.4 (2018): 4041–4065.

[2] R. Colombo and E. Rossi. *Modelling crowd movements in domains with boundaries.* IMA Journal of Applied Mathematics 84.5 (2019): 833–853.

[3] R. Burger, D. Inzunza and L. M. Villada. *High-order finite-difference WENO schemes for models of crowd dynamics*. Manuscript in preparation.

[I] Miércoles/Wednesday 26, 04:30 - 04:50, Room/aula 3, session: (SINum2-3), Invited session: Numerical solution of PDEs

[II] Departamento Matemática, Universidad del Bío-Bío, Concepción, Chile, and CI^{2}MA, Universidad de Concepción, Concepción, Chile, email: lvillada@ubiobio.cl

An extreme theorem on subspaces of integrable functions and applications to partial differential equations[I]

Un teorema de extremos sobre subespacios de funciones integrables y aplicaciones a ecuaciones diferenciales parciales

Communication / Ponencia

VILLA MORALES, JOSÉ[II]

México

In the present talk we will give general ideas of the proof that every semi-continuous function bounded below defined on a convex and closed subset of the integrable functions (or more generally, p-integrables) reaches its minimum, if such function is quasi-convex. The proof is based on the fact that every net in a convex set of measurable functions contains a subnet that is Cauchy in measure, therefore, if there is domination the convergence is in the space of the integrable functions.

Our main goal is that we will apply this result in the study of existence weak solutions for the Euler-Lagrange equation. The technique that we will use is based on the variational calculation, that is, we will take an appropriate functional defined on a convenient subspace of Sobolev functions. In such subspace we will see that the functional is differentiable and due to the theorem of the extremes it has a minimum, therefore the derivative of the functional in this minimum is zero and this is the weak solution we sought. The contribution is that the involved Sobolev space, in this case, is not reflexive and we do not imposse any kind of Palais-Smale conditions, as usual.

Keywords: Extreme theorem, quasi convex functions, weak solutions, Euler-Lagrange equations.

Mathematics Subject Classification (2010): 35A15, 28A10

Resumen

En la presenta charla daremos las ideas generales de la demostraremos que toda función semicontinua acotada inferiormente definida sobre un subconjunto convexo y cerrado de las funciones integrables (o más generalmente, p-integrables) alcanza su ínfimo, si dicha función es quasi convexa. La demostración se basa en que toda red en un conjunto convexo de funciones medibles contiene una subred que es Cauchy en medida, por ende, si hay dominación la convergencia es en el espacio de las funciones integrables.

Nuestro objetivo principal es aplicar dicho resultado al estudio de existencia de soluciones débiles de ecuaciones de Euler-Lagrange. La técnica que usaremos se basa en el cálculo variacional, es decir se introduce un funcional adecuado en un subespacio de funciones de Sobolev. En dicho subespacio el funcional es diferenciable y por el teorema de los extremos tiene un mínimo, por consecuencia la derivada del funcional es creo, en dicho punto, y tal mínimo es la solución débil buscada. La contribución radica en que el espacio, de Sobolev involucrado, no es reflexivo y no se imponen condiciones, tipo Palais-Smale, sobre el funcional como usualmente se hace.

[I] Martes/Tuesday 25, 02:20 - 02:40, Room/aula 1, session: (Deq1-2), Differential Equations / Ecuaciones Diferenciales 1

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Palabras clave: Teorema de los extremos, funciones cuasi-convexas, soluciones débiles, ecuaciones de Euler-Lagrange.

References

[1] 1. D.G. De Figueiredo. Lectures on the Ekeland variational principle with applications and detours. Tata Institute of fundamental Research, 1989.

[2] 2. H. Brezis. Functional Analysis, Sobolev Spaces and Partial Differential Equations. Springer, 2011.

[3] 3. O. Kavian. Introduction à la théorie des points critiques et applications aux problèmes elliptiques. Springer, 1993.

[4] 4. H. Le Dret. Nonlinear Elliptic PartialDifferential Equations :An Introduction. Springer 2018.

On an extreme theorem on non compact sets and the minimax theorem[I]

Sobre un teorema de extremos para conjuntos no compactos y el teorema minimax

Communication / Ponencia

VILLA MORALES, JOSÉ[II]

México

It is said that the origin of game theory begins with the minimax theorem, initially demonstrated by John von Neumann. This result has, in particular, that in zero-sum games with imperfect information there is an optimal solution, which is stochastic. In addition, this theorem has other important implications, such as the mountain pass theorem, which is used in nonlinear partial differential equations, or it is applied in the study of the problem of maximum utility in financial mathematics. In this talk we will address the minimax theorem in the context of subspaces of closed convex spaces of integrable functions. We will do this by giving, first of all, the general ideas of the demonstration of a theorem of extremes, that is, we will proof that every semi-continuous function bounded below defined on a convex and closed subset of the integrable (or more generally, p-integrable) functions reaches its minimum, if this function is quasi convex. The proof is based on the fact that every net in a convex set of measurable functions contains a subnet that is Cauchy in measure, therefore, if there is domination the convergence is in the space of the integrable functions. Imposing conditions of semicontinuity, quasi-convexity and quasi-concavity we will give a version of the minimax theorem in this context, that is, without assuming conditions of compactness, as is usually done.

Keywords: The extreme value theorem, the minimax theorem, game theory.

Mathematics Subject Classification (2010): 91A05, 28A10

Resumen

Se dice que el origen de la teoría de juegos inicia con el teorema minimax, demostrado inicialmente por John von Neumann. Dicho resultado tiene como consecuencia, en particular, que en los juegos de suma cero con información imperfecta existe una solución óptica, que es estocástica. Además, dicho teorema tiene otras implicaciones importantes, como lo es el teorema del paso de la montaña, que se usa en ecuaciones diferenciales parciales no lineales, o bien se aplica en el estudio del problema de utilidad máxima de matemáticas financieras. En la presente charla abordaremos el teorema minimax en el contexto de subespacios de espacios convexos cerrados de funciones integrables. Esto lo haremos dando, primeramente, las ideas generales de la demostración de un teorema de extremos, es decir demostraremos que toda función semicontinua acotada inferiormente definida sobre un subconjunto convexo y cerrado de las funciones integrables (o más generalmente, p-integrables) alcanza su ínfimo, si dicha función es quasi convexa. La demostración se basa en que toda red en un conjunto convexo de funciones medibles contiene una subred que es Cauchy en medida, por ende, si hay

[I] Martes/Tuesday 25, 05:30 - 05:50, Room/aula 1, session: (OR2-4), Operations Research / Investigación de Operaciones 2

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dominación la convergencia es en el espacio de las funciones integrables. Imponiendo condiciones de semicontinuidad, quasi-convexidad y cuasi-concavidad daremos una versión del teorema minimax en este contexto, es decir sin asumir condiciones de compacidad, como usualmente se hace.

Palabras clave: Teorema de los valores extremos, el teorema minimax, teoría de juegos.

References

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Multidimensional scaling in the sphere using simulated annealing[I]

Communication / Ponencia

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Costa Rica

In Multidimensional scaling (see [1,3]) what we want to do is to try to obtain a good representation of some individuals that are represented as vectors in $\mathbb{R}^n$,in a space of low dimension $\mathbb{R}^p$, $p = 2o3$, see [4,5]. In this work, we present the preliminary results of a version in which the representation is in the Sphere (see [2]), which we could say is an intermediate between $\mathbb{R}^2$ or $\mathbb{R}^3$. To obtain the optimal representation the simulation annealing optimization heuristic is used, which has shown that very good results are obtained, and even better than with traditional optimization methods, in many applications.

Keywords: Multidimensional scaling, simulation annealing, optimization heuristics.

Resumen

En el escalamiento multidimensional (ver [1,3]) lo que queremos hacer es tratar de obtener una buena representación de algunos individuos que están representados como vectores en $\mathbb{R}^n$, en un espacio de baja dimensión $\mathbb{R}^p$, $p = 2o3$, ver [4,5]. En este trabajo, presentamos los resultados preliminares de una versión en la que la representación está en la Esfera (ver [2]), que podríamos decir que es un intermedio entre $\mathbb{R}^2$ o $\mathbb{R}^3$. Para obtener la representación óptima, se utiliza la heurística de optimización de recocido de simulación, que ha demostrado que se obtienen muy buenos resultados, e incluso mejores que con los métodos de optimización tradicionales, en muchas aplicaciones.

Palabras clave: Escalamiento multidimensional, recocido de simulación, heurística de optimización.

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[I] Viernes/Friday 28, 03:05 - 03:25, Room/aula 2, session: (Opt2-1), Optimization / Optimización 2

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MetaPipe: A High-Performance Computing pipeline for QTL mapping of large metabolic datasets[I]

Communication / Ponencia

VILLEGAS-DIAZ, ROBERTO[II] Alahakoon, Dilmini[III] Fennell, Anne[IV]

United States of America

Grapevine stem, which is an agricultural waste from commercial vineyards, is a rich source of phytochemicals phenolic and anti-fungal metabolites. To date, there has been little genetic analyses of the larger body of potentially beneficial compounds that are captured during the extraction of experimentally targeted specific compound. In this study, untargeted metabolomics profiling of grapevine cane was performed using liquid chromatography-high resolution mass spectrometry (LC-HRMS) for F2 grapevine sub-population and identified 1317 metabolites/features. This dataset was too large to be analyzed using the standard QTL pipeline, therefore, the mQTL mapping was executed on a High-Performance Computing server using the library R/qtl to identify genetic architecture of cane metabolites. Forty-nine significant mQTLs were identified and QTL hotspots were detected on LG1 and LG7. Genes underlying these loci are being used to help annotate the compounds. MetaPipe uses the library Rmpi (R Message-Passing Interface) to distribute the workload across the cluster resources; we observed a reduction of the total running time from about 8 hours (running on a single compute node) to under 20 minutes, after the inclusion of this library.

Keywords: QTL mapping, metabolomics, HPC, genetics.

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[I] Miércoles/Wednesday 26, 03:05 - 03:25, Auditorium / Auditorio, session: (Bio1-1), Biomathematics / Biomatemáticas 1

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Parallel Computing using Rmpi[I]

Short course / Curso corto

VILLEGAS-DIAZ, ROBERTO[II] Fennell, Anne[III]

United States of America

R has become the go to tool for a large range of analyses in many different fields, from people working in ecological studies to bioinformaticians with their large scale workflows [1, 2]. For most needs, R has an overall good performance since many libraries will automatically scale based on the available resources. However, there are studies in which even an optimized version of R is not enough, hence the need of exploring alternatives, like parallel computing. Entering the realm of parallel computing brings a whole new set of challenges that one must overcome. The first step is to clearly identify potential bottlenecks in our workflow, then we must find an optimal splitting/blocking criteria for our data. These factors can make the parallelization of our workflows advantageous by means of reducing execution times, which allows the process of larger datasets and the exploration of alternative scenarios. The parallelization of workflows is not a trivial process, but the results are rewarding.

Objectives:

- Introduction to Parallel Computing.
- Overview of the Message Passing Interface (MPI) library and Multitasking.
- Develop a basic parallel computing workflow using the library Rmpi (parallelization of a large serial loop and a small toy dataset will be used to illustrate the concepts).
- (Time permitting) Initial steps to parallelize attendees own workflows will be made (attendes are encouraged to bring ideas of workflows that could potentially benefit of Parallel Computing).

Methodology:

- Short conceptual sessions, followed by hands-on sessions.
- The practical sessions will be remotely run on the CeNAT's supercomputer KÁBRE (https://kabre.cenat.ac.cr/) using Jupyter Notebooks (no previous knowledge required). Temporal accounts will be provided.

Requirements:

- Intermediate knowledge of R is expected.

Keywords: R, Rmpi, HPC, MPI, bioinformatics.

[I] Viernes/Friday 28, 08:00 - 11:20, Room/aula 1, session: (Tut-6), Tutorial 6

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Hodge-Euler polynomials of character varieties[I]

Polinomios de Hodge-Euler en variedades de caracteres

Communication / Ponencia

ZAMORA SAIZ, ALFONSO[II]

España

With $G = GL(n, \mathbb{C})$, let $\mathcal{X}_\Gamma G$ be the G-character variety of a given finitely presented group Γ, and let $\mathcal{X}_\Gamma^{irr} G \subset \mathcal{X}_\Gamma G$ be the locus of irreducible representation conjugacy classes. We provide a concrete relation, in terms of plethystic functions, between the generating series for Hodge-Euler (also called E-) polynomials of $\mathcal{X}_\Gamma G$ and the one for $\mathcal{X}_\Gamma^{irr} G$, generalizing a formula of Mozgovoy-Reineke. The proof uses a natural stratification of $\mathcal{X}_\Gamma G$ coming from affine GIT, the combinatorics of partitions, and formulae for symmetric products. Combining our methods with arithmetic ones yields explicit expressions for the E-polynomials of all polystable strata of some $GL(n, \mathbb{C})$-character varieties of several groups Γ, for low values of n. In the case $\Gamma = F_r$, the free group of rank r, detailed results are obtained for every n.

As an application of these geometric methods, we prove that $E(\mathcal{X}_r SL_n) = E(\mathcal{X}_r PGL_n)$, for any $n \in \mathbb{N}$, and the character variety of the free group. This settles a conjecture of Lawton-Muñoz.

These results are joint work with Carlos Florentino and Azizeh Nozad.

Keywords: Hodge-Euler polynomials, character varieties, representation of finitely generated groups.

Mathematics Subject Classification (2010): 14L30, 32S35, 14D20

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[I] Jueves/Thursday 27, 10:00 - 10:40, Room/aula 2, session: (7), Geometry and Topology / Geometría y Topología 1

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Modular Operads and Higgs Bundles[I]

Operads Modulares y Fibrados de Higgs

Communication / Ponencia

ZÚÑIGA-ROJAS, RONALD ALBERTO[II] Sánchez Guevara, Jesús E.[III]

Costa Rica

There is already a generalized description of classes of moduli spaces of geometric structures on surfaces by Giansiracusa. That description includes moduli of spin surfaces, r-spin surfaces, surfaces with a principle G-bundle, surfaces with maps to a background space, among others. Here, we want to compute the homotopy groups of the moduli spaces of k-Higgs bundles, with the modular operads as main tool, and then, compare them with the results of Hausel and the results of Bradlow et.al.

Keywords: Homotopy, Moduli Spaces, Operads, Higgs Bundles.

Mathematics Subject Classification (2010): 14D07

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[I] Viernes/Friday 28, 11:20 - 12:00, Room/aula 2, session: (GT2-3), Geometry and Topology / Geometría y Topología 2

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