UNIVERSIDAD DE
COSTA RICA

CIMPA Centro de Investigación en
Matemática Pura y Aplicada

# XXIII SIMMAC

Simposio Internacional de Métodos
Matemáticos Aplicados a las Ciencias

International Symposium on Mathematical
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Programa y Resúmenes
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San José, Costa Rica

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# XXIII Simposio Internacional de Métodos Matemáticos Aplicados a las Ciencias

## 21-25 de febrero, 2022 / february 21-25th, 2022



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San José, Costa Rica

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# PROGRAMA / PROGRAM

## Lunes / Monday

09:00 – 09:30: Inauguración

### Sesión: Optimización

11:00 –12:00: Khludnev, A.: Junction problem for thin elastic and volume rigid inclusions in elastic body (pág. 68).
**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**
14:00 – 15:00: Rodríguez, O.: Conferencia Plenaria
**15:00 – 15:20 Receso**
15:20 – 16:00: Bernabé, M.: Búsqueda Tabú en particionamiento con múltiples objetivos (pág. 23)
16:00 – 16:30: Pinheiro, A.: Decision analysis from SAPEVO-M and THOR-2 methods for the acquisition of a new hospital ship for the brazilian navy. (pág. 104)

### Sesión: Workshop Kludnev-70

11:00-11:20: Khludnev, A.:Junction problem for thin elastic and volume rigid inclusions in elastic body.(pág. 68)
11:20-11:40: Rudoy, E.: Asymptotic Justification of the Models of Thin Inclusions in an Elastic Body in the Antiplane Shear Problem and Applications. (pág. 122)
11:40-12:00: Kovtunenko, V.: Poroelastic medium with non-penetrating crack driven by hydraulic fracture. (pág. 70)

### Sesión: Ciencia de Datos

11:00 – 11:30: Arce, J.: Optimized Symbolic Correspondence Analysis for Multi-Valued Variables. (pág. 20)
11:30 – 12:00: Martinez, P.: Kernel density estimations in the machine learning world. (pág. 83)
**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**
14:00 -15:00: Rodríguez, O.: Conferencia Plenaria.
**15:00 – 15:20 Receso**
15:20 – 15:40: Guerrero, M.: Crime in young mexicans: Statistical modeling and risk quantification.(pág. 59)
15:40 – 16:00: Ramírez, R.: Natural language processing, an application to the classification of economic and political news in Mexico.(pág. 109)
16:00 – 17:00: Erazo, C.: Short course: Introduction to Shiny.(pág. 43)

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09:00 – 09:40: Cabral, G.: A fixed point theorem in the space of integrable functions and applications. (pág. 28)
**9:40 – 9:50 Receso**
09:50 – 10:30: Campos, J.: Ellipticity criteria for random walks in i.i.d. random environments. (pág. 31)
10:30 – 11:00: Arredondo, J.: Fourier Analysis with generalized integration. (pág. 21)
11:00 –12:00 Lauter, K.: Conferencia

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Sesión: Física

8:00 –8:40: Eduarte, A.: Chaotic Behavior of Geodesics in Kerr-like Spacetime. (pág. 42)

8:40–9:10: Santiago, E.: Transparent Spheres as Gravitational Lens. (pág. 125)

9:10 – 9:40: Tejedor, M.: An analysis of nonlinear ultrasonic waves in bubbly liquids by a numerical model. (pág. 140)

**9:40 – 9:50 Receso**

### Sesión: Ciencia de Datos

8:00 – 8:20: López, M.: Fuel type mapping through AI for wildfire simulations. (pág. 79)

8:20 – 8:40: López, A.: Quantile-based fuzzy clustering of multivariate time series in the frequency domain. (pág. 81)

8:40 – 9:40: Erazo, C: Short course: Introduction to Shiny (pág. 43)

**9:40 – 9:50 Receso**

9:50 – 10:30: Murillo, A.: Data Analysis with Combinatorial Optimization Heuristics (dacoh): biblioteca en R para análisis de datos usando metaheurísticas (pág. 142)

11:00 – 12:00: Plenaria SIMMAC

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Sesión: Aplicaciones a las Ciencias

14:00 – 14:40: Braz, E.: The Importance of electric inteligence (ELINT) in the estimation and parameterization of electromagnetic pulses detected by electronic warfare support measures (EWSM). (pág. 24).

14:40 – 15:00: Flores, M.: An algorithm for differentiating composite functions with a vector argument repeatedly. (pág. 47).

15:00 – 15:40: Carlos Hernández, A.: Speech spoofing detection using neural networks. (pág. 61).

**15:40 – 16:00 Receso**

16:00 – 16:30: Alvarez, E.: El modelo de árbol más cercano aplicado en un trípode enraizado bajo Jukes-Cantor y condición de reloj molecular. (pág. 16).

16:30 – 17:00: Garcia, P.: A Methodology for the Analysis of Cooperation and Conflict, in the Consensus-Negotiation. (pág. 53).

### Sesión: Estadística

14:40 – 15:00: Vázquez, H.: Análisis Multivariado y Establecimiento de una Tipología de Especies Arbóreas mediante la categorización de Modalidades. (pág. 146).

15:00 – 15:40: Román, K.: Deep Gaussian Processes and Infinite Neural Networks for the Analysis of EEG Signals in Alzheimer's Diseases. (pág. 119).

**15:40 – 16:00 Receso**

### Sesión: Análisis numérico

14:00 – 14:20: Pagola, P.: A convergent and asymptotic Laplace method for integrals. (pág. 99)

14:20 – 14:40: Lobao, D.: Linear New Approach for Trigonometric Inverse Series Applied to Newton-Raphson Method. (pág. 78).

14:40 – 15:00: Funez, W.: Identificación aproximada de señales en reconocimiento de patrones mediante la descomposición en modo dinámico (DMD) y la teoría de Koopman. (pág. 49).

15:00 – 15:20: Soto, J.: Descomposición Tensorial y sus Aplicaciones en Procesamiento de Imágenes. (pág. 136).

15:20 – 15:40: Torres, A.: Solución Numérica de una Ecuación de Difusión Bifraccional Mediante Funciones de Base Radial. (pág. 141).

**15:40 – 16:00 Receso**

16:00 – 16:30: Fallas, J.: Aproximación de la matriz de rango bajo mediante proyecciones bilaterales aleatorias y su aplicación a la compresión de imágenes (pág. 44).

16:30 – 17:00: Chavarría, J.: El algoritmo GoDec y su aplicacion al procesamiento de videos (pág. 36).

### Sesión: Sistemas dinámicos y modelación

8:00 – 9:00: Silva, L.: Singular hyperbolicity and subsectional lyapunov exponents of various orders. (pág. 130).

9:00 – 9:40: El Hadji Yaya Tall: On the spectral theory of Schrödinger operator with dynamically defined potential.(pág. 155).

**9:40 – 9:50 Receso**

9:50 – 10:30: Justen, V.: The van der pol equation: qualitative and numerical study. (pág. 67).

11:00 – 12:00: Plenaria SIMMAC

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Sesión: Contribuciones a la modelización matemática del Covid-19

8:00 – 9:00: Lima, M. Epidemiologia Matemática: COVID-19. (pág. 76).

9:00 – 9:40: Menezes. R.: CoronaSurveys: Estimating Active Cases of COVID-19

(pág. 87).

**9:40 – 9:50 Receso**.

9:50 – 10:30: Núñez, S.: Renormalization group theory and scheduler dependencies in Agent-Based Models: two modeling aspects toward higher model fidelity. (pág. 96).

10:30 – 11:00: Montes, E.: Analysis and characterization of employment and its dynamics in Mexico before and during the COVID-19 pandemic. (pág. 91).

11:00 – 12:00: Plenaria SIMMAC

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

# Miércoles / Wednesday

### Ciencia de Datos

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15:00 – 15:20: Castro, C.: On Outliers Detection and Censored Samples. (pág. 34)

### Sesión: Aplicaciones a las Ciencias

14:00 – 14:30: Flores, H.: Modeling Glucose Homeostasis Using OGTT Data: A Bayesian Approach. (pág. 48).

14:30 – 15:00: Romero, C.: On the turnpike property of the numerical solutions in a stochastic Lotka-Volterra model. (pág. 121).

15:00 – 15:30: Duarte, R.: Modelación de medios filtrantes aplicando diagramas de Voronoi-Laguerre. (pág. 39).

**15:40 – 16:00: Receso**

16:00 – 16:20: Perez, B.: Ozone study in Mexico City. An application of the hidden Marcov processes. (pág. 103).

16:20 – 16:40: Campos, W.: Análisis temporal del crecimiento del parque vehicular en San Salvador y municipios aledaños. (pág. 30).

16:40 – 17:00: Palacios, W.: Metaheuristics for sorting permutations by prefix reversals (SPBR). (pág. 100)

### Sesión: Estadística

8:00 – 8:40: Vaillant, J.: Spatio-temporal Cluster detection tests and stochastic modeling. (pág. 143)

8:40 – 9:00: Alonzo, I.:Multiple degrees of freedom Gaussian processes. (pág. 15).

9:00 – 9:40: Castillo, L.: Estimation and Validation in Statistical Modeling of two Non Negative Random Variables given Explanatory Variables based Bivariate Subcopula
(pág. 33).

**9:40 – 10:00 Receso**

10:00 – 10:40: Vázquez, H.: Estudio Exploratorio de la Forma de la Copa de los Árboles. (pág. 147).

10:40 – 11:00: Pita, O.: An Alternative Proposal Based on Trimmed Mean and Booststrapping in the Market Method for Real Estate Appraisals, case Colombia. (pág. 107).

### Sesión: Modelación

8:20 – 9:00: Venturino, E.: A grassland metaecoepidemic model with just consumers' migration. (pág. 149).

9:00 – 9:40: Lumpuy, D.: Influence of stochastic noise on hematopoietic recovery after an autologous bone marrow transplant. (pág. 82).

**9:40 – 10:00 Receso**

10:00– 10:30: Murillo, A.: Spatial Analysis Predicting Asthma Morbidity in Multiethnic Urban Rhode Island Children. (pág. 95).

10:30 – 11:00: Arroyo, J.: Local interactions influence spread of prey in a predator-prey system with group defense.(pág. 22).

11:00 – 12:00: Porter, M.: Opinion Dynamics on Social Networks. (pág. 108).

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Sesión: Álgebra y Teoría de números

13:40 – 14:00: Garcia, J.: Class Number Formula Based on the Floor of a Number. (pág. 51).

14:00 – 15:00: Li, W.: A generalization to Elkies's theorem. (pág. 75)

15:00 – 15:40: Vincent, C.: Computing hyperelliptic modular invariants from period matrices.(pág. 152).

**15:40 – 16:00 Receso**

16:00 – 17:00: Serrano, A.: How do points on plane curves generate fields? Let me count the ways. (pág. 129).

**Sesión: Contribuciones a la modelización matemática del Covid-19**

8:00 – 9:00: Lima, M.: Epidemiologia Matemática: COVID-19. (pág. 76).

9:00 – 9:40: González, G.: The Statistics of the Covid-19 Pandemic in Mexico and the Problems for Building Predictive Models. (pág. 58).

**9:40 – 10:00 Receso**

10:00 – 10:40: Nuiro, P.: A COVID-19 data-based approach using a multi-group SIHR Model with fuzzy subsets. Application to the case of the Guadeloupe archipelago. (pág. 102).

10:40 – 11:20: Molina, R.: Los modelos cohorte-temporales de la dispersión del COVID-19. (pág. 89).

11:20 – 12:00: Sánchez, F.: Modeling Covid-19 in Costa Rica: A Multilayer Network Approach (pág. 124).

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

**Sesión: Geometría y Topología**

9:00 – 9:40: Zamora, A.: The moduli stack of principal $\rho$-sheaves and Gieseker-Harder-Narasimhan filtrations (pág. 156).

**9:40 – 10:00 Receso**

10:00 – 11:00: Minicurso TR. (pág. 60).

11:00 – 12:00: Oliveira, A.: A pair of dual branes on the singular locus of the Hitchin system (pág. 98).

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

# Jueves / Thursday

**Optimización**

8:00 – 9:00: Khludnev, A.: Workshop dedicated to Prof. Alexander Khludnev 70th anniversary. (pág. 65), (pág. 73).

9:00 – 9:20: Pinheiro, A.: Selection of marine corps personnel for the courses of operation and maintenance of the joint light tactical vehicle (JLTV): an analysis from the multicriteria method ahp-gaussian (pág. 105).

9:20 – 9:40: Bento, L.: AHP-Gaussian aligned with Value Focused Thinking for strategical decision making in Brazilian Airforce load plane purchasing. (pág. 38).

**9:40 – 10:00 Receso**

10:00 – 10:30: Soria, I.: Logística inteligente aplicada a sistemas de distribución de productos de consumo masivo. Un caso de estudio de distribución de bebidas embotelladas en México. (pág. 134).

**Ondas de agua: Modelado matemático de mares y océanos.**

8:00 – 9:00: Andrade, D.: Water Waves: Mathematical modeling of seas and oceans. (pág. 19).

9:00 – 9:40: Santos, M.: Conformable spatial derivative modeling fluid flow. (pág. 126).

**9:40 – 10:00 Receso**

10:00 – 12:00: Roma, A.: A brief introduction to computational fluid dynamics: modeling, computational simulation, and applications. (pág. 118).

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

**Contribuciones a la modelización matemática del Covid-19**

8:00 – 9:00: Lima, M.: Epidemiologia Matemática: COVID-19. (pág. 76).

9:00 – 9:40: Vampa, V.: Using information-theory quantifiers to characterize COVID-19 time-series data. (pág. 144).

**9:40– 10:00 Receso**

10:00 – 10:40: Gómez, A.: SEAIR Epidemic Spreading modeling of Covid-19 for Costa Rica. (pág. 56).

10:40 – 11:20: Solís, M.:Risk classifier for COVID-19 susceptible individuals using the patient previous data. (pág. 132).

11:20 – 12:00: Subirana, J.: Caracterización de la población afectada por el COVID-19 en Santa Cruz de la Sierra. (pág. 138).

**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Riesgo y matemática financiera

13:20 – 15:40: Mesa redonda: Retos para la gestión moderna de riesgo.

**15:40 – 16:00 Receso**

16:00 – 16:30: Fernandez, E.: A contingent claims approach for computing the premium to ensure an investment in highways. (pág. 45).

16:30 – 16:50: Morales, P.: Pricing Financial Options through Modified Black-Scholes Merton Model. (pág. 92).

16:50 – 17:10: Brenes, F.: Link between financial system development and economic growth in Costa Rica: Cointegration and time series analysis. (pág. 26).

### Geometría y Topología

9:00 – 9:40: Sánchez, J.: Chain complexes and E-infinity operads. (pág. 123).

**9:40 – 10:00 Receso**

10:00 – 11:00: Minicurso TR. (pág. 60).

11:00 – 12:00: Jardim, M.: Distributions and foliations on the three dimensional projective space. (pág. 66).

### Numerical PDE

14:00 – 15:00: Solano, M.: Numerical analysis of PDE's and its role in alternative energies modelling. (pág. 131).

15:00 – 15:40: Colmenares, E.: A fully-DG method for the stationary Boussinesq system. (pág. 37).

**15:40 -16:00 Receso**

16:00 – 16:30: Lepe, F.: A virtual element approximation for the pseudostress formulation of the Stokes eigenvalue problem. (pág. 74).

16:30 – 17:00: Alvarez, M.: A priori and a posteriori error analysis of a semi-augmented mixed finite element method for double-diffusive natural convection in porous media. (pág. 18).

### Sesión: Workshop Kludnev-70

08:00-08:30: Itou, H. & Takahito, K. : A remark on crack problems with time-dependent friction condition in linearized elastodynamic body. (pág. 65).

08:30-09:00: Lazarev, N.: Equilibrium of a thermoelastic plate with nonpenetration condition. (pág. 73).

# Viernes / Friday

### Álgebra y Teoría de números

14:00 – 15:00: Krumm, D.: Classification of pre-periodic portraits for quadratic polynomials over quadratic number fields. (pág. 71).
15:00 – 15:40: Duque, J.: Enumerating triangular modular curves of small genus. (pág. 41).
**15:40 – 16:00 Receso**
16:00 – 17:00: Plenaria SIMMAC

### Ondas de agua: Modelado matemático de mares y océanos.

8:00 – 9:00: Roma, A.: A brief introduction to computational fluid dynamics: modeling, computational simulation, and applications. (pág. 118).
9:00 – 9:40: Ribeiro, R.: Trapped Waves and Collisions. (pág. 114).
**9:40 – 10:00 Receso**
10:00 – 10:40: Marcelo Velloso, M.: Gravity-capillary flows over obstacles for the fifth-order forced Korteweg-de Vries equation. (pág. 46).
10:40 – 11:20: Stuhlmeier, R.: Weakly nonlinear theory for deterministic wave forecasting. (pág. 137).
11:20 – 12:00: Rodriguez, P.: Asymptotic method applied to obtain shock waves solutions in Buckley–Leverett Equations. (pág. 117).
**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Contribuciones a la modelización matemática del Covid-19.

8:00 – 8:20: Soria, I.: A proposal mathematical model for the vaccines COVID-19 distribution network: A case study in Mexico. (pág. 135).
8:20 – 9:00: Isea, R.: Hacia un modelo matemático multiescala que unifica la dinámica de propagación del Covid-19. (pág. 64).
9:00 – 9:40: Villalobos, M.: Curve Fitting for Covid-19 Population Data Trend using Generalized Logistic Regression.(pág. 151).
**09:40 – 10:00 Receso**
10:00 – 10:40: Vides, F.: Computing Sparse Semilinear Models for COVID-19 Related Processes. (pág. 150).
10:40 – 11:20 Herrera, E.: Modeling of social contact patterns in Bogotá Colombia during the covid-19 pandemic. (pág. 62).
**11:20 – 14:00 Tiempo para almuerzo / Time for lunch.**

### Geometría y Topología

9:00 – 9:40: Komatsudani, M.: Baum Bott indexes and Vector Fields in the Projective Space.(pág. 69).
**9:40 – 10:00 Receso**
10:00 – 11:00: Minicurso TR. (pág. 60).
11:00 – 12:00: García, M.: Generalized Ricci Flow. (pág. 55).
**12:00 – 14:00 Tiempo para almuerzo / Time for lunch.**

**Numerical PDE**

14:00 – 14:30: Szyld, B.: Asynchronous Optimized Domain Decomposition Methods for the solution of PDEs. (pág. 139).

14:30 – 15:00: Galvis, J.: Fast multiscale contrast independent preconditioner for linear elastic topology optimization problems. (pág. 50).

15:00 – 15:40: Sequeira, F.: An Lp spaces-based mixed virtual element method for the two-dimensional Navier-Stokes equations. (pág. 127).

**15:40 -16:00 Receso**

16:00 – 17:00: Plenaria SIMMAC

# Lista de contribuciones / Contribution list

# Multiple degrees of freedom Gaussian processes[1]

*Short presentations (20 min)*
*Alonzo Matamoros, Izhar Asael* [2]
*Vehtari, Aki* [3]
*Finlandia*

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**Resumen/Abstract:** Gaussian process regression is a popular tool for modeling because of its flexibility for imposing non-parametric priors over functions. However, one major limitation of this model is its non-robustness, so that its predictive accuracy is compromised in the presence of outlier observations. Although several solutions using heavy-tailed distributions such as student-t processes or student-t distribution for the likelihood could be applied, that could still not suffice since it is reasonable to assume that the behavior of the tails differs depending on every observation. For this situation, assuming that every variable has its own degree of freedom should lead to a modeling improvement. In this work, we introduce the multiple degrees of freedom Gaussian process model obtained restructuring the process' covariance matrix such that its posterior follows a Generalized student-t distribution. This distribution can only be described through its hierarchical structure assigns a student-t distribution with different degrees of freedom to every observation. We derive the model's hierarchical structure, demonstrate its benefits with examples, and finally use the method in a real data application.

**Palabras clave / Key words:** Gaussian Process, hierarchical structures, generalized student-t distribution, heavy-tailed distribution.

## Referencias/References:

- Cruz, C. (2015) Modelos dinamicos estocasticos de equilibrio geral (dsge) com choques hete-rocedasticos.

- Shah, A., Wilson, A., and Ghahramani, Z. (2014). Student-t Processes as Alternativesto Gaussian Processes. In Samuel Kaski and Jukka Corander, editors,Proceedings of the Seventeenth International Conference on Artificial Intel ligence and Statistics, volume 33 of Proceedings of Machine Learning Research, pages 877–885, Reykjavik, Iceland, 22–25Apr 2014. PMLR.

- Rasmussen, C. E. and Christopher K. I. Williams (2006). Gaussian Processes for Machine Learning.

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[1]Miércoles/Wednesday 23, 8:40 - 9:00, Schedule (GMT-6)

[2]Aalto University, Espoo, Finlandia, izhar.alonzomatamoros@aalto.fi

[3]Aalto University, Espoo, Finland, izhar.alonzomatamoros@aalto.fi

# El modelo de árbol más cercano aplicado en un trípode enraizado bajo Jukes-Cantor y condición de reloj molecular[1]

*Short presentations (20 min)*
*Alvarez González, Ernesto* [2]
*México*

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**Resumen/Abstract:** En filogenética importa recobrar las relaciones ancestrales de las especies actuales. En esta charla hablaré de cómo ajustar 3 especies a dos trípodes enraizados: Jukes-Cantor sin condición de reloj molecular y Jukes-Cantor con condición de reloj molecular. Un trípode enraizado es un árbol filogenético con tres hojas, dos de éstas más emparentadas entre sí que con la tercera. Jukes-Cantor es el modelo de evolución molecular más simple, que propone iguales tasas de substitución entre nucleótidos entre cada par de ramas del árbol filogenético. La condición de reloj molecular supone una única tasa de sustitución, fija, a lo largo de todo el árbol filogenético. El ajuste a un árbol filogenético fijo sin raíz para un conjunto finito de secuencias de 2 estados se puede realizar mediante el método del árbol más cercano. Esto impone condiciones sobre los parámetros del modelo, como las longitudes de los lados del árbol. En el presente manuscrito, adaptamos dicho método a un conjunto de tres especies identificadas por sus secuencias de nucleótidos (con matriz espectral de secuencias espectrales genérica), agrupando las adeninas (A) y guaninas (G) en purinas (X), agrupando las citocinas (G) y timinas (T) en pirimidinas (Y), y al identificar el trípode enraizado propuesto como modelo de evolución que explica todas sus relaciones ancestrales con un cuartet sin raíz. Distinguimos dos tripodes de ajuste, Jukes-Cantor sin condición de reloj molecular y Jukes-Cantor con condición de reloj molecular. En cualquier caso, proporcionamos la región del espacio de parámetros que garantiza la unicidad para el ajuste. La conjugación de Hadamard juega un papel clave en tales descripciones.

**Palabras clave / Key words:** Método del árbol más cercano, conjugación de Hadamard, ajuste logarítmico de verosimilitud, reconstrucción filogenética, proceso de reducción, algoritmo de cobertura de Gröbner.

**Referencias/References:**

- Steel, M., and Hendy, M.D., and Penny, D. (1998). Reconstructing phylogenies from nucleotide pattern probabilities - a survey and some new results. Discrete Aplied Mathematics. Vol. 88. pp. 367-396. https://doi.org/10.1016/S0166-218X(98)00080-8

- Montes, A., and Wibmer, M. (2010). Gröbner bases for polynomial systems with parameters. Journal of Symbolic computation. Vol. 45. No.12, pp. 1391-1424. `doi:10.1016/j.jsc.2010.06.017`

- Steel, M.A., Hendy, M.D., Székely, L.A., and Erdös, P.L. (1992). Spectral analysis and a closest tree method for genetic sequences. Appl. Math. Lett. Vol. 5, No. 6, pp. 63-67. `doi:10.1016/0893-9659(92)90016-3`

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[1]Martes/Tuesday 22, 16:00 - 16:30, Schedule (GMT-6)

[2]Universidad Complutense de Madrid, Madrid, España, eralva01@ucm.es

- Chor, B., Hendy, M.D., and Snir, S. (2006). Maximum Likelihood Jukes-Cantor Triplets: Analytic Solutions. Mol. Biol. Evol. Vol. 23. No. 3, pp. 626-632. `doi:10.1093/molbev/msj069`

- Hendy, M. (1991). A combinatorial description of the closest tree algorithm for finding evolutionary trees. Discrete Mathematics. Vol. 96, pp. 51-58. `https://doi.org/10.1016/0012-365X(91)90469-I`

# A priori and a posteriori error analysis of a semi-augmented mixed finite element method for double-diffusive natural convection in porous media[1]

*Presentations (30 minutes)*
*Álvarez, Mario Andrés*[2]
*Costa Rica*

**Resumen/Abstract:** In this talk we present the mathematical and numerical analysis of a stationary double-diffusive natural convection problem in porous media given by a Navier-Stokes/Darcy type system, for describing the velocity and the pressure, coupled to a vector advection-diffusion equation describing the heat and substance concentration, of a viscous fluid in a porous media with physical boundary conditions. The model problem is rewritten in terms of a first-order system, without the pressure, based on the introduction of the strain tensor and a nonlinear pseudo-stress tensor in the fluid equations. After a variational approach, the resulting weak model is then augmented using appropriate redundant penalization terms for the fluid equations along with a standard primal formulation for the heat and substance concentration. Then, it is rewritten as an equivalent fixed-point problem. Well-posedness and uniqueness results for both the continuous and the discrete schemes are stated, as well as the respective convergence result under certain regularity assumptions combined with the Lax-Milgram theorem, and the Banach and Brouwer fixed-point theorems. In particular, Raviart-Thomas elements of order $k$ are used for approximating the pseudo-stress tensor, piecewise polynomials of degree $\leq k$ and $\leq k+1$ are utilized for approximating the strain tensor and the velocity, respectively, and the heat and substance concentration are approximated by means of Lagrange finite elements of order $\leq k + 1$. Optimal a priori error estimates are derived and confirmed through some numerical examples that illustrate the performance of the proposed semi-augmented mixed-primal scheme. Finally, we derive a residual-based a posteriori error estimator for the proposed finite element method, and prove its reliability and efficiency.

**Palabras clave / Key words:** Double-diffusive natural convection, Oberbeck-Boussinesq model, augmented formulation, mixed-primal finite element method, fixed point theory, a priori error analysis, a posteriori error analysis.

**Referencias/References:**

- M. Alvarez, G.N. Gatica, B. Gómez-Vargas and R. Ruiz-Baier,New mixed finite element methods for natural convection with phase-change in porous media.J. Sci. Comput. 80 (2019), no. 1, 141–174.2.

- E. Colmenares, G.N. Gatica, R. Oyarzúa,A posteriori error analysis of an augmented mixed-primal formulation for the stationary Bousinessq model.Calcolo, vol. 54(2017), 3, 1055–1095.

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[1]Jueves/Thursday 24, 16:30 - 17:00, Schedule (GMT-6)

[2]Universidad de Costa Rica, Sede de Occidente, Departamento de Ciencias Naturales, Sección de Matemática, mario.alvarezguadamuz@ucr.ac.cr

# WATER WAVES: MATHEMATICAL MODELING OF SEAS AND OCEANS[1]

*Plenary lectures (50 minutes)*

*Andrade, David*[2]          *Stuhlmeier, Raphael*[3]

*Ribeiro, Roberto*[4]          *Flamarion, Marcelo*[5]

*Colombia*

**Resumen/Abstract:** Coastal regions around the world are densely settled, popular for leisure activities, and home to critical infrastructure. While these locations thrive because of their proximity to the sea, that sea also presents a threat which must be guarded against. Coastal defenses in the form of sea walls and breakwaters are erected to protect against incursions of the sea, and yet the risk of damage looks set to increase as sea levels rise. With the intention of forecasting hazardous ocean conditions, we present a model that allows the study of the probability distribution of wave heights caused by reflection from a solid vertical wall.The model under investigation has as input a wave spectrum for the attacking waves and a constant water depth. The output is the time evolution of a correlation matrix, from which the spectral evolution can be extracted, including a time series of the variance of the free surface elevation and the probability of exceedance for the wave height.We show that depending on the spectrum and the water depth, there is a significant increase in the probability of large amplitude standing waves which can be categorized as freak-waves, i.e. waves whose height is more than twice the significant wave height, created by the reflection from the wall.This a joint work with Prof. Raphael Stuhlmeier and Prof. Michael Stiassnie.

**Palabras clave / Key words:**

**Referencias/References:**

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[1]Jueves/Thursday 24, 8:00 - 9:00, Schedule (GMT-6)

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[4]Universidade Federal do Parana (UFPR), robertoufs@gmail.com

[5]Universidade Federal Rural de Pernambuco, marcelo.flamarion@ufrpe.br

# Optimized Symbolic Correspondence Analysis for Multi-Valued Variables[1]

*Presentations (30 minutes)*

Arce, Jorge[2]          Rodriguez, Oldemar[3]

*Costa Rica*

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**Resumen/Abstract:** In this paper, we propose Optimized Correspondence Analysis (OCA), this method is an extension of the Symbolic Correspondence Analysis (SDA). OCA is a combination between Symbolic Correspondence Analysis based in interval contingency table and integer optimization methods, the idea is to choose the best matrix of integer values in the interval contingency table, we are interested in studying two different objective functions, the first objective function is minimize distance between projections and the original points, the second objective function is maximizes the explained variance. To resolve this problem we have generalized the concepts of row and column profile to interval's row and interval's column profile respectively and we have created two theorems to find the coordinates of the interval contingency table in all factorial axes. All the methods proposed in this paper can be executed in the RSDA package developed in R.

**Palabras clave / Key words:** Symbolic data analysis, correspondence analysis, multi-valued variables , interval contingency table.

**Referencias/References:**

- Billard, L. and Diday, E. (2006). Symbolic Data Analysis: Conceptual Statistics and Data Mining (United Kingdom: John Wiley & Sons Ltd)Bock, H.-H. and Diday, E. (2000). Analysis of Symbolic Data Exploratory Methods for Extracting Statistical Information from Complex Data (Berlin, Germany: Springer)

- Cazes, P., Chouakria, A., Diday, E., and Schektman, Y. (1997). Extension de l'analyse en composantes principales a des donnees de type intervalle. Statistique Appliquee XLV 3, 5–24

- Arce, J. and Rodriguez, O. (2019). Optimized dimensionality reduction methods for interval-valued variables and their application to facial recognition. Entropy 2019 doi:https://doi.org/10.3390/e21101016

- Takagia, I. and Yadohisab, H. (2011). Correspondence analysis for symbolic contingency tables based on interval algebra. Procedia Computer Science 6, 352–357. doi:10.1016/j.procs.2011.08.065

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# FOURIER ANALYSIS WITH GENERALIZED INTEGRATION[1]

*Short presentations (20 min)*
*Arredondo Ruiz, Juan[2]*
*México*

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**Resumen/Abstract:** We generalize some classical results in Fourier Analysis as the Riemann-Lebesgue lemma, continuity of the Fourier transform function and boundedness of the Fourier transform operator defined as an extension of the classical Fourier transform operator on $L^p(\mathbb{R}^\kappa)$, $1 \le p \le 2$.
**Palabras clave / Key words:** Generalized integration, Fourier Analysis, Bounded variation function.

**Referencias/References:**

- Mathematics 2020, 8(7), 1199; https://doi.org/10.3390/math8071199 - 21 Jul 2020

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[1]Martes/Tuesday 22,10:30 – 11:00,Schedule (GMT-6)
[2]Universidad Autónoma Metropolitana-I, México,iva@xanum.uam.mx

# LOCAL INTERACTIONS INFLUENCE SPREAD OF PREY IN A PREDATOR-PREY SYSTEM WITH GROUP DEFENSE[1]

*Presentations (30 minutes)*

*Arroyo Esquivel, Jorge*[2]        *Hastings, Allan* [3]

*Baskett, Marissa*[4]

*Estados Unidos*

**Resumen/Abstract:** Integrodifference equations are a discrete time spatially explicit model that describes dispersal of ecological populations through space. These models have gained more traction in ecology than continuous time models such as reaction-diffusion equations as reproduction events are usually discrete in nature. This framework is useful to study spread dynamics of organisms and how ecological interactions can affect their spread. While previous analyses often assume all individuals in a population are dispersing equally, some taxa, such as perennial plants or animal populations, have dispersive juvenile stages and limited movement of adult stages. When adults have limited movement, prey may engage in group defense to protect themselves from predation. These local interactions may limit the number of dispersing recruits that are produced, which could have an impact on how fast populations can spread.In this work we present a spatial prey-predator system using an integrodifference framework with limited movement of their adult stages and group defense in prey. We have previously used similar models to explore urchin-kelp interactions and how they affect the spread of kelp. We find that high mortality levels for sessile adults can destabilize prey at carrying capacity. Furthermore, we also find that at high prey densities, group defense leads to a slower local growth of prey in newly invaded regions due to intraspecific competition outweighing the effect of predation in prey growth.

**Palabras clave / Key words:** Integrodifference equations, predator-prey, biological spread.

**Referencias/References:**

- Neubert M.G., Kot M. & Lewis M.A. 1995. Dispersal and Pattern Formation in a Discrete-Time Predator-Prey Model. Theoretical Population Biology, 48(1),7-43.

- Dubois F., Giraldeau L.A. & Grant J.W.A. 2003. Resource defense in a group-foraging context. Behavioral Ecology, 14(1),2-9.

- Arroyo-Esquivel J., Baskett M.L., McPherson M. & Hastings A. 2021. How far to build it before they come? Analyzing the use of the Field o f Dreams hypothesis to bull kelp restoration.

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[1]Miércoles/Wednesday 23,10:30 – 11:00,Schedule (GMT-6)

[2]University of California Davis, jarroyoe@ucdavis.edu USA,

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[4]UC Davis, Davis, CA, USA,mlbaskett@ucdavis.edu

# BÚSQUEDA TABÚ EN PARTICIONAMIENTO CON MÚLTIPLES OBJETIVOS[1]

*Presentations (30 minutes)*
*Bernabé Loranca, María Beatriz[2]*
*México*

**Resumen:** El particionamiento sobre datos geográficos es de gran utilidad para resolver problemas relacionados con Diseño Territorial.Para instancias de tamaño pequeño, este problema incluso es resuelto por métodos exactos en un tiempo de respuesta aceptable. Sin embargo, para instancias de tamaño grande y debido a la naturaleza combinatoria de este problema, la complejidad computacional aumenta y el uso de métodos de aproximación se ha hecho necesario.Un caso en particular de este tipo de problemas que ha tenido nuestra atención en los últimos años es el agrupamiento por particiones para Agebs (Áreas Geoestadísticas Básicas). Algunos trabajos relacionados se han desarrollado para resolver la formación de grupos compactos de Agebs, pero la incorporación de restricciones adicionales ha sido poco tratada. Un problema interesante de aplicación muy demandado, es la extensión del agrupamiento compacto para construir grupos bajo el criterio de homogeneidad y/o balanceo en el número de objetos que componen los grupos. Este problema se traduce en un problema Multiobjetivo, el cual debe lidiar con dos objetivos para conseguir un compromiso entre ambos.Este trabajo presenta un modelo de programación matemática y su asociada implementación para lograr el equilibrio entre compacidad y homogeneidad en la cardinalidad de objetos. La metaheurística incorporada a este problema de agrupamiento territorial multiobjetivo ha sido Búsqueda Tabu. María Beatríz Bernábe Loranca, Carmen Cerón Garnica, Alberto Carrillo Canán, Rogelio González Velázquez, Gerardo Martinez Guzmán

**Palabras clave / Key words:** Búsqueda tabú, compacidad, diseño territorial, Homogeneidad, multiobjetivo, particionamiento.

**Referencias/References:**

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# The Importance of electric inteligence (ELINT) in the estimation and parameterization of electromagnetic pulses detected by electronic warfare support measures (EWSM) [1]

*Short presentations (20 min)*

*Braz Alves, Edgard*[2]          *De Araújo Costa, Arthur Pinheiro*[3]

*Amaral Alves, Jorge*[4]          *De Pina Corriça, José Victor*[5]

*Pires Filho, Jorge Costa*[6]          *Dos Santos, Marcos*[7]

*De Araújo Costa, Igor*[8]

*Brasil*

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**Resumen/Abstract:** Readiness for war is necessary for every powerful navy and depends intrinsically on the technological evolution of its Electronic Warfare (EW) equipment, including electronic warfare support measures (EWSM). With the technological advances of ships and missiles that use the low probability of detection (LPD) and Low Probability of Interception (LPI) radar navigation systems, through Pulse Compression Techniques (PCT), stances for the need of a modern EWSM. A modern EWSM is intrinsically attached with the use of a ELINT equipment combined with Digital Receivers (DRX) to improve the performance and estimation of electromagnetic signals in an environment with low Signal Noise Ratio (SNR) and enable better analysis of parameters of the radar signals received. Therefore, the technological inflection point, which can guarantee the mastery of the EW scenario in a clash, is the use of modern ELINT algorithms. In this work, the application of the Short Time Fourier Transform (STFT) and Autocorrelation Function algorithms applied in EWSM with Digital Receiver will be analyzed. The results of this application and what these bring of new information will be presented in view of the development of EWSM MK3, by the Navy Research Institute (IPQM), which will be installed in the Tamandaré Class Frigates.

**Palabras clave / Key words:** ELINT; MAGE MK3; PCT; Tamandaré Class Frigates; Brazilian Navy.

**Referencias/References:**

- ADAMY, D. L. Tactical Battlefield Communications Electronic Warfare. London: Ed. Artech House, jan. 2009. 348 p.

- ALVES, E. B. MAGE MK3: O futuro da Guerra Eletrônica na MB. Rio de Janeiro: Ed. Centro de Instrução Almirante Wandenkolk, aug. 2020. 15 p

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[1]Martes/Tuesday 22, 14:00 – 14:40,Schedule (GMT-6)

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[3]Marinha do Brasil,Brasil,thurcos91@gmail.com

[4]Escola Naval,Brasil,jorge.amaral@marinha.mil.br

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[8]Universidade Federal Fluminense,Brasil,costa_igor@id.uff.br

- BERNARD, R. L. Electronic Intelligence (ELINT) at NSA. Maryland, USA: Ed. Center for Cryptologic History National Security Agency, 2009. 18 p

- BRITTO, R. M. de. O Parâmetro Amplitude no "Deinterleaving" de Pulsos Radar. Rio de Janeiro: Ed. UFRJ, apr. 2005. 100 p.

- CAROLI, L. H. DAN interviews the General Director of Marine Material - "Força de Submarinos". Interview with Luiz Padilha. Rio de Janeiro, Available in

# LINK BETWEEN FINANCIAL SYSTEM DEVELOPMENT AND ECONOMIC GROWTH IN COSTA RICA: COINTEGRATION AND TIME SERIES ANALYSIS[1]

*Presentations (30 minutes)*
*Brenes, Fabian[2]*       *Chou-Chen, Shu[3]*
*Costa Rica*

**Resumen/Abstract:** This work aims to study the link between the development of the financial system and economic growth in Costa Rica using time series analysis. In this sense, the results of the estimated models show that the effect of economic growth is positive, when the development of the financial system increases, which is in line with some hypotheses from the economic theory. In addition, a baseline scenario for annual gross domestic product (GDP) growth in 2021 is forecasted and then contrasted with the results of a stress scenario simulation analysis.

**Palabras clave / Key words:** VAR models, cointegration, VECM, financial system, economic growth.

**Referencias/References:**

- Engle, R. F. and Granger, C. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica,55(2):251–276.

- Johansen, S. and Juselius, K. (1990). Maximum Likelihood Estimationand Inference on Cointegration — With Applications To theDemand for Money. Oxford Bulletin of Economics and Statistics,52(2):169–210.

- Levine, R. (1997). Financial Development and Economic Growth:Views and Agenda. Journal of Economic Literature, 35(2):688–726.

- Lütkepohl, H. (2005). New Introduction to Multiple Time SeriesAnalysis. Springer, Berlin.

- Pfaff, B. (2008). Analysis of Integrated and Cointegrated Time Serieswith R. Springer, New York.

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[1] Jueves/Thursday 24, 16:50 – 17:10,Schedule (GMT-6)

[2] Universidad de Costa Rica, escuela de estadística, Costa Rica,fabian.brenestrejos@ucr.ac.cr

[3] Universidad de Costa Rica, escuela de estadística, Costa Rica,shuwei.chou@ucr.ac.cr

# AVERAGING 2D STOCHASTIC WAVE EQUATION[1]

*Plenary Talk (60 min)*
*Raúl Bolaños Guerrero*

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**Resumen/Abstract:** We consider a 2D stochastic wave equation driven by a Gaussian noise, which is temporally white and spatially colored described by the Riesz kernel. Our first main result is the functional central limit theorem for the spatial average of the solution. And we also establish a quantitative central limit theorem for the marginal and the rate of convergence is described by the Total-variation distance. A fundamental ingredient in our proofs is the pointwise Lp-estimate of Malliavin derivative, which is of independent interest.

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[1]Lunes/Monday 21, 09:30 – 10:30,Schedule (GMT-6)

# A FIXED POINT THEOREM IN THE SPACE OF INTEGRABLE FUNCTIONS AND APPLICATIONS[1]

*Presentations (30 minutes)*
*Cabral García, Gabriela de Jesús*[2]
*México*

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**Resumen/Abstract:** We give sufficient conditions when a mapping $T : E \to E$ has a unique fixed point, E is a set of measurable functions that isuniformly continuous, closed and convex. The proof of the existence ofthe fixed point depends on a certain type of sequential compactnessfor uniformly integrable functions.The fixed point theorem is applied in the study of the uniqueness andexistence of some Fredholm and Caputo equations.

**Palabras clave / Key words:** Fixed point theorem, uniform integrability, Fredholm equations, Caputo fractional equations, sequential compactness.

**Referencias/References:**

- M. Abtahil, Z. Kadelburg, S. Radenović. (22 junio 2016). Fixed points of Ćirić-Matkowski-type contractions in v-generalized metric spaces. Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas volume, 111, 57-64.

- Siegfried Carl, Seppo Heikkilä . (2010). Fixed Point Theory in Ordered Sets andApplications:From differential and integral equations to game theor. Finlandia:Springer.

- Daniel Hernández-Hernández, José Villa-Morales. (2020). On the minimax theo-rem for the space of probability measures on metric spaces. Banach Publications,122, 159-168.

- Jleli, M., Samet, B. A generalized metric space and related fixed point theorems. Fixed Point Theory Appl 2015, 61 (2015). https://doi.org/10.1186/s13663-015-0312-7

- E. Karapinar. Edelstein type fixed point theorems, Fixed Point Theory Appl. 2012, 107 (2012). https://doi.org/10.1186/1687-1812-2012-107

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# HUMANITARIAN LOGISTICS USING DISTRIBUTED AND COORDINATED AUTONOMOUS AGENT MODELS

*Posters*

*Campos Reyes, María Luisa*[1]          *Sánchez Nigenda, Romeo*[2]

*México*

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**Resumen/Abstract:** Worldwide, the number of natural disasters that occurred between the years 2007 to 2019 amounts to 11,335, with an average of 872 disasters per year, which have left an unfortunate number of 613,800 deaths, with an annual average of 47,215 deaths (Statista, 2019). In addition to the human losses, disasters leave economic consequences which have been 2,182,000 million dollars in recent years. Geological disasters are considered the most dangerous since they occur suddenly, and in many cases there is no way to foresee them. As is the case with earthquakes, which are the fifth type of natural disaster with the most people affected in the years 2007 to 2019, with a total of 85,299,918 people affected worldwide. It is clear that natural disasters are a risk factor for society, so planning the distribution of humanitarian aid is a priority (Hernández, 2019). The objective of this research work is to develop a tool that can be used to design routing plans and load agents (vehicles) to bring basic necessities to different points of demand, in order to satisfy the needs of the affected people immediately after the occurrence of an earthquake. This research is aimed at proposing a humanitarian assistance logistics system model based on Multi-agent Systems, which allows the distribution of products in the event of a disaster in an effective and efficient way, through the coordination of autonomous and coordinated agents that have communication throughout the journey and are able to distribute inputs to meet the demand in disaster areas. Based on the observations made to the history of earthquakes in Mexico, it is intended to demonstrate the importance and usefulness of developing strategies that allow attention in disaster situations. A case study in Mexico is taken as a basis to validate the proposed tools.

**Palabras clave / Key words:** Humanitarian logistics, Multi-agent systems, In-kind aid distribution, Communication.

**Referencias/References:**

- Statista Research Department (2019), Los desastres naturales en el mundo - Datos estadísticos, recurso libre, disponible en https://es.statista.com/temas/3597/desastres-naturales/.

- Hernández, J. (2019), Modelo basado en Sistema Multi-Agente para distribución de ayuda en especie en Logística Humanitaria, Tesis Doctoral, Universidad Autónoma de Nuevo León.

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[1]Universidad Autónoma de Nuevo León,México,maria.camposry@uanl.edu.mx
[2]Universidad Autónoma de Nuevo León, México,romeo.sanchezng@uanl.edu.mx

# ANÁLISIS TEMPORAL DEL CRECIMIENTO DEL PARQUE VEHICULAR EN SAN SALVADOR Y MUNICIPIOS ALEDAÑOS[1]

*Short presentations (20 min)*
*Campos Granados, Walter Otoniel[2]*
*El Salvador*

**Resumen:** En los últimos años El Salvador ha experimentado un incremento sustancial del parque vehicular, el cual es evidente en las carreteras del país, pero sobre todo en el área metropolitana. Debido a esto, en las calles de San salvador capital, se producen fuertes congestionamientos diarios, con todas las dificultades que dicha situación implica. En este artículo, realizamos un análisis temporal a través de series de tiempo,realizando proyecciones para los próximos 4 años del crecimiento del parque vehicular en dicha zona. Las políticas públicas y decisiones para el sector transporte y redes viales metropolitanas, pueden apoyarse en los datos y pronósticos fehacientes aquí presentados.
**Palabras clave / Key words:** Series de tiempo; vehículos; motocicletas; predicciones.

**Referencias/References:**

- Shumway, R., Stoffer, D. (2011), Time series analysisand its applications, (3rd ed.). New York: Springer.Peña, D. (2005), Análisis de series temporales, Madrid:Alianza.

- Brockwell, P., Davis, R. (2010), Introduction totime series and forecasting, New York: Springer.Mauricio, J. (2010), Análisis Univariante de SeriesTemporales, Madrid.

- Tsay, R. (2010), Analysis of financial time series,Cambridge, Mass.Wiley.Data Science Toolkit, URL: http://www.datasciencetoolkit.org/about, Octubre2020.

- Rstudio.github.io. (2020), Leaflet For R - Introduction,URL: `http://rstudio.github.io/leaflet,Octubre2020`

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# Ellipticity criteria for random walks in i.i.d. random environments[1]

*Presentations (30 minutes)*
*Campos, José David[2]*
*Costa Rica*

**Resumen/Abstract:** We introduce ellipticity criteria for random walks in i.i.d. random environments under which we can extend the ballisticity conditions of Sznitman and the polynomial effective criteria of Berger, Drewitz and Ramírez originally defined for uniformly elliptic random walks. We furthermore give ellipticity criteria under which a random walk satisfying the condition $(T)$, is ballistic, satisfies the annealed central limit theorem or the quenched central limit theorem.
**Palabras clave / Key words:** Environment, Ballisticity, Ellipticity, Random Walk.

**Referencias/References:**

- Campos, D., Ramírez, A. (2014). Ellipticity criteria for ballistic behavior of randomwalks in random environment. Probab. Theory Relat. Fields, 160,189–251.

- Drewitz, A., Ramírez, A. (2014). Selected topics in random walks in random environment. Topics in percolative and disordered systems, 23–83, Springer Proc. Math. Stat., 69, Springer, New York.

- Guerra, E., Ramírez, A. (2020). A proof of Sznitman's conjecture about ballistic RWRE. Comm. Pure Appl. Math, 73, 2087-2103 (2020).

- Sznitman, A.S. (2004). Topics in random walks in random environment. School and Conference on Probability Theory, 203-266 ICTP Lect. Notes, XVII, Abdus Salam Int. Cent. Theoret. Phys., Trieste.

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[1]Martes/Tuesday 22, 09:50 – 10:30,Schedule (GMT-6)
[2]Universidad de Costa Rica,Facultad de Ciencias,Escuela de Matemática,Costa Rica,josedavid.campos@ucr.ac.cr

# Mathematical Models in Evoked Potential Analysis

*Posters*

*Cardo, Romina*[1]        *Corvalan, Alvaro*[2]

*Argentina*

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**Resumen/Abstract:** In this paper we will present some results that we have been able to observe from the numerical treatment of brain signals obtained from the classical measurement of the potential deflections in cranial electrodes, as in standard measurements of EEG (electroencephalograms) or ERP (evoked potentials by events), but originated in relation to the semantic processing of the brain when listening to verbal stimuli in logical and sometimes equivocal occasions.We present various methods, including Kalman Filters (with a Bayesian approach), Wavelets, Unsupervised Learning, Artificial Neural Networks and Hidden Markov Models allow, on the one hand, to extract information about the brain's interpretation and analysis of stimuli, and on the other hand to elaborate models that can partially emulate said treatment and, if necessary, be used for plausible predictions.Keywords: evoked potentials, Kalman Filters, wavelets, neural networks, hidden Markov models, Q-learning algorithm, Gaussian and non-Gaussian noises.
**Palabras clave / Key words:** Noises, Wavelets, Kalman, Markov, Q-learning.

**Referencias/References:**

- Cardo, R (2019) Tratamiento específico de Señales Biológico-Cerebrales (métodos y algunos problemas). Tesis doctoral.

- Cardo, R - Corvalán, A, (2011) Identification of the responses of brain and artificial neural networks in the presence of usual and unusual stimuli by means of Kalman-type filters, Revista de Matemática: Teoria y Aplicaciones, CIMPA. ISSN 1409-2433 ( XVII Simmac 2010 )

- Kalman, R.E. (1960) "A new approach to linear Öltering and prediction problems", Journal of Basic Engineering 82(1): 35-45.

- Gershenfeld, N. (2006) The Nature of Mathematical Modeling. Cambridge University Press, Cambridge.

- Linden, D.E.J. (2005) ìThe P300: where in the brain is it produced and what does it tell us?", The Neuroscientist Review 11(6): 1073-8584.

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# Estimation and Validation in Statistical Modeling of two Non Negative Random Variables given Explanatory Variables based Bivariate Subcopula[1]

*Presentations (30 minutes)*

*Castillo, Luis Eduardo*[2]

*Colombia*

**Resumen/Abstract:** Based on the Theory of Copulas, from a theoretical and practical approach, the estimation of parameters by Maximum Likelihood and validation of a statistical model that explains together the Non Negative Random Variables given to set of explanatory variables based in Subcopulas will be proposed. Simulated examples are presented.

**Palabras clave / Key words:** Mathematical Statistics, Statistical Modeling, Copulas Theory, Subcopulas.

**Referencias/References:**

- Erdely, A. (2017), A subcopula based dependence measure, Kybernetika 53 (2), 231 - 243.

- Joe, H., (2014), Dependence Modeling with Copulas, CRC Press Nelsen, R. B., (2006), An Introduction to Copulas, Vol. 139, Springer, New York

- Rachasingho J., Tasena, S., (2017), Metric Space of Subcopulas, Thai Journal of Mathematics, ISSN 1686-0209, 35 - 44.

- Rachasingho J., Tasena, S., (2020), A metric space of subcopulas - An approach via Hausdorff distance, Fuzzy Sets and Systems

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[1]Miércoles/Wednesday 23, 9:00 – 9:40,Schedule (GMT-6)

[2]Universidad Distrital Francisco José de Caldas, Facultad de Ingeniería, Proyecto Curricular de Ingeniería Catastral y Geodesia, Universidad Nacional de Colombia, Facultad de Ciencias Departamento de Estadística,Colombia, lecastillom@udistrital.edu.co

# On Outliers Detection and Censored Samples [1]

*Short presentations (20 min)*

Castro Kuriss, Claudia Adriana[2]        Leiva Sánchez, Víctor[3]

*Argentina*

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**Resumen/Abstract:** The study of outliers is an old problem for investigators, first attempting to establish a definition, then trying to identify possible observations of this kind, and then finding strategies to deal with this abnormal data. Nowadays we have the possibility to study data with the aid of computer science which make easier the problem of detecting few observations that behave in a different way or proceed from a different mechanism from the rest. See Hawkins [6] for definitions and genesis of outliers. It´s still an investigation issue because clearly all the fields of science need to understand and handle outliers or hotspots, i. e. observations that are different in some way from the other observations in a sample, and they are important in applied statistics, in data mining, in machine learning, in quality control, etc. Barnett and Lewis[9] made a good review of the field and defined "discordant" observations as those "statistically unreasonable" considering a probabilistic model for the data which are not necessarily outliers, and considered tests for "discordancy". While there is a general temptation to remove outliers from the data, usually unusual observations give us a better understanding of our problem or give us a clue of where the problem is. Aggarwal [1] cited credit card fraud detection, sensor events, medical diagnosis, and intrusion detection systems among other specific examples of the relevance of studying the nature and detection of outliers. Rousseeuw and Leroy [8] discuss robust procedures for detecting and handle outliers specially in regression analysis. There are several proposals of hypothesis tests to detect one or more outliers in complete samples from normal population such as the well-known Dixon´s [3][4], Grubbs´ [5], Tietjen-Moore test [9], Rosner test [7] and chi-squared tests among others. And, more recently, in complete samples from other specific distributions in the location-scale family. Even boxplots, histograms and Quantile-Quantile graphs can be regarded as tools for detecting non typical observations. The problem becomes more difficult when censoring is present. There are tests for singly and doubly censored samples from normal, exponential, Weibull and other particular distributions from the location-scale family. The object of this work is to make a review of some of the several and useful tests for one or multiple outliers and to propose a formal test with a graphical application to determine the presence of outliers in censored samples from any given distribution from the location-scale family.

**Palabras clave / Key words:** Outliers, Outlier detection, Censored samples.

**Referencias/References:**

- Aggarwal, C. (2013) "Outlier analysis". Springer. New York.

- Barnett, V. and Lewis, T. (1994) "Outliers in Statistical Data". Wiley & Sons. New York.

- Dixon, W. J. (1951). "Ratios involving extreme values". The Annals of Mathematical Statistics, 22(1), 68-78.

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[1]Miércoles/Wednesday 23, 15:00 – 15:20,Schedule (GMT-6)

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[3]Pontificia Universidad Católica de Valparaíso, PUCV, Escuela de Ingeniería Industrial. Valparaíso, Chile, victorleivasanchez@gmail.com

- Dixon, W. J. (1950) "Analysis of extreme values". The Annals of Mathematical Statistics, 21(4), 488-506.

- Grubbs, F. E. (1950) "Sample Criteria for testing outlying observations". The Annals of Mathematical Statistics, 21(1), 27-58.

# EL ALGORITMO GODEC Y SU APLICACION AL PROCESAMIENTO DE VIDEOS[1]

*Presentations (30 minutes)*

*Chavarría-Molina, Jeffry Gerardo*[2]          *Fallas Monge, Juan José*[3]

*Soto-Quirós, Juan Pablo*[4]

*Costa Rica*

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**Resumen:** Dada $X \in \mathbb{R}^{m \times n}$ una matriz densa, el algoritmo iterativo GoDec, emplea la descomposición en valores singulares (SVD) de $X$ para determinar dos matrices $L \in \mathbb{R}^{m \times n}$ y $S \in \mathbb{R}^{m \times n}$ tales que $X \approx S + L$, donde $L$ es de rango reducido y $S$ es una matriz dispersa. Esto es, determinar $L$ y $S$ tales que:

$$\min_{r(L) \leq r_0; \ Card(S) \leq k_0} \|X - L - S\|_{fr}^2$$

El algoritmo GoDec se puede aplicar para la detección de movimientos en un video grabado sobre un fondo estático, para obtener dos videos nuevos, uno con el fondo libre de los objetos en movimiento (construido con $L$) y otro en donde únicamente se muestren los objetos en movimiento, sin el fondo (construido con $S$). Se presenta una mejora (en términos de cantidad de cálculos y tiempo de ejecución) del método GoDec al sustituir la descomposición en valores singulares (SVD) por el método `BRP` (*bilateral random projection*).En esta ponencia se realizará una revisión breve del método y su aplicación al procesamiento de vídeos. Además, se realizará una comparación del rendimiento entre la forma clásica usando la SVD y la mejora basada en el método `BRP`.

**Palabras clave / Key words:** GoDec, SVD, BRP, Proyección aleatoria bilateral .

**Referencias/References:**

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[1]Martes/Tuesday 22, 16:30 – 17:00,Schedule (GMT-6)

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# A FULLY-DG METHOD FOR THE STATIONARY BOUSSINESQ SYSTEM[1]

*Presentations (30 minutes)*
*Colmenares, Eligio Antonio[2]*
*Chile*

**Resumen/Abstract:** In this work we present and analyze a finite element scheme yielding discontinuous Galerkin approximations to the solutions of the stationary Boussinesq system for the simulation of non-isothermal flow phenomena. The model consists of a Navier-Stokes type system, describing the velocity and the pressure of the fluid, coupled to an advection-diffusion equation for the temperature. The proposed numerical scheme is based on the standard interior penalty technique and an upwind approach for the nonlinear convective terms and employs the divergence-conforming Brezzi-Douglas-Marini (BDM) elements of order k for the velocity, discontinuous elements of order k-1 for the pressure and discontinuous elements of order k for the temperature. Existence and uniqueness results are shown and stated rigorously for both the continuous problem and the discrete scheme, and optimal a priori error estimates are also derived. Numerical examples back up the theoretical expected convergence rates as well as the performance of the proposed technique.

**Palabras clave / Key words:** Boussinesq equations, finite element methods, discontinuous Galerkin method, divergence-conforming elements, fixed-point theory, a priori error analysis.

**Referencias/References:**

- Arnold D. N. (1982). ."An interior penalty finite element method with discontinuous elements". SIAM J. Numer. Anal. 19 (4), 742-760.

- Cockburn B., Kanschat, G., Schötzau D. (2005). ."A locally conservative LDG method for the incompressible Navier-Stokes equations". Math. Comp. 74, 1067-1095.

- Colmenares, E., Neilan, M. (2016). "Dual-mixed formulations for the stationary Boussinesq problem. Computers & Mathematics with Applications 72, 1828-1850.

- Oyarzúa, R., Qin, T. Schötzau, D. (2014). ."An exactly divergence-free finite element method for a generalized Boussinesq problem". IMA J. Numer. Anal. 34 (3), 1104-1135.

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# AHP-Gaussian aligned with Value Focused Thinking for strategical decision making in Brazilian Airforce load plane purchasing[1]

*Short presentations (20 min)*

*Raphael Nascimento dos Santos*[2]       *Marcos dos Santos*[3]

*Leandro de Mattos Bento Soares*[4]

*Brazil*

**Resumen/Abstract:**

The Brazilian Government issued an intention to acquire two large cargo aircraft for use by the Brazilian Air Force, highlighting the tactical importance of transporting troops, armaments and supplies in war missions in a long-distance theater of operations, as well as its use in humanitarian support relief missions. The lack of these aircraft in the FAB fleet was intensified by the advent of the Covid-19 pandemic, which required the support of the Air Force in the repatriation of Brazilians who were in China and in the search for Aztrazeneca/Oxford vaccines in India, where in the first smaller FAB aircraft were used, resulting in a slow trip with several stopovers, and the second used large cargo aircraft that belonged to Brazilian airlines. This article proposes a multi-methodological approach with the combination of the Strategic Decision Framework and the AHP Gaussian (AHP-G) multi-criteria method to aid decision making on the best aircraft alternative and elimination of empirical methods of choice. The model was built considering two scenarios, considering the acquisition of new freighter aircraft and the acquisition of passenger aircraft used for subsequent conversion into freighters.

**Palabras clave / Key words:** Multicriteria Decsion Making; Supplier Selection; AHP-G

**Referencias/References:**

1 Baldini, F., Santos, M. , Coelho, L. S., Mariani, V. C. AHP Gaussiano em VBA (.1), 2021.

2 BELTON, Valerie; GEAR, Tony. On a short-coming of Saaty's method of analytic hierarchies Omega, v. 11, n. 3, p. 228-230, 1983.

3 BHUTTA, Khurrum S.; HUQ, Faizul. Supplier selection problem: a comparison of the total cost of ownership and analytic hierarchy process approaches. Supply Chain Management: an international journal, 2002.

4 BRASIL.Ministério da Defesa Comando da Aeronáutica. DCA 1-1 Doutrina Básica da ForÃ§a Aérea Brasileira, vol 2. 2020.

5 BRASIL. Ministério da Defesa. Estratégia Nacional de Defesa , 2012. Available at::, Accessed in: 25/09/2021.

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[1]Lunes/Monday 21, 16:00 – 16:30,Schedule (GMT-6)

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# Modelación de medios filtrantes aplicando diagramas de Voronoi-Laguerre[1]

*Short presentations (20 min)*

*Duarte Rivera, Roberto*[2]      *Destephen, Jorge*[3]

*Honduras*

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**Resumen/Abstract:** The separation of polluting particles from liquids and gases is a crucial industrial process used in industries like semiconductors, lubrication systems, water purification, and cleaning the air from dust and viruses.This work presents a computational model of a filter medium constructed applying Voronoi-Laguerre diagrams to represent non-woven fibrous materials. The fibrous filter is modeled as a multi-layered medium with a network of pores. This filter model agrees with the assumption made when estimating the pore size distribution of filter materials, like polyesters and celluloses, with the bubble point test, which is the technique commonly used in the industry of non-woven filtration materials. The 3D filter model is built from measured material properties, such as porosity, mean fiber diameter, thickness, and pore size distribution. With this filter model, we can implement several filtration mechanisms, and the simulations of the movement of the particles could be deterministic or stochastic. In this work, the material computational model is used to carry out Monte Carlo simulations, applying basic filtration mechanisms. As a first stage, simulations of filtration processes included the following interactions: particle-pore, particle-fiber, and particle-particle.The filter efficiency calculations, for different pore and particle size distribution, agrees with general filtration theory. The model made it possible to track and locate the captured particles in pores or fibers, which allows visualizing the structure of the filter medium with the particles in three dimensions. It also allows estimating topological properties of the medium, such as tortuosity and connectivity. The simulations developed in R estimate the efficiency of the filters material under certain process conditions and with statistical analysis. At this stage of the research, no comparisons with experimental data have been made.

**Palabras clave / Key words:** Filtration modeling, filter modeling, non-woven materials, Monte Carlo Method, Voronoi-Laguerre Diagrams.

**Referencias/References:**

- Burtseva, L., Werner, F., Salas, B. V., Pestryakov, A., Romero, R., and Petranovskii, V. (2015). Modeling of the material structure using Voronoi diagrams and tessellation methods. Univ., Fak. für Mathematik.

- Destephen, J. A. and Choi, K. J. (1996). Modeling of filtration processes of fibrous filter media. Separations Technology, 1996. 6(1): p. 55–67, Elsevier.

- N. Pan and W. Zhong (2006). Fluid Transport Phenomena in Fibrous Materials. Textile Progress, 2006 – Taylor & Francis.Rubeinstein, R. Y., & Kroese, D. P. (2016). Simulation and the Monte Carlo Method (Vol. 10). John Wiley &Sons.

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[1]Miércoles/Wednesday 23, 15:00 – 15:30,Schedule (GMT-6)

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[3]Departamento de Matemática Aplicada UNAH, Honduras, jorge.destephen@unah.edu.hn

- Sambaer, W., Zatloukal, M., Kimmer, D. (2011). 3D modeling of filtration process via polyurethane nanofiber based nonwoven filters prepared by electrospinning process. Chemical Engineering Science, Volume 66, Issue 4, 15 February 2011, Pages 613-623, Elsevier.

# Enumerating triangular modular curves of small genus[1]

*Presentations (30 minutes)*
*Duque Rosero, Juanita*[2]
*Estados Unidos*

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**Resumen/Abstract:** Triangular modular curves are a generalization of modular curves that arise from quotients of the upper half-plane by congruence subgroups of hyperbolic triangle groups. These curves arise from Belyi maps with monodromy $PGL_2(\mathbb{F}_q)$ or $PSL_2(\mathbb{F}_q)$. In this talk, we will present a computational approach to enumerate all triangular modular curves of genus 0, 1, and 2. This is joint work with John Voight.

**Palabras clave / Key words:** Number theory.

**Referencias/References:**

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# CHAOTIC BEHAVIOR OF GEODESICS IN KERR-LIKE SPACETIME[1]

*Presentations (30 minutes)*

*Adrián Eduarte[2]          Francisco Frutos[3]*

*Rodrigo Carboni[4]*

*Costa Rica*

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**Resumen/Abstract:** Recently, it has been published several solutions of Einstein's Field Equations (EFE) which models the spacetime surrounding massive and non-spherical bodies. In this paper, we study the motion of unitary mass test particles in Kerr-like with quadrupole mass moment metric which is a perturbed, non-integrable Kerr metric by using simulations in the configuration space and in the phase space. This metric represents the spacetime outside of a massive non-spherical body by the quadrupole mass moment $q$. As the $q$ parameter increases the chaotic behavior arises. We calculate the rotation number for the axis of symmetry $p_r = 0$ in the corresponding Poincaré subsection and show the existence chaotic regions in the high gravity region near the source's event horizon.

**Palabras clave / Key words:** Chaos, Geodesics, Poincaré subsection.

**Referencias/References:**

- Frutos-Alfaro, F. (2016). Approximate Kerr-Like Metric with Quadrupole, International Journal of As-tronomy and Astrophysics, 6, 334–345.

- Contopoulos, G., Lukes-Gerakopoulos, G., Apostolatos, T. A. (2011). Orbits in a Non-Kerr Dynamical System, International Journal of Bifurcation and Chaos, 21(08), 2261–2277.

- Lukes-Gerakopoulos, Georgios. (2012). Nonintegrability of the Zipoy-Voorhees metric, Phys. Rev. D,86.

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[1]Martes/Tuesday 22, 8:00 –8:40,Schedule (GMT-6)

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[3]Universidad de Costa Rica, Costa Rica,frutos62@gmail.com

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# INTRODUCTION TO SHINY[1]

*Short courses or Workshops (3 hours)*
*Carlos Andres Erazo[2]*
*Colombia*

**Resumen/Abstract:** In data science, the process of dissemination brings with a common problem: the channel for presenting information. Shiny is an R package that extends this language and brings the possibility of building interactive web applications without moving away from R's own scripts, so its learning curve does not extend in the same way that web development would require directly, the final solution can facilitate the transmission of ideas and analysis in numerous fields from research to teaching with results such as MEPHAS (Zhou, Y. et al., 2020) for statistical analysis or MVC1_R(Antonelli, T. et al., 2020)as a complement to students in multivariate calibration. By means of reactive programming (Oviedo, 2015), Shiny links input and output values, allowing the creation of interfaces for algorithms and tables, and by applying this package, it is possible to present data through a page that allows dynamic exploration without having to manipulate code, and to share these developments in a fast and flexible way, extending the usual data visualization. This course follows the model of the Shiny subsection on the official Rstudio website and is proposed to give an approach to how to build an application with shiny, how to extend and take advantage of reactive programming in the solution and finally how to manage the appearance of the web application with the basic use of HTML and CSS.

**Palabras clave / Key words:** data science, Shiny, RStudio, web application, data visualization

**Referencias/References:**

- Zhou, Y. Mizutani,S.Takagi,T. Leung, S. Tian, Y.2020.MEPHAS: An interactive graphicaluser interface for medical and pharmaceutical statistical analysis with R and Shiny.

- Antonelli, T. Olivieri, A.2020.Developing and Implementing an R Shiny Application to IntroduceMultivariate Calibration to Advanced Undergraduate Students.

- Oviedo, M. 2015.Shiny: crear una aplicación web interactiva

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[1]Lunes/Monday 21, 16:00 – 17:00,Schedule (GMT-6), Martes/Tuesday 22, 8:40 – 9:40,Schedule (GMT-6), Miércoles/Wednesday 23, 14:00 – 15:00,Schedule (GMT-6)

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# APROXIMACIÓN DE LA MATRIZ DE RANGO BAJO MEDIANTE PROYECCIONES BILATERALES ALEATORIAS Y SU APLICACIÓN A LA COMPRESIÓN DE IMÁGENES[1]

*Presentations (30 minutes)*
*Juan José Fallas Monge*[2]      *Juan Pablo Soto Quirós*[3]
*Jeffry Chavarría-Molina*[4]
*Costa Rica*

**Resumen/Abstract:**

La aproximación de rango bajo de una matriz $L \in \mathbb{R}^{m \times n}$ es un problema de optimización que busca aproximar a $L$ con una matriz $\widehat{L}_r \in \mathbb{R}^{m \times n}$ tal que

$$\|L - \widehat{L}_r\|_{fr}^2 = \min_{L_r \in \mathbb{R}_r^{m \times n}} \|L - L_r\|_{fr}^2 \tag{1}$$

Si $L = U_L \Sigma_L V_L^T$ es la descomposición en valores singulares (SVD) de $L$, entonces $\widehat{L}_r$ queda determinada por la SVD $r$-truncada , i.e,:

$$\widehat{L}_r = \lfloor L \rfloor_r = U_{L,r} \Sigma_{L,r} V_{L,r}^T \tag{2}$$

La SVD es altamente precisa, pero tiene una alta complejidad computacional para matrices grandes. Por ese motivo, en la presente ponencia se expondrá sobre un método alternativo para calcular la matriz $\widehat{L}_r$, denominado *proyecciones aleatorias bilaterales* (bilateral random projection method), el cual fue desarrrollado por y mejorado mediante un esquema de potencias, bajo ciertas condiciones de invertibilidad, por Zhou and Tao . En se extiende el esquema de potencias introducido por Zhou and Tao, relajando las condiciones de invertibilidad. A partir de ese hecho y aplicando la descomposición $QR$ de cierta matriz, se mostrará una fórmula que permite aproximar la matriz $\widehat{L}_r$, con tiempos de ejecución mucho menores que los generados con la SVD. En la parte final de la exposición se mostrará una aplicación concreta asociada a la compresión de imágenes.

**Palabras clave / Key words:** Aproximación de rango bajo, SVD, proyecciones aleatorias bilaterales, compresión de imágenes

**Referencias/References:**

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[1]Martes/Tuesday 22, 16:00 – 16:30Schedule (GMT-6)

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[4]Instituto Tecnológico de Costa Rica,Costa Rica, jchavarria@itcr.ac.cr

# A CONTINGENT CLAIMS APPROACH FOR COMPUTING THE PREMIUM TO ENSURE AN INVESTMENT IN HIGHWAYS[1]

*Presentations (30 minutes)*

*Fernandez Arias, Ernesto*[2]       *López Barrientos, José Daniel*[3]

*México*

To ensure an investment in highways a company has offered to pay to the administrator of a certain highway a premium of E if the average daily number of cars travelling on the highway exceeds at least twice a year a barrier of B cars per month. We show how to compute the fair price of such payment by means of presenting the pseudo-code and the calibration to value a financial instrument that replicates the phenomenon under the assumption that the daily traffic flow on the highway is a log-Normal random variable. Finally, we use the principles of the greeks in options tradingt o determine the sensitivity of the premium to changes in the parameters of the model.

**Palabras clave / Key words:** Contingent claims, greeks.

**Referencias/References:**

- Black, F., and Scholes, M. The pricing of options and corporate liabilities. The Journal of PoliticalEconomy 81(3) (1973), 637-654.

- Herrasti, A. Factor de Estacionalidad. C4P1T4L, 2020.

- Herrasti, A. Spreadsmap v01. C4P1T4L, 2020.[4]

- Higham, D. An algorithmic introduction to numerical simulation of stochastic differential equations. SIAMReview 43(3) (2001), 525-546.

- Higham, D. An introduction to Financial option valuation. Cambridge University Press, New York, USA,2004

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[1]Jueves/Thursday 24, 16:00 – 16:30,Schedule (GMT-6)

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# GRAVITY-CAPILLARY FLOWS OVER OBSTACLES FOR THE FIFTH-ORDER FORCED KORTEWEG-DE VRIES EQUATION[1]

*Presentations (30 minutes)*
*Marcelo Velloso Flamarion Vasconcellos*[2]
*Brazil*

**Resumen/Abstract:** In this talk, we discuss gravity–capillary waves resonantly excited by two submerged obstacles in a shallow water channel. In the weakly non-linear regime, the forced fth-order Korteweg-de Vries equation arises as a model for the free-surface displacement. The water surface is initially taken at rest over a uniform ow and the initial value problem for this equation is computed numerically using a pseudospectral method. We study nearly-resonant ows with intermediate capillary effects. Details of the wave interactions are analyzed for obstacles of different sizes. Numerical results indicate that the ow is not necessarily governed by the larger obstacle.

**Palabras clave / Key words:** Water waves, Gravity–capillary waves, KdV equation, Solitary waves

**Referencias/References:**

1 Flamarion, M. V. & Ribeiro-Jr, R. (2021) Trapped solitary-wave interaction for Euler equations with low pressure region. Comp. Appl. Math. 40:20.

2 Flamarion, M. V. & Ribeiro-Jr, R. (2021) Gravity-capillary flows over obstacles for the fifth-order forced Korteweg-de Vries equation. J. Eng. Math. 129:17.

3 Flamarion, M. V. & Ribeiro-Jr, R. (2021) Solitary water waves interactions for the forced Korteweg-de Vries equation. Comp. Appl. Math. 40:312.

4 Flamarion, M. V. (2022) Generation of trapped depression solitary waves in gravity-capillary flows over an obstacle. Comp. Appl. Math. 41:31.

5 Flamarion, M. V. & Ribeiro-Jr, R. (2022) Gravity-capillary wave interactions generated by moving disturbances. J. Eng. Math. 132:21.

# AN ALGORITHM FOR DIFFERENTIATING COMPOSITE FUNCTIONS WITH A VECTOR ARGUMENT REPEATEDLY[1]

*Short presentations (20 min)*

*Mauricio Flores[2]*      *Guillermo Fernandez-Anaya[3]*

*F. F. Reyes-Luz[4]*

*México*

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**Resumen/Abstract:** In classical calculus to obtain the n-th derivative of a product of functions, the Leibniz rule canbe used, however the problem is modified when composite functions are considered, for this type ofcase the formula of Faa di Bruno. There is a third case when compound functions receive a vectoras an argument. A proposed solution is described by Mishkov, the solution process requires longcalculations and the solution of several linear equations. In the context mentioned above, this workproposes a simple and simplified form for when compound functions receive a vector as an argument,by means of an algorithm that allows obtaining an expression for the derived n-th, using techniqueswith matrices and notation of tensors. The proposed algorithm is coded in a high-level language andan analysis of its degree of complexity is carried out to identify whether it is computable, by countingthe simple instructions of the algorithm, using the big O notation.

**Palabras clave / Key words:** Algorithm complexity, derivative, matrices, tensors

**Referencias/References:**

- D. Mazkewitsch, The n-th derivative of a product, The American Mathematical Monthly70 (7) (1963)739–742.UI

- R. L. Mishkov, Generalization of the formula of faa di bruno for a composite functionwith a vector argument,International Journal of Mathematics and Mathematical Sciences24 (7) (2000) 481–491.

- G. M. Constantine, T. H. Savits, A multivariate faa di bruno formula with applications,Transactions of theAmerican Mathematical Society 348 (2) (1996) 503–520.URL http://www.jstor.org/stable/2155187

- M. Dalarsson, N. Dalarsson, Tensors, Relativity, and Cosmology,`https://books.google.com.mx/books?id=KZOZBgAAQBAJ14ElsevierScience,`2015

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# Modeling Glucose Homeostasis Using OGTT Data: A Bayesian Approach[1]

*Presentations (30 minutes)*
*Hugo Flores-Arguedas[2]*
*México*

**Resumen/Abstract:** This paper proposes a Bayesian approach to determine transition zones from healthy patients to diabetic patients. We model glucose homeostasis by an ordinary dierential equation system that describes glucose-insulin-glucagon dynamics. From OGTT data, we infer five parameters related to insulin secretion, glucagon secretion, gastrointestinal emptying, and basal glucose level. Combining a machine learning algorithm and the posterior distribution of two parameters, we have determined two-dimensional ranges that describe a progression from healthy to an impaired condition. This approach includes several sources of uncertainty, allowing to obtain a region instead of a single value indicator.

**Palabras clave / Key words:** OGTT, Bayesian, Type 2 Diabetes

**Referencias/References:**

- Ajmera, I., Swat,M., Laibe,C., Le Novere,N., and Chelliah, V. (2013). The impact of mathematical modeling on the understanding of diabetes and related complications. CPT: pharmacometrics & systems pharmacology, 2(7):1-14.

- Salinari,S., Bertuzzi,A., and Mingrone, G (2011). Intestinal transit of a glucose bolus and incretin kinetics: a mathematical model with application to the oral glucose tolerance test. American Journal of Physiology-Endocrinology and Metabolism, 300(6):E955-E965.

- Nauck, M., Stockmann, F., Ebert,R., and Creutzfeldt,W.(1986) Reduced incretin effect in type 2 (non-insulin-dependent) diabetes. Diabetologia, 29(1):46-52.

- Flores-Arguedas, H, and Capistrán, M.A. (2021). Bayesian analysis of glucose dynamics during the oral glucose tolerance test (ogtt). Mathematical Biosciences and Engineering, 18(4):4628-4647.

- Sakaguchi, K., Takeda,K., Maeda,M., Ogawa,W., Sato,T.,Okada,S., Ohnishi,Y., Nakajima,H., and Kashiwagi,A. (2016) Glucose area under the curve during oral glucose tolerance test as an index of glucose intolerance. Diabetology international, 7(1):53-58.

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[1]Miércoles/Wednesday 23, 14:00 – 14:30,Schedule (GMT-6)

[2]Universidad Nacional Autónoma de Mexico,Instituto de Matemáticas, México, hflores@im.unam.mx

# Identificación aproximada de señales en reconocimiento de patrones mediante la descomposición en modo dinámico (DMD) y la teoría de Koopman[1]

*Short presentations (20 min)*
*William Alberto Funez Izaguirre[2]*
*Honduras*

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**Resumen/Abstract:** In this work we apply a signal identification system that uses the dynamic mode decomposition algorithm (DMD), it is based on proper orthogonal decomposition (POD), which uses computationally efficient singular value decomposition (SVD) so that it scales good for providing dimensionality reduction in high dimension systems. DMD is a technique that allows the extraction of dynamically relevant flow characteristics from experimental or numerical data, for which a comparison is made with the principal component analysis (PCA) technique and it is shown that the results obtained by DMD are very good. We also consider the application of Koopman's theory to Schrödinger's nonlinear partial differential equation where we show that the observables chosen to construct the Koopman operator are fundamental to allow a good approximation to nonlinear dynamics. If such observables can be found, then the dynamic mode decomposition algorithm can be applied to compute a finite-dimensional approximation of the Koopman operator, including its eigenfunctions, eigenvalues, and Koopman modes.

**Palabras clave / Key words:** Singular value decomposition, dynamic mode decomposition, koopman operator

**Referencias/References:**

- Brunton, S. L., y Kutz, J. N. (2014). On dynamic mode decomposition: Theory and applications. Nonlinear Dynamics, 1(2), 391-421.

- Koopman, B. O., y v. Neumann, J. (1932). Dynamical systems of continuous spectra. Proceedings of the National Academy of Sciences, 18(3), 255-263.

- Mezić, I. (2005). Spectral properties of dynamical systems, model reduction and decompositions. Nonlinear Dynamics, 41(3), 309-325.

- Schmid, P. (2010). Dynamic mode decomposition of numerical and experimental data. Journal of Fluid Mechanics.

- Vides, F. (2021). Numerical methods and computational modeling. Honduras. `https://cadds-lab.github.io/HPCMModeling.html`

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[1]Martes/Tuesday 22, 14:40 – 15:00,Schedule (GMT-6)

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# FAST MULTISCALE CONTRAST INDEPENDENT PRECONDITIONER FOR LINEAR ELASTIC TOPOLOGY OPTIMIZATION PROBLEMS[1]

*Presentations (30 minutes)*
*Juan Galvis*[2]
*Colombia*

**Resumen/Abstract:** Juan Galvis, Boyan Lazarov, Sintya Serrano, Miguel ZambranoWe study efficient algorithms for the solution of the elasticity equation posed in a domain that represents a material with properties that may vary several orders of magnitude over different scales. Here we focus on the application of the domain decomposition and multiscale approximations to topology optimization problems. Topology optimization consists in finding the efficient use of materials in different settings. In particular we consider the density formulation of the minimum compliance design. In the optimization procedure, an elasticity equation where the material properties are scaled by $E_0$ outside stiff regions; where $E_0$ is a positive regularization parameter with $E_0 < 1$. In order to solve this problem we can run an optimizer that requires, in each iteration, the solution of a finite element elasticity equation that (after a few iterations) will have high-contrast properties. Most of the computation time is spent in the solution of the linear system needed to compute the next density iterate. The time spent in computing an instance of this elasticity equation may depend on the contrast $1/E0 > 1$. In this work we design robust solvers for this elasticity equation. We use the recently introduced Generalized Multiscale Finite Element methods framework in order to construct robust methods (but adapted to the elasticity equation).

**Palabras clave / Key words:**

**Referencias/References:**

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# CLASS NUMBER FORMULA BASED ON THE FLOOR OF A NUMBER[1]

*Short presentations (20 min)*
*Jorge Garcia*[2]
*USA*

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**Resumen/Abstract:**

How could we compute the sum of the quadratic residues modules a prime number? Is there a formula for such sum? What is that sum related to? There is indeed a formula when the prime is of the form $4n - 1$, in fact this sum is $(p2) - p \cdot h$ where h is the class number of the imaginary quadratic field $Q(\sqrt{-p})$. There are several formulas for the class number when the prime is of the form $p = 4n - 1 > 3$, here is one due to Dirichlet $h = (\sqrt{p})/(2\pi) \sum_{r=1}^{\infty} x(r)/r$, where $x$ is the Dirichlet character. Using elementary methods, we count the quadratic residues of a prime number of the form $p = 4n - 1$ in a manner that has not been explored before. Let $rp(k)$ be the residue of $k$ (the remainder of $k$ when we divide by $p$). We now add the residues of $k2$ and $(2n-k)2$ for small values of $p$. We observe some patterns as $k$ ranges from 1 to $2n$. Unfortunately these patterns do not hold for larger primes, however, we need to make some adjustments to those patterns as follows. We start with $m = 1, 2, 3 \cdots$ and depending on if $k2 - k$ is in $(mp - k, (m + 1)p - n - 1]$ or in $((m + 1)p - n - 1, (m + 1)p - k)$ we add the residues of $k2$ and $(2n - k)2$. We observe that when $k2 - k \in (mp - k, (m + 1)p - n - 1]$ the sum $rp(k2) + rp((2n - k)2)$ is constant. The same happens in the other interval. We then proceed to add theses constants accordingly. The simplicity of the pattern found leads to a novel formula for the class number $h(-p)$ of the imaginary quadratic field $Q(\sqrt{-p})$. Such formula is computable and does not rely on the Dirichlet character or the Kronecker symbol at all. Examples are provided and formulas for the sum of the quadratic residues are also found.

**Palabras clave / Key words:** Class number, Quadratic Residues, Imaginary fields, Quadratic field, Sum of quadratic residues

**Referencias/References:**

- H. Cohen, A course in computational algebraic number theory, vol. 138 of Graduate Text inMathematics., Springer-Verlag, New York, 1993.

- P. G. L. Dirichlet, Beweis des satzes, dass jede unbegrenzte arithmetische progression, derenerstes glied und differenz ganze zahlen ohne gemeinschaftlichen factor sind, unendlich vieleprimzahlen enthält. abhandlungen der königlich preussischen akademie der wissenschaften von.,Abhandlungen der Königlich Preussischen Akademie der Wissenschaften von., (1837), pp. 45—-81.

- P. G. L. Dirichlet, Beweis des satzes, dass jede unbegrenzte arithmetische progression, derenerstes glied und differenz ganze zahlen ohne gemeinschaftlichen factor sind, unendlich vieleprimzahlen enthält. abhandlungen der königlich preussischen akademie der wissenschaften von.,Abhandlungen der Königlich Preussischen Akademie der Wissenschaften von., (1837), pp. 45—-81.

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[2]California State University Channel Islands, USA, jorge.garcia@csuci.edu

- J. Garcia, On certain sums of qudratic residues and jumps. preprint, 2021.

- W. Narkiewicz, Elementary And Analytic Theory Of Algebraic Numbers, Springer, 2004.

# A Methodology for the Analysis of Cooperation and Conflict, in the Consensus-Negotiation[1]

*Short presentations (20 min)*

*Pedro Garcia del Valle y Duran*[2]          *Eduardo Gamaliel Hernández-Martínez*[3]

*Guillermo Fernández-Anaya*[4]

*México*

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**Resumen/Abstract:** The XXI Century has imposed the need to innovate and globalize all over around, this demand better relationships of cooperation and collaboration among all kind of groups, organizations, countries, communities, and human beings. To understand inter-intra and network behaviors it is a priority in the process of decision making specially when worldwide organisms need to contribute to peace. Therefore, consensus or conflict agreements and how them change over time has significant effects and consequences [3].The study from mathematical point of view of algorithms and functions for groups or individual preference aggregation mechanisms, become relevant to understand the process of voting consensus-negotiation. Cooperation or conflict arise from rather complicated decision-making arrangements among individuals, groups and organizations.Considering these ideas and decision and voting models, this contribution aims to develop a methodology to aid for the analysis of cooperation and conflict during negotiations among agents.An agent or a decision maker is the representation of a unit in the real world (individuals, groups, organizations, cars, patients, etc); which has its own characteristics, rules of behavior and lives in an environment. Agent characteristics can be static (constant) or dynamic (variable), intrinsic or relational. The environment can be random, for example through random social networks or trusted networks or random placement of companies in the product space, etc. And the environment can also be real, for example, social networks based on data (epidemies, facebook, etc), labor unions, etc. Therefore, we could also think that there is no environment.The interaction among agents is described by means of social network topologies, whether fixed or variable, which codify the communication of agents with each other, through the various relationships that can be established between them. Relationships can mean friendship relationship, leadership relationship, trust relationship, influence relationship, empathy relationship in an opinion or empathy relationship of thought or consensus relationship. And it is the emergent interaction of the dynamics of opinion, friendship, influence, trust, etc. of the nodes individually or of groups of nodes, focused on solving a decision-making task that leads us to conflict or cooperation.Social choice theory is concerned with the mathematical model designs and the analysis of methods for collective decision making. Our model is based on a preference profile matrix that we will call Greatest Common Decision Maker aggregation procedure and will compare it against Borda count and Pluralism voting social choice aggregation preference elections [1], [2].This work shows how the semi magic squares or conflict decision matrix arrays that appear in the case of 3x3 or 4x4 or nxn dimension arrays, aid to characterize conflict or consensus. Aggregation of individual preferences into collectivities is not as simple as summing preferences into collective preferences [4], [5].Conflict resolution or consensus agreement or negotiation processes put forward how decision maker opinions, purposes, and thoughts, define different priorities or preference scales among alternatives

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[1]Martes/Tuesday 22, 16:30 – 17:00,Schedule (GMT-6)

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to elect. And it refers to a set of techniques to find the best, non-violent solution to a conflict or problem or misunderstanding that exists between two or more decision makers [4].The Greatest Common Decision Maker aggregation preference procedure facilitates and automates the consensus reaching process in a more efficient way.

**Palabras clave / Key words:** Consensus, aggregation, preference, profile, Borda count, Greatest Common Decision Maker

**Referencias/References:**

1 Ivan Palomares and Luis Martinez. "A semi supervised multiagent system model to support consensus-reaching process", IEEE transactions on fuzzy systems, vol. 22, no. 4, august (2014)

2 Wade D. Cook and Lawrence M. Seiford. "On the Borda-Kendall consensus method for priority ranking problems". Management Science. Vol. 28, No. 6 (1982)

3 Emerson Peter. "The original Borda count and partial voting". Social Choice Welfare 40:353-358 (2013)

4 Carlo Matini and Jan Sprenger. "Opinion aggregation and individual expertise". Academy of Finland Centre of Excellence in the Philosophy of the Social Sciences, Department of Political and Economic Studies. University of Helsinki, Finland. March 20, 2015.

5 Gleb Beliakov, Ana Pradera, and Tomasa Calvo. "Aggregation functions: a guide for practitioners". Springer-Verlag Berlin Heidelberg. 2007

# GENERALIZED RICCI FLOW[1]

*Garcia-Fernandez,Mario[2] (España)*
*Plenary lectures (50 min)*

The generalized Ricci flow equation is a geometric evolution equation which has recently emerged from investigations into mathematical physics, Hitchin's generalized geometry program, and complex geometry. The generalized Ricci flow can regarded as a tool for constructing canonical metrics in generalized geometry and complex non-Kähler geometry, and extends the fundamental Hamilton/Perelman theory of Ricci flow. In this talk I will give an introduction to this topic, with a special emphasis on the applications to complex geometry. Based on joint work with Jeffrey Streets and the book "Generalized Ricci Flow"(University Lecture Series Vol. 76, 2021, AMS).

**Palabras clave / Key words:**

**Referencias/References:**

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[1]Viernes/Friday 25, 11:00 – 12:00,Schedule (GMT-6)

[2]Universidad Autónoma de Madrid and ICMAT, España, mario.garcia@icmat.es

# SEAIR Epidemic Spreading modeling of Covid-19 for Costa Rica[1]

*Thematic Sessions: Presentations (30 minutes)*

*Gomez Meléndez, Agustín*[2]          *Rojas Rojas, Guaner*[3]

*Costa Rica*

In this paper, we present a mathematical model of an infectious disease according to the characteristics of the COVID-19 pandemic for Costa Rica during 2020 and 2021. The proposed enhanced model, which will be referred to as the SEAIR+HD (Susceptible-Exposed-Infectious-Recovered, Hospitalized and Diseases) we use the time the average time for incubation of the virus, the time before any symptoms will appear and the period of time between the infection and re recovery time, as well as the reproduction numbers rate $R_0$ and $R_t$ to adjust the intensity of the infection from one generation to another. In the model, the infected and the basic reproduction numbers are compared under the influence of intervention policies. The results will show the importance policy of restricting residents' movements in preventing the spread of COVID-19 pandemic are verified.

**Palabras clave / Key words:** SEAIR, Costa Rica, Modeling, Covid-19, Simulation, R.

**Referencias/References:**

- Basnarkov L. (2021). SEAIR Epidemic spreading model of COVID-19.Chaos, solitons, and fractals,142, 110394. `https://doi.org/10.1016/j.chaos.2020.110394` `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7598527/`

- Liu, X. X., Fong, S. J., Dey, N., Crespo, R. G., & Herrera-Viedma, E. (2021). A new SEAIRD pandemic prediction model with clinical and epidemiological data analysis on COVID-19 outbreak. Applied Intelligence, 1–37. Advance online publication. `https://doi.org/10.1007/s10489-020-01938-3`

  `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7775669/`

- Ge, J., He, D., Lin, Z., Zhu, H., & Zhuang, Z. (2020). Four-tier response system and spatial propagation of COVID-19 in China by a network model.Mathematical biosciences,330, 108484. `https://doi.org/10.1016/j.mbs.2020.108484` `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7544595/`

- Nawaz, Y., Arif, M.S. & Ashraf, M.U. Development of Explicit Schemes for Diffusive SEAIR COVID-19 Epidemic Spreading Model: An Application to Computational Biology.Iran J Sci Technol Trans Sci(2021). `https://doi.org/10.1007/s40995-021-01214-0` `https://link.springer.com/article/10.1007/s40995-021-01214-0`

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[1]Jueves/Thursday 24, 10:00 – 10:40,Schedule (GMT-6)

[2]Coordinador Unidad de Estadísticas Observatorio del Desarrollo Universidad de Costa Rica, Costa Rica, agustin.gomez@ucr.ac.cr

[3]Investigador Instituto de Investigaciones Psicológicas,Escuela de Estadística,Observatorio del Desarrollo, Costa Rica, guaner.rojas@ucr.ac.cr

- Basnarkov, Lasko. (2020). SEAIR Epidemic spreading model of COVID-19. Chaos, Solitons & Fractals. 142. 110394. 10.1016/j.chaos.2020.110394.
  https://www.researchgate.net/publication/346469343_SEAIR_Epidemic_spreading_model_of_COVID-19

# THE STATISTICS OF THE COVID-19 PANDEMIC IN MEXICO AND THE PROBLEMS FOR BUILDING PREDICTIVE MODELS[1]

*Presentations (30 minutes)*

*González Farías, Graciela M.*[2]      *Márquez Urbina, José Ulises* [3]

*Rodríguez González, D. Iván*[4]

*México*

We propose an appropriate parametrization for a compartmental model to understand the evolution of the pandemic in Mexico, which allows obtaining information about different relevant aspects for the management of the pandemic. Such a parametrization uses the Effective Reproduction Number $R_t$ and different projections into the future of $R_t$ to further assist in the management process. The uses of the proposed methodologies are exemplified by analyzing a Mexican state; the main quantities derived from the compartmental model, such as the asymptomatic, mild symptoms at home, hospitalized (in regular bed), and ICU cases, are adjusted to obtain, by state and age group, the mortality rate, recovered cases and remaining susceptible population.

**Palabras clave / Key words:**

**Referencias/References:**

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[1]Miércoles/Wednesday 23, 9:00 – 9:40,Schedule (GMT-6)

[2]Centro de Investigación en Matemáticas A.C. Departamento de Probabilidad y Estadística, México, farias@cimat.mx

[3]CONACYT-CIMAT, Departamento de Probabilidad y Estadística, México, ulises@cimat.mx

[4]CIMAT,Departamento de Servicios Tecnológicos, GTO, México, drodriguez@cimat.mx

# CRIME IN YOUNG MEXICANS: Statistical modeling and risk quantification[1]

*Short presentations (20 min)*

*María Teresa Guerrero San Vicente*[2]　　　　*Carlos Cuevas Covarrubias*[3]

*México*

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**Resumen/Abstract:**

Insecurity and crime have become the main social problem in México. It is observed that criminals start antisocial behavior at younger ages each time. We present a statistical model for supervised classification. Two different techniques are applied (CHAID and logistic regression) both integrated with statistical learning. This process optimizes the area under the ROC curve for the final model controlling the effects of imbalanced sample sizes. The result is an interpretable, parsimonious, as well as accurate linear function. A real dataset of Mexican young people is analyzed. The objective is to quantify their risk of engaging in criminal conducts. Men and women are analyzed separately. The main contribution of this work is a classification criterion that expresses risk as a probability based on variables related to each person´s lifestyle; for instance: educational level, influence form friends, imprisoned relatives, neigborhood characteristics, alcohol, tobacco and drugs consumption.

**Palabras clave / Key words:** Discrimination, CHAID, logistic regression, statistical learning, ROC curve.

**Referencias/References:**

■ Anderson, J.A. (1982). Handbook of Statistics: Classification Pattern Reconigtion and Reduction of Dimensionality , P.R. Krishnaiah and L.N. Kanal, Vol. 2, Chapter 7 169 -191.

■ Bekkar, M. Kheliouane, D.H. Akrouf, A.T. (2013). Evaluation Measures for Models Assessment over Imbalanced Data Sets, Journal of Information Engineering and Applications, Vol.3, No.10, 27 - 38.

■ Hastie, T. Tibshironi, R. Friedman, J (2009). The Elements of Statistical Learning, Data Mining, Inference and Prediction. Springer, 2nd ed.

■ Instituto Nacional de Estadística y Geografía, (2015). Encuesta de Cohesión Social para la Prevención de la Violencia y la Delincuencia (ECOPRED) 2014 Estructura de la base de datos *INEGI* Disiponible en: `https://www.inegi.org.mx/contenidos/programas/ecopred/2014/doc/ecopred14_base_datos.pdf`

■ Martínez-Lanz, P., Carabaza, R., Hernández, A. (2008). Factores de riesgo predisponentes a la delincuencia en una población penal femenina. Enseñanza e Investigación en Psicología, 13(2),301-318. ISSN: 0185-1594. Disponible en:
`https://www.redalyc.org/articulo.oa?id=292/29213207.`

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[1]Lunes/Monday 21, 15:20 – 15:40,Schedule (GMT-6)

[2]Centro de Investigación en Estadística y Matemáticas Aplicadas, Universidad Anáhuac, México, teresa.guerrero@anahuac.mx

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# ALGEBRAIC GEOMETRY AND CLASSICAL REPRESENTATION THEORY: A CONNECTION[1]

*Short courses or Workshops (3 hours)*

*Hernandez, Alberto*[2]      *Rojas, Ignacio*[3]

*Boza, Juan*[4]

*Costa Rica*

Given a finitely generated algebra over a field $k$, $A = k\langle a_1, \ldots, an \rangle$ there is an ideal $I \subseteq B = k\langle x_1, \ldots, x_n \rangle$ such that $A \approx= k\langle x_1, \ldots, x_n \rangle / I$. For every representation of $A$ of dimension d there is a space of $d \times d$ matrices $k\langle T_1, \ldots, T_n \rangle$ that vanishes at every polynomial $p \in I$. We can identify $k(d \times d)n$ with $Ad = A_n d_2$ the affine space of dimension $nd_2$. One can prove that there is an ideal of polynomials $I* \in k\langle Ad \rangle$ such that the set of representations of dimension $d$ of $A$ is in correspondence with the closed affine set defined by $I*$. To achieve this we will devote the first 1.5 hours of this mini course to the rudiments of algebraic geometry: Point sets of $R_n$ and $A_n$, ideals of polynomials, Zariski topology, Hilberth's theorem and decomposition of a set of zeroes in irreducible parts.

**Palabras clave / Key words:** Zariski Topology, Ideal of Polynomials, Affine Space, Finitely Generated Algebras, Finite Representation Theory

## Referencias/References:

- (1) Eisenbud D. and Harris J.: 3264 and All That: A second course in algebraic geometry. Cambridge University Press, 2016.

- (2) Gortz U. and Wedhorn T. : Algebraic Geometry I: Schemes with examples and exercises. Springer Studium Mathematik - Master. Springer Fachme- dien Weisbaden, 2020.

- (3) Harris J. : Algebraic Geometry: A first course. Graduate texts in Mathe- matics. Springer, 1992.

- (4) Larrion F. , Raggi G. and Salmeron L. : Rudimentos de mansedumbre y salvajismo en teoría de representaciones. Sociedad Matemática Mexicana, UNAM, 199.

- (5) Kraft H. and Riedtmann C. : Geometry of Representations of Quivers. Representations of algebra, London Mathematical Society, 116, p. 109 - 145, 2001.

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[1] Miércoles/Wednesday 23, 10:00 – 11:00,Schedule (GMT-6), Jueves/Thursday 24, 10:00 – 11:00,Schedule (GMT-6), Viernes/Friday 25, 10:00 – 11:00,Schedule (GMT-6)

[2] Universidad de Costa Rica, Costa Rica, albertojose.hernandez@ucr.ac.cr

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[4] Universidad de Costa Rica, Costa Rica, juan.boza.cordero@gmail.com

# Speech spoofing detection using neural networks[1]

*Presentations (30 minutes)*

*Carlos Alberto Hernández Nava*[2]          *Pedro Lara Velázquez*[3]

*Eric Alfredo Rincón García*[4]          *Sergio Gerardo De los Cobos Silva*[5]

*Miguel Ángel Gutiérrez Andrade*[6]          *Roman Anselmo Mora Gutiérrez*[7]

*México*

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**Resumen/Abstract:** In this project, a model capable of detecting speech spoofing attacks is developed. The databases of the ASVspoof 2017 and ASVspoof 2019 challenges were used, in which these types of attacks can be found. To carry out this task, it is necessary to first perform a pre-processing of the audios, that is, to extract audio features, among the most known methods are MFCC (Mel Frequency Cepstral Coefficients), CQCC (Constant Q Cepstral Coefficients), spectrograms and LFCC (Linear Filter Cepstral Coefficients). It was decided to use the spectrograms obtained from the audios as the main analysis tool, to later be used in a model based on SCN (Spatial Convolutional Neural Networks), the model obtains only two possible results, genuine or spoof. The results indicate that this strategy has a very good performance.

**Palabras clave / Key words:** Audio spoofing detection, classifiers, convolutional neural networks.

**Referencias/References:**

- M. Todisco et al., "ASVspoof 2019: Future Horizons in Spoofed and Fake Audio Detection," in Proc. of Interspeech 2019, 2019.

- B. B T, L. Kin Wah Edward, S. Lui, J.-M. Chen, and D. Herremans, "Toward Robust Audio Spoofing Detection: A Detailed Comparison of Traditional and Learned Features," IEEE Access, vol. PP, p. 1, 2019.

- M. Dua, C. Jain, and S. Kumar, "LSTM and CNN based ensemble approach for spoof detection task in automatic speaker verification systems," J. Ambient Intell. Humaniz. Comput., 2021.

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[1]Martes/Tuesday 22, 15:00 – 15:40,Schedule (GMT-6)

[2]Posgrado en Ciencias y Tecnologías de la Información, Universidad Autónoma Metropolitana-Iztapalapa, Av. San Rafael Atlixco 186, 09340, CDMX, México, cahn@xanum.uam.mx

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# Modeling of social contact patterns in Bogotá Colombia during the covid-19 pandemic[1]

*Presentations (30 minutes)*

*Eddy herrera*[2]      *Jualian Andres Cardenas García*[3]

*Carlos Andres Erazo Garzon*[4]      *Javier Ricardo Becerra Bedoya*[5]

*Fabian Alexis Pallares Jaimes*[6]      *Maria Camila Cuellar Avella*[7]

*Leidy Jasblendy Hoyos Peña*[8]      *Leidy Geraldine Gómez Medina*[9]

*Colombia*

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**Resumen/Abstract:** The knowledge and understanding of social contact patterns of people is an important input in the analysis of possible scenarios and estimation during and after epidemic outbreaks, such as for the management of mobility policies, the design of cities among others. This knowledge provides a quantitative answer to questions associated with public health and thus effectively designing control strategies, such as on the vaccination, trade circle, opening of colleges and universities, etc. during emergencies that ease health (Mistry, D. et al., 2021) and (Walker, PGT. et al., 2021) y that impact to a lesser extent the contact patrons of people from different countries. The structure of contact patterns, for example, socials often described as free scale networks, can determine the behavior characteristic of an epidemic (Eubank, S. et al., 2004) and (Salathe, M. et al., 2013); If some studies on the sciences of data have found associations between sex, age, etc., these are in settlements with different social, cultural, political, and economic structures than the city of Bogotá. This investigation will examine trends related to places, activities, and closings of social contact points in the city of Bogotá through developing a methodology for accessing and structuring databases from information extracted from web applications, that allows exploring the potential and techniques of data sciences with RStudio implemented in Shiny. As preliminary results, we have the idea that in the dynamics of social contact, people's contact in restaurants continues to be a common pattern, however, disturbing situations such as limited opportunities, which are intensified by the afternoon at night and which is concentrated in them restaurant subcenters (for example, Zona T), while for the çoffee.ªctivity

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[1] Viernes/Friday 25, 10:40 – 11:20,Schedule (GMT-6)

[2] Pontificia Universidad Javeriana Facultad de Ciencias Departamento de Matemáticas Bogotá, Colombia, eherrera@javeriana.edu.co

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the contact is intensified on Sundays in traditional areas in Bogotá associated with other activities of the recreation and sport category that invite to pay more attention to the causes and consequences of patterns of microsocial contact in a ciudad.

**Palabras clave / Key words:**

**Referencias/References:**

1 Eubank, S. et al. (2004) 'Modelling disease outbreaks in realistic urban social networks´. Nature 429,180-184. Available at:

   `https://www.nature.com/articles/nature02541.pdf`

2 Mistry, D´. et al. (2021) 'Inferring high-resolution human mixing patterns for disease modeling´ Nat Commun 12, 323 (2021).

   `https://doi.org/10.1038/s41467-020-20544`

3 Salathe, M. et al. (2013) 'The dynamics of health behavior sentiments on a large online social network'. EPJ Data Sci. 2,1-12. Available at:

   `https://epjdatascience.springeropen.com/articles/10.1140/epjds16`

4 Walker PGT, Whittaker C, Watson OJ, Cucunuba ZM, et al. The impact of COVID- 19 and strategies for mitigation and suppression in low- and middle-income countries. Science. 2020;369(6502):413-422. Available at:

   `https://science.sciencemag.org/content/sci/369/6502/413.full.pdf`

# Hacia un modelo matemático multiescala que unifica la dinámica de propagación del Covid-19[1]

*Presentations (30 minutes)*
*Raúl Isea[2]*
*Venezuela*

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**Resumen/Abstract:**

El mundo está afrontando una pandemia causada por el SARS-CoV-2 donde se han acumulado más de 223 millones de contagios diversos países, tras el incidente inicial registrado en diciembre de 2019 en Wuhan (China) [1]. Desde entonces, la comunidad académica se ha volcado en modelar y predecir la dinámica de contagio que permita ayudar a diseñar políticas públicas para detener el avance del virus [ver por ejemplo 2-5], pero hasta la fecha, no hay un modelo único que logre explicar y mucho menos predecir a mediano y largo plazo la propagación del Covid-19 en el mundo.Más aún, recientemente se determinó la capacidad de mutar el virus [6] dificultando controlar el avance del mismo, poniendo en tela de juicio las estimaciones iniciales de la población que se debía vacunar para contrarrestar la pandemia [6.7].Hasta la fecha, existe una solución analítica que planteaba ocho escenarios diferentes que permitía explicar la dinámica de contagio desde el origen del virus en los murciélagos, posteriormente contagiar al hospedero, hasta alcanzar a la población humana [3]. En vista de ello, se propone una solución basada en un modelo compartimental que permite unificar todas las posibles escalas de interacción, considerando además factores ambientales, sin pasar por alto las políticas de distanciamiento social y planes de vacunación.

**Palabras clave / Key words:** Compartimental, Ecuaciones Diferenciales

**Referencias/References:**

- (1) Isea, R. (2021). Origen del SARS-CoV-2 desde una perspectiva Bioinformática. Revista Electrónica Conocimiento Libre y Licenciamiento, 12(23): 1.

- (2) Isea, R. (2020) La dinámica de transmisión del Covid-2019 desde una perspectiva matemática. Revista Observador del Conocimiento, 5(1): 15.

- (3) Isea, R. (2021). Analytical solutions of the transmissibility of the SARS-CoV-2 in three interactive populations. International Journal of Coronavirus, 2(4):1.

- (4) Isea, R. (2020). Characterizing the transmission dynamics of the cases registered by Covid-19 in Venezuela according to epidemic wave and the value of the Mantissa. International Journal of Coronavirus, 2(2):8.

- (5) Isea, R. (2021). A missing data on Covid-19 forecasts. International Journal of Coronavirus, 3(2):27.

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[1] Viernes/Friday 25,08:20 – 09:00,Schedule (GMT-6)

[2] Fundación Instituto de Estudios Avanzados, Hoyo de la Puerta, Baruta, Venezuela, raul.isea@gmail.com

# A REMARK ON CRACK PROBLEMS WITH TIME-DEPENDENT FRICTION CONDITION IN LINEARIZED ELASTODYNAMIC BODY[1]

*WorkShop dedicated to Prof. Alexander Khludnev*

*Hiromichi Itou*[2]          *Kashiwabara Takahito*[3]

*Japon*

**Resumen/Abstract:** We consider a crack problem with a time-dependent friction condition in a linearized elastodynamic body. We suppose that the crack is fixed and the frictional force $g$ acting on the crack is given, and it depends on the time as well as space variables [1].This is regarded as an extension of the result reported in [2] to a crack problem, where a condition the threshold $g$ cannot depend on a time variable $t$ was needed. In this talk, we give a remark that $\partial g/\partial t = 0$ is an unnecessary requirement, and show the unique existence of a solution by using Galerkin's method.

**Palabras clave / Key words:** Crack, friction, linearized elastodynamics

**Referencias/References:**

- Itou, H. and Kashiwabara, T. (2021). Unique solvability of crack problem with time-dependent friction condition in linearized elastodynamic body.Mathematical notes of NEFU, 28(3), 121-134.

- Duvalt, G. and Lions, J-L. (1976). Inequalities in mechanics and physics, Springer-Verlag,Berlin.

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[1]Jueves/Thursday 24, 08:00-08:30,Schedule (GMT-6)

[2]Tokyo University of Science, Japon, h-itou@rs.tus.ac.jp

[3]The University of Tokyo,Japon, h-itou@rs.tus.ac.jp

# DISTRIBUTIONS AND FOLIATIONS ON THE THREE DIMENSIONAL PROJECTIVE SPACE[1]

*Presentations (30 minutes)*
*Marcos Jardim*[2]
*Brazil*

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**Resumen/Abstract:** Let $TX$ and $\Omega^1 X$ denote the tangent and cotangent bundles of the non-singular projective variety $X$. A *codimension $k$ holomorphic distribution* on $X$ is the data of a closed subset $|Z| \subset X$ and, for each point $p \in X \setminus |Z|$, a subspace $T(p) \subset \mathrm{T}pX$ of codimension $k$. In this talk, I will focus on $X = \mathbb{P}^3$, so that either $k = 1$ or $k = 2$; the latter case is called a *foliation by curves*. In sheaf theoretical terms, the previous information can be summarized in a short exact sequence

$$0 \longrightarrow T \longrightarrow T\mathbb{P}^3 \longrightarrow N \longrightarrow 0$$

where $N$ is a torsion free sheaf of rank $k$, called the *normal sheaf*, and $T$ is a reflexive sheaf of rank $3 - k$, called the *tangent sheaf*. I will present a survey of recent results on the classification of foliations by curves

and codimension 1 distributions on $\mathbb{P}^3$ in terms of the Chern classes of $N^\vee$ and $T$, respectively. I will give a description of the possible singular loci and describe some of the components of the moduli spaces of these objects.

**Palabras clave / Key words:**

**Referencias/References:**

- O. Calvo-Andrade, M. Corrêa, M. Jardim, Codimension one holomorphic distributions on the projective three-space. IMRN 23 (2020), 9011–9074.

- M. Corrêa, M. Jardim, S. Marchesi, Classification of foliations by curves of low degree on the three-dimensional projective space. Preprint arXiv:1909.06590.

- M. Corrêa, M. Jardim, A. Muniz, Moduli of Distributions via Singular Schemes. Preprint arXiv:2010.02382.

- H. Galeano, M. Jardim, A. Muniz, Codimension one distributions of degree 2 on the three-dimensional projective space. J. Pure Appl. Algebra 226 (2022) 106840.

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# THE VAN DER POL EQUATION: QUALITATIVE AND NUMERICAL STUDY[1]

*Presentations (30 minutes)*

*Vinícius Juten Pinto*[2]       *Luciana Silva Salgado*[3]

*Brazil*

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**Resumen/Abstract:** This expositive paper aims at the study of nonlinear equations, focused on the van der Pol equation, including deduction, qualitative analysis and numerical examples. The van der Pol equation is deduced using an electrical circuit as a physical model. The qualitative analysis is divided into two parts, the theoretical enunciation and its application. The main theorems used in this study are the Poincar+e Bendixson's and Lyapunov's theorems. The construction of a Lyapunov function is also made. At last, a series of numerical examples are graphically presented using computational tools such as Python and Octave. The phase portraits and temporal behavior of the van der Pol equation are presented, along with the basin of attraction obtained experimentally, compared with the basin of attraction yielded by the Lyapunov function. Therefore, the numerical study provides a visual representation for the results stated in the qualitative analysis.

**Palabras clave / Key words:** van der Pol equation, Lyapunov function, qualitative analysis, numerical integration

**Referencias/References:**

- Pol, B. V. (1926). LXXXVIII.On "relaxation-oscillations". The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 2(11), 978-992.

  doi:10.1080/14786442608564127

- Viana, M., & Epinar, J. (2018). Equa̧c~oes Diferenciais - Uma Abordagem de Sistemas Dinamicos. Rio de Janeiro: IMPA.

- Strogatz, S. H. (1994). Nonlinear dynamics and chaos: with applications to physics, biology, chemistry and engineering. New York: Perseus Books Publishing.

- Jordan, D. W., & Smith, P. (2007). Nonlinear Ordinary Differential Equations: An introduction for Scientists and Engineers. New York: Oxford University Press.

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# JUNCTION PROBLEM FOR THIN ELASTIC AND VOLUME RIGID INCLUSIONS IN ELASTIC BODY[1]

*WorkShop dedicated to Prof. Alexander Khludnev*
*Alexander Khludnev[2]*
*Russia*

**Resumen/Abstract:** The talk is concerned with an equilibrium problem for 2D elastic body with a thin elastic inclusion and a volume rigid inclusion. It is assumed that the inclusions have a common point. A delamination of the thin inclusion from the surrounding elastic body is assumed thus forming an interfacial crack between the inclusion and the elastic body. Inequality type boundary conditions are imposed at the crack faces to prevent interpenetration between the faces. Moreover, a connection between the crack faces is characterized by a positive damage parameter. Passages to the limit are justified as the damage parameter tends to infinity and to zero. In addition to this, a passage to limit is analyzed as a rigidity parameter of the thin inclusion tends to infinity. Limit models are investigated. In particular, junction conditions at the common point are found for all cases considered.

**Palabras clave / Key words:** Thin elastic inclusion, junction conditions, rigid inclusion, crack, damage parameter, variational inequality

**Referencias/References:**

- Khludnev, A.M., Faella, L. and Perugia, C. (2017). Optimal control ofrigidity parameters of thin inclusions in composite materials. ZAMP.

- Khludnev, A.M. (2017). Rigidity parameter identification for thininclusions located inside elastic bodies. J. Opt. Theory Appl., v. 172, N 1, pp. 281-297.

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[1]Lunes/Monday 21,11:00 −12:00,Schedule (GMT-6)

[2]Lavrentyev Institute of Hydrodynamics SB RAS, Novosibirsk State University, Russia, khlud@hydro.nsc.ru

# BAUM BOTT INDEXES AND VECTOR FIELDS IN THE PROJECTIVE SPACE.[1]

*Presentations (30 minutes)*
*Midory Komatsudani Quispe[2]*
*Peru*

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**Resumen/Abstract:**

A polynomial vector field in the complex space can define a one-dimensional foliation on the projective space of certain degree. We can associate to each singularity of the foliation its Baum-Bott indexes. Fixing the degree, we assign to each foliation its Baum-Bott indexes, we call it the Baum-Bott map. We would like to know the maximum number of possible universal relations among these indexes. This number can be found through the generic rank of the Baum-Bott map. We give an upper bound of the generic rank of the map. We also determine the generic rank for degree-2 foliations.

**Palabras clave / Key words:** Baum-Bott index, holomorphic foliation, Baum-Bott map, Jouanolou foliation.

**Referencias/References:**

- Komatsudani-Quispe, M (2020). The generic rank of the Baum-Bott map for degree-2 foliations on even-dimensional projective spaces.Journal of Singularities, volume 20, 103-127.

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[1]Viernes/Friday 25, 9:00 – 9:40,Schedule (GMT-6)
[2]University of Plymouth,Inglaterra, midorykq@gmail.com

# POROELASTIC MEDIUM WITH NON-PENETRATING CRACK DRIVEN BY HYDRAULIC FRACTURE[1]

*WorkShop dedicated to Prof. Alexander Khludnev*

*Victor Kovtunenko*[2]

*Austria*

**Resumen/Abstract:**

A new class of unilateral variational models appearing in the theory of poroelasticity is introduced and studied. A poroelastic medium consists of solid phase and pores saturated with a Newtonian fluid. The medium contains a fluid-driven crack, which is subjected to non-penetration between the opposite crack faces. The fully coupled poroelastic system includes elliptic-parabolic governing equations under the unilateral constraint. Well-posedness of the corresponding variational inequality is established based on the Rothe semi-discretization in time, after subsequent passing time step to zero. The NLCP-formulation of non-penetration conditions is given which is useful for a semi-smooth Newton solution strategy.

**Palabras clave / Key words:** variational inequality, optimal control, inverse problem, shape optimization, singularity

**Referencias/References:**

- Itou, H., Hirano, S., Kimura, M., Khludnev, A, M., Kovtunenko, V.A. (Eds). (2020). Mathematical Analysis of Continuum Mechanics and Industrial Applications III: Proceedings of the International Conference CoMFoS18. Singapore: Springer

- Khludnev, A.M., Kovtunenko, V.A. (2000). Analysis of Cracks in Solids. Southampton: WIT-Press

- Kovtunenko, V.A. (2021). Poroelastic medium with non-penetra;ng crack driven by hydraulic fracture: varia;onal inequality and its semidiscretization. J. Comput. Appl. Math. 405, 113953

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[1]Lunes/Monday 21, 11:40-12:00,Schedule (GMT-6)

[2]University of Graz, Austria, victor.kovtunenko@uni-graz.at

# CLASSIFICATION OF PRE-PERIODIC PORTRAITS FOR QUADRATIC POLYNOMIALS OVER QUADRATIC NUMBER FIELDS[1]

*Thematic Sessions: Presentations (30 minutes)*
*David Krumm*[2]

**Resumen/Abstract:**

To every pair $(K, c)$, where $K$ is a quadratic number field and $c \in K$, we associate a directed graph $G(K, c)$ whose vertices are the elements of $K$ having finite orbit under iteration of the polynomial map $x \mapsto x^2 + c$. In a standard analogy between pre-periodic points of polynomial maps and torsion points on abelian varieties, this family of directed graphs corresponds to the family of torsion subgroups of elliptic curves defined over quadratic number fields. In this talk we discuss recent joint work with John Doyle on a classification theorem analogous to known facts about elliptic curves proved by Kamienny and Kenku–Momose.

**Palabras clave / Key words:** arithmetic dynamics, uniform boundedness conjecture, elliptic curves.

**Referencias/References:**

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# Machine Learning on Encrypted Data
*Plenary Talk (60 min)*
*Kristin Lauter*

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**Resumen/Abstract:**

As the world adopts Artificial Intelligence, the privacy risks are many. AI can improve our lives, but may leak our private data. Private AI is based on Homomorphic Encryption (HE), a new encryption paradigm which allows the cloud to operate on private data in encrypted form, without ever decrypting it, enabling private training and private prediction. In 2016 the ICML CryptoNets paper showed for the first time that it was possible to evaluate neural nets on homomorphically encrypted data, and opened new research directions combining machine learning and cryptography. The security of Homomorphic Encryption is based on hard problems in mathematics involving lattices, a candidate for post-quantum cryptography. This talk will explain Homomorphic Encryption, Private AI, and show HE in action.

# Equilibrium of a thermoelastic plate with nonpenetration condition[1]

*Short presentations (20 min)*
*Nyurgun Lazarev[2]*
*Russia*

**Resumen/Abstract:**

We consider a nonlinear mathematical model for a plate. On the curve of a crack nonlinear boundary conditions are imposed. The model is formulated as a variational problem. We prove existence and uniqueness of a solution.

**Palabras clave / Key words:** nonpenetration condition, crack, variational inequality, thermoelasticity

**Referencias/References:**

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# A VIRTUAL ELEMENT APPROXIMATION FOR THE PSEUDOSTRESS FORMULATION OF THE STOKES EIGENVALUE PROBLEM[1]

*Thematic Sessions: Presentations (30 minutes)*

*Felipe Lepe*[2]

*Chile*

**Resumen/Abstract:**

In this talk we present a virtual element method (VEM) for a pseudostress formulationof the Stokes eigenvalue problem. This formulation allows to eliminatethe velocity and the pressure, leading to an elliptic formulation where the only unknown is the pseudostress tensor. Adapting the non-compact operator theory, we prove that our method provides a correct approximation of the spectrum and is spurious free. We derive optimal a priori error estimates, which we confirm with some numerical tests. Also we present a computational spurious analysis of the proposed method

**Palabras clave / Key words:** Spectral problems, Stokes eigenvalue problem, virtual element method, error estimates

**Referencias/References:**

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# A generalization to Elkies's theorem[1]

*Plenary lectures (50 minutes)*
*Wanlin Li[2]*
*Canada*

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**Resumen/Abstract:**

Elkies proved that for a fixed elliptic curve over Q, there exist infinitely many primes at which its reductions are supersingular. In this talk, we give the first generalization to Elkies's theorem for some curves of genus $> 2$. We consider families of cyclic covers of the projective line ramified at 4 points whose moduli space is embedded in a Shimura curve.This is joint work in progress with Elena Mantovan, Rachel Pries, and Yunqing Tang.

**Palabras clave / Key words:**

**Referencias/References:**

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# Epidemiologia Matemática: COVID-19[1]

*Short courses or Workshops (3 hours)*
*Marina Lima[2]     Anny Silva[2]*
*largeJoão Frederico Meyer[3]*
*Brazil*

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**Resumen/Abstract:**

Desde o final de Dezembro de 2019, o mundo vem enfrentando uma das mais devastadoras pandemias da história, a COVID-19. Até fevereiro de 2020, a então desconhecida doença respiratória recebeu o nome de COVID-19 (sigla para, em inglés, Corona Virus Disease) e o vírus causador foi nomeado Sars-CoV-2, por ser um coronavrus semelhante ao causador da SARS, em 2003. A COVID-19 teve origem em uma província chinesa e, em 11 de março de 2020, a Organização Mundial da Saúde (OMS) classificou a mesma como uma pandemia, reconhecendo que a doença já tinha se espalhado por diversos continentes e havia transmissão sustentada entre pessoas. O primeiro caso registrado no Brasil foi em 26 de fevereiro de 2020, o qual foi também o primeiro caso registrado na América do Sul. A principal forma de transmissão da COVID-19 é entre pessoas, através de gotículas de saliva expelidas por uma pessoa infectada ao tossir ou espirrar. Assim, as recomendações da OMS foram a adoção de medidas de higiene e segurança respiratória, tais como o uso de máscara, distanciamento social, diminuição da circulação de pessoas e, em alguns locais, a estratégia de lockdown. Tais estratégias foram eficazes em muitos países, mas, em outros, como no Brasil, não foram implantadas de forma eficiente, o que resultou em um enfrentamento inadequado da pandemia. O pico da primeira onda no Brasil foi registrado em agosto de 2020 [1] e, apesar disso, nos meses seguintes, algumas medidas de restrição foram relaxadas. Então, em novembro, houve um aumento alarmante dos casos, resultando em uma segunda onda, com amplitude maior que a primeira. Dentre as causas possíveis, destacamos as eleições municipais, o relaxamento da população com as medidas restritivas e a descoberta da variante Gama, primeiramente observada em Manaus (capital de um estado do norte do Brasil e que vivenciou um colapso no sistema de saúde, devido á COVID-19) e que logo se espalhou por todo o país, por ser mais infecciosa e severa que a cepa original. Ademais, casos da variante Delta, primeiramente detectada na índia em dezembro de 2020, foi registrada no Brasil em abril de 2021. Essa variante e mais infecciosa que a cepa original e rapidamente se espalhou por diversos países, o que contribuiu na manutenção de elevados registros de casos e mortes diários no Brasil [1]. Diante do cenário do caos pandêmico em todos os países, o desenvolvimento das vacinas em tempo recorde foi fundamental. No Brasil, a campanha de vacinação contra a COVID-19 teve início em 18 de janeiro de 2021 e, atualmente, quatro tipos de vacinas estão disponíveis para a população, sendo que cada uma possui um esquema vacinal diferente e taxas distintas de efetividades. Até o momento, 55 % da população está completamente imunizada [2], e apesar de essa ser uma taxa relativamente baixa, a vacinação tem sido de extrema importância no controle da pandemia, na diminuição do registro de casos e da fatalidade dos mesmos. Neste contexto, modelos matemáticos têm uma importância estratégica para nortear as medidas mais eficientes e muitos trabalhos foram desenvolvidos durante a pandemia, com o intuito de descrever a dinâmica da COVID-19, incluindo o comportamento

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[1]Miércoles/Wednesday 23, 8:00 – 9:00,Schedule (GMT-6)

[2]IMECC - Unicamp, Brasil, marina@ime.unicamp.br

[2]IFPR - Pinhais,Brasil, anny.silva@ifpr.edu.br

[3]IMECC - Unicamp, Brasil, jmeyer@unicamp.br

da população, as variantes do vírus, as estratégias de contenção da doença, a vacinação, entre outros [3]. Com o desenvolvimento dos trabalhos, podemos buscar a melhor maneira de informar a população sobre o perigo da doença, a eficácia das medidas adotadas e importancia da vacinação, visando uma redução dos danos causados pela pandemia. A nossa proposta para esse minicurso é abordarmos a construção de modelos matemáticos que descrevem o comportamento da pandemia da COVID-19, partindo do modelo mais simples, o modelo SIR proposto por Kermack e McKendrick, até a elaboração de modelos mais complexos, incluindo as variantes do vírus e o esquema vacinal. Para todos os casos, realizaremos simulações, utilizando os dados da pandemia no Brasil, como exemplo, e discutiremos a influência dos fatores comportamentais e externos na dinâmica da doença e como as estratégias foram eficientes no controle da mesma. O minicurso está organizado como: 1 - Introdução histórica e modelos de crescimento (Malthus e Verhulst, modelos discretos - equações de diferenças, modelos contínuos- equações diferenciais); 2 - Modelo SIR; 3 - Contextualização da COVID-19; 4 – Modelos com mais compartimentos; 5 - Utilização dos dados de [1] e [2] para construção das curvas; 6 - Ajuste das curvas e estimativas de parâmetros; 7 - Simulações numéricas utilizando o software GNU Octave (freeware). Pré-requisitos: cálculo e álgebra linear básicos.

**Palabras clave / Key words:** COVID-19; Epidemiologia Matemática; Modelagem Matemática; Variantes do Sars-Cov-2.

**Referencias/References:**

1 Worldometers, COVID-19 Coronavirus Pandemic, disponível em `https://www.worldometers.info/coronavirus/` ,Online; Acessado em 28 de outubro de 2021.

2 Our World in Data, Brazil: Coronavirus Pandemic Country Prole, disponível em `https://ourworldindata.org/coronavirus/country/brazil`, Online; Acessado em 28 de outubro de 2021.

3 Meyer, J.F.C.A., Lima, M., Espitia, C., Longo, F., Laiate, B., Gois, A., e Kunz, C., Different approaches to the modelling of COVID-19, Trends in Computational and Applied Mathematics, 2021, doi: 10.5540/tcam.2021.022.04.00515.

# Linear New Approach for Trigonometric Inverse Series Applied to Newton-Raphson Method[1]

*Short presentations (20 min)*
*Diomar Cesar Lobao[2]*
*Brazil*

**Resumen/Abstract:**

The purpose of this article is to show that not only can the inverse series of sines be used to approximate the Newton-Raphson method but also the inverse series of the tangent as well as the hyperbolic sine and hyperbolic tangent. These representations result in a new proposal to formulate the Newton-Raphson method as an approximation through a linear interpolation function. Numerical simulations show that the present proposal provides excellent numerical results.

**Palabras clave / Key words:** Newton-Raphson method. Inverse trigonometric series. Linear interpolation. Hyperbolic series. Iterative methods.

**Referencias/References:**

- KUMAR, M., SINGH, A. K., AND SRIVASTAVA, A(2015). A New Fifth Order Derivative Free Newton-Type Method for Solving Nonlinear Equations. Appl. Math. Inf. Sci. 9, No. 3, 1507-1513.

- POTRA, F. A., PTAK, V.(1984), Nondiscrete induction and iterative processes, Research Notes in Mathematics, 203, Pitnam, Boston.

- SRIVASTAV, V. K., THOTA, S., KUMAR, M. (2019). A New Trigonometrical Algorithm for Computing Real Root of Non-linear Transcendental Equations. Int. J. Appl. Comput. Math. Springer. Published online 15 march 2019. Available from internet: https://doi.org/10.1007/s40819-019-0600-8. Acess in: Feburary 05, 2020.

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[1]Martes/Tuesday 22,14:20 – 14:40,Schedule (GMT-6)
[2]Universidade Federal Fluminense - UFF-VCE Brasil, lobaodiomarcesar@yahoo.ca

# Fuel type mapping through AI for wildfire simulations[1]

*Short presentations (20 min)*

*Marcos López De Castro*[2]      *Diego Prieto Herráez*[3]

*José Manuel Cascón*[4]      *María Isabel Asensio Sevilla*[5]

*Gianni Pagnini*[6]

*España*

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**Resumen/Abstract:**

In the simulation of forest fires, an important limitation is the correct characterization of the surface vegetation in land cover maps (Domingo et al., 2020). Unfortunately, there exists a lack of accuracy in these maps with errors that derive from the seasonal nature of the vegetation and, specially, due to the lack of updating. This can result in less accurate predictions when wildfire models are applied to real-world situations. New remote sensing technologies are capable of providing up-to-date information on the state of the forests surface. In the last decade we have also seen how artificial intelligence algorithms can efficiently process information to solve many different types of problems. In this work we propose a method for fuel type classification using satellite imagery and artificial deep neural networks (ADNN). Machine learning techniques has been used successfully to binary classification of crop cover (Fang et al., 2020) and in prediction of future behaviour of land features such as fuel moisture(Rao, Williams, Flefil, & Konings, 2020). Our work is based on pixel-based processing cells, so the prediction of fuel type is carried out by classifying isolated pixels.We have employed 7 bands of ETM+ sensor in Landsat 7 mission to create our imagery dataset. The model has been applied in Castilla y León, a Spanish region. We have carried out the classification of the surface vegetation in different fuel types according to the Rothermel classification criteria. We have compared the performance of our model between no-combination and combination of some spectral bands. No-combination scenario try to predict fuel type only with classic spectral bands. In the other hand, combination scenario try to predict fuel type with the most suitable combination of classic spectral bands that highlight the characteristics of the land cover. Determine which bands combinations offers more accuracy in the predictions can be critical in order to make accurate predictions (Bhuiyan et al., 2020).The model may also be assisted with information of physics parameters, such as surface temperature, or land parameters, such as height, to increase the predictions accuracy. The output of the model proposed are georeferenced data which can be used to carry out simulations of a real fire (Prieto, Asensio, Ferragut, Cascón, & Morillo, 2017).

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[1]Martes/Tuesday 22, 8:00 – 8:20,Schedule (GMT-6)

[2]BCAM-Basque Center for Applied Mathematics, Alameda de Mazarredo 14, 48009 Bilbao, Basque Country, Spain, malopez@bcamath.org

[3]Applied Mathematics Departament, University of Salamanca, Casas del Parque 2, 37008 Salamanca,España, dpriher@usal.es

[4]Economy and Economic History Department, University of Salamanca, Building FES, Campus Miguelde Unamuno, 37007 Salamanca, Spain; Fundamental Physics and Mathematics University Institute, University of Salamanca, Casas del Parque1, 37008 Salamanca, casbar@usal.es

[5]Applied Mathematics Departament, University of Salamanca, Casas del Parque 2, 37008 Salamanca; Fundamental Physics and Mathematics University Institute, University of Salamanca, Casas del Parque1, 37008 Salamanca,España, mas@usal.es

[6]BCAM-Basque Center for Applied Mathematics, Alameda de Mazarredo 14, 48009 Bilbao, BasqueCountry, Spain; Ikerbasque-Basque Foundation for Science, Plaza Euskadi 5, 48009 Bilbao, Basque Country, Spain, gpagnini@bcamath.org

**Palabras clave / Key words:** Wildfire, Fuel type mapping, Rothermel fuel types classification, Deep Neural Networks, Satellite imagery.

**Referencias/References:**

- Bhuiyan, M. A. E., Witharana, C., Liljedahl, A. K., Jones, B. M., Daanen, R., Epstein,H. E., . . . Agnew, A. (2020). Understanding the Effects of Optimal Combination of Spectral Bands on Deep Learning Model Predictions: A Case Study Based on Permafrost Tundra Landform Mapping Using High Resolution Multispectral Satellite Imagery. Journal of Imaging, 6(9), 97.

- Domingo, D., de la Riva, J., Lamelas, M. T., García-Martín, A., Ibarra, P., Echeverría,M., & Hoffrén, R. (2020). Fuel Type Classification Using Airborne Laser Scanningand Sentinel 2 Data in Mediterranean Forest Affected by Wildfires. Remote Sensing, 12(21), 3660.

- Fang, P., Zhang, X., Wei, P., Wang, Y., Zhang, H., Liu, F., & Zhao, J. (2020). The Classification Performance and Mechanism of Machine Learning Algorithms in Winter Wheat Mapping Using Sentinel-2 10 m Resolution Imagery. Applied Sciences, 10(15),5075.

- Prieto, D., Asensio, M. I., Ferragut, L., Cascón, J. M., & Morillo, A. (2017). A GIS-based fire spread simulator integrating a simplified physical wildland fire model and a wind field model. International Journal of Geographical Information Science, 31(11), 2142–2163.

- Rao, K., Williams, A. P., Flefil, J. F., & Konings, A. G. (2020). SAR-enhanced mapping of live fuel moisture content. Remote Sensing of Environment, 245 , 111797.

# QUANTILE-BASED FUZZY CLUSTERING OF MULTIVARIATE TIME SERIES IN THE FREQUENCY DOMAIN[1]

*Short presentations (20 min)*
*Ángel López-Oriona*[2]
*España*

**Resumen/Abstract:**

A novel procedure to perform fuzzy clustering of multivariate time series gen- erated from different dependence models is proposed. Different amounts of dis- similarity between the generating models or changes on the dynamic behaviours over time are some arguments justifying a fuzzy approach, where each series is associated to all the clusters with specific membership levels. Our procedure considers quantile-based cross-spectral features and consists of three stages: (i) each element is characterized by a vector of proper estimates of the quantile cross-spectral densities, (ii) principal component analysis is carried out to cap- ture the main differences reducing the effects of the noise, and (iii) the squared Euclidean distance between the first retained principal components is used to perform clustering through the standard fuzzy C-means and fuzzy C-medoids algorithms. The performance of the proposed approach is evaluated in a broad simulation study where several types of generating processes are considered, including linear, nonlinear and dynamic conditional correlation models. Assess- ment is done in two different ways: by directly measuring the quality of the re- sulting fuzzy partition and by taking into account the ability of the technique to determine the overlapping nature of series located equidistant from well-defined clusters. The procedure is compared with the few alternatives suggested in the literature, substantially outperforming all of them whatever the underlying pro- cess and the evaluation scheme. Two specific applications involving air quality and financial databases illustrate the usefulness of our approach.

**Palabras clave / Key words:** Multivariate time series; Clustering; Quantile cross-spectral density; Fuzzy C-means; Fuzzy C-medoids; Principal component analysis

**Referencias/References:**

1  T. W. Liao, Clustering of time series data: A survey, Pattern Recognit. 38 (11) (2005) 1857–1874.

2  T.-c. Fu, A review on time series data mining, Eng. Appl. Artif. Intell. 24 (1) (2011) 164–181.

3  S. Rani, G. Sikka, Recent techniques of clustering of time series data: A survey, Int. J. Comput. Appl. 52 (15) (2012) 1–9.[

4  S. Aghabozorgi, A. S. Shirkhorshidi, T. Y. Wah, Time-series clustering–a decade review, Information Systems 53 (2015) 16–38.

5  E. Maharaj, P. D'Urso, J. Caiado, Time Series Clustering and Classifica- tion, Chapman & Hall/CRC Computer Science and Data Analysis Series, CRC Press, 2019.

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[1]Martes/Tuesday 22, 8:20 – 8:40,Schedule (GMT-6)
[2]University of A Coruña, España, oriona38@hotmail.com

# Influence of stochastic noise on hematopoietic recovery after an autologous bone marrow transplant[1]

*Short presentations (20 min)*
*Dennis Lumpuy Obregón[2]*
*Cuba*

**Resumen/Abstract:**

The application of differential equations systems in stem cell maturation processes allows the representation and predictive visualization of the results obtained from initial clinical data. In the present work, a study of the cell maturation process after chemotherapy is carried out. Starting from the deterministic models that represent this process, a case is chosen to study, from which the probabilistic model is presented, which has the influence of stochastic noise. The proposed probabilistic model is solved for the case of eight compartments, this represents the maturation of hematopoietic cells in obtaining neutrophilic granulocytes, and variations in the noise diffusion coefficients are applied, conclusions are reached on the effects of the representation stochastic from its representation using Mathematica software. In addition to a biological interpretation of the mathematical results obtained in the representation of the stochastic system, including the influence of stochastic noise in the equations of the proposed system.

**Palabras clave / Key words:** stem cells, chemotherapy, probabilistic model, stochastic noise, neutrophilic granulocytes

**Referencias/References:**

- A. Marciniak-Czochra, T. S. (2009). Modelling of asymmetric cell division in hematopoietic stem cells-regulation of self-renewal is essential for efficient repopulation. Stem Cells Dev. 18, 377-385.

- A. Marciniak-Czochra, T. S. (s.f.). Mathematical models of hematopoietic reconstruction after stem cell transplantation. En C. T. H.G., Model Based Parameter Estimation: Theory and Applications. Springer

- Verlag. Fried, W. (2009). Erythropoietin and erythropoiesis. Exp. Hematol, 37, 1007-1015.

- Metcalf, D. (2008). Hematopoietic cytokines. Blood, 111, 485-491.

- Pazdziorek, P. l. (2012). Mathematical model of stem cell. Preprint.

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[1]Miércoles/Wednesday 23, 9:00 – 9:40,Schedule (GMT-6)
[2]Universidad Central "Martha Abreu"de Las Villas,Cuba, dlumpuy@uclv.cu

# KERNEL DENSITY ESTIMATIONS IN THE MACHINE LEARNING WORLD[1]

*Short presentations (20 min)*
*Pablo Martinez-Camblor[2]*
*USA*

**Resumen/Abstract:**

In biomedical research, binary classification problems arise in a wide variety of problems, mainly involved in diagnostic and prognostic tasks but also have presence, for instance, in personalized medicine. The overall objective is to use the available information to correctly allocate subjects in groups. Frequently, this information implies high-dimensional data and the rationality behind the derived classification rules is difficult to understand. An adequate classification rule is frequently a trade-off between sensitivity and specificity. The ROC curve is a graphical tool which helps to understand, evaluate and compare the accuracy of diagnostic processes. We propose a procedure for estimating the optimal classification rules based on a penalized estimator of the underlying probability distribution functions in both the negative and positive populations. We study its asymptotic properties and its finite-sample behavior. Through Monte Carlo simulations, we compare our proposal with a support vector machine based ROC curve. We also illustrate its practical use on a real-world data problem. Results suggest that, despite some modern techniques promise to improve the results provided by other more traditional methods, in the binary classification problem, the limit is the actual relationship among the density functions. Statistical methods can provide a close approximation for the targeted quantity. Besides, to keep some rationality in the statistical analyses could result in much better classification accuracy than those based on computational power.

**Palabras clave / Key words:** Binary classification problem, Kernel density estimator, Machine learning, Robust estimator.

**Referencias/References:**

- Zhou, X.-H., Obuchowski, N.A. and McClish, D.K. (2002). Statistical Methods in DiagnosticMedicine. Wiley Blackwell, New York

- Perez-Fernandez, S., Martinez-Camblor, P., Filzmoser, P. and Corral N. (2021). Visualizingthe decision rules behind the ROC curves: understanding the classification process.AStA Advances in Statistical Analysis, (105):135-161.

- McIntosh,M. W. and Pepe, M.S. (2002). Combining several screening tests: Optimality ofthe risk score. Biometrics, 58(3):657-664.

- Martinez-Camblor, P., Perez-Fernandez, S. and Diaz-Coto, S. (2021). Optimal classificationscores based on multivariate marker transformations. AStA Advances in StatisticalAnalysis, pages 1-19

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[1] Lunes/Monday 21, 11:30 – 12:00,Schedule (GMT-6)

[2] Dartmouth College - Geisel School of Medicine,USA, pmcamblor@hotmail.com

- Luckett, D.J., Laber, E.B., El-Kamary, S.S., Fan, C., Jhaveri, R., Perou, C.M., Shebl, F.M.,and Kosorok, M.R. (2020). Receiver operating characteristic curves and confidence bands forsupport vector machines. Biometrics, pages 1-9

# Construction of the average variance extracted adaptive index for construct validation using adaptive regressions

*Posters*

*PATRICIA MENDES DOS SANTOS*[1]

*Brazil*

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**Resumen/Abstract:**

Among the many advantages that the structural equation modeling (SEM) technique provides, the flexibility to include latent variables in a covariance structure assumed by a theoretical model that explains their linear relationships with observed variables stands out. The inclusion of these variables is important in the composition of a construct, resulting from a directly unobservable theoretical concept. However, based on an empirical knowledge represented by the specification of two factorial models that relate the endogenous and exogenous observed variables to one or more latent variables. These models are defined as measurement models, in which a structural model defines the relationship between latent variables. Assuming that a construct is mathematically formed by linear combinations of observed variables, it is important to analyze the number of variables to be used in its formation. This provides enough information for a concept to be characterized in its interpretation. A considerable number of indices and coefficients have been proposed to validate the constructs, for example, the Average Variance Extracted (AVE)[2], which is the average amount of variation that a latent construct is able to explain in the observed variables to which it is theoretically related. The conventional indices are formed by factor loadings resulting from estimated least square or maximum likelihood regressions. In this respect, a new proposition that provides new factor loadings could result in a more informative AVE index. Based on this fact, in this work a procedure was used to estimate factor loadings by means of adaptive linear regressions. This procedure resulted in a combination of estimations obtained by the method of least squares, and robust estimations, generated by LTS regression. this study aimed at estimating the AVE index by following a plug-in estimation procedure, that is, replacing the variance of errors with the factor loadings obtained in the adaptive regressions. A Monte Carlo simulation study was performed considering different numbers of outliers generated by distributions t student e uniform and sample sizes defined as $n = 50 e 100$[1]. It was concluded that, in formative structural models, the ALR method showed good efficiency for correctly specified models. The results obtained from the ALR method for models with specification errors showed low efficiency, as expected.

**Palabras clave / Key words:** adaptive regression; structural equation model, outliers, contaminação, taxa de mistura

**Referencias/References:**

1  Dos Santos , P. M.; Cirillo, M. A. (2021) Construction of the average variance extracted index for construct validation in structural equation models with adaptive regressions. Communications in Statistics - Simulation and Computation.

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[1]UNIVERSIDADE FEDERAL DE LAVRAS,Brasil, patymendesdossantos@hotmail.com

2 Valentini, F.; Damásio, B.F. (2016). Variância média extraída e confiabilidade composta: Indicadores deprecisão. Psicologia: Teoria e Pesquisa 32 (2), 1–7.

3 R DEVELOPMENT CORE TEAM. (2021) R: a language and environment for statistical computing. Vienna, 409 p.

# CoronaSurveys: Estimating Active Cases of COVID-19[1]

*Presentations (30 minutes)*

*Raquel Menezes[2]　　　　Carlos Baquero[3]*

*Portugal*

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**Resumen/Abstract:**

The COVID-19 disease epidemic caused by the SARS-CoV-2 virus started having a deep impact in societies across the world as the virus spread globally in early 2020. Not surprisingly, during its initial months, the knowledge about virus properties and the ability to test for its presence or correctly identify symptoms was limited. These factors, when coupled with the fast spread of the pandemic made it very challenging to obtain accurate estimates of the numbers of individual cases. This problem affected the estimation of a number of important metrics, including the number of daily cases, the cumulative number of cases, or the proportions of active and contagious cases at a given time and place. In this talk, we address these limitations and discuss approaches proposed in [1,4] that try to predict the true magnitude of actual cases. Specifically, we aim to assess the number of active cases at a given point in time, i.e., how many people are sick with COVID-19. The first class of approaches depend on the accuracy of the official reporting of COVID-19 cases and deaths [2,3], which can be an issue in some regions. The second class of approaches is survey-based and built on data collected by the CoronaSurveys project-coronasurveys.org, and by the University of Maryland and Carnegie Mellon University with the support of Facebook [5]. We observe that in some countries (like Greece or Portugal) the most recent estimates from official data and from surveys match. However, in other countries (like Brazil or India) the surveys data gives a much larger number of active cases, possibly due to under reporting in the official data. The conclusion is that estimates via surveys is a viable option to estimate active number of cases in countries with reduced testing capacity or suboptimal reporting infrastructures.

**Palabras clave / Key words:** COVID-19, survey, indirect reporting, active cases, estimation

**Referencias/References:**

1　Álvarez, J., et al (2021). Estimating Active Cases of COVID-19, arXiv:2108.03284 [physics.soc-ph]. 2nd KDD Workshop on Data-driven Humanitarian Mapping: Harnessing Human-Machine Intelligence for High-Stake Public Policy and Resiliency Planning.

2　Johns Hopkins University & Medicine. Johns Hopkins Coronavirus Resource Center. `https://coronavirus.jhu.edu`, 2020. Accessed: 2021-06-02.

3　Worldometer. COVID-19 Coronavirus Pandemic. `https://www.worldometers.info/coronavirus/`, 2020. Accessed: 2021-06-02.

4　Garcia-Agundez, A., et al (2021).Estimating the covid-19 prevalence in Spain with indirect reporting via open surveys. Frontiers in Public Health, 9.

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[1]Martes/Tuesday 22, 9:00 – 9:40,Schedule (GMT-6)

[2]University of Minho,Portugal, rmenezes@math.uminho.pt

[3]Department of Informatics Engineering, University of Porto,Portugal, cbm@fe.up.pt

5  Facebook Data for Good. COVID-19 symptom survey – request for data access.
   `https://dataforgood.fb.com/docs/covid-19-symptom-survey-request-for-data-access/`
   , 2020. Accessed: 2021-01-24.

# Los modelos cohorte-temporales de la dispersión del COVID-19.[1]

*Presentations (30 minutes)*
*Roberto Molina Cruz*[2]

**Resumen/Abstract:**

Las enfermedades virales como el COVID-19 son un problema de salud pública, cuya solución requiere reducir la velocidad de trasmisión de la enfermedad entre las personas. Para esto son necesarias intervenciones sociales en la forma de políticas públicas, las cuales deben ser efectivas y eficientes dadas sus consecuencias socio-económicas en la población.Estas políticas públicas deben ser diseñadas, implementadas y evaluadas con información epidemiológica relevante, propia de un sistema nacional de información en salud robusto, la cual debe ser analizada utilizando varios tipos de modelos estadísticos y matemáticos. Así para la aplicación de los modelos epidemiológicos es necesario el fortalecimiento del sistema nacional de información en salud del país.Para enfrentar la dispersión de las enfermedades virales como el COVID-19, nos parecen relevantes los modelos cohorte-temporales basados en series de tiempo estadísticas, los cuales proponemos utilizar en la forma siguiente. Con la información de las personas infectadas en años anteriores, agrupadas en cohortes definidas según las características relevantes en la transmisión de estas enfermedades, se estiman las tasas de transmisión entre las cohortes definidas de la población. Luego, al identificar los casos actuales de una enfermedad similar, se determinan las cohortes de la población relevantes para el diseño de políticas públicas adecuadas.Para esto proponemos los modelos de series de tiempo vectoriales, en particular los modelos auto-regresivos de orden 1 –VAR(1)– cuya aplicación ilustramos utilizando datos recientes de Alemania, publicados por el Instituto Robert Koch. También describimos los modelos hhh4, estos son modelos especiales de series de tiempo vectoriales, que para su elaboración es necesaria información suplementaria, posiblemente obtenida mediante una encuesta de la población.

**Palabras clave / Key words:** COVID-19, sistemas de información en salud, modelos vectoriales autoregresivos, modelos hhh4

**Referencias/References:**

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# Modelación del COVID-19 en Costa Rica: Modelo SIR

*Posters*

*Moisés Monge Cordonero*[1]          *Daniel Josué Sabater Guzmán*[2]

*Joshua Cervantes Artavia*[3]

*Costa Rica*

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**Resumen/Abstract:**

Throughout history, various epidemics have affected mankind, so understanding the behavior of diseases, particularly epidemics, has aroused human interest. With the study of epidemics in the 19th century, a key concept called the law of mass action emerged. Based on this concept, several mathematical models have been developed, including the SIR model developed by Kermack and McKendrick in 1927. This paper presents the application of the SIR Model, using data from the period from March 6, 2020 to April 4, 2020, from the Geographic Health Observatory of the Ministry of Health of Costa Rica. Based on these data, a model of the development of the epidemic in Costa Rica was obtained, which was compared with the actual behavior of the epidemic, thus identifying the differences between the two and concluding the accuracy of this model in the country, obtaining that although it is true it can be constituted in a tool to analyze the R0 infection rate, the model assumes conditions that diverge significantly from reality.

**Palabras clave / Key words:** SIR Model, mathematical epidemiology, COVID-19.

**Referencias/References:**

- Brauer, F., Castillo-Chavez, C. (2012) Mathematical models in population biology and epidemiology. doi:10.1007/978-1-4614-1686-9

- Brauer, F., Castillo-Chavez, C., De La Pava, E., Barley, K., Castillo-Garsow, C. W.,Chowell, D., ... Moreno, V. M.. (2015) Modelos de la propagación de enfermedades infecciosas.. Recuperado de https://bit.ly/3btXEV6

- Chaves, L., Hurtado, L., Rojas, M., Friberg, M., Rodr´ıguez, R., y Ávila-Aguero, M.. (2020). COVID-19 Basic reproduction number and assessment of initial suppression policies in Costa Rica. Mathematical Modelling of Natural Phenomena, 15(32), 1-13. doi:10.1051/mmnp/2020019

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[3]Universidad de Costa Rica,Costa Rica, joshua.cervantes@ucr.ac.cr

# ANALYSIS AND CHARACTERIZATION OF EMPLOYMENT AND ITS DYNAMICS IN MEXICO BEFORE AND DURING THE COVID-19 PANDEMIC[1]

*Presentations (30 minutes)*
*Edwin Montes Orozco[2]*
*México*

**Resumen/Abstract:**

In this work we present the characterization of the behavior and dynamics of employment in the Mexican population before and during the COVID-19 pandemic. This characterization is carried out with the use of two complex multiplex networks, where each node represents a federative entity (state) of the country where the intralayer relationships are given by the quantification of the generation and loss of jobs; while the interlayer connections are the replicas of each of the states, for each period; where, specifically for this work, the years 2018, 2019, 2020 and 2021 are contemplated. On the other hand, with the aim of analyzing the main characteristics that cause the loss or conservation of employment before and during the pandemic, using the problem of robust coloring in the complementary graph, it is sought to generate $k + 1$ communities such that the average stiffness is minimized (per layer) but the color coincidence (between layers) is maximized. Therefore, we expect that a determination of the employment behavior in Mexico will be obtained.

**Palabras clave / Key words:**

**Referencias/References:**

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# Pricing Financial Options through Modified Black-Scholes Merton Model[1]

*Short presentations (20 min)*

*Paula Beatriz Morales Bañuelos*[2]      *Nelson Muriel Torrero*

*Guillermo Fernández-Anaya*

*México*

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**Resumen/Abstract:**

Due to the substantial volatility faced by corporations, financial institutions, and even non-profit organizations, which is caused by both internal and external factors, among the latter are the constant globalization of transactions, asymmetric information, transaction costs, unforeseen variations in interest rates, and currently the impact of COVID-19 on the economy.Therefore, these firms must resort to the means to mitigate the decrease in profits, the generation of losses, and the technical bankruptcy in a powerful way. Among the hedging instruments are financial derivatives, contracts that generate rights or obligations for the parties involved. The underlying can be the exchange rate, interest rates, commodities, and even sustainable energy. A significant advantage of these instruments is that they adapt to the firms' needs due to their enormous usefulness in designing and implementing strategies. Hence is essential to know the market price of these instruments. According to the information provided by the Mexican Derivatives Market, the fair value of financial options is obtained from the amount resulting from applying the traditional Black Scholes Merton (BSM) model (1973), which fluctuates with supply and demand until reaching equilibrium. The objective of this investigation is to provide a better approximation of the equilibrium value. We considered the dependence of the stochastic differential equation parameters concerning time and included them in the underlying conformal derivates. Additionally, we carry out an empirical analysis, particularly considering the information of the Mexican market. We calculated the European call options by applying the traditional BSM models (1973), the Standard Fractional Brownian Movement (2017), and the model developed in this work. We compared the results of each model with the real value at which each option contract was sold, concluding that the model developed in this research is the one that most approximates the market value of the arrangements.

**Palabras clave / Key words:** European call financial options, Variant parameters over time, Conformal derivatives Standard Fractional Movement

**Referencias/References:**

- F. Black, M. Scholes (1973). The pricing the options and corporate liabilities, Journal of Political Economy 81. 637-659.

- R. Merton (1973). Theory of rational option pricing. Bell Journal of Management Sciences 4. 141-183.

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[1]Jueves/Thursday 24, 16:30 – 16:50,Schedule (GMT-6)

[2]Universidad Iberoamericana, A.C. Ciudad de México,México, paula.morales@ibero.mx

- D.A. Njamen, E. Djeutcha, (2017). Solving Black-Scholes Equation Using Standard Fractional Brownian Motion, Journal of Mathematics Research, 11. 142-157.

- R. Rodrigo, R. Mamon, (2006). An alternative approach to solve the Black-Scholes equation with time-varying parameters. Applied Mathematics, 19. 398-402.

# Using Linear Regression Modeling to Describe Water Consumption Histories for Municipalities in the Department of Cundinamarca, Colombia

*Posters*

*Mateo Moreno Aponte*[1]          *Olga Viviana Pita Celis*[2]

*Colombia*

**Resumen/Abstract:**

Water, as a non-renewable life resource, constitutes 80 percent of most organisms on the planet. The most common uses are agriculture, industrial and domestic consumption. In Colombia, there are many factors that affect water consumption, agricultural, industrial and commercial processes, among others, which have undergone changes due to the accelerated development brought about by globalization; likewise, factors such as the growth of urban areas, the increase in the commerce sector and the coverage of the aqueduct service considerably affect the figures of water consumption in the country.The purpose of the proposal is to estimate a linear regression model to describe the historical water consumption of the Cundinamarca municipalities in Colombia, in order to make a diagnosis of the variables that determine water consumption in these municipalities, in order to lay the foundations for making decisions regarding the appropriate management of water resources.

**Palabras clave / Key words:** Water Consumption, Linear Regression, Water Resources Management

**Referencias/References:**

- Fajardo Monroy, M. G., Cazar Almache, F. E. (2017). Formulación de un modelo de consumo de agua potable para la ciudad de Cuenca. `http://dspace.uazuay.edu.ec/handle/datos/7509`

- Jiménez, D. F., Orrego, S. A., Cossío, D. M., Vásquez, F. A., Ponce, R. D. (2017). Efecto de la variabilidad climática sobre la demanda de agua para uso residencial urbano: El caso de la ciudad de Manizales, Colombia. Revista Desarrollo y Sociedad.`https://doi.org/10.13043/dys.79.3`

- Seguido, A. F. M. (2017). Factores que inciden en el consumo de agua doméstico. Estudio a partir de un análisis bibliométrico. Estudios Geográficos, 78 (282), 257-281. `https://doi.org/10.3989/estgeogr.201709`

- Wooldridge, J. M. (2010). Econometric analysis of cross subsection and panel data. Massachusetts Institute of Technology.Wooldridge, J. M. (2013). Introductory Econometrics: A Modern Approach. Cengage Learning.

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[2]Universidad Distrital Francisco José de Caldas, Sede de Ingeniería, ovpitac@correo.udistrital.edu.co

# SPATIAL ANALYSIS PREDICTING ASTHMA MORBIDITY IN MULTIETHNIC URBAN RHODE ISLAND CHILDREN[1]

*Presentations (30 minutes)*
*Anarina Murillo[2]*
*USA*

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**Resumen/Abstract:**

Urban environments contribute to greater asthma morbidity and a a higher prevalence of the asthma and obesity co-morbidity among low-income Latino and Black/African American children. Multi-level approaches are needed to improve lifestyle behaviors within the context of geographic location to address inequities in pediatric asthma and obesity. This study implements spatial analysis and a multi-level model to predict asthma morbidity and determine the contribution of community-level spatial risks in a multiethnic pediatric sample of urban children and families. The novel features of this study are the inclusion of community-level spatial risks and lifestyle behaviors to examine the moderating role of obesity on asthma morbidity in urban children. Findings of this study may inform evidence-based solutions that address geographic needs of children and families from high-risk groups to improve lifestyle behaviors, asthma control, obesity, and overall health outcomes of children.

**Palabras clave / Key words:** Urban Environment, Children, Spatial Statistics, Asthma, Obesity

**Referencias/References:**

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[1]Miércoles/Wednesday 23, 10:00– 10:30,Schedule (GMT-6)

[2]Department of Biostatistics School of Global Public Health New York University,USA, anarina.murillo@nyu.edu

# Renormalization group theory and scheduler dependencies in Agent-Based Models: two modeling aspects toward higher model fidelity[1]

*Presentations (30 minutes)*
*Santiago Núñez-Corrales[2]*
*USA*

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**Resumen/Abstract:**

This work discusses the study of two agent-based modeling phenomena in relation to contagion models and their fidelity to reality. Formally, stochastic contagion models are captured by interacting particle systems and their statistics [1,2] for which some renormalization properties have been elucidated [5]. In a SARS-CoV-2 contagion model for the Urbana-Champaign, the use of renormalization group theory (RGT) allows running the model within a one-hour limit and a limited number of compute cores, in correspondence with time constraints imposed by the need to explore as many scenarios as possible for decision-making purposes [4]. We present here the corresponding renormalization group for this contagion process, its computational implementation, and discuss the advantages and limitations of the technique. We then explore scheduler dependencies in Agent-Based Models (ABM) simulations. These are known to exist, but often remain sidelined in practice, and continue to be theoretically and technically opaque. Understanding whether the differences introduced by scheduling choices yield significant deviations from both analytic results and phenomenological observation can provide insights on whether those discrepancies may lead to meaningful differences of scientific interpretation or decision making. Here we demonstrate their presence and non-trivial nature in a variant of the standard agent-based SIRD contagion model, one in which an agent's local decisions are informed by both their local environment and the consensus of their spatially non-local social network where event priorities are computed from the network centrality of each agent. Preliminary simulation outcomes suggest that priority scheduling introduces resonant stochastic fluctuations modulated by social mimicry [3].Finally, we discuss the implications of RGT and scheduler dependencies in the larger context of model fidelity as an overarching simulation goal.

**Palabras clave / Key words:** agent-based models, interacting particle systems, model fidelity, renormalization group theory, scheduler dependencies

**Referencias/References:**

1 Kipnis, C. & Landim, C.Scaling limits of interacting particle systems. Springer Science & Business-Media (1998).

2 Lafuerza, L. F. & Toral, R. On the effect of heterogeneity in stochastic interacting-particle systems.Scientific Reports 3, 1–8 (2013).

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3 Mudigonda, S., N ìu Þnez-Corrales, S., Venkatachalapathy, R., & Graham, J. Scheduler dependencies in Agent-Based Models: A case-study using a contagion model.The Computational Social Science (CSS 2021) Annual Conference. Santa Fe NM, Nov 4 – 7 (2021).

4 Núñez-Corrales, S. & Jakobsson, E. The Epidemiology Workbench: a Tool for Communities to Strategize in Response to COVID-19 and other Infectious Diseases.medRxiv (2020).

5 Wallace, D. C. Renormalization and statistical mechanics in many-particle systems. I. Hamiltonian perturbation method.Physical Review 152, 247 (1966).

# A PAIR OF DUAL BRANES ON THE SINGULAR LOCUS OF THE HITCHIN SYSTEM[1]

*Plenary lectures (50 minutes)*
*André Oliveira[2]*
*Portugal*

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**Resumen/Abstract:**

In [FGOP] we studied the fixed point loci on the moduli space M of GL(n,C)-Higgs bundles (over a curve) for the action of tensorization by a line bundle of order n. It is a hyperholomorphic subvariety, carrying a hyperholomorphic bundle. Thus it is what's called a BBB-brane on M. There is a corresponding BAA-brane on M - i.e. a complex Lagrangian subvariety equipped with a flat bundle - which may be described in terms of Hecke modifications. Such branes lie over the singular locus of the Hitchin system and in [FGOP] we proved that their restriction to the locus of nodal spectral curves are dual branes under mirror symmetry. In this talk I will give an overview of this work with E. Franco, P. Gothen and A. Peón-Nieto. If time allows, I will also mention work in progress where we aim to achive a more detailed description of those branes over the most singular fibre of the Hitchin system, namely the nilpotent cone.

**Palabras clave / Key words:**

**Referencias/References:**

- Franco, E., Gothen, P., Oliveira, A., Peón-Nieto, A. (2021). Unramified covers and branes on the Hitchin system, Advances in Mathematics, 377 (2021), 107493

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[1]Miércoles/Wednesday 23, 11:00 – 12:00,Schedule (GMT-6)
[2]Universidade do Porto,Portugal, andre.oliveira@fc.up.pt

# A CONVERGENT AND ASYMPTOTIC LAPLACE METHOD FOR INTEGRALS[1]

*Short presentations (20 min)*
*Pedro Pagola Martinez*[2]     *José López*[3]
*Pablo Palacios*[4]
*España*

**Resumen/Abstract:**
Watson's lemma and Laplace's method provide asymptotic expansions of Laplaceintegrals $F(z) :=$ $R \int_{0100}^{-zf(t)} f(t)g(t)dt$ for large values of the parameter z. They are usefultools in the asymptotic approximation of special functions that have a Laplace integral representation. But in most of the important examples of special functions, the asymptotic expansion derived by means of Watson's lemma or Laplace's method is not convergent. A modifcation of Watson's lemma was introduced in [Nielsen, 1906] where, by the use of inverse factorial series, a new asymptotic as well as convergentexpansion of F(z), for the particular case f(t) = t, was derived. In this paper we gosome steps further and investigate a modifcation of the Laplace's method for F(z),with a general phase function f(t), to derive asymptotic expansions of F(z) that arealso convergent, accompanied of error bounds. An analysis of the remainder of thisnew expansion shows that it is convergent under a mild condition for the functions f(t)and g(t), namely, these functions must be analytic in certain starlike complex regionsthat contain the positive axis $[0, \infty)$. In many practical situations (in many examples of special functions), the singularities of f(t) and g(t) are of this region and then thismethod provides asymptotic expansions that are also convergent. We illustrate this modifcation of the Laplace's method with the parabolic cylinder function U(a, z), providing an asymptotic expansions of this function for large z that is also convergent.

**Palabras clave / Key words:** Asymptotic expansions of integrals; Watson's lemma; Laplace's method; convergent expansions; special functions.

**Referencias/References:**

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# METAHEURISTICS FOR SORTING PERMUTATIONS BY PREFIX REVERSALS (SPBR)[1]

*Presentations (30 minutes)*

*Wilmer José Palacios*[2]          *Fernando José Hernández Gómez*[3]

*Nicaragua*

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**Resumen/Abstract:**

Sorting permutations by prefix reversals (SPBR) is a classical combinatorial optimization problem whose main objective is to sort a permutation of n elements reversing the leftmost (prefix) blocks of that permutation. Technically, a given permutation $\pi$ must be transformed into an identity permutation named id. Similarly, it could be compared in magnitude to a stack of pancakes that must be rearranged with a spatula by inserting it at any point and inverting its order so that after several iterations the stack is ordered. However, since 2012 it has been shown that this problem belongs to the NP-Hard class, which makes it unfeasible in practical terms to construct an optimal solution in polynomial time or less. In fact, in recent years, the academic community has tried to use heuristic and metaheuristic approximation algorithms that provide better results. In this research, heuristic and metaheuristic algorithms were designed and implemented, based on the criteria proposed by the reviewed literature. Also, a family of life-inspired metaheuristics was proposed that have proven to be very efficient in finding solutions in large search spaces. The algorithms used during the implementation of this research work were written with Python, using the Google Colab tool. In addition, the basic concepts related to modern permutation theory and its elementary ordering methods were reviewed. The evaluation of the algorithms was performed using the set of results provided by the literature of the scientific community in the last 10 years. We showed the advantages and disadvantages of using the different methods proposed and ultimately which of them will prove to be the most appropriate depending on the context in which the problem is placed. Finally, this work contributes greatly to the dissemination, extension, and improvement of the study of combinatorial optimization from the point of view of the implementation and evaluation of algorithms.

**Palabras clave / Key words:** sorting permutations, heuristics algorithms, metaheuristics algorithms, combinatorial optimization

**Referencias/References:**

- Brito, K. L., Oliveira, A. R., Dias, U., and Dias, Z. (2019). Heuristics for the reversal and transposition distance problem. IEEE/ACM transactions on computational biology and bioinformatics, 17(1):2–13.

- Bulteau, L., Fertin, G., and Rusu, I. (2012). Pancake flipping is hard. In Proceedings of the 37th international conference on Mathematical Foundations of Computer Science, pages 247–258.

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- Dias, U., Galv~ao, G. R., Lintzmayer, C. N., and Dias, Z. (2014). A general heuristic for genome rearrangement problems. Journal of bioinformatics and computational biology, 12(03):1450012.

- Gates, W. H. and Papadimitriou, C. H. (1979). Bounds for sorting by prefix reversal. Discrete mathematics, 27(1):47–57.

- Lintzmayer, C. N. (2016). The Problem of Sorting Permutations by Prefix and Suffix Rearrangements. PhD thesis, PhD thesis, University of Campinas, Institute of Computing, 2016. In English.

# A COVID-19 DATA-BASED APPROACH USING A MULTI-GROUP SIHR MODEL WITH FUZZY SUBSETS. APPLICATION TO THE CASE OF THE GUADELOUPE ARCHIPELAGO.[1]

*Presentations (30 minutes)*

*Silvere Paul Nuiro*[2]        *Sebastien Regis*[3]

*Woody Merat*[4]        *Andrei Doncescu*[5]

*Guadalupe*

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**Resumen/Abstract:**

**Palabras clave / Key words:** COVID-19 simulation, SIR multi-group, fuzzy subsets, data-based approach, aggregation operators

**Referencias/References:**

- Ivorra, B.,Fernandez, M.R.,Vela-Perez, M.,and Ramos, A.M. (2020). Mathematical modeling of the spread of the coronavirus disease 2019 (covid-19) taking into account the undetected infec- tions. the case of china. Communications in Nonlinear Science and Numerical Simulation, 88.

- Magal, P.,Seydi, O.,and Webb, G. (2018). Final size of a multi-group sir epidemic model: Irreducible and non-irreducible modes of transmission. Mathematical Biosciences, 301:59–67.

- Regis, S.,Nuiro, S.P.,Merat, W.,and Doncescu, A. (2021). A data-based approach using a multi- group sir model with fuzzy subsets. application to the covid-19 simulation in the islands of guadeloupe. To appear in Biology.

- Kumar Das, D.,Kar, T.K.,Khatua,A.,and Jana, S. (2021). The effectiveness of contact tracing in miti- gating covid-19 outbreak: A model-based analysis in the context of india. Applied Mathematics and Computation.

- Williamson, E., and et al. (2020). Opensafely: factors associated with covid-19-related hospital death in the linked electronic health records of 17 million adult nhs patients. medRxiv preprint. `https: //doi.org/10.1101/2020.05.06.20092999`

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[1]Miércoles/Wednesday 23, 10:00 – 10:40,Schedule (GMT-6)

[2]Université des Antilles (FWI) Laboratoire LAMIA, EA4540, paul.nuiro@univ-antilles.fr

[3]Université des Antilles (FWI) Laboratoire LAMIA, EA4540, sebastien.regis@univ-antilles.fr

[4]Université des Antilles (FWI) Laboratoire LAMIA, EA4540, woody.merat@univ-antilles.fr

[5]Université des Antilles (FWI) Laboratoire LAMIA, EA4540, andrei.doncescu@univ-antilles.fr

# Ozone study in Mexico City. An application of the hidden Marcov processes[1]

*Short presentations (20 min)*
*Blanca Rosa Pérez Salvador[2]*
*México*

**Resumen/Abstract:**

Tropospheric ozone is a pollutant that affects us when it reaches high concentration levels, for this reason, it is important to study it. In this work, ozone is studied using Hidden Markov Model, considering that there are environmental conditions in the atmosphere that cannot be measured, but that they affect raising or lowering the concentration levels of the ozone. In a Hidden Markov Model, two simultaneous stochastic processes coexist, the first is a Markov Chain that remains hidden and the second is the result of a random variable whose distribution function depends on the state of the chain. In the studding case, the Environmental Conditions is the Markov Chain and Ozone Levels are the random variables.

**Palabras clave / Key words:**
Environmental pollution, Markov chains, conditional probability, stochastic processes

**Referencias/References:**

1 Altman, R.M (2004). "Assessing the Goodness-of-Fit of Hidden Markov Models". Biometrics, Vol. 60(2), pp. 444-450.

2 Cappé, O., Moulines, E. y Rydén, T. (2005) "Inference in hidden Markov models". Springer, New York.

3 Dempster, A.P., Laird,N.M., y Rubin, D.B. (1977) "Maximum-likelihood from incomplete data via the EM algorithm", Journal of the Royal Statistical Society. Series B (Methodological), Vol. 39(1), pp. 1-38.

4 Gomez-Losada, A., Pires, J.C.M.,Pino-Mejías, R. (2016) "Of background air pollution exposure in urban environments using a metric based on Hidden Markov Models". Atmospheric environment,

5 Petrushin, A. Valery. (2000) "Hidden Markov Models: Fundamentals and Applications", Center for Strategic Technology Research.

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[1]Miércoles/Wednesday 23, 16:00 – 16:20,Schedule (GMT-6)
[2]Universidad Autónoma Metropolitana Iztapalapa, México, psbr@xanum.uam.mx

# Decision analysis from SAPEVO-M and THOR-2 methods for the acquisition of a new hospital ship for the Brazilian Navy[1]

*Short presentations (20 min)*

*Pinheiro De Araújo Costa,Arthur*[2]     *De Pina Corriça, José Victor*[3]

*Carvalho Leandro*[4]     *Braz Alves, Edgard*[5]

*De Araújo Costa, Igor*[6]     *Dos Santos, Marcos*[7]

*Brasil*

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**Resumen/Abstract:** Considering that the Brazilian Navy Refitting Program aims to acquire a hospital ship between 2023 and 2030, this article aims to assist the Navy in making the decision-making of the best hospital ship to be purchased. This paper presents a new approach based on Multi-Criteria Decision Analysis (MCDA), through its implementation and feasibility related to the decision-making process regarding the evaluation of one hospital ship for the Brazilian Navy. For this purpose, the SAPEVO-M method was used for the analysis of weights, and, for the analysis of alternatives and criteria, the THOR-2 method was used. Six vessels were compared considering their operative and hospital criteria. The chosen ship would initially be used to fighting coronavirus and, in addition, the Brazilian Navy would have its first hospital ship ready to operate and provide support in a possible military conflict. After the application of these methods, the hospital ship USNS Mercy was selected as the most advisable to be purchased.

**Palabras clave / Key words:** : Multi-Criteria Decision Analysis; Hospital Ship; SAPEVO-M method; THOR-2 method.

## Referencias/References:

- ALIM, A.A. Ships Hospital. Focus, 2015.

- BELTON, V.; STEWART, T. Multiple criteria decision analysis: an integrated approach. [s.l.] Springer Science Business Media.

- BERTRAND, J. W.M.; FRANSOO, J.C. Operations management research methodologies using quantitative modeling. International Journal of Operations Production Management,v. 22, n. 2, p. 241-264, 2002.

- CARDOSO, R. S. et al. Use of SAD in decision support in the disposal of plastic waste and material management. Operational Research, v. 29, n. 1, p. 67-95, 2009.

- CASTELLS ICART, J. Esperanza del Mar: estudio y comparación con otros buques hospital. 2014.

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# Selection of marine corps personnel for the courses of operation and maintenance of the joint light tactical vehicle (JLTV): an analysis from the multicriteria method AHP-Gaussian[1]

*Short presentations (20 min)*

*Pinheiro De Araújo Costa,Arthur*[2]      *De Pina Corriça, José Victor*[3]

*Carvalho Leandro*[4]      *Braz Alves, Edgard*[5]

*De Araújo Costa, Igor*[6]      *Dos Santos, Marcos*[7]

*Brazil*

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**Resumen/Abstract:** The fight against crime has become one of the most significant challenges for the State in the face of the dominance of criminal factions inBrazilian communities. In this context, recently, the Brazilian Navy (BN)acquired 12 Light Armored Vehicles on Wheels 4x4 Joint Light TacticalVehicle (JLTV). The acquisition of these vehicles ensures a high degree ofversatility and flexibility to the Brazilian Marine Corps (BMC), expandingits operational readiness and capacity to project power in areas of nationalstrategic interest. Given the above, this article aims to create a methodology for ordering the three most qualified military personnel to carry out theArmored Vehicle Operation Course for JLTV. The Multi-Criteria DecisionAnalysis (MCDA) method Analytic Hierarchy Process (AHP)-Gaussianwas used to generate the ordering of the alternatives, as will be seen duringthis research. In addition, the work in question has the potential to makea significant contribution to society, as the Hybrid Method AHP-Gaussiancan be expanded in other applications, serving as a basis for decision making in the most diverse areas of the public and private sectors.

**Palabras clave / Key words:** Joint Light Tactical Vehicle (JLTV); AHP-Gaussian; Brazilian Navy

**Referencias/References:**

- Dong, Q., & Cooper, O. (2016). A peer-to-peer dynamic adaptive consensus reaching model for the group AHP decision making. European Journal of Operational Research, 250(2), 521–530.

- Santos, M., Costa, I. P. de A., & Gomes, C. F. S. (2021). Multicriteria decision-making in the selection of warships: a new approach to the AHP method. International Journal of the Analytic Hierarchy Process, 13(1). `https://doi.org/10.13033/ijahp.v13i1.833`

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[1]Jueves/Thursday 24, 9:00 – 9:20,Schedule (GMT-6)

[2]Marinha do Brasil, thurcos91@gmail.com

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[6]Universidade Federal Fluminense, costa_igor@id.uff.br

[7]Instituto Militar de Engenharia - IME, marcosdossantos_doutorado_uff@yahoo.com.br

- Fernandes, G. H., Fernandes, R. A. P., & dos Santos, M. (2020). Aplicação Do Método Simple Aggregation of Preferences Expressed By Ordinal Vectors-Multi Decision Makers (Sapevo-M) para seleção de viaturas blindadas do corpo de fuzileiros navais (CFN) em missões de garantia da lei e da ordem (GLO). November.

- Gomes, C. F. S., Costa, H. G., & de Barros, A. P. (2017). Sensibility analysis of MCDA using prospective in Brazilian energy sector. Journal of Modelling in Management.

- Greco, S., Figueira, J., & Ehrgott, M. (2016). Multiple Criteria Decision Analysis: State of art surveys (Vol. 37). Springer.

# An Alternative Proposal Based on Trimmed Mean and Booststrapping in the Market Method for Real Estate Appraisals, case Colombia[1]

*Short presentations (20 min)*

*Olga Viviana Pita Celis*[2]    *Luis Eduardo Castillo Méndez*[3]

*Colombia*

**Resumen/Abstract:**

The Market Method is a valuation process that seeks to calculate thecommercial value of a real estate property based on a study of recent offers ortransactions; these offers must have similar and comparable characteristicsto the property under study. In this way, the statistical analysis using thismethod is based on Exploratory Statistics, particularly the use of the Meanand Statisitcal Dispersion such as the Ordinary Variance and the Coefficientof Variation, since from these calculations certain conditions are establishedto make the application of this method valid.When putting this method into practice, there are certain restrictions thatprevent it from being fully applied, the most common being a very smallsample size of offers and the appearance of outliers, which hinders theanalysis and therefore the calculation of the appraisal.To improve the appraisal calculation, a methodology based on TrimmedMean and Bootstrapping is presented in order to make it more accurate andfree from the influence of the reduced sample size and outliers.

**Palabras clave / Key words:** Exploratory Statistics, Robust Methods, Bootstrapping, Valuation Methods, Real Estate Property.

**Referencias/References:**

- Hampel, F. R., Ronchetti, E. M., Rousseeuw, P. J., and Stahel, W. A (2005)Robust Statistics - The Approach Based on Influence Functions, Wiley.Huber, P. J. (2004) Robust Statistics, Wiley.

- Maronna, R., Martin, D. and Yohai, V. (2006) Robust Statistics - Theoryand Methods, Wiley.Resolución 620 de 2008 [IGAC]. Por la cual se establecen los procedimientospara los avalúos ordenados dentro del marco de la Ley 388 de 1997. 23 deseptiembre de 2008.

- Rousseeuw , P. J. and Leroy, A. M. (2003) Robust Regression and OutlierDetection, Wiley.

- Wilcox, R. R. (2016) Introduction to Robust Estimationand Hypothesis Testing. Academic Press, Stanford, California. 4th Edition.

[1]Miércoles/Wednesday 23, 10:40 – 11:00,Schedule (GMT-6)

[2]Universidad Distrital Francisco José de Caldas, Sede de Ingeniería, Colombia, ovpitac@correo.udistrital.edu.co

[3]Universidad Distrital Francisco José de Caldas, Sede de Ingeniería, Colombia, lecastillom@udistrital.edu.co

# Opinion Dynamics on Social Networks[1]

*Plenary lectures (50 minutes)*
*Mason Porter[2]*
*USA*

**Resumen/Abstract:**

From the spreading of diseases and memes to the development of opinions and social influence, dynamical processes are affected significantly by the networks on which they occur. In this talk, I'll review recent work by my collaborators and me on social influence and opinion models on networks. I'll discuss diverse flavors of models — including threshold models of social contagions, voter models that coevolve with network structure, and bounded-confidence models with continuous-valued opinions — and present how such processes are affected by the networks on which they occur.

**Palabras clave / Key words:** networks, opinion dynamics, dynamical systems

**Referencias/References:**

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# Natural language processing, an application to the classification of economic and political news in Mexico[1]

*Short presentations (20 min)*
*Ricardo César Ramírez García[2]*
*México*

**Resumen/Abstract:**

The objective of this work was to classify texts, using deep learning models such as Convolutional and Recurrent Neural Networks. To compare the performance of these two models the following models were also fitted: Multilayer Perceptron, Logistic Regression and Support Vector Machines. This work's motivation was to classify texts or audios to identify fraud in the insurance sector. In this work, 2,786 news were obtained from the Mexican Newspaper "La Jornada". Of these items, 1,393 were taken from the Economy subsection and 1,393 from the Polytical subsection. The 2,786 news were separated into a training set (70 % of the observations) and a validation set (30 % of the observations). Before training the models, the text was preprocessed, that is, special characters were re- moved, text was converted to lowercase, accents, pronouns, articles, and in general words that did not add value for the objective at hand, were removed. The minimum units with meaning known as "tokens" were the words. Once the texts had been preprocessed, they were vectorized using Hot encoding and Word Embedding techniques. For the first technique we used a 5,000 word dictionary and to analyze the news the first 100 words of each preprocessed text were taken. To choose the hyperparameters of each model, cross validation with 3 layers was used, once these were chosen, the models were trained using cross-validation with 10 layers and 5 repetitions, with a different seed in each repetition, to obtain 50 estimators of the measures used to compare the performance of the models in the training set. The model selected from the selection and tunning process was the Recurrent Neuronal Network LSTM (Long Short Term Memory), obtaining in the validation set, an accuracy of 0.9749, sensitivity of 0.9831, specificity of 0.9667 and an area under the ROC curve of 0.9749.

**Palabras clave / Key words:** Text classification, Convolutional Neural Network, Recurrent Neural Network, Multilayer Perceptron, Support Vector Machines, Cross Validation

**Referencias/References:**

1  Aggarwal, Charu C. (2018). Neuronal Networks and Deep Learning. New York: Springer.

2  Bishop, C. M. (2006). PATTERN RECOGNITION AND MACHINE LEARNING. Cam- bridge U.K.: Springer.

3  Boser, B., Guyon, I., Vapnik, V. (1992). A training Algorithm for Optimal Margin Classi- fiers. Proceedings of the Fifth Annual Workshop on Computational Learning Theory, pp. 144-152.

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[1]Lunes/Monday 21, 15:40 – 16:00,Schedule (GMT-6)

[2]Universidad Anáhuac Norte, México, ricardo.ramirezg@anahuac.mx

4  Chollet, F. (2018). DEEP LEARNING with PYTHON. New York: Manning Publications Co.

5  Goodfellow, I., Bengio, Y., Aaron, C. (2017). DEEP LEARNING. Cambridge, MA: MIT Press.

# ACTUARIAL MATHEMATICAL RESERVE FOR THE EXTRACTION OF NON-RENEWABLE RESOURCES FROM NON-NEGATIVE LOSS VARIABLES

*Posters*

*Rigoberto Real Miranda* [1] *& José Daniel López Barrientos,*

*México*

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**Resumen/Abstract:** Based on the traditional definition of the actuarial mathematical reserve for life insurance, the mathematical reserve for a non-renewable resource is constructed and studied, which considers the extraction dynamics of this resource as part of the benefit obtained. Although non-renewable resources are finite, it is assumed that the remaining lifetime of the resource has an infinite time horizon, and that its distribution is in one of the Exponential, Weibull, Gamma or Chen forms. An algorithm or iterative process is also presented that, more generally, allows calculating the components of the mathematical reserve, regardless of the distribution or the parameters of the remaining life time of the non-renewable resource.

**Palabras clave / Key words:** Reserva matemática actuarial, programación dinámica, recurso no-renovable, juegos diferenciales.

**Referencias/References:**

- Anderson, S. T., Kellogg, R., & Salant, S. W. (2014, July). Hotelling under pressure (WorkingPaper No. 20280). National Bureau of Economic Research.

- Bowers, N., Gerber, H., Hickman, J., Jones, D., & Nesbitt, C. (1997). Actuarial mathematics. The Society of Actuaries.

- Chen, Z. (2000). A new two-parameter lifetime distribution with bathtub shape or increasing failure-rate function. Statistics & Probability Letters, 49(2), 155-161.

- Deshmukh, S. D., & Pliska, S. R. (1980). Optimal consumption and exploration of nonrenewableresources under uncertainty. Econometrica, 48(1), 177–200.

- Devarajan, S., & Fisher, A. C. (1981). Hotelling's economics of exhaustible resources: Fifty years later. Journal of Economic Literature,19(1), 65–73.

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# Modified GFI and AGFI indexes performance in structural equation modeling in relation to the degree of heterogeneity and violation of the multivariate normality assumption

*Posters*
*Mariana Resende*[1]
*Brasil*

**Resumen/Abstract:**

In general, the fit quality of a structural equation model (SEM) is verified by several indexes, which, in summary, assess the correspondence between the sample covariance matrix and the covariance implied by the model that adequately represents the interrelationships between the indicators involved in the study [1]. In this sense, a modification in the GFI and AGFI indixes was proposed, incorporating in the sample covariance matrix a correction that considers repetitions in the observed variables. The objective was to evaluate the performance of these modified indexes in SEM a relation to the degree of heterogeneity (GH) and the violation of the multivariate normality assumption. Among the scenarios used in the Monte Carlo simulation procedure, the relative efficiency between the covariance estimators as a function of the number of observed variables was considered as a criterion. Values for GH = 2, 4, 6 and 8 were assigned, which made it possible to quantify the efficiency of the covariance matrix estimator imposed by the model in relation to the sample covariance matrix. Regarding the assumption violation of the multivariate normality, we proceeded with the simulation of multivariate normals contaminated with outliers generated by the t-Student and Lognormal distributions, as they are symmetrical and have excess kurtosis, the mixing probabilities were set at $\alpha = 5\%$ and 15 %. With these scenarios specification, a script was developed in R software 3.6.0 [2] to validate the proposed indexes. In the ideal situation where the structural model is adjusted for data that meet the normality assumption, and that the covariance matrices are weakly heterogeneous (GH = 2), the average estimates of the conventional GFI and AGFI indices and the modified results indicate problems of numerical inconsistency from the tenth repetition, are observed negative results. By increasing the degree of heterogeneity (GH = 8), between the matrices of covariance involved in the indexes formulations, a greater situation of lack of adjustment is contemplated, the results indicate that the numerical inconsistency was also extended. Comparing the results in relation to the degree of heterogeneity, it was noted that the estimates of the GFI and AGFI indexes, in the conventional form, remained close to unity, indicating a good fit of the model. However, when considering the repetitions, the modified indexes resulted in a decrease in their results. This effect is more pronounced for a high degree of heterogeneity (GH = 8), since this situation portrays a greater distance from the covariance matrices involved in the indexes. Regarding the effect of outliers observations generated by the multivariate t-Student distribution, the adjustment indices proposed as a function of the GH of the sample and structural covariance matrices, it was observed that the increase in the number of repetitions resulted in a decrease in the estimates of the indexes, with stabilization from the tenth repetition, regardless of the degree of heterogeneity and the amount and percentages of outliers contained in the original sample. The GFI and AGFI indixes values with low and high outlier contaminations ($\alpha = 5\%$ and 15 %), given a low degree of heterogeneity (GH = 2), showed average values that

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[1]Universidade Federal de Lavras, Brasil, mresende31@gmail.com

show an acceptable fit ($GFI > 0{,}95$). In the case of samples contaminated with outliers belonging to a distribution with excess kurtosis, in this case, the Lognormal, was found that the results were more discrepant in relation to the increase in the degree of heterogeneity. It was concluded that the improvement of the GFI and AGFI indexes to incorporate the repetitions effect of the observed variables was promising, since it presented robustness properties in relation to the presence of outliers and showed diagnostic evidence of a model with good and bad fit. It is recommended to use up to four repetitions so that numerical problems do not occur when computing the index estimates.

**Palabras clave / Key words:** structural model, outliers, contamination, covariance

**Referencias/References:**

1  Cirillo, M. A.; Barroso, L. P. (2017) "Effect of outliers on the GFI quality adjustment index in structural equation model and proposal of alternative índices". Communications in Statistics - Simulation and Computation 46, 1895–1905

2  R DEVELOPMENT CORE TEAM. (2011) R: a language and environment for statistical computing. Vienna, 409 p.

# TRAPPED WAVES AND COLLISIONS[1]

*Presentations (30 minutes)*
*Roberto Ribeiro Junior[2]*
*Brazil*

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**Resumen/Abstract:**

According to quantum mechanics all particles in the universe have the properties of waves and vice versa. Hence, to comprehend the nature and its manifestation, it is indispensable to understand waves. A phenomenon called trapped wave is an example of a situation in which a wave behaves like a "particle". Indeed, a trapped wave is a wave that remains trapped in a certain region, bouncing back and forth, until it reaches a certain threshold and escapes out - what resembles light bouncing in a laser cavity. Trapped waves have been studied mainly in the context of the forced Korteweg-de Vries (fKdV) model, little is known about this phenomenon in the full Euler equations framework. In this talk I will revisit trapped waves solution for the fKdV equation and analyze its features in details. Besides, we will provide a description of the dynamic of trapped wave collisions. One characteristic noticed is that, although the dynamic of one wave is affected by the other one, statistically this feature is not evident. I will also present findings from our study on trapped waves solutions for the Euler equations, which shows waves trapped in a low-pressure region. This talk is based on results already published and in progress in collaboration with Marcelo V. Flamarion (UFRPE) and Paul Milewski (University of Bath).

**Palabras clave / Key words:** Forced Korteweg-de Vries equation, Euler equation, Numerical methods, Conformal mapping, Spectral numrical methods

**Referencias/References:**

- Flamarion, M. V. & Ribeiro-Jr, R. (2021) Trapped solitary-wave interaction for Euler equations with low-pressure region. Comp Appl. Math., 40.

- Flamarion, M. V., Milewski P.A.,Ribeiro-Jr, R. (2021) Trapped solitary waves and collisions for the forced Korteweg-de Vries equation. arXiv:2109.06051.

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[1]Viernes/Friday 25, 9:00 – 9:40,Schedule (GMT-6)
[2]Federal University of Paraná,Brasil, robertoribeiro@ufpr.br

# Code-based Cryptography: Past, Present, Future[1]
*Plenary Talk (60 min)*
*Angela Robinson*

**Resumen/Abstract:** Public key cryptography protects the privacy and security of our global digital communication infrastructure. All widely-deployed public key cryptographic systems are based on the difficulty in solving variations of the integer factorization and discrete logarithm problems. In 1991, Peter Shor presented quantum algorithms that could solve these problems significantly faster than classical computers. Consequently, a full-scale quantum computer would upend the security and privacy of our digital world. The National Institute of Standards and Technology (NIST) initiated a process to update current public-key standards to schemes believed to be quantum-resistant. NIST made a worldwide call for quantum-resistant public-key cryptographic algorithms and, in response, received over 80 submissions to be considered for standardization. NIST is currently in the 3rd round of analysis and 3 of the remaining 15 algorithms are based on error-correcting codes. Error correcting codes were originally designed to improve communication across noisy channels, enabling the correction of errors introduced in transit. Messages are encoded by adding some redundancy in such a way that errors introduced by the channel can be removed from the received information, and then the receiver can decode (remove redundancy) to recover the original message. In the 1970's it was discovered that cryptosystems could be designed based on error-correcting codes if errors were strategically introduced by the sender so that only the intended receiver could decode. Due to the inefficiency of early schemes, these results were not actively pursued by cryptographers until decades later. In this talk, we will explore the foundations of code-based cryptography, the history of securing code-based cryptosystems, and role code-based cryptosystems could play in securing our digital world.

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[1] Viernes/Friday 25, 16:00 – 17:00,Schedule (GMT-6)

# Historia y Evolución de los Métodos Simbólicos de Reducción de la Dimensión[1]
*Plenary Talk (60 min)*
*Oldemar Rodríguez Rojas*

**Resumen/Abstract:** En esta conferencia inicialmente explicaremos de qué se trata el Análisis de Datos Simbólico, luego nos concentramos en presentar un recorrido por la historia del desarrollo de las principales contribuciones en este campo, prestando especial énfasis en el desarrollo de métodos de reducción de la dimensión. Iniciaremos con el Análisis en Componentes Principales, presentando el método de vértices y el método de los centros, luego hablaremos del Análisis Factorial de Correspondencias simples y múltiples para variables multivaluadas, métodos de escalamiento multidimensional para distancias de tipo intervalo, entre otros. Finalmente presentaremos los desarrollos más recientes en técnicas reducción de la dimensión, como son los métodos T-SNE y UMAP Simbólicos. Además, veremos algunas implementaciones en Python y en R de los métodos presentados.

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[1]Lunes/Monday 21, 14:00 – 15:00,Schedule (GMT-6)

# Asymptotic method applied to obtain shock waves solutions in Buckley–Leverett Equations[1]

*Presentations (30 minutes)*

*Panters Rodriguez Bermudez*[2]     *Fernanda Sousa*[3]

*Diomar Lobão*[4]     *Gustavo Alvarez*[5]

*Baldomero Valiño Alonso*[6]

*Brazil*

**Resumen/Abstract:**

We apply the asymptotic method developed by V. P. Maslov to obtain approximated shock wave solutions of the generalized Riemann problem to the Buckley–Leverett (BL) equation, which models two-phase flow in porous media. The associated Hugoniot–Maslov chain is calculated, truncated and solved numerically to obtain approximated shock's trajectories and profiles. The results show the efficiency of this method to capture the shock wave when compared with some classical finite differences schemes. We also compare the results obtained in the present work with the results obtained via the same asymptotic method, but based in a previous polynomial approximation of the Buckley–Leverett flux. It was observed that the application of the Asymptotic method preceded by a polynomial approximation of the flux function, does not work well for long time simulation values. Estimation of errors was performed to establish that comparison.

**Palabras clave / Key words:** asymptotic methods, shock waves, Buckley–Leverett equation, Hugoniot–Maslov chains

**Referencias/References:**

- Danilov, V.G. and Omelyanov G. A (1999). "Calculation of the singularity dynamics for quadratic nonlinear hyperbolic equations. Example: the Hopf equation," in: Nonlinear Theory of Generalized Functions, Chapman & Hall/CRC Research Notes in Mathematics Series, vol. 401, Chapman & Hall/CRC, Boca Raton, pp. 63–74.

- Maslov, V.P. (1977) Propagation of Shock Waves in Isoentropic non Viscous Gas. Covremiennie Problemi Matemátiki, vol. 8, Itogui Naúki i Téjniki, VINITI Moscow (in Russian)

- Rodríguez-Bermudez, P., Sousa, F. V. , Lobão, D. C., Alvarez, G. B. and Valiño-Alonso, B. (2021) Hugoniot-Maslov Chain for Shock Waves in Buckley-Leverett Equations. Accepted for publication in Mathematical Notes (ISSN 0001-4346), Springer, 17 pages.

- Rodríguez-Bermudez, P. and Valiño-Alonso B. (2007) "Hugoniot–Maslov chains of a shock wave in conservation law with polynomial flow," Mathematische Nachrichten, 280, pp. 907–915.

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[1] Viernes/Friday 25, 11:20 – 12:00,Schedule (GMT-6)

[2] Universidade Federal Fluminense,Brasil, pantersrb@id.uff.br

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[5] Federal Fluminense University,Brasil, benitez.gustavo@gmail.com

[6] Havana University, pantersrb@id.uff.br

# A BRIEF INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS: MODELING, COMPUTATIONAL SIMULATION, AND APPLICATIONS[1]

*Short courses or Workshops (3 hours)*
*Alexander Megiorin Roma[2]*
*Brasil*

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**Resumen/Abstract:**

The main goal of this short course is to present, in a rather pragmatic manner, someimportant aspects involved in the process of the derivation of mathematical models andof the implementation of computational methods in the field of computational fluid dynamics. As a "case study", focus is given to problems involving interactions between thefluid flow and immersed boundaries; to be more exciting, an application to the hemodynamics of the left heart is mentioned as an example. The basic mathematical modelis described in details and a numerical discretization is presented. These lecture noteswere translated from a reviewed and updated text, first used in a short course presented in the $68_o$ Seminário Brasileiro de Análise, Instituo de Matemática e Estatística, Universidade de São Paulo(IME-USP), November 12-14,2008.

**Palabras clave / Key words:** navier-stokes equations, biofluid dynamics, immersed boundary method,incompressible flows, elastic interfaces, adaptive mesh refinement, SAMRAI, VisIt, Subversion, Doxygen

**Referencias/References:**

1 Nachbin, A. (2001). ."Aspectos de modelagem matemática em dinâmica dos fluidos". Publicações Matemáticas, IMPA.

2 Roma, A.M. (2001). Üma abordagem computacional a alguns problemas de dinâmica defluidos biológicos". Matemática Universitária, 30:15-39.

3 Roma, A.M.; Peskin, C.S.; Berger, M.J. (1999). ."An adaptive version of the immersed boundary method". J. Comp. Phys., 153:509-534.

4 Peskin, C.S. (1972). "Flow patterns around heart valves: A numerical method". J. Comp.Phys., 10:252-271.

5 B.E. Grith and N.A. Patankar (2020). Ïmmersed methods for fluid-structure interaction". Annual Review of Fluid Mechanics, 52:421-448.

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[1]Jueves/Thursday 24, 10:00 – 12:00, Viernes/Friday 25, 8:00 – 9:00,Schedule (GMT-6)

[2]Universidade de São Paulo, Departamento de Matemática Aplicada, Brasil, roma@ime.usp.br

# Deep Gaussian Processes and Infinite Neural Networks for the Analysis of EEG Signals in Alzheimer's Diseases[1]

*Presentations (30 minutes)*

*Krishna Román[2]*       *Andy Cumbicus[3]*

*Saba Infante[4]*       *Rigoberto Fonseca-Delgado[5]*

*Ecuador*

**Resumen/Abstract:**

Deep Gaussian Processes (DGPs) are hierarchically represented by a sequential composition of a prior Gaussian processes and are equivalent to a multi-layer neural network (NN) of infinite width. DGPs are non-parametric statistical models and are used to characterize patterns of complex nonlinear systems, due to their flexibility, greater generalization capacity, and because they provide a natural way to make inferences about the parameters and states of the system. In this article, a hierarchical Bayesian structure is proposed to model the weights and biases of a deep neural network, a general formula is deduced to calculate the integrals of Gaussian processes with non-linear transfer densities, and a kernel is obtained to estimate the covariance functions. To illustrate the methodology, an empirical study is carried out analyzing a database of electroencephalograms (EEGs) for the diagnosis of Alzheimer's disease. Additionally, the DGPs models are estimated, and compared with the NN models for 5, 10, 50, 100, 500, and 1000 neurons in the hidden layer, considering two transfer functions: Rectified Linear Unit (ReLU) and hyperbolic Tangent (Tanh). The results show good performance in the classification of the signals. Finally, the mean square error was used as a goodness of fit measure to validate the proposed models, obtaining low estimation errors.

**Palabras clave / Key words:** Deep Gaussian Process, Alzheimer Disease, Electroencephalogram

**Referencias/References:**

- Lee, J; Bahri, Y; Novak, R; Schoenholz, S; Pennington, J; Sohl-Dickstein, J.(2018). Deep Neural Networks as Gaussian Processes. arXiv:1711.00165v3 (stat.ML)

- Cho, Y; Saul, L. (2009). Kernel methods for deep learning. In Advances in neural information processing systems, pp. 342-350.

- Matthews, A; Rowland, M; Road, W; Hron, J; Turner, R; Ghahramani, Z. (2018). Gaussian Process Behaviour in Wide Deep Neural Networks. arXiv:1804.11271v2 (stat.ML).

- Williams, C. (1996). Computing with infinite networks.NIPS'96: Proceedings of the 9th International Conference on Neural Information Processing Systems. December 1996. Pages 295–301.

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[1] Martes/Tuesday 22, 15:00 – 15:40,Schedule (GMT-6)

[2] Yachay Tech University, krishna.roman@yachaytech.edu.ec

[3] Yachay Tech University, andy.cumbicus@yachaytech.edu.ec

[4] Yachay Tech University, sinfante@yachaytech.edu.ec

[5] Metropolitan Autonomous University, rfonseca@izt.uam.mx

- Martínez-Arias, P., Fonseca-Delgado, R., Salum, R., Amaro-Martín, I,. (2020). Alzheimer's disease diagnosis system using electroencephalograms and machine learning models. Iberian Journal of Information Systems and Technologies. pp. 275–288.

# On the turnpike property of the numerical solutions in a stochastic Lotka-Volterra model[1]

*Short presentations (20 min)*

*Cutberto Salvador Romero-Meléndez*[2]      *David Castillo-Fernández*[3]

*Leopoldo González-Santos*[4]

*México*

**Resumen/Abstract:**

We study a property of the long-term behavior of solutions of a Lotka–Volterrasystem with stochastic environmental fluctuations, known as turnpike property.In optimal control theory, the optimal solutions dwell mostly in the neighborhoodof a balanced equilibrium path, corresponding to the optimal steady-statesolution. Our study shows, by means of the Stochastic Maximum Principle,that this turnpike property is preserved, when the noise in the system is small.Numerical simulations are implemented to support our results.

**Palabras clave / Key words:**

**Referencias/References:**

1 D'Ancona, U. (1954). The struggle for existence. E. J. Brill, Leiden.

2 Faulwasser, T., M. Korda, C. N. Jones and D. Bonvin (2014). Turnpike anddissipativity properties in dynamic real-time optimization and economic.MPC 53rd IEEE Conference on Decision and Control, 2734-2739

3 Lotka, A.J. (1956). Elements of mathematical Biology. Unabridge republicationof: Elements of physical biology. New Tork, Dover.

4 Volterra, V. (1931). Lecons sur la theorie mathematique de la lutte pour lavie. Paris: Gauthier-Villars.

5 Liu, J., Zhao, W. (2019). Dynamic Analysis of Stochastic Lotka–VolterraPredator-Prey Model with Discrete Delays and Feedback Control, Complexity,vol. 2019.

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# Asymptotic Justification of the Models of Thin Inclusions in an Elastic Body in the Antiplane Shear Problem and Applications[1]

*WorkShop dedicated to Prof. Alexander Khludnev*

*Evgeny Rudoy[2]*

*Russia*

**Resumen/Abstract:**

The equilibrium problem for an elastic body having an inhomogeneous inclusion with curvilinear boundaries is considered within the framework of antiplane shear. We assume that there is a power-law dependence of the shear modulus of the inclusion on a small parameter characterizing its width. We justify passage to the limit as the parameter vanishes and construct an asymptotic model of an elastic body containing a thin inclusion. We also show that, depending on the exponent of the parameter, there are the five types of thin inclusions: crack, rigid inclusion, ideal contact, elastic inclusion, and a crack with adhesive interaction of the faces. The strong convergence is established of the family of solutions of the original problem to the solution of the limiting one.

**Palabras clave / Key words:** antiplane shear, composite material, thin inclusion, asymptotic analysis

**Referencias/References:**

- Rudoy, E. (2017). On Numerical Solving a Rigid Inclusions Problem in 2D Elasticity. Z. Angew. Math. Mech. 68, 19.

- Furtsev, A., Itou, H. and E. Rudoy. (2020). Modeling of Bonded Elastic Structures by a Variational Method: Theoretical Analysis and Numerical Simulation. Internat. J. Solids Structures, 182–183, 100–110.

- Rudoy, E. M. (2020). Asymptotic Modelling of Bonded Plates by a Soft Thin Adhesive Layer. Siberian Elect. Math. Reports 17, 615–625.

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[1] Lunes/Monday 21, 11:20-11:40,Schedule (GMT-6)

[2] Novosibirsk State University, Russia, rem@hydro.nsc.ru

# Chain complexes and E-infinity operads[1]

*Presentations (30 minutes)*
*Jesús Sánchez-Guevara[2]*
*Costa Rica*

**Resumen/Abstract:**

"An E-infinity coalgebra structure on chain complexes of simplicial sets with integer coefficients is induced by the Barratt-Eccles operad. The morphisms determined by the E-infinity coalgebra structure contain a family of higher diagonals on chains, starting with an homotopic version of the iterated Alexander-Whitney diagonal. This is done by (Smith; 1994) and (Berger, Fresse; 2004).

In this work we present a new E-infinity operad inducing an E-infinity coalgebra structure on chain complexes, which is designed following the ideas by Smith. Moreover, we show that the Barratt-Eccles operad can be obtained from our operad by an operadic quotient, which is a direct consequence of the way we design the operadic composition. The associated operad morphism between this operads is a quasi-isomorphism because both of them are E-infinity operads.

It is worth pointing out our operad presents similarities with the bar-cobar resolution of Ginzburg-Kapranov. Berger and Moerdijk identified this resolution with the W-construction of Boardman and Vogt. As a consequence, the W-construction of the Barratt-Eccles operad gives a cofibrant resolution of it. Then, our operad may be seen as a middle point between the Barratt-Eccles operad and its W-construction."

**Palabras clave / Key words:** Operad theory, Chain complexes, $E_\infty$-coalgebras, Barrat-Eccles operad

**Referencias/References:**

- Barratt, M. G. and Eccles, P. J. (1974). ⌐ + -structures-I: a free group functor for stable homotopy theory, Topology 13, no. 1, 25 – 45.Berger, C. and Fresse, B. (2004). Combinatorial operad actions on cochains, Mathematical Proceedings of the Cambridge Philosophical Society 137, 135–174.

- Ginzburg, V. and Kapranov, M. (1994). Koszul duality for operads, Duke Math. J. 76, no. 1, 203–272.

- Prouté, A. (1983). Sur la transformation d'Eilenberg-Maclane, C. R. Acad. Sc. Paris 297, 193–194.

- Smith, J. R. (1994). Iterating the cobar construction, American Mathematical Society: Memoirs of the American Mathematical Society, no. 524, American Mathematical Society.

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[1]Jueves/Thursday 24, 9:00 – 9:40,Schedule (GMT-6)
[2]Universidad de Costa Rica,Costa Rica, jesus.sanchez_g@ucr.ac.cr

# Modeling Covid-19 in Costa Rica: A Multilayer Network Approach[1]

*Presentations (30 minutes)*
*Fabio Sanchez[2]*

**Resumen/Abstract:** During the 2020 Covid-19 pandemic in Costa Rica, different groups developed modeling techniques to understand the transmission dynamics of the disease. The modeling team, EpiMEC, developed deterministic models early in the pandemic to provide insight into the early disease dynamics. During the same period, the team developed a multilayer network model that allowed for more flexibility and included preventive measures and interventions from health authorities in the country. The model provided information for decision-makers in the country during the pandemic in Costa Rica.
**Palabras clave / Key words:**

**Referencias/References:**

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[1]Miércoles/Wednesday 23, 11:20 – 12:00,Schedule (GMT-6)
[2]Universidad de Costa Rica, Costa Rica, fsanchez1019@gmail.com

# Transparent Spheres as Gravitational Lens[1]

*Short presentations (20 min)*
*Edwin Santiago[2]*
*Costa Rica*

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**Resumen/Abstract:**

In this contribution, we present a short account of gravitationallenses and how to calculate dierent properties of its images in thecase of having a transparent distribution of matter such as the uniformtransparent sphere, isothermal gas sphere, non-singular isothermal gassphere and a transparent King prole. With the help of XFGLensessoftware, and numerical methods, dierent images arising from all ofthese proles, and the dierent caustics and critical curves are shown.The images were consistent with several previous results that are ex-pected for transparent proles, like having an odd number of images,and reducing the number of images by two when the source passesthrough the caustic. The curves shown in the caustics where the as-troid, the Cassini ovals. For the critical curves, the most commoncurve was the ellipse, and the Cassini ovals, which is consistent withthe fact that these curves are common in gravitational lenses.

**Palabras clave / Key words:** Gravitational Lenses, Caustics, Critical Curves, Density Mass Profiles, Simulations

**Referencias/References:**

- 1. Adler, R. J., Barber, W. C., and Redar, M. E., 1995, Gravitational lenses and plastic simulators, American Journal of Physics, 63, 536.

- 2. Frutos-Alfaro, F., 2001, A Computer Program to Visualize Gravitational Lenses, American Journal of Physics, 69, 218-222.

- 3.Huwe, P., and Field, S. 2015, Modern Gravitational Lens Cosmology for Introductory Physics and AstronomyStudents, The Physics Teacher, 53, 266.

- 4.Schneider, P., Ehlers, J., and Falco, E., 1992, Gravitational Lenses, Springer, Berlin.

- 5.Selmke, M., 2021, An optical n-body gravitational lens analogy, American Journal of Physics, 89, 11.

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[2]Universidad de Costa Rica, Costa Rica, edsantilea@gmail.com

# CONFORMABLE SPATIAL DERIVATIVE MODELING FLUID FLOW[1]

*Presentations (30 minutes)*

*Milagros del Carmen Santos Moreno*[2]       *C. Valencia Negrete*

*G. Fernández Anaya*

*México*

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**Resumen/Abstract:**

Fractional calculus has been accomplished to model a wide range of phenomena. More recently, the conformable derivative has been receiving attention for its ability to reproduce some behaviors of the classical derivative. Zhao et al [3] presented an extension of the classical space derivative and the con formable fractional derivative, for a function $f(u) : [0, \infty) \to \mathbb{R}$, for all $u > 0$ and $\alpha \in (0, 1] : D_\psi^\alpha f(u) = lim_{\epsilon \to 0} \frac{f(u + \epsilon \psi(u, \alpha)) - f(u)}{\epsilon}$ where $\phi(u, \alpha)$ is the fractional conformable generalized function, a continuous real function, satisfying: $\psi(u, 1) = 1, u \in \mathbb{R}^+; \psi(u, \alpha) \neq 0, u \in \mathbb{R}^+; \psi(u, \alpha) \neq \psi(u, \beta); \alpha \neq \beta \in (0, 1]$. If $\psi(u, 1) = 1, D_\psi^\alpha f(u)$ degenerates to the usual first-order derivative and has no relationship with fractional order $\alpha$. If $\psi(u, 1) = u^{1-\alpha}$ the conformable derivative agrees with the Khalil's defnition [2].

Most studies with the conformable derivative in fluid flow focus on time vari- ables for Navier-Stokes equations [1]. We present the effect of the conformable spatial function $\psi(y, \alpha)$ in a uni dimensional, steady-state model and the fluid's velocity profile for different values of the exponential parameter $\alpha$. The selected function is an exponential form with three parameters: $\psi(y, \alpha) = a^{(1+by)(1-\alpha)}$ The parameters are optimized to compare the velocity profile to a flow through a homogeneous porous medium with constant permeability. The results showed that the selected generalized conformable model could describe the ow through a porous medium accurately.

**Palabras clave / Key words:** Conformable spatial derivative, Navier-Stokes equations, porous media

**Referencias/References:**

- Arzu Akbulut and Melike Kaplan. Auxiliary equation method for time-fractional differential equations with conformable derivative. Computers and Mathematics with Applications, 75(3):876 - 882, 2018.

- R. Khalil, M. Al Horani, A. Yousef, and M. Sababheh. A new defnition of fractional derivative. J. Comput. Appl. Math., 264:65 - 70, 2014.

- D. Zhao, X. Pan, and M. Luo. A new framework for multivariate general conformable fractional calculus and potential applications. Physica A,5(10):271-280, 2018.

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# AN Lp SPACES-BASED MIXED VIRTUAL ELEMENT METHOD FOR THE TWO-DIMENSIONAL NAVIER-STOKES EQUATIONS[1]

*Presentations (30 minutes)*
*Filánder A Sequeira Chavarría*[2]
*Costa Rica*

**Resumen/Abstract:**

In this talk we extend the utilization of the Banach spaces-based formulations, usually employed for solving diverse nonlinear problems in continuum mechanics via primal and mixed finite element methods, to the virtual element method (VEM) framework and its respective applications. More precisely, we propose and analyze an $L^p$ spaces-based mixed virtual element method for a pseudostress-velocity formulation of the two-dimensional Navier-Stokes equations with Dirichlet boundary conditions. To this end, a dual-mixed approach determined by the introduction of a nonlinear tensor linking the usual pseudostress for the Stokes equations with the convective term, is employed. As a consequence, this new tensor, say $b$, and the velocity $bu$ of the fluid constitute the unknowns of the formulation, whereas the pressure is computed via a postprocessing formula. The simplicity of the resulting VEM scheme is reflected by the absence of augmented terms, on the contrary to previous works on this and related models, and by the incorporation in it of only the projector onto the piecewise polynomial tensors and the usual stabilizer depending on the degrees of freedom of the virtual element subspace approximating $b$. In turn, the non-virtual but explicit subspace given by the piecewise polynomial vectors of degree $lek$, is employed to approximate $bu$. The corresponding solvability analysis is carried out by using appropriate fixed-point arguments, along with the discrete versions of the Babuška-Brezzi theory and the Banach-Nečas-Babuška theorem, both in subspaces of Banach spaces. A Strang-type lemma is applied to derive the *a priori* error estimates for the virtual element solution as well as for the fully computable approximation of $b$, the postprocessed pressure, and a second postprocessed approximation of $b$. Finally, several numerical results illustrating the performance of the mixed-VEM scheme and confirming the rates of convergence predicted by the theory, are reported.

**Palabras clave / Key words:**

**Referencias/References:**

1 R.A. Adams and J.J.F. Fournier, Sobolev Spaces. Second edition. Pure and Applied Mathematics (Amsterdam), 140. Elsevier/Academic Press, Amsterdam, 2003.

2 P.F. Antonietti, L. Beir~ao da Veiga, D. Mora and M. Verani, A stream virtual elementformulation of the Stokes problem on polygonal meshes. SIAM J. Numer. Anal. 52 (2014), no. 1,386–404.

3 L. Beir~ao da Veiga, Private communication. (2021).

4 L. Beir~ao da Veiga, F. Brezzi, L. Marini, G. Manzini and A. Russo, H(div) and H(curl)-conforming virtual element method. Numer. Math., 133 (2016), no. 2, 303–332.

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[1]Viernes/Friday 25, 15:00 – 15:40,Schedule (GMT-6)
[2]Universidad Nacional, Costa Rica, filander.sequeira.chavarria@una.cr

5 L. Beir~ao da Veiga, F. Brezzi, L. Marini and A. Russo, Mixed virtual element methodsfor general second order elliptic problems on polygonal meshes. ESAIM Math. Model. Numer.Anal., 50 (2016), no. 3, 727–747.

# HOW DO POINTS ON PLANE CURVES GENERATE FIELDS? LET ME COUNT THE WAYS[1]

*Plenary lectures (50 minutes)*
*Allechar Serrano Lopez*[2]          *Michael Allen*[3]
*Renee Bell*[4]          *Robert Lemke Oliver*[5]
*Tian An Wong*[6]
*USA*

**Resumen/Abstract:**

In their program on diophantine stability, Mazur and Rubinsuggest studying a curve $C$ over $\mathbb{Q}$ by understanding the field extensions of $\mathbb{Q}$ generated by a single point of $C(\overline{\mathbb{Q}})$; in particular, they ask to what extent the set of such field extensions determines the curve $C$. A natural question in arithmetic statistics along these lines concerns the size of this set: for a smooth projective curve $C/\mathbb{Q}$ how many field extensions of $\mathbb{Q}$ — of given degree and bounded discriminant — arise from adjoining a point of $C(\overline{\mathbb{Q}})$? Can we further count the number of such extensions with specified Galois group? Asymptotic lower bounds for these quantities have been found for elliptic curves by Lemke Oliver and Thorne, for hyperelliptic curves by Keyes, and for superelliptic curves by Beneish and Keyes. We discuss similar asymptotic lower bounds that hold for all smooth plane curves $C$, using tools such as geometry of numbers, Hilbert irreducibility, Newton polygons, and linear optimization.

**Palabras clave / Key words:** arithmetic statistics, density theorems

**Referencias/References:**

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[1]Miércoles/Wednesday 23, 16:00 – 17:00,Schedule (GMT-6)

[2]Harvard University, USA, serrano@math.harvard.edu

[3]Oregon State University,USA, allenm3@math.oregonstate.edu

[4]University of Pennsylvania, USA, rhbell@math.upenn.edu

[5]Tufts SIMMersity,USA, robert.lemke_oliver@tufts.edu

[6]University of Michigan-Dearborn, tiananw@umich.edu

# SINGULAR HYPERBOLICITY AND SUBSECTIONAL LYAPUNOV EXPONENTS OF VARIOUS ORDERS[1]

*Plenary lectures (50 minutes)*
*Luciana Silva Salgado*[2]
*Brazil*

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**Resumen/Abstract:** It is given notions of singular hyperbolicity and subsectional Lyapunov exponents oforders beyond the classical ones, namely, other dimensions besides the dimension 2 and the full dimension of the central subbundle of the singular hyperbolic set. It is obtained a characterizationof dominated splittings, partial and singular hyperbolicity in this broad sense, by using Lyapunov exponents and the notion of infinitesimal Lyapunov functions . Furthermore, it is given alternative requirements to obtain singular hyperbolicity. As an application we obtain some results related to singular hyperbolic sets for flows.

**Palabras clave / Key words:** Dominated splitting, partial hyperbolicity, subsectional hyperbolicity, Lyapunov function

**Referencias/References:**

- Salgado, L., L.S. (2019)Singular Hyperbolicity and subsectional Lyapunov Exponents of Various Orders. Proc. of Amer. Math. Soc., Vol.147, n.2, 735-749. `https://doi.org/10.1090/proc/14254`

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[1]Martes/Tuesday 22, 8:00 – 9:00,Schedule (GMT-6)
[2]Universidade Federal do Rio de Janeiro,USA, lsalgado@im.ufrj.br

# Numerical analysis of PDE's and its role in alternative energies modelling[1]

*Plenary lectures (50 minutes)*
*Manuel Solano[2]*
*Chile*

**Resumen/Abstract:**

Numerical Analysis (NA) of Partial Differential Equations (PDEs) is present in almost all areas of applied mathematics and has a strong impact in engineering science, as well as in the private and public sectors. Its purpose is the design and analysis of the numericalmethods behind the algorithms that perform the approximation of the solutions of PDEs in the most efficient possible way.In this direction, during the last decade, our interest has been the development, convergence analysis and computational implementation of a variety of numerical methods to solve the PDEs arising from modelling solar and nuclear energy generation devices.In this talk we will focus on the role of NA in simulations of photovoltaic solar cells and nuclear fusion reactors. Through these applications we will give a broad explanation of the different mathematical tools that are present on each step of the process that goes from the PDE to the computational simulation. The mathematical framework in this process includes the study of weak formulations of Maxwell's and Helmholtz equations, discretization through Galerkin schemes, convergence and stability analyzes and computational implementation.

**Palabras clave / Key words:**

**Referencias/References:**

- Sánchez, N., Sánchez-Vizuet, T. and Solano, M.E. (2021). "A priori and a posteriori error analysis of an unfitted HDG method for semi-linear elliptic problems". Numerische Mathematik, 148, 919-958

- Monk, P., Rivas, C., Rodríguez, R. and Solano, M.E. (2021). "An asymptotic model based on matching far and near field expansions for thin gratings problems..ᴱˢAIM: M2AN, 55, S507-S533

- Sánchez-Vizuet, T. and Solano, M.E. (2019). "A Hybridizable Discontinuous Galerkin solver for the Grad-Shafranov equation". Computer Physics Communications, 235, 120-132

- Solano, M.E., Faryad, M., Lakhtakia, A. and Monk, P.B (2014). "Comparison of rigorous coupled-wave approach and finite element method for photovoltaic devices with periodically corrugated metallic back reflector". JOSA A, 31(10), 2275-2284

- Cockburn, B., Qiu, W. and Solano, M. (2014). "A priori error analysis for HDG methods using extensions from subdomains to achieve boundary-conformity". Mathematics of Computations, 82 (286), 665-699

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[1]Jueves/Thursday 24, 14:00 – 15:00,Schedule (GMT-6)

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# RISK CLASSIFIER FOR COVID-19 SUSCEPTIBLE INDIVIDUALS USING THE PATIENT PREVIOUS DATA[1]

*Presentations (30 minutes)*

*Maikol Solís*[2]     *Carlos Pasquier*[3]

*Costa Rica*

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**Resumen/Abstract:**

Despite the high coverage achieved by vaccination against COVID-19, the danger of new variants, such as delta and mu, threaten new waves of infections. These waves put pressure on health systems, increasing the disease fatality. To reduce its pressure, the governments impose control measures that generate discomfort and economic damage to the population. Identifying possible outbreaks, asymptomatic or presymptomatic cases is a key factor in controlling the pandemic (Slifka and Gao 2020). However, the diagnostic RT-PCR tests are expensive, require specialized personnel, and takes a long time to deliver the result. Using rapid tests or less accurate, but faster and cheaper pooling techniques as a complement to the standard test (RT-PCR) is a useful strategy (Watkins et al. 2020; World Health Organization 2020). CostaRica has implemented the same strategies to detect better the infected cases(Ministerio de Salud 2021a; Ministerio de Salud 2021b)Currently, some protocols classify patients based only on symptomatic and epidemiological criteria. In this talk, we will explore the use of COVID-19 risk classification models based on previous epidemiological and sociodemographic characteristics. The aim is to develop a score to determine the patient's positiveness before performing any clinical test. This additional input will help to determine the best mass sampling strategy for the population according to the model's predicted values. We evaluate these models to reduce the economic cost and maximize their detection capacity. In Escobar et al. (2020), they have used these models to optimize the pandemic cost of a massive testing. We can use the same principle for different health events and different stages of the pandemic.

**Palabras clave / Key words:** COVID-19, Classification, Risk, Socioeconomic data, Sociodemografic data

**Referencias/References:**

- Escobar, María et al. (July 2020). "Smart Pooling: AI-Powered COVID-19 Test-ing." In:medRxiv, p. 2020.07.13.20152983.doi:10.1101/2020.07.13.20152983.

- Ministerio de Salud (Nov. 2021a). "LS-SS-012. Lineamientos generales para eluso de pruebas alternativas (antígeno, pruebas moleculares isotérmicas) alestándar de oro (RT- PCR) para el diagnóstico de COVID-19." In.— (Mar. 2021b).LS-VS-001. Lineamientos Nacionales Para La Vigilancia deLa Enfermedad COVID-19. Tech. rep. Costa Rica: Ministerio de Salud.

- Slifka, Mark K. and Lina Gao (Oct. 2020). "Is Presymptomatic Spread a Ma-jor Contributor to COVID-19 Transmission?" In:Nature Medicine26.10,pp. 1531–1533.issn: 1546-170X. doi:10.1038/s41591-020-1046-6

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[1]Jueves/Thursday 24,10:40 – 11:20,Schedule (GMT-6)

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[3]Universidad de Costa Rica,Costa Rica, CARLOS.PASQUIER@ucr.ac.cr

- Watkins, Anne E. et al. (Sept. 2020). "Pooling Saliva to Increase SARS-CoV-2Testing Capacity." In:medRxiv: The Preprint Server for Health Sciences. doi:10.1101/2020.09.02.20183830

- World Health Organization (Sept. 2020).Antigen-Detection in the Diagnosis ofSARS-CoV-2 Infection Using Rapid Immunoassays. Tech. rep. World Health Organization.

# Logística inteligente aplicada a sistemas de distribución de productos de consumo masivo. Un caso de estudio de distribución de bebidas embotelladas en México.[1]

*Short presentations (20 min)*
*Isidro Soria Arguello[2]*
*México*

**Resumen/Abstract:**

En este trabajo se estudia el problema de la distribución de productos de una empresa embotelladora de bebidas embotelladas en el Valle de México. La solución se genera construyendo un modelo de optimización y se usa Relajación Lagrangiana para explotar la estructura del subproblema. El problema dual lagrangiano se resuelve empleando el método del subgradiente programado en Python.La determinación de una solución factible al problema de optimización se consigue mediante un algoritmo heurístico. Los resultados obtenidos se comparan con el valor óptimo del problema original encontrado mediante un programa comercial con la finalidad de determinar la calidad de la solución encontrada. Finalmente, se aplica la metodología antes descrita a cuatro escenarios correspondientes a los años 2021-2024 para dar continuidad al crecimiento del negocio de bebidas.

**Palabras clave / Key words:**

**Referencias/References:**

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# A PROPOSAL MATHEMATICAL MODEL FOR THE VACCINES COVID-19 DISTRIBUTION NETWORK: A CASE STUDY IN MEXICO[1]

*Presentations (30 minutes)*

*Isidro Soria Arguello*[2]      *Rafael Torres Escobar*[3]

*Hugo Alexer Perez Vicente*[4]      *Tomas Guillermo Perea Rivera*[5]

*México*

**Resumen/Abstract:** Coronavirus disease 2019 (COVID-19) has been the most recent disease, with millions of deaths worldwide. Fortunately, vaccines have been developed to immunize the population. However, the distribution of the vaccines is also a significant challenge. Generally, each country defines its strategy to bring it closer to the target population, considering that depending on the type of vaccines is defined the adequate transport for their conservation. In this work, a mathematical model is proposed for the distribution of different COVID-19 vaccines in Mexico. Our results suggest an efficient strategy to meet demand in a given period.

**Palabras clave / Key words:** Distribution Network, Vaccines, COVID-19, Mixed Integer Linear Programming, Optimization.

**Referencias/References:**

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[1] Viernes/Friday 25, 8:00 – 8:20,Schedule (GMT-6)

[2] Universidad Iberoamericana, México, isidro.soria@ibero.mx

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[4] hugo.perez@ibero.mx

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# Descomposición Tensorial y sus Aplicaciones en Procesamiento de Imágenes[1]

*Short presentations (20 min)*
*Juan Pablo Soto Quiros[2]*
*Costa Rica*

**Resumen/Abstract:**

The set of data observed in real-life applications (for example, in data mining and signal processing) contains latent information that can be very useful in achieving a satisfactory result. The way these data are represented is essential to be able to extract this underlying information and, in various disciplines, the need has arisen to manipulate data described in multiple dimensions called tensors. In this case, the concept of tensors is defined, which is a multilinear generalization of matrices (tensors of order two) and of vectors (tensors of order one), where the data is organized in three or more directions.This presentation will present a detailed study of the basic concepts of tensors and of some mathematical tools that will support the development of the theories that are exposed in this talk. Mainly, the tensor decomposition (also called tensor factorization) will be explained, which is fundamental when it comes to extracting the common components that keep the different modes that make up the tensor.Additionally, a set of applications of tensor decomposition in image processing will be shown. Among these applications, their relationship in the compression of color images will be explained.

**Palabras clave / Key words:** Tensor Decomposition, Image Processing, Multilinear Algebra

**Referencias/References:**

- Kolda, T. G., & Bader, B. W. (2009). Tensor decompositions and applications. SIAM review, 51(3), 455-500.

- de Almeida, A. L. F., Favier, G., da Costa, J. P. C. L., & Mota, J. C. M. (2016). Overview of tensor decompositions with applications to communications. In Signals and images: advances and results in speech, estimation, compression, recognition, filtering, and processing (Vol. 12, pp. 325-356). CRC-Press.

- Cichocki, A., Mandic, D., De Lathauwer, L., Zhou, G., Zhao, Q., Caiafa, C.,& Phan, H. A. (2015). Tensor decompositions for signal processing applications: From two-way to multiway component analysis. IEEE signal processing magazine, 32(2), 145-163.

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[1]Martes/Tuesday 22, 15:00 – 15:20,Schedule (GMT-6)

[2]Instituto Tecnológico de Costa Rica, Costa Rica, jusoto@tec.ac.cr

# Weakly nonlinear theory for deterministic wave forecasting[1]

*Presentations (30 minutes)*
*Raphael Stuhlmeier[2]*
*United Kingdom*

**Resumen/Abstract:** Deterministic wave forecasting aims to provide a wave-by-wave prediction of the free surface elevation based on measured data. Such information about upcoming waves can inform marine decision support systems, control strategies for wave energy converters, and other applications. Unlike well-developed stochastic wave forecasts, the temporal and spatial scales involved are modest, on the order of minutes or kilometres. Due to the dispersive nature of surface water waves, such forecasts have a limited space/time horizon, which is further impacted by the effects of nonlinearity. I will discuss the application of the reduced Zakharov equation, and simple frequency corrections derived therefrom, to preparing wave forecasts. Unlike procedures based on solving evolution equations (e.g. high order spectral method), such corrections entail essentially no additional computational effort, yet show marked improvements over linear theory.

**Palabras clave / Key words:**

**Referencias/References:**

- R. Stuhlmeier and M. Stiassnie, Deterministic wave forecasting with the Zakharov equation, Journal of Fluid Mechanics , (2021) 913 A50.R.

- Stuhlmeier and M. Stiassnie, Nonlinear dispersion for ocean surface waves, Journal of Fluid Mechanics, 859 (2019), 49-58.

- M. Galvagno, D. Eeltink, and R. Stuhlmeier, Spatial deterministic wave forecasting for nonlinear sea-states, under review

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# CARACTERIZACIÓN DE LA POBLACIÓN AFECTADA POR EL COVID-19 EN SANTA CRUZ DE LA SIERRA[1]

*Presentations (30 minutes)*

*Juan Fernando Subirana Osuna*[2]      *Alejandro Paredes La Torre*[3]

*Bolivia*

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**Resumen/Abstract:**

El presente trabajo busca caracterizar la relación entre la presencia de COVID-19 en los hogares de Santa Cruz de la Sierra con otras variables descriptivas de la situación del hogar, en este sentido se cuenta con el análisis de la base de datos levantada de manera conjunta entre la Gobernación del Departamento de Santa Cruz y la Alcaldía del municipio de Santa Cruz de la Sierra con la aplicación de pruebas masivas en diversas zonas de la ciudad.El estudio considera la descripción de cada variable levantada, posteriormente se analiza la relación de éstas con la presencia o no de COVID-19 en los hogares; para ello se aplica un modelo de regresión logística, para detectar, identificar y caracterizar la relación de las variables analizadas con la presencia o no de COVID-19 al momento de la toma de información o de manera previa.

**Palabras clave / Key words:** Modelling

**Referencias/References:**

- Bacaër, N. (2011). McKendrick and Kermack on epidemic modelling (1926–1927). In: A Short History of Mathematical Population Dynamics. London: Springer. doi:https://doi.org/10.1007/978-0-85729-115-8_16

- Bolaño-Ortiz, T., Camargo-Caicedo, Y., Puliafito, S., Ruggeri, M., Bolaño-Diaz, S., Pascual-Flores, R., . . . Cereceda-Balic, F. (2020). Spread of SARS-CoV-2 through Latin America and the Caribbean region: A look from its economic conditions, climate and air pollution indicators. Environmental Research(191), 109938. doi:https://doi.org/10.1016/j.envres.2020.109938.

- Greene, W. H. (2018). Econometric Analysis (8th ed.). India: Pearson Education.

- Hendry, D. F. (1995). Dynamics Econometrics (Primera ed.). New York, Estados Unidos: Oxford University Press.

- Jackson, J. K., Weiss, M. A., Schwarzenberg, A. B., & Nelson, R. M. (2020). Global economic effects of COVID-19. Recuperado el 2021, de World Health Organization.

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[1]Jueves/Thursday 24, 11:20 – 12:00,Schedule (GMT-6)

[2]Universidad Privada de Santa Cruz de la Sierra, Facultad de Ciencias Empresariales, Bolivia, juansubirana@upsa.edu.bo

[3]Universidad Privada de Santa Cruz de la Sierra, Facultad de Ciencias Empresariales,Bolivia, a2018115588@estudiantes.upsa.edu.bo

# Asynchronous Optimized Domain Decomposition Methods for the solution of PDEs[1]

*Presentations (30 minutes)*

*Daniel B Szyld*[2]

*USA*

**Resumen/Abstract:** Asynchronous methods refer to parallel iterative procedures where each process performsits task without waiting for other processes to be completed, i.e., with whateverinformation it has locally available and with no synchronizations with other processes.For the numerical solution of a general linear partial differential equation on a domain,Schwarz iterative methods use a decomposition of the domaininto two or more (possibly overlapping) subdomains.In essence one is introducing new artificial boundary conditionson the interfaces between these subdomains.In the classical formulation, these artificial boundary conditions areof Dirichlet type. Given an initial approximation, the methodprogresses by solving for the PDE restrictedto each subdomain using as boundary data on the artificial interfacesthe values of the solution on the neighboring subdomain from the previous step.This procedure is inherently parallel, since the (approximate) solutionson each subdomain can be performed by a different processor.In the case of optimized Schwarz, the boundary conditions on the artificial interfaces areof Robin or mixed type.In this way one can optimize the Robin parameter(s) and obtain a very fast method.Instead of using this method as a preconditioner, we use it as a solver, thus avoidingthe pitfall of synchronization required by the inner products.In this talk, an asynchronous version of the optimized Schwarz method is presented forthe solution of differential equations on a parallel computational environment.A coarse grid correction is added and one obtains a scalable method.Several theorems show convergence for particular situations.Numerical results are presented on large three-dimensional problemsillustrating the efficiency of the proposedasynchronous parallel implementation of the method.

**Palabras clave / Key words:** Domain Decomposition, Numerical Solutions of PDEs, parallel aasynchronous methods

**Referencias/References:**

- Frederic Magoules, Daniel B. Szyld, and Cedric Venet, Asynchronous Optimized Schwarz Methods with and without Overlap. Numerische Mathematik, vol. 137 (2017) 199–227.

- Mireille El Haddad, Jose C. Garay, Frederic Magoules, and Daniel B. Szyld, Synchronous and Asynchronous Optimized Schwarz methods for one-way subdivision of bounded domains, Numerical Linear Algebra and Applications, vol. 27 (2020), paper number e2279, 30 pages.

- Christian Glusa, Erik G. Boman, Edmond Chow, Sivasankaran Rajamanickam, and Daniel B. Szyld, Scalable Asynchronous Domain Decomposition Solvers, SIAM Journal on Scientific Computing. vol. 42 (2020) C384–C409.

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[1]Viernes/Friday 25, 14:00 – 14:30,Schedule (GMT-6)

[2]Temple University, Department of Mathematics, Philadelphia,USA, szyld@temple.edu

# AN ANALYSIS OF NONLINEAR ULTRASONIC WAVES IN BUBBLY LIQUIDS BY A NUMERICAL MODEL[1]

*Short presentations (20 min)*

*María Teresa Tejedor Sastre*[2]      *Christian Vanhille*[3]

*España*

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**Resumen/Abstract:** In this work we study the propagation of ultrasonic waves in liquids with gas bubbles. These media are extremely nonlinear. A tiny void fraction changes the properties of the medium drastically. The gas bubbles not only produce high nonlinearity, but also introduce dispersive phenomena and attenuation that can be decisive for the ultrasonic behavior. Several results obtained by a numerical model are presented here, which allow us to analyze some complex effects associated with this problem. The model solves a differential system that couples the nonlinear oscillations of the bubbles and the acoustic field. This work is funded by the National Agency for Research (Ministerio de Ciencia e Innovación, Spain) and the European Regional Development Fund (project DPI2017- 84758-P).

**Palabras clave / Key words:** modelos numéricos, acústica no lineal, líquidos con burbujas

**Referencias/References:**

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[1]Martes/Tuesday 22, 9:10 – 9:40,Schedule (GMT-6)

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[3]Universidad Rey Juan Carlos, España, christian.vanhille@urjc.es

# Solución Numérica de una Ecuación de Difusión Bifraccional Mediante Funciones de Base Radial[1]

*Short presentations (20 min)*

Anthony Torres Hernández[2]       Fernando Brambila Paz[3]

*México*

**Resumen/Abstract:**

Using a discretization of the Caputo fractional derivative, the numerical solutions of the bifractional diffusion equations that can be derived from the Black-Scholes equation are determined by radial basis functions.

**Palabras clave / Key words:** Fractional Calculus, Radial Basis Functions, Black-Scholes Equation

**Referencias/References:**

- Carlos Alberto Torres Martinez and Carlos Fuentes (2017). Applications of radial basis function schemes to fractional partial differential equations.

- A. Torres-Hernandez, F. Brambila-Paz, and C. (2020). Torres-Martinez. Numerical solution using radial basis functions for multidimensional fractional partial differential equations of type Black-Scholes.

- C. A. Martinez and F. Brambilla-Paz (2019). Numerical comparison between rbf schemes with respect to other approaches to solve fractional partial differential equations and their advantages when choosing non-uniform nodes.

- A. Torres-Hernandez, F. Brambila-Paz, and C. Torres-Martinez (2019). Proposal for use the fractional derivative of radial functions in interpolation problems.

- Hongmei Zhang, Fawang Liu, Ian Turner, and Qianqian Yang (2016). Numerical solution of the time fractional black–scholes model governing european options

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[1]Martes/Tuesday 22, 15:20 – 15:40,Schedule (GMT-6)

[2]UNAM, México, anthony.torres@ciencias.unam.mx

[3]UNAM, México, fernandobrambila@gmail.com

# DATA ANALYSIS WITH COMBINATORIAL OPTIMIZATION HEURISTICS (DACOH): BIBLIOTECA EN R PARA ANÁLISIS DE DATOS USANDO METAHEURÍSTICAS[1]

*Short presentations (20 min)*
*Javier Trejos*[2]     *Alex Murillo*[3]
*Costa Rica*

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**Resumen/Abstract:** Se introduce una biblioteca para hacer análisis multivariado de datos en R, usando metaheurísticas de optimización combinatoria con el objetivo de evitar los óptimos locales que los métodos tradicionales suelen encontrar. En el caso de la clasificación automática o agrupamiento vía particiones para datos numéricos, se optimiza la inercia intraclases por medio de cuatro heurísticas: i) sobrecalentamiento simulado, ii) algoritmo genético, iii) búsqueda tabú, y iv) colonias de hormigas. Los métodos, originales de los autores, se comparan a los métodos clásicos, como k-medias y clasificación jerárquica de Ward, mostrándose una mejoría considerable en los resultados. En el caso del escalamiento multidimensional, se optimiza el criterio de Stress y el S-Stress usando la heurística de sobrecalentamiento simulado, comparándose los resultados con los métodos conocidos de Kruskal, Alscal y Smacof. La biblioteca se ha implementado en R y se pondrá a disposición de la comunidad científica.

**Palabras clave / Key words:** análisis de datos, sobrecalentamiento simulado, algoritmo genético, búsqueda tabú, colonias de hormigas.

**Referencias/References:**

- Trejos, J.; Murillo, A.; Piza, E. (1998) "Global stochastic optimization for partitioning", in Advances in Data Science and Classification, A. Rizzi et al. (Eds.), Springer Verlag, Berlin: 185-190. Doi: `10.1007/978-3-642-17103-1_3`

- Piza, E.; Murillo, A.; Trejos, J. (1999) "Nuevas técnicas de particionamiento en clasificación automática", Revista de Matemática: Teoría y Aplicaciones 6(1): 51-66. Doi: 10.15517/RMTA.V6i1.168Trejos,

- J.; Murillo, A.; Piza, E. (2004) "Clustering by ant colony optimization", in: D. Banks, L. House, F.R. McMorris, P. Arabie & W. Gaul (Eds.) Classification, Clustering, and Data Mining Applications, Springer, Berlin, 25-32. Doi: `10.1007/978-3-540-73560-1_22`

- Murillo, A., Vera, J. and Heiser, W. (2205) "A Permutation-Translation Simulated Annealing Algorithm for L1 and L2 Unidimensional Scaling", Journal of Classification 22:119-138. Doi: 10.1007/s00357-005-0008-5

- Vera, J., Heiser, W. and Murillo, A. (2007) "Global Optimization in Any Minkowski Metric: A Permutation-Translation Simulated Annealing Algorithm for Multidimensional Scaling", Journal of Classification 24:277-301. Doi: 10.1007/s00357-007-0020-1

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# Spatio-temporal Cluster detection tests and stochastic modeling[1]

*Presentations (30 minutes)*
*Jean VAILLANT*[2]     *Walguen OSCAR*[3]
*Eddie SAINTE-ROSE*[4]
*Guadalupe*

**Resumen/Abstract:** We consider the general situation where spatio-temporal data are collected over a study period in a spatial region and cluster detection is required for decision making. The classical Kulldorff scan method has to be adapted when the Poisson model assumption is not appropriate, for example in case of overdispersion. We introduce a Cox process associated with environmental effects based on a Gaussian copula and gamma distributed margins. Sampling properties are presented taking into account the spatial covariate random field. The likelihood ratio test is developed. An illustration with data collected in Martinique is made.

**Palabras clave / Key words:** Cox process, cluster detection, likelihood ratio test, copula; negative multinomial distribution

**Referencias/References:**

- Krupskii, P.; Genton, M.G. (2017). Factor copula models for data with spatio-temporal dependence. Spat. Stat., 22, 180–195.

- Landry, C.; Abadie, C.; Bonnot, F.; Vaillant, J. (2021). A Spatio-temporal Stochastic Model for an Emerging Plant Disease Spread in a Heterogeneous Landscape. Int. J. Comput. Appl., 975, 1–7.

- Kulldor, M. (1997). A spatial scan statistic. Communications in Statistics-Theory and methods, 26, 6, 1481-1496.

- Allevius, B., Hohle, M. (2018) . An unconditional space-time scan statistic for zip-distributed data. Scandinavian Journal of Statistics, 46, 1, 142-159.

- Oscar, W., Vaillant, J. (2021). Cox processes associated with spatial copula observed through stratified sampling. Mathematics, 9,5,524.

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[1]Miércoles/Wednesday 23, 8:00 – 8:40,Schedule (GMT-6)

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# USING INFORMATION-THEORY QUANTIFIERS TO CHARACTERIZE COVID-19 TIME-SERIES DATA[1]

*Presentations (30 minutes)*
*Victoria Vampa[2]*
*Argentina*

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**Resumen/Abstract:**

The first cases of coronavirus disease (COVID-19) were reported in December 2019 in Wuhan, China. After the initial outbreak, the COVID-19 spread very quickly to several provinces of China and most countries around the world. It was declared a pandemic in March 2020. Up to now, more than two hundred and twenty million cases of infected individuals have been confirmed in over 200 countries, having produced nearly five million deaths. In our research, the time series of daily infected cases and daily deaths are analyzed and compared for different countries. We use entropic information-theory quantifiers to evaluate unpredictability and disorder in those time series. We appeal to two different methodologies for defining a probability distribution: i) Bandt-Pompe permutation method, and ii) Wavelet Analysis. The former is based on computing the entropy associated with an ordinal pattern probability distribution and depends on two parameters: the embedding dimension and the time delay. The Wavelet Analysis involves the use of a discrete wavelet transform and the definition of a time-scale density function based on the decomposition coefficients. The proposed mathematical tools allow us to characterize the COVID-19 time series of infections and deaths, following their evolution for each country. We aim to contribute to a better understanding of the dynamics of the pandemic.

**Palabras clave / Key words:** Information Theory, Permutation Entropy, Bandt–Pompe Methodology, Wavelet Transform, Wavelet Entropy, pandemic

**Referencias/References:**

1   Kowalski A.M., Martín M.T., Plastino A.L., Proto A. and Rosso O.A.(2003).Wavelet statistical complexity analysis of classical limit. Phys. Lett. A 311, 180-191.

2   Arenas A., Gómez-Gardeñes J., Granell C.and Soriano-Paños D., EPIDEMIC SPREADING: TAILORED MODELS FOR COVID-19. `https://doi.org/10.1051/epn/202050`

3   Fernandez L.H.S., Araujo F.H.A.,, Silva M.A.R. and Acioli-Santos B. (2021). Predictability of COVID-19 worldwide lethality using permutation-information theory quantifiers, Results in Physics, Volume 26,July, 104306.

4   Zanin M., Zunino L., Rosso O.A. and Papo D. (2012).Permutation entropy and its main biomedical and econophysics applications: a review, Entropy, 14(8), 1553-1577.

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5  Kowalski A.M., Portesi M., Vampa V., Losada M. and Holik F. (2021).Information contained in the COVID-19 series of data, `https://doi.org/10.13140/RG.2.2.14908.16007`

# Análisis Multivariado y Establecimiento de una Tipología de Especies Arbóreas mediante la categorización de Modalidades[1]

*Presentations (30 minutes)*

*Héctor Javier Vázquez*[2]       *Juganaru-Mathieu Mihaela*[3]

*México*

**Resumen/Abstract:** Considerando los amplios beneficios de los árboles en el espacio urbano, es importante considerar dentro de las políticas de plantación y programas de mantenimiento, guías para definir que especies son más adecuadas para elegir el árbol más adecuado para el sitio de plantación más adecuado. En este trabajo se realiza un estudio exploratorio multivariado para establecer una tipología de especies arbóreas, considerando un número de características relacionadas con el ambiente: tolerancia a la salinidad del suelo, tolerancia a la temperatura, tolerancia a la sequía, tolerancia al maltrato; así como la tolerancia o resistencia a diferentes niveles de contaminación. Dadas las características categóricas de la información disponible, con modalidades ausentes, se propone el uso del Análisis de Correspondencias Múltiples (ACM) para su estimación. La aplicación del ACM con las modalidades estimadas, la Clasificación Jerárquica Acumulada, y l categorización de sus modalidades, sugieren una tipología de nueve grupos para las 134 especies descritas, aunque se deja abierta la posibilidad de integrar otras características y criterios de validación de expertos en arboricultura urbana.

**Palabras clave / Key words:** árboles, análisis multivariado, tipología, contaminación del aire, reforestación urbana

**Referencias/References:**

- Jossé J., Chaventb M., Liquetc B., y Hussona F. (2012). Handling Missing Values with Regularized Iterative Multiple Correspondence Analysis. Journal of Classification 29, 1, 91-116.

- Lebart, Ludovic ; Morineau, Alain ; Piron Marie (2006). Statistique Exploratoire Multidimensionnelle, Ed. Dunod, 480 pp.

- Vázquez, Héctor Javier, Juganaru-Mathieu, Mihaela (2014), Handling Missing Data in a Tree Species Catalog Proposed for Reforesting Mexico City, IC3K: Proceedings of the International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - Volume 1, October 2014 Pages 457–464, `https://doi.org/10.5220/0005158404570464`

- Vázquez, Héctor Javier, Juganaru-Mathieu, Mihaela (2016), Exploring Urban Tree Site Planting Selection in Mexico City through Association Rules, IC3K 2016: Proceedings of the International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge ManagementNovember 2016 Pages 425–430 `https://doi.org/10.5220/0006085604250430`

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[1]Martes/Tuesday 22, 14:40 – 15:00,Schedule (GMT-6)

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# Estudio Exploratorio de la Forma de la Copa de los Árboles[1]

*Short presentations (20 min)*
*Héctor Javier Vázquez[2]*
*México*

**Resumen/Abstract:** Sin duda uno de los elementos más visibles e importantes de los árboles es su copa, pues es allí, donde se encuentran las hojas. Estos son los órganos dominantes, donde se realiza la fotosíntesis, una de las funciones básicas para la vida en la tierra. El tamaño, la forma, la disposición, la densidad de las hojas y ramas de la copa son elementos a considerar para evaluar la salud de los árboles, su capacidad fotosintética y su capacidad para secuestrar carbono. El objetivo de este estudio es explorar la variabilidad entre diversas formas de copas de un conjunto de especies de árboles, mediante la comparación de puntos de referencia o "landmarks", aplicando el Análisis de Procrustes y el Análisis de Componentes Principales. Esto con el fin de evaluar si existen asociaciones entre la forma de la copa del árbol y modelos alométricos.Las formas se comparan con los 22 modelos arquitecturales propuestos por Francis Hallé (Hallé, 2010).

**Palabras clave / Key words:** morphometrics, multivariate analysis, copa de árbol, allometry.

**Referencias/References:**

- Hallé F. (2010). Arquitectura de los árboles (2010) Bol. Soc. Argent. Bot. 45 (3-4): 405-418.

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[1]Miércoles/Wednesday 23, 10:00 – 10:40,Schedule (GMT-6)

[2]Universidad Autónoma Metropolitana, México, hjv@azc.uam.mx

# Double Generalized Procrustes Analysis on multi-way public education expenditure data

*Posters*

*María Concepción Vega-Hernández*[1]      *Carmen Patino-Alonso*[2]

*España*

**Resumen/Abstract:** Society has always been very interested in what the government spends its money on public education. However, at times, it is not easy to handle this volume of information. Therefore, the aim of this paper is to study public education expenditure using Generalized Procrustes Analysis (GPA) when working with multidirectional data. The data treated are a sequence of tables from several countries where different public expenditures on education have been measured over time (2005-2019), and which have been segmented into two datasets taking into account the nominal GDP in millions of U.S. dollars (high income countries and low income countries). The application of GPA is proposed in two different ways: one to represent the consensuses of high income countries and low income countries and another for the consensuses of the expenditure variables. Finally, a coinertia analysis will be performed to plot the co-inertia of the public education expenditure structures of high- and low-nominal GDP countries.

**Palabras clave / Key words:** Generalized Procrustes Analysis; multi-way; public education expenditure; countries.

**Referencias/References:**

- Dray, S., Chessel, D., and Thioulouse, J. (2003). Co-intertia and the linking of ecological data tables. Ecology, 84, 3078–3089,

  doi:10.1890/03-0178.

- Gower, J.C. (1975). Generalized procrustes analysis. Psychometrika, 40, 33–51,

  doi:10.1007/BF02291478.

- Halásková, M. and Halásková, R. (2017). Public expenditures in areas of public sector: Analysis and evaluation in eu countries. Sci. Pap. Univ. Pardubice, Ser. D Fac. Econ. Adm., 24, 39–50.

- Osis, S.T., Hettinga, B.A., Macdonald, S.L., and Ferber, R. (2015). A novel method to evaluate error in anatomical marker placement using a modified generalized Procrustes analysis. Comput. Methods Biomech. Biomed. Engin., 18, 1108–1116,

  doi:10.1080/10255842.2013.873034.

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# A GRASSLAND METAECOEPIDEMIC MODEL WITH JUST CONSUMERS' MIGRATION[1]

*Presentations (30 minutes)*
*EZIO VENTURINO*[2]
*Italy*

**Resumen/Abstract:** This work presents a resource-consumer model with two patches.Consumers can freely move among them. It is more general than a metapopulation system, in that it containsfungal disease affecting resources of the second patch. The situation describes a grassland-herbivores environment,where one patch is managed in an extensive way and has a wider plant diversity, while the other one ishighly fertilized leading to an important forage production. Herbivores feed both on healthy or infected crop,moving between the two patches.Behaviors emerging from some parts ofthe model, respectively formed by uncoupled patches and by the purely demographic coupled model are assessedthrough the characterization of the system's equilibria.Results are compared with the purely demographicmodel to highlight the role of the disease in this dynamics. System bifurcations and the system equilibria response to parameters perturbations have been explored.Disease eradication is possible under suitable circumstances.Coexistence of the five populations through persistent oscillations is also possible,but not at a stable level.

**Palabras clave / Key words:** Eco-epidemiology, Metapopulation, Holling type-II, Stability analysis, Grassland-herbivores model

**Referencias/References:**

- Thibault Moulin, Antoine Perasso, Ezio Venturino,A metaecoepidemic model of grassland ecosystem with only consumers' migration,to appear in BMB.

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# Computing Sparse Semilinear Models for COVID-19 Related Processes[1]

*Presentations (30 minutes)*
*Fredy Vides[2]*
*Honduras*

**Resumen/Abstract:** In this talk, the theoretical and computational aspects of the identification, classification and numerical simulation of some COVD-19 related processes, are presented. From an empirical standpoint, sparse identification methods for semilinear time series models tend to allow the computation of descriptive models corresponding to a given process under study, with a smaller amount of training data than standard nonsparse approximate model identification methods, due primarily to the fact that the corresponding matrices of parameters to be identified have less entries to be determined. In addition, the computational cost of the predictions corresponding to the behavior of a given system is reduced, due to the sparsity of the matrices of parameters involved in the computation of the transition operators determined by the sparse model identification algorithms. In this talk, some general results in operator approximation theory with applications to sparse model identification of COVID-19 related processes are presented. The approximation of the corresponding state-transition operators determined by matrices of parameters to be identified, will be approached by proving the existence of easily computable integers that can be applied to estimate the computability of approximate sparse representations of the matrices of parameters, and as a by-product of the computation of these numbers one can obtain low-rank approximations of submatrices of the trajectory matrices corresponding to some data measured from the processes under study, that can be used to compute the sparse approximants of the matrices of parameters. Some connections of these theoretical and computational methods with the numerical simulation of COVID-19 related processes will be presented.

**Palabras clave / Key words:** System identification, sparse representation, time series, recurrent neural network, gated recurrent unit.

**Referencias/References:**

- Vides, F. (2021). Sparse system identification by low-rank approximation. CoRR, abs/2105.07522. URL https://arxiv.org/abs/2105.07522.

- Vides, F. (2021). Computing Sparse Autoencoders and Autoregressors for Signal Modeling. Technical report. URL

  https://github.com/FredyVides/SPAAR/blob/main/Documentation/SpAAR_FVides.pdf.

- Vides, F (2021). SPAAR: A toolset of Python programs for signal modeling and indentification via sparse autoencoders and autoregressors.

  URL https://github.com/FredyVides/SPAAR

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[1]Viernes/Friday 25, 10:00 – 10:40,Schedule (GMT-6)

[2]Universidad Nacional Autónoma de Honduras, Scientific Computing Innovation Center,Honduras, fredy.vides@unah.edu.hn

# Curve Fitting for Covid-19 Population Data Trend using Generalized Logistic Regression[1]

*Presentations (30 minutes)*
*Mario Alberto Villalobos Arias*[2]
*Costa Rica*

**Resumen/Abstract:** In this work, a proposal is presented for the estimation of populations using generalized logistic curve fitting. These types of curves are used to study population growth, in this case population of people infected by the Covid-19 virus; and it can also be used to approximate the survival curve used in actuarial and similar studies. The resulting model could also be used to approximate daily cases and other data related to the pandemic, such as the number of hospitalized and ICU cases. In addition, an adjustment method for the detection of second and subsequent waves is also proposed. Examples are presented for some Latin American countries.

**Referencias/References:**

- Fekedulegn, Desta; Mairitin P. Mac Siurtain; Jim J. Colbert (1999). Parameter Estimation of Nonlinear Growth Models in Forestry (PDF). Silva Fennica. 33 (4): 327-336. Archived from the original (PDF) on 2011-09-29.

- Pella, J. S.; Tomlinson, P. K. (1969). A Generalised Stock-Production Model. Bull. Inter-Am. Trop. Tuna Comm. 13: 421-496.

- Richards, F. J. (1959). A Flexible Growth Function for Empirical Use. Journal of Experimental Botany. 10 (2): 290-300. doi:10.1093/jxb/10.2.290

- Villalobos-Arias, Mario (2020) Using generalized logistics regression to forecast population infected by Covid-19, https://arxiv.org/abs/2004.02406

- Villalobos-Arias, Mario (2020) Estimation of population infected by Covid-19 using regression Generalized logistics and optimization heuristics.

  http://www.kerwa.ucr.ac.cr/handle/10669/80859

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# Computing hyperelliptic modular invariants from period matrices[1]

*Presentations (30 minutes)*
*Christelle Vincent[2]*
*USA*

**Resumen/Abstract:** We define the modular invariants of a hyperelliptic curve to be the value of certain Siegel modular functions that correspond to classical invariants of hyperelliptic curves, evaluated at a period matrix of the Jacobian of the curve. In this talk, we discuss this correspondence between modular functions and invariants of curves, as well as certain computational considerations that arise when recognizing the invariants as algebraic numbers from their floating point approximation. This is joint work with Ionica, Kilicer, Lauter, Lorenzo Garcia, Massierer and Manzateanu.

**Palabras clave / Key words:** hyperelliptic Jacobians, Siegel modular forms, modular invariants

**Referencias/References:**

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# Structuring and modeling of complex problems using the value-focused thinking (VFT) and electre-mor methods: products classification in a beverage warehouse

*Posters*

Lucas Vitorino[1]      *Marcos Dos Santos*[2]

*Carlos Francisco Simões Gomes*[3]      *Igor Pinheiro de Araújo Costa*[4]

*Brazil*

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**Resumen/Abstract:** O armazém é um elemento fundamental da logística, que precisa de formas eficientes de classificar e atribuir um local de armazenagem. O problema de atribuição de local de armazenamento (slap) pode ser tratado como um problema de multicritérios através de métodos de tomada de decisão que estabelecem a classificação de unidades de armazenamento (skus) influenciados pela opinião do tomador de decisão. Este artigo visa aplicar o pensamento focado no valor (vft) e os métodos de eletrificação para apoiar o processo de tomada de decisão (dm) estratégico na classificação de unidades de inventário através de múltiplos critérios, em um armazém de uma empresa de distribuição. Os resultados encontrados mostraram que, entre 100 skus, 8 % foram alocados na classe a de maior prioridade, 19 % na classe b de prioridade intermediária e 73 % dos skus, a grande maioria, foram atribuídos à classe menos.

**Palabras clave / Key words:** MULTICRITERIA ANALYSIS; STORAGE LOCATION ASSIGNMENT PROBLEM; ELECTRE-MOR; SLAP; VFT.

## Referencias/References:

- Costa, I. P. De A et al. (2021a), Choosing flying hospitals in the fight against the COVID-19 pandemic: structuring and modeling a complex problem using the VFT and ELECTRE-MOr methods. IEEE Latin America Transactions, v. 19, n. 6, p. 1099–1106.

- Fontana, M. E.; López, J. C. L.; Cavalcante, C. A. V.; & Noriega, J. J. S. (2020), Multi-criteria assignment model to solve the storage location assignment problem. Revista Investigación Operacional, v. 41, n. 7, 1019-1029.

- Gomes, L.; Mury, A.-R.; Gomes, C. F. S. (1997), Multicriteria ranking with ordinal data. Systems Analysis-Modelling-Simulation, v. 27, n. 2, p. 139–146.

- Keeney, R. L. (1992), Value-Focused Thinking: A Path to Creative Decision Making. Harvard University Press, Cambridge, Massachusetts.

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[4]Federal Fluminense University, Department of Production Engineering, costa_igor@id.uff.br

- Micale, R., La Fata, CM, & La Scalia, G. (2019), Uma abordagem combinada de ELECTRE TRI e TOPSIS com valores de intervalo para resolver o problema de atribuição de local de armazenamento. Computadores e Engenharia Industrial, v. 135, p. 199-210.

# ON THE SPECTRAL THEORY OF SCHRÖDINGER OPERATOR WITH DYNAMICALLY DEFINED POTENTIAL[1]

*Presentations (30 minutes)*
*El Hadji Yaya Tall[2]*
*Brazil*

**Resumen/Abstract:** The commonly accepted mathematical model of an electron in a crystal with impurities is that of a Schrödinger equation resulting from a potential sum of a periodic oscillation to which is added random noise. The mathematical study of this equation highlights, under certain assumptions on the noise, that it gives rise to a strictly positive Lyapunov exponent, which also tends to exponentially localize the wave function. Much of the mathematical study of Schrödingeroperator is motivated by an observation made in 1958 by the American physicist Philip Anderson who args that while idela crystal are always conductors, the presence of impurities should cause the crystal to loose all its conductivity properties and, thus become an insulator : the electrons are trapped due to the crystal lattice disorder. This discovery earned Anderson the Nobel Prize for Physics in 1977.We consider the discrete time independent Schrödinger operator $H$ defined in $\ell^2(\mathbb{Z})$ by

$$[H(\psi)](n) = \psi(n+1) + \psi(n-1) + V(n)\psi(n)$$

where $V : \mathbb{Z} \to \mathbb{R}$ is a bounded function. $V$ is called the *the potential* it models the medium to which the quantum state $\psi$ is exposed.The term

$$\Delta\psi](n) = \psi(n+1) + \psi(n-1)$$

in $H$ is the discrete Laplacian, and it arises from the kinetic energy by quantization.The time-independent Schrödinger equation describes the so-called orbitals or stationary waves in quantum mechanics. It is the eigenvalue equation of Hamiltonian or Schrödinger operator $H$

$$H\psi = E\psi \tag{3}$$

where $\psi$ is the wave function, $E$ is the energy of the quantum state $\psi$.In this talk we will study equation 3 when the potential is dynamically defined, by using tools coming from ergodic theory. More precisely we will first introduce the notion of linear cocycle for the Schrödinger equation and study the associated Lyapunov exponents and see what can we say about the solutions of 3.

**Palabras clave / Key words:**

**Referencias/References:**

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# THE MODULI STACK OF PRINCIPAL $\rho$-SHEAVES AND GIESEKER-HARDER-NARASIMHAN FILTRATIONS[1]

*Presentations (30 minutes)*
*Alfonso Zamora*[2]

**Resumen/Abstract:** Given a smooth projective variety $X$ and a connected reductive group $G$ defined over a field of characteristic $0$, we define a moduli stack of principal $\rho$-sheaves that compactifies the stack of $G$-bundles on $X$. We apply a recent theory to construct a moduli space of Gieseker semistable principal $\rho$-sheaves. This provides an intrinsic stack-theoretic construction of the moduli space of semistable singular principal bundles. An important outcome is the definition of a schematic Gieseker-Harder-Narasimhan filtration for $\rho$-sheaves, which induces a stratification of the stack by locally closed substacks and refines the previously known canonical slope parabolic reduction.
**Palabras clave / Key words:**

**Referencias/References:**

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