Sesión de Pósteres de Matemática Computacional
Congreso Bienal de la Real Sociedad Matemática Española
Santander, 4 - 8 febrero 2019

Jueves 7 de Febrero de 2019, Facultad de Ciencias de la UC, de 16:00 a 17:00

P1. **J. García-Maribona López-Sela** (IHCantabria, Universidad de Cantabria)
A 2D One-Phase Numerical Modeling Approach for Sediment Transport Assessment.

P2. **D. Lucio** (IHCantabria, Universidad de Cantabria)
A coupling stochastic methodology to model the long-term wave climate. Application to the simulation of meteo-oceanographic conditions over the Port of Melilla (Spain).

P3. **B. Di Paolo** (IHCantabria, Universidad de Cantabria)
CFD modelling for wave and current interaction with floating bodies: coastal and offshore engineering applications.

P4. **J. Matías Sepulcre** (Universidad de Alicante)
Some theoretical results and algorithms for the generation of densifiable sets.

P5. **F. Pla** (Universidad de Castilla La Mancha)
A Schwarz domain decomposition method applied to a Rayleigh-Bénard convection problem.

P6. **D. Ruiz-Antolín** (Universidad de Cantabria)
Numerical evaluation of discrete Painlevé equations.

P7. **I. Sarría** (Universidad Internacional de La Rioja)
Convergencia local de familias paramétricas de cuarto y quinto orden de métodos iterativos en espacios de Banach y su dinámica.

P8. **J. Tonelli-Cueto** (Berlin Mathematical School/Technische Universität Berlin)
Computing the Homology of Semialgebraic Sets in Weak Exponential Time.

A 2D One-Phase Numerical Modeling Approach for Sediment Transport Assessment

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Abstract. In Maritime Engineering. problems related with scour and sediment transport have been becoming more important in last decades. The reason is that maritime structures are subjected to increasingly extreme conditions. Some common examples of this kind of problems are scour around cylindrical piles like the ones used for offshore wind turbines, platforms or bridges, scour in front of breakwaters or propeller-induced scour.
Regarding the available techniques to evaluate and design protections against scour, three separate groups can be distinguished: semi-empirical formulae, physical modeling and numerical modeling. Numerical models are still in development stage, and can potentially provide a fast and accurate way to assess the problem combined with lower costs than physical modeling, however, at this point numerical models which provide high precision have a excessive computational cost.
Within numerical modeling, CFD (Computational Fluid Dynamics) software is of special interest as it provides high precision for complex processes.In this work, a sediment transport model coupled with CFD has been developed,it is two-way coupled as it considers the effect of hydrodynamics in sediment transport and vice versa. The sediment transport is solved in an Eulerian approach and the influence of sediment transport in hydrodynamics is introduced by varying the boundary conditions for the hydrodynamic model rather than modifying its equations. As hydrodynamic model, IH-2VOF is selected, aiming to reach a suitable computational cost and enough precision in results.
The developed model is able to transport sediment with both bedload and suspended mechanisms and change the seabed morphology accordingly. The former is solved with a combination of analytical and empirical formulae while suspended transport is computed by numerically solving an advective-diffusive transport equation.
Although the validation of the model is still in progress, the preliminary results are promising and the computational cost is significantly smaller compared with existing similar models.

Keywords: Numerical Modeling, Sediment Transport, Eulerian, Scour, CFD

A coupling stochastic methodology to model the long-term wave climate. Application to the simulation of meteo-oceanographic conditions over the Port of Melilla (Spain).

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Abstract. Stochastic analysis of maritime structures along their lifecycle requires the simulation of realistic meteo-oceanographic conditions including extreme events and regular conditions. It is therefore necessary to adequately characterize the long-term wave climate in order to obtain reliable wave-driven events.

These meteo-oceanographic events (also known as sea-states) are characterized by a multidimensional nature (i.e. there is a high cross-correlation between the wave height, the wave period, the wave direction and the sea level), a time-dependence (i.e. seasonal or intra-annual variability) and a self-dependence (i.e. consecutive events are correlated). In order to achieve these targets, this work introduces a novel stochastic modeling to obtain a multivariate and non-stationary self-dependent long-term climate model at hourly time-scale in a coastal site.

By means of interlinking stochastic models, the proposed model relates the multivariate and non-stationary incident wave climate (so-called predictand) to the continuous-time Markov process of the regional atmospheric conditions (so-called predictor). Due to the physical relationship between the large-scale predictor and the local predictand, a better modeling of the predictor involves a better modeling of the sea-states. Thus, the methodology consist in coupling the statistical model for the predictor (predictor chronology model at monthly time-scale in order to characterize the intra-annual variability) and the statistical models for the predictand (Multivariate-statistical models for the predictand characterization at hourly time-scale). This provides an uncertainty reduction in a statistical and physical realistic way.

The results of the application to the Port of Melilla highlight that the proposed methodology does allow to simulate the long-term wave climate at hourly time-resolution but with a correct extreme value distribution, taking into account that the sea-state variables are cross-correlated, auto-correlated and non-stationary.

Joint work with:
A. Tomás. Environmental Hydraulics Institute "IHCantabria", University of Cantabria.
J. L. Lara. Environmental Hydraulics Institute "IHCantabria", University of Cantabria.
P. Camus. Environmental Hydraulics Institute "IHCantabria", University of Cantabria.
I. J. Losada. Environmental Hydraulics Institute "IHCantabria", University of Cantabria.

Keywords: Multivariate, Non-stationary analysis, Markov process, Extremes, regular conditions.

CFD modelling for wave and current interaction with floating bodies: coastal and offshore engineering applications.

Benedetto Di Paolo

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Abstract. Computational fluid dynamics (CFD) modelling of wave-current interaction with floating structures is still a very challenging issue, especially whit respect to large body displacements. To simplify the problem and to get results with a good approximation and a reasonable computational time, potential flow models have been widely applied in this research field. Despite of the good performance of potential flow models which has in predicting floating body dynamics, there are still physical processes which are not correctly reproduced with the same approximation when handling large body displacements. Indeed, because of the assumption of small displacements when high non-linear effects become relevant, the accuracy of these models decreases. In addition, the presence of restrictions to motion induced by mooring elements, also introduces additional non-linear features which are out of the capabilities of potential flow models.
The use of Navier-Stokes models based on Finite Volume Method (FVM) overcomes potential model limitations, especially for non-linear effects. On the other hand, several issues arise when using CFD models to solve wave and current interaction with moving bodies, such as floating body numerical treatment (e.g. dynamic meshes), mooring implementation (high non linearity) or computational cost.
In this work, we present a numerical analysis of wave and current interaction with floating bodies using the most accurate technique to perform the dynamics.

Joint work with:
Javier L. Lara. University of Cantabria - Environmental Hydraulics Institute "IH Cantabria" - Universidad de Cantabria
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Keywords: Navier-Stokes, Computational fluid dynamics, Fluid-structure interaction, floating structures, OpenFOAM

Some theoretical results and algorithms for the generation of densifiable sets

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Abstract. A very well known class of subsets in a metric space (E, d) is that of the Peano continua, i.e., the compact connected and locally connected sets, which were characterized in 1913 by Hahn and Mazurkiewicz as the continuous images of the unit interval $I = [0, 1]$. This work is focused on the densifiable sets, which are those sets, say D, with the property of containing for arbitrarily small $\alpha > 0$ a Peano continuum P_α such that the Hausdorff's distance from P_α to D is less than or equal to α. Specifically, we will show some densifiable sets which are generated by means of some functional equations related to the partial sums of the Riemann zeta function, and we will also analyse the case of the Sierpinski gasket. Finally, we will present the description of some models which have been implemented in Maple to generate the curves that densify all such sets.

Keywords: Densifiable sets · Sierpinski gasket · Partial sums of the Riemann zeta function · Functional equations · Maple

A Schwarz domain decomposition method applied to a Rayleigh-Bénard convection problem

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Abstract. The aim of this work is to introduce a Schwarz domain decomposition numerical method for a stationary Rayleigh-Bénard convection problem. The incompressible Boussinesq Navier-Stokes equations are coupled with a heat equation. The problem is defined in a two dimensional rectangular domain. The nonlinearity of the stationary problem is discretized by a Newton method. Each step in the Newton method is solved using a Schwarz domain decomposition method with the domain partitioned into several subdomains such that appropriate interface conditions are considered. Their convergence properties are studied theoretically including two artificial parameters in the equations. The numerical resolution confirms the theoretical results. The convergence rate is less than one with overlap and also the convergence is achieved for large aspect ratio values, which are inabordable for the standard Legendre collocation method. Convergence is optimal for some values of the parameters. Other computational advantages of this methodology is the parallelization and the high order.

Joint work with:
Henar Herrero. Universidad de Castilla-La Mancha
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Keywords: Rayleigh-Bénard convection, Legendre collocation, Domain decomposition method

Evaluación numérica de ecuaciones de Painlevé discretas

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Resumen. Muchos casos de ecuaciones de Painlevé discretas aparecen en el estudio de los coeficientes de las relaciones de recurrencia que satisfacen ciertos polinomios ortogonales asociados a pesos semiclásicos. Un primer intento de evaluación de las soluciones de estas ecuaciones podría ser la evaluación directa de la relación de recurrencia no lineal que las define. Sin embargo, se observa en múltiples casos, como puede ser la ecuación discreta alternativa de Painlevé I (alt-$\mathrm{dP_I}$) o la ecuación discreta de Painlevé IV ($\mathrm{dP_{IV}}$), que dicha evaluación directa, en ambos sentidos de la recurrencia, produce serias inestabilidades para el caso no negativo. No obstante, hay otros casos, como ciertas formas discretas de Painlevé III, que no presentan dicha inestabilidad. Se observa que precisamente las soluciones inestables toman por punto inicial soluciones recesivas de ciertas ecuaciones diferenciales lineales como puede ser el caso de alt-$\mathrm{dP_I}$ cuyo punto de partida utiliza las funciones de Airy Ai(x). El interés de nuestra investigación se centra tanto en la explicación del fenómeno de inestabilidad descrito arriba como en la descripción de métodos efectivos de evaluación numérica y asintótica de las soluciones no negativas de estas recurrencias cuando la evaluación directa de la recurrencia es inestable.

Trabajo en colaboración con:
Alfredo Deaño Cabrera. Universidad de Kent

Palabras clave: Ecuaciones de Painlevé discretas, relaciones de recurrencia no lineales

Convergencia local de familias paramétricas de cuarto y quinto orden de Métodos iterativos en espacios de Banach y su dinámica

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Resumen.
Muchos problemas de las Ciencias Aplicadas, incluyendo la Ingeniería, pueden resolverse mediante la búsqueda de soluciones de ecuaciones de la forma

$$F(x) = 0 \tag{1}$$

donde $F : D \subseteq X \to Y$ es un operador no lineal de Fréchet diferenciable en un dominio convexo abierto D de un espacio de Banach X con valores en un espacio de Banach Y utilizando modelado matemático. Excepto en casos especiales, las soluciones de estas ecuaciones no se pueden encontrar de forma exacta. Esta es la principal razón por la que los métodos de resolución más comúnmente utilizados suelen ser iterativos. El análisis de la convergencia de métodos iterativos se divide generalmente en dos categorías: análisis de convergencia semilocal y análisis de convergencia local. El primero se basa en la información alrededor de un punto inicial para proporcionar criterios que garanticen la convergencia de los procesos de iteración, mientras que el análisis de convergencia local se basa en la información alrededor de una solución para encontrar estimaciones de los radios calculados de las bolas de convergencia.

Este trabajo trata sobre el estudio de la convergencia local de una familia de métodos iterativos para resolver ecuaciones no lineales en espacios de Banach de cuarto y quinto orden. Se establece bajo el supuesto que la derivada de primer orden de Fréchet satisface la condición de continuidad de Lipschitz. Se demuestra un teorema de convergencia para estudiar las regiones de existencia y unicidad para la solución. Se muestra la eficacia del estudio de convergencia resolviendo una serie de ejemplos numéricos que incluyen una ecuación integral de tipo Hammerstein no lineal y calcula los radios de las bolas de convergencia. Se comparan los radios de las bolas de convergencia y se observa que son mayores al utilizar nuestro método que con otros. Junto con el estudio del comportamiento dinámico, estos son los objetivos de este póster.

Trabajo en colaboración con:
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Abhimanyu Kumar. Indian Institute of Technology Kharagpur

Palabras clave: Convergencia local, Espacios de Banach, Métodos iterativos, Dinámica, Mathematica, Planos de parámetros, Planos dinámicos

Computing the Homology of Semialgebraic Sets in Weak Exponential Time

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Abstract. A semialgebraic set is a set described by real polynomials and inequalities. In this poster, we present a numerical algorithm for computing the homology (Betti numbers and torsion coefficients) of semialgebraic sets. This algorithm works in weak exponential time for a wide family of absolutely continuous distributions. This means that outside a subset of data having exponentially small measure, the cost of the algorithm is single exponential in the size of the data. All previous algorithms proposed for this problem have doubly exponential complexity (and this is so for almost all input data).
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Trabajo en colaboración con: / Joint work with:
Peter Bürgisser. Technische Universität Berlin
Felipe Cucker. CityU Hong Kong

Keywords: semialgebraic geometry, homology, numerical algorithm