Second SIMNUMAR meeting 2015

Aula máster M2i, Edificio da Área Científica, Campus Elviña (A Coruña)

Programme 22 June 2015

10:00-10:50
Seabed ping-echo models: a review
Daniel Rodríguez-Pérez. Departamento de Física Matemática y de Fluidos, Universidad Nacional de Educación a Distancia

10:50-11:40
A numerical approach to seabed characterization in coastal environments
Andrés Prieto. Departamento de Matemáticas, Universidade da Coruña

11:40-12:10: Coffee break

12:10-13:00
Statistical Classification of seabed from sonar data: FDA and multivariate approaches
Javier Tarrío. Departamento de Matemáticas, Universidade da Coruña

13:00-13:50
A Partition of the Unity Finite Element Method for heterogeneous media in underwater acoustics
Paula M. López-Pérez. Departamento de Matemáticas, Universidade da Coruña

Organizers:
L. Hervella (UDC)
A. Prieto (UDC)

Video streaming:
http://iemath2.cesga.es/videos/

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Abstracts

Seabed ping-echo models: a review

D. Rodríguez-Pérez (Departamento de Física Matemática y de Fluidos, Universidad Nacional de Educación a Distancia), N. Sánchez-Carnero (Departamento de Física Aplicada, Universidade de Vigo)

When a single-beam sonar pings a packet of energy is sent spreading and attenuating in the water. Then it is backscattered and detected as an echo back at the echosounder. The relationship between the properties of the signals emitted and received helps characterize the backscattering target. The ping finite length, the finite target size or extended area, etc. together with the ondulatory properties of coherent sound waves pose difficulties to understand how echoes are formed and how affected by other target properties we could be interested in. This talk will review some models of single beam echo formation: from the simplest geometrical models to more elaborate directivity function or ondulatory models. Then we will revise the coherence properties of the sound waves transmitted down and upwards through the water column and their effects on the echo formation.

A numerical approach to seabed characterization in coastal environments

A. Prieto (Departamento de Matemáticas, Universidade da Coruña), Noela Sánchez-Carnero (Departamento de Física Aplicada, Universidade de Vigo)

The characterization of the seabed in coastal environments does not only involve the determination of the depth in the water column but also the geological classification of the bottom surface and the identification of the presence of marine vegetation. The physical exploration of these coastal environments are performed by means of side-scan sonars, which allow to measure the acoustic response of the elements on the seabed from the surface of the sea. In this talk, the mathematical modeling of the coastal fluid media (highly heterogeneous and depending on several state variables) and the poroelastic models to govern the structural behavior of the seabed will be revised. From a numerical point of view, since the fluid medium is assumed unbounded, it will be required the use of the Perfectly Matched Layer technique to truncate the computational domain. In addition, side-scan sonars typically involve measurements in a range from 1kHz to 200kHz and so efficient numerical procedures to approximate accurately the time-harmonic motion in hydro-acoustic problems at high-frequency regime will be considered.

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Statistical Classification of seabed from sonar data: FDA and multivariate approaches

J. Tarrío (Departamento de Matemáticas, Universidade da Coruña), N. Sánchez-Carnero (Departamento de Física Aplicada, Universidade de Vigo), A. Prieto (Departamento de Matemáticas, Universidade da Coruña)

This work shows several alternative statistical methodologies to classify different types of seabed from sonar data. Application examples in engineering and material science are provided to introduce the methodologies. Supervised and non supervised classification tools are implemented to experimental sonar data obtained in Murcia region (Spain). Partial Least Squares (PLS) dimension reduction combined with supervised classification methods such as Linear Discriminant Analysis (LDA) are applied. Alternatively, new Functional Data Analysis (FDA) classification techniques such as Functional Generalized Additive Models are implemented to the same dataset.

A Partition of the Unity Finite Element Method for heterogeneous media in underwater acoustics

L Hervella-Nieto, P. M. López-Pérez, A. Prieto (Departamento de Matemáticas, Universidade da Coruña)

The numerical approximation of time-harmonic wave propagation problems can be obtained by means of standard Finite Element Methods (FEM) based on polynomial local basis. However, for high frequency values and even assuming homogeneous media those discretizations lead to approximated solutions that differ from the exact solution due to the so-called pollution effect. To mitigate the numerical pollution, the Partition of the Unity Finite Element Method (PUFEM) has been used to deal with the time-harmonic wave propagation in underwater acoustics and computational mechanics. In this kind of methods, the FEM discretization space is modified by enriching the basis functions with plane waves, and so inserting free-space solutions of the homogeneous model into the standard local polynomial basis. In this talk, heterogeneous time-harmonic wave propagation problems are numerically solved by means of a PUFEM method, which uses a novel enrichment procedure. Instead of using simple plane wave solutions of a constant-coefficient partial differential equation, the proposed method is based on local solutions of the variable coefficient model.
Some numerical experiments are carried out to illustrate the performance of this novel PUFEM procedure with respect to the mesh size, the quadrature schemes (either exact or semi-analytic schemes based on high-order Gauss-Legendre rules), the number of functions used in the enrichment procedure, and the behavior of the discrete method with respect to the angular frequency.

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