Symposium: Waves, Model reduction and Imaging

13:00-13:30 Welcome with Coffee

13:30 - 13:50 Mike Zaslavsky, Schlumberger-Doll Research

Multi-scale S-fraction reduced-order models for massive wavefield simulations: We present a reduced-order multi-scale method for solving large time-domain wavefield simulation problems. The algorithm consists of the embarrassingly parallel "off-line" stage for computing multi-scale reduced-order model for each coarse grid cell and highly parallelizable "online" stage for the time-domain simulation performed within the obtained multi-scale framework. The performance of the method is illustrated on 3D composite anisotropic elastic problems.

13:50 - 14:10 Bastiaan de Hon, Technical University Eindhoven

Space-time Green's functions on a 3D simple cubic lattice: We have recently found a no-neighbours recurrence scheme for generating discrete space-time lattice Green's function (LGF) sequences for 3D scalar wavefields on a simple cubic lattice, which is a crucial step towards the development of an FDTD domain decomposition method known as discrete Green's function diakoptics. An apparently anomalous late-time high-frequency phenomenon can be fully explained through a singularity analysis of the spectrogram. The recurrence scheme breaks down at certain lattice points at some discrete instant in time, which can be avoided upon applying the FDTD stencil to the neighbours of the singular lattice point up to the breakdown instant.

14:10 - 14:30 Liliana Borcea, University of Michigan

Transformation of active array data to its born approximation via truncated ROMs: We introduce a novel algorithm for nonlinear processing of data gathered by an active array of sensors which probes a medium with pulses and measures the resulting waves. The algorithm is motivated by the application of array imaging, which seeks to invert the nonlinear mapping from the reflectivity to the array data. Many existing imaging methodologies ignore the nonlinearity and work under the assumption that the Born (single scattering) approximation is accurate. This leads to image artifacts when multiple scattering is significant. Our algorithm seeks to transform the array data to those corresponding to the Born approximation, so it can be used as a pre-processing step for any linear inversion method. The nonlinear data transformation algorithm is based on a reduced order model defined by a proxy wave propagator operator that has four important properties. First, it is data driven, meaning that it is constructed from the data alone, with no knowledge of the medium. Second, it can be factorized in two operators that have an approximately affine dependence on the unknown reflectivity. This allows the computation of the Fre'chet derivative of the reflectivity to the data mapping which gives the Born approximation. Third, the algorithm involves regularization which balances numerical stability and data fitting with accuracy of the order of the standard deviation of additive data noise. Four, the algebraic nature of the algorithm makes it applicable to scalar (acoustic) and vectorial (elastic, electromagnetic) wave data without any specific modifications.

14:30 - 14:50 Koen van Dongen, Delft University of Technology

Full-waveform inversion for breast ultrasound: Ultrasound is gaining interest as an alternative for X-ray mammography. By measuring the acoustic wave field accurately, the opportunity arises to reconstruct speed of sound profiles inside the breast. These profiles are useful to differentiate between cancerous and healthy breast tissues. Reconstructing these profiles from the measured wave field is a non-linear inverse problem. In my presentation, I will show how full-wave nonlinear inversion can be used to obtain speed of sound profiles.

14:50 - 15:30 Coffee Break

15:30 - 15:50 Vladimir Druskin, Druskin Algorithms

Model reduction of graph-Laplacians and spectral clustering: We show how model reduction technique developed earlier for large scale diffusion and wave propagation can be applied to clustering of big data sets via graph-Laplacians. We verify efficacy of our approach on examples of from "Stanford Large Network Dataset Collection".

15:50 - 16:10 Kees Wapenaar, Delft University of Technology

Marchenko imaging: Imaging of reflection data is usually based on the assumption that the data contain primary reflections only. Multiple reflections are treated as primaries and are imaged at wrong positions. To address this problem, we derived 3D Marchenko-type equations, which relate reflection data at the surface to Green's functions between virtual sources anywhere in the subsurface and receivers at the surface. Based on these equations, we derived an iterative scheme by which these Green's functions can be retrieved from the reflection data at the surface. This iterative scheme requires an estimate of the direct wave of the Green's functions in a background medium. Note that this is precisely the same information that is also required by standard reflection imaging schemes. However, unlike in standard imaging, our iterative Marchenko scheme retrieves the multiple reflections of the Green's functions from the reflection data at the surface. For this, no knowledge of the positions and properties of the reflecting interfaces is required. Once the full Green's functions are retrieved, reflection imaging can be carried out by which the primaries are mapped to their correct positions, with correct reflection amplitudes and without distorting interference by the multiples. In the presentation I will illustrate this methodology with numerical examples and discuss its potential and limitations.

16:10 - 16:30 Fernando Guevara Vasquez, University of Utah

Imaging small polarizable scatterers with polarization data: We present a method for imaging small scatterers in a homogeneous medium from polarization measurements of the electric field at an array. The medium is illuminated with a point source whose location is known but for which we only know it's polarization. We show how to preprocess the polarization data to extract an approximation to full measurements of the electric field at the array. Although this approximation has very significant errors, we prove that it can be used to image the position and location of the small scatterers using an electromagnetic version of Kirchhoff migration.

16:30 - 16:50 Martin van Gijzen, Delft University of Technology

Efficient iterative solution methods for multi-frequency elastic wave propagation problems: We present a comparison study for three different iterative Krylov methods that we have recently developed for the simultaneous numerical solution of wave propagation problems at multiple frequencies. The three approaches have in common that they require the application of a single shift-and-invert preconditioner at a suitable seed frequency. The focus of the present work, however, lies on the performance of the respective iterative method. We conclude with numerical examples that provide guidance concerning the suitability of the three methods.

16:50 - 17:10 Martijn van Beurden, Technical University Eindhoven

Translation-invariant bases for spatial spectral methods applied to electromagnetic scattering by penetrable objects in layered media: Gabor frames and shifted Hermite interpolation polynomials, as examples of translation-invariant bases, are considered to construct numerical schemes for domain integral equations pertaining electromagnetic scattering by dielectric objects embedded in a layered medium. Translation-invariant bases bring the advantage of preserving translation invariance present in layered media and giving rise to fast transformations via FFTs. The downside of these bases is that they can be prone to Gibbs-like phenomena at material interfaces. Pros and cons of such methods will be discussed.

17:10-19:10 Buffet and Drinks

3rd of July in room 'Kubus' in Building 26 (south of Civil Engineering, Van der Burghweg 1)

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