Fast transforms and eigenvalue decompositions of the one-way wave equation

Exploration geophysics aims at getting an image of the subsurface. Due to the huge datasets (terabytes) involved, efficiency is an important aspect. The imaging is done with acoustical energy, described by the wave equation. Decomposition of the wave equation into a coupled set of so called one-way wave equations is often applied, because of the fact that it is possible to develop extrapolation algorithms. An extrapolation algorithm uses data only at one depth level to "extrapolate" the wavefield to the next depth level. If the medium parameters do not change in the lateral direction a extrapolation algorithm is efficiently carried out if the wavefield is decomposed in plane waves. In this case the plane waves are the eigenfunctions of the system and the extrapolation algorithm consists of simple multiplications. A Fast Fourier transform efficiently carries out this plane wave decomposition. The earth's subsurface, however, generally varies in the lateral direction.

For such a medium it can be shown that the ideal transform of the wavefield is given by the eigenvalue decomposition of the system. However, an eigenvalue decomposition generally does not match a fast transform. The Fourier transform and the local sine transform will be used to bridge the gap between the *ideal* transform and a *fast* transform. It will be shown that it is possible to relate the distortions of the ideal (diagonal) structure to the medium parameters via the *local sine transform*. The theory of pseudo-differential operators plays an important role in the derivations. Examples will illustrate the potentials of bridging the gap between the eigenvalue decompositions and fast transforms.

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Solution of Diffusion Equations for Oscillatory Hydrogen Entrance Concentrations in Iron Membranes with Parallel Trap Reactions

The aim of the present study is to model the diffusion of hydrogen in iron membranes, subjected to sinusoidal entrance concentrations and to conditions, which are experimentally accessible, i.e., flux-measurement for the exit side at nil concentration.

Concentration and flux expressions as functions of (x, t) are presented for tree cases: 1) Ideal diffusion without traps; 2) Diffusion with a single parallel reversible trap-reaction (capture and release), but for trap concentrations $>> [H]$; 3) As 2), but considering a finite concentration of free and occupied traps.

Case 1 was solved by means of the Duhamel theorem and the others, using a semi-analytical method. The obtained solutions are expected to be useful to access velocity constants of different hydrogen-trap reactions acting simultaneously, and also for Electrochemical Impedance Spectroscopy associated to Hydrogen Permeation tests, a method, which we are trying to develop. The solution for membranes with different types of traps is in progress.

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Elastoplastisches Stoffverhalten beim Konsolidationsproblem

Auf der Basis der Theorie poröser Medien (Mischungstheorie – erweitert um das Konzept der Volumenanteile) wird ein Modell entwickelt, das zur Beschreibung von Konsolidationsvorgängen geeignet ist. Zur Erfassung der Materialeigenschaften bindiger Böden wird ein elastoplastisches Materialgesetz verwendet. Die elastischen Eigenschaften werden durch ein verallgemeinertes HOOKEsches Gesetz beschrieben. Der elastische Bereich wird durch eine Einflächen-Fließbedingung im Spannungsraum vom plastischen Bereich getrennt. Die zugehörige Fließregel ist nicht-assoziativ. Das Modell wird numerisch mit der Methode der Finiten Elemente behandelt. Anhand von Beispielrechungen wird die Plausibilität des Modells demonstriert.

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A Numerical Procedure for Minimizing the Maximum Cost

This paper deals with the numerical solution of the Bellman quasi–variational inequality (QVI) associated to the optimal control problem with minimax cost considered by Barron – Ishii [Nonlinear Analysis, Theory, Methods & Applications, 13 (1989), pp. 1067–1090]. In that problem the cost functional is the max of a function of the time, the state, and the control. This differs from the problems usually considered in the field of optimal control, where an accumulated cost is minimized.

We present an approximation method for the numerical solution of the QVI. The procedure employs both discretization on time and on spatial variables. By using linear finite elements, we get a fully discrete approximation that converges with rate $\sqrt{k}$, being k the triangulation size. We prove the optimality of this estimate. We present computational examples and we also generalize the previous results for the case where the cost functional includes an integral term.

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Approximate Solutions of Singular Integral Equations with Conjugation

The problem of applicability of some approximation methods for a solving of the singular integral equations with conjugation

$$\begin{aligned}(Ax)(t) &= a(t)x(t) + \frac{b(t)}{\pi i}\int_\Gamma \frac{x(s)}{s-t}ds + c(t)\overline{x(t)} + \frac{d(t)}{\pi i}\int_\Gamma \frac{\overline{x(s)}}{s-t}ds \\ &+ \int_\Gamma k_1(t,s)x(s)ds + \int_\Gamma k_2(t,s)\overline{x(s)}ds = f(t), \quad t \in \Gamma, \qquad (1)\end{aligned}$$

where Γ is a piecewise smooth curve or an interval, is considered. Coefficients of the equations (1) are continuous. Under these assumptions we give necessary and sufficient conditions for stability of approximation methods under consideration. The stability of the methods depends on invertibility of some operators $A_\tau, \tau \in \Gamma$, which belong to the algebra of Toeplitz operators acting in space l^2_σ. We establish criteria for the Fredholmness of A_τ and give some estimates for the indexes of $A_\tau, \tau \in \Gamma$. As a special case of singular integral equations with conjugation we consider Muskhelishvili equation and double layer potential equation. For such objects some properties of operators $A_\tau, \tau \in \Gamma$, are established.

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Application of Stochastic Modelling of Rough Surfaces for Predicting Abrasive Wear

A basic problem in mathematical modelling of abrasive wear phenomena consists in the geometric description of contacts of rough surfaces in dependence on material parameters and mechanical properties influencing the wear process. Interpreting the asperity heights of rough surfaces as two-dimensional, homogeneous, ergodic, stochastic fields formulas for geometric quantities like the mean heigh, gradient, and curvature of the asperities, section area and number of maxima over a given level can be derived which represent the basis for the contact modelling. With restriction to isotropic GAUSSian fields, the model parameters can be determined for real technical surfaces by statistical evaluation of profilometry data. The successful practical application of the resulting algorithm for wear calculation could be proved in comparison with experiments. First results for extending the model to the practically important case of contacts of anisotropic surfaces are represented.

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