International Journal of Computational Acoustics, Vol. 9, No. 4 (2001)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

A DIRECT DISCRETE FORMULATION FOR THE WAVE EQUATION*

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Received 10 June 1999
Revised 7 September 2000

The paper shows how to give a *direct* discrete formulation of the wave equation starting directly from physical laws, i.e. without passing through differential formulation. Using global variables instead of scalar and vector field functions, a close link between global variables and spatial and temporal elements immediately appears. A preliminary classification of physical variables into three classes: configuration, source and energy variables and the use of two cell complexes, one dual of the other, gives an unambiguous association of global variables to the spatial and temporal elements of the two complexes. Thus, one arrives at a discrete formulation of d'Alembert equation on an unstructured mesh.

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

International Journal of Computational Acoustics, Vol. 9, No. 3 (2001)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

AN HEXAHEDRAL FACE ELEMENT METHOD FOR THE DISPLACEMENT FORMULATION OF STRUCTURAL ACOUSTICS PROBLEMS*

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Received 23 June 1999
Revised 6 March 2000

Several finite element methods for the numerical computation of elastoacoustic vibrations are compared. They are applied to two formulations based on different variables to describe the fluid: presssure and displacement potential in one case, and displacements in the other. While the first one is discretized by standard Lagrangean finite elements for both variables, the second one is solved by "face" Raviart-Thomas elements. In each case we consider both tetrahedral and hexahedral meshes. Elastoacoustic eigenmodes have been computed for a test example by means of MATLAB implementations of all these methods. The numerical results allow us to compare all of them in terms of error versus number of degrees of freedom and computing time.

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

International Journal of Computational Acoustics, Vol. 9, No. 4 (2001)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

A COMPARISON OF NUMERICAL METHODS FOR ACTIVE SONAR ARRAY PERFORMANCE*

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Received 22 July 1999
Revised 7 November 2000

Low frequency active sonar (LFAS) arrays are complicated devices requiring careful design. Prototype LFAS arrays are expensive to construct and test. Accurate prediction of acoustic and electrical performance is therefore of great interest to LFAS designers. This generally involves solving a fully coupled problem relating the electrical drive to the resulting acoustic field. To derive results a numerical solution method is clearly the only recourse. This paper compares various numerical techniques in terms of accuracy, efficiency and overall applicability for the solution of LFAS problems. These are based around finite element (FE) and boundary element (BE) descriptions of the surrounding acoustic medium. Here we consider a pure FE approach based on wave envelope elements and a combined FE/BE scheme using an approximate BE formulation. These are contrasted with a pure BE approach that has been demonstrated to provide accurate predictions of LFAS array performance over a number of years. A piston stack transducer and a line array of free-flooding ring projectors are considered as example LFAS problems. The acoustic, structural and electrical responses are considered.

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

International Journal of Computational Acoustics, Vol. 9, No. 3 (2001)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

ON THE EFFICIENT IMPLEMENTATION OF THE INTEGRAL EQUATION METHOD IN ELASTODYNAMICS*

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Received 18 June 1999
Revised 15 June 2000

The authors deal with low-cost computer implementation of the integral equation method in application to wave excitation, propagation and diffraction phenomena in solids. Typically these are frequency domain problems of seismic and physical acoustics and of nondestructive testing. Fast codes are obtained basing on analytical extracting and taking account of singular and slowly converging components of the solution beforehand. The present paper gives ideas of several such approaches, which have already proved their efficiency in practical applications. More details including numerical examples and discussion of similar methods known from the literature can be found in the surveyed papers.[1–12]

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

International Journal of Computational Acoustics, Vol. 9, No. 4 (2001)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

A GENERALIZED MODE MATCHING METHOD FOR SCATTERING PROBLEMS WITH UNBOUNDED OBSTACLES*

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Received 16 September 1999
Revised 6 June 2000

The two-dimensional time-harmonic acoustic scattering by a semi-infinite waveguide composed of two parallel rigid plates is considered. An original mode matching method is developed to avoid the use of the Wiener–Hopf technique, generalizing usual mode matching methods to the case of unbounded media. A brief description of the method is given by means of Fourier decomposition leading to a well-posed variational problem with unknown being the trace of the solution on a well-chosen interface.

From the numerical point of view, a local approximation is first considered by using Lagrange P1 finite elements on a segment of the interface. This leads to the computation of oscillatory integrals involving Fourier transform and complex square root functions. As a matter of accuracy, a special function is added to the finite element space, in order to take into account the asymptotic behavior of the solution.

Finally, this method is extended to deal with local perturbations of the media by coupling the previous method to a classical integral one.

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

International Journal of Computational Acoustics, Vol. 9, No. 4 (2001)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

AILU FOR HELMHOLTZ PROBLEMS: A NEW PRECONDITIONER BASED ON THE ANALYTIC PARABOLIC FACTORIZATION*

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Received 15 July 1999
Revised 3 October 2000

We investigate a new type of preconditioner which is based on the analytic factorization of the operator into two parabolic factors. Approximate analytic factorizations lead to new block ILU preconditioners. We analyze the preconditioner at the continuous level where it is possible to optimize its performance. Numerical experiments illustrate the effectiveness of the new approach.

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

International Journal of Computational Acoustics, Vol. 8, No. 3 (2000)

INTERNATIONAL ASSOCIATION
FOR MATHEMATICS AND
COMPUTERS IN SIMULATION

APPLICATION OF A DOMAIN DECOMPOSITION METHOD WITH LAGRANGE MULTIPLIERS TO ACOUSTIC PROBLEMS ARISING FROM THE AUTOMOTIVE INDUSTRY*

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Received 12 July 1999
Revised 29 February 2000

The Finite Element Tearing and Interconnecting method for the Helmholtz equation is a recent nonoverlapping domain decomposition method for solving linear systems arising from the finite element discretization of Helmholtz problems in bounded domains. This method was validated on two-dimensional external problems with first-order absorbing boundary conditions. The purpose of this paper is to study the robustness and efficiency of iterative methods for the solution of the associated interface problem for three-dimensional interior problems arising from the automotive industry.

*Presented at ICTCA'99, the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

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VISUALIZATION OF THE ENERGY FLOW IN AND AROUND A FLUID LOADED ELASTIC SPHERE*

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Received 10 July 1999
Revised 15 December 2000

The energy flow in and around a fluid loaded elastic sphere can be visualized by the instantaneous elastodynamic Poynting vector field and its time averaged complex cognate. The instantaneous field can be used to animate and follow the energy flow around the sphere much as one can follow the ripples of wind through a wheat field. The real and imaginary parts of the complex elastodynamic Poynting vector field can be used to show the traveling and standing wave components of the energy field, respectively. Special attention is given to the fluid/elastic boundary and energy coupling between the solid and fluid media. Numerous vector field plots and several animations will be shown.

*Presented at ICTCA'99 the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

NOISE PREDICTION BASED ON THE SPECTRAL METHOD FOR SOLVING A DISSIPATIVE BOUNDARY VALUE PROBLEM IN ACOUSTICS AND ITS NUMERICAL REALIZATION*

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Received 20 July 1999
Revised 3 October 2000

With intensive progress in noise control engineering it is necessary to solve diverse and highly complicated problems on vibrations of dissipative acoustical systems. The mathematical problems can be realized exactly in the specific cases only. Among approximate ways for solving the problems on dissipative acoustical vibrations of compressible gas or liquid the spectral method, based on the variational principle, is presented. The paper deals, first of all, with a new approach to noise prediction, i.e. forced vibration of a compressible gas. As a polyharmonic vibration, noise consists of the set of monoharmonic oscillations. There were no variational principles for stationary forced oscillations of dissipative distributed parameter systems when complex displacement amplitudes exhibit phase lag relative to pressure amplitudes due to the energy loss. Such a principle is stated in the paper. The starting boundary value problem has mixed nonhomogeneous conditions. The approach is illustrated by the modelling of compressible gas oscillations inside a device for producing resonance acoustical vibrations by means of steady excitation of the gas. This sonic generator, incorporating a resonator is under consideration as an example of the variational approach fitted to the problem quite adequately.

*Presented at ICTCA'99 the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.

SINC SOLUTION OF THE SHALLOW WATER EQUATIONS*

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Received 12 August 1999
Revised 17 May 2000

A sinc-Galerkin procedure is developed to approximate the solution of the shallow water equations. An integration of the shallow water equations with respect to the time variable leads to a nonlinear Volterra integral equation. Sinc approximations to both derivatives and indefinite integral reduce the integral equation to an explicit system of algebraic equations. Applications of the scheme to the variable-depth shallow water equations (thus having a source term) are given.

*Presented at ICTCA'99 the 4th International Conference on Theoretical and Computational Acoustics, May 1999, Trieste, Italy.