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An arbitrary Lagrangian Eulerian finite-element approach for fluid-structure interaction phenomena. (English) Zbl 1062.74617

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Summary: The present contribution is concerned with the design of a family of consistent fluid-structure interaction algorithms based on a unique temporal and spatial discretization of the governing equations. The characterization of the moving fluid-structure interface is realized by means of the arbitrary Lagrangian Eulerian technique. The spatial discretization is performed with the finite-element method, whereby either a first-order upwind scheme or the classical second-order upwind Petrov-Galerkin technique are used to discretize the linearized fluid equations while the standard Bubnov-Galerkin method is applied to the structural equations. In order to streamline coupling, the structure is discretized in a velocity-based fashion. The temporal discretization of both the fluid and the structural equations is embedded in the generalized-α framework by making use of classical Newmark approximations in time. To quantify the sources of error of the proposed algorithms, systematic studies in terms of the one-dimensional piston model problem are presented.

MSC:

74S05 Finite element methods applied to problems in solid mechanics
74F10 Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)
76M10 Finite element methods applied to problems in fluid mechanics
76N15 Gas dynamics (general theory)

Keywords:

fluid-structure interaction; arbitrary Lagrangian Eulerian technique; compressible Euler flow; non-linear structural dynamics; monolithic and partitioned time-integration schemes

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References:

[1] Lagrangian and Eulerian finite element techniques for transient fluid-structure interaction problems. In Transactions of the 4th International Conference on Structural Mechanics in Reactor Technology?volume B: Thermal and Fluid/Structure Dynamics Analysis, (eds). North-Holland: Amsterdam, 1977; B(1/2):1-12.

[2] Finite element analysis of transient dynamic fluid-structure interaction. In Advanced Structural Dynamics, (ed.). Applied Science Publishers: London, 1980; 255-290.

[3] Belytschko, Nuclear Engineering and Design 49 pp 17– (1978)

[4] Hughes, Computer Methods in Applied Mechanics and Engineering 29 pp 329– (1981)

[5] Liu, Nuclear Engineering and Design 65 pp 221– (1981)

[6] Liu, Computer Methods in Applied Mechanics and Engineering 58 pp 51– (1986)

[7] Nomura, Computer Methods in Applied Mechanics and Engineering 95 pp 115– (1992)

[8] Fluid-Struktur-Interaktion mit stabilisierten Finiten Elementen. Dissertation, Bericht des Instituts f?r Baustatik Nr. 31, Universit?t Stuttgart, 1999.

[9] Braess, Computer Methods in Applied Mechanics and Engineering 190 pp 95– (2000)

[10] Simulation num?rique de ph?nomnes d'interaction fluid-structure. Ph.D. Thesis, ?cole Nationale des Ponts et Chauss?es, Paris, 1995.

[11] Piperno, Computer Methods in Applied Mechanics and Engineering 124 pp 79– (1995)

[12] Farhat, International Journal for Numerical Methods in Fluids 21 pp 807– (1995)

[13] Farhat, Computer Methods in Applied Mechanics and Engineering 157 pp 95– (1998)

[14] Conservation laws for fluid-structure interactions. In Proceedings of the International Symposium on Computational Methods for Fluid-Structure Interaction, Trondheim, Norway, 1999.

[15] Partitionierte L?sungsans?tze in der Strukturdynamik und der Fluid-Struktur-Interaktion. Dissertation, Bericht des Instituts

f?r Baustatik Nr. 36, Universit?t Stuttgart, 1999.

[16] Blom, Computer Methods in Applied Mechanics and Engineering 167 pp 369– (1998)

[17] Huerta, Computer Methods in Applied Mechanics and Engineering 69 pp 227– (1988)

[18] Nonlinear Finite Element Analysis for Continua and Structures. Wiley, New York, 2000.

[19] Hauke, Computer Methods in Applied Mechanics and Engineering 153 pp 1– (1998)

[20] Brooks, Computer Methods in Applied Mechanics and Engineering 32 pp 199– (1982)

[21] Hughes, Computer Methods in Applied Mechanics and Engineering 45 pp 217– (1984)

[22] Hughes, Computer Methods in Applied Mechanics and Engineering 58 pp 305– (1986)

[23] Newmark, Journal of the Engineering Mechanics Division 85 pp 67– (1959)

[24] Chung, Journal of Applied Mechanics 60 pp 371– (1993)

[25] Kuhl, Archives of Computational Methods in Engineering 7 pp 299– (2000)

[26] Jansen, Computer Methods in Applied Mechanics and Engineering 190 pp 305– (2000)

[27] Simo, Computer Methods in Applied Mechanics and Engineering 111 pp 111– (1994)

[28] Simo, Zeitschrift fur Angewandte Mathematik und Physik 43 pp 757– (1992)

[29] Partitioned analysis of coupled systems. In Computational Methods for Transient Analysis, (eds). North-Holland: Amsterdam, 1983; 157-219.

[30] Conserving algorithms for nonlinear dynamics. In New Methods in Transient Analysis, (eds). The Winter Annual Meeting of the American Society of Mechanical Engineers, Anaheim, CA. The American Society of Mechanical Engineers: New York, 1992; 41-50.