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Séminaire commun
LaMCoS-Ecole Doctorale MEGA
Mécanique, Energétique, Génie Civil, Acoustique

State-Space Algorithms for Time Integration in Dynamics: Non-linearity, Dissipation and Accuracy

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In recent years the classic time integration algorithms, based on collocation of the equation of motion at selected points in time, are gradually being replaced by algorithms of conservation type, based on an integral of the equations of motion. The presentation will give an overview of some central issues and new results for conservative integration algorithms: non-linearity, dissipation and accuracy. The state-space formulation serves as a unifying feature of the algorithms.

The conservation algorithms start from an integrated form of the equations of motion. By this operation the inertia terms take the form of finite increments of momentum, while internal forces and loads appear via their time integrals. It is demonstrated, that these integrals hold the key to accurate integration of kinematically non-linear problems, and the particular role of the geometric stiffness is identified.

In most structural models the dynamics of interest is associated with the low-frequency modes. It is therefore of interest to develop algorithms that dissipate the energy of the high-frequency modes, that often do not represent the behavior of the original problem well. In contrast to collocation algorithms the conservation format does not contain algorithmic parameters, and artificial dissipation must therefore be introduced explicitly. It is shown how dissipation can be introduced into a conservation algorithm via two balanced extra terms. These terms lead to adequate damping of the high-frequency modes, but also influence the low-frequency regime. This undesirable side-effect can be removed by a novel technique where the dissipation terms are introduced via auxiliary state-space variables, related to displacements and velocities by scalar filter equations.

The time integrals of internal forces and loads are typically represented by suitable mean values in conservation algorithms. This limits the corresponding algorithms to second order accuracy. The crucial limitation of the accuracy is the phase error, which is identical to that of the classic collocation algorithms. It is demonstrated, how fourth order accuracy can be obtained by use of an improved representation of the time integrals. While the extended state-space formulation of high-frequency damping can fairly easily be adapted to non-linear kinematics, the fourth order algorithm is still only available for linear systems.

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