Fundamentals of Structure-Dependent Integration Methods for Time Integration: an Eigen-Based Theory

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ABSTRACT

An eigen-based theory for structure-dependent integration methods is constructed and it can provide the fundamental basis for the successful development of this type of integration methods. It is proved that a structure-dependent integration method can simultaneously combine unconditional stability and explicit formulation since it is proposed to accurately integrate low frequency modes while no instability is guaranteed for high frequency modes. Hence, this type of integration methods is a breakthrough for Dahlquist barrier. In general, it is very promising for solving inertial problems, where the total response is dominated by low frequency modes. In addition, it can be both explicitly and implicitly implemented for time integration although an explicit implementation is of practical significance since it can save many computational efforts due to the combination of unconditional stability and explicit formulation. A typical procedure to develop structure-dependent integration methods is constructed. In general, a coupled equation of motion for a multiple degree of freedom system can be decomposed into a series of uncoupled modal equations of motion by means of an eigen-decomposition technique. Next, an eigen-dependent integration method is developed to solve each modal equation of motion. Finally, all the eigen-dependent integration methods are combined to form a structure-dependent integration method by employing a reverse procedure of the eigen- decomposition technique.

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