Goal-oriented mesh adaptation for FE-vibration analyses of shell-like structures

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As is well known, the semidiscrete approach in structural dynamics consists of the spatial discretization of the continuous equation of motion by use of the finite element method and the temporal discretization by use of a suitable time stepping scheme. Both discretization steps contribute to the total discretization error. Here we restrict ourselves to the spatial discretization error. Thus the contribution deals with spatially adaptive schemes in finite element computations of structural vibrations of shells. In order to estimate the spatial discretization error with regard to an arbitrary functional of the solution the well-known Dual-Weighted-Residual-Concept (DWR) of Becker and Rannacher [1] is applied. I.e. for the error representation the residual of the numerical solution is weighted with the dual or adjoint problem which can be interpreted as the influence function of the quantity of interest. The dual problem is a backward problem in time which characterizes the spatial and temporal transport of the spatial discretization error. The error estimation is based on the numerical solution of the error representation, see e.g. [2]. Due to the Galerkin-orthogonality of the residual of the discrete primal solution the discretization of the dual problem is usually performed applying a higher order approximation.

In order to find simplifications for the error estimation we propose to take into account the physical nature of the considered problem. In structural dynamics one has to distinguish between wave propagation problems and vibration problems. As it is almost impossible to find a simplification for the errors estimation for wave propagation problems our focus is only on vibrations of shell-structures. For vibration problems the modal decomposition of the total discretization error results in the split of the error into a pure spatial error – the error in the discretization of the eigenmodes – and a pure temporal error – the error in the approximation of the natural frequencies. For vibration problems we propose to neglect this so-called phase error, since it mainly results in a phase shift between the exact and the numerical solution. Consequently our approach takes only into account the state variables at the current time and the temporal coupling of the primal and the dual problem can be neglected in this case. Thus the dual problem is reduced to a static problem at the current time/state. With this approach the numerical effort for the error estimation corresponds to the effort of the error estimation in global norms, such as the energy norm [3],[4].

Numerical examples show that this strongly simplified approach is a suitable basis for adaptive mesh adaptation schemes within the vibration analysis of shell type structures.

References

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