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Advanced Methods for Solutions in the Time-Domain

Computational structural dynamics is governed by discretization in space and time. Besides the classical Finite Element Method in the space-domain and Newmark's scheme in the time-domain there are several additional methods with specific advantages and special properties.
In the space-domain the Boundary Element Method and more recently the Scaled Boundary Finite Element Method have been established.
In the time-domain, there are well-structured families of time stepping schemes with some nice properties in order to control numerical stability and to indicate and estimate the error. Consequently it is possible to establish a time-step adaptation in order to reach a certain level of accuracy.
One typical family of time-stepping schemes is represented by Pade-series for the exponential. These series are related to implicit methods and thus are contrary to Taylor series expansions which are a prior unstable. Stability and accuracy of the Pade-schemes can be studied directly and in addition, there are strong relations to simple polynomial approaches in the time domain.
Pade-series can be used, too, in order to solve the stability of time delay-systems which appear typically in structural control.
The behaviour of material with memory depends on its time history and thus asks for nonlocal solutions. For material with exponential decaying memory internal degrees of freedom are introduced and accompanied by additional evolution differential equations. However, there are materials with rational and thus non-exponential memory, which causes fractional derivatives in the time-domain.
Modal decoupling plays a leading role in system-theory and thus in structural dynamics. Some non-conventional applications appear when elimination spurious modes, establishing frequency-to-time relations and methods in system identification.
All these aspects concerning the time-domain will be explained and elaborated in detail. Some basic results are published among others in the following papers:

- Ruge: Restricted Pade-scheme in computational structural dynamics.
  Computers and Structures (2001) Vol. 9, 1913-1921
- Ruge, Trinks: Consistent modelling of infinite beams by fractional dynamics.
  Nonlinear Dynamics (2004) Vol. 38, 267-284
- Ruge: A priori local error estimation with adaptive time-stepping.
  Communications in Numerical Methods in Engineering (1999) vol. 15, 479-491