

# SUCCESSIVE ITERATION PROCESS TO INTEGRATE NONLINEAR DIFFERENTIAL EQUATIONS SYSTEMS

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Motion equations for a meshed structure, as in a finite element approach for dynamical analysis of structures, form a differential equations system

$$[M]\{\ddot{U}\} + [C]\{\dot{U}\} + [K]\{U\} = \{F(t)\}, \quad (1)$$

with initial conditions  $t = 0$ ,  $\{U\} = \{U_0\}$ ,  $\{\dot{U}\} = \{v_0\}$ , where

-  $[M]$ ,  $[C]$ ,  $[K]$  are coefficients matrix of system,

-  $\{\ddot{U}\}$ ,  $\{\dot{U}\}$ ,  $\{U\}$ ,  $\{F\}$ , are unknowns, their derivatives and external forces vectors, written in the global coordinates system. The unknown values  $\{U\}$  are time varying functions,  $\{U\} = \{U(t)\}$ .

For some mechanical structures, which include compliant elements like springs, dumping elements, nonrigid joints etc., the motion equations (1) are a strong nonlinear differential second order equations, with matrix coefficients depending of unknowns, their derivatives and eventually of the time:

$$[M] = [\Phi(u, \dot{u}, \ddot{u}, t)], [C] = [\Phi(u, \dot{u}, \ddot{u}, t)], [K] = [\Phi(u, \dot{u}, \ddot{u}, t)]. \quad (2)$$

To integrate this systems there are not a direct method like for linear systems. The solution results after a successive iteration process. Integration will be made at discrete time moments  $t$ ,  $t+\Delta t$ ,  $t+2\Delta t, \dots, t+n\Delta t$ , in considered interval of solutions.

At each time step  $i$  would evaluate characteristic matrix of structure  $[M]$ ,  $[K]$  and  $[C]$ , but these depend of unknowns and their derivatives would be known at this time. The exit of this situation is a *successive iterations process*, which involves followings steps at each discrete time moments:

- on initialize unknowns with an arbitrary set of values;
- on calculate the first and second order derivatives of unknowns using the initial values with a regressive differential method;
- on determine characteristic matrix of system  $[M]$ ,  $[K]$  and  $[C]$ ;
- on integrate resulting linear system using a numerical method;
- on compare the resulted solution with iteration starting values; if the errors are grater than admitted tolerance on proceed an another iteration using start values the solution determinated at anterior iteration;

In this paper are detailed this procedure for integration of the motion equations resulting from a finite element approach in dynamical analysis of a compliant structure.

## REFERENCES

- [1] Munteanu, M., *Numerical Methods in Mechanical Structure Dynamic. Laboratory and Course Support*, Transilvania University Braşov, 1998 (in romanian).
- [2] Pele, A.-V., Băban, C.F., Bungău, C.: *Numerical Solution of Differential Equations Systems in Dynamical Analysis of Structures*, MicroCAD 2002 International Scientific Conference, pp. 53-58, ISBN 963 661 515 2, Miskolc, Hungary, 2002.