

THE BEAUTY OF ROTORDYNAMICS

G. Genta

Dept. of Mechanics, Politecnico di Torino

giancarlo.genta@polito.it

ABSTRACT

Rotordynamic analysis may involve the solution of nonlinear algebraic equations or sets of equations and a common approach is to use Newton-Raphson algorithm. However, it is well known that its convergence properties are complex when multiple solutions exist, and that their basins of attractions usually have complex, fractal shapes. The initial choice of the trial vector can be critical in deciding toward which solution the algorithm converges.

The study of the convergence properties of the Newton-Raphson algorithm is then important to devise a strategy aimed at obtaining the required solutions with the lowest possible number of attempts. However, apart from their practical values, the results in terms of convergency maps are interesting also because of the aesthetical value of the fractal plots.

Two cases of potential interest are investigated in the present paper: the first one comes from nonlinear rotordynamics and deals with the simple model of a nonlinear rotor, the Jeffcott rotor, while the second one is derived from linear rotordynamics and shows an application of Myklestad-Prohl method to a damped system.

In the first case the Newton-Raphson method is applied to a nonlinear equation written explicitly and the Jacobian matrix is computed in closed form. In the second case the basic problem is the solution of the characteristic equation, which is nonlinear in the natural frequency or the critical speed. When damping is included into the model its solution is not straightforward, and Newton-Raphson procedure is perhaps the best approach. However, the equation cannot be written explicitly and the Jacobian matrix must be approximated numerically.

The fractal basins of attraction resulting from Newton-Raphson algorithm have been studied in other contexts, and the color representations of the resulting maps have been recognized to have a strong esthetical value.

In the present work the maps obtained for two mentioned rotordynamics problems are studied with two aims:

- to evaluate the sensitivity to the starting solution in actual application
- to evaluate the possibility of obtaining drawings of aesthetical value.

Two examples of the maps so obtained are shown below.

