Real stability of an efficient family of iterative methods for solving nonlinear systems

Francisco I. Chicharro*, Alicia Cordero*, Juan R. Torregrosa*

The most of nonlinear models appearing in Science and Engineering can be approached, by means of a discretization process, to a system of nonlinear equations. The solutions of these systems are usually estimated by means of iterative methods, mainly Newton’s scheme, due to its simplicity and efficiency.

In the last years, many researchers have designed new iterative schemes trying to improve the original Newton’s procedure, in terms of order of convergence, efficiency or stability. Many tools have been used to get this aim: composition or weight-function procedures, non-direct extension of scalar schemes, pseudocomposition (that is, using different schemes as stating point of a predictor-corrector method), etc. In 2016 (see [1]), the authors proposed a fourth-order family of parametric methods specifically designed for solving nonlinear systems that included a fifth-order scheme with the best computational efficiency index, up to our knowledge.

Once the convergence and efficiency analysis is made, it is useful to study the dependence of the elements of the family of iterative methods to the initial estimations used. Then, the real dynamical tools (see [2]) allow us to study the stability of the fixed points, the existence of free critical points depending on the parameter and the chaotic behavior found (period-doubling bifurcations, strange attractors, ...) in some specific methods by means of Feigenbaum diagrams. Finally, some dynamical planes are presented to show in practice the theoretical performance of the schemes.

Acknowledgements

This research was partially supported by Ministerio de Economía y Competitividad MTM2014-52016-C02-2-P and Generalitat Valenciana PROMETEO/2016/089.

References


*Departamento de Matemática Aplicada, Universitat Politècnica de Valencia, Cno. de Vera s/n, 46022–Valencia (SPAIN). Email: frachiolo@upvnet.upv.es, acordero@upv.es, jrtorre@upv.es