

Richardson extrapolation and its variants

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Richardson extrapolation is a sequence acceleration method, which has long been used to enhance the accuracy of time integration methods for solving differential equations. Its classical version is based on a suitable linear combination of numerical solutions obtained by the same numerical method with two different discretization parameters. We present the principle of Richardson extrapolation, and introduce two possible generalizations of this method called repeated Richardson extrapolation (RRE) and multiple Richardson extrapolation (MRE). We investigate how the application of these schemes changes the absolute stability regions of certain underlying numerical methods, including explicit and implicit Runge-Kutta methods, an issue that is important when stiff systems of ordinary differential equations are to be solved numerically. The convergence of the new methods obtained by combining certain Runge-Kutta methods with these generalized Richardson extrapolation procedures are also analysed and illustrated with numerical experiments.