Accepted Manuscript

Generalizing global error estimation for ordinary differential equations by using coupled time-stepping methods

Emil M. Constantinescu

PII: S0377-0427(17)30248-0
DOI: http://dx.doi.org/10.1016/j.cam.2017.05.012
Reference: CAM 11143

To appear in: *Journal of Computational and Applied Mathematics*

Received date : 14 September 2016
Revised date : 9 May 2017

Please cite this article as: E.M. Constantinescu, Generalizing global error estimation for ordinary differential equations by using coupled time-stepping methods, *Journal of Computational and Applied Mathematics* (2017), http://dx.doi.org/10.1016/j.cam.2017.05.012

Generalizing Global Error Estimation for Ordinary Differential Equations by Using Coupled Time-Stepping Methods☆

Emil M. Constantinescu[1]

Abstract

This study introduces new time-stepping strategies with built-in global error estimators. The new methods propagate the defect along with the numerical solution much like solving for the correction or Zadunaisky's procedure; however, the proposed approach allows for overlapped internal computations and, therefore, represents a generalization of the classical numerical schemes for solving differential equations with global error estimation. The resulting algorithms can be effectively represented as general linear methods. Several explicit self-starting schemes akin to Runge-Kutta methods with global error estimation are introduced, and the theoretical considerations are illustrated on several examples.

Keywords: Ordinary differential equations, Time integration, Local and global error estimation

1. Introduction

The global error or a posteriori error represents the actual numerical error resulting after applying a time-stepping algorithm. Calculating this error and controlling it by adapting the step size are generally viewed as expensive processes, and therefore in practice only local error or the error from one step to the next is used for step size control or as a proxy for error estimation [1, 2, 3, 4]. In general, however, local error estimates cannot predict how those local errors will propagate through the simulation, and for some problems these local errors can grow to be larger than intended. Therefore, from the end-user perspective, local error estimation (LEE) is not always suitable, especially for problems with

☆This material is based upon work supported by the U.S. Department of Energy, Office of Science, Advanced Scientific Computing Research Program under contract DE-AC02-06CH11357, FWP #56706 and #57K87.

Email address: emconsta@mcs.anl.gov (Emil M. Constantinescu)

[1]Mathematics and Computer Science Division, Argonne National Laboratory, 9700 S. Cass Avenue, Lemont, IL 60439.