Copyright © 2011 ICCES ICCES, vol.16, no.1, pp.9-9

Fifth-Order Exact Analytic Continuation Numerical Integration Algorithm

James D. Turner, Manoranjan Majji and John L. Junkins

Summary

Numerical integration methods have been developed for predicting the evolution of the response of dynamical systems. Standard algorithms approach approximate the solution at a future time by introducing using a truncated power series representation that attempts to recover an n-th order Taylor series approximation, while only numerically sampling a single derivative model. Successful applications of this approach include: (1) Runge-Kutta methods which build up an approximation for a single step; (2) Predictor-Correction methods that use several back solutions to approximate the next step, and (3) Gear methods for handling stiff differential equations. The major innovation of this paper is the introduction of computational differentiation techniques for developing a rigorous n-th order Taylor series analytic continuation model for differential equations. The system dynamics is assumed to described by a first-order vector differential equation of the form: (1.1)

Turner's Object-Oriented Coordinate Embedding Algorithm (OCEA) provides the n-th order jacobians required for modeling the higher-order time derivatives required in the Taylor expansion given by: (1.2)

Analytic models for the second through fifth order time derivatives of Eq. (1.1) are given by (1.3)

where the denotes an n-dimension dot product operation. Various strategies are investigated for controlling the step-size appearing in Eq. (1.1). For example, one can assume the following dynamic step-size control strategy: (1.4)

Several orbit modeling applications will be presented and comparisons made with existing methods for accuracy and computational efficiency. A step size can be computed for each variable and the minimum value is then used to propagate the state estimate.