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ON A HIGH-PERFORMANCE INTEGRATOR OF THE EQUATIONS OF ORBITAL MOTION OF BODIES IN NEAR-EARTH SPACE

Abstract

To accurately determine the trajectory of bodies in near-Earth space, various numerical methods are used that could solve the Cauchy problem of ordinary differential equations. Common methods today are multistep implicit Gauss-Jackson method of 8 order of accuracy, explicit one-step embedded Dormand-Prince, and Kutta-Felberg methods, as well as collocation one-step implicit Gauss-Everhart methods. The first method from those listed above has a significant drawback characteristic of all multistep methods - the difficulty of changing the integration step and finding multiple solutions at the initial time. Embedded methods, like any explicit methods of Runge-Kutta, have a rather high staging, which increases their resource intensity. Gauss collocation methods lack the above-mentioned disadvantages: they combine high accuracy with relatively low stages and flexibility of changing the integration step.

Unresolved to date are questions about the estimation of the local error and the choice of a step in the Everhart method. The well-established algorithm based on the estimation of the error by the last term in the solution representation greatly overestimates the integration error, which leads to an unreasonable decreasing the step and, as a consequence, to an increasing the calculation time. The authors of this paper have proposed another algorithm based on the construction of auxiliary solution by eliminating one of the collocation points of the Everhart method. The new algorithm does not significantly increase the computational complexity since it does not require additional calculation of the right hand side of the differential equation. The authors have shown that when using the left Gauss-Rado partition, it is most effective to exclude the first collocation point. The distribution of points in this partition is such that the leftmost point provides a more accurate calculation of the auxiliary solution and a more correct estimate of the local error and the integration step.

Testing has shown that for near-Earth orbits, the acceleration of integration when using it reaches up to 2 times (for elliptical orbits) compared to the well-known analogue with the same accuracy of the result. In addition, the new method for estimating the error and choosing the step has shown good properties in the integration of the Arenstorf orbit.