Usage of Automatic Differentiation in Some Practical Problems of Celestial Mechanics

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Abstract. Building numerically integrated orbits (ephemeris) of celestial bodies has been for a long time an area of celestial mechanics with rich outcome in terms of both science and technology. The model of ephemeris contains a large number of initial parameters and constants that are determined from observations and have an uncertainty. The algorithm requires the first-order derivatives of orbital parameters w.r.t all the determined parameters in the whole timespan of observations. One of the approaches of obtaining those derivatives, examined in this work, is the integration of the derivatives simultaneously with the equations of motion. That requires calculating a function and its partial derivatives w.r.t. a number of parameters at the same time, which is essentially the case for the automatic differentiation technique.

Another usage of the automatic differentiation is the propagation of uncertainty of initial parameters and constants to orbits; the uncertainty, which generally grows with time, can be estimated via the (time-dependent) Jacobian matrix obtained with the numerical integration.

On another note, automatic differentiation allows to build a numerical integrator that is not based on difference schemes like the traditional methods used in celestial mechanics (see papers of Jorba and Zou on Taylor method).

Some preliminary practical results are presented.

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