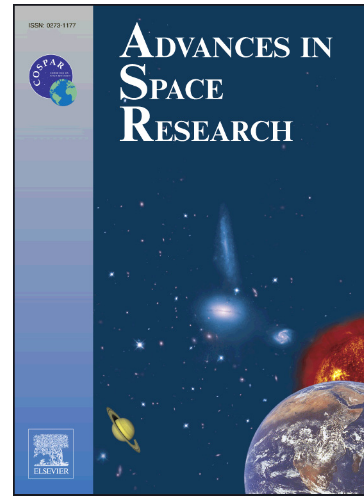

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Numerical Algebra Solution: A New Algorithm for the State Transition Matrix

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Abstract:

A new algorithm named the numerical algebra solution for the state transition matrix is proposed in this paper. The objective of the solution is to yield a comparable accuracy of the trajectory at the least computational cost. To validate it, the time consumption and accuracy performance of the numerical algebra solution are compared with those of the numerical integration and difference quotient method for both the real-time and post-processed orbit determination. Simulation results with the measurement noise only show that the time consumption of the numerical algebra solution accounts for about 60% and 40% of the numerical integration method for the real-time and post processing, respectively. Furthermore, the maximum position RMS difference of the numerical algebra solution with respect to the numerical integration method is about 1.04 mm and 0.01 mm for the real-time and post processing, while the position error of the numerical integration method is about 1.20 m and 0.30 mm, respectively. These accuracy performances demonstrate that the difference between the numerical algebra and integration solution is indistinguishable and can be accepted in the orbit determination. Advantageously, the numerical algebra solution can improve the computational efficiency greatly, which is particularly important for the real-time orbit determination.

Keywords: numerical algebra solution; state transition matrix; variational equation; time consumption.

1. Introduction

The solution of the state transition matrix (STM) is a necessity in the orbit determination, not only because it relates the state of the satellite from current to initial time but also because it propagates the covariance of the state (Battin, 1964; Liu, 2000; Montenbruck and Gill, 2000; Tapley,et al., 2004a). Theoretically, if the initial state and forces acting on the satellite are precisely known, the precise orbit can be computed by integration methods. In practice, however, neither the initial state nor the forces acting on the satellite can be known accurately before orbit determination (Xu, 2007; Xu and Xu, 2013). Therefore, observations from different geodetic techniques, such as Global Navigation Satellite System (GNSS) or Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS), should be applied to determine these parameters (Tapley, et al., 1994; Willis, et al., 2003; Willis, et al., 2010; Jin, 2012). During the orbit determination, STM plays an important role in both the observation and state equation, through which the initial state and force model parameters can be calculated precisely.

The determination of STM has two outstanding characteristics (Montenbruck and Gill, 2000).

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