Initial Satellite Orbit Determination with a Direct Multiple Shooting Method

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Abstract: After a satellite has been launched, the determination of its initial orbit is the primary question to be answered by mission control in order to prepare for high precision orbit determination and orbital transfers. This task becomes particularly complicated whenever the actual orbit differs significantly from the intended orbit because of rocket malfunctions. Such a failure occurred for example during the launch of the ARTEMIS satellite.

In order to determine the orbit of a satellite, range, range rate and angle measurements are performed by ground stations. Given a set of measurement data, a parameter estimation problem in a system of ordinary differential equations, which in this case models the satellite dynamics, can be formulated.

For the solution of this problem, we use a direct multiple shooting method. A crucial issue for the successful application to orbit determination problems is the selection of initial guesses. For this purpose we introduce a tailored projection method.

We investigate the performance of our method on the ARTEMIS scenario, for which observation data was provided by the European Space Agency (ESA). We will evaluate their suitability as input for the direct multiple shooting method by drawing a comparison of the achieved convergence behavior to that of the direct single shooting method currently employed at the ESA. In addition, the quality of the generated initial guesses will also be assessed visually using 3D animations.

The talk is based on joint work with our cooperation partners at the ESA, Dr. G. Gienger, Dr. S. Pallaschke, and Dr. G. Ziegler.

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