Attitude Estimation of Falcon 9 Rocket Body Based on Automatic Differentiation

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The photometric observation of space objects involves continuous monitoring by ground-based or space telescopes, recording the variation of their brightness over time, forming the light curves. By analyzing the characteristics of the light curves, the attitude of the target can be estimated, including parameters such as synodic period and axis orientation. By modeling different space objects as a closed set of facets and determining the area, normal direction, and surface scattering properties of each facet, a photometric model of the target can be established by adding all essential voxels. The target's attitude can be effectively estimated by combining this model with the measured light curves. However, the photometric model function expression established through this method is comparatively complex, resulting in a time-consuming and low-precision parameter estimation process. To address this issue, this study innovatively applies the Automatic Differentiation method to infer the rotational state of space objects. With the application of Automatic Differentiation, the speed and precision of parameter optimization process are significantly improved, and the phenomenon of multiple solutions caused by symmetry is discovered. Additionally, the relationship between axis orientation and the initial phase of target in the context of multiple solutions is explored.