Autonomous Orbit Navigation of Sun Synchronous Spacecraft

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For several centuries, orbit determination of objects within the solar system has been a fascinating problem that attracted the attention of the masters of mathematics, physics and astronomy. Typically, near-Earth spacecraft orbit determination involves operating upon measurements of range and range rate based on ground tracking or, on-board processing of Global Positioning System (GPS). However, ground tracking usually incurs extensive cost and human effort to support each spacecraft mission, and GPS is not available outside near-Earth orbits or for deep space missions. Considering the cost, automating navigation and navigation-related operations using only on-board measurements should greatly reduce total system cost and assure mission continuity if ground tracking or communication is interrupted. Motivated by these reasons, a method for autonomous orbit navigation of Sun synchronous spacecraft is considered which is completely independent of ground tracking systems. The radial velocity (Doppler measurement) and the directional data (from a Sun sensor) to the Sun are assumed to be available as measurements along with the directional data from the spacecraft to the Earth measured from an Earth sensor. The observability of the orbit with the available measurements is investigated by utilizing both analytical and numerical tools. Autonomous orbit navigation is obtained by using an extended Kalman filter. For a typical example, autonomous navigation can be accomplished within an accuracy of less than 50 m in position and less than 1.0×10^{-4} km/sec using the Doppler and line-of-sight to the Sun and line-of-sight to the Earth. This result is confirmed by the Monte-Carlo simulation.