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Representation of Unknown and Unmodeled Space Events for Satellites : Characteristics and Applications

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A new way of representing unknown and unmodeled space events (USEs) with Thrust-Fourier-Coefficients (TFCs) is introduced and its applications to satellite orbit determination (OD) and event detection are studied. A USE is regarded as an event due to unknown changes of force model caused by unplanned maneuvers, unknown deployment, collision, or some other drastic change in space environment. A satellite's motion under USEs, transitioning between two arbitrary orbit states, can be represented as an equivalent orbital maneuver connecting those two states by applying the Fourier series representation of perturbing accelerations. This event representation with TFCs rigorously provides a unique control law that can generate the given secular behavior of a satellite due to a USE. This technique enables us to facilitate the analytical propagation of orbit information across a USE, which allows for the usage of an existing pre-event orbit solution to compute a post-event orbit solution. By directly appending TFCs and the represented event dynamics to a regular OD filter, the modified filter using TFCs is able to blend post-event tracking data to improve a post-event orbit solution in the absence of a dynamics model of USE. Case studies with simulated tracking data show that the event representation using TFCs helps to maintain OD across a period of USEs. In addition, when there is measurement data available during USEs, a modified sequential filter with TFCs is able to detect the onset and the termination time of an event. This event representation-based OD and event detection distinguishes itself from other approaches in that it does not rely on any assumption or *a priori* information of a USE. This generic approach enables us to fit tracking data in real time and therefore to maintain a satellite tracking in the presence of USEs. This method has the advantage of avoiding the difficulty of manual parameter tuning and, thus, is able to provide more accurate post-event OD solution with a single OD filter.