Search Strategy Applicable for Breakup Fragments in the Geostationary Region

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論　文　要　旨

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論文題名

Search Strategy Applicable for Breakup Fragments in the Geostationary Region

(静止軌道領域における破砕由来スペースデブリの効率的な探索方法に関する研究)

論　文　内　容　の　要　旨

This dissertation proposes an effective search strategy applicable for fragmentation debris generated by energetic breakups of large space objects, e.g., satellites and rocket upper-stages, in the geostationary region. There are two definitive breakups in the geostationary region whose occurrences were occasionally confirmed by observations soon after the breakups. Past observation campaigns for the geostationary region have been found thousands of uncatalogued space objects, which may be associated with breakups. Moreover, it is confirmed that some of large space objects in the geostationary region have experienced unintended orbital change, i.e., orbital anomaly, that might be associated with breakup. Thus, search for the fragmentation debris will directly contribute to verify relations between uncatalogued space objects, breakups, and suspected orbital anomalies for the better understandings of current situations in the geostationary region.

The search strategy to be proposed in this dissertation utilizes orbital debris modeling techniques that describe debris generation and orbit propagation. The orbital debris modeling can predict behaviors of individual and group of fragmentation debris at breakups and also at observations. The search strategy, thus, enables effective observation planning, sensitive detection, straightforward origin identification, and breakup event characterization.

This dissertation introduces five principal roles required for the search strategy and verifies the roles in each chapter. The second chapter formulates the search strategy based on orbital debris modeling techniques. The third chapter addresses the deterministic origin identification of fragmentation debris, which enables simultaneous search for multiple breakup events and identification of unconfirmed breakups. The fourth chapter addresses the probabilistic origin identification of fragmentation debris, which enables characterization of breakup scale and improvement of orbital debris

modeling in the search strategy. The fifth chapter formulates breakup event characterization methodologies including fragmentation profile assessment and breakup scale assessment. The breakup scale assessment is demonstrated by applying a Bayesian approach combined with the probabilistic origin identification technique. The sixth chapter addresses unconfirmed breakup identification by evaluating uncertainties of unconfirmed breakups, and by applying the deterministic origin identification technique.

Along with theoretical confirmations of the search strategy to be addressed in each chapter, this dissertation also conducts empirical confirmations of the search strategy. The empirical confirmations utilize ground-based optical measurement techniques, which is a common approach for the geostationary objects observation. Optical sensor to be used consists of a small aperture telescope ($\leq$1m) equipped with a charge coupled devise camera. Through the theoretical and empirical confirmations from the second chapter to the sixth chapter, this dissertation will finally establish the effective search strategy that contributes to define current situation in the geostationary region.

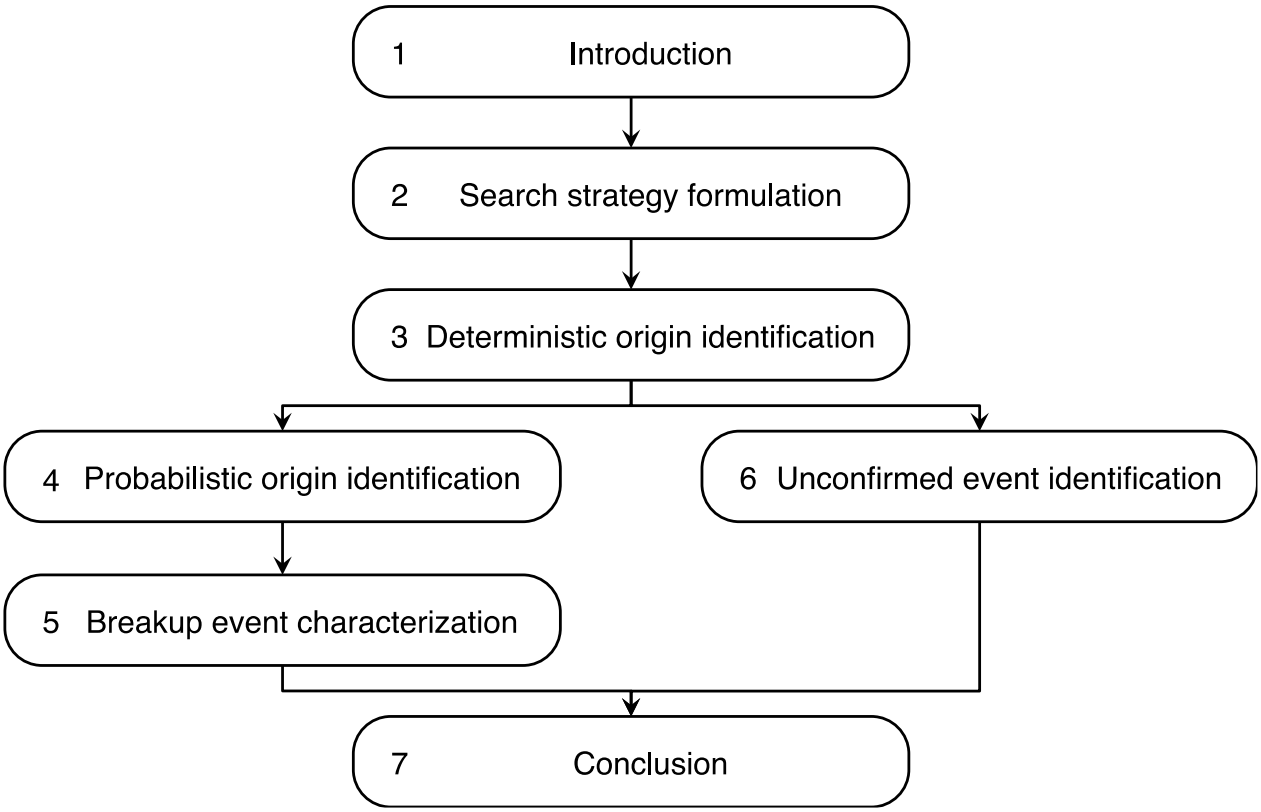

Figure 1. The structure of the dissertation.