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JOINT DETECTION AND TRACKING FOR WEAK SPACE DEBRIS

Abstract

There are lots of space debris flying on the low earth orbit, which could bring forever damage to the spacecraft if collision happening, then more space debris give birth. As for space surveillance radar, space debris are characteristic of small physical size, weak radar cross section, fluctuating cluster, so they are come down to the multiple weak target detection and tracking problem. Based on the radar measurement, the paper, puts forward an joint detection and tracking method for multiple weak space debris, which discards the traditional detection before tracking (DBT) thought, applies the common Bayes filter framework based on the random finite set theory at the radar signal processing level, replaces the motion state transition model with the echo state transition model, evaluates the echo's parameters such as phase, Doppler frequency, amplitude and their change rules, then gets the number and the parameters of the space debris. The joint detection and tracking method contains 4 vital steps. The first one is to design the echo state transition model. The echo state vector is composed of the phase, Doppler frequency and amplitude of the signal, and the process noise is white Gaussian. The model should describe such four transition modes as standard Markov density, death, spawn and birth. The second one is to design the observation model. The observation vector is the measurement from the receiver's I/Q channels which are independent, and the measurement noise is Gaussian distributed. The observation modeshould satisfy the three observation results: detection, misdetection and false alarm. At the third step, a cardinalized probability hypothesis density (CPHD) filter is proposed. While the CPHD filter updating, it refreshes the probability hypothesis density which denotes the multiple target motion states, and the cardinality distribution which is the target number, simultaneously. The last step is the sequential Monte Carlo (SMC) implementation for the CPHD filter. In the space surveillance illustration of the linear frequency modulation ubiquitous radar, the multiple weak targets moving along the straight line are simulated, the result indicates that when the signal-noise-rate is lower than 8dB, the method still keeps the high detection probability, and estimates the number correctly. So the joint detection and tracking method is able to play an important role in the surveillance of space debris which is smaller than 10cm.