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Orbit Determination and Propagation - SST (9)

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RESIDENT SPACE OBJECT ORBIT DETERMINATION USING A MULTIRECEIVER RADAR SYSTEM

Abstract

The increasing in-orbit population of resident objects is currently fostering many Space Surveillance and Tracking (SST) initiatives, which are based on the use of ground sensors. Italy contributes to the EUSST initiative with the BIstatic RAdar for LEo Survey (BIRALES), whose transmitter is the Radio Frequency Transmitter, located at the Italian Joint Test Range of Salto di Quirra in Sardinia, and whose receiver is a portion of the Northern Cross Radio Telescope, located at the Medicina Radio Astronomical Station, near Bologna.
In order to perform orbit determination (OD) from BIRALES observations, receiver raw data shall be properly processed, such that angular profiles are correctly reconstructed. Based on the receiver array configuration, its field of view (FoV) is currently populated with many independent beams and a multibeam orbit determination algorithm was developed to process the acquired data. Unfortunately, the results are negatively affected by the simultaneous presence of multiple grating lobes in the receiver gain pattern and by the signal quality.
This work proposes an alternative approach to track reconstruction: the Music Approach for Track Estimate and Reconstruction (MATER) algorithm. First, the signal direction of arrival (DOA) is estimated with the MUltiple SIgnal Classification (MUSIC) technique, which exploits the signal correlation matrix. The DOA time profile is then obtained through a clustering process, based on a RANdom SAmple Consensus (RANSAC) algorithm.
For catalogued objects, the available ephemerides can be exploited in the DOA estimation process to save computational time and to avoid ambiguity in the solution. The estimated track is then exploited in an OD process, coupled with the slant range and Doppler shift measurements. In order to check the consistency of the determined orbit with the observation data, a probabilistic correlation criterion is used. For uncatalogued objects, multiple track candidates occur due to lobes ambiguity. In order to solve such an ambiguity, all candidates enter an initial OD process. Consequently, multiple orbits are reconstructed,

together with their probabilistic correlation indexes. The correct track is selected as the one corresponding to the orbit featuring the best index.
MATER is first tested on a synthetic dataset of 899 LEO passages. The algorithm converges to the correct solution in 100% and 99.6% of the cases for catalogued and uncatalogued objects, respectively. The obtained angular accuracy is in the order of 1e-3 deg. The failures tend to occur on passages close to the FoV boundaries. In addition, MATER performance on real data is presented.