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ADAPTIVE ANGULAR TRACK ESTIMATION FOR RESIDENT SPACE OBJECT ORBIT DETERMINATION

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The increasing in-orbit population of resident objects is fostering many Space Surveillance and Tracking (SST) initiatives, among which the European SST (EUSST) framework, which are currently 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 (RFT), 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, the receiver raw data shall be properly processed. This is a particularly sensitive process, especially for the angular profile reconstruction. Based on the receiver array configuration, BIRALES field of view (FoV) is currently populated with many independent beams and a multibeam orbit determination algorithm was developed in past works to process the acquired data. However, 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: 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 covariance matrix.
For catalogued objects, the available ephemerides are exploited in the DOA estimation process to save computational time and to solve the ambiguity in the solution. The DOA time profile is then obtained through a clustering process, based on a RANdom SAmple Consensus algorithm, and the resulting angular track is exploited in an OD process, coupled with the slant range and Doppler shift measurements. To check the consistency of the determined orbit with the observation data, a probabilistic correlation criterion is used.
For uncatalogued objects, multiple estimations of the signal DOA are instantaneously obtained due to the ambiguity caused by the sensor array configuration. This causes, after the clustering phase, the presence of multiple track candidates. To solve such an ambiguity, these candidates enter an initial OD process, which benefits from slant range and Doppler shift measurements. Then, the SNR (Signal to Noise Ratio) profile is reconstructed for each candidate and compared to the one recorded during the observation. The correct track is selected as the one corresponding to the SNR featuring the best matching.
MATER is first tested on a synthetic dataset of 899 LEO passages. The algorithm converges to the correct solution in 100