Bi-Static Radar Interferometry for Space Debris Localisation using Australia Telescope Compact Array

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Space debris comprises artificial objects that remain in Earth orbit after more than six decades of space activities. The increasing growth of the orbital debris population exhibits a critical risk for existing space missions as well as upcoming orbital missions. Therefore, there has been an ever-growing interest in expanding the network of available sensors to detect, localise and characterise the space debris in orbit about the Earth in an effort to increase and maintain Space Situational Awareness (SSA). Currently, optical, laser ranging, and radar sensors constitute the backbone of SSA networks. Complementary to the existing sensors, Radio Astronomy interferometers featuring extremely high sensitivity, narrow beamwidth, and wide bandwidth offer an excellent opportunity for SSA activities.

We consider a bi-static radar scenario including a single directional transmitter as well as a radio astronomy correlator array and propose a system model for location refinement of space debris. In particular, we study the Australia Telescope Compact Array (ATCA) which is an array of six 22-metre Cassegrain reflector antennas located at the Paul Wild Observatory near Narrabri in New South Wales (NSW) as the receive array measuring the spatial correlation of reflected echoes. On the transmit side, we consider a sharp continuous waveform (CW) transmission from NASA's Deep Space Network (DSN) stations located at Tidbinbilla in the Australian Capital Territory (ACT).

Considering an array of receivers forming a radio telescope, generally, two types of data are available, 1) raw voltages or baseband signal at each antenna, and 2) visibilities or spatial correlation lags at the output of the correlator. Given that the latter is a more widespread and manageable output for a correlator array, we employ visibilities and develop a direction of arrival (DoA) estimation method based on Multiple Signal Classification (MUSIC) technique to localise the reflections within the primary beam of individual antennas.

We carried out a measurement campaign in June 2021 to demonstrate the capability of the proposed system model. Various abandoned objects in Geostationary Orbit (GEO) and Medium Earth Orbit (MEO) were illuminated by a 36-metre DSN transmitter, and the corresponding visibilities were recorded by ATCA. We employed the proposed technique on the recorded data and were able to estimate the directions within a few hundredths of a degree of accuracy. A more detailed system model, verification method and error analysis will be shown in the presentation.