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# RF TOMOGRAPHIC IMAGING FOR SUBSURFACE MAPPING OF SMALL BODIES USING A MOBILE SENSOR NETWORK

**Abstract**

Understanding the internal structure of small bodies is crucial for planetary defence, in-situ resource utilisation (ISRU), and planetary science. Previous applications of Radio Frequency Tomographic Imaging (RTI) in space exploration have typically relied on orbiter-lander configurations or sparse transceiver networks, where the majority of measurement paths must first travel through a large region of space. This reduces the interaction with the target medium, resulting in low measurement path volume density and limiting the resolution of subsurface structures.

This study simulates RTI for a network of surface-dwelling robots, where all measurement paths pass entirely through the small body, ensuring maximum volume ratio within the measurement medium. Although the initial network configuration is sparse, coverage improves over time as the robots move, gradually increasing measurement path density and refining reconstruction accuracy. We compare the performance of the Algebraic Reconstruction Technique (ART), the Simultaneous Iterative Reconstruction Technique (SIRT), and back-projection in processing these progressively enriched datasets.

Our current work is conducted in a 2D simulation framework around true asteroid topographic data for sensor positioning to assess the fundamental behaviour of reconstruction algorithms as additional measurement paths are introduced. Attenuation along each RF path is computed by discretising the straight-line path between transceivers using Bresenham's algorithm and averaging the product of a constant attenuation factor with the square root of the permittivity for each intersected grid cell. Future work will extend this approach to 3D to capture the full complexity of subsurface structures. Moreover, we plan to incorporate multiple frequency bands to enable material property discrimination, thereby enhancing RTI's capability in identifying heterogeneous subsurface features and inferring compositional variations.

These further investigations will address challenges related to signal attenuation, interference, and the dynamic repositioning of sensor nodes. The findings demonstrate that a progressively densified, surface-based sensor network offers significant advantages over traditional sparse RTI setups, providing valuable insights for optimising reconstruction techniques for small-body exploration. This work lays the foundation for a progressive RTI reconstruction methodology in the subsurface mapping of asteroids and other small bodies, with future developments aimed at refining reconstruction methods, addressing deployment challenges, and validating the approach through controlled physical tests.