Royal Academy of Engineering

Vision to Radio, Computer Vision based Spatial Modelling for Future Networks

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Combining computer vision, efficient electromagnetics modelling and radio channel measurements to provide a consistent understanding of the local environment for enhanced energy efficiency, reliability and security in future intelligent networks. Research focus for Dr Timothy Pelham at the University of Bristol, together with interests in next generation antenna array design, radar systems, and open source electromagnetics models (LyceanEM).

Background

The drive for secure, spectrally & energy efficient broadband communications requires beamforming between nodes in both mobile communications and more homogeneous networks. Spatial Intelligence is intended to allow the formation of accurate channel models at the node level using a combination of radio and other sensing modalities such as computer vision to create a Digital Twin of the Environment. This can be used by LyceanEM to inform accurate beamforming and sensing in the local environment [1].

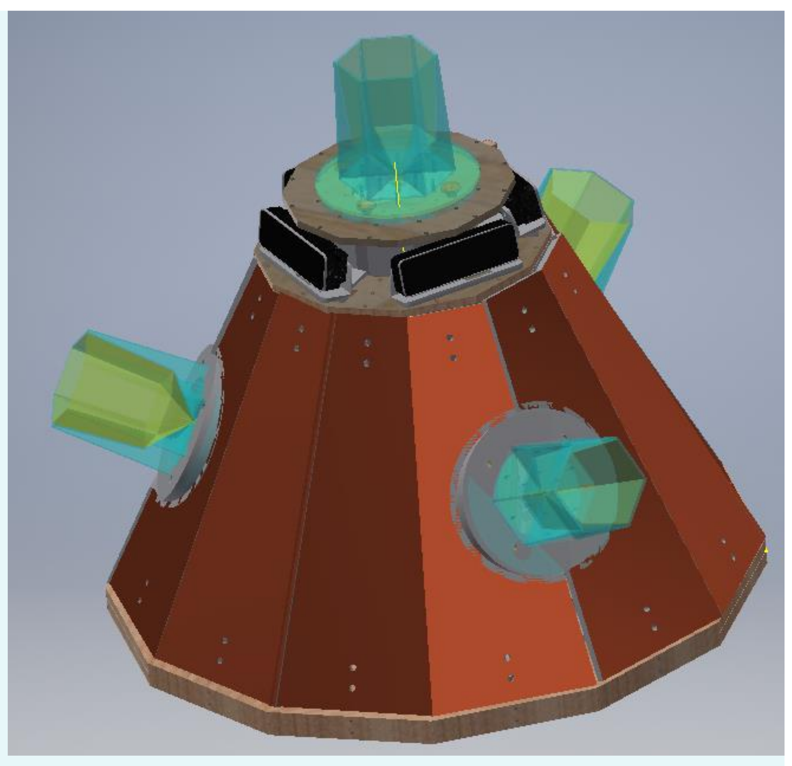


Figure 1: Spatial Intelligence Node

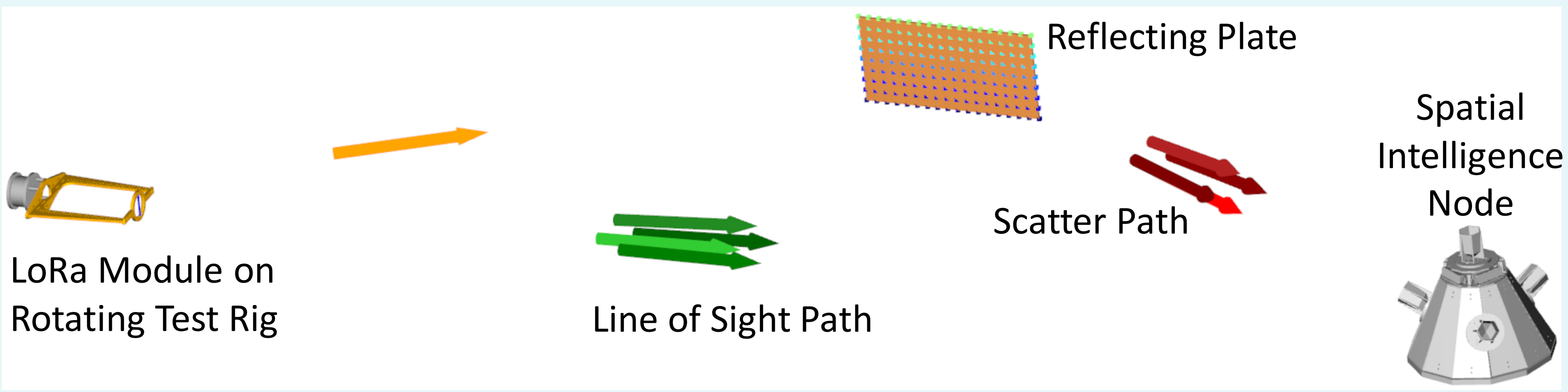


Figure 2: Anechoic Chamber Setup for LoRa measurements

Method

The Spatial Intelligence Node is populated by an Nvidia Orin AGX, providing 275 TOPS at 60W, 3 Oak-D W cameras, and 2 USRP B210 software defined radios, providing 4x4 MIMO. This allows for spatial mapping within the Anechoic Chamber, radio mapping of the line of sight and scatter from a LoRa transmitter. Rotation of the LoRa mount allows for spatial and RF fingerprinting of multiple LoRa modules, and combined characterization of the consistent scene within the anechoic chamber [2].

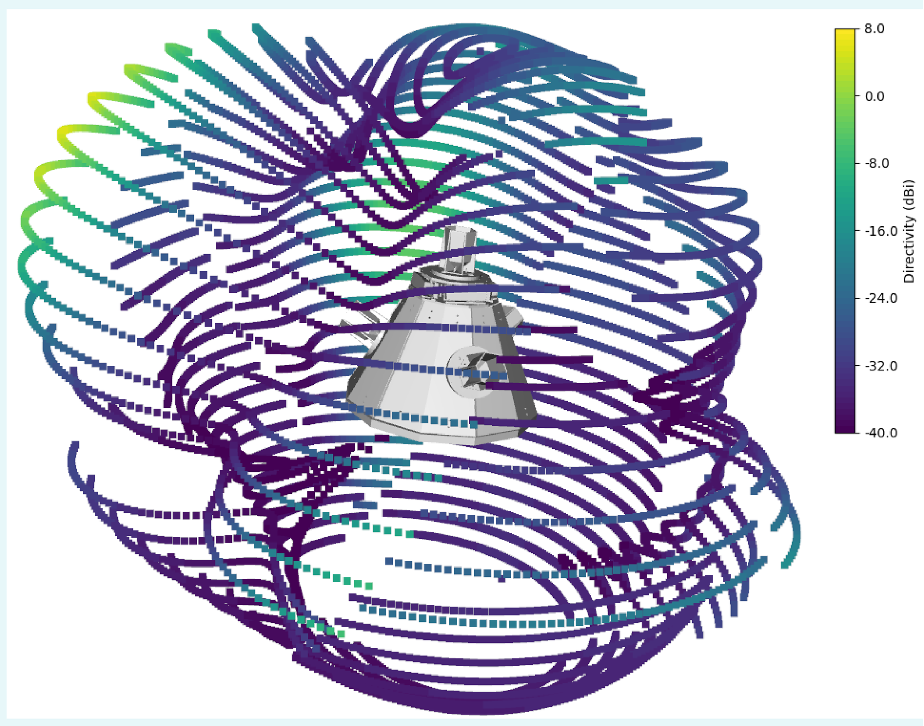
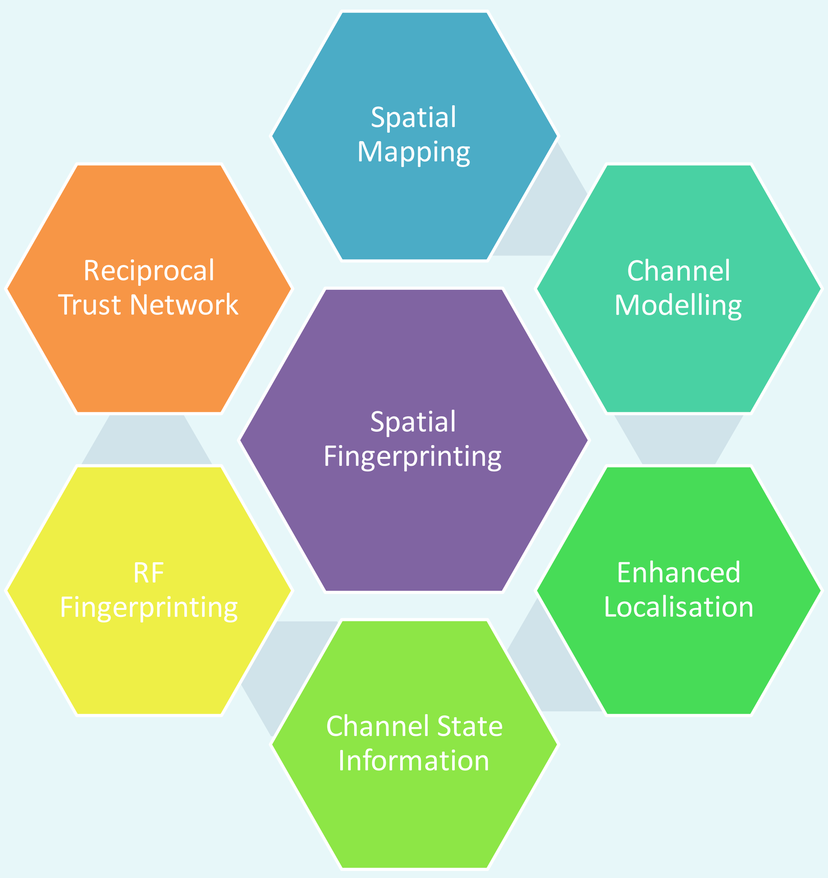


Figure 3: Beamformed Total Directivity Pattern



Applications

This multi-domain fusion approach to spatial modelling and radio sensing has a wide range of future applications. The primary interest for continuing research is that of Spatial Intelligence, allowing the creation of self-securing wireless networks. The spatial mapping approach also allows for the primary scatter of a surface to be calculated and cancelled, with applications in medical imaging, ground penetrating radar, and environment characterization.

[1] Pelham, T. G., Freire, A. L., Hilton, G., & Beach, M. (2021). Polarimetric Scattering with Discrete Raytracing for OTA Analysis. In *15th European Conference on Antennas and Propagation, EuCAP 2021* [9410981] (15th European Conference on Antennas and Propagation, EuCAP 2021).

[2] Nair, M., Cappello, T., Dang, S., & Beach, M. A. (2022). RF Fingerprinting of LoRa Transmitters Using Machine Learning with Self-Organizing Maps for Cyber Intrusion Detection. Manuscript in preparation.

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