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# HVOX: Scalable Interferometric Synthesis and Analysis of Spherical Sky Images

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Analysis and synthesis are key steps of the radio-interferometric imaging process, serving as a bridge between the visibility and sky domain. They can be expressed as partial Fourier transforms involving a large number of non-uniform frequencies and spherically-constrained spatial coordinates. Due to the data non-uniformity, these partial Fourier transforms are computationally expensive and represent a serious computational bottleneck in the image reconstruction process.

The W-gridding algorithm achieves log-linear complexity for both steps by applying a series of 2D non-uniform FFTs (NUFFT) to the data sliced along the so-called W frequency coordinate. A major drawback of this method however is its restriction to direction-cosine meshes, which are fundamentally ill-suited for large field of views. (Heavy pixel distortion as the radial distance increases.)

During the last SKACH meeting, we introduced HVOX, a novel algorithm for analysis/synthesis based on a 3D-NUFFT. Unlike W-gridding, the latter is compatible with arbitrary spherical meshes such as the popular HEALPix scheme for spherical data processing. Relying on the 3D-NUFFT allows one to optimally select the size of the inner FFTs, in particular the number of W-planes. This results in a better performing and user-friendly algorithm. To cope with the challenging scale of next-generation of radio telescopes, we proposed moreover a chunking strategy that partitions both the Fourier and image domains to balance the load amongst workers and distribute the 3D-NUFFT computational graph over multiple threads or processes with reduced memory requirements.

In this talk we present the latest developments related to HVOX, namely its new software interface and some novel benchmarking results demonstrating its scalability for both SKA and LOFAR. We also exemplify its use in the context of TART, a 24 element synthesis array radio-telescope observing the entire sky continuously and optimised for transient events detection (e.g., satellites, near-earth objects and high-energy cosmic rays).

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