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Unconstrained SARA for wide-field imaging in Radio interferometry

A. Wilber[(1)], A. Dabbech[(1)], A. Jackson[(2)], and Y. Wiaux[(1)]
(1) Institute of Sensors, Signals and Systems, Heriot-Watt University, Edinburgh EH14 4AS, UK
(2) EPCC, University of Edinburgh, Edinburgh EH8 9BT, United Kingdom

Modern radio interferometers are able to map the radio sky over large fields of view and frequency bands with extreme sensitivity and resolution. Given the sheer data volumes provided by these instruments, such capabilities give rise to important computational challenges in the data processing. In solving the ill-posed inverse problem underlying radio-interferometric imaging, a class of imaging and calibration methods was devised in the recent years, promoting an average sparsity image model (the SARA model), and underpinned by algorithmic structures defined in the framework of optimization theory. The iterative scheme underlying these algorithms requires data gridding and de-gridding operations at each iteration. In this work, we present a highly parallelized form of the measurement operator in reduced dimension to enable wide-field imaging. The low-dimensional operator results from merging the two consecutive de-gridding and gridding operations into a single sparse holographic matrix encoded by blocks to enable parallel computation. We leverage the resulting measurement operator in the monochromatic unconstrained SARA approach [1, 2] whose iterative scheme consists in a forward step imposing the fidelity to data via a parallellized gradient operation based on the holographic matrix, followed by a backward step enforcing the average sparsity prior model via dedicated proximal regularization operators. We validate the efficiency of our approach on early science and pilot survey observations from the Australian Square Kilometre Array Pathfinder (ASKAP) in comparison with the state-of-the-art CLEAN-based method in the WSClean software. We recover radio images of size 242 MB spanning a field of view of 3.36 deg squared from about 1.5 GB sized-data and we showcase the high resolution and dynamic range, enabled by unconstrained SARA, through the level of details observed on the bright sources and the detection of faint diffuse emissions. This abstract summarizes work from two full papers in preparation [3, 4].

References

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