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Cygnus A jointly calibrated and imaged via non-convex optimisation from JVL A data

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Radio interferometric (RI) data are noisy under-sampled spatial Fourier components of the unknown radio sky affected by direction-dependent antenna gains. Failure to model these antenna gains accurately results in a radio sky estimate with limited fidelity and resolution. The RI inverse problem has been recently addressed, in simulation, via a joint calibration and imaging approach which consists in solving a non-convex minimisation task, involving suitable priors for the DDEs, namely temporal and spatial smoothness, and ℓ_1 -sparsity for the unknown radio map [1]. Building on these developments, we propose to promote strong sparsity of the radio map. *i.e.* in ℓ_0 sense, via a non-convex regularisation function that is the log-sum penalty. The resulting minimisation task is addressed via a sequence of non-convex minimisation tasks composed of re-weighted ℓ_1 image priors, which are solved approximately. We demonstrate the efficiency of the approach on RI observations of the celebrated radio galaxy Cygnus A obtained with the Karl G. Jansky Very Large Array at X, C, and S bands. More precisely, we showcase that the approach enhances data fidelity significantly while achieving high resolution high dynamic range radio maps, confirming the suitability of the priors considered for the unknown DDEs and radio image. As a clear qualitative indication of the high fidelity achieved by the data and the proposed approach, we report the detection of three background sources in the vicinity of Cyg A, at S band. The approach is implemented in MATLAB (code available on the Puri-Psi webpage [2]). This abstract summarises a full paper by the authors [3].

References

- [1] A. Repetti, J. Birdi, A. Dabbech, and Y. Wiaux, “Non-convex optimization for self-calibration of direction-dependent effects in radio interferometric imaging. *Monthly Notices of the Royal Astronomical Society*, 470(4), 3981–4006, 2017. <https://doi.org/10.1093/mnras/stx1267>.
- [2] <https://basp-group.github.io/Puri-Psi/>.
- [3] A. Dabbech, A. Repetti, R. Perley, O. M. Smirnov, and Y. Wiaux, “Cygnus A jointly calibrated and imaged via non-convex optimisation from JVL A data,” *submitted to Monthly Notices of the Royal Astronomical Society*, January 2021. <https://researchportal.hw.ac.uk> ID:43616441.