Research internship
at
CentraleSupelec/L2S and Observatoire cote d'azur

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Title : Calibration of massive array for the radio astronomy application

Keywords : big data, massive array, calibration, Maximum Likelihood

Abstract :
In the context of radio astronomy [1], recent and future radio interferometers such as the LOw Frequency Array (LOFAR) and the Square Kilometer Array (SKA) are composed of a huge number of antennas with a wide field of view, resulting in large collecting area and high resolution imaging. To meet the theoretical optimal performance bounds and avoid severe distortions in the image reconstruction [2], array calibration is a crucial step which amounts to estimate all unknown perturbation effects along each signal propagation path [3]. A robust calibration algorithm based on a broad class of distributions, gathered under the so-called compound-Gaussian modeling, has recently been proposed [4]. Robustness to the presence of outliers is essential in radio astronomy since interferers and punctual events corrupt the observations and some unknown unmodelled weak sources are present in the background.

The price to pay is an increased complexity of the calibration algorithm. This complexity can be an obstacle when the number of antennas to be calibrated and/or the number of sources used for the calibration are large. The objective of this master internship is to study the scalability of the algorithm [4] w.r.t. the number of antennas and sources. It includes a bibliographic review on antenna calibration for radio-astronomy, the use of a data simulation software package, a comparison with a reference algorithm such as StEFCal and a detailed analysis of [4] in order to identify possible improvements. If the effective parallelization of the method(s) on High Performance Server (HPC) with multiple GPU boards is not planed in this internship, distribution of computation should be anticipated in the definition of the algorithm(s).

[1] A.-J. van der Veen and S. J.Wijnholds, “Signal processing tools for radio astronomy,” in Handbook of Signal Processing Systems. Springer, 2013, pp. 421–463.

[2] R. Ammanouil, A. Ferrari, D. Mary, R. Flamary, C. Ferrari and D. Mary, “Multi Frequency Image Reconstruction for Radio-Interferometry with Self-Tuned Regularization Parameters” in 25th European Signal Processing Conference, (EUSIPCO), 2017.

[3] S. J. Wijnholds, S. van der Tol, R. Nijboer, and A.-J. van der Veen, “Calibration challenges for future radio telescopes,” *IEEE SignalProcessing Magazine*, vol. 27, no. 1, pp. 30–42, 2010.

[4] V. Ollier, M. N. E. Korso, R. Boyer, P. Larzabal and M. Pesavento, "Robust Calibration of Radio Interferometers in Non-Gaussian Environment," in *IEEE Transactions on Signal Processing*, vol. 65, no. 21, pp. 5649-5660, Nov.1, 1 2017.